Status of SMR R&D in China

Mr. Zengguang LEI
China National Nuclear Corporation (CNNC)
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  - General status
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Section I

Applications of SMR in China

Applications of SMR

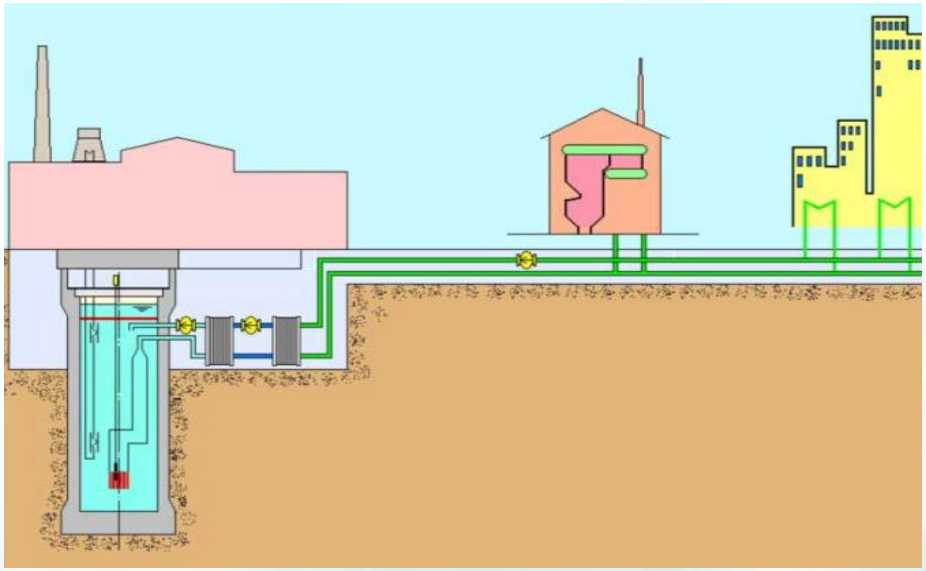
- Replacement for small coal power plants

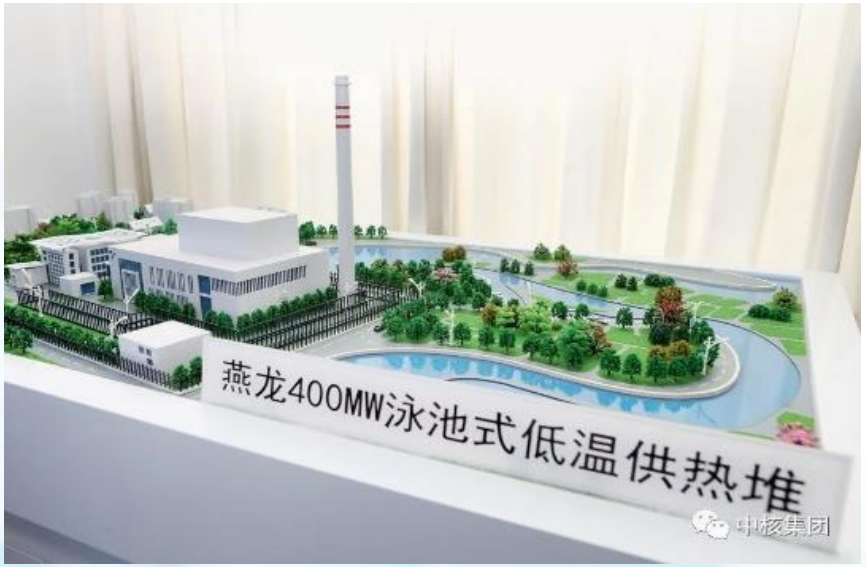
Applications of SMR

- Provide power for small-sized electricity grids

Applications of SMR

- Regional heat supply



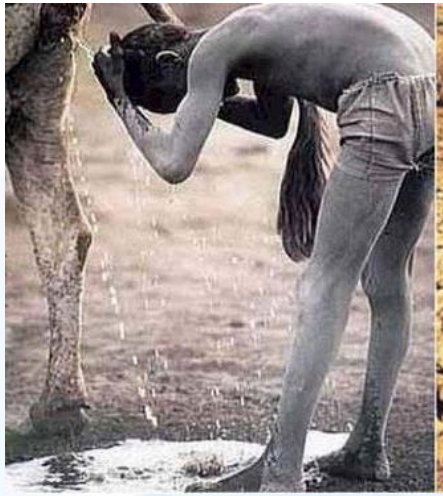


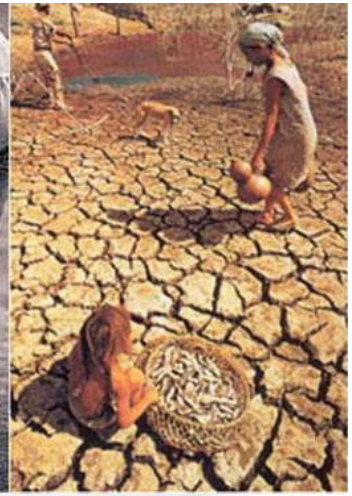
Applications of SMR

- Floating power plant

Applications of SMR

- Sea water desalination





Section II

SMR R&D Status in China

SMR R&D Status in China

- SMR R&D have been carried out since 1980s in China;
- Current status of SMR R&D in China:
  - Most SMRs are of PWR type and integral designed
  - Heavy metal SMRs are still in a very early stage
  - Integral SMR of PWR type is state-of-the-art
  - Multi-functional application
- Among a variety of designs, CNNC focuses on three main models:

  ACP100，DHR and HTR-PM.

CNNC SMR Design #1: ACP100

ACP100:

- The ACP100 is based on 50 years' experience on small reactors and 30 years' experience on power reactors.
- The preliminary design was completed in 2015.

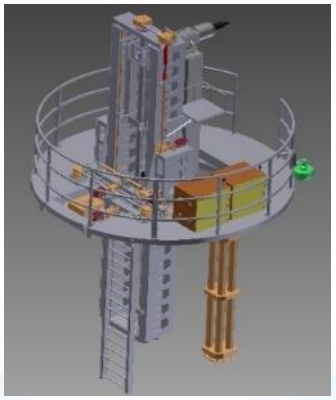
CNNC SMR Design #1: ACP100

A series of experiments were conducted on key components and systems.

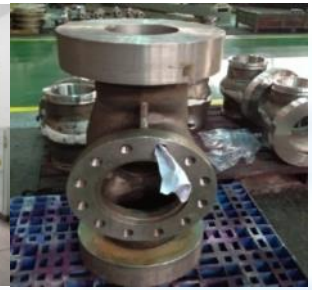
CNNC SMR Design #1: ACP100

Mock-up of key equipment were tested.

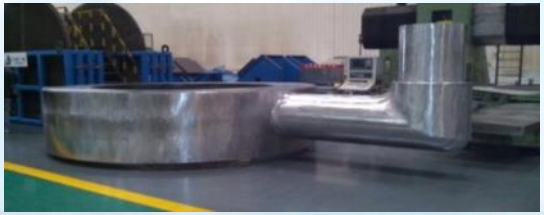
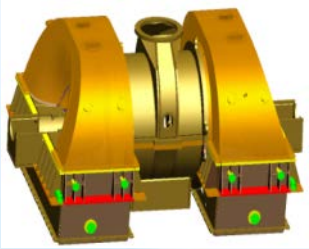




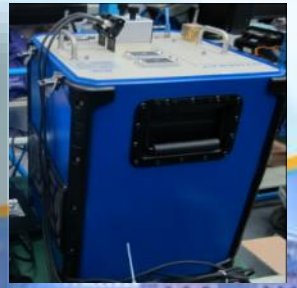






CNNC SMR Design #1: ACP100

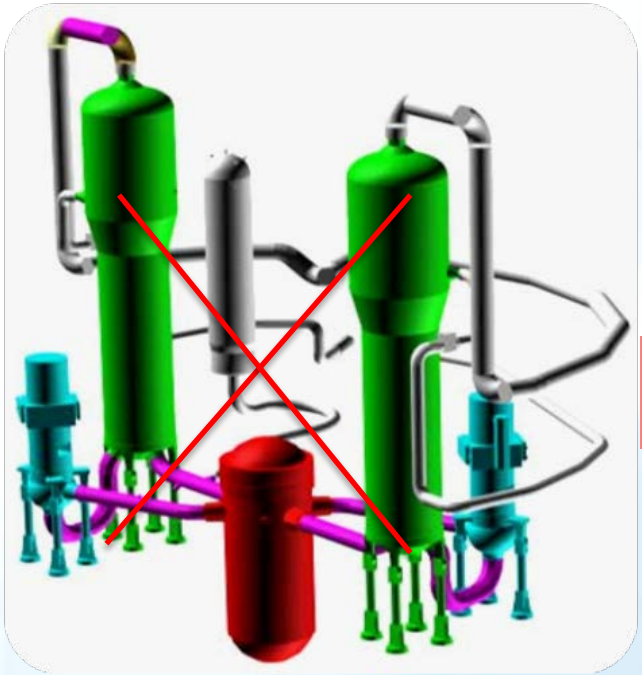
The Specifications of ACP100 Demonstration Project

Parameters	Value
Thermal power，MWth	385
Electric power，MWe	126.5
Reactor life, year	60
Refueling period, year	2
Core damage frequency (CDF)	<1E-6/year
Large release frequency (LRF)	<1E-7/year
Fuel type	AF3GS
Number of fuel assemblies	57
Core height，m	2.15
Outlet temperature of SG，℃	293.8
Pressure of SG, Mpa	4.5
Feedwater flow rate, t/h	596.8

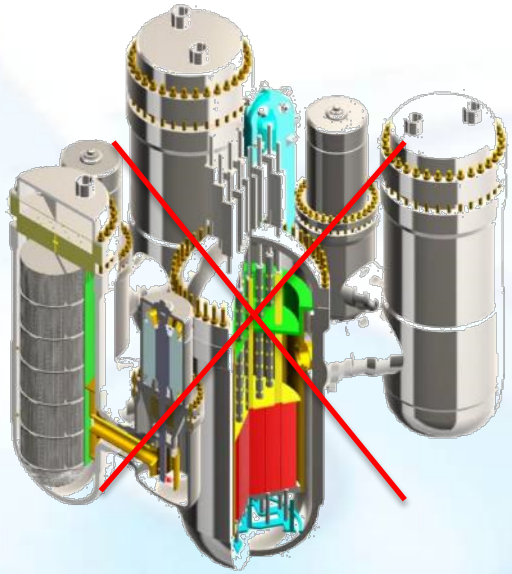
CNNC SMR Design #1: ACP100

Layout of ACP100

compact → safe → integral



conventional loop type reactor



renewed compact design

ACP100

advanced integral design

CNNC SMR Design #1: ACP100

In Apr 22, 2016, ACP100 passed the Generic Reactor Safety Review (GRSR) undertaken by IAEA.

CNNC SMR Design #1: ACP100

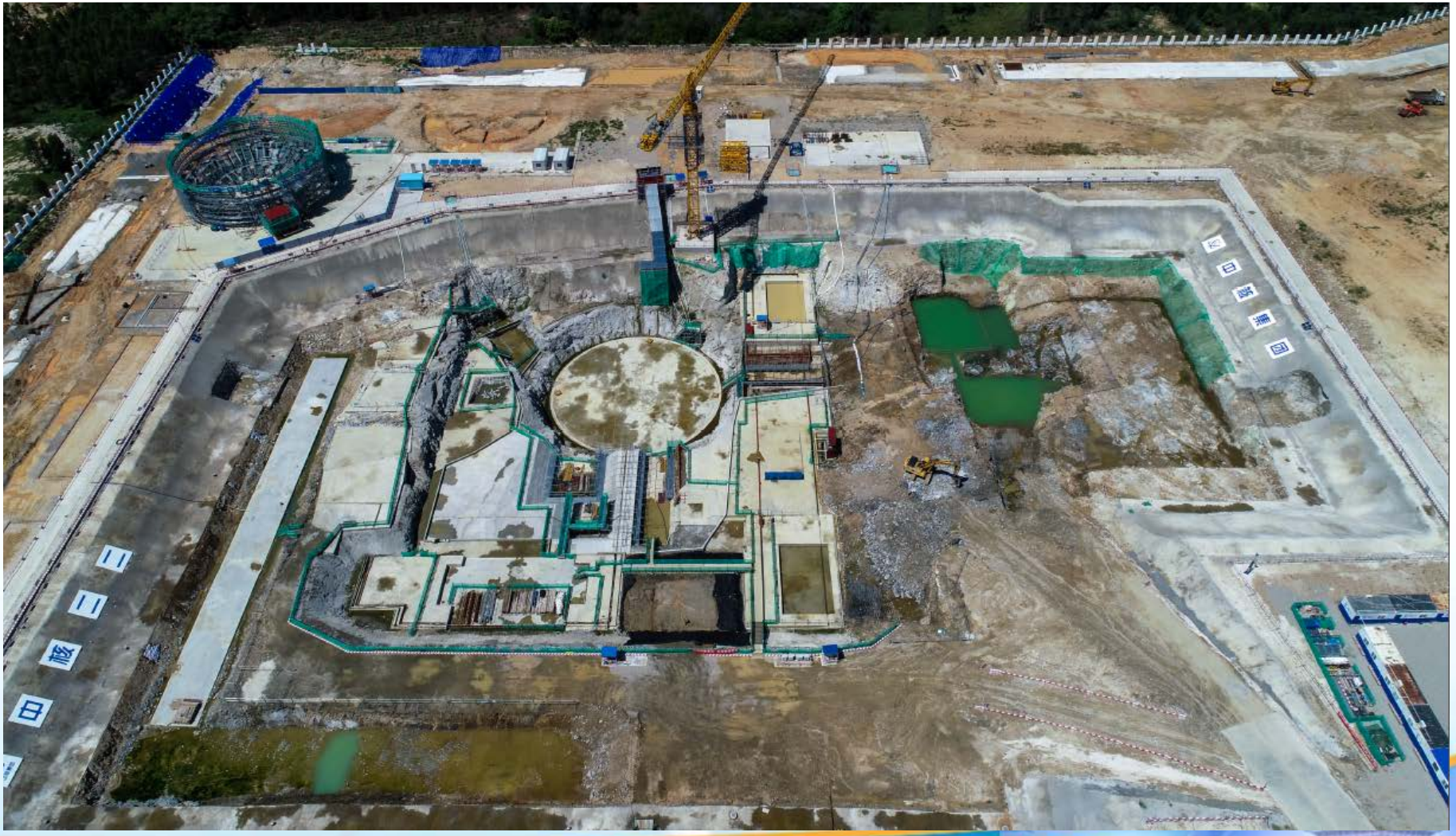
- **ACP100 Demonstration Project: Linglong-1 in Changjiang, Hainan.**

Development Milestones

- 2019.7.18 The start of the Linglong One demonstration project
- 2020.6.23 NNSA approved the preliminary safety analysis report
- 2021 FCD

CNNC SMR Design #1: ACP100

➢ **The SMR site, up to Jun 30, 2020.**



CNNC SMR Design #2: DHR

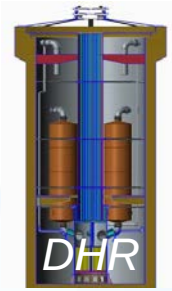
DHR:

- The DHR(Deep-pool Low-temperature Heating Reactor) is a pool type District Heating Reactor with a thermal power of 400 MW.
- Formally released in Beijing on November 28, 2017.

CNNC SMR Design #2: DHR

- **The DHR is developed on the basis of the light water swimming pool reactor (SPR-IAE).**

Scaling-up & optimizing

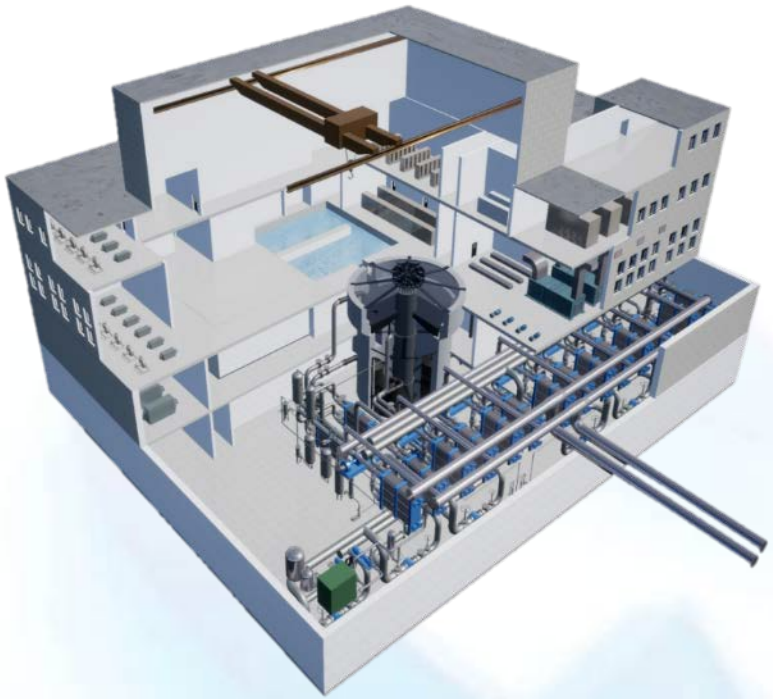


• Cooling tower	Heat discharge mode	• Heat supply
• Several MW	Power	• Hundreds of MW
• One month	Refueling cycle	• Over one year
• 40℃	Core outlet temperature	• ~100℃
• Relay on manual operation	Control	• Highly automated

CNNC SMR Design #2: DHR

item	parameter	item	parameter
thermal power /MW	400	enrichment of equilibrium refueling	3.10%
cooling type	forced	refueling period /EFPD	450
diameter of pool /m	10.0	average discharge burnup /GWD/tU	~30
depth of pool /m	26	refueling number per year /assembly	24
height of active zone /m	2.4	temperature of pool water /℃	68
equivalent diameter of core /m	2.02	inlet/outlet of core /℃	68/98
type of assembly	truncated PWR assembly(CF3-S)	inlet/outlet of secondary circuit /℃	63.5/93.5
number of assemblies	69	inlet/outlet of heating loop /℃	60/90
form of assembly	$17\times17_{-25}$	pressure of core /MPa	0.6
diameter of fuel rod /mm	9.5	pressure of secondary /MPa	1.2
fuel loading of core /t	23.45	pressure of heating loop /MPa	1.6
average linear power density /kW/m	8.87	type of heat exchanger for primary circuit and secondary circuit	plate heat exchanger

CNNC SMR Design #2: DHR



- ✓ **district heating**
- ✓ **sea water desalination**
- ✓ **radioisotope production**

Features

- zero core-melting
- easy decommissioning
- low investment requirement

Economy Evaluation

- Lower Construction cost
- Cheaper than natural gas

CNNC SMR Design #2: DHR

Demonstration and Validation(49-2 SPR)

Demonstration Project

Commercial Operation

Development Milestones

- 2017.11 The demonstration heating project of 49-2 SPR
- 2017.11.28 Formally released DHR-400(in Chinese "Yanlong").
- 2020.7.6 CNNC officially submitted the project proposal to NEA.
- 2022.6 FCD
- 2024.6 Possess ability of heat supply

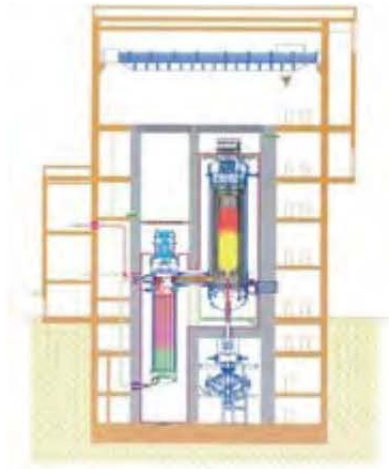
CNNC SMR Design #3: HTR-PM

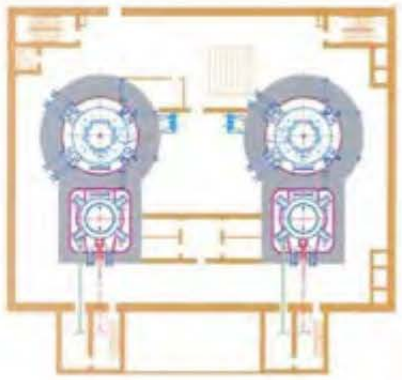
HTR-PM:

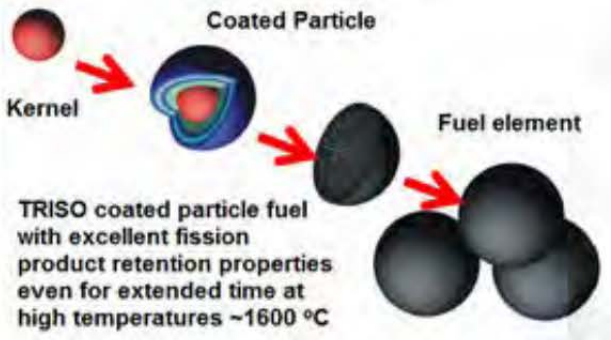
- Based on the success of HTR-10, HTR-PM inherits the characteristics of inherent safety and modular design.
- HTR-PM is the world's first commercial demonstration of high-temperature gas-cooled reactor which is considered one of the Generation IV reactors, and has two modules with a total capacity of 210 MWe.

CNNC SMR Design #3: HTR-PM

- **Main Design Features**
  - Coolant/moderator : Helium/graphite
  - Primary circulation: Forced circulation
  - NSSS Operating Pressure(primary/secondary): 7MPa/13.25MPa
  - Inlet/ outlet helium temperatures : 250/750°C
  - Fuel type/assembly array: Spherical elements with coated particle fuel
  - Refuelling Cycle (months): On-line refuelling

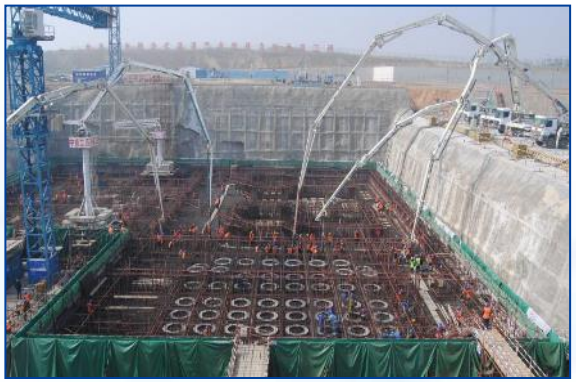
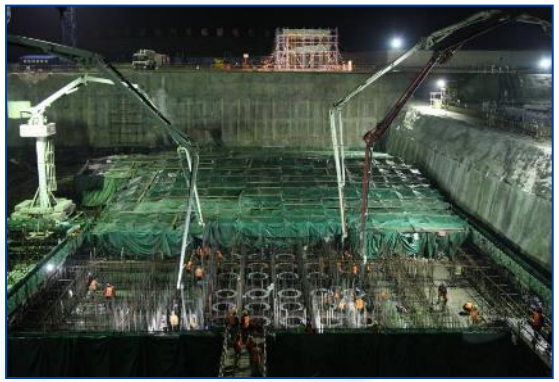
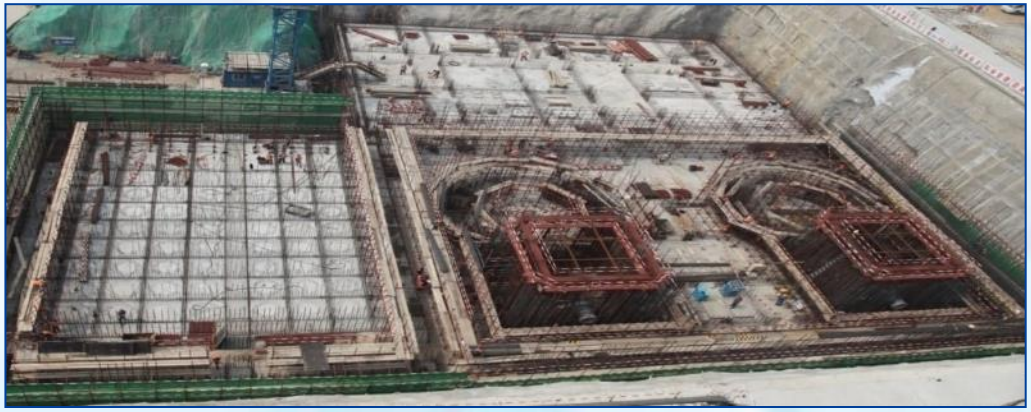




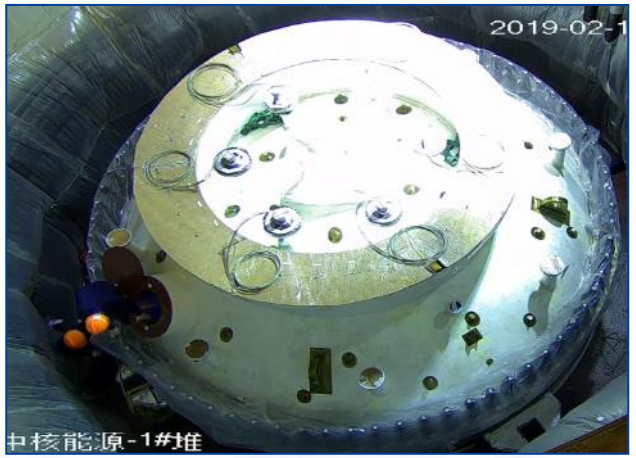


CNNC SMR Design #3: HTR-PM

The first concrete of HTR-PM demonstration power plant was poured on 9 December 2012, in Rongcheng, Shandong Province.


CNNC SMR Design #3: HTR-PM



Development Milestones

- 2012.12.9 FCD of Nuclear Island
- 2014.9.7 FCD of Conventional island
- 2020.11.3 Cold Function Test completed
- 2020.12.30 Hot Function Test started
- 2021 Reactor reaches criticality
- 2022 Commercial operation

Section III

Prospects

Prospects

- **Advanced SMR is playing an increasingly important role in the nuclear energy development of China. R&D has been carried out by many universities and research institutions.**
  - water cooled SMR
  - high temperature gas cooled SMR
  - molten salt SMR, etc.

- **The key driving forces of SMR development :**
  - fulfilling the need for flexible power generation
  - replacing ageing fossil-fired units
  - enhancing safety performance
  - offering better economic affordability.

Prospects

- **The deployment of SMR is still facing many challenges, more work should be taken:**
  - Establishing regulations, design standards and supervision system for SMR
  - Public acceptance issues
  - Implementation of passive safety
  - Economically competitive

Thank you for your attention!