

# CNNC's ACP100 SMR: Technique Features and Progress in China

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- 1. Background**
- 2. ACP100 technique features**
- 3. Progress of ACP100**
- 4. ACP SMR Series Products**
- 5. Governmental Support & International Cooperation**
- 6. Our Team**



# 1

# Background



# 1. Background

## 1.1 Why do we need SMR ?

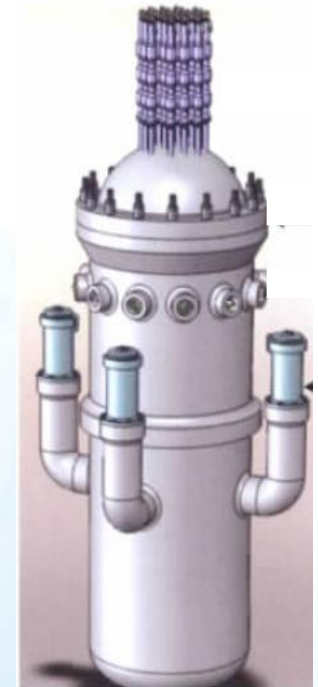
- Fukushima nuclear accident in Japan sounds the alarm for the nuclear safety again.
- To stop developing nuclear power is not a mind choice: increasing demand of energy sources, increasingly lack of fossil energy sources, warming up of global climate, and rising price of mineral fuel, etc.
- SMR can provide another **safe, economic and reliable clean** energy source for the world.



# 1. Background

## 1.2 About ACP100

- An **Integrative type SMR**, 125MWe, is being developed by CNNC (China National Nuclear Corporation).
- Large LOCAs (loss-of-coolant accidents) are physically impossible.
- On utilization of existing PWR technology and **verified** passive systems to cope with the consequences of accident events.
- Flexibility for **different purposed application**.



# 1. Background

## □ Applications of the ACP100



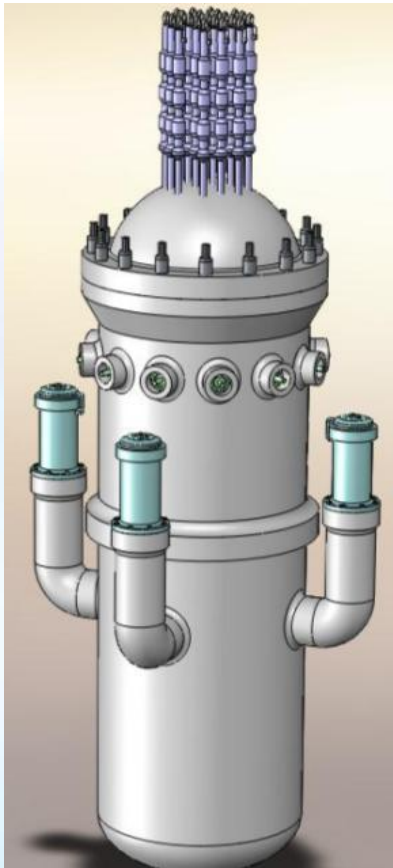
# 2

## ACP100 Technique Features



## 2. ACP100 technique features

### 2.1 Main design parameters



Thermal power	385MWt
Rated electric power	~125MWe
Hot steam output	600t/h, >290 °C, 4MPa,a
Hot steam and electricity Co-generation output	300t/h hot steam + 62.5MWe
Water output (by RO)	65,000t/d drinking water
Water and electricity Co-generation output (by MED)	100,000t/d distilled water + 80MWe
Design life	60 years
Refueling period	2 years
Coolant average temperature	303°C
Operation pressure	15MPa,a

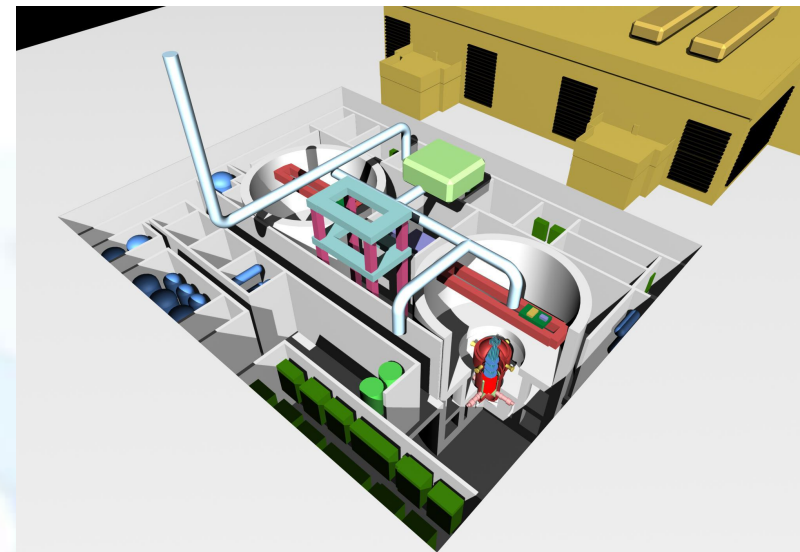




## 2. ACP100 technique features

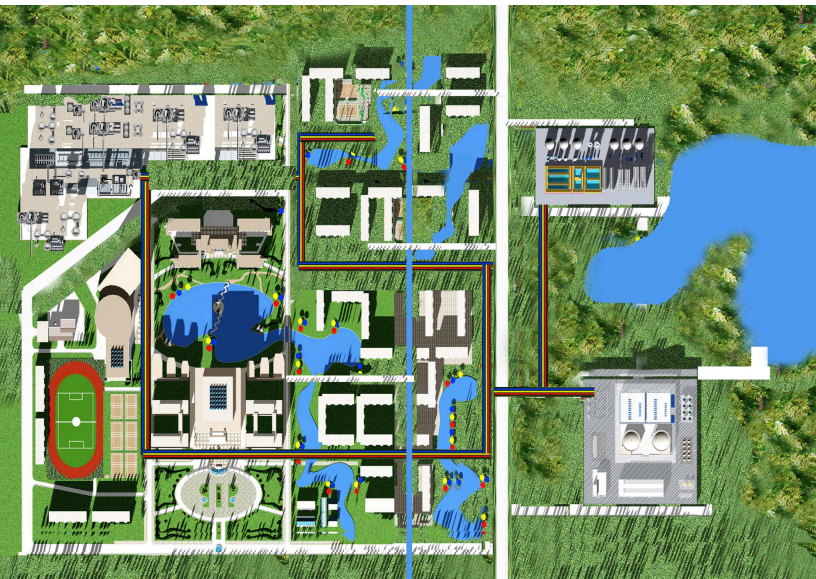
### 2.1 Main design parameters

Fuel assembly type	<b>CF3S assembly</b>
Fuel active section height	<b>2150mm</b>
Fuel assembly number	<b>57</b>
Fuel 235U enrichment	<b>4.2%</b>
Drive mechanism type	<b>magnetism lifting</b>
Control rod number	<b>25</b>
Reactivity control method	<b>Control rod, solid burnable poison and solvable boron</b>
Steam generator type	<b>OTSG</b>
Main pump type	<b>canned pump</b>



## 2. ACP100 technique features

### 2.1 Main design parameters

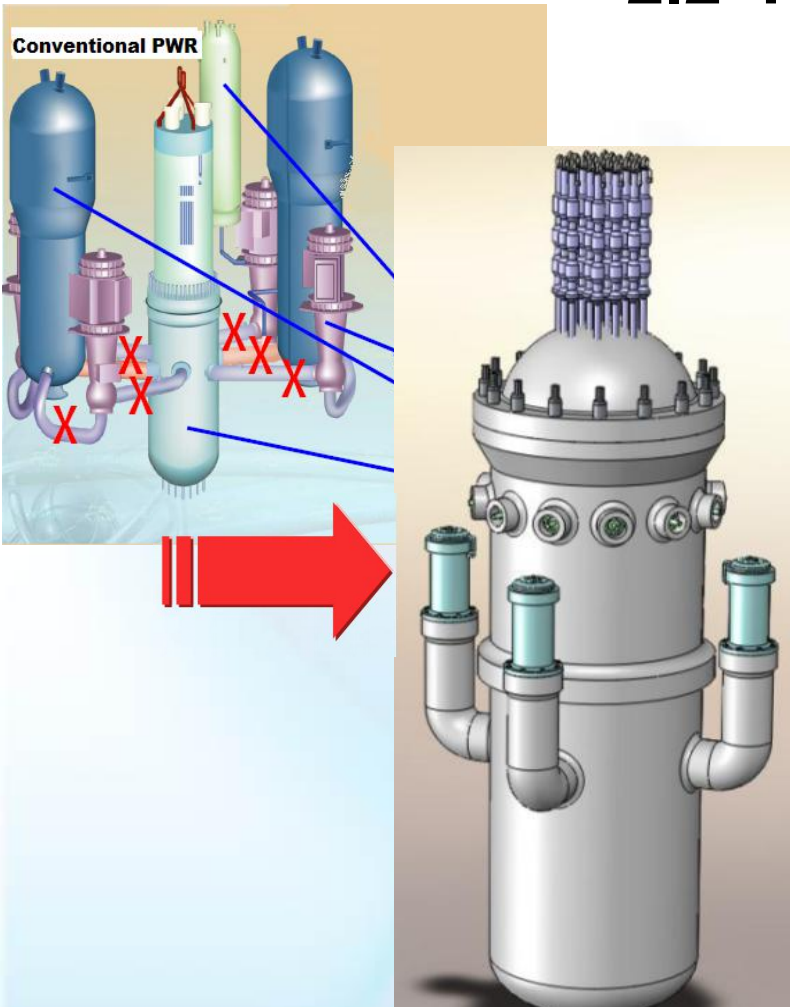


Reactor power-control operation program	primary constant average temperature
Thermal power plant operation model	Base load operation (Mode-A)
SSE level ground seismic peak acceleration	0.3g
Core damage frequency (CDF)	$<10^{-6}$
Large Release frequency (LRF)	$<10^{-7}$



## 2. ACP100 technique features

### 2.2 Reactor type & Technique route



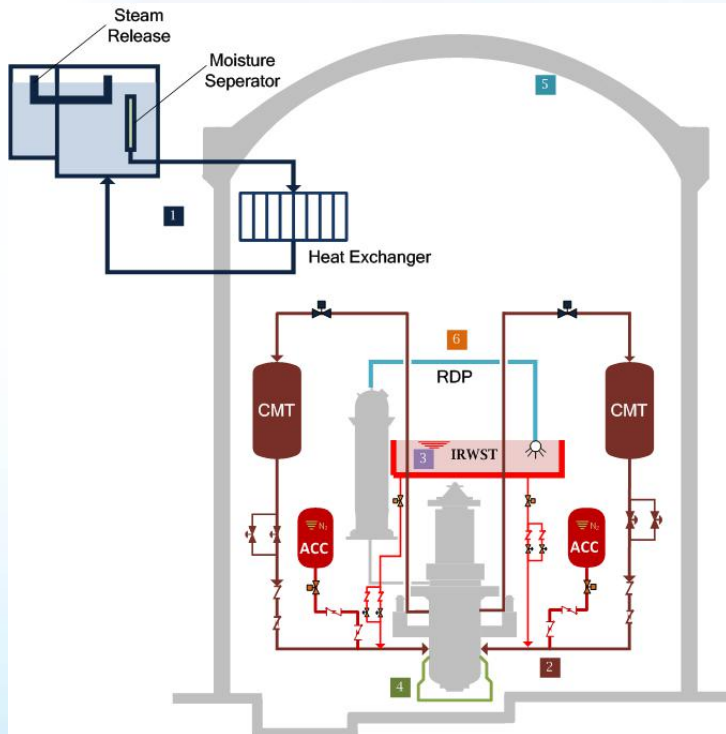
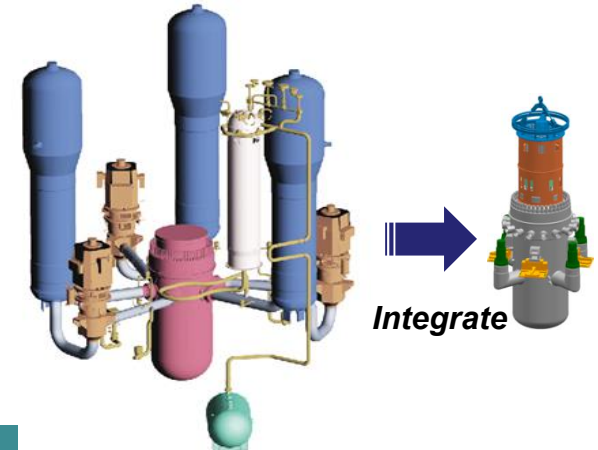
- Adopt **integrative layout** in stead of the traditional distributed layout. Eliminate large LOCA accident by design.
- Eliminate the technique risk to the most extent, by utilizing **existing PWR technique** storage and industry foundation, and **verified new techniques** .



## 2.3 Safety Features

### Integration

- Canned motor pumps integrated into RPV;
- Integrated OTSGs;
- Integrated reactor head package design.



### Passive

- **1** Passive Core Cooling System;
- **2** Passive Residual Heat Removal System;
- **3** Passive Containment Cooling System.

### Severe accident *prevention / mitigation measures*

- **4** Passive Cavity Flooding System;
- **5** Passive Hydrogen Re-combiner System;
- **6** Automatic Depressurization System ;
- APC shell, protection from External Events ;
- Deep-buried NSSS .



### 2.4 Advantages

#### Proven

- Normal operation systems on mature technology with rich experience and excellent performance
- Proven equipment and manufacturing capability
- Evolutionary technical improvements verified and evaluated by a series of experiments and tests

#### Safe

- Integrated reactor and Increased safety margin
- Passive ESF design philosophy
- Complete SA prevention and mitigation measures
- Reinforced protection against external hazards
- Minimization of emergency planning zone

#### Economy

- Prolonged plant design lifetime of 60 years
- High plant availability >90%
- Extended refueling cycle of 24 months
- Construction period and cost under control
- Mature equipment procurement channel



# 3

## Progress of ACP100



## 3. Progress of ACP100

### 3.1 R&D progress

No.	Item	Status	Plan
1	Top general design	Finished	Oct 2010
2	Conceptual design	Finished	May 2011
3	Optimized conceptual design	Finished	Nov 2011
4	Preliminary standard design	Finished	Dec 2012
5	Pre-PSAR	Submitted	Jun 2013
6	Key test researches	Finished	Dec 2014
7	PSAR	Submitted	Dec 2014
8	Project application condition	Satisfied	Dec 2014



## 3. Progress of ACP100

### 3.2 Third-party independent verification by NRSC (1)

- ✓ ACP100 nuclear reactor design is analyzed using code SCIENCE and MCNP.
- ✓ ACP100 accident analysis is verified using RELAP5 code.
- ✓ ACP100 criticality safety analysis for the spent fuel storage is verified using Monte-Carlo code.
- ✓ At-power level 1 PSA for internal initiating events is verified.





## 3. Progress of ACP100

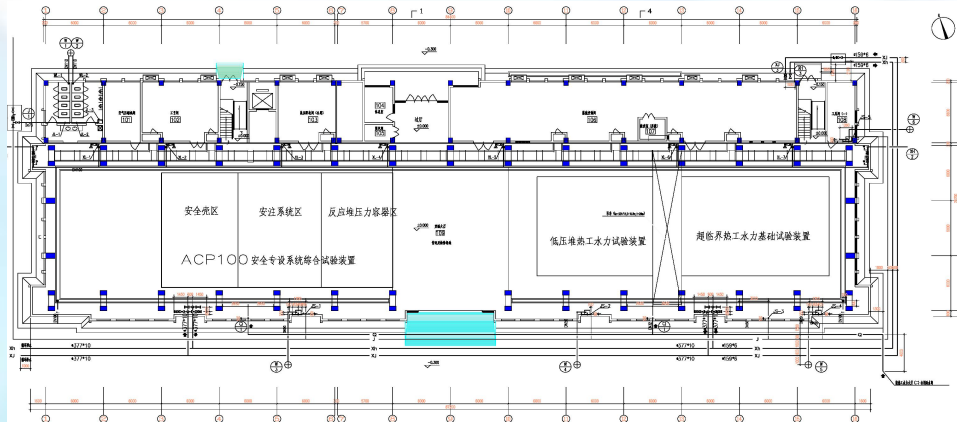
### 3.2 Third-party independent verification by NRSC (2)

- ✓ ACP100 severe accident source term and dose consequence is verified using MELCOR code.
- ✓ The design and analysis of the rupture protection for main steam lines of ACP100 is verified using ANSYS code.
- ✓ Stress analyses and assessment of reactor pressure vessel for ACP100 is verified using ANSYS code.
- ✓ Dynamic failure analysis of steam generator internal pipes is verified using ANSYS code.



## 3.3 Test and verification (1)

- ◆ The test programs were proposed to verify the design features of ACP100. The facilities were put to commission in 2013. By far, **lots of engineering data have been obtained** and provided powerful support for ACP 100 license.
- ◆ In order to verify the feasibility, reliability and rationality of the new design features, **7 performance tests and 7 qualification tests of equipments** have been done.



Thermal hydraulic testing hall

# 3. Progress of ACP100

## 3.3 Test and verification (2)

- ◆ Some photos of tests



## 3. Progress of ACP100

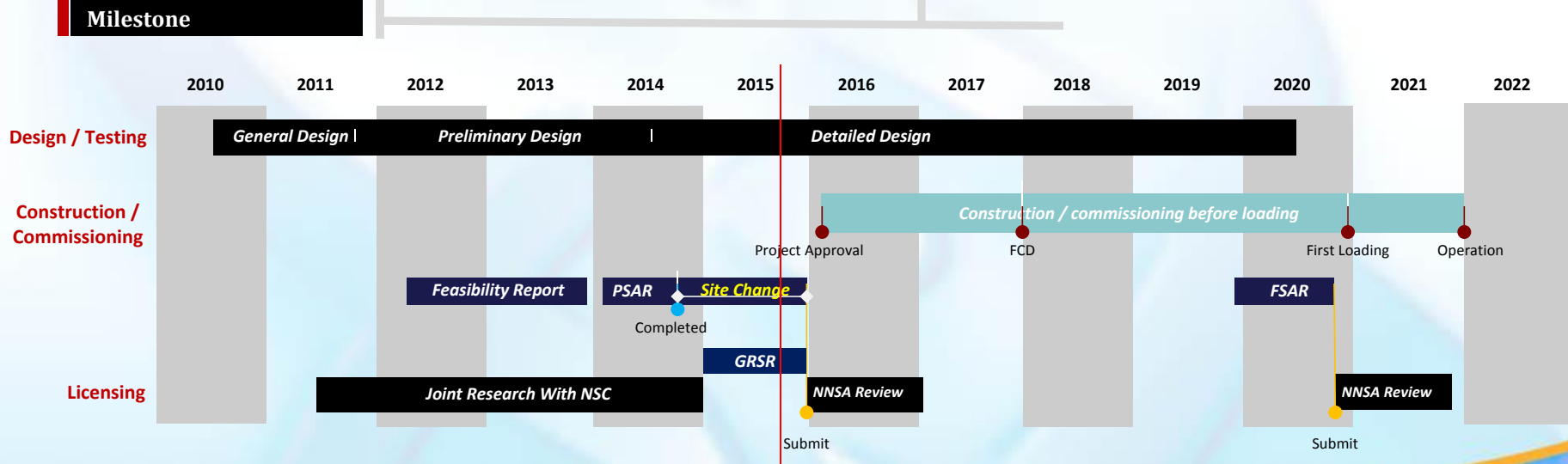
### 3.4 Licensing

- A contract of ACP100 combined research with NRSC in 2011, and developed the following works:
  - the concept design was approved;
  - witness passive integration test research, and the test program was approved;
  - conduct integral system tests;
  - evaluate design improvements.
- Standard design safety analysis research with NRSC in year 2012.
- Several specific research programmers and standard design safety analysis combined research with NRSC in year 2013.
- **The PSAR of ACP100 has been submitted in the end of 2014.**
- **International Safety Review of ACP100 by IAEA has been accomplished on April 22, 2016. The 1st SMR completion of GRSR in the world.**



# 3. Progress of ACP100

## 3.5 Demonstration Project (2016)



### 3. Progress of ACP100

#### Demonstration Project (Changjiang 2016)

**Changjiang nuclear power site, Hainan, China, as illustrated in Figure, was chosen to build the first of a kind (FOAK) ACP100 demonstration project.**

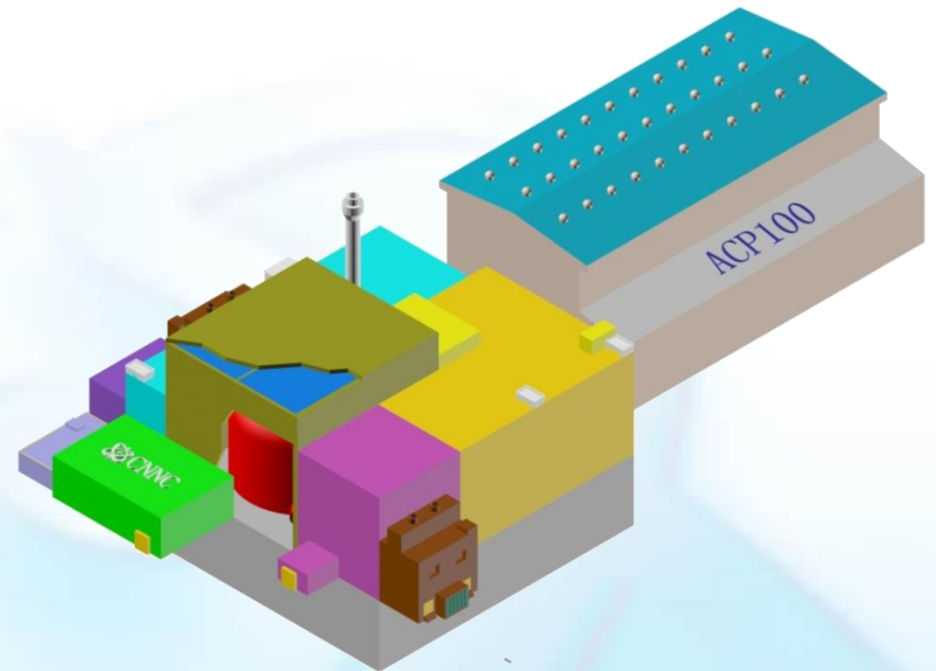
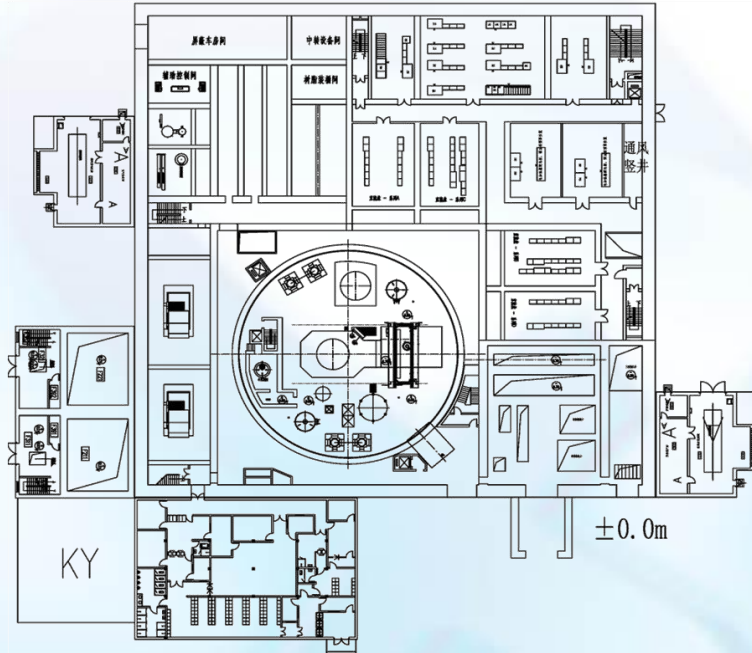
**The first concrete will be done on the day of 30th Dec. 2017.**



### 3. Progress of ACP100

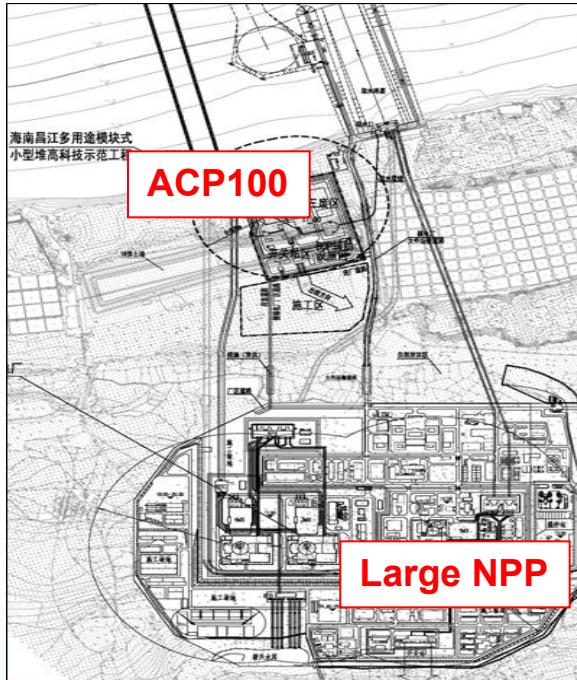
## Demonstration Project (Changjiang 2016)

- The layout of the demonstration project



# 3. Progress of ACP100

## Demonstration Project (Changjiang 2016)





# 4

# ACP SMR Series Products



## 4. ACP SMR Series Products

- R&D on serilization of reactor power to satisfy the different requirements from **different subdivided market.**

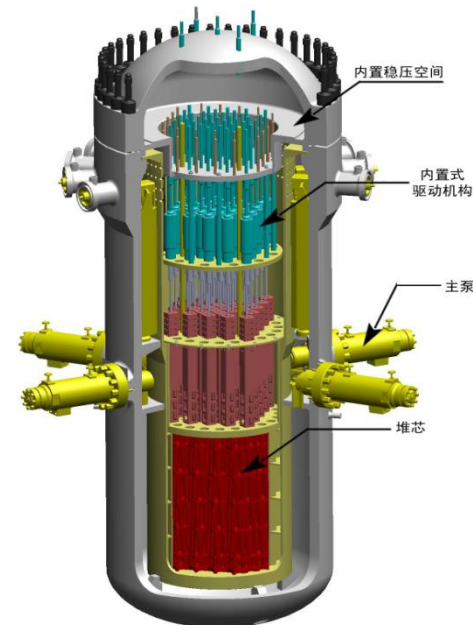
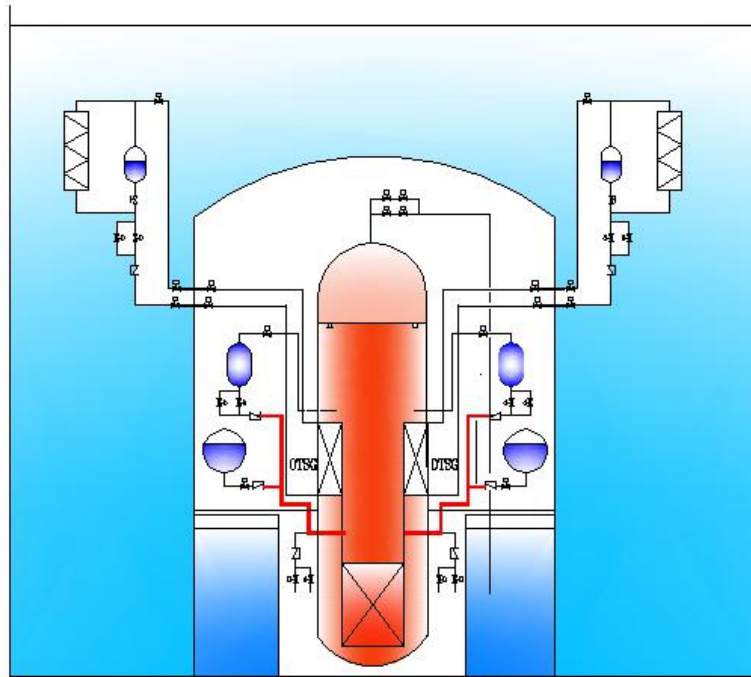
Item	Electrical Power	Research Phase
ACP25	25MWe	Basic Design
ACP50	50MWe	Conceptual Design
ACP100	<b>125MWe</b> / 100MWe	Preliminary Design
ACP200	200MWe	Conceptual Design



## 4. ACP SMR Series Products

### □ R&D on Advanced SMR: ACP100+.

Further exciting improvement of **safety** by utilizing internal PZR, internal CRDM, horizontal canned pump, etc.



## 4. ACP SMR Series Products

- R&D on **Non Electric Applications**, such as Floating NPP:  
ACP100S  
ACP25S



# 5

## Governmental Support & International Cooperation



## Acquired policy support from the Government

1

**The 12th Five-Year Plan for Energy Development** puts forth that a SMR demonstration project with independent intellectual property rights will be implemented.

2

**The National Development Program for Strategic Emerging Industries during the 12th Five-Year Plan Period** puts forth that fourth-generation nuclear reactors including fast breeder reactor and SMR technologies will be developed and demonstration projects will be launched timely.

3

**The Medium and Long-term Nuclear Power Development Program (2011~2020)** puts forth that investment in R&D on technologies including SMR will be increased and a demonstration project will be implemented timely.

4

**The 12th Five-Year Plan for National Energy Science and Technology (2011-2015)** puts forth that SMR is listed as a major research project (Y28) and a major demonstration project (S26).

5

**Energy Technology Revolutionary Innovation Action Plan (2016-2030)** puts forth that focuses will be put on important fields like advanced power equipment, including third-generation nuclear power systems and SMRs, which are much-needed for development of the energy industry

6

In **the Made in China 2025 - Implementation Plan for Energy Equipment**, China's energy technology strategy proposes to focus on development of SMR technologies and promotion of the SMR demonstration project in the field of nuclear energy.



# International Cooperation

**CNNC has organized relevant groups to actively carry out exchanges and cooperation with foreign companies in order to promote technological progress and marketing of SMR. In recent years, it has carried out a series of activities for communications with IAEA and countries like USA, France, Canada, UK, Russia, Saudi Arabia, Jordan and others. The SMR ACP100 has been recognized by international counterparts.**

ACP100 has passed the technological assessment of SMR by NNL authorized by the UK government and taken priority for cooperation with the UK



IAEA is carrying out the general reactor safety review for ACP100



Communication with the Babcock & Wilcox



Communication with ROSATOM



Communication with AREVA

# 6

# Our Team





- An oversize solely state-owned enterprise, established in 1955
- Having a complete system of nuclear science, technology and industry



CNNC



- **Already exported:** 6 nuclear power units and 8 reactors or nuclear power installation in 7 countries.
- **In negotiation on export:** UK, Sweden, Slovenia, Russia, Egypt, Algeria, Sudan, Ghana, Nigeria, South Africa; Iran, Saudi Arabia, Jordan, Armenia, UAE; Pakistan, Malaysia, Kazakhstan, Indonesia; Argentina, Brazil, Mexico, Chile, Uruguay.
- **Permanent bodies:** Pakistan, Algeria, Argentina, UK, Russia, Saudi Arabia, Egypt, Iran, Brazil.



**CHASNUPP- III&IV in  
Pakistan  
(2×CNP300)**



**KANUPP- II&III in Pakistan  
(2×ACP1000)**



**MNSR in Ghana, Iran,  
Pakistan, Nigeria,  
Syria**



## R&D team

Nuclear Power Institute of China, China Nuclear Power Engineering Co., Ltd. and CNNC New Energy Co., Ltd has established a joint R&D team to carry out R&D and design on the SMR ACP100 and the team has so far made a lot of achievements in scientific research.

## Achievements of research

- ▶ The standard design has been completed in combination with the demonstration project
- ▶ Applications of 81 invention patents and 99 utility model patents have been received by State Intellectual Property Office

## Achievements of design

- ▶ Reports for Two Assessments and the Feasibility Study Report completed
- ▶ The general design scheme completed
- ▶ The preliminary design completed
- ▶ PSAR report completed
- ▶ 3D design completed

Nuclear Power Institute of China



核能大厦



China Nuclear Power Engineering Co., Ltd.





® ACP100

Thank You !

