Status of SMR R&D in China

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Section I

Applications of SMR in China
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
Sea water desalination
Section II
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.
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.
A series of experiments were conducted on key components and systems.
Mock-up of key equipment were tested.
### The Specifications of ACP100 Demonstration Project

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Thermal power, MWth</td>
<td>385</td>
</tr>
<tr>
<td>Electric power, MWe</td>
<td>126.5</td>
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<tr>
<td>Reactor life, year</td>
<td>60</td>
</tr>
<tr>
<td>Refueling period, year</td>
<td>2</td>
</tr>
<tr>
<td>Core damage frequency (CDF)</td>
<td>&lt;1E-6/year</td>
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<tr>
<td>Large release frequency (LRF)</td>
<td>&lt;1E-7/year</td>
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<tr>
<td>Fuel type</td>
<td>AF3GS</td>
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<tr>
<td>Number of fuel assemblies</td>
<td>57</td>
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<tr>
<td>Core height, m</td>
<td>2.15</td>
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<tr>
<td>Outlet temperature of SG, °C</td>
<td>293.8</td>
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<tr>
<td>Pressure of SG, Mpa</td>
<td>4.5</td>
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<tr>
<td>Feedwater flow rate, t/h</td>
<td>596.8</td>
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</tbody>
</table>
CNNC SMR Design #1: ACP100

Layout of ACP100

- compact
- safe
- integral

- conventional loop type reactor
- renewed compact design
- advanced integral design
In Apr 22, 2016, ACP100 passed the Generic Reactor Safety Review (GRSR) undertaken by IAEA.
ACP100 Demonstration Project: Linglong-1 in Changjiang, Hainan.

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

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

- Cooling tower
- Several MW
- One month
- 40°C
- Relay on manual operation

Heat discharge mode
- Power
- Refueling cycle
- Core outlet temperature
- Control

Scaling-up & optimizing
- Heat supply
- Hundreds of MW
- Over one year
- ~100°C
- Highly automated
<table>
<thead>
<tr>
<th>Item</th>
<th>Parameter</th>
<th>Item</th>
<th>Parameter</th>
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</thead>
<tbody>
<tr>
<td>Thermal power /MW</td>
<td>400</td>
<td>Enrichment of equilibrium refueling</td>
<td>3.10%</td>
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<td>Cooling type</td>
<td>Forced</td>
<td>Refueling period /EFPD</td>
<td>450</td>
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<td>Diameter of pool /m</td>
<td>10.0</td>
<td>Average discharge burnup /GWD/tU</td>
<td>~30</td>
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<tr>
<td>Depth of pool /m</td>
<td>26</td>
<td>Refueling number per year /assembly</td>
<td>24</td>
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<tr>
<td>Height of active zone /m</td>
<td>2.4</td>
<td>Temperature of pool water /℃</td>
<td>68</td>
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<tr>
<td>Equivalent diameter of core /m</td>
<td>2.02</td>
<td>Inlet/outlet of core /℃</td>
<td>68/98</td>
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<tr>
<td>Type of assembly</td>
<td>Truncated PWR assembly (CF3-S)</td>
<td>Inlet/outlet of secondary circuit /℃</td>
<td>63.5/93.5</td>
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<tr>
<td>Number of assemblies</td>
<td>69</td>
<td>Inlet/outlet of heating loop /℃</td>
<td>60/90</td>
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<td>Form of assembly</td>
<td>17×17.25</td>
<td>Pressure of core /MPa</td>
<td>0.6</td>
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<td>Diameter of fuel rod /mm</td>
<td>9.5</td>
<td>Pressure of secondary /MPa</td>
<td>1.2</td>
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<td>Fuel loading of core /t</td>
<td>23.45</td>
<td>Pressure of heating loop /MPa</td>
<td>1.6</td>
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<tr>
<td>Average linear power density /kW/m</td>
<td>8.87</td>
<td>Type of heat exchanger for primary circuit and secondary circuit</td>
<td>Plate heat exchanger</td>
</tr>
</tbody>
</table>
Features
- zero core-melting
- easy decommissioning
- low investment requirement

Economy Evaluation
- Lower Construction cost
- Cheaper than natural gas

✓ district heating
✓ sea water desalination
✓ radioisotope production
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
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.
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
The first concrete of HTR-PM demonstration power plant was poured on 9 December 2012, in Rongcheng, Shandong Province.
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
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.
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!