

# SMR Global Status Report September 2020

## Introduction

This report examines the global status of Small Modular Reactors (SMRs) and reviews their readiness for deployment. Small reactors have been in wide use for more than 50 years to reliably power submarines, aircraft carriers and ice-breakers and the early power reactors for electricity generation were “small”. A widely accepted definition of “small” is less than 300 MWe. Reports from Parliamentary inquiries at Federal and State levels in Australia in 2019 identified SMRs as suitable for Australian conditions. In August 2020 the US Nuclear Regulatory Commission (NRC) issued a final safety evaluation report (FSER) for NuScale’s SMR. This completes the safety review and allows a Design Certification to be issued. This is the first SMR to pass NRC assessment and is a major milestone in the deployment of SMRs.

Reviewing the latest generation of SMRs for electricity generation, this report identifies that the two reactors at Pevek are now in commercial operation producing electricity and district heating, three other SMRs are under construction and many more are at an advanced stage of licensing.

This report separately categorises SMRs according to their design features as Light Water Reactors (Gen III/Gen III+) or Gen IV Reactors.

## Light Water Reactors (Gen III/Gen III+)

Country	Reactor/ Company	Module size	licences	Construction	Operation
Russia	<b>KLT-40S</b> PWR Floating Power Plant Rosatom	35 MWe	June 2019 Operating licence	2007 vessel construction commenced June 2010 vessel launched 2013 reactors installed, 2 x 35 MWe 2019 deployed at Pevek, Chukotka region	In commercial operation May 2020 supplying electricity and district heating
Argentina	<b>CAREM</b> IPWR CNEA/INVAP	27 MWe	Sept 2013 Construction Licence for Atucha site	Feb 2014 first concrete. <b>Construction in progress</b>	<i>Target 2023</i>

China	<b>ACPR50S</b> PWR Floating Power Plant CGN	60 MWe		Nov 2016 contract with Donfang Electric Corp for the pressure vessel. <i>Construction in progress</i>	<i>Target 2020</i>
USA	<b>NuScale</b> IPWR NuScale Power	60 MWe	DCA Jan 2017 (NRC) <b>Final Safety Evaluation Report issued Aug 2020</b> , <i>Design Certification Rule to signature authorities Oct 2020</i> CNSC phase1/2 vendor design review started Jan 2020	DOE providing site at INL. DOE awarded \$16.5m in matching funds to UAMPS to secure site and water and prepare COLA to NRC	<i>UAMPS first module in operation Target 2029</i>
USA	<b>SMR-160</b> IPWR SMR LLC (Holtec)	160 MWe	NRC pre-application activities. Phase 1 vendor design review by Canadian Nuclear Safety Commission (CNCS) started July 2018, completed Aug 2020		<i>Target 2026</i>
South Korea	<b>SMART</b> IPWR KAERI	100 MWe	Design approval 2012 (now updating for passive safety )	March 2015 MOU with Saudi Arabia	
China	<b>ACP-100</b> IPWR CNNC/NPIC	100 MWe	April 2015 IAEA Generic Reactor Safety Review Agreement. PSAR approved June 2020 SAR approved by CNNSA	March 2019 EIA for site at Changjiang, Hainan. July 2019 Preliminary site work commenced. <i>Construction scheduled start Dec 2019.</i>	<i>Target 2025</i>
USA	<b>BWRX-300</b> BWR GE-Hitachi	300 MWe	Phase 1/2 vendor design review by CNSC started Jan 2020 December 2019 started regulatory licensing process with NRC. First topical report lodged.	MOU's with Estonia, Poland and Czech Republic	
UK	<b>PWR</b> Rolls-Royce Consortium	440 MWe	<i>Will be licensed first in UK</i>	MOU with Turkey's state-owned EUAS International ICC	<i>Target 2029</i>

## Gen IV Reactors

Country	Reactor / Company	Module size	Licence	Construction	Operation
China	<b>HTR-PM</b> High Temperature Gas-cooled Reactor (HTGR) China Nuclear Engineering Corporation (CNEC) + Tsinghua University Institute of Nuclear and New Energy Technology (INET)	105 MWe		2014 construction commenced at Shidaowan, Shandong Province 2x105 MWe HTGRs drive one 210 MWe turbine	2020
Canada	<b>MMR</b> Micro Modular Reactor High Temperature Gas-cooled Reactor (HTGR) Ultra Safe Nuclear Corporation with Global First Power	15 MWth (5MWe)	Feb 2019 CNSC phase 1 vendor design review completed. <i>Phase 2 pending.</i>	In 3rd stage of process to site demonstration SMR at Chalk Rivers site. March 2019 site preparation licence application to CNSC. Joint project with Ontario Power Generation (OPG)	
Canada	<b>IMSR 400</b> Integrated Molten Salt Reactor Terrestrial Energy	195 MW	Feb 2016 CNSC Phase 1 vendor design review completed. Phase 2 review commenced Dec 2018	<i>Preferred site at Idaho National Labs</i> 2019 qualified to enter 2 <sup>nd</sup> stage for deployment at Chalk River	2020's
USA	<b>Aurora Powerhouse</b> Micro reactor Sodium cooled Fast Reactor (SFR) Oklo Inc	1.5 MW	2016 started pre-application activities with NRC. March 2020 submitted COLA to NRC	Oklo has a permit for a site at Idaho National Labs.	
Canada	<b>ARC 100</b> Sodium cooled Fast Reactor (SFR) ARC Nuclear Canada Inc	100 MWe	Oct 2019 CNSC Phase 1 vendor design review completed		
UK/Canada	<b>Moltex Energy Stable Salt Reactor</b> Molten salt reactor (MSR) Moltex Energy	2 x 150 MWe	Dec 2017 CNSC Phase 1 vendor design review started.	Nov 2019 - final negotiations for project at Chalk River site. Jacobs assisting with development	

Country	Reactor / Company	Module size	Licence	Construction	Operation
USA	<b>XE-100 High temperature gas-cooled reactor (HTGR)</b> X-Energy LLC	75 MWe (300 MWe four pack 4x75)	July 2020 CNSC phase 1/2 commenced		
USA	<b>KP-FHR</b> TRISO fuel, fluoride salt cooled Kairos Power	140 MWe	CNL collaboration agreement funded under Canadian Nuclear Research Initiative (CNRI)		

## Description of some Advanced Projects

### KLT-40S Floating Nuclear Power Plant (Russia)

Russia has used small nuclear reactors to power icebreakers for many years. In 2007 they started a project to install two KLT-40S reactors producing 35 MWe each on a non-propelled vessel to supply electricity to remote regions. The 144m long, 30m wide vessel was launched in 2010 at the Baltic shipyard in Saint Petersburg and the two 35 MWe KLT-40S reactors were installed in 2013. In 2018 the vessel named *Akademik Lomonosov* was towed to Murmansk for fuelling. The operating licence was issued in June 2019 before deployment at Russia's northernmost city of Pevek, Chukotka region where it is replacing old power plants. On 19 December 2019 the plant was connected to the grid and started supplying electricity. In July 2020 the supply of district heating commenced. The average temperature in Pevek falls to  $-27^{\circ}\text{C}$  in winter!

**Status: In Commercial Operation**

### CAREM (Argentina)

CNEA/INVAP in Argentina are well known for their design and construction of research reactors, including ANSTO's OPAL 20 MW (thermal power) reactor at Lucas Heights, Sydney. OPAL does not produce electricity. CAREM (Central Argentina de Elementos Modulares) was designed with an output of 27 MWe as a prototype integral PWR. Construction commenced in February 2014 at a site adjacent to the existing Atucha NPPs. Construction is now well advanced with a target operating date in 2023.

**Status: Under Construction**

## HTR-PM (China)

High Temperature Gas Cooled Reactor in advanced state of construction. Helium cooled, operates at a much higher temperature (750°C) than PWR (340°C) giving higher efficiency and possibility of supply of high temperature process heat.

***Status: construction nearly completed***

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### DEFINITIONS:

**PWR** - Pressurised Water Reactor (the most common type of reactor, used in submarines and nuclear power plants for more than 50 years).

**IPWR** - Integral Pressurised Water Reactor. Steam generators inside reactor pressure vessel.

**DCA** – US Nuclear Regulatory Commission (NRC) Design Certification Application. Allows a design to be licensed without a site being identified.

**COLA** – US NRC combined construction and operating licence application. Brings more certainty to the licencing process by combining the construction and operating licences so that once construction starts the project can continue to completion. The design certification can be referenced in the COLA.