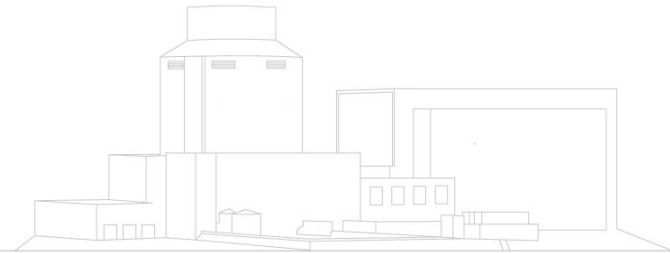




Technology Innovation: SNPTC's Practice and Prospect

Chiba, May 18th, 2015

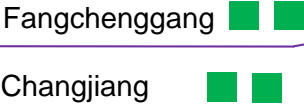
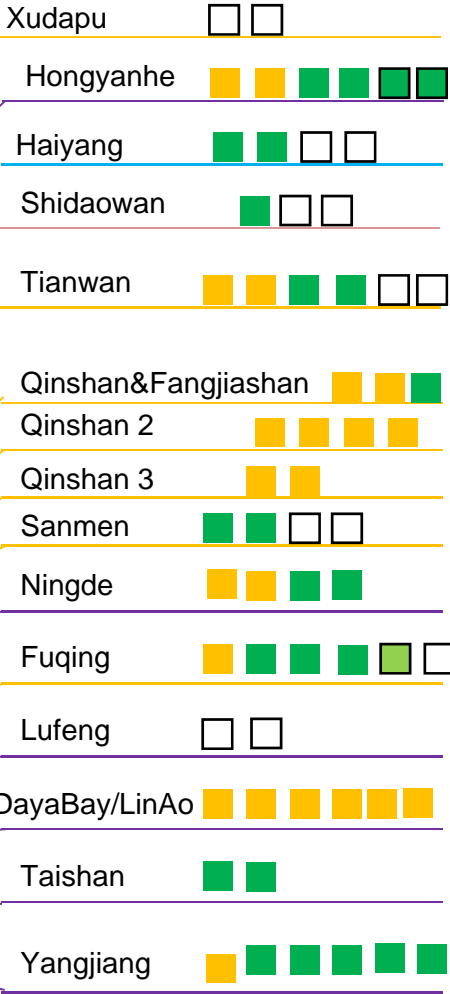
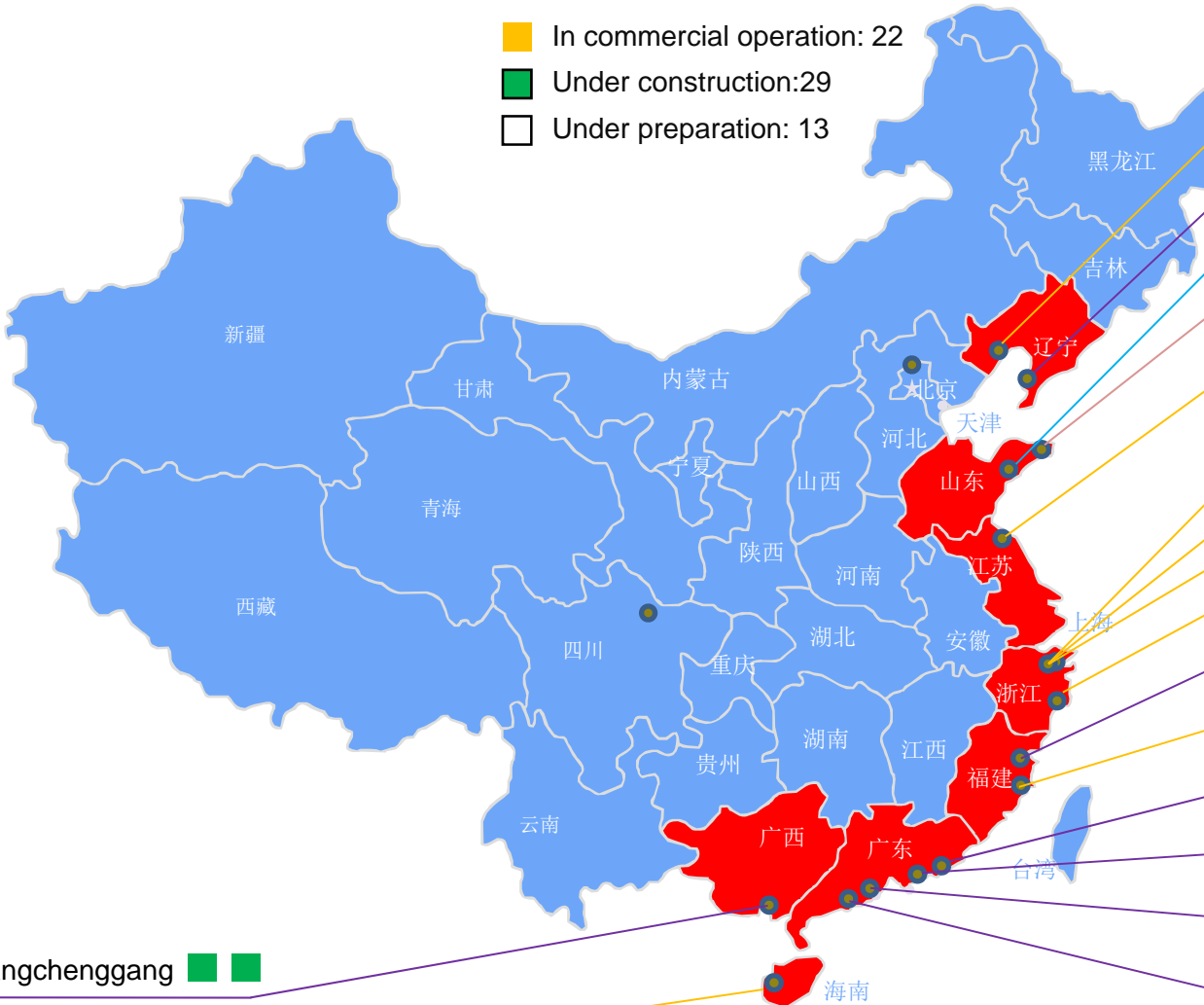
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- 2. SNPTC's Technology Innovation Practice**
- 3. China AP1000 Projects Status**
- 4. CAP1400 Characteristics and Project Status**
- 5. Future Prospect of SNPTC**

NPPs in China Mainland

■ In commercial operation: 22
■ Under construction: 29
 Under preparation: 13



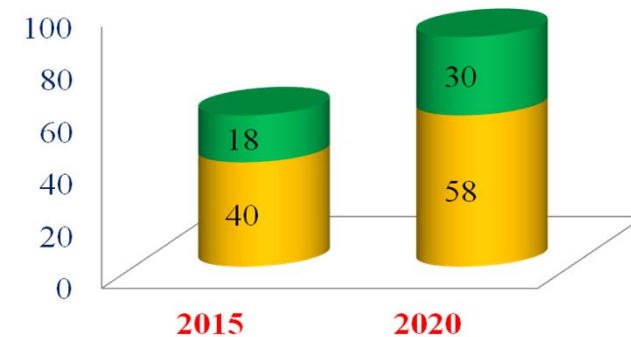
Nuclear Development Strategy in China

Development Plan:

- Mid to long term nuclear development plan

Development Principle:

- Safe and Efficient
- Highest safety standard and most advanced technology
- GIII NPP Technology
- Hold Public in high regards



■ 在运 (In operation, GW)
■ 在建 (Under construction, GW)



Nuclear Safety Requirements in China

Basic principle: Quality First, Safety First

Chinese nuclear safety regulations are based on IAEA nuclear safety standards and combined with the other international practice.

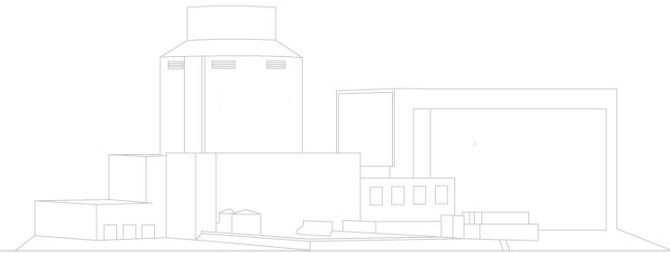
The safety goal, safety requirements and methodology are consistent with the international safety standards and practice.

Since Fukushima accident, Chinese Regulator has issued a lot of new or revised regulations to enhance the safety standard.

Nuclear safety Plan issued by Chinese Government defines the safety goals for new constructed nuclear power plants:

- The NPPs constructed before 2015 shall satisfy $CDF < 10^{-5}$, $LERF < 10^{-6}$
- The NPPs constructed after 2015 shall be practical elimination of large scale radioactivity release to environment.

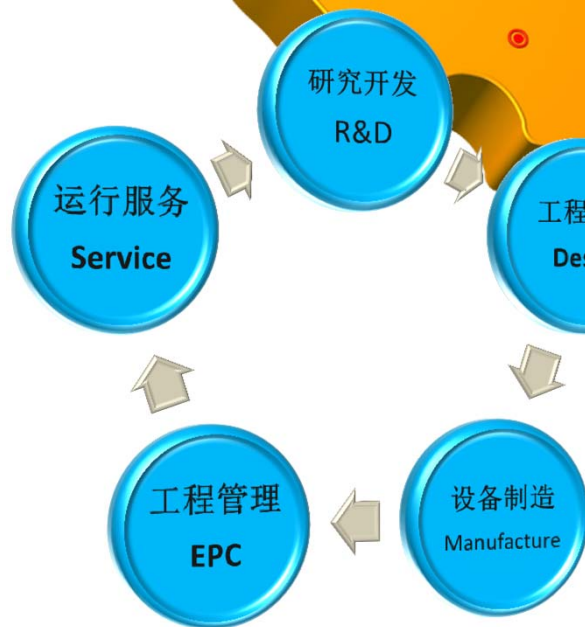
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SNPTC: State Nuclear Power Technology Company

- SNPTC has 14 subsidiary corporations.
- SNPTC employees has reached about 9000.
- SNPTC covers R&D, NPP design, NPP EPC, Key equipment Manufacture, NPP O&M, Lifetime service, Fuel, etc..
- SNPTC Provides Design, EPC, Maintenance for conventional electrical power and new energy.



中核包头燃料元件股份有限公司 (参股) CBNF (share holding)

公司总部 Headquarters
 国核电力院 SNPDR
 国核研发中心 R&D Center
 国核软件中心 Software Center
 国核大学 SNP Univ.
 国核服务 SWSC

国核山东院 SDEPCI
 国核山东核设备厂 SNPEMC
 国核示范工程 SNPDP

国核锆业SNZ
 国家能源核级锆材研发中心
 Zirc Research Center

上海核工院 SNERDI
 国核工程公司SNPEC
 国核自仪 SNPAS
 国核运行服务公司 SNPSC

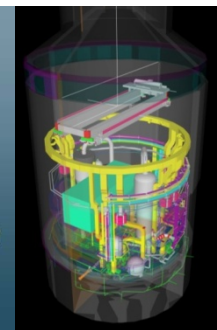
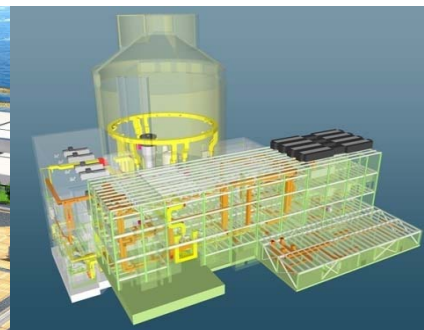
湖南核电有限公司 (参股)
 Hunan Nuclear Power Company
 (share holding)

SNPTC's technology Capability



7 Industrial Bases

- 科研开发
R&D
 - CAP1400
 - CAP1700
 - SMR
 - Gen 4 NPP Technology

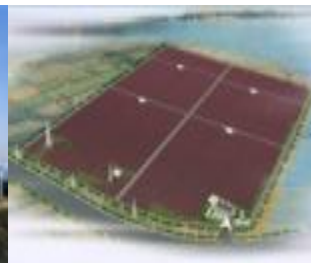


	H	G	F	E	D	C	B	A
8	B_00	D_88_12	B_00	D_88_12	B_00	D_88_12	C_00	A_00
9	0	0	0	0	0	0	0	0
10	19070	24480	19085	24531	19005	24655	19070	22778
11	D_88_12	B_00	D_88_12	B_00	D_88_12	B_00	D_88_12	C_00
12	0	0	0	0	0	0	0	0
13	24480	19070	24488	19704	24595	19827	21881	12604
14	B_00	D_88_12	B_00	D_88_12	B_00	D_88_12	A_00	A_00
15	0	0	0	0	0	0	0	0
16	19085	24488	19070	24458	19070	24348	24441	6939
17	D_88_12	B_00	D_88_12	B_00	D_88_12	B_00	C_00	C_00
18	0	0	0	0	0	0	0	0
19	24535	19704	24458	19773	24177	19047	C_00	9780
20	B_00	D_88_12	B_00	D_88_12	B_00	C_00	C_00	C_00
21	0	0	0	0	0	0	0	0
22	19008	24395	19070	24177	17962	21201	14918	
23	D_88_12	B_00	D_88_12	B_00	D_88_12	B_00	C_00	C_00
24	0	0	0	0	0	0	0	0
25	24655	19827	24348	19047	19047	19518	9690	
26	B_00	D_88_12	B_00	D_88_12	C_00	C_00	0	0
27	0	0	0	0	0	0	0	0
28	21881	12604	12604	14918	9690			
29	A_00	C_00	A_00	C_00				
30	0	0	0	0				
31	7329	12604	6939	9780				

Region #BA
BOC Burnup
EOC Burnup

7 Industrial Bases

- 工程设计
Engineering
 - CAP1000电厂设计
 - CAP1000 Full Plant Design
 - CAP1400电厂设计
 - CAP1400 Full Plant Design
 - 其他 Others



核电 Nuclear

火电 Thermal

风能 Wind

太阳能 Solar

生物质 Bio

电网 Grid

7 Industrial Bases

- 工程建设
Project Construction
 - 三代核电总承包管理体系和能力
 - EPC Capability for Gen III NP Projects
 - 火电总承包能力
 - EPC Capability for Thermal Power Projects
 - 新能源总承包能力
 - EPC Capability for New Energy Projects



7 Industrial Bases

合格供应商体系 Qualified Supplier System

- More than 700 qualified suppliers were certified
- Gen III NP supply chain could support 6-8 AP/CAP units annually.
- 2-5 suppliers for each key equipment



7 Industrial Bases

电站寿期服务

Plant Life Service

- 在役和役前检查 Pre/In-service Inspection
- CV性能验证 CV Performance Test
- 换料服务 Refueling
- 寿命评估和老化管理 Life & Aging Management
- 特种维修 Special Repair

国核运行



7 Industrial Bases

电站运行

Plant Operation

- 首批AP1000机组调试
- Commissioning of First AP1000 Units
- CAP1400示范电站运营管理
- Operation & Management of CAP1400 Plant



SNPTC



AP1000模拟机

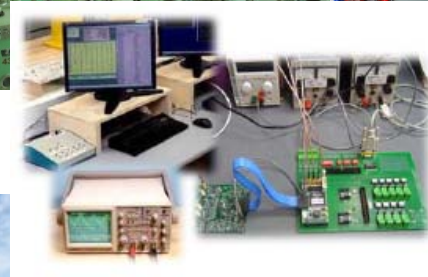
7 Industrial Bases

- 核电标准体系
NP Standard System
 - 牵头建立ASME中国国际工作组，最终目标建立中国先进核电标准体系.
 - Leading ASME CIWG to set up China's own advanced NP standards and codes system.



5 Technical Platforms

- 试验验证平台
Test and Verification Platform
- 软件开发平台
Software Development Platform
- 设备材料鉴定平台
EQ Platform
- 燃料研发平台
Fuel R&D Platform
- 技术经济研究平台
Economic Research Platform



5 Technical Platforms

Gen III Passive NP Technology Test and Verification Platform
Based on 6 CAP1400 test and verification facilities.



ACME
(Qinghua university)



IVR (Shanghai Jiaotong University)



CERT tests
(kaifeng Plant)



Hydraulic Simulation test
(NPIC/CNNC)



SG hot performance test
(Rinpoc/CNNC)



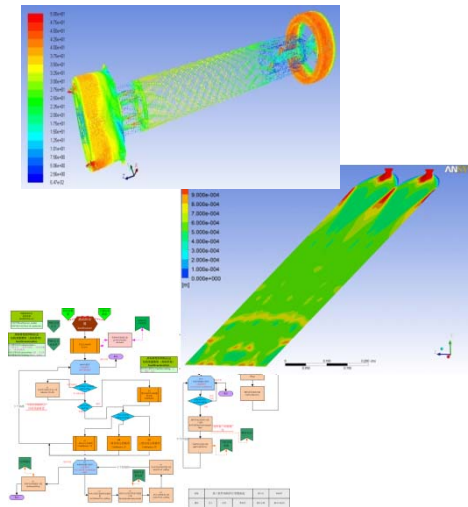
FIV test (NPIC/CNNC)

5 Technical Platforms

- 软件开发平台

Software Development Platform

- 核电设计软件 NP engineering software
- 运行支持软件 Operation support software
- 先进数值模拟技术 Advanced numerical simulation technology



5 Technical Platforms

- 设备材料鉴定平台

EQ Platform

- 核电设备材料鉴定中心。
- NEQ



5 Technical Platforms

- 燃料元件包壳材料研发平台

Fuel R&D Platform

- Fuel R&D and design
- Manufacturing technology of fuel cladding
- R&D of SiC and other nonmetallic materials for fuel



5 Technical Platforms

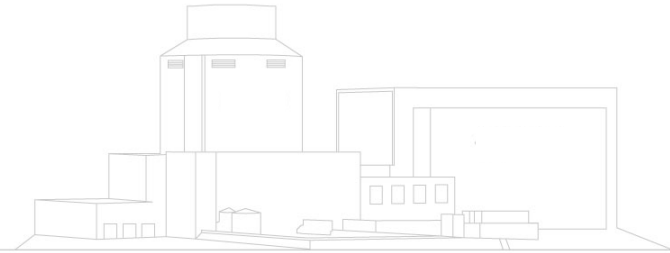
- 技术经济研究平台

Technical Economic Research Platform

- 三代核电成本与电价、财税保险等产业政策、三代核电技术经济标准和建设定额等
- Cost and pricing of Gen III NP, taxation and fiscal policies, economic standards and construction norms etc



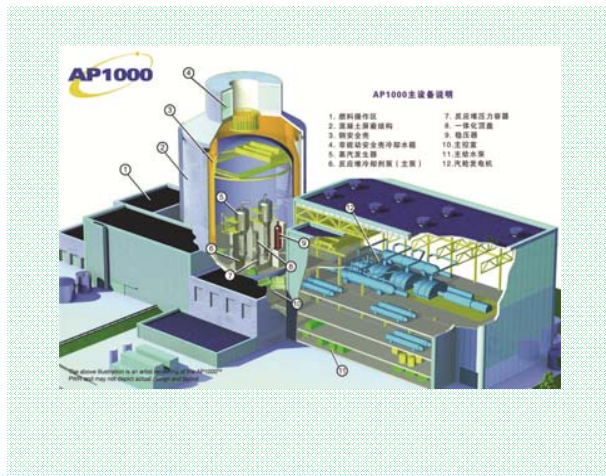
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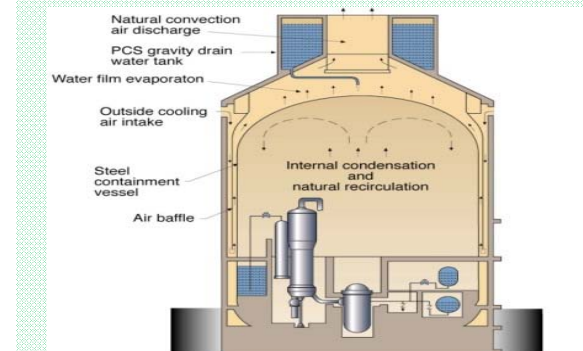
AP1000 Projects in China

“Passive Safety” from concept to engineering reality



Haiyang AP1000 NPP

Sanmen AP1000 NPP



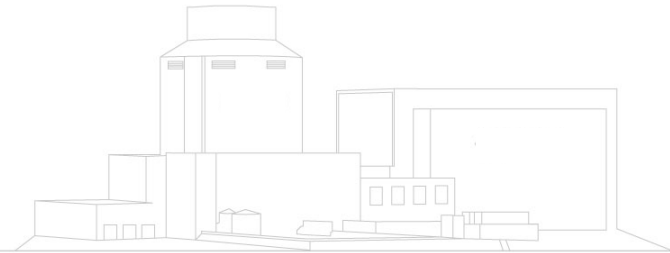
First AP1000 Nuclear Power Unit status

Sanmen Unit 1 (As of May 14st 2015)

- Civil work has completed,
- Installation of equipment (except for RCPs, Squib valves) has almost completed.
- 163 (248 in total) handover packages have completed.
- System flushing and equipment tests are ongoing.
- Cold function test is expected starting before December,2015.



CONTENTS

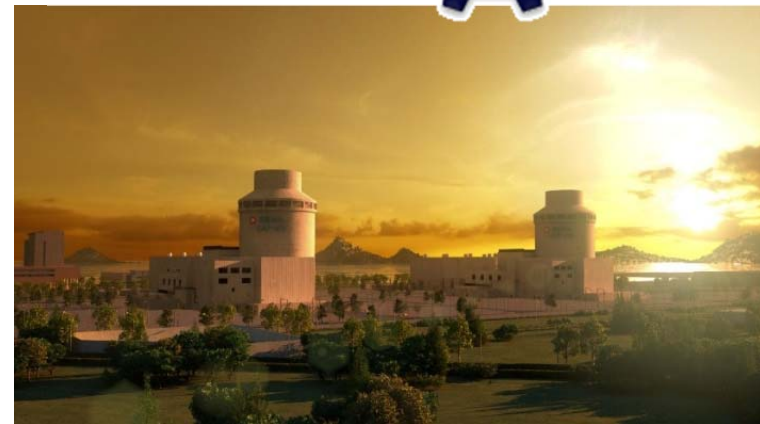


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CAP1400 Nuclear Power Plant



- **Based on AP1000**
- **Passive Safety Feature**
- **Verified and Validated Design**
- **Complete Intellectual Property**

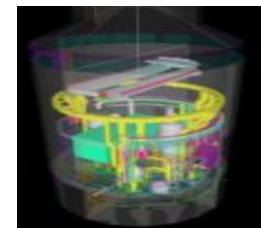
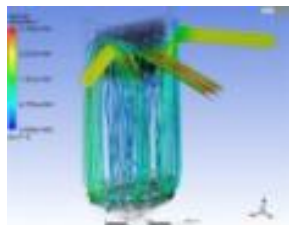


Features of CAP1400 NPP

Feature/Parameter	CAP1400
Thermal Power , MWt	4040
Electric Power , MWe	~1500
TAVG of RCS , °C	304
Pressure of RCS , MPa(a)	15.5
Number of Fuel Assembly	193
Linear power density W/cm	181
Type of SG	New Developed
Pressure of SG outlet MPa(a)	6.02
Flow of SG(each loop) kg/s	1122
Flow of RCP m ³ /h	21642
DNBR Margin	>15%

Characteristics of CAP1400 NPP

- 20%+ output than AP1000
- New configuration of the plant
- Enhancement of the RNS,CCWS,EWS,SFS.
- Enhancement of the capability after 72 hrs without human intervention
- Enhancement of the capability against extreme external events
- Increase in the Volume of containment
- More reliable and more efficient containment venting and filtering system for keeping integrity of containment after sever accident
- Modified Reactor Internals
- Modified SG, Coolant piping, Squib valves.....

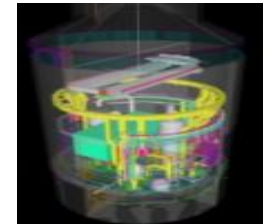
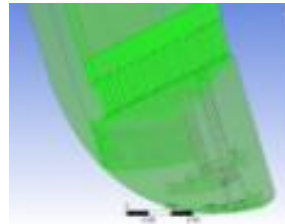
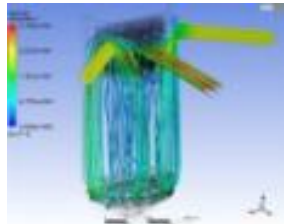


General Performance of CAP1400 NPP

Safety performance

Satisfying the international advanced nuclear safety requirements, achieving the advanced safety objectives.

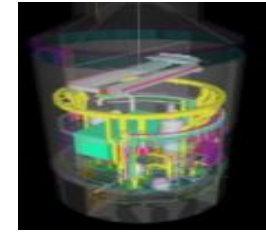
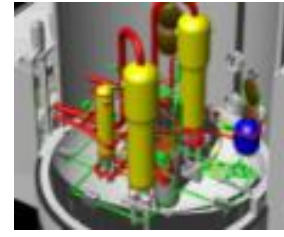
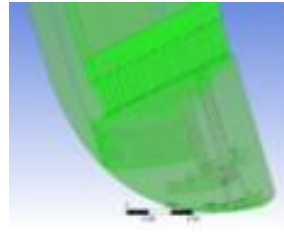
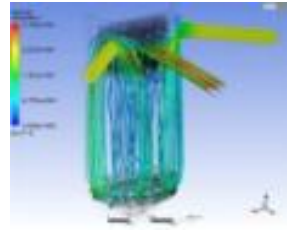
- Core damage frequency less than 4.02×10^{-7} /yr
- Design base SSE 0.3g
- Over 15% reactor core thermal margin
- 72 hours without operator action to sustain intact core and integral containment
- Occupational radiation expose dose less than 1.0 person•Sv/yr



General Performance of CAP1400 NPP

Safety performance

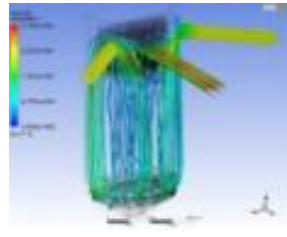
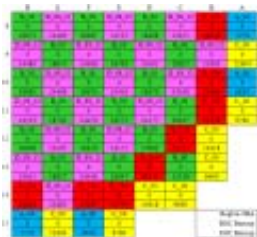
- Super capability against Blackout and other External Events by adopting mobile power and pumps
- Resistance to a commercial aircraft impact
- Containment integrity after severe accident kept by combination of IVR, Hydrogen control and Containment Venting and Filtering System
- Minimization of the radioactive waste by Optimized radioactive waste handling system



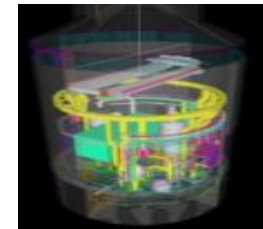
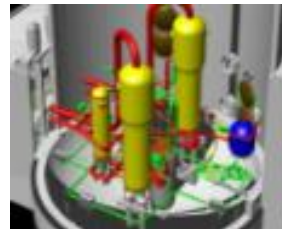
General Performance of CAP1400 NPP

Economy performance

- High Capacity : ~1500MWe(gross)
- High Availability: 60 years lifetime, 93% unit target availability
- Shorter construction period: Parallel construction by modularization
- Simplification: Less components(Piping/Pump/Valve)
- Localization: Key equipment and material localized
- Standardization : standard Design for batch construction
- Competition: lower construction price



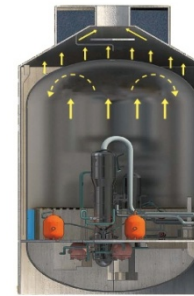
SNPTC



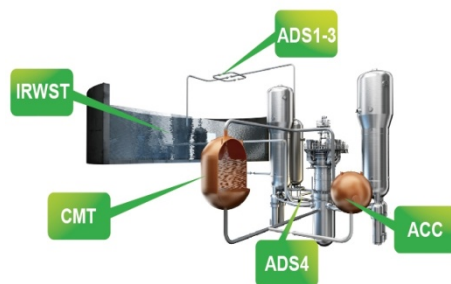
Specific Features of CAP1400 NPP

Passive feature design

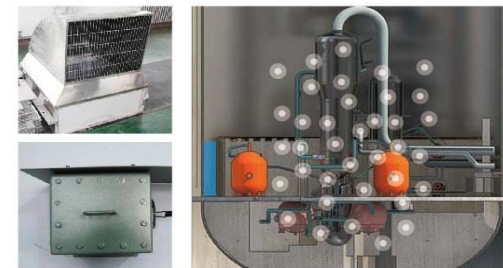
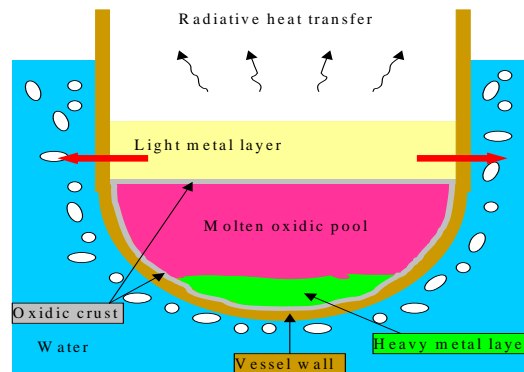
- Passive containment cooling system
- Passive Residual Heat Removal System:
- Passive Safety Injection System: CMT, ACC, IRWST
- Additional Passive Hydrogen Recombiner
- Passive MCR Emergency Habitability System
- Automatic Depressurization Subsystem: ADS1-3, ADS4



Passive Containment Cooling System



Passive Core Cooling System



Passive Auto-catalytic Hydrogen Recombiner

Specific Features of CAP1400 NPP

Enhancement of Safety Margin

- The PXS tanks/piping/valves is with the bigger margin. ADS4 Valve is designed as 18 inch.
- The steel containment of CAP1400 is with bigger margin in the free volume.
- The pumps, valves, piping and supports of ESWS, CCWS, RNRS and Spent Fuel Pool Cooling System are enhanced.

Containment Capability

Term	CAP1400 Value
Designed Internal Pressure	0.443MPa
Deterministic Severe Accident Capacity	0.832MPa
Maximum Pressure Capability	0.946MPa

Specific Features of CAP1400 NPP

Enhancement of Safety Margin

— Against External Events

- Safety Shutdown Earthquake (SSE) for Safety-related SSC, and the Peak Ground Acceleration (PGA) is 0.3g.
- Seismic margin assessment is also considered, that is, HCLPF activity level shall be no less than 0.5g (failure probability less than 5% with 95% confidence).
- Plant layout satisfies “Dry Site” Criterion: site drainage system is designed for the storm of once of 1000 years, and assessed by the maximum rain.
- A lot of measures are taken in design to prevent the internal flooding.

Validation and Verification of CAP1400 design

- ◆ 17 tests (including 887 sub-tests) have been completed for verifying CAP1400 design.
- ◆ 6 large scale test facilities are used for obtaining key design data.
- ◆ Design verification and validation has been completed.
- ◆ CAP1400 design has been reviewed by special expert group (80 specialists) organized by State Energy Administration.
- ◆ Safety reviewed of CAP1400 has been completed by Regulator (NNSA).
- ◆ Test data validates the is scientific and rational and greatly supports safety review.



IVR试验台架
IVP testloop



SG汽水分离热态试验台架
MW Separation testloop



非能动堆芯冷却系统综合性能试验台架 (ACME testloop)



非能动安全壳冷却系统综合试验台架 (CERT)

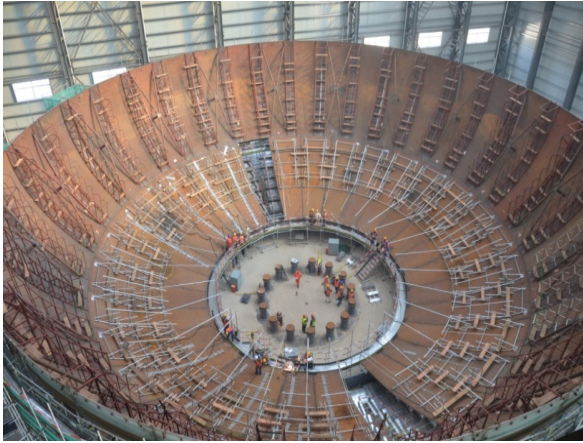


水力模拟试验台架
Hydraulic simulation testloop



流致振动试验台架
FIV testloop

CAP1400 Project Progress in China



CAP1400 Project site



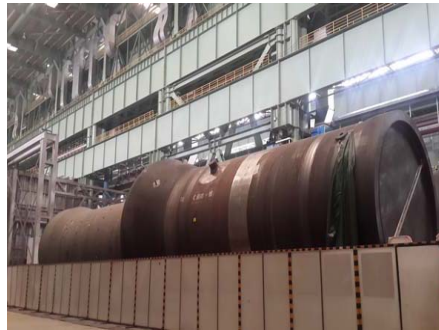
CR10模块（钢制安全壳基础）
Module CR10(CV Base)

MANUFACTURE OF KEY EQUIPMENT

Reactor Vessel



Steam Generator

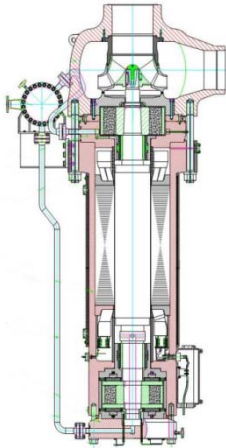


Squib Valve



MANUFACTURE OF KEY EQUIPMENT

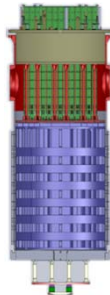
canned RCP



RUV RCP

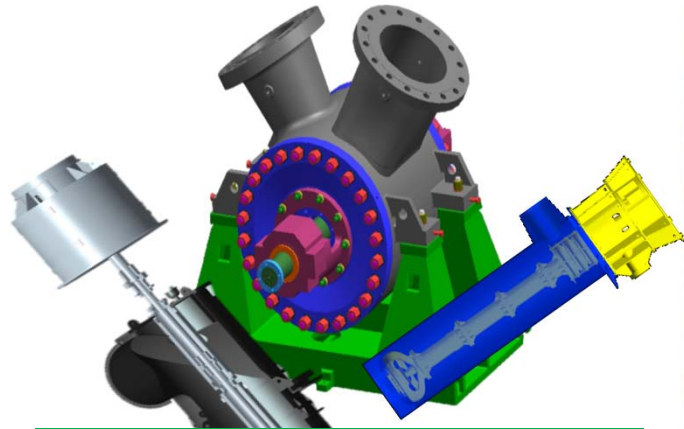


Reactor Internal



Main Pipe Forging

MANUFACTURE OF KEY EQUIPMENT



Feedwater pump,
Condensate water pump
Essential water pump



Turbine

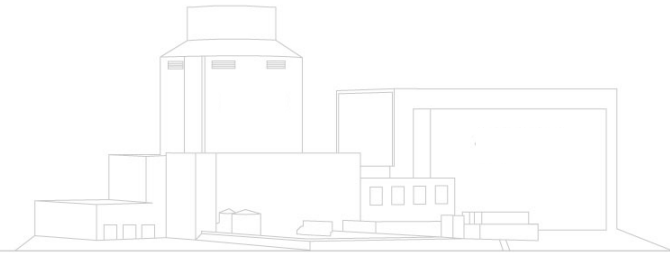


I & C



Generator

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Prospect of SNPTC

1. Fundamental R&D for nuclear power

- Key materials, I&C, Advanced fuel design, etc.
- Verification and Validation platforms for advanced NP technology innovation

2. Software development

Taking COSINE software as the leading products, to establish a nuclear power software system which covers nuclear power plant lifetime.

3. New NPP design

- CAP1000 and CAP1400 standard design
- CAP1700 development
- Gen 4 NP technology development, including MSR, TWR, Fast Reactor, HTGCR,



Prospect of SNPTC

4. Engineering Management

Based on the experience from AP1000, CAP1400 Projects, to establish systematic, high efficient and advanced Passive NPP engineering management system.

5. Lifetime Service

- Full capability to serve all lifetime of the NPPs
- Key supplier of resolution for NPP complex issues

6. Supplier System

A complete Nuclear Power Qualified Supplier System for whole plant equipment and component of AP/CAP NPPS.



Prospect of SNPTC

International Cooperation

- Closely cooperate with WEC for enhancement of passive NPP technology and for global market.
- Cooperate with the organizations and institutes around the world on R&D of nuclear power technology.
- Establish the platform for international industry to share our experience and knowledge from AP1000 and CAP1400 projects.
- Provide assistance to the newcomer of nuclear power, including training, joint research, etc.
- Actively participate in global nuclear power market, including EPC of NPPs, equipment supply, lifetime service, EQ, technology cooperation, etc



Conclusion

SNPTC has a sound capability for nuclear power technology development and abundant advanced NPP engineering and construction experience. We are looking forward to enhancing international cooperation and to making greater contribution to the nuclear industry.





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