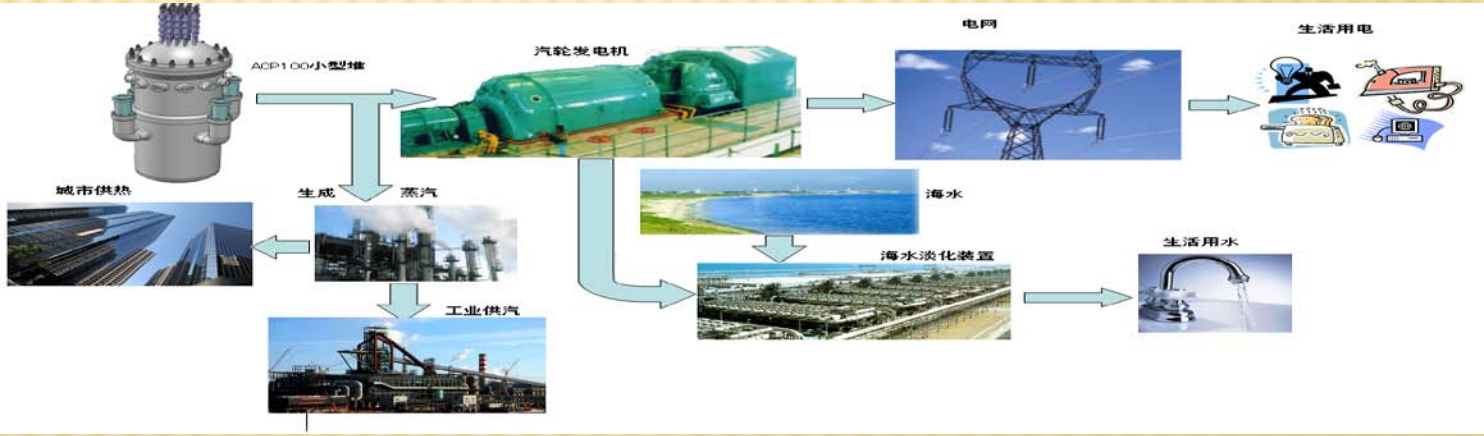
Development and Licensing of ACP100

The 3rd regional workshop on "Technical and Regulatory Issues Facing Nuclear Power Plants - Leveraging Global Experience“
Shanghai, China on 15 -16 May 2018.

CONTENTS

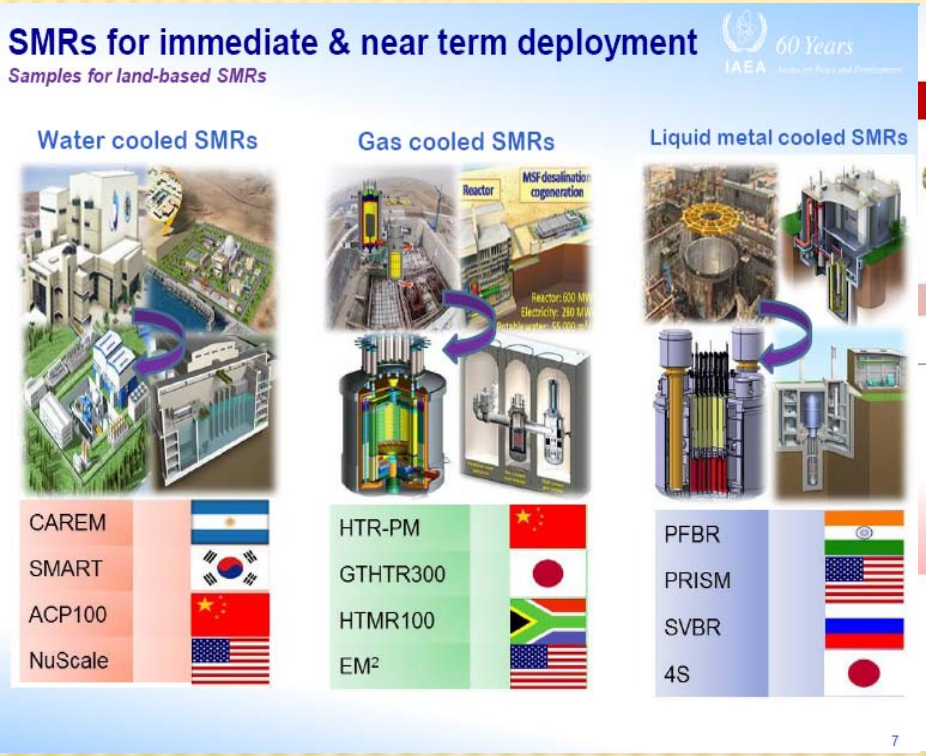
Background

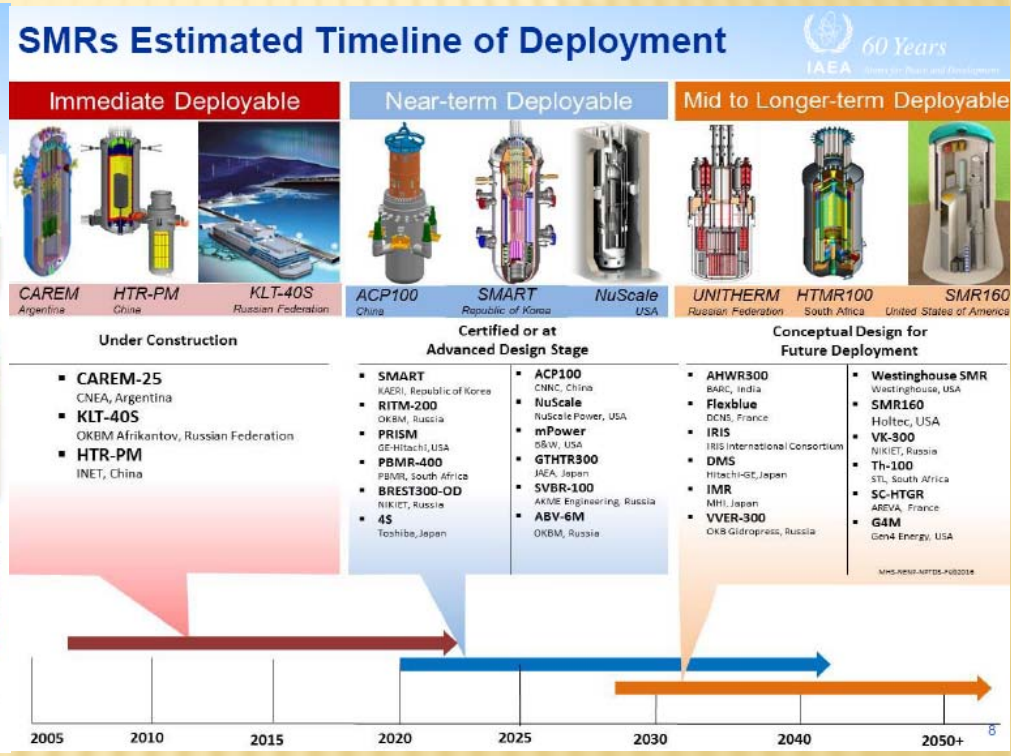
- *SMR (less than 300Mwe, IAEA definition) is suitable for small electricity grid, district heating, process heating supply, seawater desalination*



Background

Main developed and innovated SMRs over the member states





Introduction of ACP100

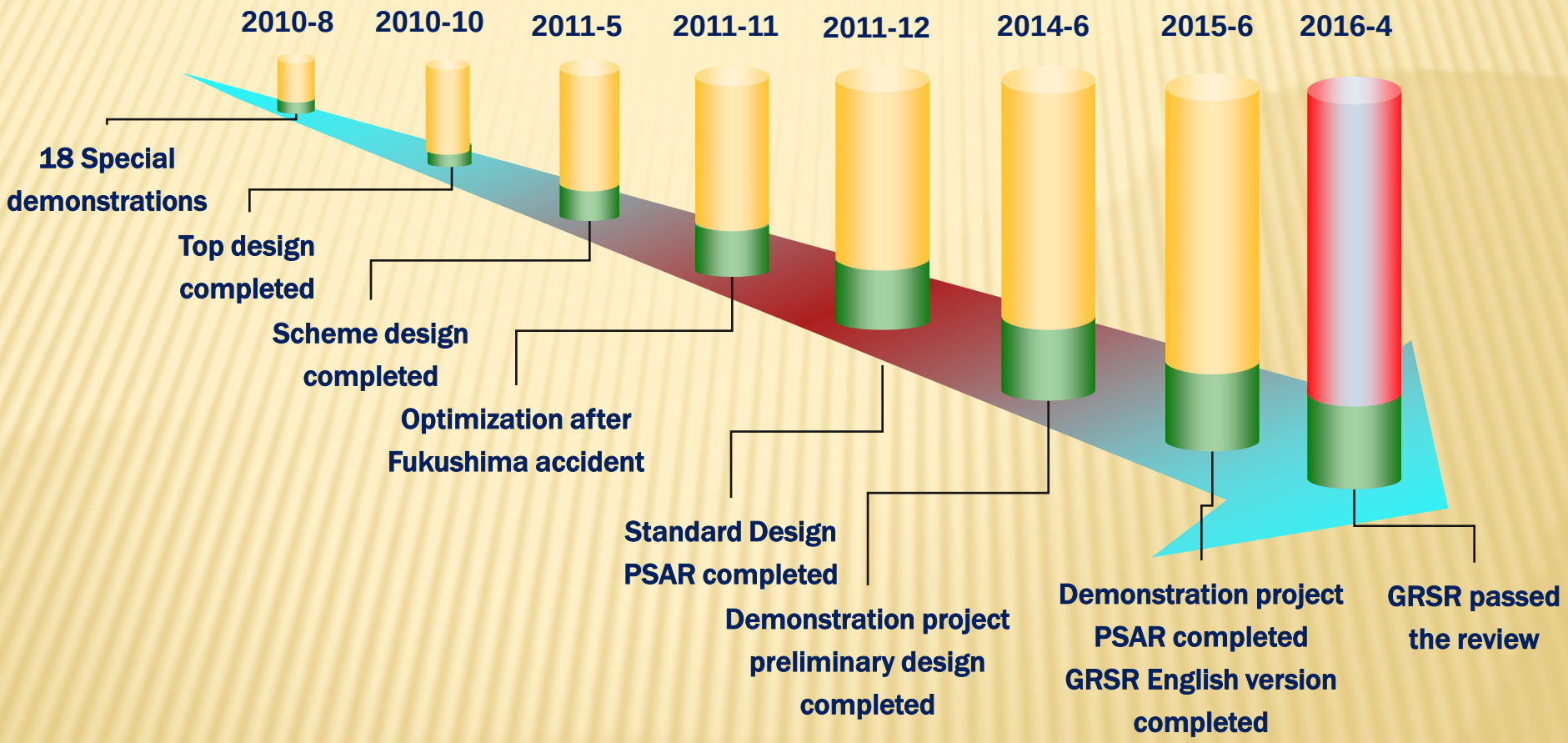
- CNNC SMR, code ACP100, is an innovative PWR based on existing PWR technology , adapting “passive” safety system and “integrated” reactor design technology;

- CNNC stared R&D on ACP100 from 2010 to 2017

- The modular design technique is used to control the product quality and shorten the site construction period.

Introduction of ACP100

Roadmap of ACP100 development



Design parameters of ACP100

Main design parameters

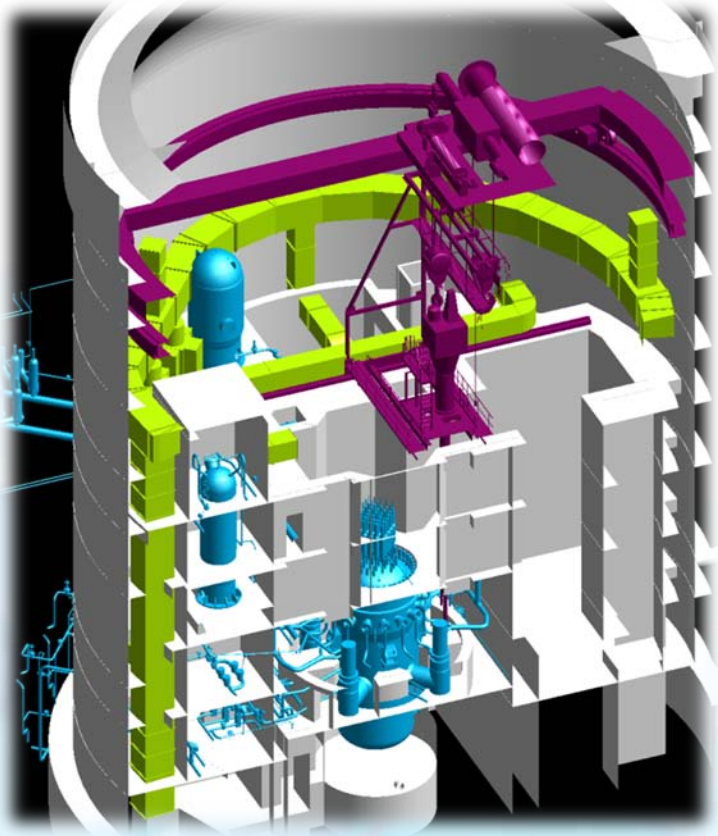
ACP100

Thermal power	385MWt
Electrical power	～125MWe
Design life	60 years
Refueling period	2 years
Coolant inlet temperature	282 ℃
Coolant outlet temperature	323 ℃
Coolant average temperature	303 ℃
Best estimate flow	10000 m^3/h
Operation pressure	15MPaa
Fuel assembly type	CF3 shortened assembly
Fuel active section height	2150 ㎜
Fuel assembly number	57

Design parameters of ACP100

Main design parameters

Fuel enrichment	4.45%
Drive mechanism type	Magnetism lifting
Control rod number	25
Reactivity control method	Control rod、solid burnable poison and boron
Steam generator type	OTSG
Steam generator number	16
Main steam temperature	>290 ℃
Main steam pressure	4MPaa
Main steam output	560t/h
Main feed water temperature	105 ℃
Main pump type	canned pump
Main pump number	4



Design parameters of ACP100

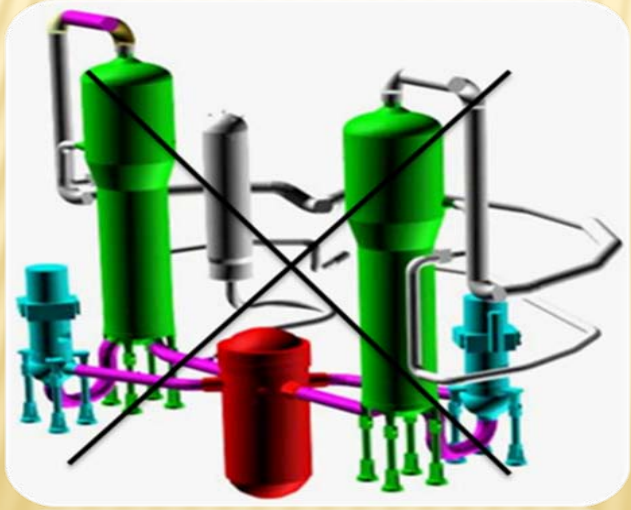
Main design parameters

Reactor power-control operation program	primary constant average temperature
Thermal power plant operation model	Base load operation（Mode-A)
Plant design life	60 years
SSE level ground seismic peak acceleration	0.3g
Predicted Core Damage Frequency (CDF)	＜1E-7 Per reactor year
Predicted Large Release Frequency (LRF)	＜1E-8Per reactor year

Technical Aspects

(1) Integral reactor module

The reactor coolant system has been integrated reactor module, which is illustrated in Figure. The reactor module is consisted of reactor vessel, once-through steam generators, canned motor pumps, reactor internals and integrated reactor head package.



Technical Aspects

(2) Reactor coolant system

ACP100

– ***system function and composition***
- ***4 main pumps***
- ***16 OTSG***
- ***1 pressurizer***

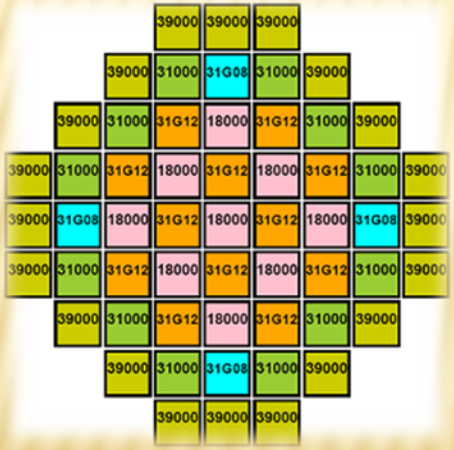
– ***system description***
- ***operation pressure 15.0MPa***
- ***core exit temperature 325 ℃***

Technical Aspects

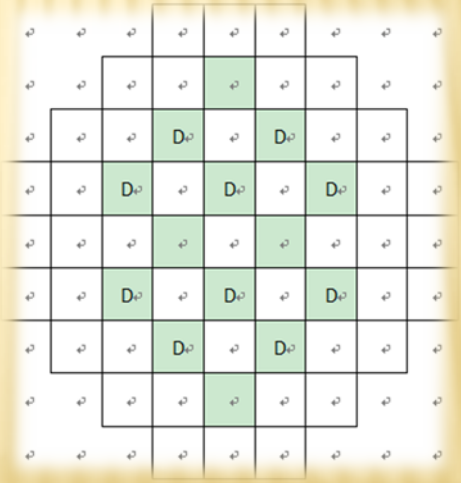
(3) Reactor Core

57 CF3S fuel assembly with Gd2O3 solid burnable poison

During refueling 24 4.45% enrichment new fuel assemblies load；



Core layout



Advanced core detection system

Technical Aspects

(4) Fully passive safety system

ACP100 adopts fully passive safety system, which is illustrated in Figure:

passive core cooling system,
passive residual heat removal system,
passive containment heat removal system,
passive inhabitation system,
automatic depressurization system,
passive hydrogen control system.

Safety and licensing strategy Aspects

(1) ACP100 Safety design conception

- No active Emergency Core Cooling System
- No active containment spray and recirculation system.
- No active safety system shared between units.
- No need for operator intervention after accident for 72 hours.
- No safety-related emergency AC power.
- NSSS integral design minimizes both the probability and impact of design basic accident (DBA).
- Mitigate DBA without non-safety system. Emergency planning zone is limited inside the site boundary.

Safety and licensing strategy

(2) Special design aspects

Safety enhancing

- *Integral primary system* → *Elimination of LB-LOCA*
- *Canned motor pump* → *Reduction of SB-LOCA*
- *Negative feedback coefficient and decreased linear power density* → *Increased safety margin*
- *High capacity of natural circulation in the primary system* → *Inherent safety*

Safety and licensing strategy

(3) Passive safety system

Safety enhancing

- Core make-up tank
- Accumulator

→ Core coverage

- All injection water with boron

→ Forbidden the core return to critical

- Multi stages ADS

→ Core depressurization

- Passive residual heat removal
- Submersion of the cavity during accidents
- Natural circulation between core and cavity
- Heat conducted to the large pool outside of containment

→ Decay heat removal

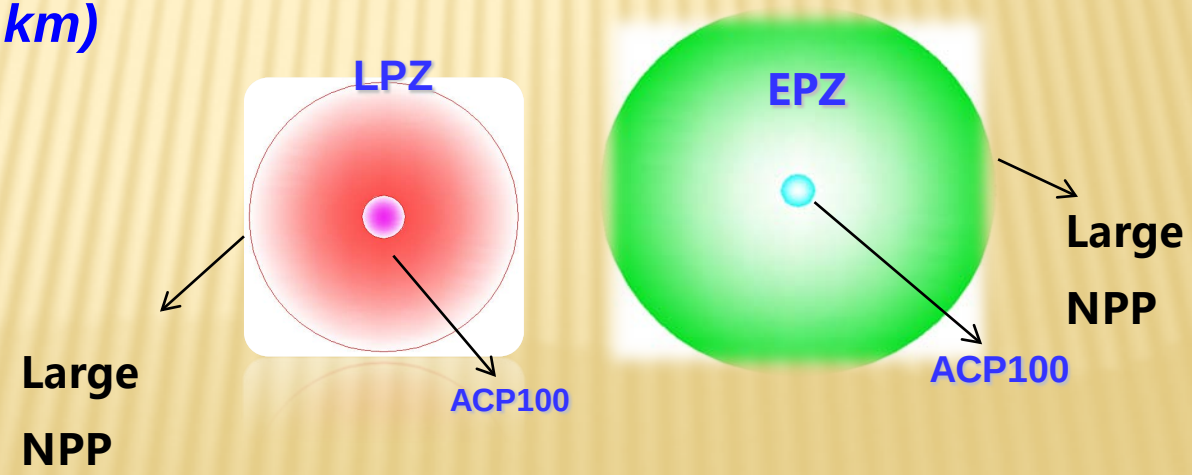
Safety and licensing strategy

(4) Non-residential Area and Planned Restricted Zone Study

Non-residential area (EAB): Less than 300 m; (for large reactor 500m)

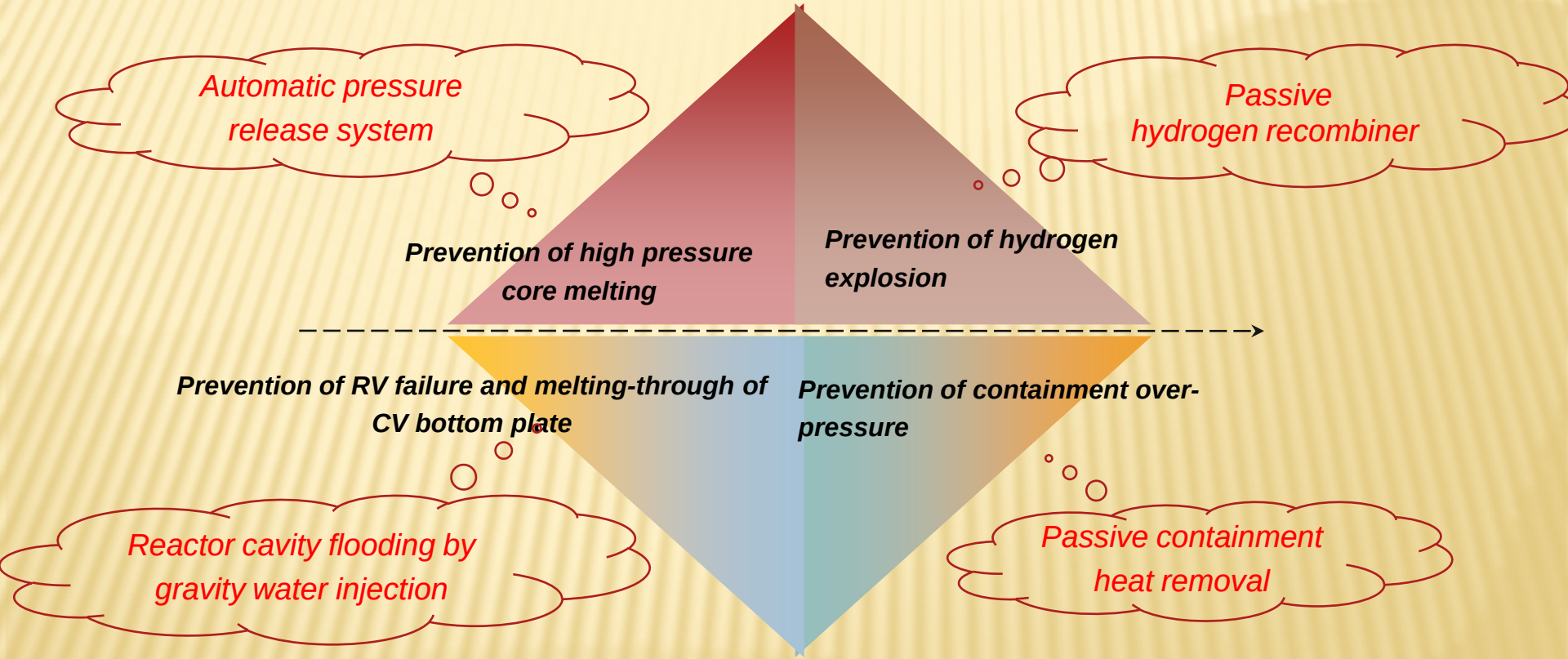
Planned restricted zone (LPZ): Less than 800 m; (for large reactor 5km)

Eemergency plan zone (EPZ): Internal zone Less than 400 m; (for large reactor 3~5 km) External zone Less than 600 m. (for large reactor 7~10 km)



Safety and licensing strategy

（5） Severe accident prevention and Mitigation measures



Safety and licensing strategy

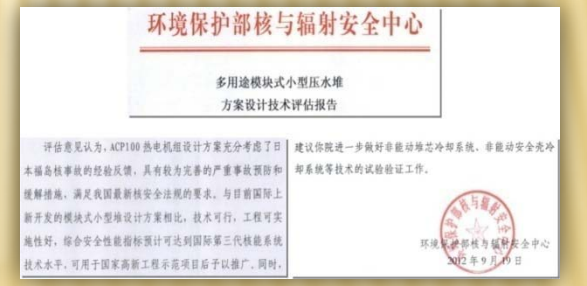
(6) Third party verification (1/2)

Signed a contract of SMR combined research with National Nuclear & Radiation Safety Center (NSC) from 2011 to 2015.

NSC gave the comments on the SMR research report;

NSC perform 3rd party calculation and safety analysis by different codes/software.

NSC perform 3rd party passive integration test research by their own staffs;



环境保护部核与辐射安全中心

多用途模块式小型压水堆
方案设计技术评估报告

评估意见认为，ACP100热电机组设计方案充分考虑了日本福岛核事故的经验反馈，具有较为完善的严重事故预防和缓解措施，满足我国最新核安全法规的要求。与目前国际上新开发的模块式小型堆设计方案相比，技术可行，工程可实施性好，综合安全性能指标预计可达到国际第三代核能系统技术水平，可用于国家高新工程示范项目后子以推广。同时，建议你院进一步做好非能动堆芯冷却系统、非能动安全壳冷却系统等技术的试验验证工作。

环境保护部核与辐射安全中心
2012年9月19日

Safety and licensing strategy Aspects

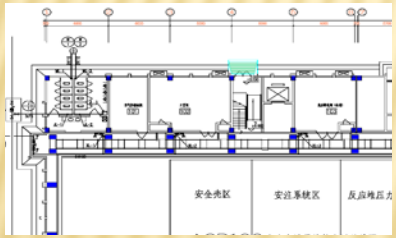
(7) Third party verification (2/2)

IAEA gave the review comments on ACP100 Generic Reactor Safety Review （GRSR） report on April 22, 2016, the 1st SMR completion of GRSR in the world.

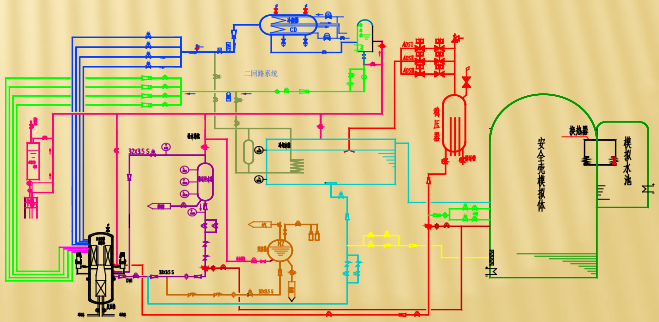
Testing & Verification

Seven test research subjects

- Control rod drive line cold and hot test
- Control rod drive line anti-earthquake test
- Internals vibration test research
- Fuel assembly critical heat flux test research
- Passive emergency core cooling system integration test
- CMT and passive residual heat removal system test research
- Passive containment heat removal testing



➢Thermal hydraulic testing hall



Passive emergency core cooling system

Testing & Verification

Code number	Name	Period
1	control rod drive line cold and hot testing	2011-2013
2	passive emergency core cooling system integration testing	2011-2013
3	internals vibration testing	2012-2014
4	fuel assembly critical heat flux testing	2011-2014
5	CMT and passive residual heat removal system testing	2011-2013
6	control rod drive line anti seismic testing	2012-2014
7	passive containment heat removal testing	2013-2015

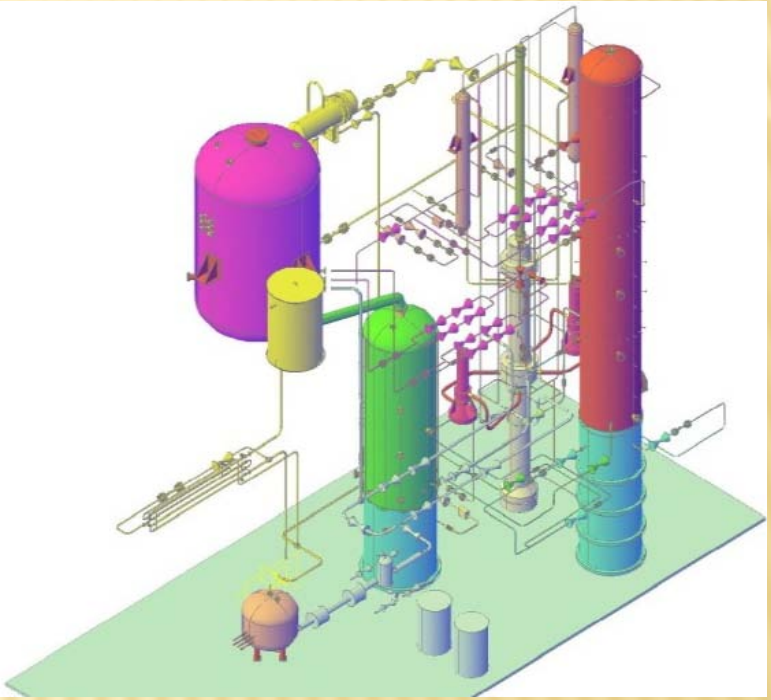
Testing & Verification

Control rod drive line related testing

Testing & Verification

Passive emergency core cooling system integration testing

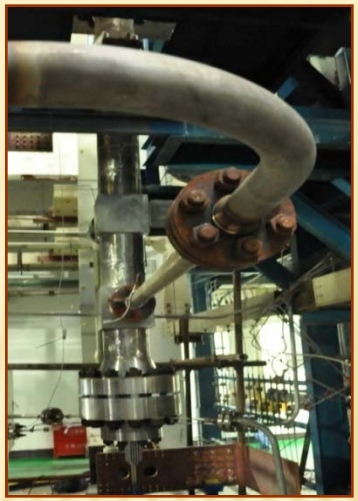
- Over 3 years, CNNC had constructed the most comprehensive passive engineering safety system testing facility. Core cooling system integration testing, Passive residual heat removal system testing had finished on this facility



Testing & Verification

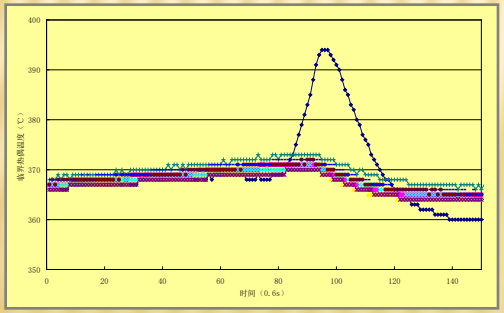
Fuel assembly critical heat flux testing

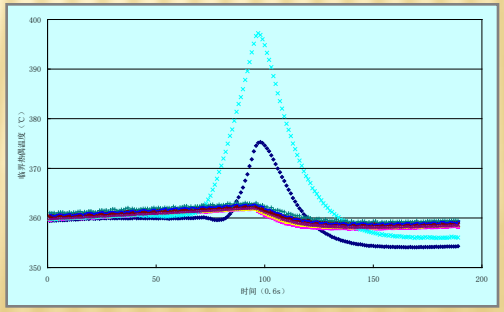
CHF testing facility



CHF testing tube

CHF heating assembly

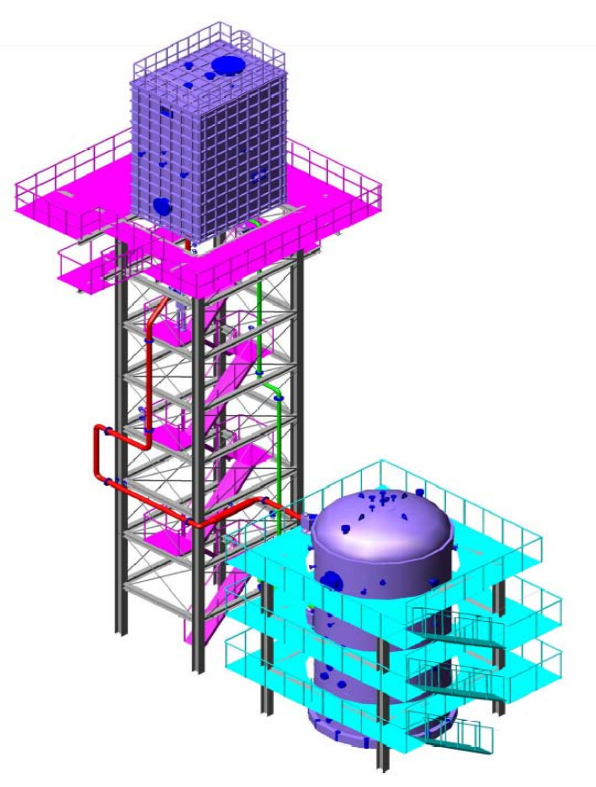




Testing & Verification

Passive containment heat removal testing

The results of the testing indicate the passive containment heat removal system is sufficient to conduct the heat to the ultimate heat sink



中核集团 CNNC

Thanks and Questions