



CASTLETOWN LAW

Criteria for Site Selection for Civil Nuclear Energy



Criteria for Site Selection for Civil Nuclear Energy

In past months and years, the British Government launched consultations to address the dilemma facing British Industry around the planning process and the criteria for siting and locating nuclear energy plants.

Much has been said about the proposed changes to the planning system that will be heralded in by EN7 allowing for major infrastructure to be subject to a completely refreshed planning process from 2026 onwards.

The 2023/24 consultation set out the following as part of its intention:

“We now need to produce a new nuclear NPS, not only to provide an effective planning framework beyond 2025 but also to take advantage of the advanced nuclear technologies that will come onstream and provide the flexibility needed to meet the UK’s nuclear ambitions. EN-6 will continue to be an important and relevant consideration in any planning process for projects at the sites listed in EN-6, as well as amendments to DCOs for projects that were consented under EN-6, when the new NPS is designated.”

So, this new nuclear National Planning Statement (NPS) is intended to cater for the new nuclear technologies and take advantage of the opportunity to allow nuclear energy to be a fundamental part of the UK’s energy approach. The reforms as they materialise have to be looked at in the context that the existing nuclear sites in the UK were designated following a nomination process in 2006-2008 based on the technology characteristics of onsite fabrication, assembly and construction of GW-scale reactors. The selection criteria were largely risk-based and for the purpose of this discussion paper, the risk criteria considered were the historic radiation emission risks from an incident causing a release of ionised vapour from a PWR technology.

As the statement quoted suggests, the new NPS EN7 will look at the DCO process for existing and newly designated nuclear sites. In this paper I start to look at what that actually means. On one reading this is simply a consultation on how the DCO process can be improved through a new NPS to address some of the shortcomings of the existing NPS. I question whether this helps the objective of enabling new nuclear technologies to come onstream and provide the flexibility needed to meet the UK’s nuclear ambitions. Others are considering and have written recently about the issues around the consenting process under DCO provisions, and I do not consider those to any material extent here.

If the ambition is to utilise the planning system to enable expedited delivery of nuclear power plant on existing nuclear sites, the objective of having an NPS which refines the existing processes and accelerates the consents achievable, may meet the need of the ambition.

If, however, the ambition is to use the timeline available to replace the existing fossil fuel and gas generation systems with a mixed generation where base load and flexibility are provided by nuclear energy, different criteria apply. The location of nuclear power plants close to industry, allowing nuclear power plants to supply under private contract to industry and not to grid, and locating advanced (GEN IV) nuclear power plants close to conurbations and centres of population, are all issues that are in the minds of the advanced nuclear technology providers, no matter what stage in the technology approval process they are.

It is imperative that these GEN IV and SMR technologies are not treated as the same because SMR technology is almost exclusively based on existing PWR nuclear technology that is proven and operates throughout multiple jurisdictions. The 440 or so existing PWR and similar technology reactors provide around 9% of the world’s energy supply.

Addressing the Future

According to the IEA:

“Global electricity demand is forecast to grow by around 4% in 2024, up from 2.5% in 2023, the IEA’s Electricity Mid-Year Update finds.”

This growth figure is not predicted to begin levelling off for at least 20 years and, in some predicted scenarios, for nearly 50 years.

The growth in demand for energy has to be met without dependence on fossil fuels for three reasons. Firstly, fossil fuel emissions are poisoning the planet, secondly fossil fuels have a limited lifetime, and thirdly, the diminishing availability of fossil fuels has inevitable price increase pressures, and those prices will be controlled by international commercial organisations whose objective is to maximise profit. So, for example, the UAE are already planning for no reliance on the oil economy in 20/30 years’ time, the UK and other fossil fuel industry jurisdictions have a similar longevity profile.

My view is that the energy transition is not just about transitioning away from fossil fuels because of climate change; it is also about finding a new enduring solution to energy provision for generations to come in a way which is safe, secure and reliable.

The relevance to the consultation and any proposed EN7 is the need to consider how energy of the future is produced, where it is produced, how it is transmitted and how it is affordable within any jurisdiction whilst providing a nationally secure energy supply to consumers. In my view, tinkering with the DCO process and consenting onshore and offshore wind and solar, does not meet the challenge of solving the long-term security and affordability of energy, required by industry and the national consumer base.

UK government modelling suggests:

“The UK’s annual electricity demand is expected to increase from 320.7 TWh to between 550-680 TWh in 2050. This is due to the transition to clean electricity, including electric cars, low-carbon heating systems, and electrification of heavy industry.”

On any view, this doubling of demand, whilst energy generation sources are being shut down, is in urgent need of attention. Nuclear power generation in 2022 in the UK was just under 6GW.

In 2024, seven out of the nine nuclear power reactors present in the United Kingdom had a remaining operational life of one to two years. EDF UK announced that Heysham II and Torness 1 & 2 will stop their activity in 2028 instead of 2030, as previously planned.

To take advantage of the “new nuclear technologies that will come on stream” and to fill the seismic hole in energy generation security, something more is needed, and I question whether the great progress in SMR-PWR technology is the only answer. I set out my reasons for this below.

In relation to SMR technologies the IAEA have said this:

“Given their smaller footprint, SMRs can be sited on locations not suitable for larger nuclear power plants. Prefabricated units of SMRs can be manufactured and then shipped and installed on site, making them more affordable to build than large power reactors, which are often custom designed for a particular location, sometimes leading to construction delays. SMRs offer savings in cost and construction time, and they can be deployed incrementally to match increasing energy demand.”

I question what this actually means in terms of where the smaller footprint sites may be because the characterisation of sites for PWR reactor technology is not likely to change in the proposed planning review and so whilst the footprint size may reduce, the criteria for site selection will remain unless characterisation criteria are changed. This means the SMR-PWR fleets of the future are likely to be located on the existing nuclear sites already available unless and until a different set of criteria apply. These criteria are even more important for Generation IV technologies which aspire to be co-located with industry and conurbations to supply power and heat at low cost on long-term supply contracts. It is clear that to meet the future demand for energy, the criteria for selecting nuclear sites and permitting nuclear technology locations will have to be looked at.

A little bit of History

The existing criteria can be traced back to the 1960s but the more recent paper by the Health and Safety Executive Nuclear Directorate in 2008 provides a helpful precis of where things were at that time. The paper has a number of statements which are consistent with the approach being followed in 2024/25.

- ALARP applies in recognition that risk cannot be entirely eliminated.
- Emergency preparedness is appropriate.
- Control procedures and operator procedures apply to limit consequences of any risk materialised.
- Locations must be in places where population density does not exceed specified thresholds.
- Planning laws require the consideration of the density risk for any development in a nuclear power plant “consultation zone”.
- In 2008 the updated approach for demographic criteria for new nuclear power stations was reported on to government. This used IAEA approaches and the NII Safety Assessment Principles (SAPs).
- The approach assumed the use of technologies that had been in use for circa 50 years and were demonstrably safe.
- The Strategic Siting Assessment criteria as previously set out in a number of papers reference the exclusion of a site from consideration where the population density criteria were not met.
- Where a site met the Strategic Siting Assessment criteria it could be included in the government National Nuclear Policy statement.

The Government then, through DECC, sought nominations for sites that met the Strategic Siting Assessment criteria for inclusion in what was to be a new round of nuclear power station sites.

And Now

I look below at whether it is permissible under the current legal regulatory regime for SMR-PWR technology to be deployed on sites other than existing nuclear sites and whether for Generation IV technologies we need a new nomination or characterisation process to enable new sites to be designated, subject to meeting technology criteria.

By technology criteria, I mean the technology is certified or approved as technology which can operate safely in a location where the previously applied demographic risks are not applicable because the technology has met a standard of evidence on an ALARP basis which satisfies the technology regulator. As a result, the planners are therefore obliged to accept that the risk of an incident with any material emission is so small that it is safe to locate close to industrial locations and conurbations, subject to other security and safety criteria being met.

The criteria to be met in a Strategic Siting Assessment Study are complex and technically challenging, but I am focussing on the emissions risk criteria.

I start by looking at the 2021 Orano Report to the ONR on Safety Zones around nuclear installations. The Orano Report presents the following findings:

The review indicated that, within the context of ONR's sampling-based regulatory approach:

- *The proposed minimum 3km OCZ (outer consultation zone) is appropriate.*
- *The proposed 30km zone for significant developments could be reduced to 12km if airports, launch sites, and hydraulic fracturing were moved to a new, special case category, as below. This would leave major hazard facilities, such as chemical plant and major pipelines in the 12km zone. During the review, it was identified that military installations storing munitions should also be considered as within the 12km zone.*
- *An additional special case category (irrespective of distance from nuclear sites) should be introduced for developments that can have very long-range impacts: airports and launch sites, reservoirs, hydraulic fracturing, military airspace use (e.g. training areas) and military practice, bombing or firing ranges.*

In essence this validated a view that an Outer Consultation Zone of 3km could be appropriate, a 30km zone was not necessary and could be limited to 12km and that special case activities should be classified to ensure planning for those special cases of a site development were mutually exclusive. The zone circumference was considered and it was found there were no material reasons from not simply adopting a circular zone approach.

The justifications for the 3 and 12 km OCZ are given in the paper and are said to be based on research and comparative studies.

Why OCZ is needed

The initial and primary consideration must always be safety and prevention of accidents from which the risk of harm from radioactive emissions requires reactive measures.

Large industrial and power generation facilities carry material risks in terms of harm of pollution in the local area arising from incidents or accidents which cause emissions or an uncontrolled event beyond normal projected risk events. Nuclear has a higher public profile than other industries even though its safety record is demonstrably better than most other major industrial activities and much better than most comparable types of power generation.

Several theories have been advanced to explain the fear that many people have of radiation: the fact that it can harm without being felt, that it is capable of causing cancer, that it can harm unborn children, or simply that people do not understand and therefore dread it more than other risks. Although, the worst energy-related post-war accident in Western Europe was the overtopping of a dam in northern Italy which killed more than 2,000 people in 1963, it is seldom cited as a high-risk technology. Taking dam construction as an example the facts demonstrate that historically, dams are one of the biggest killers in the event of a defect or failure, in energy production facilities:

- Banqiao Dam failure, China, 1975

This dam failure is considered the deadliest in history, with estimates of the death toll ranging from 85,600 to 240,000. The failure also caused 11 million people to lose their homes.

- Derna Dam collapse, Libya, 2023

The collapse of two dams in Derna, Libya, after Storm Daniel caused flooding and killed an estimated 5,900 to 20,000 people.

- Bento Rodrigues dam disaster, Brazil, 2015

The failure of an iron ore containment dam killed 19 people and released 60 million cubic meters of iron waste.

- Brumadinho dam disaster, Brazil, 2019

At least 134 people died in this disaster, and as many as 252 people are unaccounted for.

- Jagersfontein Tailings Dam Collapse, South Africa, 2022

A structural failure caused a mudslide that destroyed a town and surrounding farmland.

If the risks from nuclear power stations are comparatively small, why are the restrictions and obligations placed on civil nuclear energy generators so prescriptive. (I look at the public perception issue on this further below). The first part of this relates to radiation emissions from nuclear installations. Although, the occurrence of these incidents in nuclear power generation is low in comparison to other industrial-scale events causing harm, it remains a legitimate concern in the view of the public and so must be addressed.

Council directive 2009/71 Euratom – established in law the licensing principle that:

“provision must be made whereby the construction and operation of plants for the generation of nuclear power, radioactive waste safe management or dismantling of nuclear plants at the end of life cycle, and all related activities are considered to be activities of compelling interest to the state and as such subject to a single licence issued at the request of the applicant”

The 96/29 Euratom Directive (now repealed but largely incorporated within Council Directive 2013/59/Euratom) applies to: *“all practices involving a risk from ionising radiation emanating from an artificial source or from a natural radiation source in cases where natural radionuclides are or have been processed in view of their radioactive, fissile or fertile properties. Such practices include in particular the production, processing, handling, use, holding, storage, transport, import to and export from the Community and disposal of radioactive substances. On the other side, this Directive shall not apply to exposure to radon in dwellings or to the natural level of radiation, i.e. to radionuclides contained in the human body, to cosmic radiation prevailing at ground level or to aboveground exposure to radionuclides present in the undisturbed earth's crust. The above-mentioned practices may be carried out only upon prior authorization and must be reported to the competent authorities.”*

Title III of the Directive is entirely devoted to such reporting and authorisation. Article 5 concerns authorisation and clearance for disposal, recycling or reuse of radioactive substances or materials containing radioactive substances. Further, Title IV deals with justification, optimisation and dose limitation for practices. Title V lays down rules relating to estimation of effective dose. Title IX regulates with detail the interventions to be undertaken in case of radiological emergencies.

Public Perception and Risk

Although there are several types of radiation, for the purpose of this paper they are referred to generically. Radiation from radionuclides is a part of our earth - it has existed all along. Naturally occurring radioactive materials are present in the floors and walls of our homes, schools, or offices and in the food we eat and drink. Man has always been exposed to natural radiation arising from the earth as well as from outside the earth. The radiation we receive from outer space is called cosmic radiation or cosmic rays.

We also receive exposure from man-made radiation, such as X-rays, radiation used to diagnose diseases and for cancer therapy. Fallout from nuclear explosives testing and small quantities of radioactive materials released to the environment from coal and nuclear power plants are also sources of radiation exposure to man. Exposure to radiation occurs in the following ways:

- We are surrounded by naturally occurring radioactive elements in the soil and stones and cosmic rays entering the earth's atmosphere from outer space.
- We receive internal exposure from radioactive elements, which we take into our bodies through food and water and through the air we breathe.
- We have radioactive elements (Potassium 40, Carbon 14, Radium 226) in our blood or bones.
- Medical and dental treatments.
- Industrial examination and testing processes.
- Routine discharges from industrial processes, including oil, gas, coal and nuclear power generation.

Considering radiation exposure as a risk, one measure of the risk of biological harm is the dose of radiation that the tissues receive. The unit of absorbed radiation dose is the sievert (Sv). Since one sievert is a large quantity, radiation doses normally encountered are expressed in millisievert (mSv) or microsievert (μ Sv), which are one-thousandth or one-millionth of a sievert. For example, one chest X-ray will give about 0.2 mSv of radiation dose.

The international body the International Commission on Radiological Protection (ICRP) originating in 1928 is the global body which examines, considers and recommends the approach to be taken on radiation protection. The recommendations form the basis for documents such as the IAEA joint paper on Basic Safety Standards for Radiological Protection.

In the UK the amount of exposure to radiation in addition to the normal daily exposure experienced is governed by the Ionising Radiations Regulations 2017. The regulations have a number of limits on the exposure to which persons may be exposed.

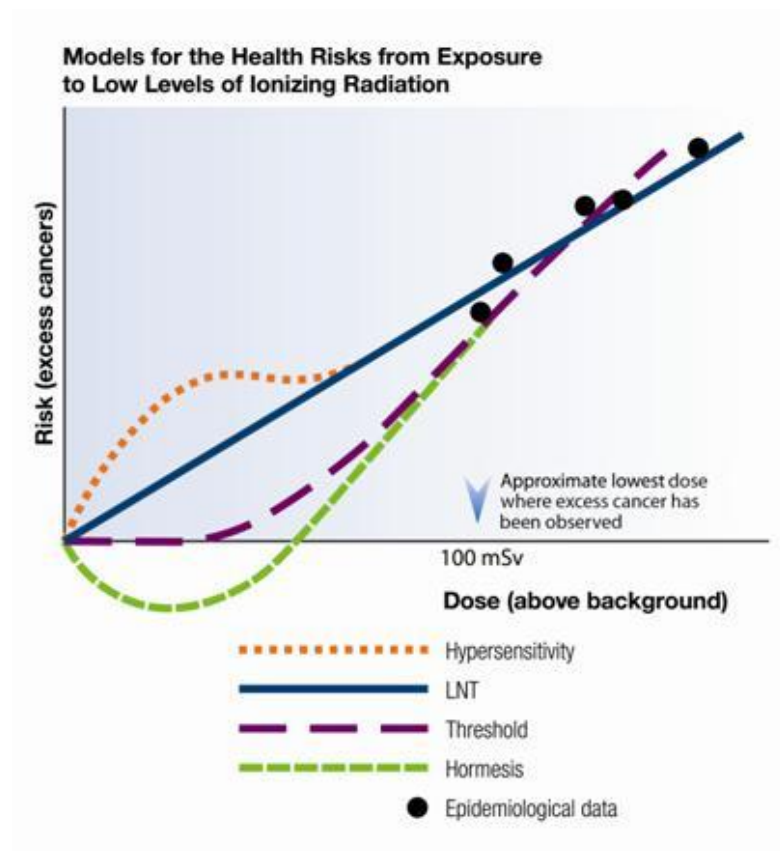
There is some debate about the way in which ICRP levels are assessed. Currently the ICRP uses the Linear Non-Threshold (LNT) assessment model. A simple explanation of the approach comes from the Canadian Nuclear Regulator, the CNSC, as follows:

"The risks from radiation have been largely derived from atomic bomb survivor studies, where the incidence of disease (principally cancer) was plotted against radiation dose. Where there was data, the dose response was linear, meaning that as dose increased so did cancer risk. However, below the lowest data point, the natural incidence of the disease masked any effects that may have been caused by radiation. Because of this, the LNT model assumes that cancer incidence as it relates to radiation dose behaves in the same way as at higher doses; that is, in a linear manner."

The approach of the ICRP is under re-assessment, in part because the ICRP and others have recognised that the assumed starting point of when any radiation exposure is harmful to health, may not be the correct starting point. A recent paper from Cambridge University suggests there may be alternative approaches which are more appropriate:

"In nuclear safety cases, facilities must demonstrate and provide evidence that radiation protection measures are incorporated into their engineering designs to minimise exposures to workers and the public to ALARA. The principle has been incredibly successful as a driver to minimize exposures, as evidenced by the recorded doses of exposure to nuclear workers in the UK. Although exposure limits are set at 1mSv/yr (public) and 20mSv/yr (nuclear workers), the mean dose to a nuclear worker in the UK is of the order of 0.4mSv/yr. On top of that, natural background exposure in the UK varies between 2 and 8 mSv/yr. This prompts the question: when have we reduced exposures sufficiently and how much are we willing to spend on reducing exposures that are already below background levels?"

The image below from the Canadian National Research Council (CNRC) shows the different methods of evaluation, which are used here simply to demonstrate that the ICRP approach is under reconsideration but may not change in the near future. The Cambridge University group assessment is that it may take the 30 works streams around 10 years to reach a revised view.



Application of Outer Consultation Zones (Public Exposure Risk)

In the context of the zones applicable, the objective of having defined areas for planning controls is to limit the extent of development to protect against an incident giving rise to a higher than permitted radiation dosage affecting a resident population and to limit the risk to a resident population from higher than permitted radiation doses arising from the day to day permitted activities on operational sites. In my view, there is no arguable case that the ICRP levels recommended in its reports as adopted and issued jointly by many international bodies should be reduced. The approach I consider below is how the safety case of the applicable technology may allow the Safety Zones around nuclear installations to be reduced based on comparable risks to health.

Comparable Risk

It is claimed by many technology owners that SMR-PWR reactors have a different risk profile from onsite constructed GW size reactors. I have heard questions raised about whether modularity of itself may introduce a risk to the technology which adversely affects the safety characteristics from a radiological emissions point of view. I do not subscribe to that view, but notwithstanding the question over modular construction affecting risk, it is certain that the overall safety will be regulated, and appropriate requirements imposed. There has been an assumption that smaller and modular means safer than the GW size preceding technology, and whilst that may be the case, the evidence to support a case for the safety of SMR-PWRs being materially safer than GW size PWRs is needed. Unless that addresses the risk on an ALARP analysis, I believe there will be a very strong public view that location of SMR-PWR technologies should be on or adjacent to existing nuclear-licensed sites.

Considering the IAEA statement above:

“Given their smaller footprint, SMRs can be sited on locations not suitable for larger nuclear power plants. Prefabricated units of SMRs can be manufactured and then shipped and installed on site, making them more affordable to build than large power reactors, which are often custom designed for a particular location, sometimes leading to construction delays. SMRs offer savings in cost and construction time, and they can be deployed incrementally to match increasing energy demand.”

I wonder if size matters if the safety case in relation to radiological risk and the required planning restrictions do not create a scenario where the risk from the SMR-PWR reactors is not demonstrated to be less than the GW size plants.

In nuclear terms, the size of a PWR is irrelevant if the safety is not proven to be better than what is already located on nuclear-licensed sites, and to force the position onto the public may have an adverse impact on nuclear power generation overall.

Safety is Overriding Requirement

The regulations and the many papers published in relation to this, all reference safety as the priority criteria in the siting characteristics. The safety approach we have referenced above is the operational safety normal operations, taking into account the risks of accidental aerosol dispersal of radioactive material and the operational risk of normal operational radiation levels causing exposure through activities normally carried out on the site. The ICRP designs the exposure levels for the normal activities and for the purpose of this paper, it is considered highly unlikely that any change will be made to those levels in the foreseeable future.

As above, I have considered the ALARP risk approach for PWR technologies being adapted for SMR deployment and based on the public perception issues and the previous safety criteria imposed on projects at HPC, Wylfa and Sizewell C, I believe there will be a very significant risk of challenge if the SMR-PWR site selection criteria are changed from those previously applied. This challenge will likely arise from anti-nuclear pressure groups, which, despite the factual evidence, will argue that SMR-PWRs are in exactly the same category as GW reactors, and so their location selection should not be relaxed.

The challenge to the SMR-PWR developers will be to demonstrate the differential safety features of the SMR-PWR technologies and achieve regulatory approval for their site selection on the sites of their choice. In the short term and in light of the GBN sites available for SMR-PWR deployment, it is likely in my view that the initial deployment of SMR-PWR will be on previously identified nuclear licensed sites. This poses a problem for those developers who wish to deploy SMR-PWR technology on sites, where, for example, there are off-takers willing to sign up to long-term private wire PPAs to support the industrial energy demand they have for the future industrial growth they want to invest in.

In the short term, in my view, these developers may have to rely on existing nuclear-licensed sites and sites which are adjacent to current industrial sites where COMAH applies or a similar OCZ applies to the activities within the site.

In his report ‘Tolerability of Risk’ on Sizewell B (revised in 1992), Sir Frank Layfield made the following observation:

“This does not mean that the SAPs can never be adapted to new circumstances. On the contrary, it will be necessary to develop the detailed approach so far adopted by NII in relation to any new designs proposed for nuclear power stations in the UK having regard to the approach adopted in other countries, so far as seems sensible and safe. It seems right however, at a time when no such proposals are in immediate prospect, to bring up to date the thinking that has applied so far, and to republish, in the Tolerability document, the overall approach and standards which the Health and Safety Commission and HSE intend should apply, whatever changes may in future be made in the approach described in the SAPs.”

The paper goes on to consider the societal considerations and the application of the ALARP principles as a risk management approach based on the desirability of the outcome.

The task in my view for SMR-PWR developers is now to define how to bring “up to date the thinking that has applied so far”. The approach of using empirical evidence of the safety in operation of the SMR-PWR technologies to demonstrate the radiation hazard risk is well within regulatory required levels and should now be made available. This will support the safety case and the risk of a breach of containment leading to aerosol dispersal complying with the ALARP and ALARA principles.

I take this view and approach because in my view, the prospects of changing the legislation applicable to the technological assessment process, the Generic Design Assessment (GDA) and the application of regulation is unlikely to happen in the timeline necessary to allow commercial deployment of SMR-PWR technology in the UK. As noted in the quotation above it is necessary to develop the detailed approach and to have regard to the approach adopted in other countries, so far as sensible and safe.

Without a multilateral approach to resolving the issue of site characterisation for SMR-PWR technologies it may be a long time before there is a clear pathway for deployment on current non-nuclear licensed sites.

Application of ALARP in Context

While the application of ICRP standards is a useful starting point, the critical question, in my view, is achieving an approach which can bring the risk of danger from exposure to radiation to the lowest level reasonably achievable within the levels which are known to bring a risk. In the context of modern technology and the alarm and shutdown response systems, the key issue, I believe is to question why the same standard of risk profile as applied to historic GW projects would continue to be applied without a detailed assessment of the risk which actually arises as opposed to the historically assumed risk. So far as I can see and with thanks to others who have provided input into the research on this, the criteria applied utilise the same semi-urban locational criteria as applied to AGR and PWR programmes without adjustment for the technology improvements within reactor safety designs and other technology advancements for control of the risk of emissions and public health hazards.

Although site selection has a number of components in this paper, I am considering only radiological protection within the site characterisation criteria because I perceive (perhaps incorrectly in the view of some) that design approval of technology, safety systems, emergency response and environmental and ecological aspects are satisfied on the current design of applicable technology aspects and so the site availability question is largely dependent on site location and its characterisation. Site characterisation is, in my view, the key to how sites may be made available for integration of nuclear technologies into the overall industrial landscape in the near future.

The point made in many of the papers reviewed is that there is a critical need to address the issue of risk in the public perception. So, the risk of exposure to nuclear radiation both inside the plant boundary (generally governed by site licensing and operational controls) and outside the site boundary, where the public perception risk is most apparent, is in need of information and explanation. The nuclear industry and its representative organisations have failed to recognise and address this public perception risk, and this, in turn, is a major factor in the thinking and approach of politicians in the UK.

I understand from those who have been most helpful in reviewing this paper that the modern reactor designs under consideration as GEN IV reactors in the UK are able to claim to have core damage and release criteria of $< 10^{-6}$ /annum, which brings them within the international regime expectations and within the expectations of ONR, BSO and ALARP. The reasoning behind this is that the new GEN IV technologies are low-output technologies, meaning the application of a one-size-fits-all approach to emissions risk is appropriate. The proportionate approach, which is espoused by many across the nuclear engineering sector, suggests the Radiological (Emergency Preparedness

in Public Information) Regulations 2019 need to be applied more discriminately, perhaps with positive discrimination in favour of those GEN IV technologies which can demonstrate the Safety Assessment Principles (SAP) probability thresholds are met.

One area that seems to be missing is the lack of comparable risk in the proportionality approach of ALARP. Most applications of ALARP in the context of nuclear technology and, in particular, in the area of emissions risk only consider the application for a particular technology on a specific site. There is, in my view, a very strong case to consider the comparable risk to public health from other emitting technologies. I question whether it is appropriate to impose a standard of safety on nuclear technologies, based on historic assumptions on now outdated technology, when other technologies and some which are not subject to regulated control, such as vehicle emissions, are allowed to operate in proximity to conurbations and population centres, when technologies which are demonstrably safe (I mean here GEN IV technologies) within the context of ONR standards when applied proportionately, are not.

In my view, the application of ALARP principles should enable GEN IV technologies to be considered as a localisation option for long-term replacement of coal and gas plant. Applied correctly, based on the technology claims of GEN IV, ALARP could be applied to positively encourage and enable localised deployment of the technologies.

GEN IV

For the purpose of this paper, I am considering primarily two GEN IV technologies - Molten Salt and Lead Fast, in each case, with output of up to 100MWe equivalent per individual plant. Each technology has a history dating back to the 1960's with proven tests and operational prototypes (I mention HTGR below). MSR and LFR reactors are said to have a number of inherent benefits, which each technology owner claims in different ways. In summary these are claimed to be:

- Single point safety assured manufacture in factory environment of reactor technology.
- Single closed loop gravity operating model so no pressurisation release risk.
- Ambient solid state for intermediary material (Lead or Salt).
- Default safety removes fissile material from vessel so no residual risk after shut down.
- Each unit has a small footprint of circa less than one football pitch.
- Flexible outputs of heat, steam and electricity.
- Decreasing cost of manufacture and long-term lower cost of electricity.
- Capable of replacing existing gas and coal generation plants as they become obsolete.
- Maintaining localised industrial supply and support for future industrial growth.
- Reducing stress on grid and transmission infrastructure.
- Long term predictable low cost, reliable 24/7 energy supply.

In some cases, industrial energy users are considering utilising investment into these technologies to avoid energy deprivation for businesses as the availability of gas and other sources becomes less reliable and more expensive. At the time of writing this, several of the global businesses in the digital communications and data industries and the chemicals industry have announced their intention to embrace nuclear power as the future energy solution for their business.

These two GEN IV technologies claim not to have the risks applicable to PWR (or AGR) and SMR-PWR and are claimed to be much more acceptable in terms of actual and perceived risk. Whether this will be accepted in public perception will be a matter for the technology owners, public bodies and industry associations to address in the material they disseminate to the public. To date, the information available, from the technology owners, government and industry associations has, in my view been confused and unclear. The terminology used within the nuclear industry confuses anyone not closely involved in the nuclear industry.

In my view, there should be a clear and educated approach to public information provision on GEN IV technologies. The difficulty may be in getting a common voice among GEN IV technology owners and developers to agree on what the message should be. Given the list of benefits I have extracted from existing information, which seems to be relatively generic I would hope such an approach would not be too difficult. Utilising an appropriate approach will in my view, materially impact the public perception of the risk attached to nuclear energy generation using GEN IV technologies.

Back to Safety

Utilising the data in the Orano Report and the approach recommended across a number of institutions including the “Tolerability of Risk” Report, by Sir Frank Layfield, it seems to me that a sensible, safe and regulatory supportable approach on GEN IV technologies would be to apply a minimal recommended Planning Zone (OCZ) for approved GEN IV technologies, for Government to consider directing the planning authorities to adopt such an approach, but to maintain the competent licence holder and operator criteria under existing standards.

In my view this would be the catalyst for the resurgence of industrial capability in the UK, allowing localised energy generation to support the needs of local conurbations and industrial hubs, without the inordinate cost of rebuilding transmission infrastructure over decades to come.

In my view, for GEN IV technologies to be deployed on local sites and even within the 3km zone proposed by Orano, it will be necessary for them to establish through testing and data collection over a reasonable period of time that:

- a) The level of operational emissions is within the accepted levels published by ICRP.
- b) That accidental emissions from an inadvertent release of radiation, will not increase the approved level of emissions.

By utilising a proportionate approach to risk considerations on a comparable basis it may be possible to reduce the risk zone consideration to an extended site boundary radius (possibly to as little as a 150M radius), thereby allowing adjacent development of an appropriate nature to be progressed - allowing energy hungry industries to co-locate and remove the need for transmission grid expansion to feed those industries, many of which are already located quite close to energy production plants and within COMAH designated sites.

Is GEN IV Ready?

The question has been part of the nuclear conversation for well over a decade. In fact, the Government has published a series of papers on this since 2012, all of which support the view that advanced nuclear technology (SMR and GEN IV) will be part of the future energy generation required in the UK and will provide for long term energy security at a predictable stable cost.

The technology owners` view is that the GEN IV technologies will meet the Fundamental Safety Principles set out in 2016 by the IAEA (Safety of Nuclear Power Plant Design), which imposes a requirement:

- a) To control the radiation exposure of people and radioactive releases to the environment in operational states;

- b) To restrict the likelihood of events that might lead to a loss of control over a nuclear reactor core, nuclear chain reaction, radioactive source, spent nuclear fuel, radioactive waste or any other source of radiation at a nuclear power plant;
- c) To mitigate the consequences of such events if they were to occur.

“In order to satisfy the safety principles, it is required to ensure that for all operational states of a nuclear power plant and for any associated activities, doses from exposure to radiation within the installation or exposure due to any planned radioactive release from the installation are kept below the dose limits and kept as low as reasonably achievable. In addition, it is required to take measures for mitigating the radiological consequences of any accidents, if they were to occur.”

All GEN IV technology owners espouse this approach and claim that their technology by the nature of the designs and methods of manufacture demonstrably achieve the requirement stated and the ten safety principles stated in the IAEA paper. The queue of activity before the relevant authorities get to GEN IV technology is just too long and expensive in the UK, so we are seeing technology owners looking at developing the FOAK or prototype reactors in other jurisdictions. Getting through a DCO process to locate a nuclear power plant on a non-nuclear licensed site could take 5-7 years.

I believe, based on the information from a number of technology owners, that the capacity in Government and the relevant institutions required to facilitate progress is lacking because they have too much on their desks from other ongoing technology developments. They are directed not to divert focus away from those other projects to GEN IV technologies. This is not a criticism but, in my view, a statement of fact based on the resources available within Government and institutions to deal with the significant increase in nuclear technology developments.

Perhaps, as has happened with fusion technology, which is governed and regulated by the UKAEA, there should be a separate approach to the considerations applicable to GEN IV technologies. The separate body could be jointly funded by Government and the industry participants in the GEN IV space. To some extent this happens already with the ONR receiving funding from industry for the processes undertaken by the ONR for specific technologies.

Decarbonisation of the government estate across all areas of activity, both civil and military, is likely to be the next milestone achievement for the UK government and hard-to-abate parts of industry and military operations such as transport will need help to achieve the targets set by Government.

In 2024, maybe we should be taking a longer-term view and accept that gas is a diminishing resource with increasing costs beyond the control of a single government. That GEN IV nuclear could provide locally available, sustainable, green, reliable baseload flexible energy which will reduce dependency on gas, create energy security and independence, and, if the UK gets it right, allow the UK to become a world leader in the delivery of energy supply to anywhere in the world that wants it.

In the anniversary year of the opening of Calder Hall by HM Queen Elizabeth II and reflecting that it took only 4-6 years to get from concept to operation in a time when resources were comparatively limited, but energy security and industrial regeneration were seen as the prime objectives of government, we could perhaps lean more to working cooperatively as a nation and delivering the much needed roadmap and clarity for the nuclear industry as a UK international institution.

As the UK Government paper ‘Powering Up Britain’ stated in 2023:

“Nuclear energy has been used reliably and safely in the UK for over 60 years and we have extensive experience of the full nuclear life cycle, from front-end design through to decommissioning.”

The House of Commons Science, innovation and Technology Committee on Delivering Nuclear Power 2022/23 made a very clear recommendation:

Therefore, a core recommendation of our inquiry is that the Government should develop and publish a clear Nuclear Strategic Plan, which:

- includes decisions needed in the short, medium and long term;*
- contains specific dates at which decisions will be made, and what information is needed for those decisions to be made;*
- is drawn up in conjunction with the relevant organisations in the nuclear industry, and is jointly owned by all, in the manner of the Nuclear Sector Deal; and*
- has the support of Parliament as a whole and stakeholders outside the Government in order to agree a set of policies which go beyond the lifetime of any single administration, as is required given the 60-year plus life of many of the decisions required to be made.*

If we look forward to the next 60 years of energy use in the UK, the answer seems pretty obvious. A generation mix of renewables with GEN IV nuclear becoming the primary base load supply and support for energy supply is what is needed. Multiple papers and consultations and re-consideration of policy statements will not achieve this. It will need a combined approach to creating a new model of energy provision in the UK, maybe Great British Energy will achieve this, but it currently looks like a focus on GEN IV nuclear deployment may still be at the back of the queue!

High Temperature Gas Reactors (HTGR)

Although I have not included HTGR within the focus of this paper, it is claimed that these also have inherent safety built in. In 2023 the NNL which was leading on HTGR in UK said:

“Gareth Headdock, Vice President of Government and New Build, NNL said: “We are delighted to see high temperature gas reactors chosen as a key green technology for the UK’s future energy security. These reactors provide a unique combination of high temperature, inherent safety, and a high technology readiness level - in time for the UK to fulfil our net zero commitments.”

I don’t have enough data to say an incident in a HTGR will result in failsafe, with immediate shut down and no emissions risk, but that is what I understand is the aspiration. In 2014 the Oak Ridge Laboratory published a paper on the safety of HTGR but largely focussed on safety based on the fuel (TRISO) used. My reading of the paper as a layperson, is there are a number of areas which are raised in the global development sphere, and which may justify inclusion of HTGR in the same considerations as MSR and LFR’s, but I have not been able to ascertain whether that is the case at the time of writing.

Conclusions

There is, in the Oak Ridge paper, an interesting comparison of the “Accident site boundary dose-limits comparison for various projects and countries”, which largely supports and is consistent with the views expressed in this paper and which support my conclusions below.

- SMR-PWR will need a change in law and regulation for the application of criteria to enable their deployment on non-nuclear licensed sites.
- There is no technical basis on which objection to the location of SMR-PWR or GEN IV technology should be objected to on sites where the existing OCZ is 13km.

- On some sites where the OCZ is applied as 3km there will be brownfield sites on which GEN IV technology could be deployed.
- Reviewing the GEN IV technology safety case on a proportionate justification basis could open up a new era of power generation in the UK.
- Not enabling the next generation (GEN IV) technologies to flourish in the UK will push developers and investors into other jurisdictions.
- Industrial and commercial growth recognises the need for long-term stable energy solutions and pricing and this can be achieved through GEN IV nuclear power plants.
- The advance in technologies, safety assessment criteria and advanced design simulations, suggests it is time to review the position based on the need as stated to meet the challenge - *“it will be necessary to develop the detailed approach so far adopted by NII in relation to any new designs proposed for nuclear power stations”*.

Without this approach, it is unlikely the UK policy, as stated below, will be met:

“We now need to produce a new nuclear NPS, not only to provide an effective planning framework beyond 2025 but also to take advantage of the advanced nuclear technologies that will come onstream”

Andrew Renton

03.12.24

1. A schedule of papers considered in preparation of this discussion paper is available on request.
2. Grateful thanks to: Mike, Steve, Simon, Maroof, Tracey and Mhairi for their invaluable insights, help and support.



CASTLETOWN LAW



Andrew Renton

e: andrew.renton@castletownlaw.com

t: +44 (0) 7721 829 943

www.castletownlaw.com