

中国の核電設計院への福島原発事故の説明と意見交換 報告

2011年7月5日

日中科学技術交流協会 永崎隆雄

日本国の東日本大震災と津波により、福島県の東京電力福島第一原子力発電所が全電源喪失状態に陥り、炉心溶融の大事故を起こし、世界の国々に多大の影響を与えた。

この事故の経験を世界の原子力安全の向上に役立てねばならないと考え、**日本国政府が出した**関連する事故情報と対策を中国の原子力発電設計エンジニア機関に提供し、意見交換を行った。

中国側から、多大の関心を集め、時期に合った我々の訪問に多大の感謝を受け、活発な質疑がなされ、今後の交流の活発化が求められた。

この事故の影響で中国国民の原子力発電への不安が増長しており、福島1の早期の安定停止と下記のような重大事故時でも動く安全性と信頼性の高い設備が求められている。

電源がなくても作動

津波対策：設置場所の高度化、防水水密化

高放射線下で動く：ロボット化、遠隔操作化

又、この事故で、中国の原子力発電所の安全点検がなされており、現在、運転中の14基は検査を終了した。建設中の原子力発電所について7月1日より検査が始まる予定で、8月末に結論が出る予定である。又申請中の28箇所は申請を中止している。

中国の安全規画（計画）の発布はこれらの目途が立ってからであり、さらに新しい原子力発電中長期計画は安全規画（計画）の発布後になる。

中国への影響で一番大きいのは安全性の強化による原子力発電の建設コスト上昇である。

今後の対策は、安全性と経済性と環境友好性の同時成立が求められている。

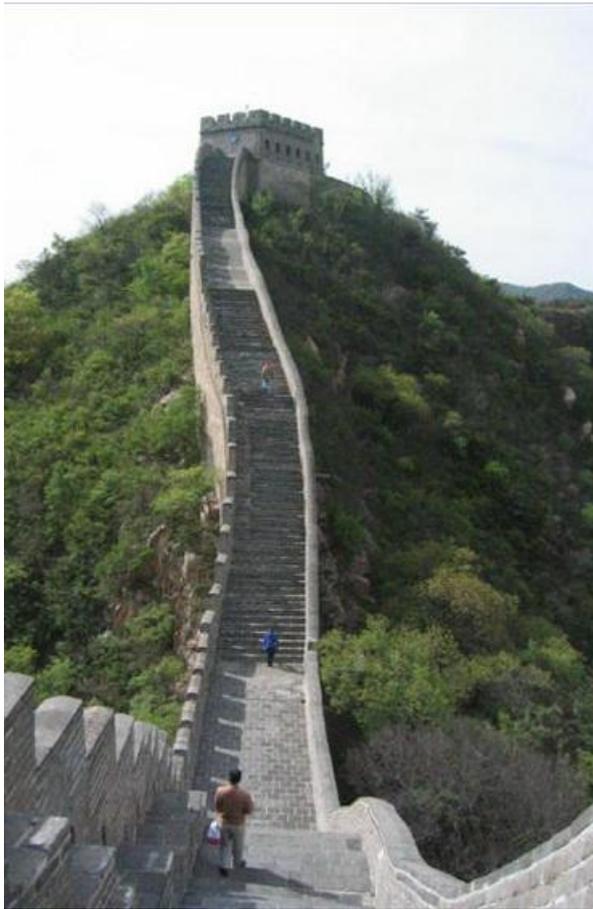
訪問日程と訪問先

6月27日	中広核工程有限公司	CNPEC	深セン市大亜湾原子力発電基地内
6月28日	中国核動力研究設計院	NPIC	四川省成都市
6月29日	中国核電工程有限公司	CNPE	北京市
6月30日	中国原子能科学研究院	CIAE	北京市
	中国核能行業協會	CNEA	北京市
7月1日	上海核工程研究設計院	SNERDI	上海市

訪問者

日中科学技術交流協会 事務局長 永崎隆雄 他4名

1. 中国側資料

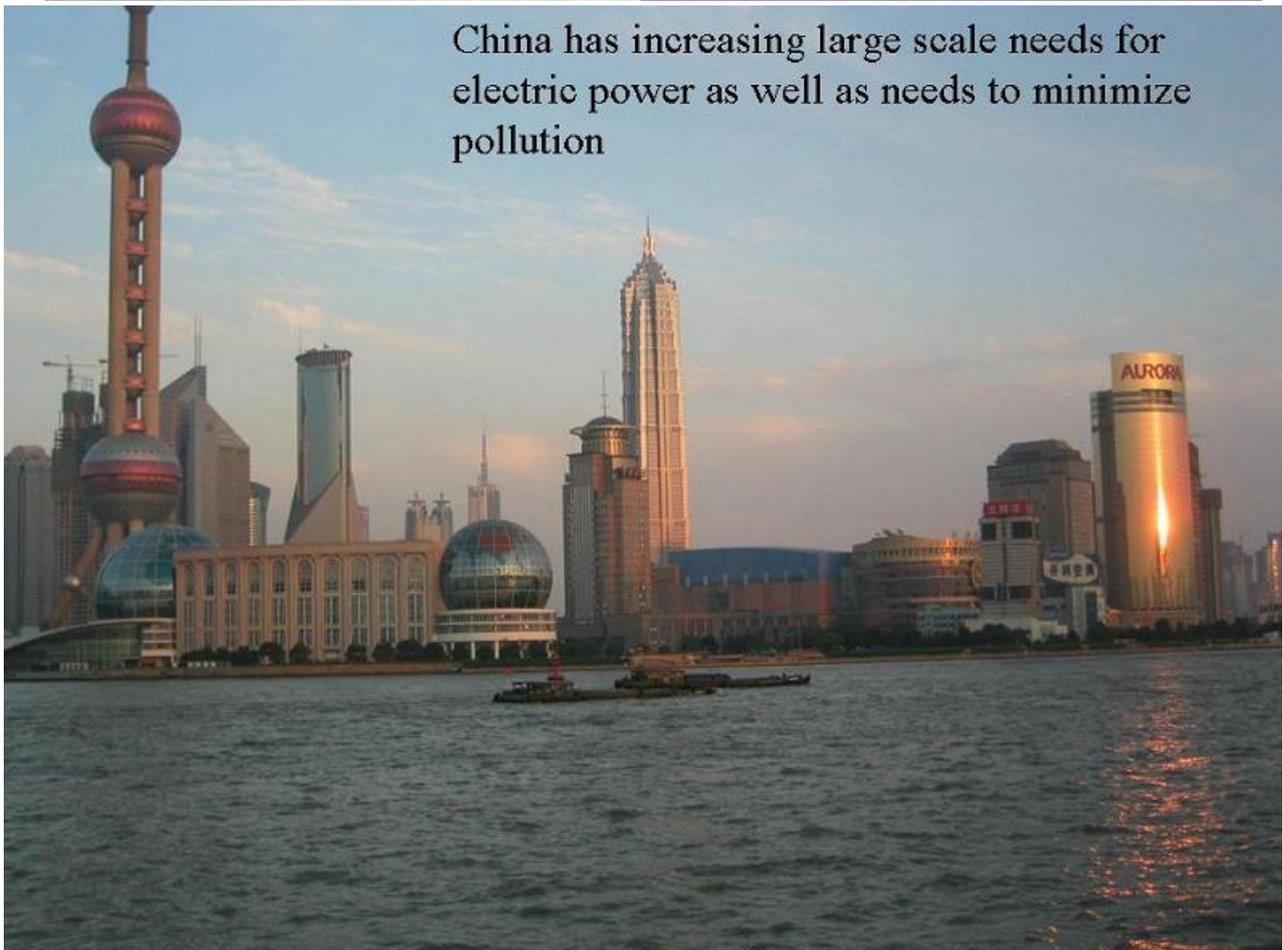


Nuclear Power in Mainland
and
Nuclear Power
Institute of China (NPIC)

Xiong Ru,
Senior Engineer, NPIC

at NPIC in Chengdu

May. 2011

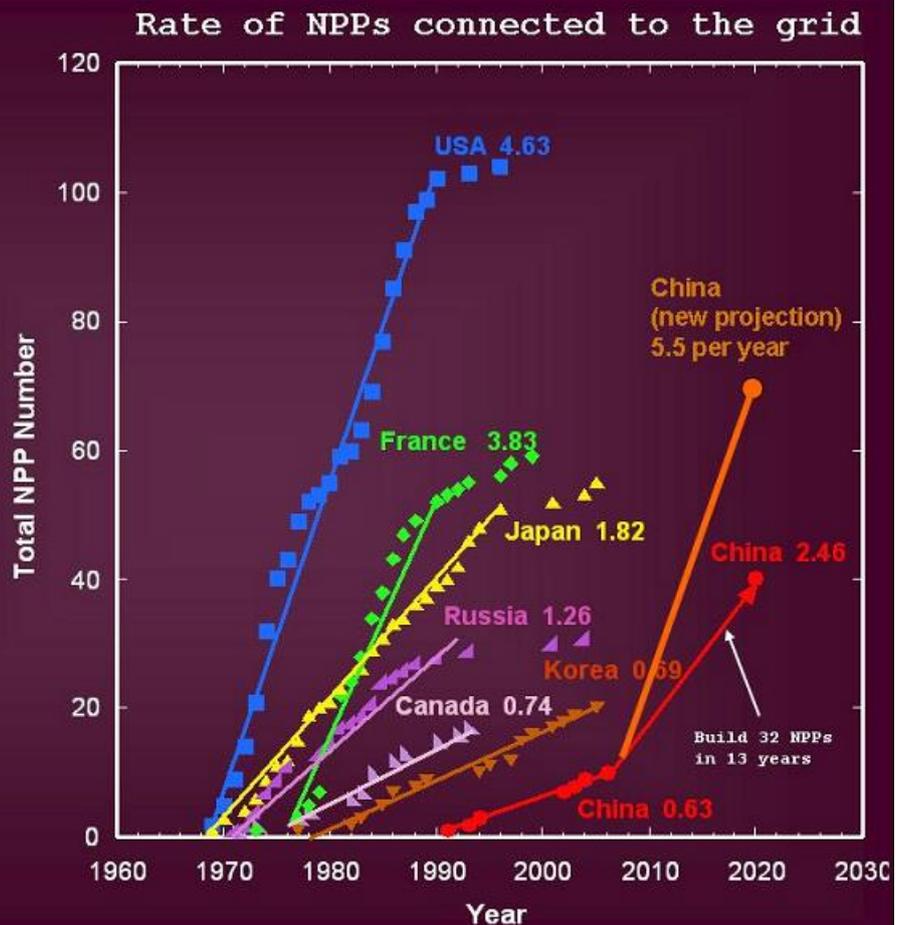


China has increasing large scale needs for
electric power as well as needs to minimize
pollution

China intends to build at least 70,000 MWe by 2020

Planned rate of constructing new NPPs in China compared with past rates in other countries

Straight lines drawn through best initial linear fit-- the maximum persistent rate of construction



Operating Nuclear Power Plants in China

NPP Name	Unit No.	Type	Nominal Power (MWe)	Construction Start Date	Date of First Connection to the Grid
Qinshan NPP	CN-1	PWR	310	1985-03-21	1991-12-15
Daya Bay NPP	Unit1	CN-2	984	1987-08-07	1993-08-31
	Unit2	CN-3		1988-04-07	1994-02-07
Qinshan Phase II NPP	Unit1	CN-4	650	1996-06-02	2002-02-06
	Unit2	CN-5		1997-04-01	2004-03-11
LingAo NPP	Unit1	CN-6	990	1997-05-15	2002-02-26
	Unit2	CN-7		1997-11-28	2002-09-14
Qinshan Phase III NPP	Unit1	CN-8	720	1998-06-08	2002-11-19
	Unit2	CN-9		1998-09-25	2003-06-12
Tianwan NPP	Unit1	CN-10	1060	1999-09-20	2006-05-12
	Unit2	CN-11		2000-09-20	-
Qinshan Phase II Extension NPP		PWR	2×650	2005-12-15 (Unit1)	-
LingAo Phase II NPP		PWR	2×1000	2006-04-28(Unit1)	-

The image shows a map of China with red markers indicating the locations of nuclear power plants. Three callout bubbles identify specific sites: Tianwan (2R), Qinshan (5R), and Daya Bay (4R). To the right of the map are three photographs of nuclear power plants, each with a corresponding callout bubble. The top photo is Tianwan (2R), the middle is Qinshan (5R), and the bottom is Daya Bay (4R). In the bottom right corner, there is a small image of a traditional Chinese bronze mask.

The three sites for Chinese NPP, 13

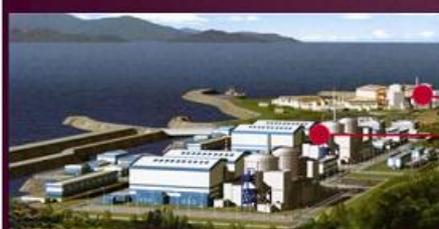
Locations of mature imported nuclear technology



Tianwan PWR (VVER) 2x1060MWe, turnkey plant imported from Russia. Located in Jiangsu Province.



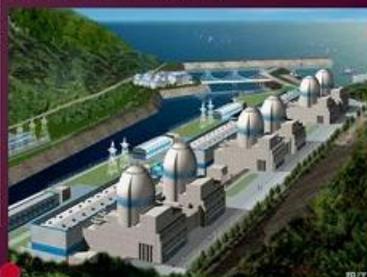
Qinshan phase III CANDU HWR type 2x728MWe. Imported from Canada, BECL. Located in Zhejiang Province.



Daya Bay and Lingao 4x984/990MWe units. Turnkey. Imported from France, Areva. Final Lingao II is Chinese. Located in Guangdong Province.

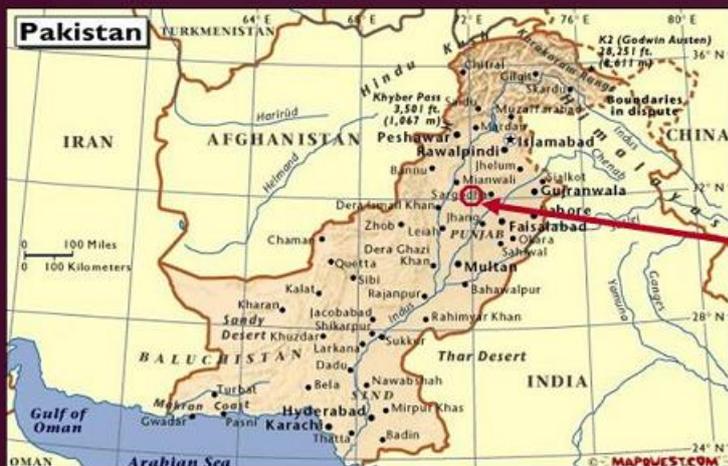


Sanmen site. 2x1000/1500MWe US Westinghouse advanced plants. Located in Zhejiang Province.



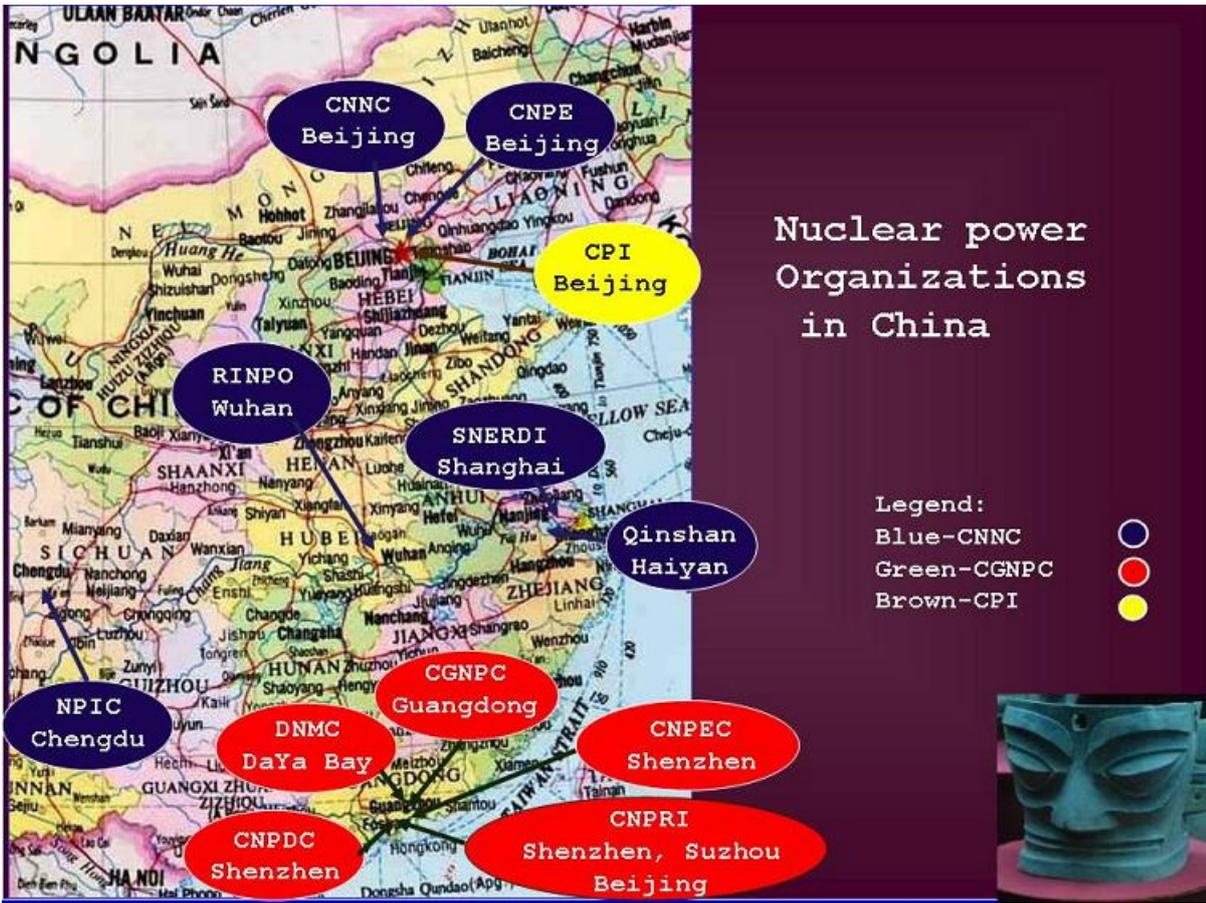
Yangjiang site 2x1000/1500MWe US Westinghouse advanced plants. Located in Guangdong Province.

China exports PWR plant to Pakistan



Chashma, site of CHASNUPP-1,2
First Chinese exports of nuclear reactors.

- Two loop PWR.
- 300 MWe.
- First power to grid: June 2000, now in 3rd cycle.
- CHASNUPP-3,4: in process



Nuclear Power Institute of China

中国核动力研究设计院



NPIC - *Nuclear Power Institute of China*

- large-scale nuclear power research institute
- largest comprehensive base in China for nuclear reactor engineering design, research, testing, operation and small batch production.



1965,
contribution

*"Cradle of China's
Nuclear Power Engineering"*

4 milestones

1970: 1st Pressurized Water Reactor (PWR) of China

1980: 1st High Flux Engineering Test Reactor (HFETR) of China

1990: 1st Pulsed Reactor (PR) of China with U-ZrHAl fuel

2002: Qinshan Phase-II, NSSS Design and Related Engineering Tests , 600MW



1970: 1st Pressurized Water Reactor (PWR) of China, 30 MWe

Qinshan NPP Phase-II

Chinese designed and built plant



- Connect to grid 2002
- 600MWe
- NPIC designed NSSS
- NPIC conducted all supporting engineering tests



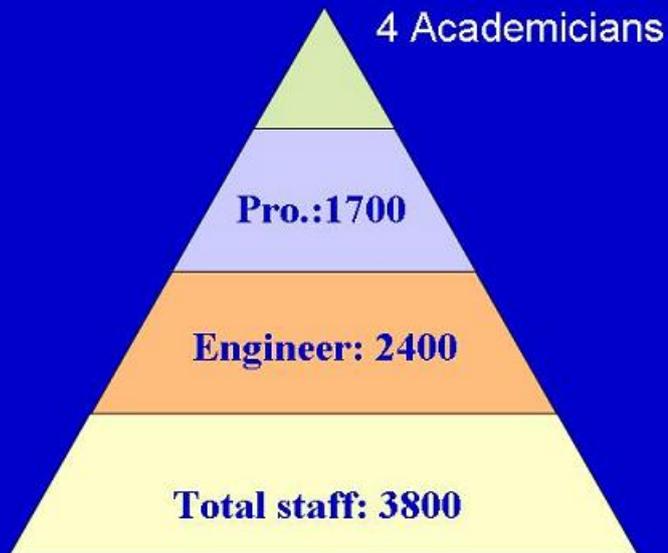
Qinshan NPP Phase II (600MW×2) demonstrated that China was capable of designing and constructing large NPP.

NPIC is now in charge of: engineering design and technical support for all the Domestic Advanced Generation II Nuclear Plants in China, focus on Nuclear Island:

Qinshan Phase II,
Ling'ao Phase II,
Hongyanhe NPP
Fuqing NPP
Fangjiashan, NPP
Ningde, NPP
Yangjiang, NPP



Staffing and organization at NPIC



CNNC
(China National Nuclear Corporation)



NPIC

Administration Divisions

Nuclear Power Design Sub-institute

Reactor Operation & Application Sub-institute

Reactor Engineering Exp. & Test Sub-institute

Nuclear Fuel & Material Sub-institute

Civil Engineering Design Sub-institute

Information Center

Enterprises Management Division

Technology Support Center

90 laboratories: examples of major fields

核动力工程
Nuclear power general
engineering

核动力装置与系统
Nuclear power installation
and system

反应堆运行
Reactor operation

屏蔽
Shielding

反应堆结构
Reactor structure

反应堆安全
Reactor safety

核燃料和元件
Nuclear fuel and
element

物理 Physics

控制与仪表
I & C

废物处置
Waste treatment

水化学
Water chemistry

热工水力
Thermal hydraulics

无损探伤
Non-destructive
inspection

辐照与环境保护
Radiation and
environment
protection

力学
Mechanics

计算机与民用工程
Computer and civil
engineering, etc.

1. Nuclear Fuel & Materials
2. Nuclear design technogy

- ◇ Corrosion experiments equipment-
dynamic corrosion loops, CERT, autoclaves
- ◇ Microstructure analysis facilities
SEM, TEM, XRD
- ◇ Thermal & physical properties testing equipment
MTS, Fatigue, Creep, Impact, mechanical properties
Thermal conductivity, etc.
- ◇ Materials Processing Equipment
- ◇ Hot cell

1. Nuclear equipment certificate Center
2. Non-destructive testing (NDT) center

国家级重点实验室

核燃料及材料
NATIONAL KEY LABORATORY FOR
NUCLEAR FUEL AND MATERIALS



Large-scale Thermal-hydraulic Test Facility

R and D fields at NPIC

- 反应堆运行和应用 Reactor Operation and Applications
- 反应堆工程 Reactor Engineering
- 材料科学 Material Science
- 核动力工程设计 Nuclear Power Engineering
- 辐照应用技术 Irradiation Applications Technology
- 核装置退役技术 Decommission Technology for Nuclear Facility
- 核电厂运行支持与服务 NPP Operation Support & Service
- 放射性废物的管理技术 Radioactive Waste Management Technology
- 核安全与环境保护 Nuclear Safety and Environment Protection
- 计算科学与工程支持 Advanced Computing Science & Engineering Support
- 情报服务 Information Service

NPP Projects



Qinshan Phase- I

- 秦山一期工程 Qinshan Phase- I
- 秦山二期工程 Qinshan Phase- II
- 秦山二期扩建工程 Qinshan Phase- II Extension Project
- 岭澳二期核电工程 Lin Ao Phase- II
- 方家山核电工程 Fangjiashan NPP
- 红沿河核电工程 Hongyanhe NPP
- 宁德核电工程 Ningde NPP

International collaborations

NPIC ---open

more than 40 countries and organizations

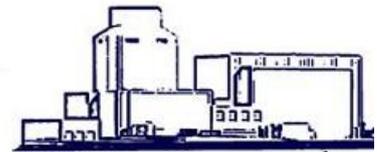
100 companies and research institutes

**France, USA, Canada, UK, Germany,
Russia, Japan, British, IAEA, Korea, etc.**

To be international research intitute

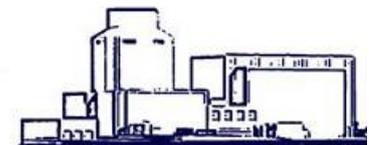
熱烈歡迎 日中科學技術交流協會 蒞臨訪問交流

上海核工程研究设计院
2011年7月1日



SNERDI简介 Overview of SNERDI

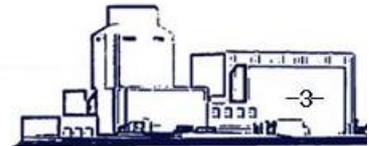
上海核工程研究设计院
Shanghai Nuclear Engineering Research and Design Institute
(SNERDI)



1. 概述 Introduction
2. 取得的成就 Achievement
3. 承担的任务及进展 Major Activities Ongoing
4. 重大专项 Large Advanced PWR Project

2011-7-5

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Shanghai Nuclear Engineering Research & Design Institute



1. 概述 Introduction

1. 2007年，SNERDI整建制划转国家核电技术公司，成为SNPTC的下属设计院。现有员工1300人左右。

SNERDI has become a subsidiary of the State Nuclear Power Technology Corporation (SNPTC) since June 2007. Now has about 1300 employees.

2. SNERDI是中国3家核电设计院之一，具备完整的核岛设计能力。

SNERDI is one of the three research and design institutes on nuclear power plant in China.

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1. 概述 Introduction

□ 国家核电技术公司的定位 Position of SNPTC

1. 代表国家对外签约，受让第三代先进核电技术

On behalf of Chinese government, to introduce advanced 3rd generation nuclear power technology;

2. 是通过消化、吸收、再创新形成中国核电技术品牌的主体；

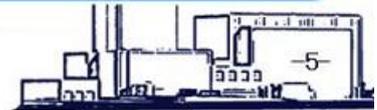
To develop China's own brand name nuclear power technology through assimilation, absorption and innovation ;

3. 是实现第三代核电技术引进、工程建设和自主化发展的主要载体和研发平台。

SNPTC is a key entity and platform for 3rd generation nuclear power technology introduction, project construction and self-reliance development.

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1. 概述 Introduction

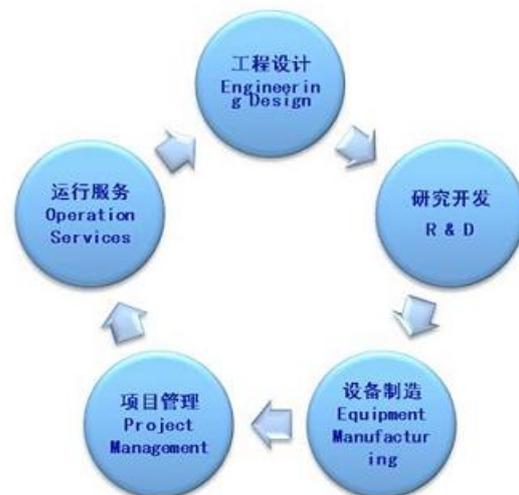
□ 国家核电技术公司的主业
Business Scope of SNPTC

— 核电的技术研发、应用、推广和服务

Nuclear Power technology Research & Development, Application, Technology Support & Consulting Service ;

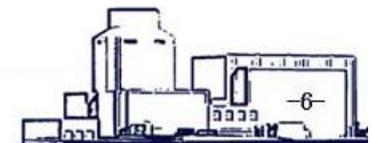
— 电力工程承包与相关服务

Power & Grid's Project Engineering, Procurement, Construction and Technology Service.



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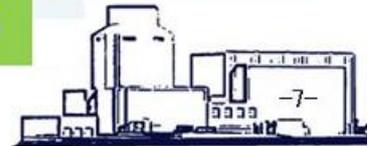
1. 概述 Introduction

9家核心企业和2家参股企业的分布 11 Subsidiaries and 2 Share holding



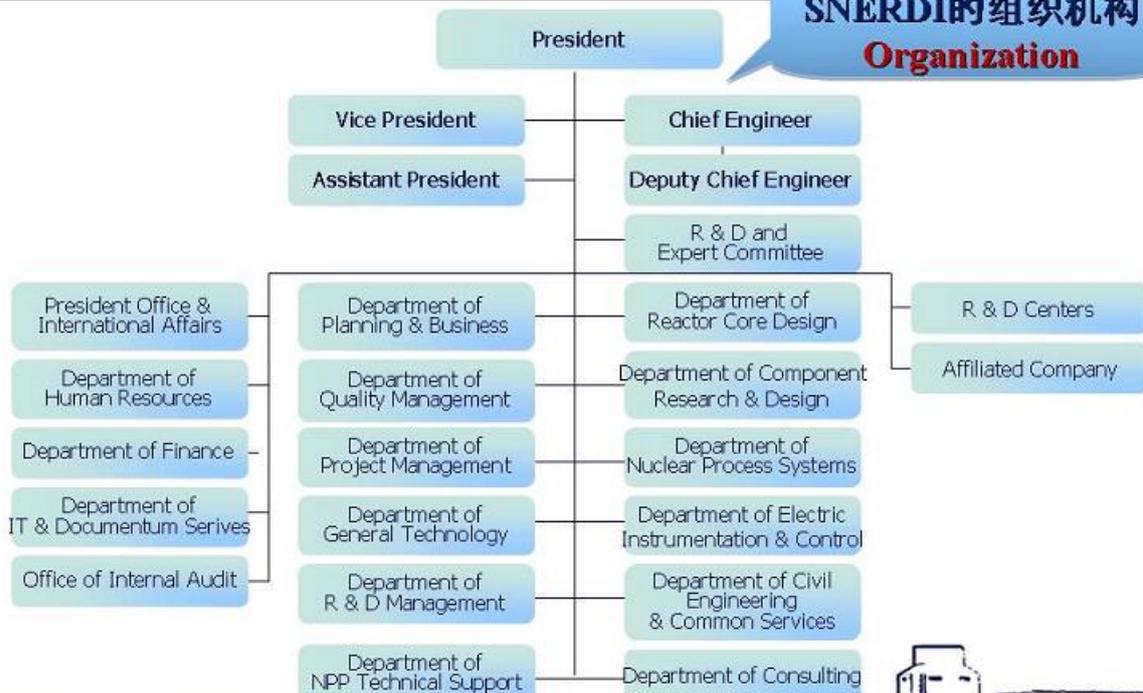
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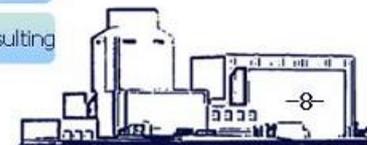
1. 概述 Introduction

SNERDI的组织机构
Organization



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2. 取得的成就 Achievement

----秦山核电厂 Qinshan Phase 1 NPP

1. 是中国大陆第一座商用核电厂。

The 1st NPP in mainland of China.

2. 秦山核电厂是2环路，30万千瓦核电厂，由SNERDI承担总包设计和核岛设计，常规岛由华东电力设计院承担。

3. A 2-loop, 300MWe PWR plant designed by SNERDI (overall, NI) and ECEPDI(CI).

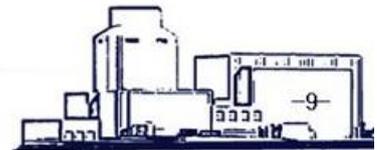
4. 1st power to grid in Dec. 15, 1991, 8th cycle under operation.

5. Excellent operation records achieved in recent years.

6. SNERDI provides full scope and lifetime support for Qinshan NPP-1.

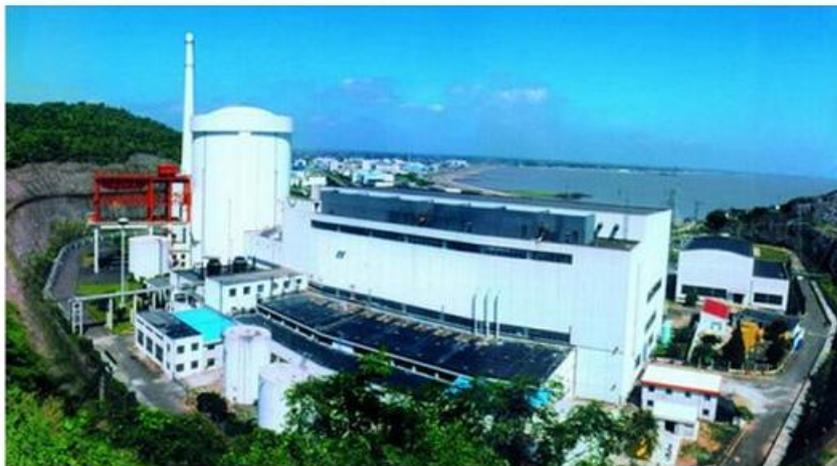
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2. 取得的成就 Achievement

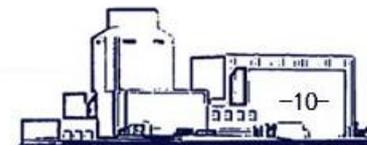
----秦山核电厂 Qinshan Phase 1 NPP



**The First Self-design and Self-construct NPP
in Mainland China**

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国家核电
SNPTC

2. 取得的成就 Achievement ----恰希玛核电厂 Chashma Phase 1 NPP

1. 是一个交钥匙项目 A turn-key project.
2. 秦山核电厂是2环路，30万千瓦核电厂，由SNERDI承担总包设计和核岛设计，常规岛由华东电力设计院承担。

A 2-loop, 300MWe PWR plant designed by SNERDI and ECEPDI.

3. 设计和建造过程中，采用了最新有效的法规和标准。

International codes and standards followed in plant design and construction.

4. 秦山核电厂是恰希玛核电厂的参考电厂，但是还是做了大量的设计改进和厂址适应性改进。

While taking Qinshan-1 as reference plant, many improvements were made:

- 核岛基础，给水系统，厂房布置等等

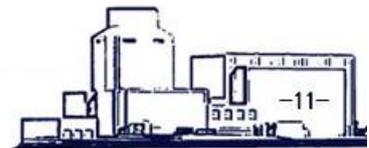
Foundation, EFWS, layout, etc.

5. 恰希玛核电厂2000年6月13日首次并网发电

June 13th power to grid in June 2000.

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国家核电
SNPTC

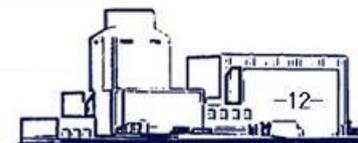
2. 取得的成就 Achievement ----恰希玛核电厂 Chashma Phase 1 NPP



The First NPP Ever Exported from China

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2. 取得的成就 Achievement

----Technical Service to Qinshan Phase 3 (CANDU-6)

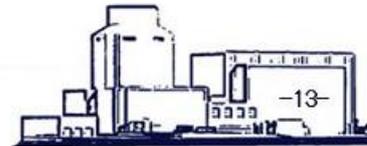
SNERDI是秦山三期CANDU-6型核电厂设计和建造的技术后援单位，同时承担BOP的施工管理。

SNERDI is the supporting institution of Qinshan phase 3, the CANDU project, in the following area:

- 参与秦山三期的建造工程管理，负责BOP的建造管理任务。
Participating Qinshan CANDU project construction management, i.e, BOP construction management.
- PSAR和FSAR报告编制，安全审评对话中的技术支持。
Technical support for PSAR and FSAR.
- 参与调试 Participating Qinshan CANDU NPP commissioning.
- 运行，维修，执照申请和安全审评的全过程支撑
Technical supporting for operation, maintenance, licensing and safety analysis.

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2. 取得的成就 Achievement

----Technical Service to Qinshan Phase 3 (CANDU-6)



728 Mwe×2 Units

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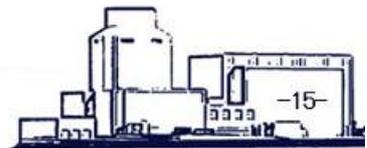


SNERDI为运行电厂提供技术支持和服务，包括下述领域。 In the following area:

- 1.核电厂燃料管理 Plant reload/fuel cycle management
- 2.核电厂定期安全审评 Periodic safety review
- 3.核电厂系统改进和升级 Plant system modification/upgrading
- 4.设备可靠性评价和电厂老化管理
Equipment assessment and life time management
- 5.核电厂运行状态评估 Plant operation status evaluation
- 6.核电厂PSA Probability Safety Assessment

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1. 恰希玛2期核电厂 Pakistan Chashma NPP-2 project.
 - 项目总包合同由CNNC与PAEC在2004年5月2日签订。
Contract signed in May 2, 2004 between CNNC and PAEC.
 - SNERDI作为总包设计院，承担总体和核岛的设计任务。
SNERDI, as a design contractor, is responsible for overall design, NSSS, main equipment, I&C, civil engineering, BOP, etc.
 - 项目于2005年12月浇灌第一罐混凝土。现已并网发电
1st concrete scheduled in 2005. Now has been connected to grid.

恰希玛2号机组合同签字仪式
Signing Ceremony of Chashma Phase 2

开展恰希玛3和4号机组的设计 Design
for Chashma NPP-3/4.



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3.承担的任务及进展

Major Activities Ongoing

2. 红沿河项目 Hong Yan He project (Gen. II plus):
- 4台机组的设计合同2007年7月正式签订 Design contract for four units signed in July, 2007
 - SNERDI负责NSSS之外的施工设计 SNERDI is responsible for the detailed design

Detailed Design Contract Signing Ceremony



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3.承担的任务及进展

Major Activities Ongoing

3. AP1000三门和海阳自主化依托项目 AP1000 Self-Reliance project for Sanmen and Haiyang.
- SNERDI是总体设计院，承担总体和BOP设计 SNERDI is the overall design institute and responsible for overall, and BOP design.



Contract Signing Ceremony for Overall Design of AP1000 San Men



Contract Signing Ceremony for Overall Design of AP1000 Hai Yang

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3.承担的任务及进展 Major Activities Ongoing

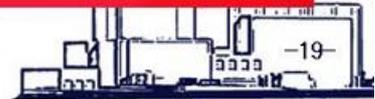
4. AP1000自主化依托项目西屋公司设计分包 AP1000 Self-Reliance project subcontract of Westinghouse
5. AP1000自主化依托项目SWI设计分包 AP1000Self-Reliance project subcontract of SWI

Subcontract Signing Ceremony
for design of AP1000



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3.承担的任务及进展 Major Activities Ongoing

SNERDI参与西屋分包的专业技术人员在美集体合影
SNERDI's design participation in AP1000 under AP1000 subcontract
of Westinghouse.



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6. SNERDI正在开展AP1000技转的消化吸收

The AP1000 technology transfer contract now is carrying out in SNPTC and SNERDI, in which includes five contracts between SNPTC and WEC joint team.

□ 课堂培训

Classroom Training at SNERDI

□ 工作培训

On-Job-Training at Westinghouse

The Pellet

A biweekly publication for Westinghouse Nuclear Fuel Columbia Site employees and retirees.



July 11, 2008

Engineers complete course at new Technology Training Center

The first engineers here to learn AP1000 PWR product design at the new Technology Training Center finished the two-week introductory training session on Wednesday, July 2.

About 15 engineers participated in the session; four were from the Shanghai Nuclear Engineering Research and Design Institute (SNERDI), two were from our licensee Industrias Nucleares Brasileiras SA (INB) and the rest were from the Columbia Site and the Energy Center. For Westinghouse engineers, the session is not mandatory; trainees chose sections in which they wanted to participate based on their specific qualification needs.

Routinely offered to staff and customers, the course is a key starter component of the yearlong training program that Chinese engineers will follow to become Westinghouse-qualified engineering experts. Once trained, these engineers will be working in support of the new Chinese AP1000 reactors - first for Westinghouse, and eventually, for SNERDI.

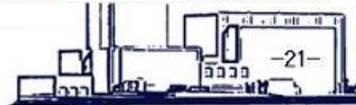
Upon completion of the introductory session, engineers continue training in fuel mechanical design with one-on-one mentoring, which is offered by our engineers and other subject-matter experts. In the future, manufacturing engineers will come to Columbia to learn how we make fuel, beginning with the Conversion process through Final Assembly, then to packaging for shipment to the customer.



Above: The engineers who finished the introductory AP1000 PWR product design course, along with their instructors, at the new Technology Training Center in Trailer 7. Left: Dr. Y.C. Lee, a Columbia Site engineer, gives trainees some final instructions on the last day of their two-week session.

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□ 大型先进压水堆重大专项
Large Advanced PWR Project

- ◆ 大型先进压水堆核电站重大专项是在消化、吸收、全面掌握我国引进的三代核电AP1000非能动技术的基础上，开发的具有我国自主知识产权、功率更大的非能动大型先进压水堆核电厂示范工程

The purpose for Large Advanced PWR Project is to develop and construct large advanced passive PWR with independent intellectual property rights based on the transferred AP1000 Technology

SNERDI是示范工程研发的主体
SNERDI is the lead institute for Large Advanced PWR research and design.



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□ CAP1400 示范工程 Demonstration Plant for CAP1400

- ◆ 确定示范工程厂址选择山东荣成石岛湾核电厂址作为示范工程厂址

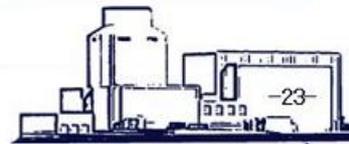
The Demonstration Unit for CAP1400 is determined to be built at Shidaowan, Rongcheng in Shandong Province

- ◆ 与华能合资建国核示范电站有限公司
Establishing a joint venture of State Nuclear Demonstration Plant Corporation with CHNG



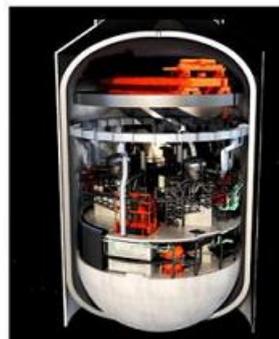
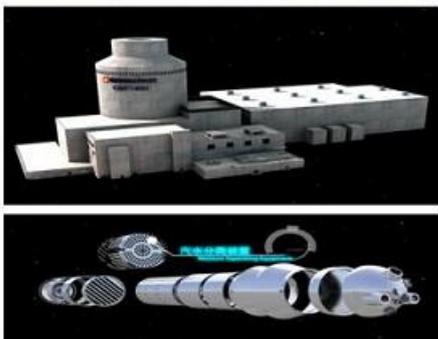
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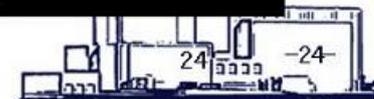
目前: Currently:

- CAP1400概念设计已通过国家评审, 全面进入初步设计阶段; CAP1400 concept design has passed state review and in the phase of preliminary design.
- 全面启动非能动堆芯冷却系统、安全壳冷却、堆内熔融物滞留等6项试验验证台架建设工作; Testing loop construction for 6 items, including PCCS, container cooling and IVR etc has been fully started.
- 开展了压力容器、蒸汽发生器、常规岛T/G包, 以及重型吊车等长周期设备采购的前期工作; Pre-procurement work for long-cycle equipments, including RPV, SG, T/G package of CI has been started.

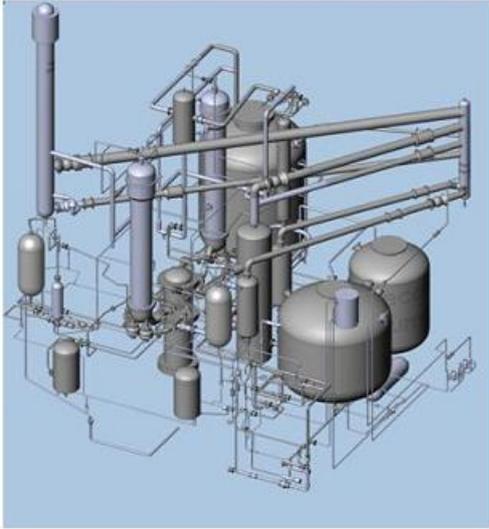


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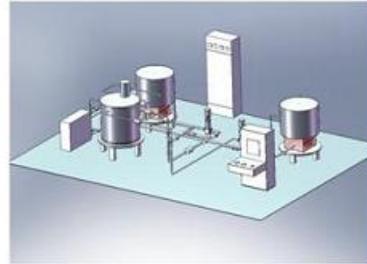
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一、CAP1400非能动堆芯冷却系统整体性能试验台架 (ACME)



二、CAP1400核电站TVR试验



1. 熔融池金属层传热特性试验



2. 提高临界热通量关键因素试验

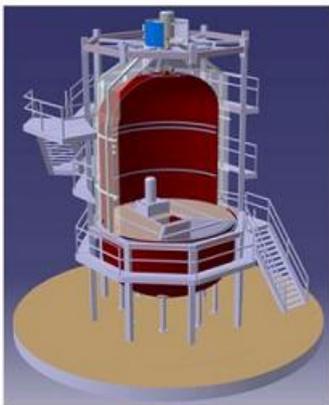
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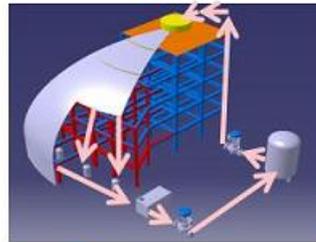


三、CAP1400非能动安全壳冷却系统试验设施

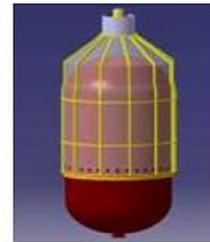
1. CAP1400非能动安全壳冷却系统综合性能试验设施



2. CAP1400非能动安全壳冷却系统关键性能试验设施 分3个单项试验



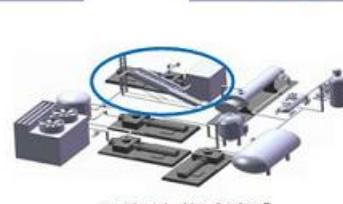
① 水分配试验



③ 耦合试验



二维切片本体试验系统概貌 (方案A)



平板本体试验系统概貌 (方案B)

② 壳内冷板试验

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谢谢!
Thanks

