国家核电 SNPTC

Introduction of Nuclear Power Development and Related EQ Activities in China

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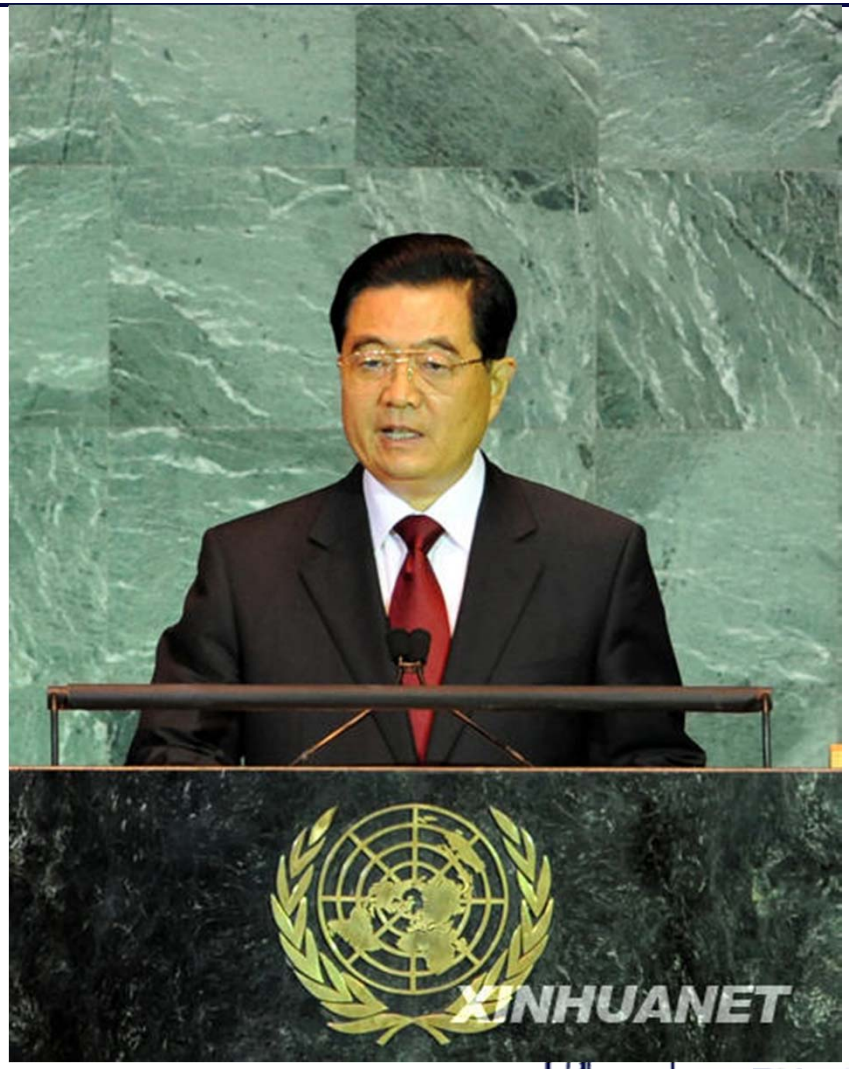
IEEE/IEC Meeting
13-17 June, 2011, Goteborg, Sweden

Contents

- Status of Chinese NPP Development
- Activities of EQ in China
- Conclusions

Status of Chinese NPP Development （1）

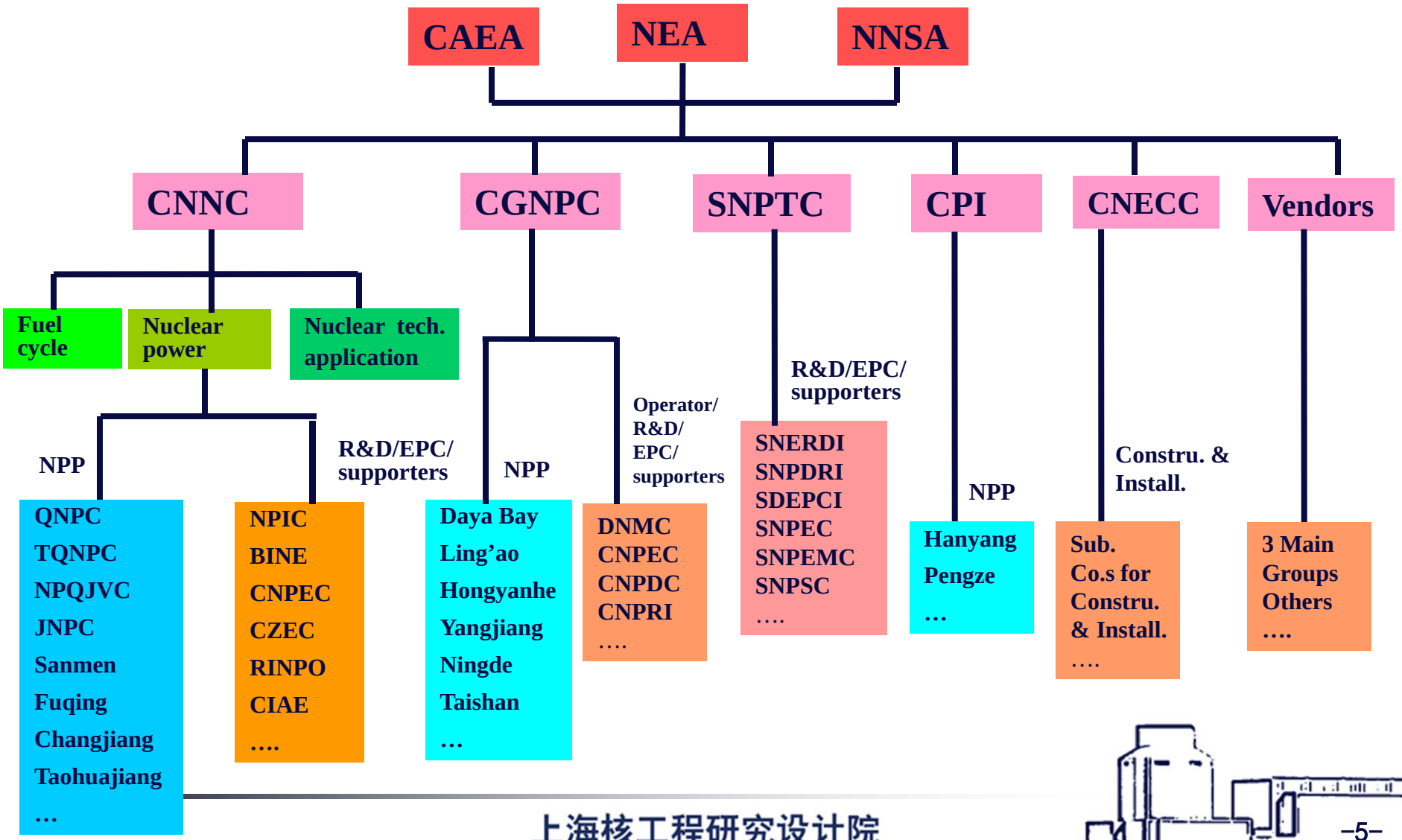
- **Sept. 22, 2009, Chinese President Hu Jintao declared in UN Climate Summit on:**
  - **Develop actively reproducible and nuclear power；**
  - **By the year 2020, the rate of non-fossil energy will reach as high as 15%；**
  - **……**



Status of Chinese NPP Development （2）

- China initiated nuclear power since 1970s
- The first NPP, Qinshan-I, a 300 MWe PWR unit independently designed by SNERDI, started operation in Dec. 1991.
- At present, China has totally 13 units in operation with total capacity about 10,740 MWe, 28 units under construction, many others under planning…
- By the year 2020, the total nuclear power capacity will reach to at least 75,000 MWe with another 45,000 MWe capacity under construction. It means more new units will be completed within this decade…
- Great potential need and challenge on ageing management and PLiM for Chinese NPPs in the future.
  - 2020 second largest nuclear power capacity in the world (more than 80 units)
  - 2030 largest nuclear power capacity in the world (more than 200 units)

Status of Chinese NPP development (3)



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List of Operational NPPs in China

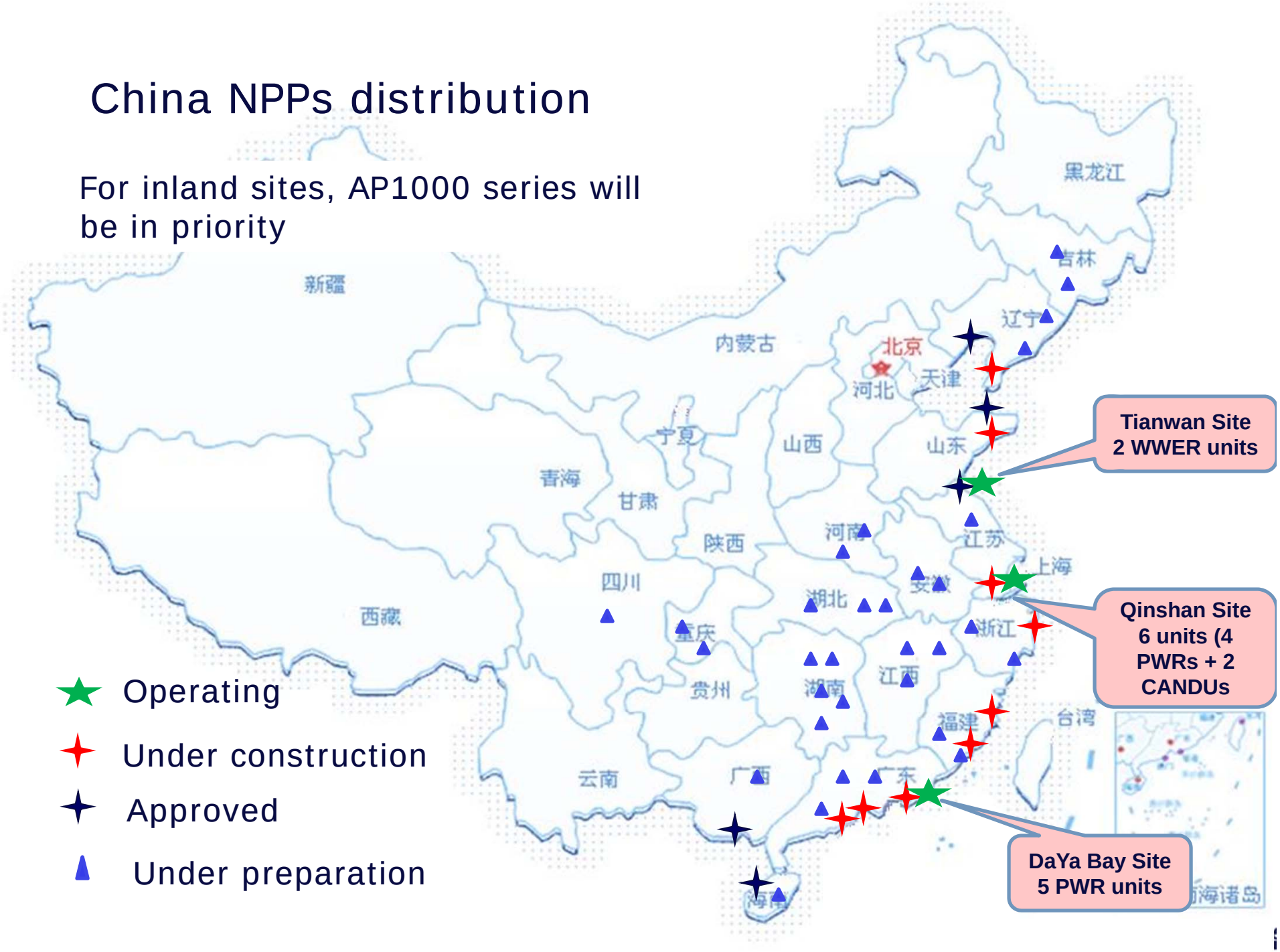
NPP Name		Owner	Type	Nominal Power (MWe)	Construction Start Date	Date of First Connection to the Grid
Qinshan NPP (single unit)		CNNC	PWR	310	1985-03-21	1991-12-15
Daya Bay NPP	Unit1	CGNPC	PWR	984	1987-08-07	1993-08-31
	Unit2	CGNPC		984	1988-04-07	1994-02-07
Qinshan Phase II NPP	Unit1	CNNC	PWR	650	1996-06-02	2002-02-06
	Unit2	CNNC		650	1997-04-01	2004-03-11
	Unit3	CNNC		650	2006-03-28	2010-08-01
LingAo NPP	Unit1	CGNPC	PWR	990	1997-05-15	2002-02-26
	Unit2	CGNPC		990	1997-11-28	2002-09-14
	Unit3	CGNPC		990	2005-12-15	2010-07-15
Qinshan Phase III NPP	Unit1	CNNC	CANDU	720	1998-06-08	2002-11-19
	Unit2	CNNC		720	1998-09-25	2003-06-12
Tianwan NPP	Unit1	CNNC	WWER	1060	1999-09-20	2006-05-12
	Unit2	CNNC		1060	2000-09-20	2007-05-14

List of NPPs under construction

Nmae	Onwer	Type	Power（MWe）	Date of FCD	Date of to grid (1st unit)
LinAo-II	CGNPC	CPR1000	1080×2	2005-12	2010-07
Qinshan-II (ext)	CNNC	CNP600	650×2	2006-04	2010-08
Hongyanhe	CGNPC/CPI	CPR1000	1080×4	2007-04	2012-03
Ningde	CGNPC	CPR 1000	1080×4	2008-02	2012-12
Fuqing	CNNC	CNP1000	1080×（2+ 4）	2008-11	2013-07
Fangjiashan	CNNC	CNP1000	1080×2	2008-12	2013-10
Yangjiang	CGNPC	CPR1000	1080×6	2008-12	2013-10
Sanmen	CNNC	AP1000	1250×2	2009-04	2013-10
Haiyang	CPI	AP1000	1250×2	2009-09	2014-04
Taishan	CGNPC	EPR	1750×2	2009-10	2013-12
Total			2980 / 28 + 4		

China NPPs distribution

For inland sites, AP1000 series will be in priority



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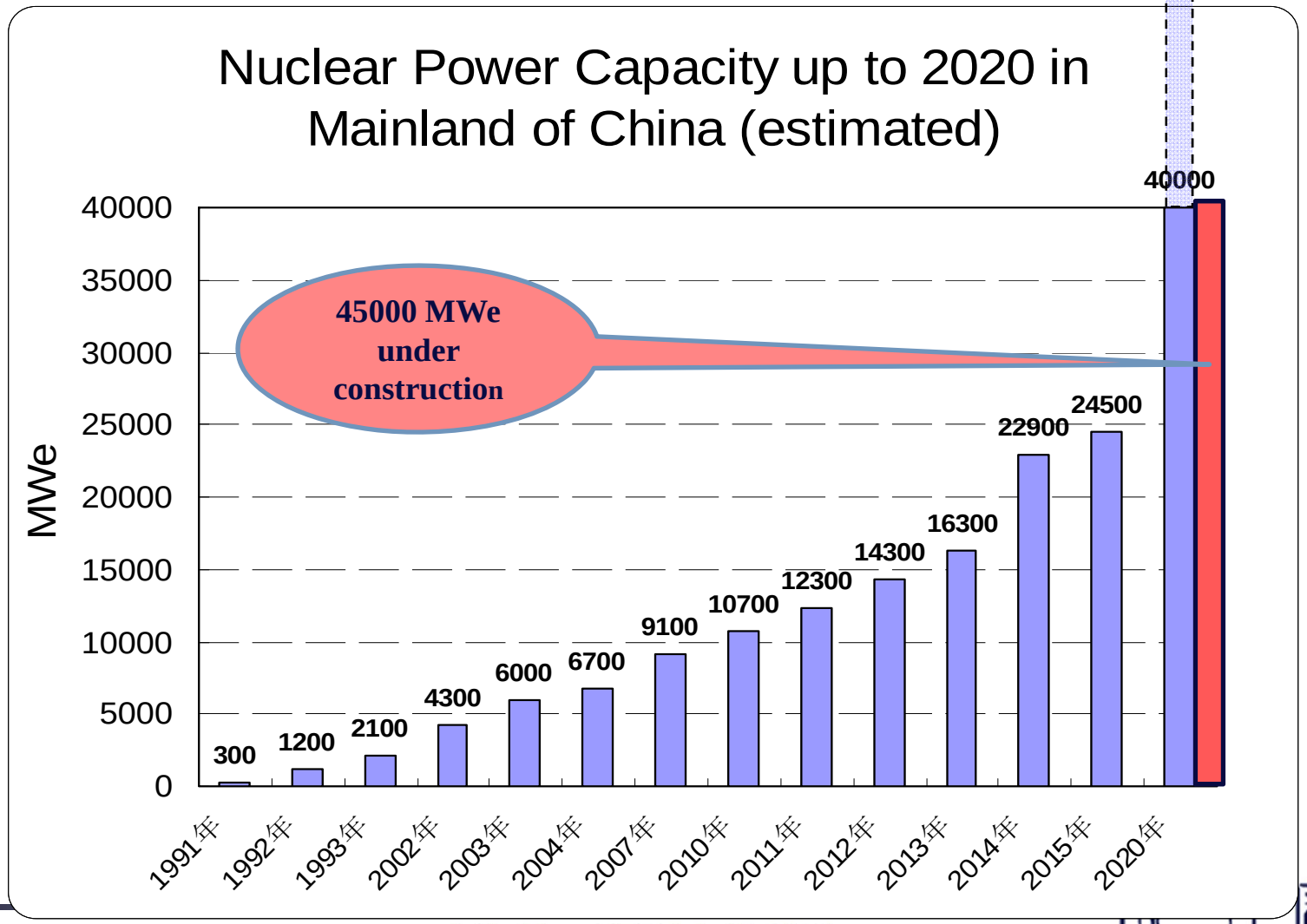
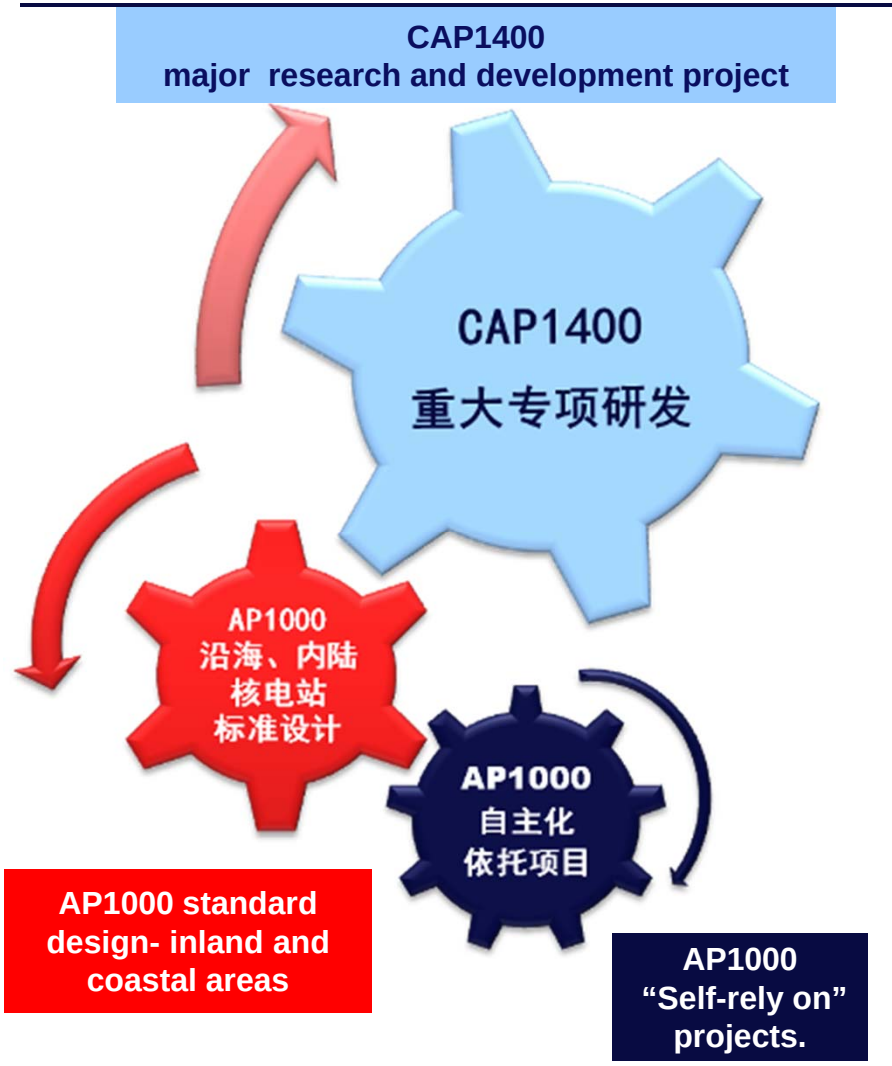
75,000 ?



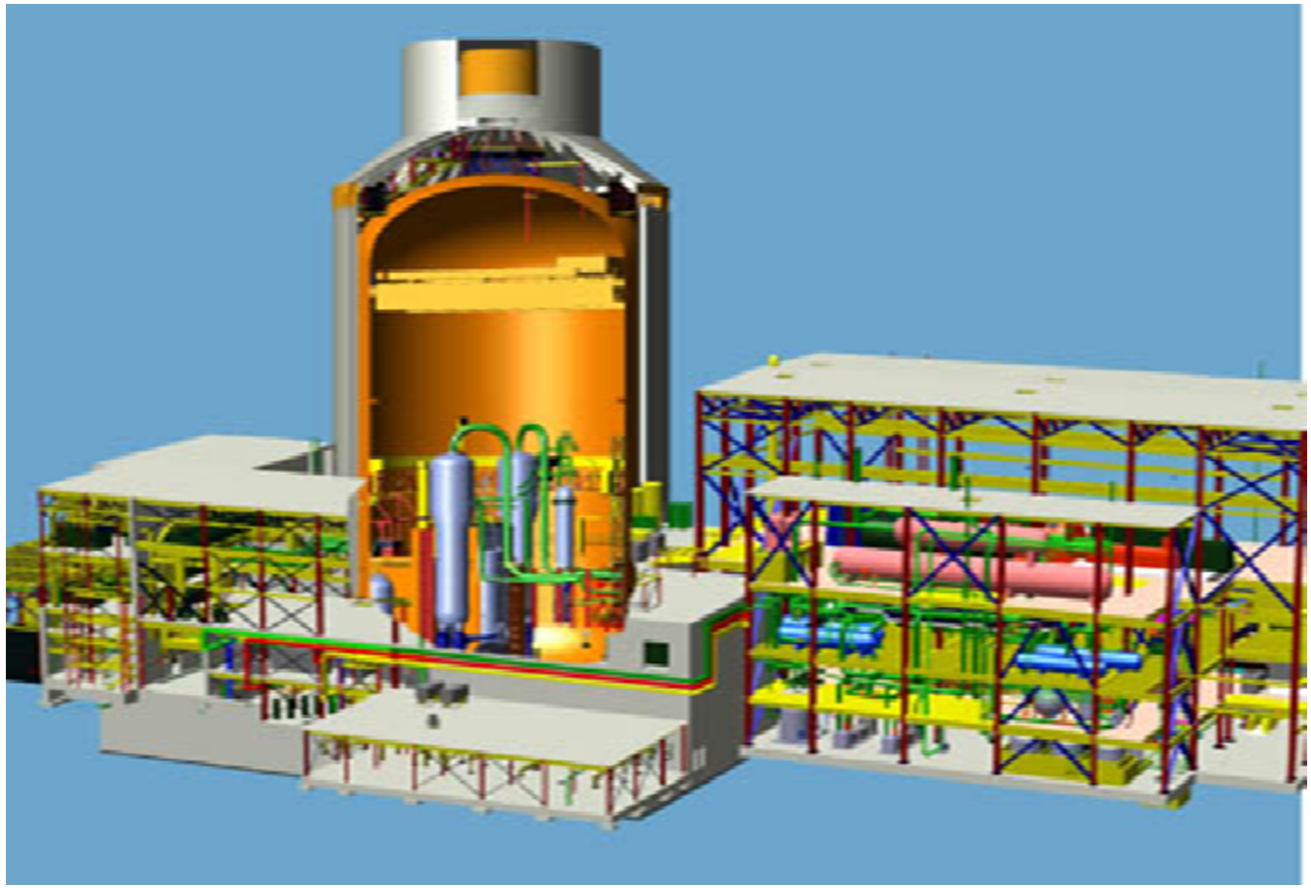
“Three-step” strategy for localization of AP1000 series



- Step 1: WEC consortium gives priority to , we fully participate in – self reliance projects
- Step 2: Domestic companies give priority to, WEC consortium provides technical support
- Step 3: fully independent innovation

Why AP1000 ?

- Simplicity
- Safety
- Maturity
- Cost benefit



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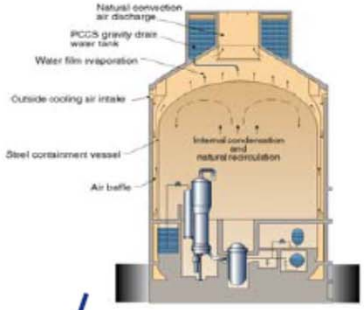
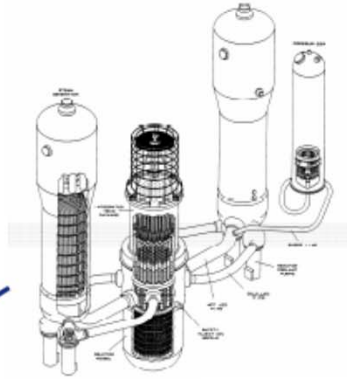
Why AP1000?

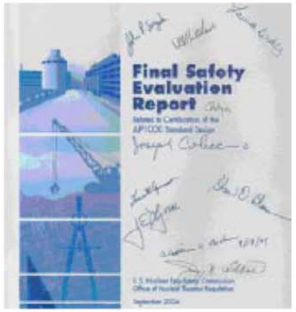
Extensive Testing of Passive Safety Systems

Simplified Passive Safety Systems

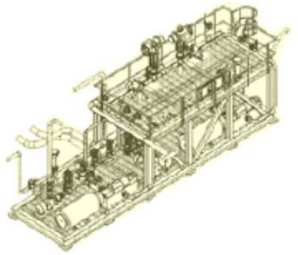




Proven Advanced Design Features

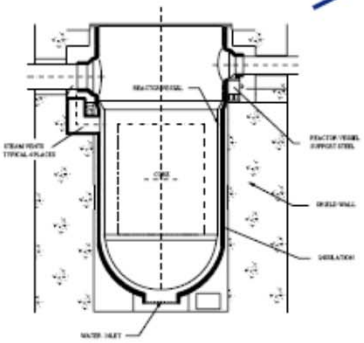


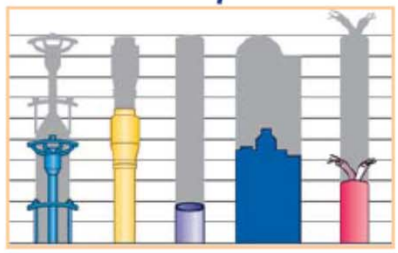
US Licensing Approval



Modular Construction

PRA and Severe Accident Mitigation Features





Reduced Components and Commodities

Short Engineering and Construction Schedule

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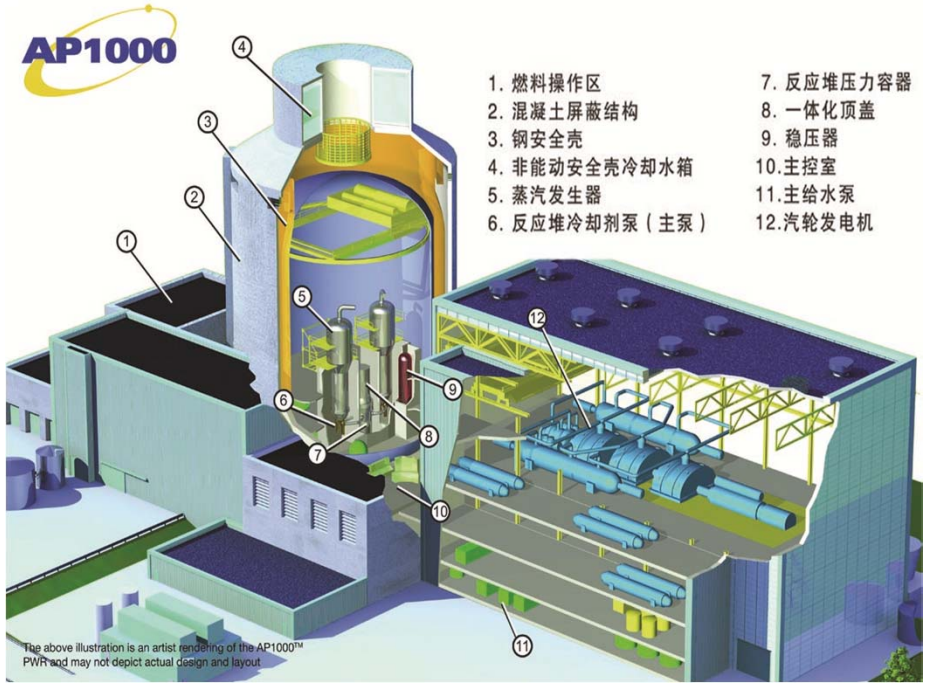
Why AP1000 ?

1. Main features of AP1000：

- Passive safety systems to improve safety performance
- Simplified design comparing with traditional NPPs
- Modularization in design and construction, significantly shortening the period of construction

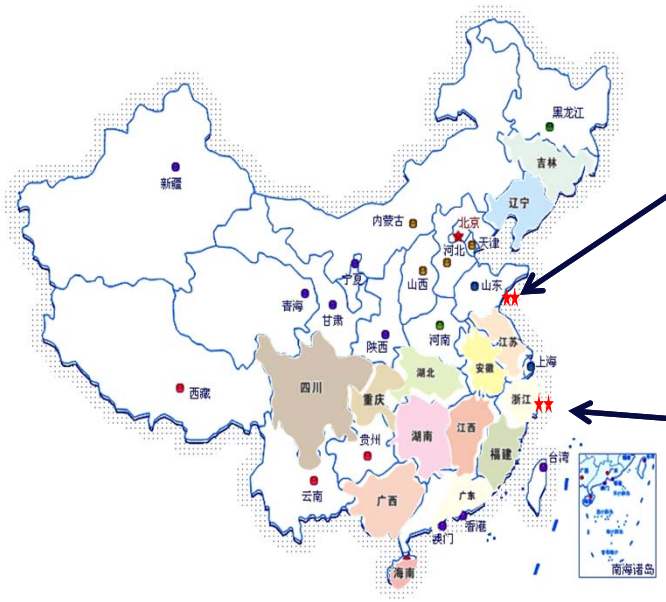
- Main improvements in safety features

- Independent to emergent AC
- Independent to operators
- Non active components
- Containment integrity being ensured under DBA
- IVR consideration
- Sufficient safety margin
- Defense in-depth



Progress of AP1000

- AP1000 Projects in China
  - Sanmen Site: 2 AP1000 units as phase 1,
  - Haiyang Site: 2 AP1000 units as phase 1



Progress of AP1000

- Main participants of AP1000 projects (first 4 units)

Main participants	Sanmen site	Haiyang Site
Utilities	Sanmen NPP	Haiyang NPP
WEC Consortium	NI Engineering + Supplier for A1 Equipment + Technical Responsibility for NI	
SNERDI	Overall design + Technical support + Engineering for BOP	
SNPEC (incl. JPMO)	Project Management for NI + Supplier of non A1 equipment	
MHI	Engineering for thermal systems of CI + Layout + Supplier of main equipment of CI	Supplier of main equipment of CI
ECEPDI	Engineering of auxiliary systems and BOP +Layout + Engineering plant building	
SNPDRI		Engineering of CI
CNECC	Construction and installation for NI	

Progress of AP1000

- Milestones of AP1000

里程碑内容 Milestones	三门核电站1号/2号机组 SM NPP1/2# Unit	海阳核电站1号/2号机组 HY NPP1/2# Unit
浇注第一灌混凝土 FCD	2009.03/2010.01	2009.09/2010.07
冷态试验开始 Cold Test	2012.10/2013.08	2013.04/2014.02
热态试验开始 Hot Test	2012.12/2013.10	2013.06/2014.04
开始首次装料 First Fuel Loading	2013.05/2014.03	2013.11/2014.09
首次临界 First Criticality	2013.07/2014.05	2014.01/2014.11
首次并网 First Connection to Grid	2013.08/2014.06	2014.02/2014.12
性能试验结束 Completion of Performance Tests	2013.11/2014.09	2014.05/2015.03

Progress of AP1000

- Localization of main components

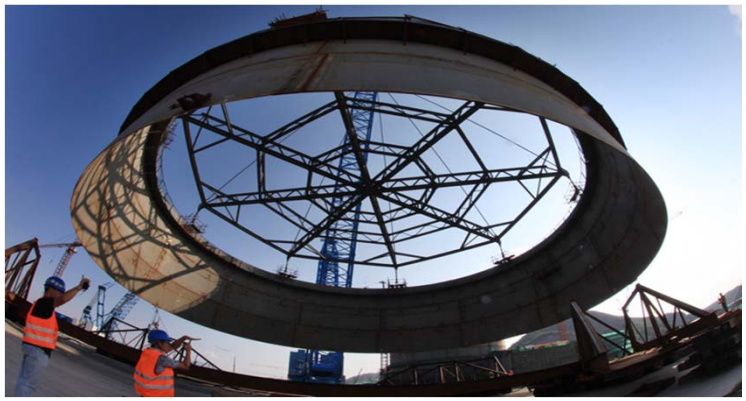
Main Components	Sanmen 1#	Haiyang 1#	Sanmen 2#	Haiyang 2#
RCP	WEC	WEC	WEC	WEC/CHN
Squib valve	WEC	WEC	WEC	WEC/CHN
RPV	WEC	WEC	CHN	CHN
SG	WEC	WEC	CHN	CHN
RI	WEC	WEC	CHN	CHN
CRDM	WEC	WEC	CHN	CHN
Refueling Machine	WEC	CHN	CHN	CHN
Steel Containment	WEC	CHN	CHN	CHN
Primary Piping	CHN	CHN	CHN	CHN
Pressurizer	CHN	CHN	CHN	CHN

Progress of AP1000

- 三门1#机组于2009年3月31日成功完成核岛筏基第一罐混凝土浇注。标志着世界首台AP1000核电机组进入主体工程全面建设阶段。2#机组也于2009年12月17日完成FCD。
- 海阳1#机组核岛第一罐混凝土浇注于2009年9月26日顺利完成。2#机组于2010年6月22日完成FCD。

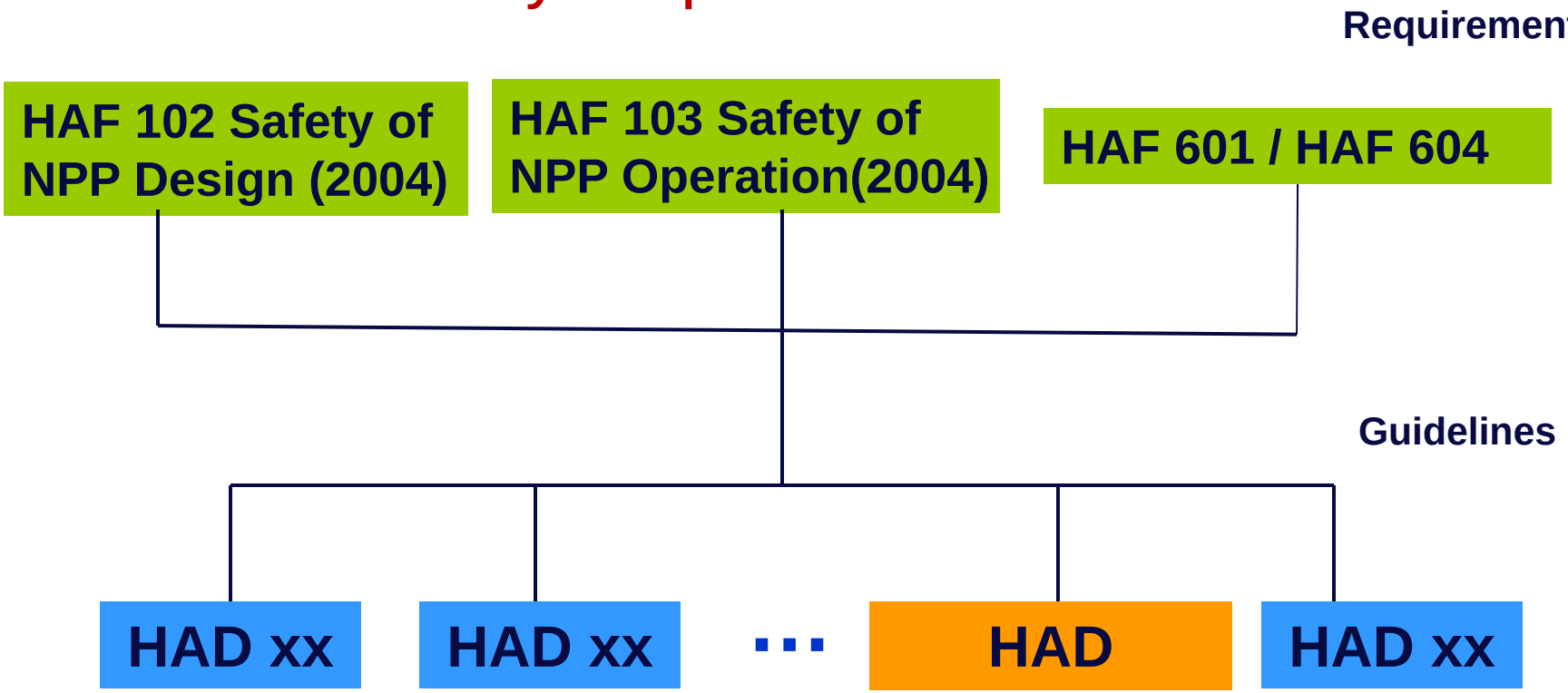
Progress of AP1000

- 三门1号机组反应堆厂房
  - 9月12日 三门核电1号机组钢制安全壳CV筒体第三环吊装就位。



EQ Activities in China

Nuclear safety requirements



EQ Activities in China

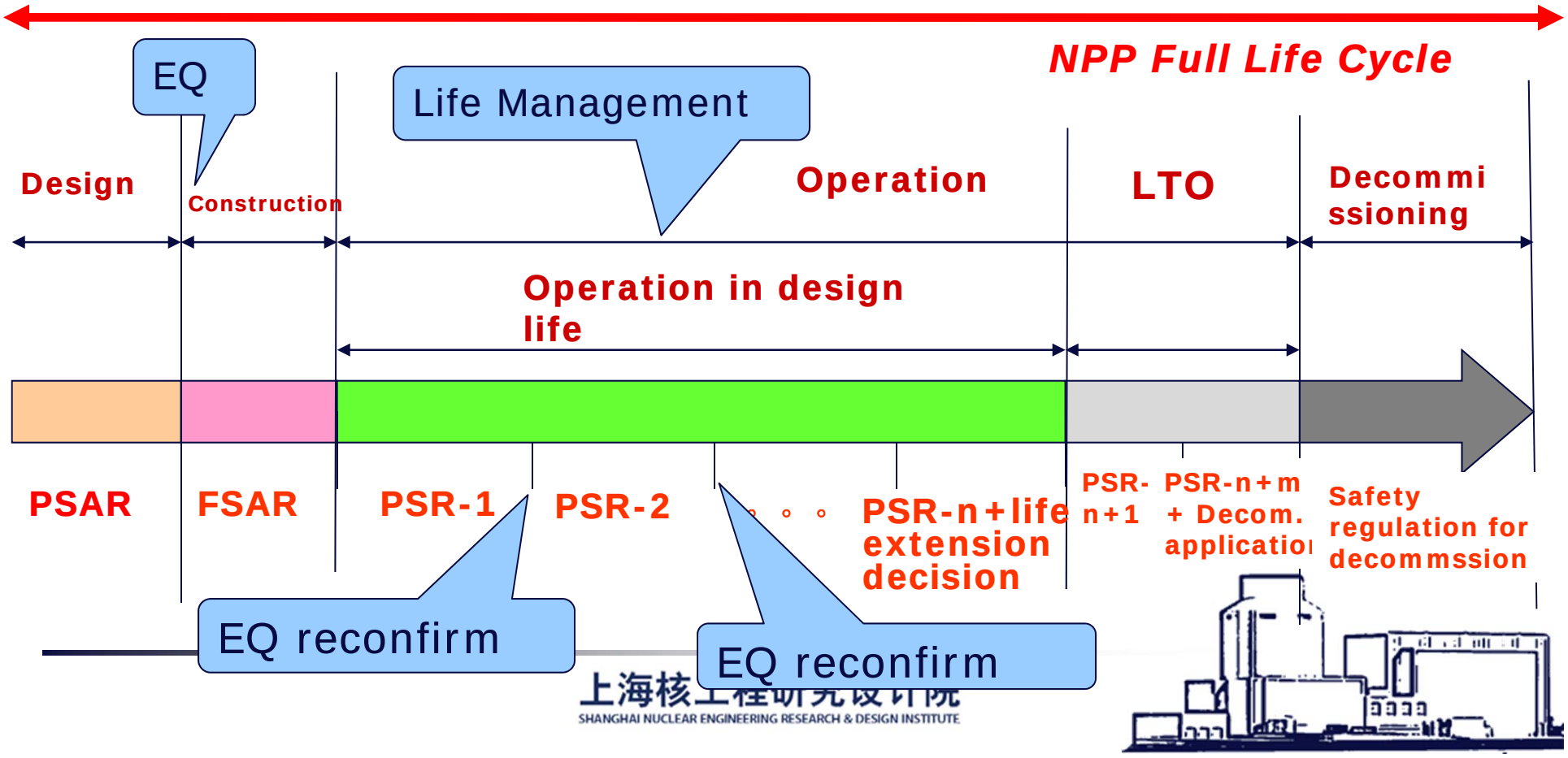
- EQ is defined as an activity to establish and maintain evidences for demonstrating that safety-related equipment can perform its specified safety functionalities during various normal and expected operating events as well as accident conditions in design life, for example 60 years.

- Only a qualified equipment can be used in nuclear facilities. Equipment without qualification can not be accepted and installed on sites.

- EQ includes environmental qualification (thermal ageing, irradiation, vibration, mechanical wear, EMC, LOCA, etc.) and seismic qualification. EQ is a key element as distinguished nuclear safety equipment from industrial products.

EQ Activities in China

- A concept in IAEA NS-G-2.12 that EQ is a vital activity in full life cycle ageing management for NPPs
- To ensure a equipment performing safety-related functions in a qualified and healthy status from very beginning



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EQ Activities in China

Main standards and guidelines:

- RG1.89: Environment Qualification for Electric Apparatus
- RG1.100: Seismic qualification for Mechanical and electric equipment
- ASME QME-1: EQ for Active Mechanical Equipment
- IEEE-344: Seismic Qualification for Class 1E Equipment
- IEEE-323: Requirements of EQ for Class 1E Equipment
- IEEE 382: EQ for Safety Class Valve Actuators
- HAF-J0053: Guideline of seismic qualification for safety class equipment
- GB 50276: Code for NPP Seismic Design

EQ Activities in China – SNERDI

- **Qinshan Nuclear Power Plant**
  - First NPP in mainland of China
  - Developed independently by domestic design institutes
  - SNERDI is responsible for its overall design and NSSS design
    - Nuclear island
    - Main equipment in NSSS (except the reactor coolant pump)
    - Instrumentation, control and electrical equipments
    - Final safety analysis report (FSAR) was compiled by SNERDI
    - Periodical safety review (PSR)

EQ Activities in China – SNERDI

- **Pakistan Chashma 300MWe NPPs**

➢ The biggest export project of China

➢ Unit 1 and 2 were completed and unit 3&4 are on the construction stage

➢ SNERDI is the overall and nuclear island design institute

➢ Reviewed by the owner and the IAEA experts

➢ PSAR and FSAR have been evaluated by Pakistan National Nuclear Safety Bureau

EQ Activities in China – SNERDI

- **R&D for 300MWe NPP**
  - 546 scientific programs and various tests and researches
  - A lot of calculations and analyses
  - A few of specific software
  - 22 testing circuits

A LOCA Facility ever used for 300MWe design in SNERDI

EQ Activities in China – AP1000

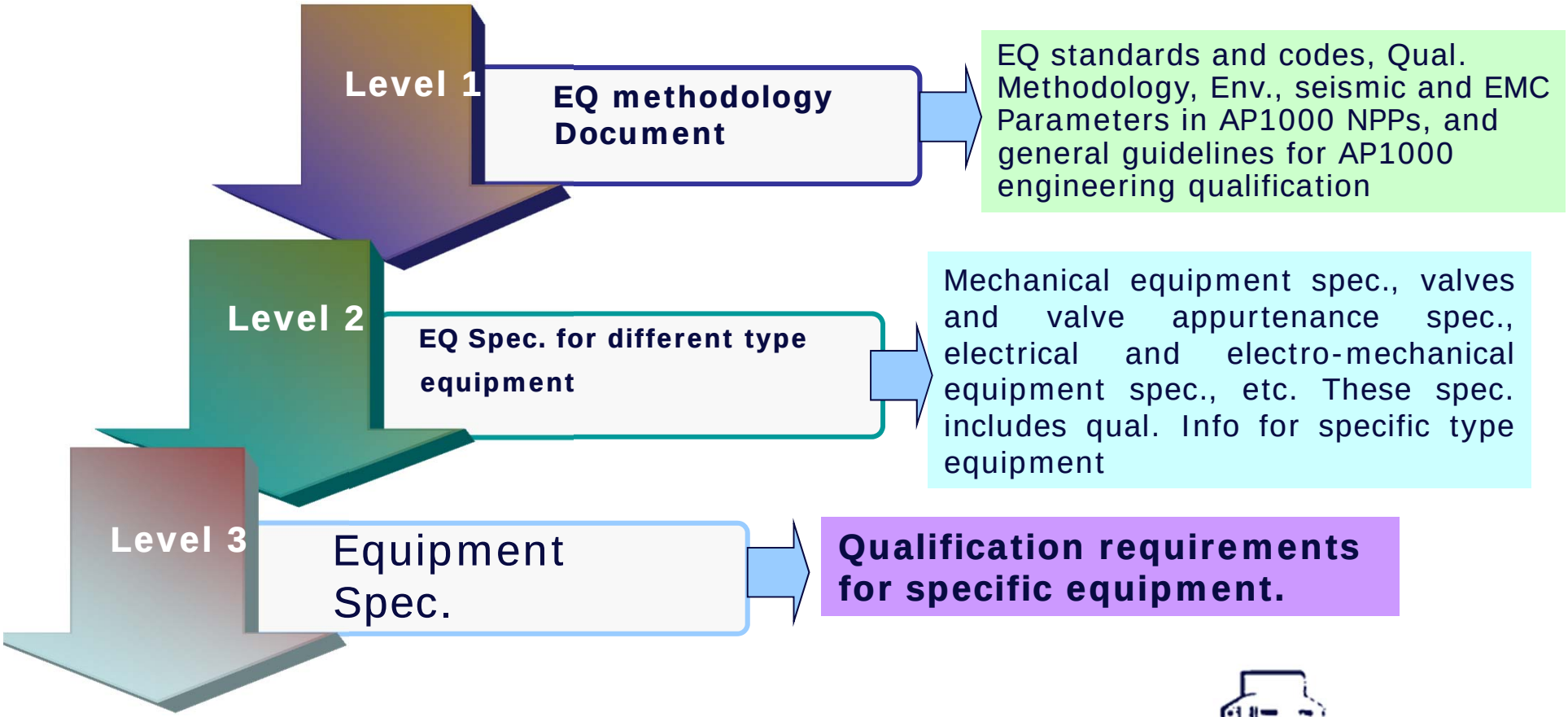
Introduction

For AP1000 NPPs, Westinghouse (WEC) develops related documents to address criteria, acceptable methodology and procedures for environmental, seismic and EMC qualification of safety-related equipment.

These requirements are used for electrical equipment, mechanical and electro-mechanical equipment, valves and valve appurtenances, I&C systems, cables, penetrations, connectors and field sensors, which are located in harsh and non-harsh environment inside and outside containment.

EQ Activities in China – SNERDI

Three levels of AP1000 EQ documents



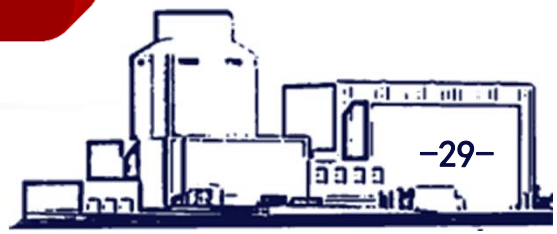
EQ Activities in China – SNERDI

Difficulties in Env. and seismic qual. requirements for AP1000 EQ

1.The frequency range in seismic qual. is up to 100Hz, which in existing standard is generally up to 50Hz.

2. Required Input Motion (RIM) acceleration is 6.0g, instead of existing 4g or 4.5g.

◆3. The initial temperature increase in LOCA test is very steep, reaching 138℃ within 1 second.



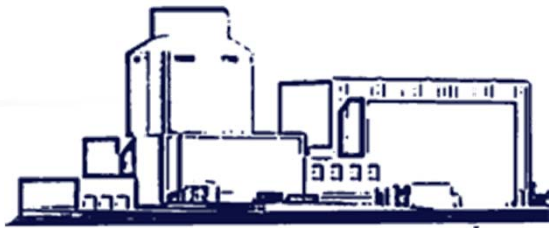
EQ Activities in China – SNERDI

- SNERDI is subcontracted by WEC for MCR components EQ in China, supported by CITIIAS in Shanghai with EMC test and NPIC in Chengdu with environmental and seismic qualifications.

- SNERDI is taking full responsibility for the Work package, compiling Test Plans, reviewing Test Procedures and Test Reports, overseeing qualification tests, performing seismic FEM analyses (Spectrum and time history), forming EQDP

- SIPAI is performing EMC test, preparing EMC Test Procedure and Test report

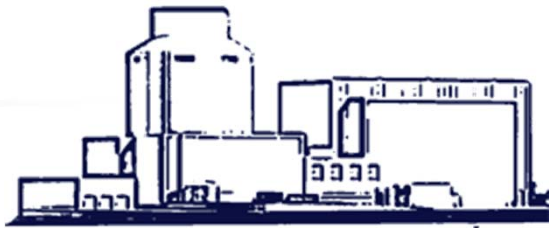
- NPIC is performing environmental and seismic tests, preparing Test Procedures and Test Reports



EQ Activities in China – SNERDI

EQ Related Activities in SNERDI

- Set up EQ technical system
- Promote EQ platform construction
- EQ technical requirements investigation
- EQ methodology research
- EQ technology incorporation



EQ Activities in China – Summary

- Dozens of years' sustaining practices has built SNERDI the competent role of performing EQ satisfying existing international philosophies, and has organically assembled a collaborating EQ team as well, which in whole, actually, constitutes the dominant culture of EQ in China.

- The technical requirements on Equipment Qualification for AP1000 are considerably enhanced comparing to those for existing nuclear power units, which brings forward new challenges to domestic equipment qualification capability. It should be given sufficient awareness on EQ importance and its acceleration influence on equipment localization during the process of Supporting Project construction and Gen. III Nuclear Power Localization.

EQ Activities in China – Summary

- Establish and improve AP1000 EQ technical system via digestion, absorption and in-depth study on AP1000 EQ technical documents, implementation of equipment qualification work of Supporting Project, and existing EQ experience based on engineering practice. On this basis, establish long-term strategic cooperative partnership with qualified domestic institutions and universities so as to form AP1000 EQ technical system and corresponding operating mechanism.

EQ Activities in China – Summary

- After Fukushima accident, more strict requirements are implemented by related parties. March 16, 2011, State Council put forward 4 measures based on lessons learned from Fukushima:
- To carry out immediately comprehensive special safety inspection to all nuclear power facilities
- To enhance safety management to all operational NPPs
- To comprehensively review all NPPs under construction in reference with the latest and most advanced C&S
- To strictly control the approval for new NPP projects and the approval procedure for new NPPs will be suspended until the approval of Nuclear Safety Planning which is now under compilation

Conclusions

- **In the past 40 years, China has accumulated much experience on nuclear safety issues including EQ**
- **China has an ambitious plan to develop NPPs based on strict nuclear safety requirements and related C&Ss**
- **For AP1000, which will be the main NPP type in China in future, EQ is a big challenge.**
- **In spite of Fukushima accident, China will continue to develop NPP but in more careful way and under more strict supervision.**

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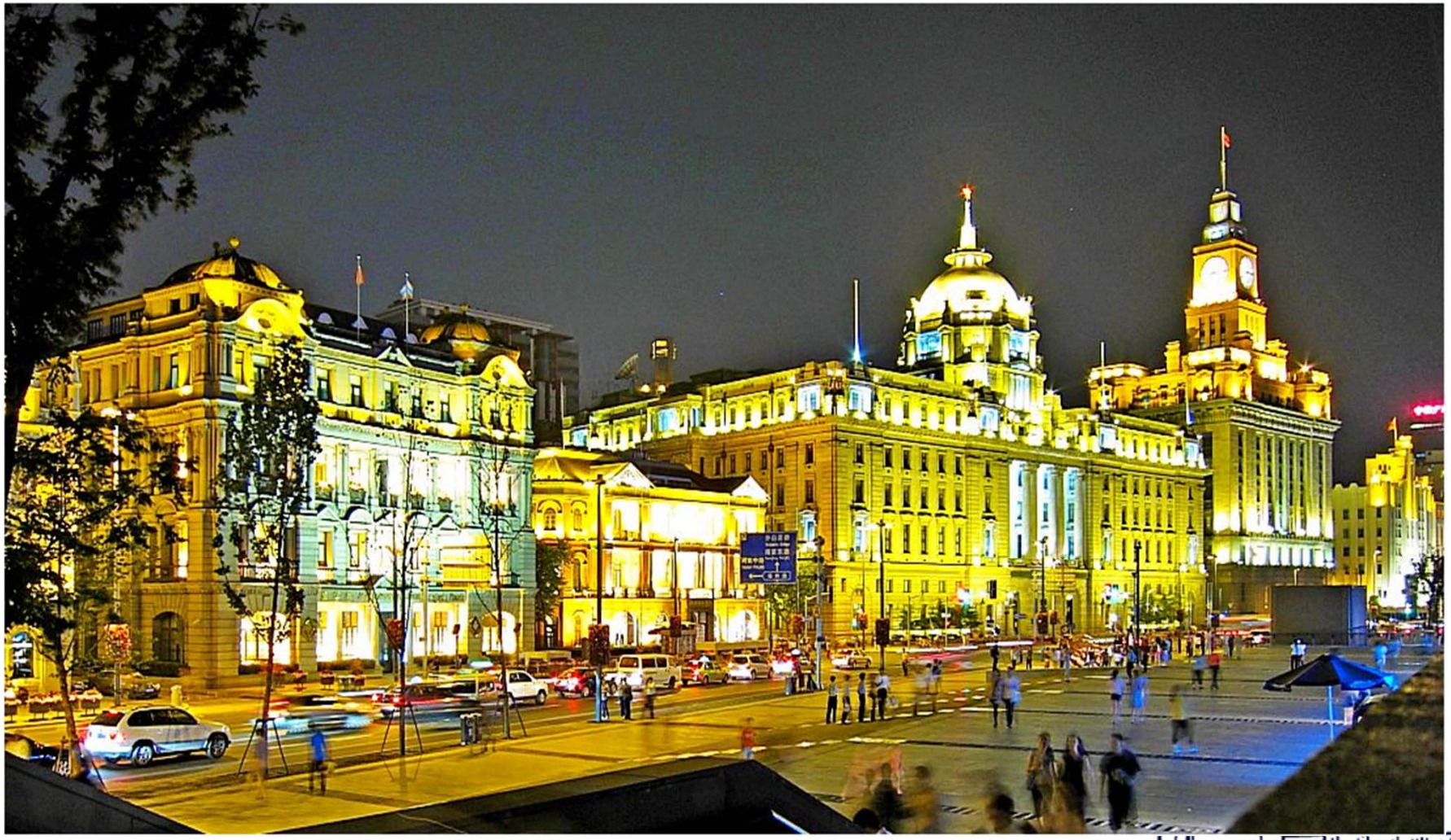

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Thanks !
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