Sizewell C Project

Radioactive Substances Regulation (RSR) Permit Application

Non-Technical Summary

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CONTENTS

1 INTRODUCTION

1.1 NNB Generation Company (SZC) Limited

1.The Operator of the RSR permit would be NNB Generation Company (SZC) Limited, hereafter referred to as SZC Co., which is a wholly owned subsidiary of NNB Holding Company (SZC) Limited which in turn is 80% owned by EDF Holdings Limited and 20% owned by Chinese General Nuclear (CGN).

1.2 Purpose of this report

2.This report supports the application for a Radioactive Substance Activity Operational Environmental Permit, hereafter referred to as the RSR permit, associated with a new nuclear power station (Sizewell C). Sizewell C would produce and discharge radioactive waste, therefore requires an environmental permit[1] under the Environmental Permitting Regulations 2016 (as amended) [Ref 1]. Solid radioactive waste is proposed to be stored on site until it is transported offsite to an appropriately licensed and permitted waste receiver. Liquid and gaseous radioactivity is proposed to be managed, treated and discharged from the site. These discharges will be minimised through the adoption of appropriate systems and operation strategies on site.

3.This application presents details of the solid, liquid and gaseous radioactive waste generated during the operation of Sizewell such as:

- The sources of the waste;
- The proposed permit limits for the discharge of the gaseous and liquid waste; and,
- Potential impacts to the public and the environment from these discharges and solid waste disposals.

4.The application shows that the design was environmentally optimised to ensure an appropriate balance between benefits to the public and environment; and costs to the operator. It describes the commitments identified by SZC Co., recognised as areas of future work, to ensure compliance against the RSR permit, and is a demonstration of SZC Co. as a competent operator and permit holder.

5.A forward work plan is proposed to address these commitments during the progress of the programme to deliver more detailed information. The forward work plan provides a scope and proposed programme relevant to each commitment, ensuring:

- The implementation of Best Available Techniques;
- The application of good practices in areas where information is yet to be fully developed; and,
- Timescales / project milestones are in place where such steps are required.

6.The scope of this application relates to radioactive discharges from the active commissioning and operation of Sizewell C. The other operational environmental permits being applied for in concert with this application are:

[1] The need for a permit for the disposal of radioactive waste is set out in Schedule 23 of the Environmental Permitting Regulations 2016 (SI 2016, No. 1154).

- Water Discharge Activity
- Combustion Activity

7. Activities related to construction and initial cold flush testing will be the subject of separate environmental permit applications, which are not being applied for at this time.

1.3 Sizewell C Site

8. Sizewell is situated in the East of England, directly to the north of the existing Sizewell B power station, the site will also include the pipeline that will be used to discharge cooling water into the Sizewell Bay area.

9. The proposed Sizewell C power station would consist of the following facilities:

Figure 1-1 Location of Sizewell C in relation to the current Sizewell nuclear sites

- Two UK EPR^{TM} units
  - In a pressurised water reactor, water which is pumped through the reactor is heated by the energy generated by the fission of atoms. This water is kept under pressure to prevent it boiling. The heated water then flows to a heat exchanger where it transfers its thermal energy to a secondary system where steam is generated and flows to turbines.
- Turbine and generators which convert the thermal energy from the reactors into electricity.
- Pumping station for the sea water used for cooling the steam once it has passed through the turbines.
- A Radioactive Waste Management Facility in which solid radioactive waste will be processed and packaged. These wastes will be appropriately disposed of, or sent to the Interim Storage Facility.
- An Interim Storage Facility for Intermediate Level Waste in which higher activity solid radioactive waste will be stored and monitored until it can be disposed of to a dedicated waste management facility.
- An Interim Storage Facility for Spent Fuel in which the fuel used to generate the electricity will be stored and monitored. The fuel will be stored in a dry fuel store until it can be disposed of to a dedicated waste management facility.
- Electricity distribution systems, offices, workshops and welfare facilities where radioactive materials or wastes will not be processed or stored.

10. The two UK EPR^{TM} reactors and associated facilities at Sizewell C will each have the capacity to generate approximately 1,670 megawatts of electricity. They will provide a combined generating capacity of approximately 3,340 megawatts, which is enough electricity for around 6 million homes. Each reactor will have systems and processes for minimising and managing gaseous and liquid radioactive wastes, and discharging them to the environment in accordance with the conditions and limits set by the Environment Agency. More information on the proposed site and its surroundings is presented in Chapter 1 of the RSR permit application Head Document [Ref 2].

1.4 Proposed activities

11. The application which is being applied for is a permit to perform radioactive substances activities relating to the production, storage, treatment, monitoring and disposal of radioactive waste in solid[2], liquid and gaseous form. These cover the disposal of radioactive waste from the operation of the two UK EPR^{TM} reactor units, and associated facilities (including spent fuel and waste on site storage). The volume and characteristics of the radioactive waste stored/discharged will depend on the operation strategy of Sizewell C. The RSR permit covers normal operations, which in this context, are defined as planned situations, such as routine start-up, shutdown and maintenance of systems, and those events which, while unplanned, are not unexpected during the lifetime of the plant (fuel defects, while rare, are not unexpected during the planned lifetime of operation). It is noted that abnormal and accident conditions are covered under the Nuclear Site Licensing regime, and the Nuclear Site Licence application for Sizewell C is currently in preparation - to be submitted during RSR permit determination.

[2] Including non-liquid phase liquid

1.5 Design reference

12. The information presented in this application is based on the reference design adopted by SZC Co. to prepare pre-construction activities. This reference design was the frozen Hinkley Point C design (known as Reference Configuration 2 for Hinkley Point C), which was adopted by SZC Co. as Reference Configuration 0. This design reference configuration includes an amalgamation of previous milestones in the development of the UK EPR™ to date:

- UK EPR™ Pre-Construction Environment Report;
- UK EPR™ Pre-Construction Safety Report; and
- Design changes and developments since the UK EPR™ Generic Design Assessment[3], regarding constructability, UK context, resolution of Generic Design Assessment Findings and applicable Hinkley Point C RSR Information Condition closure. Some UK EPR™ twin unit design developments including:
  - Interim Storage Facility for Spent Fuel
  - Interim Storage Facility for Intermediate Level Waste
  - Extension to Radioactive Waste Treatment Building for the second of the two reactor units

13. This application, and the Sizewell C design, has been produced utilising a replication strategy. Where practicable the design from Hinkley Point C (Reference Configuration 2) has not been modified, specifically with regards to this application. The Nuclear Island - where the majority of the radioactive waste generation and management takes place - is the same as Hinkley Point C. There are, however, a number of site-specific features that are not part of the replication strategy (Section 1.6).

1.6 Replication

14. The SZC Co. strategy is to replicate the Hinkley Point C design and approach as far as practicable. SZC Co. aims to construct and operate a twin Unit UK EPR™ nuclear power station, at Sizewell C. The reference design baseline for Sizewell C (Reference Configuration 0) is taken from the current mature design for Hinkley Point C (Reference Configuration 2). It is the intention to only modify elements of the design which require changes for site specific reasons. From an RSR permit perspective, there is minimal change between the Hinkley Point C and Sizewell C design. The key site specific features are as follows:

- Heat Sink – the intake cooling water source is different, there are different tidal patterns and therefore the system and structure needs to be of site-specific design. There is no impact to the Nuclear Island design.
- Nuclear Island stack height – the dispersion of gaseous discharges is dependent on the site surroundings and sensitivity of the surrounding habitats. The Sizewell C modelling resulted in the same stack height as designed at Hinkley Point C, therefore this did not impact the design.

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[3] The Generic Design Assessment for the UK EPR™ involved a rigorous and structured examination of detailed environmental, safety and security aspects of the station design. The assessment was carried out against the Safety Assessment Principles, defined by the Office for Nuclear Regulation; and, RSR Environmental Principles, defined by the Environment Agency.

- Size and shape of the spent fuel and intermediate level waste storage facilities, due to the site layout. There is no change to the function of the structures, systems or components.

1.7 Management systems

15. SZC Co. is committed to learning from experience (internally and externally) and setting its own high standards when ensuring compliance with all its legal and regulatory obligations. SZC Co. is developing appropriate management arrangements for Sizewell C that will utilise best practice, and to take advantage of relevant guidance from national and international bodies[4]. SZC Co. is also taking full advantage of the best practices from parent company and affiliates, particularly NNB GenCo (HPC) with regards to the learning from the current construction of a similar site at Hinkley Point C. These parent companies and affiliates are experienced designers, constructors and operators of nuclear power plants.
16. A key aspect of the management arrangements is that they will be part of a fully integrated management system. Throughout the design, construction and operation of the power station, the arrangements will be aligned with the practical needs of the facility and will meet relevant regulatory obligations. The strategy for developing these arrangements, to comply with the environmental permit, is ensuring that they are fit for purpose and implemented at the appropriate time during the lifecycle of the power station.
17. As part of this application SZC Co. has developed a forward work plan to outline the development of future management arrangements. These will provide the appropriate controls and robust processes to deliver environmental protection, and compliance with the environmental permit conditions.
18. More information on management arrangements are presented in Chapter 7 of the RSR Permit Application Head Document [Ref 2].

2 TECHNICAL DESCRIPTION OF SIZEWELL C RADIOACTIVE SUBSTANCES ACTIVITIES

2.1 Source of the Radioactive Waste

19. The proposed power station at Sizewell C would use nuclear fission to generate heat which is then used to make steam. Each of the two units has a pressurised water reactor which uses water – under pressure to stop it from boiling - to transfer the heat via a primary system to the steam generators (boilers). A secondary system carries the steam through turbines which turn the generators that produce the electricity, which is exported to the National Grid. The steam is then condensed with cooling water taken from the sea before being returned to the steam generators to be heated again (through reheaters). Figure 2-1 shows the different water systems used in a pressurised water reactor as described.

[4] Including, but not limited to, the Environment Agency, World Association of Nuclear Operators (WANO), and the International Atomic Energy Agency (IAEA)

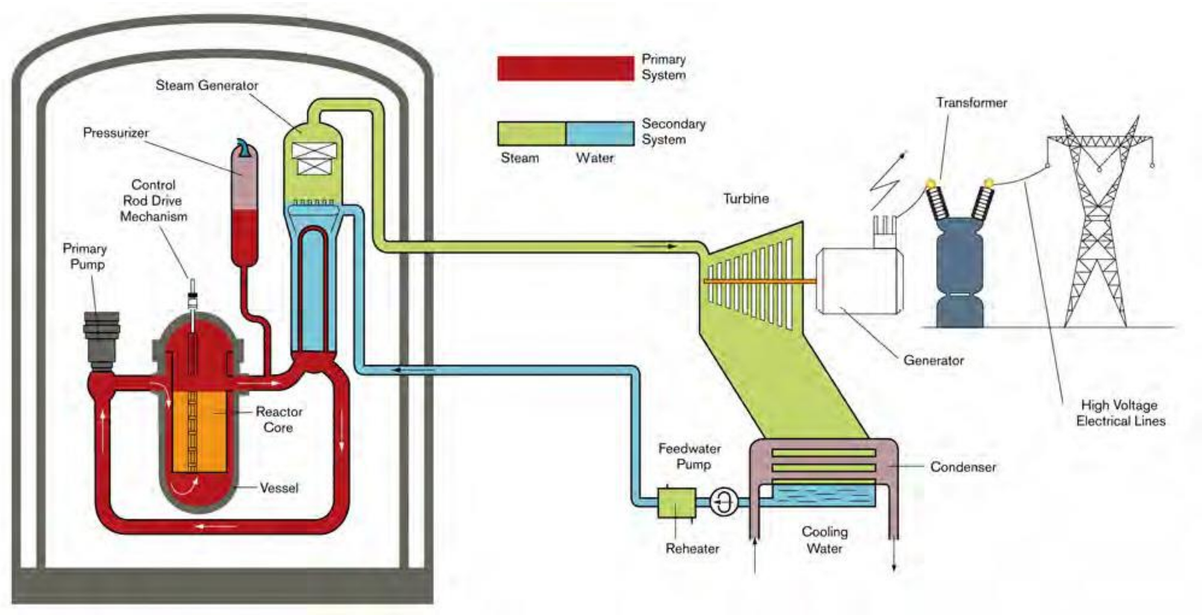

Figure 2-1 Generic layout of the electricity generating process in a pressurised water reactor

20. The fuel used in UK EPR™ reactors has radioactive properties. Nuclear fission involves splitting atoms which generates heat and other radioactive substances called fission products, neutrons and radiation. The fuel is designed to contain the radioactive substances both during operations and subsequent storage. However, some of the radioactivity may pass through the fuel casing. Very occasionally some of the radioactivity in the fuel may enter the water in the reactor (primary system). There are systems to detect and remove as much of this radioactivity as possible but some will be discharged to the environment.

21. The neutrons that are generated during nuclear fission interact with other materials that are present in the reactor to create additional radioactive substances. These are called activation products and will typically account for a significant proportion of the radioactivity in the radioactive discharges expected at SZC. Activation products are present in solid, liquid and gaseous form. Significant efforts have been invested to reduce the amount of activation products that will be generated during the operation of the reactors at SZC. A number of techniques have also been identified that will allow activation products to be captured, therefore minimising the associated discharge to the environment.

22. The UK EPR™ reactors are designed to contain as much of the radioactivity as possible during operations. Periodically the reactors must be shut down for routine maintenance and surveillance activities. During this time, some of the fission and activation products that have accumulated in the reactor during operations will be removed and will become waste. As discussed in this application, SZC Co. has a range of techniques for managing and minimising these radioactive wastes, however, some of the radioactivity will be discharged to the environment. It is noted that the discharges of radioactivity is at low levels such that they do not impact human health or the environment; and further detail is provided in the radiological impact assessment presented in Chapter 5 of the Head Document [Ref 2].

23. SZC Co. has a number of waste management processes and systems that are designed to capture radioactivity to prevent or minimise its discharge to the environment. These processes generate a range of wastes where the radioactivity is in a concentrated form. The concentrated form allows easier management of the waste, through implementation of the 'concentrate and contain' principle. These wastes must be disposed of or carefully stored to prevent the radioactivity escaping and entering the environment.

24. SZC Co. plans to store the fuel that has been used in the reactors (known as spent fuel) on site until a dedicated waste management facility has been developed in the UK. The current spent fuel storage facility stores the fuel in dried, passively safe containers, and therefore there is a minimal amount of waste generated from this process. The first spent fuel is not expected to be produced until a number of years after operations have started as fuel is removed from the reactor during outages, and must be stored for initial cooling in a pool located near the reactor before it can be transferred for interim storage.

25. Sizewell C will be equipped with a wide range of systems, processes and facilities that provide a safe and pleasant environment for those who work there. There include ventilation systems, changing rooms and offices. Some of the wastes from these areas could potentially be radioactive and are therefore appropriately processed, treated, stored and disposed of as set out in the RSR Permit Application Head Document [Ref 2].

2.2 Radioactive waste management

26. SZC Co. has plant, processes and systems to manage all the radioactive waste from the time that it is unavoidably created through to its eventual discharge to the environment; or disposal to a suitable and competent waste management contractor. The main features of waste management are:

- **Gaseous wastes.** Radioactive gases from the reactor are planned to be dried and held in charcoal filled tanks. This process allows some of the radioactivity to decay and significantly reduces the amount of radioactivity to be discharged. All gaseous radioactive wastes are passed through filters which capture any radioactive particles that might be present. Gaseous waste is also sampled before discharge.

- **Liquid wastes.** Drainage systems are design to segregate liquid waste, depending on the source and how radioactive it is. A number of techniques will be used including ion-exchange and filtration to remove some of the radioactivity from the liquid waste. All the processed liquid waste will be collected in tanks to allow it to be sampled and analysed before discharge.

- **Solid wastes.** Solid waste is segregated based on its physical, chemical and radioactive properties. Solid wastes with higher levels of radioactivity will be processed to ensure they meet long-term safety requirements, and then stored in the Interim Storage Facility for Intermediate Level Waste. Solid wastes with lower levels of radioactivity are processed using a number of techniques such as shredding and low force compaction before being packed into disposal containers. They are then held in transit storage until they can be disposed of to an appropriately permitted waste management contractor. This ensures that future policy changes or new technologies will not limit SZC Co.'s ability to dispose of such waste.

27. Further information on the production, treatment, management and disposal of radioactive waste is presented in Chapter 2 of the RSR Permit Application Head Document [Ref 2], and other chapters and supporting documents as identified in Chapter 2.

3 OPERATING TECHNIQUES TO PROTECT THE PUBLIC AND THE ENVIRONMENT

3.1 Commitment to protecting the public and the environment

28. SZC Co. is part of EDF Energy, which is one of the UKs major energy utility companies. SZC Co. has adopted the EDF Energy corporate environment policy [Ref 3]. Safety is EDF Energy's number one priority. EDF Energy cares for the environment and is committed to the principles of sustainability. Improving environmental performance is as important as any other business objectives. The following key principles guide all work activities at EDF Energy:

    - Always meet all applicable environmental legal requirements, regulations and other codes of practice.
    - Individuals are always committed to improving the environmental performance.
    - Learning from experience (internal and external) to prevent environmental damage, and reduce the risk of harm in the future.
    - Individuals will identify, report and deal with hazards to help prevent harm to the environment.
    - All employees and any contractors will apply due care for the environment no matter how urgent or important the risk.

3.2 Optimisation

29. Protecting the environment and the public from the potentially harmful effects of radioactive substances is a key objective of this application and the work undertaken by SZC Co. This objective is undertaken in parallel with others such as safety, use of resources and operational performance.

30. Environmental optimisation is sought through an examination of influential factors. This is a continuous process, which will be applied throughout the life of the power station at Sizewell C. Environmental optimisation ensures that discharges and impacts have been reduced as low as reasonable achievable; and well beyond legal limits whilst taking into account societal and economic factors. The key principles for applying optimisation are:

    - Evolution;
    - Integration; and
    - Opportunity.

31. The output of the optimisation process is compiled into the Environment Case which will be maintained throughout the life of Sizewell C. Initially developed for Hinkley Point C, the Environment Case included in this application has been reviewed and rewritten to suit SZC Co. and the Sizewell C project. The process for applying optimisation, and for developing the Environment Case for Sizewell C, has utilised the available learning and work completed (and planned) to date by NNB GenCo (HPC) for Hinkley Point C. The case demonstrates that SZC Co. is employing the Best Available Techniques, to optimise performance.

32. To achieve optimised performance, SZC Co. will apply a range of techniques including engineering systems and management arrangements that will minimise the amount of radioactivity in the waste produced and disposed of.

33. To identify the required actions and timings for optimised performance, SZC Co. will apply processes and procedures that will describe the basis for selecting most appropriate systems and controls; and to demonstrate that they are the best available.

3.3 As Low As Reasonably Achievable and Best Available Techniques

34. During application of environmental optimisation, where disposal is unavoidable, further techniques are deployed to ensure that the risk of such disposals are minimised.

35. Protection optimisation is conducted on the basis that radiological doses and risks to workers and members of the public should be kept As Low As Reasonably Achievable (the ALARA principle).

36. These techniques typically cover a range of engineering and management processes and practices and, when taken together, they are referred to as the Best Available Techniques.

37. Environmental optimisation, through the demonstration and application of Best Available Techniques, is (and will be) incorporated into the integrated management system as applicable throughout the project lifetime, including modification and change control. As described in the management arrangements and forward work plan, Chapters 7 and 8 of the RSR Permit Application Head Document [Ref 2], procedures and associated guidance documents produced to support Hinkley Point C are being reviewed and adopted where relevant for implementation into the Sizewell C project.

38. There are seven key principles which have informed the approach to demonstrate Best Available Techniques, these are included within the RSR Permit Application Head Document [Ref 2] and are as follows:

- Reduce risks and impact to people and the environment.
- Apply the waste hierarchy.
- Determine and implement Best Available Techniques at the most appropriate stage.
- Demonstrate the application of best practices, guidance and standards.
- Demonstrate the selection of Best Available Techniques to deliver optimised performance.
- Adopt a proportionate, open and transparent approach.
- Ensure adequate and appropriate training.

3.4 Environment Case

39. The Environment Case builds on foundations demonstrated during the Generic Design Assessment phase, and the current Hinkley Point C design as well as that which will be demonstrated through the implementation of the Forward Work Plan.

40. The Environment Case is presented using the Claims-Arguments-Evidence terminology, defined as follows:

- Claim – A high-level statement of what is being sought in terms of environmental optimisation. The Claim may be based on a specific permit condition or regulatory requirement.

- Argument – An element that contributes to achieving a claim (or claims). It links the evidence to the claim. The argument can be deterministic, qualitative and/or quantitative, and contributes to the demonstration that a claim is valid. The Environment Case includes "sub-arguments" that allows complex arguments to be further subdivided, where needed.

- Evidence – This is used as the basis of the argument i.e. how the argument is validated. Evidence can be facts, (e.g. based on established scientific principles and prior research or practices elsewhere), or assumptions.

41. The high level claims that make up the Sizewell C Environment Case as follows:

    - **Claim 1** - SZC Co. Shall Eliminate or Reduce the Generation of Radioactive Waste.
    - **Claim 2** - SZC Co. Shall Minimise the Amount of Radioactivity Discharged or Disposed of to the Environment
    - **Claim 3** - SZC Co. Shall Minimise the Volume of Radioactive Waste Disposed to Other Premises
    - **Claim 4** - SZC Co. Shall Minimise the Impacts on the Environment and Members of the Public from Radioactive Waste that is Discharged or Disposed of to the Environment
    - **Claim 5** - SZC Co. Shall Undertake Appropriate Monitoring to Check Compliance with the Conditions of the RSR Permit.

42. The Environment Case shows that the techniques used at Sizewell C are Best Available Techniques and meet the regulatory requirements as laid out in the permit.
43. Further detail, including the arguments and evidence supporting these claims is provided in Chapter 3 of the RSR Permit Application Head Document [Ref 2].

3.5 Integrated Radioactive Waste Strategy

44. The Integrated Radioactive Waste Strategy produced for this RSR permit application is focused on the radioactive waste strategy only. The forward work plan includes a commitment to define when a fully Integrated Waste Strategy will be developed.
45. The Integrated Radioactive Waste Strategy presents how the production, handling, discharge and disposal of radioactive wastes (gaseous, liquid and solid) and spent fuel will be managed throughout the lifecycle of the Sizewell C installation.
46. In order to develop this Integrated Radioactive Waste Strategy for Sizewell C, SZC Co. has utilised a set of core principles adopted from NNB GenCo (HPC) and the existing Integrated Waste Strategy for the Hinkley Point C site. At the foundation of the Integrated Waste Strategy is the waste hierarchy:

    - Prevention
    - Minimisation
    - Reuse
    - Recycling

- Energy recovery
- Disposal

47. The Sizewell C UK EPR™ is like other pressurised water reactors operating worldwide in that the basic production "unit" is based on a primary system, a secondary system and a cooling system. Considerable detail concerning the make-up and operation of these systems is presented in the Environment Case. Whilst waste will arise from operation of all three sub-systems, the generation of radioactive wastes is principally associated with operation of the primary (reactor) circuit during start up, normal operation, and shutdown (fuelling and maintenance) conditions. Various radioisotopes arise from fuel fission and the activation of: reactor circuit components; various constituents of the liquid coolant; and corrosion products. Once present in coolant, radioactive materials are readily transported to all parts of the coolant circuit, and thereby into other reactor support systems. Therefore, a number of effluent processing systems are employed to capture and treat such arisings from the primary circuit, leading to the production of the following general radioactive waste streams for recycling, interim storage or disposal:

- solid waste (which includes mobile wastes such as resins and sludges that are treated and consigned off-site for disposal and non-aqueous phase liquids such as oils);
- liquid waste (discharged via the liquid effluent discharge pipeline); and
- gaseous waste (discharged via stacks).

4 DISCHARGE LIMITS FOR RADIOACTIVE WASTE

4.1 Significant radionuclides

48. A wide range of radionuclides will be generated during the operation of Sizewell C. The significant radionuclides for gaseous and liquid discharges have been identified and are expected to receive discharge limits from the Environment Agency as part of the permit grant process. These significant radionuclides and key groups of radionuclides are presented in Table 4-1.

Table 4-1 Summary of Radionuclides Proposed for Discharge Limits

Gaseous Radionuclides	Liquid Radionuclides
Tritium	Tritium
Carbon-14	Caesium-137
Iodine-131	Carbon-14
Noble Gases*	Cobalt-60
Beta-emitting radionuclides associated with particulate matter**	Other radionuclides***

Gaseous Radionuclides	Liquid Radionuclides

* Noble Gases comprise: Argon-41, Krypton-85 (Kr-85), Krypton-85m (Kr-85m), Krypton-87 (Kr-87), Krypton-88 (Kr-88), Krypton-89 (Kr-89), Xenon-131m (Xe-131m), Xenon-133 (Xe-133), Xenon-133m (Xe-133m), Xenon-135 (Xe-135), Xenon-135m (Xe-135m), Xenon-137 (Xe-137), Xenon-138 (Xe-138);

**Beta-emitting radionuclides associated with particulate matter; comprising of isotopes Chromium-41 (Cr-41), manganese-54 (Mn-54), Iron-59 (Fe-59), Cobalt-58 (Co-58), Cobalt-60 (Co-60), Caesium-134 (Cs-134), Caesium-137 (Cs-137). This is a combination of the list of 'other fission and activation products' presented for Generic Design Assessment and 'Any Other Activity (AOA)', which is RSR limited for Sizewell B and Sizewell C; and

***Other fission and activation products comprising isotopes: Chromium-51 (Cr-51), Mn-54, Iron-55 (Fe-55), Fe-59, Co-58, Nickel-63 (Ni-63), Zinc-65 (Zn-65), Niobium-95 (Nb-95), Zirconium-95 (Zr-95), Silver-110m (Ag-110m), Tellurium-123m (Te-123m), Antimony-124 (Sb-124), Antimony-125 (Sb-125), Cs-134 and Cerium-144 (Ce-144).

49. The limits proposed for Sizewell C are based on those granted in the Hinkley Point C RSR permit, as such there are some differences between what was assessed in the UK EPR™ Generic Design Assessment, and what was proposed in the Hinkley Point C RSR application. Justification for the differences in limits between GDA and Hinkley Point C has been provided in the Hinkley Point C permit application, and justification for replicating those limits for Sizewell C is provided in the Sizewell C permit application; all of which are justified based on their assessed impact on the environment.

4.2 Estimated Best Performance

50. Discharges of radioactivity are measured and reported in becquerels. The unit of radioactivity is the becquerel (Bq) which relates to one radioactive disintegration per second. Each gigabecquerel is equal to 1,000,000,000 Bq.

51. SZC Co. has calculated the very best performance that can be expected in terms of radioactive discharges from the power station at SZC. The calculations take account of operational experience at other power stations in the UK and France, including the predicted performance for Hinkley Point C.

52. Actual performance will be affected by a range of factors such as reactor shutdowns, maintenance activities, fuel performance and the performance of waste management systems. These factors will build upon the discharges calculated for the expected best performance, and have been taken into account in the limits that are proposed.

Table 4-2 Annual expected best performance for gaseous discharges

Radionuclides	Expected Best Performance (GBq y^{-1})
Tritium	1000
Carbon-14	700
Noble Gases	1600
Iodine-131	0.005
Beta-emitting radionuclides associated with particulate matter	0.008

Table 4-3 Annual expected best performance for liquid discharges

Radionuclides	Expected Best Performance (GBq y^{-1})
Tritium	104,000
Carbon-14	46
Cobalt-60	0.36
Caesium-137	0.114
Other Radionuclides	804

4.3 Proposed limits

53. SZC Co. is proposing limits for radioactive discharges and disposals that reflect the expected performance from the operation of Sizewell C. The radioactive waste production and management aspects of the Sizewell C design are considered to be fully replicated from the Hinkley Point C design. The limits proposed for Sizewell C are based on those already permitted at Hinkley Point C.

54. Proposed limits have been assigned to specific radionuclides or groups of radionuclides based on a range of factors that are included in guidance published by the Environment Agency. These factors include: The potential impact on people and the environment; the quantity discharged/disposed of; the potential to persist or accumulate in the environment; and, the degree to which they indicate plant performance.

55. Chapter 4 of the RSR Permit Application Head Document demonstrates that although the receiving environment and local receptors are different at Sizewell C compared to Hinkley Point C, the replication of technology between sites has led to the same proposed discharge limits [Ref 2]. These discharges were demonstrated as ALARA through Sizewell C specific assessments, ensuring that the resulting dose at Sizewell C would be well below the dose constraint values; whilst also enabling a consistent operating approach across the two sites.

56. The proposed limits include a number of contingencies that have been assigned to take account of performance factors anticipated during routine operations. These contingencies explain why the proposed limits – in some cases - are considerably higher than the best performance that have been calculated and presented in section 4.1.

Table 4-4 Proposed Gaseous Limits (12-month Rolling Basis)

Radionuclides	Proposed Annual Limits (GBq y^{-1})
Tritium	6,000
Carbon-14	1,400
Noble gases	45,000
Iodine-131	0.4
Beta emitting radionuclides associated with particulate matter	0.12

Table 4-5 Proposed Liquid Limits (12-month Rolling Basis)

Radionuclides	Proposed Annual Limits (GBq y^{-1})
Tritium	200,000
Carbon-14	190
Cobalt-60	6
Caesium-137	1.9
Other Radionuclides	12

NOT PROTECTIVELY MARKED

5 MONITORING

5.1 Plant monitoring

57. Plant Monitoring is planned to ensure compliance with permit conditions, including the application of Best Available Techniques, comprising:

- Discharge monitoring: enabling the operator to demonstrate compliance with the permit conditions and disposal limits;
- Solid waste characterisation and sentencing; and
- In-process monitoring: taking place prior to discharge. This monitors the composition of radioactive substances in primary coolant, process fluids, reactor off-gas and associated effluent, and takes measurements of plant conditions to enable the diagnostics of systems or components serving an environmental protection function.

58. Further information on the proposed monitoring that will take place is presented in Chapter 5 of the RSR Permit Application Head Document [Ref 2] and Support Document C1.

5.2 Environmental monitoring

59. Environmental monitoring programmes are undertaken in the vicinity of all nuclear sites in the UK. The environmental monitoring around the Sizewell C site will be informed by the local environment as well as exposure pathways which vary over time. Initial monitoring has been undertaken to support the planning process for the proposal of the construction of the Sizewell C Nuclear Power Station. This will be revisited as the project gets closer to commissioning to confirm the pre-operational baseline. Given this is some time in the future there is no benefit in developing detailed programmes at this stage of the project. This programme will be developed at an appropriate point in the project lifetime which builds on, and is consistent with, the approach developed at Hinkley Point C.

60. The Sizewell C monitoring programme will take account of the lifestyles and diets of people who live within the vicinity. Local reference groups have been assessed based on those people who are most affected by the associated activities. Examples of sample types within each environment include, but are not limited to:

- Marine environment – Fish and shellfish; beach dose rates; fishing gear; sediment; and seawater.
- Terrestrial environment – Milk and milk products; and grass.

61. Further information on the proposed monitoring that will take place is presented in Chapter 5 of the RSR Permit Application Head Document [Ref 2] and Support Document C2.

6 RADIOLOGICAL IMPACT ASSESSMENT

6.1 Background

62. Radiation describes any process in which energy travels through a medium or through space (other than via conduction/convection). There are two broad classes of radiation:

- Ionising radiation, released by radioactive materials which emit high-frequency electromagnetic waves or sub-atomic particles with sufficient energy to cause ionisation; and,

- Non-ionising radiation (typically low to mid-frequency electromagnetic radiation, e.g. radio waves), which come from other sources. In this document the term radiation is used to mean ionising radiation.

63. Everyone is exposed to radiation from natural and man-made sources. The impacts from exposure to radiation are presented as doses. The unit for radiation dose is the sievert (Sv); a millisievert (mSv) is one thousandth of a sievert.

64. Public Health England assess the radiation exposure to the UK population and it has calculated that the average exposure to a member of the public in the UK is 2.7 mSv [Ref 4]. Approximately 85% of this is due to exposure from natural radiation. The remainder from man-made (artificial) sources is dominated by exposure from medical sources of radiation, such as X-rays. The graph below, Figure 6-1, presents the average breakdown of radiation exposure to a member of the public in the UK.

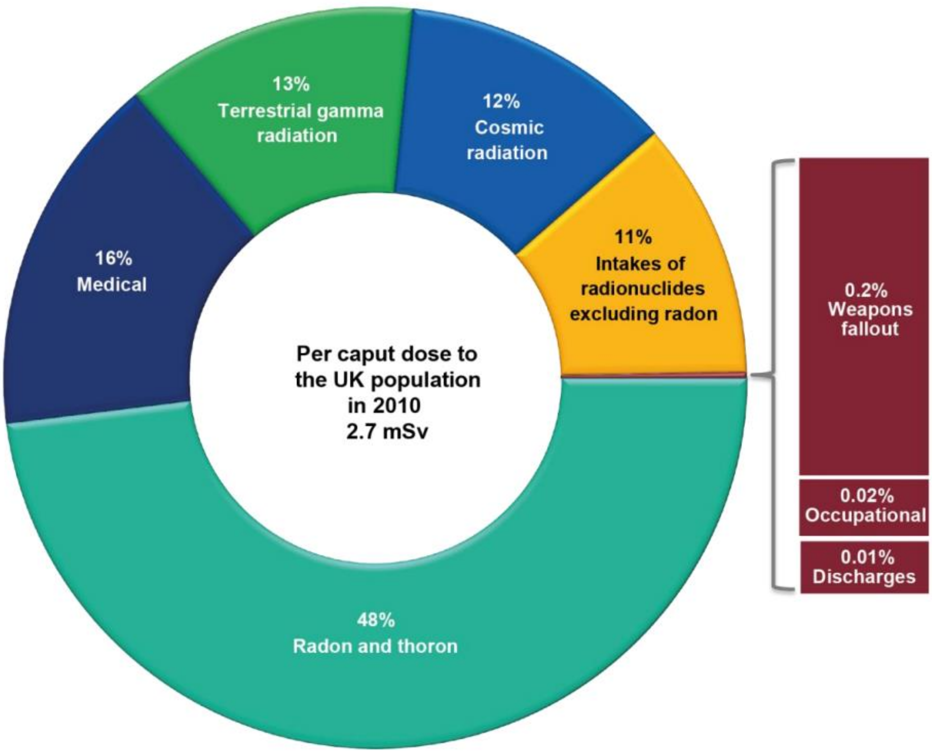

Figure 6-1 Breakdown of per caput dose to UK population in 2010[3]

6.2 Human

65. People living near Sizewell C may be exposed to very low levels of radioactivity from the associated discharges and disposals of radioactive waste, however, this is not significant when compared with the background exposure levels, see Figure 6-1 above. Using established criteria and relevant data, SZC Co. have defined a set of characteristics for a hypothetical group of people whose lifestyles and diets would result in

them being the most exposed demographic to any radioactive discharges from Sizewell C. Using this data, a conservative estimate of the impacts on people from the associated discharges and disposals of radioactive waste has been developed. These estimated discharges are noted to be significantly less than the UK public dose limit. And in reality, it is expected that based on normal operations the actual exposure would be even less.

66. The following inputs have been used to undertake the radiological impact assessment

- Discharges - expected best performance discharges against proposed limits.
- Habits Data - generic food ingestion rate against site specific food ingestion rates.
- Food Source – 100% locally sourced seafood against 50% locally sourced seafood.

6.2.1 Doses

67. The methodology used and the results of the assessment of radiological dose to members of the public associated with the operational phase of Sizewell C are described in further detail in Chapter 6 of the RSR Permit Application Head Document [Ref 2]. Assessments have been carried out as follows, along with sensitivity analyses and screening assessments:

6.2.1.1 Annual doses

68. Annual doses to Candidates for the Representative Person, i.e. an individual receiving a prospective dose that is representative of the more highly exposed individuals in the population, arising from continuous discharges of aqueous and gaseous radionuclides into the environment. The impacts from liquid and gaseous discharges at the limits being proposed are presented in Chapter 4 of the RSR Permit Application Head Document [Ref 2].

69. The representative person - who is expected to receive the highest dose from exposure to continuous site discharges – was the adult member of the fishing family who received 12 µSv/y. This is equivalent to approximately 0.44% of the average exposure to a member of the public in the UK.

6.2.1.2 Collective dose to UK, European and world populations

70. The long-term impact to a population from a single year of discharge, to allow dose impact of long-lived radionuclides which remain in circulation after their discharge has stopped. As recommended by the Environment Agency a period of 500 years is selected.

71. The per caput dose to UK, European and World population from both aqueous and gaseous discharges was calculated to be between 2.1 nSv/y and 4.5 nSv/y for discharges from Sizewell C (and between 2.6 nSv/y and 6.0 nSv/y for discharges from Sizewell B and C). A nanosievert (nSv) is one billionth of a sievert; and the UK regulatory agencies and advisory bodies consider that the risks associated with annual average per caput dose in the nanosievert range are trivial, and should be ignored in the authorisation decision making processes.

6.2.1.3 Direct radiation

72. Dose from exposure to direct radiation and skyshine from site infrastructure. Skyshine is the indirect radiation emitted as a result of reflection and scattering off the atmosphere, i.e. radiation escaping from roofs of storage facilities and being reflected to the representative person by the atmosphere.

73. The highest annual dose from direct radiation is calculated to be 3.7 µSv/y to a Sizewell B worker; around 0.14% of the average exposure to a member of the public in the UK.

6.2.1.4 Short-term releases

74. Dose from short-term releases of gaseous radionuclides into the atmosphere. The impacts from short-term ‘peaks’ in discharges that may occur from occasional activities such as start-up, shut-down and plant maintenance.

75. The highest expected short-term dose is calculated to be 6.9 µSv/y to the infant member of the farming family, around 0.4% of the average exposure to a member of the public in the UK.

6.2.1.5 Build-up of radionuclides in the environment.

76. The impacts of radioactivity that accumulates in the environment to ensure that future populations are afforded the same degree of protection as current populations.

77. The highest dose from this pathway was calculated to be 3.4 nSv/y, and is therefore considered trivial.

6.2.2 Conclusions

78. All individual doses calculated were significantly less than the corresponding source and site constraints and the public dose limit. Sensitivity analyses have shown that the predicted doses are likely to be bounding and that actual exposure will be less. Collective dose has also been shown to be trivial.

79. Full details of the radiological impact assessment undertaken are presented in Chapter 6 of the RSR Permit Application Head Document [Ref 2] and Support Document D1.

6.3 Non-Human Biota

80. SZC Co. recognises that discharges and disposals of radioactivity from Sizewell C could potentially have an impact on the environment around the site. However, it is noted that this impact is expected to be significantly below relevant background radiation. A comprehensive and detailed assessment of the effects of the associated discharges on non-human species in four habitats that are in the vicinity of the site has been undertaken. These habitats, which were chosen as they were representative of the range of surrounding eco-systems present, are:

- **Habitat 1**, a terrestrial habitat, representative of Sizewell Marshes Site of Special Scientific Interest. This lies adjacent to the west and north of the Sizewell site. The terrestrial habitat was selected as it will experience the highest air concentrations and deposition due to both proximity to the site and being in the direction of maximum air concentrations (as modelled in PC CREAM). The dose rates calculated will therefore be the highest of the terrestrial habitats of interest.

- **Habitat 2**, a marine habitat, representative of the Outer Thames Estuary Special Protection Area to the east of the Sizewell site.

- **Habitat 3**, a coastal habitat, representative of a portion of the Minsmere-Walberswick Heaths and Marshes Site of Special Scientific Interest, Special Protection Area and Ramsar located to the north of the site. This habitat includes both shoreline and the adjacent terrestrial area, therefore it is assumed to be impacted by both aqueous and gaseous discharges.

- **Habitat 4**, a freshwater habitat, representative of the scrape in the centre of Minsmere Nature Reserve, within Minsmere-Walberswick Heaths and Marshes Special Protection Area.

- **Habitat 5**, encompasses a mixed habitat representative of the marshland within the Minsmere-Walberswick Heaths and Marshes Site of Special Scientific Interest, Special Protection Area and Ramsar.

81. The conclusions of this non-human radiological impact assessment are that the impact will be very low for all of the different habitats in the Sizewell area. SZC Co. has also explored the cumulative impacts on the environment from Sizewell B and Sizewell C, but not including Sizewell A[5]. The impact will remain very low, with only a slight increase of the dose to non-human species when compared to Sizewell C alone.

82. The assessments assume that discharges will be made at the limits proposed in this application. This conservative approach means that the actual impacts will be significantly lower than those calculated in the assessments. Despite this, the dose to the worst affected organism was calculated to be 0.8 µGy/h which is significantly lower than the current threshold dose rate of 40 µGy/h. When combined discharges are considered the dose to the worst affected organism was 2.7 µGy/h, still more than one order of magnitude below the threshold rate. Full details of the radiological impact assessment undertaken are presented in Chapter 6 of the RSR Permit Application Head Document [Ref 2] and Support Document D2.

6.4 Assessment tools

83. SZC Co. has used a number of assessment tools to model the way that the discharges of radioactivity will enter the environment and for determining impacts on humans and non-human species. The development and application of these tools are subject to stringent quality assurance processes. The main tools used were:

- Dispersion Modelling. This models the movement and concentration of pollutants in the environment from the discharges. SZC Co. has used both atmospheric and marine models.
- PC-Cream. SZC Co. has made estimates with this tool which was developed for the European Commission by the UK Health Protection Agency to assess the impact of radioactive discharges from routine releases to air and sea.
- ERICA Integrated Approach. Developed by the European Commission to determine the impacts on non-human species. It is a three-tier approach that uses data from a range of scientific literature and field studies organised around different wildlife groups.
- Environment Agency R&D Methodology 128. This allows the impacts on wildlife from noble gases, which are not covered by ERICA, to be determined. It uses data on the movement of radionuclides in the environment and provides a number of approaches to determining exposures.

7 MANAGEMENT ARRANGEMENTS

7.1 Company Manual

84. Environment Agency guidance defines “management arrangements” as the specific arrangements for managing compliance with the RSR permit as well as business systems that act to support compliance.

[5] Sizewell A data has not directly been included because the site has already permanently ceased operation and all fuel has been removed from the site. It is undergoing decommissioning and is expected to reach care and maintenance status while Sizewell C is under construction / in early operation, and the discharges from Sizewell A are expected to be minimal therefore will not impact Sizewell C discharges

85. The Company Manual, included in the application, describes the organisation and management of the company and constitutes the "management prospectus" which supports the application for a Nuclear Site Licence (NSL) and RSR permit for the installation and operation of SZC. The Company Manual shows how the current organisation and appropriate governance, oversight and control arrangements in place are appropriate, and will be developed in the future as the project progresses. This will ensure safety and an effective company organisation.

7.2 Compliance matrix

86. SZC Co. will implement its replication strategy, including the adoption of NNB GenCo (HPC)'s tried and tested management arrangement, to timescales that address the RSR permit compliance risk for each phase of the project. Arrangements will be fit for purpose for the relevant stage of the project and the associated RSR permit risks.

87. The matrix identifies the management arrangements which are, or will be, put in place to deliver compliance with the RSR permit.

8 CONCLUSION

8.1 Summary of application

88. The project at Sizewell C is to build two UK EPR™ nuclear reactors capable of producing low-carbon electricity to tackle climate change that would provide around 7% of the UK's electricity, enough for approximately 6 million homes. The replication of the Hinkley Point C design, which has already been approved, reduces overall cost meaning it is competitive with other low-carbon technologies[6].

89. SZC Co. is applying for a number of consents, licences and permits, including the RSR environmental permit to allow the disposal of radioactive waste under Schedule 23 of the Environmental Permitting (England and Wales) Regulations 2016 (as amended).

90. SZC Co. has developed this application so that it can be considered in parallel with the application for planning permission, under the Development Consent Order to the Planning Inspectorate. The information presented in this submission is consistent with that required by the Environment Agency for determining the application for an RSR environmental permit, and specifies limits that deliver good environmental protection.

91. SZC Co. believes this application contains sufficient information to enable the Environment Agency to determine whether a RSR environmental permit can be granted.

92. This application has been built on the confidence gained from the permitting process followed by NNB GenCo (HPC) at Hinkley Point C and transferring this knowledge and learning to Sizewell C.

93. SZC Co. believes that this application has demonstrated that the performance of the two UK EPR™s (and the associated facilities) at Sizewell C have been optimised, and that Best Available Techniques have been applied and demonstrated.

94. The highest impact from radioactive discharges to a member of the public from the activities under RSR Environmental Permit regulations was to an adult member of a fishing family, living close to the Sizewell

[6] The UK Parliamentary Office of Science and Technology (No. 383, June 2011) details carbon footprint of electricity generation over the whole lifecycle.

site. The highest dose resulting from exposure to short-term discharges of gaseous radionuclides from Sizewell C, summed across the relevant terrestrial pathways, was an infant member of a farming family. These doses are considerably below the dose limit of 1mSv/y set out in the Basic Safety Statutory Directive [Ref 5] and well below the dose constraints issued in the legislation for both Sizewell C (source constraint of 300 µSv/y) and in-combination effect of Sizewell B and Sizewell C (site constraint of 500 µSv/y).

95. SZC Co. is submitting this information to the Environment Agency to allow determination of this application, including a consultation on the submission, as considered appropriate by the Environment Agency. SZC Co. will respond to any requests for clarification and information from the regulator in a timely and efficient manner to enable them to complete their process.

8.2 Forward Work Plan and Commitments

96. Given the early application in support of the planning process and the current stage of development of the site, this RSR permit application submission includes a forward work plan defining the activities and commitments made in advance of operation and hence discharges occurring from Sizewell C in order to demonstrate compliance against the RSR permit.

97. Within the forward work plan is a programme under each commitment setting out how SZC Co. expects to deliver the commitment, including associated milestones for completion. These milestones correspond to the project milestones where there is a change in activity, and therefore change in RSR permit compliance arrangements. Learning from the progress and compliance at Hinkley Point C, and the knowledge of the Information Conditions and commitments associated with the Hinkley Point C RSR permit, have been considered to inform the commitments identified for this application. The 12 commitment identified to support the Sizewell C RSR permit application are titled as follows:

- Commitment 1: Organisational Learning
- Commitment 2: Organisational Capability and Arrangements Development
- Commitment 3: Design Control
- Commitment 4: Monitoring Specifications
- Commitment 5: Environmental Radioactivity Monitoring Programme
- Commitment 6: Care and Maintenance Arrangements
- Commitment 7: Radioactive Waste Management Arrangements
- Commitment 8: Higher Activity Waste Management
- Commitment 9: Integrated Waste Strategy and Site Wide Environment Safety Case
- Commitment 10: Decommissioning Arrangements
- Commitment 11: Assessment of Feasibility of Removing Secondary Neutron Sources
- Commitment 12: Chemistry Specifications

NOT PROTECTIVELY MARKED

98. The Forward Work Plan is presented in full in Chapter 8 of the RSR Permit Application Head Document [Ref 2].

8.3 References

Ref	Title	Document No.	Version No.	Location	Author
1	Environmental Permitting Regulations 2016 (as amended)	No. 1154	-	http://www.legislation.gov.uk/uksi/2016/1154/introduction/made Last accessed: 31/01/2020	HM Government
2	RSR Permit Application Head document	100115743	1.0	EDRMS	SZC Co.
3	EDF corporate Environment policy	EDFE-POL-ENV-1	6.0	EDMRS	SZC Co.
4	PHE (W B Oatway, et al), Ionising Radiation Exposure of the UK Population: 2010 Review	PHE-CRCE-026	Published 2016	https://www.gov.uk/government/publications/ionising-radiation-exposure-of-the-uk-population-2010-review Last accessed: 31/01/2020	Public Health England
5	Council Directive 92/43/EEC of 21 May 1992 on the conservation of natural habitats and of wild fauna and flora	92/43/EEC	-	https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:31992L0043&from=EN Last accessed: 31/01/2020	European Commission

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