

China's CGN ACPR50S Floating Nuclear Power Plant (FNPP) Concept

Peter Lobner, 15 May 2021

1. Introduction

In 2016, China General Nuclear Power (CGN) announced that it planned to develop a floating nuclear power plant (FNPP) based on their 200 MWt / 60 MWe modular ACPR50S marine pressurized water reactor (PWR).



2. FNPP vessel design

CGN's target market includes coastal areas as well as isolated electrical grids at offshore oil production fields and on isolated islands. The CGN FNPP will be a conventionally constructed, flat bottom double hull and double bottom barge.



CGN concept drawing of an FNPP. Source: CGN

For applications at coastal or island sites, the FNPP most likely will be moored at a dock that will provide protection against severe weather. This FNPP vessel may be unpropelled, requiring ocean-

going tugs to deliver the vessel to the site. The CGN FNPP can deliver the following services:

- Electric power production
- Drinking water production with the MED process, which uses steam or waste heat from power production
- Domestic water production with the reverse osmosis (RO) process
- Low temperature process heat for lithium bromide absorption refrigeration or ammonia absorption refrigeration.

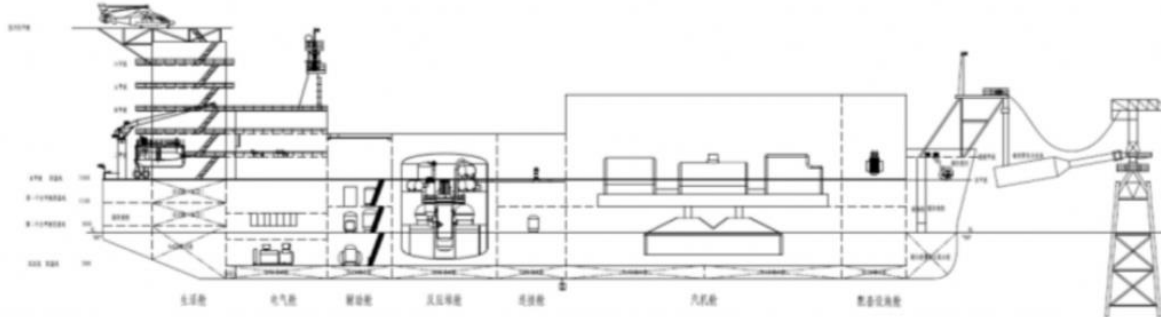
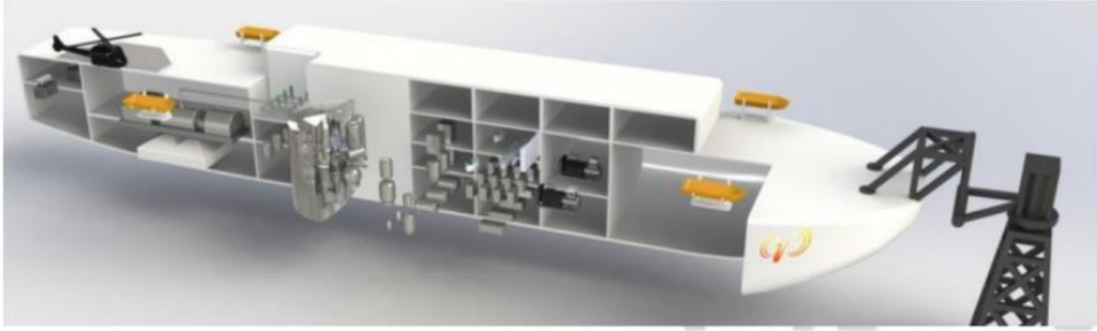
The following onshore facilities are required to support the FNPP:

- Fuel building to support refueling and temporary storage of spent fuels
- Radioactive waste treatment building for disposal of nuclear waste
- Maintenance building

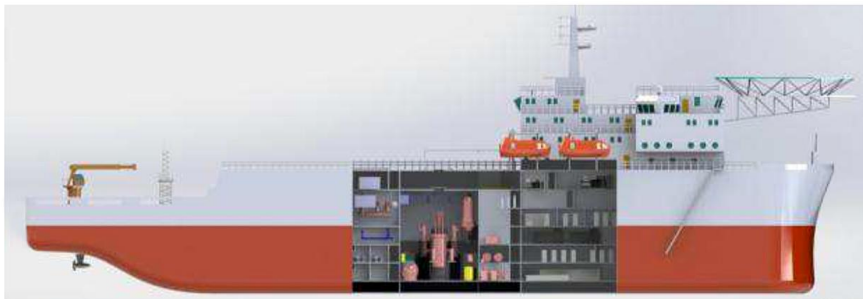


CGN ACPR50S FNPP at shore-side facility. Source CGN via IAEA

For offshore applications, a different mooring method will be required, such as single-point mooring to a tower in shallow water or a buoy in deep water. For offshore applications, the FNPP may be self-propelled and/or may have a dynamic positioning system.



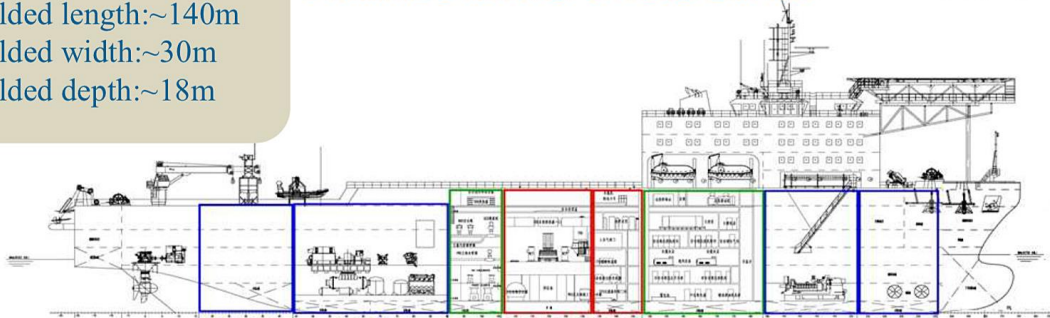
CGN design concepts for offshore FNPPs with a single ACPR50S and a single point mooring. Source, all graphics: CGN



Offshore Platform:
living area and process systems

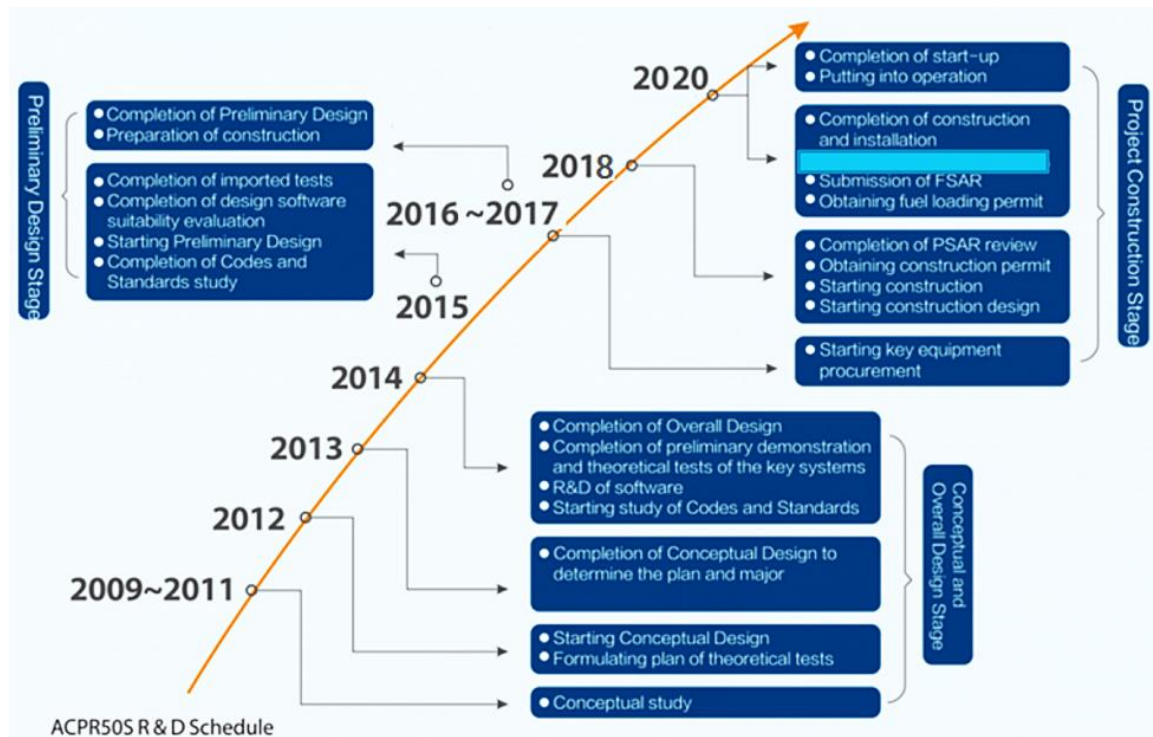
8 cabins totally
moulded length:~140m
moulded width:~30m
moulded depth:~18m

Floating Platform Overall Layout



3. Reactor design

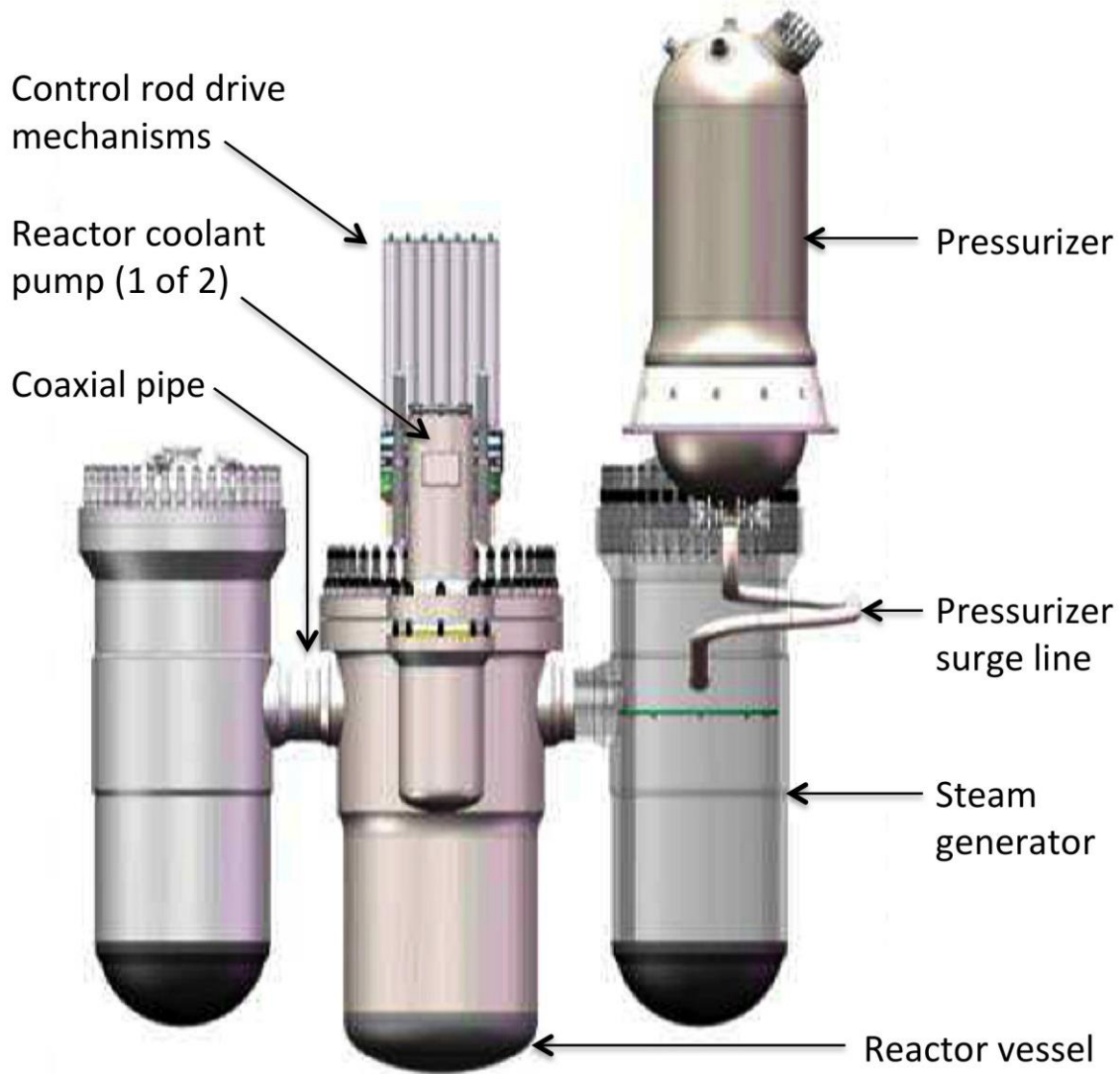
CGN is developing two versions of the ACP50 reactor indigenously designed compact, modular PWR. The earliest work on the land-based ACPR50 began in the 2009 to 2011 time frame. Their development plan, circa 2016, is shown in the following chart.



Development of the ACPR50S for marine applications started in 2012 according to the following milestone schedule that lags the land-based ACPR50 schedule by only about a year.

- 2012: Technical proposal of FNPP
- 2013 – 2018: Key technology research
- 2013: Preliminary conceptual design of ACPR50S
- 2015: Conceptual design of ACPR50S
- 2015: Earlier stage preparations of demonstration project approved by China government
- 2016 – 2018: Preliminary design of ACPR50S
- 2017 – 2022: Demonstration project

China's National Development and Reform Commission (NDRC) approved the ACPR50S reactor design in January 2016 as part of the 13th Five-Year Plan for innovative energy technologies and encouraged CGN to accelerate its research and development process. On 4 November 2016, CGN announced that it had signed the pressure vessel purchase agreement with Dongfang Electric for the demonstration ACPR50S reactor.



*ACPR50 primary system elevation view.
ACPR50S is expected to be similar.
Source: CGN & CNPRI (Oct 2017)*



*ACPR50 installation. ACPR50S is expected to be similar.
Source: CGN & CNPRI (Oct 2017)*

Basic design parameters for the ACPR50S are summarized in the following table.

Parameter	ACPR50S
Thermal power	200 MWt
Electrical power	About 60 MWe
Reactor type	Modular
Refueling interval	2.5 years
Design life	40 years
Coolant avg. temp	310 °C (590 °F)
Primary pressure	15.5 MPa

	(2,248 psia)
Pressurizer (PZR)	Separate PZR
# fuel assemblies	37 x shortened 17x17 assemblies
Fuel enrichment	< 5%
Reactivity control	16 Ag-In-Cd control rods, Gd solid burnable poison
Steam generator type	2 x helical coiled tube, once-through (OTSG)
Main steam pressure	4.68 MPa (679 psia)
Main coolant pumps	2 x canned-motor pumps

Source: CGN & CNPRI (Oct 2017)

4. FNPP development plans

In 2016, CGN teamed with China Shipbuilding Industrial Corp. (CSIC) and the China National Offshore Oil Corp. (CNOOC) to develop an FNPP using CGN's 60 MWe ACPR50S modular PWR. Originally, their plans were to commission an inaugural unit by 2022.

In addition to onshore NPP regulations, the vessel requirements and maritime conditions also are considered in the design. For example, the ACPR50S design considers the effects of ocean waves and swells on passive fluid systems thermal-hydraulic performance and on control rod mechanical performance (i.e., insert when tilted by 45° and remain in the reactor core).

CGN is working with China Ship Research and Design Center (CSRDC) to address design requirements on maritime safety. In addition, they are working with Lloyd's Register to investigate handling severe internal / external events involving an FNPP. China Nuclear Power Technology Research Institute (CNPRI) also has a role in addressing these issues on behalf of the FNPP designers, CNNC and CGN.

CGN expects that its FNPP can replace the current gas turbine power sources used in the isolated grids found in deep-water oil production fields. In October 2017, a representative of CSIC claimed that the first CGN demonstration project may be deployed off China's north coast to support CNOOC drilling platforms in the Bohai Sea. CNOOC's sixth-generation semi-submersible rigs can operate at water depths of 1,500 meters (4,921 ft). When a typhoon or other severe weather condition threatens the offshore site, oil and gas operations may be temporarily suspended. In such cases, the FNPP may need to be moved (or travel under its own power) to a safe area until the storm passes.



*Rendering of a CGN ACPR50S FNPP at an off-shore facility.
Source CGN*

Since late 2018, there has been almost no news on the construction status of a CGN FNPP. Based on the CGN schedules discussed about five years ago, a demonstration unit was planned by about 2022. If CGN is still working to that schedule, something news should be surfacing soon.

5. For more information

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