Status Report - Rolls-Royce SMR (United Kingdom)

Downloaded on: Nov 17, 2026 2:27 PM CET

Published Date : Oct 15, 2024 6:58 PM CET

1. Overview

- ☐ **In Operation**
- ☐ **Under Construction**
- ☐ **Described in**

Link to PRIS	--

- ☑ **New Concept**

Number of Units	--
Year	2026

Reference Plant

Name of Site	--
Link to PRIS	--
Net Power Output (MWe)	470
Gross Power Output (MWe)	--

1.1 Introduction

The Rolls-Royce SMR has been developed to deliver a market driven, affordable, low carbon, energy generation capability. The developed design is based on optimised and enhanced use of proven technologies that presents a class leading safety outlook and attractive market offering with minimum regulatory risk. Rapid, certain and repeatable build is enhanced through site layout optimisation and maximising modular build, standardisation and commoditisation.

The Rolls-Royce SMR is primarily intended to supply baseload electricity for both coastal and inland siting. The design can be configured to support other heat-requiring or cogeneration applications, as well as provide a primary, carbon free, power source for the production of e-fuels.

Figure 1. Rolls-Royce SMR design

1.2 Development Milestones

2015	Rolls-Royce development of initial reference design
2016	Formation of consortium for design of whole power station concept
2017	Mature design concept developed
2022	Formal regulation entered in the UK
2026	Projected start of first of a kind construction
2030	Planned first of a kind commercial operation

1.3 Design organization or vendor company

1.4 Links to designer/vendor website

https://www.rolls-royce-smr.com/

1.5 Design Description

The design philosophy for the Rolls-Royce SMR is to optimise levelised cost of electricity with a low capital cost. The power output is maximised whilst delivering robust economics for nuclear power plant investment and a plant size that enables modularisation and standardisation throughout.

1.6 Licensing Application Support Documents

1.7 Reactor Unit in PRIS

2. Category Fields

Table 1: ARIS Category Fields

ARIS Category	Value	Units of Examples
Current/Intended Purpose	Commercial – Electric/Non-Electric	e.g. Commercial – Electric/Non-electric, Prototype/FOAK, Demonstration, Experimental

Main Intended Application (once commercial)	Baseload, Non-electric (Cogeneration and power source for the production of e-fuels)	e.g. Baseload, Dispatchable, Off-grid/Remote, Mobile/Propulsion, Non-electric (specify)
Reference Location	On Coast, Inland	e.g. On Coast, Inland, Below-Ground, Floating-Fixed, Marine-Mobile, Submerged-Fixed (Other-specify)
Reference Site Design (reactor units per site)		e.g. Single Unit, Dual Unit, Multiple Unit (# units)
Core Coolant	H2O	H2O, D2O, He, CO2, Na, Pb, PbBi, Molten Salts, (Other-specify)
Reactor Core Size (1 core)	30 MWth <= Thermal power < 1000 MWth	e.g. Thermal Power < 30 MWth, 30 MWth ≤ Thermal power < 1000 MWth, 1000 MWth ≤ Thermal power ≤ 3000 MWth, Thermal power > 3000 MWth
Reactor Type	PWR	e.g. PWR, BWR, HWR, SCWR, GCR, GFR, SFR, LFR, MSR, ADS
Reactor Size	SMR	e.g. PWR, SMR
Neutron Moderator	H2O	e.g. H2O, D2O, He, CO2, Na, Pb, PbBi, Molten Salts, (Other-specify)
NSSS Layout	Loop-type (3 loop(s))	e.g. Loop-type (# loops), Direct-cycle, Semi-integral, Integral, Pool-type
Primary Circulation	Forced	e.g. Forced (# pumps), Natural
Thermodynamic Cycle	Rankine	e.g. Rankine, Brayton, Combined-Cycle (direct/indirect)
Secondary Side Fluid	H2O	e.g. H2O, He, CO2, Na, Pb, PbBi, Molten Salts, (Other-specify)
Fuel Form	Fuel Assembly/Bundle	e.g. Fuel Assembly/Bundle, Coated Sphere, Plate, Prismatic, Contained Liquid, Liquid Fuel/Coolant
Fuel Lattice Shape	Square	e.g. Square, Hexagonal, Triangular, Cylindrical, Spherical, Other, n/a
Rods/Pins per Fuel Assembly/Bundle	17x17	e.g. #, n/a
Fuel Material Type	Oxide	e.g. Oxide, Nitride, Carbide, Metal, Molten Salt, (Other-specify)
Design Status	Detailed Design	e.g. Conceptual, Detailed, Final (with secure suppliers)
Licensing Status		e.g. DCR, GDR, PSAR, FSAR, Design Licensed (in Country), Under Construction (# units), In Operation (# units)
Neutron Spectrum	Thermal	e.g. Fast, Thermal

3. Parameter Fields

Table 2: ARIS Parameter Fields

ARIS Parameter	Value	Units of Examples
Plant Infrastructure		
Design Life	60	Years
Lifetime Capacity Factor		%, defined as Lifetime MWe-yrs delivered / (MWe capacity * Design Life), incl. outages
Major Planned Outages		# days every # months (specify purpose, including refuelling)
Operation / Maintenance Human Resources		# Staff in Operation / Maintenance Crew during Normal Operation
Reference Site Design		n Units/Modules
Capacity to Electric Grid	470	MWe (net to grid)
Non-electric Capacity		e.g. MW(th) heat at x ºC, m3/day desalinated water, kg/day hydrogen, etc.
In-House Plant Consumption		MWe
Plant Footprint	40000	m2 (rectangular building envelope)
Site Footprint		m2 (fenced area)
Emergency Planning Zone		km (radius)
Releases during Normal Operation		TBq/yr (Noble Gases / Tritium Gas / Liquids)
Load Following Range and Speed		x – 100%, % per minute
Seismic Design (SSE)	0.3	g (Safe-Shutdown Earthquake)
NSSS Operating Pressure (primary side)	15.5	MPa(abs), i.e. MPa(g)+0.1, at core outlet
NSSS Operating Pressure (secondary side)	7.8	MPa(abs), i.e. MPa(g)+0.1, at secondary side outlet
Primary Coolant Inventory (incl. pressurizer)		kg
Nominal Coolant Flow Rate (primary)		kg/s
Nominal Coolant Flow Rate (secondary)		kg/s
Core Inlet Coolant Temperature	295	ºC
Core Outlet Coolant Temperature	325	ºC
Available Tempeature as Process Heat Source		ºC
NSSS Largest Component	RPV	e.g. RPV (empty), SG, Core Module (empty/fuelled), etc.
- NSSS Largest Component Length	7900	mm
- NSSS Largest Component Diameter	4200	mm
- NSSS Largest Component Thickness		mm
- NSSS Largest Component Weight	150	tonne

Reactor Vessel Material		e.g. SS304, SS316, SA508, 800H, Hastelloy N
Steam Generator Design		e.g. Vertical/Horizontal, U-Tube/ Straight/Helical, cross/counter flow
Secondary Coolant Inventory		kg
Pressurizer Design		e.g. separate vessel, integral, steam or gas pressurised, etc.
Pressurizer Volume		m3 / m3 (total / liquid)
Containment Type		Dry (single/double), Dry/Wet Well, Inerted, etc.
Containment Volume		m3
Spent Fuel Pool Capacity and Total Volume		Years of full-power operation / m3
Non Electric Application		-
Core Delta Temperature	30	ºC
Fuel/Core		
Single Core Thermal Power	1358	MW(th)
Refuelling Cycle	18	months or “continuous”
Fuel Material	UO2	e.g. UO2, MOX, UF4, UCO
Enrichment (avg./max.)	<4.95	%
Average Neutron Energy		eV
Fuel Cladding Material		e.g. Zr-4, SS, TRISO, E-110, none
Number of Fuel “Units”		Specify as Assembly, Bundle, Plate, Sphere, or n/a
Weight of one Fuel Unit		kg
Total Fissile Loading (initial)		kg fissile material (specify isotopic and chemical composition)
% of fuel outside core during normal operation		Applicable to online refuelling and molten salt reactors
Fraction of fresh-fuel fissile material used up at discharge		%
Core Discharge Burnup	50-60	MWd/kgHM (heavy metal, eg U, Pu, Th)
Pin Burnup (max.)		MWd/kgHM
Breeding/Conversion Ratio		Fraction of fissile material bred in-situ over one fuel cycle or at equilibrium core
Reprocessing		e.g. None, Batch, Continuous (FP polishing/actinide removal), etc.
Main Reactivity Control	Control rods	e.g. Rods, Boron Solution, Fuel Load, Temperature, Flow Rate, Reflectors
Solid Burnable Absorber		e.g. Gd2O3
Core Volume (active)		m3 (used to calculate power density)

Fast Neutron Flux at Core Pressure Boundary		n/(cm²*s)
Max. Fast Neutron Flux		n/(cm²*s)
Core Control Rod Absorber		-
Core Soluble Neutron Absorber		-
Safety Systems		
Number of Safety Trains	Active / Passive	% capacity of each train to fulfil safety function
- reactor shutdown	Active/Passive	- / - / -
- core injection	Active/Passive	- / - / -
- decay heat removal	Active/Passive	- /- / -
- containment isolation and cooling	N/A	- / - / -
- emergency AC supply (e.g. diesels)	N/A	- / - / -
DC Power Capacity (e.g. batteries)		Hours
Events in which Immediate Operator Action is required		e.g. any internal/external initiating events, none
Limiting (shortest) Subsequent Operator Action Time		Hours (that are assumed when following EOPs)
Severe Accident Core Provisions		e.g. no core melt, IVMR, Core Catcher, Core Dump Tank, MCCI
Core Damage Frequency (CDF)		x/reactor-year (based on reference site and location)
Severe Accident Containment Provisions		e.g., H2 ignitors, PARs, filtered venting etc.
Large Release Frequency (LRF)		x/reactor-year (based on reference site and location)
Overall Build Project Costs Estimate or Range (excluding Licensing, based on the Reference Design Site and Location)		
Construction Time (nth of a kind)		Months from first concrete to criticality
Design, Project Mgmt. and Procurement Effort		Person-years (PY) [DP&P]
Construction and Commissioning Effort		PY [C&C]
Material and Equipment Overnight Capital Cost		Million US$(2015) [M&E], if built in USA
Cost Breakdown	%[C&C]/%[M&E]	
- Site Development before first concrete		(e.g. 25/10) (30/40) (20/25) (20/10) (5/15) (----------) (to add up to 100/100)
- Nuclear Island (NSSS)		
- Conventional Island (Turbine and Cooling)		
- Balance of Plant (BOP)		

- Commissioning and First Fuel Loading		
Factory / On-Site split in [C&C] effort		%/% of total [C&C] effort in PY (e.g., 60/40)
Nuclear System		
System Steam Flow Rate		kg/s
System Steam Pressure		MPa
System Steam Temperature		ºC
System Feedwater Flow Rate		kg/s
System Feedwater Temperature		ºC
Reactor Core		
Active Core Height		m
Equivalent Core Diameter		m
Average Linear Heat Rate		kW/m
Average Fuel Power Density		kW/kgU
Average Core Power Density		MW/m3
Outer Diameter Of Fuel Rods		mm

4. Plant Layout, Site Environment and Grid Integration

SUMMARY FOR BOOKLET

The power station is designed for installation on an extensive range of inland and coastal sites, across a wide range of soil and earth conditions, whilst maintaining a compact site footprint of approximately 40,000 m2. This flexibility is enabled through design features such as seismic isolation for key safety areas. The nuclear reactor is located in the Reactor Island, adjacent to Turbine Island with the Cooling Water Island following. Support buildings and auxiliary services are situated within a berm that sweeps around the site and provides a layer of protection from external hazards.

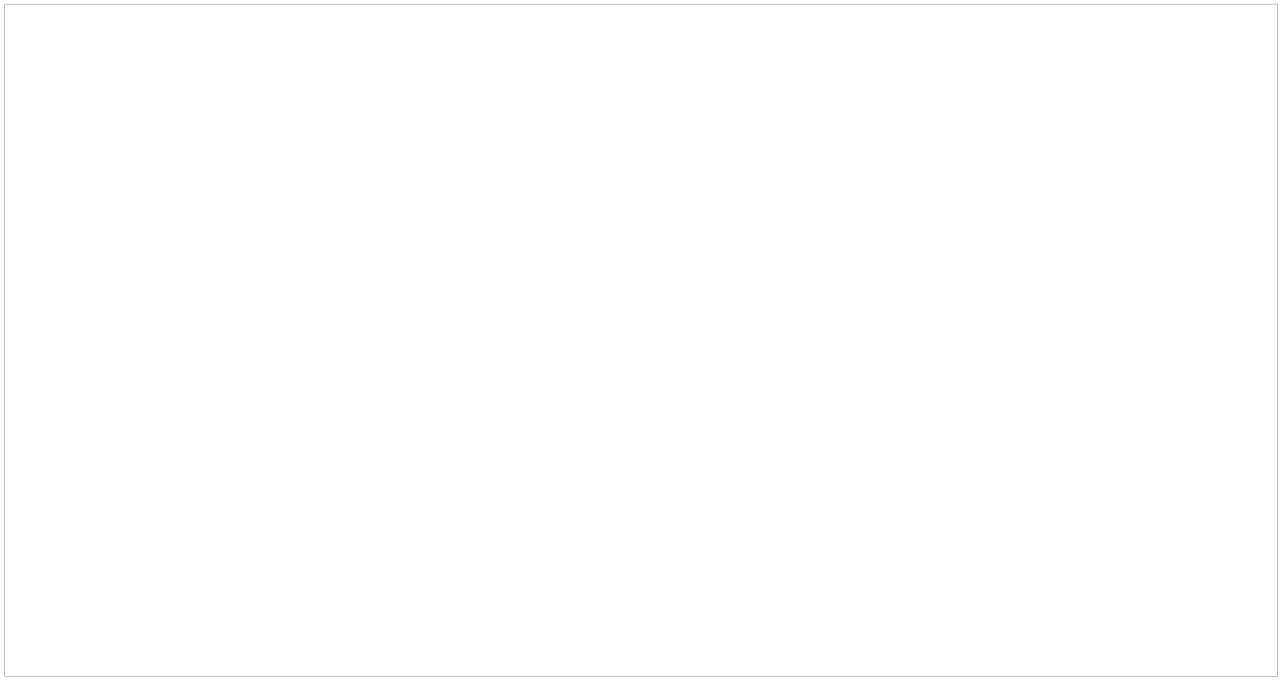


Figure 2. Plant layout

4.1 Site Requirements during Construction
4.2 Site Considerations during Operation
4.3 Grid Integration

5. Technical NSSS/Power Conversion System Designn

SUMMARY FOR BOOKLET

Nuclear Steam Supply System

The Rolls-Royce SMR is a close-coupled three-loop Pressurised Water Reactor employing an indirect Rankine cycle. Coolant is circulated via three centrifugal Reactor Coolant Pumps to three corresponding vertical u-tube Steam Generators.

Reactor Core

The nuclear fuel is industry standard UO2 enriched up to 4.95%, clad with a zirconium alloy and arranged in a 17x17 assembly. The core contains 121 fuel assemblies and has an active fuelled length of 2.8 m, delivering a thermal power of 1358 MW(t). Through cycle reactivity compensation is provided using gadolinia neutron poison. Different fuel assemblies contain different poison loadings, through inclusion of different numbers of poison pins and different gadolinia weight loading. All poison pins in a single fuel assembly have the same gadolinia loading.

Reactivity Control

Duty reactivity control is provided through movement of control rods and use of the negative moderator temperature coefficient inherent to Pressurised Water Reactors. No concentration of soluble boron is maintained in the primary coolant for duty reactivity control, which facilitates a simplified plant design and eliminates risks associated with boric acid as well as the environmental impact of boron discharge.

Reactor Pressure Vessel and Internals

The Reactor Pressure Vessel comprises the upper shell containing the six Reactor Coolant Loop nozzles, three Direct Vessel Injection nozzles, the lower shell consisting of a plain cylindrical forging with no circumferential welds present within the high flux region of the core and the torispherical lower head.

The Integrated Head Package forms an assembly of the reactor head area components. It comprises the Reactor Pressure

Vessel Closure Head with torispherical profile and outer bolting flange, Control Rod Drive Mechanisms and their cooling system, In-Core Instrumentation, integral missile shield and lifting assembly.

The lower Reactor Pressure Vessel Internals comprise the core barrel which holds the fuel and diverts coolant flow from the coolant inlets to the flow distribution device, the flow distribution device which diverts, straightens and distributes the coolant flow prior to entry into the inlet plenum and the radial neutron reflector.

The upper Reactor Pressure Vessel Internals take coolant from the outlet of the fuel assemblies and transfer it to the outlets. The upper internals comprise the upper support barrel which holds the fuel in place and the control rod housing columns which align and support the control rods and control rod drive shafts.

Reactor Coolant System

The Reactor Coolant System is a three-loop close-coupled configuration. Steam Generators are located around the circumference of the Reactor Pressure Vessel, with short close-coupled pipework connections between them. The pressuriser is connected to the pipework hot leg. A centrifugal Reactor Coolant Pump is mounted directly to the outlet nozzle of the corresponding Steam Generator. Each Steam Generator is elevated above the Reactor Pressure Vessel to ensure that a sufficient thermal driving head is available for natural circulation flow for situations where pumped flow from the Reactor Coolant Pumps is unavailable.

Figure 3. Reactor coolant system

Instrumentation and Control System

The Rolls-Royce SMR plant is controlled and protected by a number of control and instrumentation systems. The Reactor Plant Control System manages duty operations and uses an available in industry programmable logic controller or distributed control system. It uses mixed analogue and non-programmable digital sensors and communicates on hardwired multichannel digital electrical networks. Opportunities to use smart devices and wireless technologies are being pursued.

The Reactor Protection System provides shutdown in response to a fault. The Reactor Protection System contains priority logic, which from the range of input signals received determines whether to initiate reactor shutdown. The Hardwired Diverse Protection System uses non-programmable electronics and as such provides a diverse means to shut down the plant in response to fault conditions.

Post-Accident and Severe Accident Management Systems within the Nuclear C&I System provide clear plant status displays, over the days and months following a postulated accident.

5.1 Primary Circuit
5.2 Reactor Core and Fuel
5.3 Fuel Handling
5.4 Reactor Protection

5.5 Secondary Side
5.6 Containment/Confinement
5.7 Electrical, I&C and Human Interface
5.8 Unique Technical Design Features (if any)

6. Technology Readiness

SUMMARY FOR BOOKLET

Testing Conducted for Design Verification and Validation

The Rolls-Royce SMR design is based on optimised and enhanced use of proven technologies. Test rigs have been designed for validation of safety claims of the key safety systems, utilising established test facilities reflecting that safety systems are based on readily provable phenomena.

Design and Licensing Status

The Rolls-Royce SMR entered formal design assessment by UK regulators in 2022 and targets completion in time for construction of the first of a kind power station to commence in 2026.

6.1 Deployed Reactors
6.2 Reactors under Licensing Review
6.3 Reactors in the Design Stage

7. Safety Concepts

SUMMARY FOR BOOKLET

Engineered Safety System Approach and Configuration

The Rolls-Royce SMR design has been developed through a combined system engineering and safety assessment approach. The safety informed design supports the process by which risks are demonstrated to be acceptable and as low as reasonably practicable. Defence in depth is provided through multiple layers of fault prevention and protection in the form of independent and diverse active and passive systems, with multiple trains per system. Passive safety systems are designed to deliver their safety functionality autonomously for 72 hours, minimising the demand on human actions and electrical power.

Decay Heat Removal System

The Rolls-Royce SMR employs both active and passive decay heat removal systems. Condenser Decay Heat Removal utilises the Steam Generators and the normal duty steam condenser to cool the primary plant. It utilises most of the same equipment used for steam condensing during power operation. Heat is eventually passed to the tertiary heat sink. Passive Decay Heat Removal is a dedicated safety system that utilises the Steam Generators and the Local Ultimate Heatsink system to cool the primary plant. Both means of heat rejection are closed loop between the Reactor Pressure Vessel and the Steam Generators and decay heat can be passed from the core to the Steam Generator through either pumped reactor circuit flow or natural circulation flow.

Emergency Core Cooling System

Emergency Core Cooling provides decay heat removal through depressurisation of the Reactor Coolant System and sustained supply of injected coolant by gravity feed. The function includes three accumulators connected directly to the Reactor Vessel pipework associated with gravity drain from the Refuelling Pool to the Reactor Vessel and three containment sump screens. The Emergency Core Cooling function also places requirements on the Reactor Coolant Pressure Relief

System for emergency blowdown and Local Ultimate Heatsink System to transfer heat from the Passive Containment Cooling heat exchangers to the environment.

Spent Fuel Cooling Safety Approach / System

Active and passive cooling systems provide robust decay heat removal defence in depth during fault conditions. Reactivity control is provided in a soluble boron-free environment using geometric spacing and solid neutron poison racks.

Containment System

The reactor circuit and other key systems are located within a steel containment vessel to confine release of materials during faulted and accident conditions. The Rolls-Royce SMR also adopts in-vessel retention to confine the postulated melt in severe accidents.

Plant Safety and Operational Performances

Plant conditions have been analysed using industry validated codes to demonstrate significant safety margin across the levels of defence in depth. The Probabilistic Safety Assessment calculates a core damage frequency from plant faults of <1E-07 per year of power operation, and that no single fault or class of faults makes a disproportionate contribution to risk, i.e. a balanced risk profile is achieved. Internal and external hazard assessments have defined the design basis and informed the plant layout to optimise segregation. Key equipment is protected by the hazard shield which is resilient against external hazards including aircraft impact and tsunami.

The Rolls-Royce SMR is designed for full compliance with the U.K. Grid Code, including frequent load following between 50% and 100% power at a rate of 3-5% per minute with a design target to allow operation at lower power e.g. house load operation (stable operation for at least two hours supplying only the power station's house load).

A 15-day outage period is targeted to support high availability (at least 90% availability over the 60-year life of the Rolls-Royce SMR), including a target period of 8 days for refuelling.

7.1 Safety Philosophy and Implementation
7.2 Transient/Accident Behaviour

8. Fuel and Fuel Cycle

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Fuel Cycle Approach

The Rolls-Royce SMR operates on an 18-month fuel cycle, with a three-batch equilibrium core. Refuelling is managed through the provision of an in-containment refuelling pool which temporarily stores both new and used fuel during a refuelling outage. Used fuel is subsequently transferred to an external spent fuel pool for storage prior to transfer to long term dry cask storage.

Waste Management and Disposal Plan

The Rolls-Royce SMR waste treatment systems are based on use of proven technologies and best available techniques. Industry lessons learned and good practices have been used in the development of systems to minimise active and non-active wastes and discharges, through both design and operational practices adopted. Standardised waste treatment system components and modules are used to achieve the flexibility required for the waste informed design. Operation without soluble boron in the primary coolant allows significant reduction in environmental discharges and concomitant simplification of the waste treatment systems.

8.1 Fuel Cycle Options
8.2 Resource Use Optimization

8.3 Unique Fuel/Fuel Cycle Design Features

9. Safeguard & Physical Security

SUMMARY FOR BOOKLET

9.1 Safeguards
9.2 Security
9.3 Unique Safeguards and/or Security Features

10. Project Delivery & Economics

SUMMARY FOR BOOKLET

10.1 Project Preparation and Negotiation
10.2 Construction and Commissioning
10.3 Operation and Maintenance