Status Report - PRISM (United States of America)

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1. Overview

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

Link to PRIS	--

- ☑ **New Concept**

Number of Units	--
Year	--

Reference Plant

Name of Site	--
Link to PRIS	--
Net Power Output (MWe)	311
Gross Power Output (MWe)	311

1.1 Introduction

The PRISM design uses a modular, pool type, liquid sodium cooled reactor. The reactor fuel element design most commonly used is a metal alloy comprised of uranium, plutonium and zirconium. The reactor employs passive shutdown and decay heat removal features.

Figure 1. Schematic view of PRISM

1.2 Development Milestones

1.3 Design organization or vendor company

1.4 Links to designer/vendor website

1.5 Design Description

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	e.g. Baseload, Dispatchable, Off-grid/Remote, Mobile/Propulsion, Non-electric (specify)

Reference Location	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	Na	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	SFR	e.g. PWR, BWR, HWR, SCWR, GCR, GFR, SFR, LFR, MSR, ADS
Reactor Size	SMR	e.g. PWR, SMR
Neutron Moderator	None	e.g. H2O, D2O, He, CO2, Na, Pb, PbBi, Molten Salts, (Other-specify)
NSSS Layout	Pool-type	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		e.g. H2O, He, CO2, Na, Pb, PbBi, Molten Salts, (Other-specify)
Fuel Form		e.g. Fuel Assembly/Bundle, Coated Sphere, Plate, Prismatic, Contained Liquid, Liquid Fuel/Coolant
Fuel Lattice Shape		e.g. Square, Hexagonal, Triangular, Cylindrical, Spherical, Other, n/a
Rods/Pins per Fuel Assembly/Bundle		e.g. #, n/a
Fuel Material Type	Other	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	Fast	e.g. Fast, Thermal

3. Parameter Fields

Table 2: ARIS Parameter Fields

ARIS Parameter	Value	Units of Examples
Plant Infrastructure		
Design Life		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	311	MWe (net to grid)
Non-electric Capacity		e.g. MW(th) heat at x °C, m3/day desalinated water, kg/day hydrogen, etc.
In-House Plant Consumption		MWe
Plant Footprint		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)		g (Safe-Shutdown Earthquake)

NSSS Operating Pressure (primary side)		MPa(abs), i.e. MPa(g)+0.1, at core outlet
NSSS Operating Pressure (secondary side)		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		ºC
Core Outlet Coolant Temperature	485	ºC
Available Tempeature as Process Heat Source		ºC
NSSS Largest Component		e.g. RPV (empty), SG, Core Module (empty/fuelled), etc.
- NSSS Largest Component Length		mm
- NSSS Largest Component Diameter		mm
- NSSS Largest Component Thickness		mm
- NSSS Largest Component Weight		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	485	ºC
Fuel/Core		
Single Core Thermal Power	840	MW(th)
Refuelling Cycle	18	months or “continuous”
Fuel Material	U-Pu-Zr	e.g. UO2, MOX, UF4, UCO
Enrichment (avg./max.)	26/--	%
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		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	N/A	- / - / -
- core injection	Passive	- / - / -
- decay heat removal	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)	1E-6	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

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

5. Technical NSSS/Power Conversion System Designn

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Description of the nuclear systems

The PRISM reactor core is designed to meet several objectives:

- To increase fuel burnup;
- To limit the burnup reactivity swing; and
- To provide an 18 to 24 month refuelling interval.

The reactor is designed to use a heterogeneous metal alloy core. The core consists of 198 fuel assemblies, 114 reflector assemblies, 66 radial shield assemblies, 10 control and 3 shutdown assemblies. The PRISM fuel and core can be tailored to specific missions ranging from plutonium disposition to the maximization of fuel efficiency.

The primary heat transport system is contained entirely within the reactor vessel. The flow path goes from the hot sodium pool above the reactor core through the intermediate heat exchangers (IHXs), where heat is transferred to the intermediate heat transport system (IHTS); the sodium exits the IHX at its base and enters the cold pool. Four electromagnetic pumps take suction from the cold pool and discharge into the high pressure core inlet plenum. The sodium is then heated as it flows upward through the reactor core and back into the hot pool.

Heat from the IHTS is transferred to a steam generator where superheated steam is produced. This high pressure, high temperature steam drives the turbinegenerator to produce electricity.

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)

Underground containment on seismic isolators with a passive air cooling ultimate heat sink; part of the advanced recycling centre for spent nuclear fuel

6. Technology Readiness

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

7. Safety Concepts

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Description of the safety concept

The passive shutdown characteristics of the reactor core provide diverse and independent means of shutdown in addition to the control rod scram. The passive features comprise several reactivity feedback properties including: the Doppler effect, sodium density and void, axial fuel expansion, radial expansion, bowing, control rod drive line expansion and reactor vessel expansion. The negative feedbacks maintain the reactor in a safe, stable condition.

The passive Reactor Vessel Auxiliary Cooling System (RVACS) provides primary cooling during all design basis accident conditions and Anticipated Transients without Scram (ATWS). This passive system operates effectively without electricity or operator intervention for an unlimited amount of time. Heat is transferred from the reactor vessel to the containment vessel by thermal radiation and then to the surrounding atmospheric air by natural convection. Redundant decay heat removal is provided by the Auxiliary Cooling System (ACS), which consists of natural circulation of air past the shell side of the steam generator. The combination of systems allows for reduced plant outages for inspections and maintenance.

7.1 Safety Philosophy and Implementation
7.2 Transient/Accident Behaviour

8. Fuel and Fuel Cycle

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8.1 Fuel Cycle Options

8.2 Resource Use Optimization
8.3 Unique Fuel/Fuel Cycle Design Features

9. Safeguard & Physical Security

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

10. Project Delivery & Economics

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Deployment Status and Planned Schedule

The PRISM design was commenced in 1981 with support from several U.S. Government development programs. The design incorporates test data and operating experience from previous U.S. sodium reactors such as GE's Southwest Experimental Fast Oxide Reactor, and Experimental Breeder Reactor II. PRISM was reviewed by the U.S.'s Nuclear Regulatory Commission from 1987 to 1994 as part of a pre-application licensing review. GEH envisages PRISM most commonly deployed with integral used fuel recycling in areas interested in improving disposal strategies for used nuclear fuel. Also, due to PRISM's affinity for use of low-cost, plutonium bearing fuel, GEH is currently pursuing the use of PRISM to address the UK government's plans to dispose of plutonium via reuse in power reactors. In 2012, the UK's Nuclear Decommission Authority contracted GEH to carry out feasibility work in a number of key areas including the proposed commercial structure, the disposability of the fuel, the risk transfer model, the costs, and the ability to license in the UK.

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