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On the Sustainability of WCR Development in China

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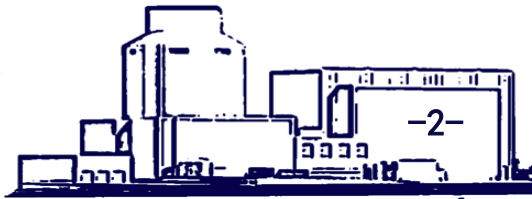


Foreword

China has become one of the largest electricity production and consumption countries in the world. However, the electricity consumption per person is only the half of the world's average. That is to say, in order to become a medium developed country in the middle of this century, the continuous electricity demand increase in China is the must. Meanwhile, due to the fossil fuel-based energy structure, China has been one of the largest countries of SO_2 and CO_2 emissions in the world.

Considering the challenges of national security, energy safety, and environment safety, as the most practicable large-scale alternative energy source, WCR nuclear power plant has an excellent perspective in the Chinese energy development program of this century. Of cause, the good opportunities are coupled with austere challenges.

1. Opportunities

1.1 Inconsistent status of China's energy

1.1.1 Contradiction between energy demand and its supply

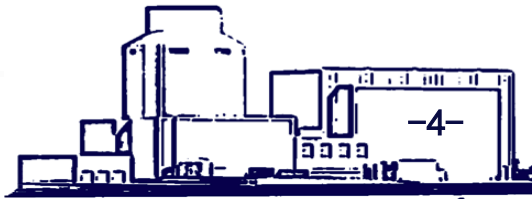
1.1.2 Imbalanced distribution of energy resource and its consumption

1.1.3 Irrational energy structure and its environment impact

1.2 Significant roles of WCR NPPs in China

1.2.1 Significance to energy security

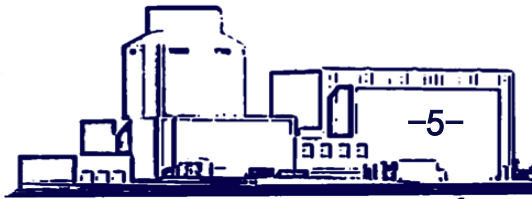
1.2.2 Significance to environment safety



1.1.1 Contradiction between energy demand and its supply

For the goals of well-off society by 2020 and medium developed country by 2050, the rapid development of China's national economy, the speed up of industrialization and urbanization, as well as the upgrade of people's life standard are all foreseeable. The considerable gap between energy demand and its supply will become more serious.

Per capita reserves	Coal	Oil	Gas
China/World's average	50%	11%	4%



1.1 Inconsistent status of China's energy

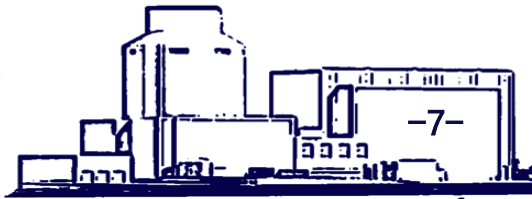
1.1.2 Imbalanced distribution of energy resource and its consumption

In China the geographical distribution of energy resource is imbalanced, such as nearly 80% of coal reserves distribution in the North, more than 70% of water resource in the Southwest, and the energy resource of eight provinces of South China together with Shangdong, Hebei provinces only occupy 13% of our whole country, however, their population is 63%, and energy consumption is 65%. For example, half of the national rail freight volume and one third of the water freight volume are used for transporting coal, yet it is unable to meet the energy demand for those regions, resulting in not only the heavy burden to the transportation systems, but also the considerable increase in coal price.

1.1 Inconsistent status of China's energy

1.1.3 Irrational energy structure and its environment impact

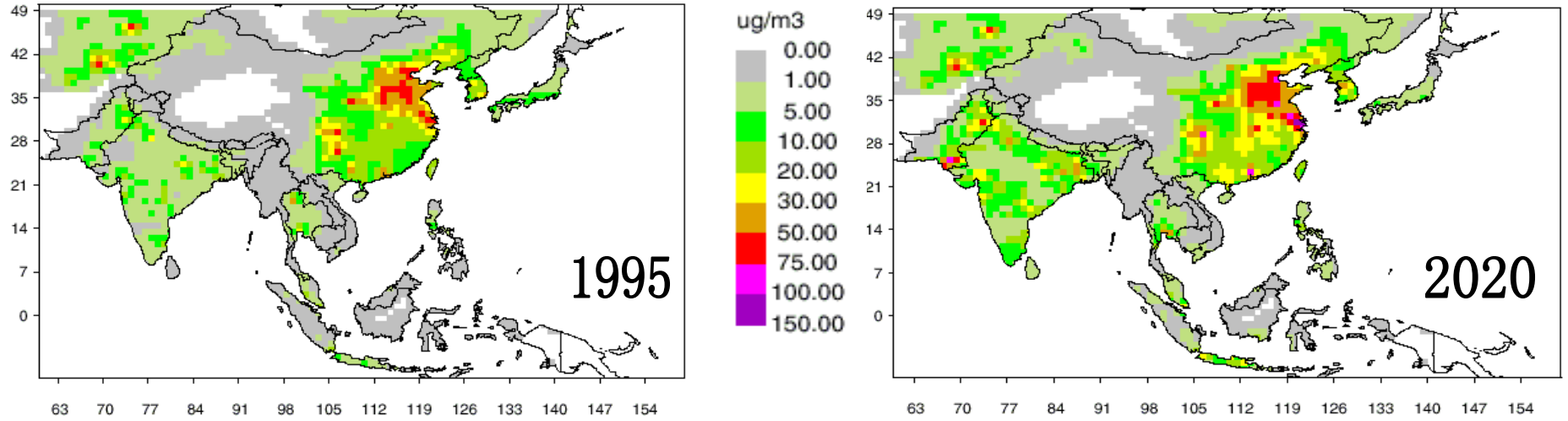
At present, in the electricity supply, coal accounts for 74%, hydropower accounts for 24%, and nuclear power accounts for only 1.6% . Large-scale coal firing causes the serious environmental pollution problem. For example, the acid rain coverage has already been very large. In 2005, among the monitored 696 cities in the country, the acid rain appeared in 357 cities (i.e. 53.1% occupation), and among the 111 cities in those special controlled zones, it appeared in 103 cities (i.e. 92.8% occupation), including 25 cities (22.5% occupation) meeting with more than 80% frequency of acid rain, and 27 cities (24.3% occupation) subjected to rain water with PH value less than 4.5. In general, the pollution level seems getting higher yet.



1.1 Inconsistent status of China's energy

China has become No.1 of both SO_2 and CO_2 emission country in the world.

SO_2 environment density map in Asia



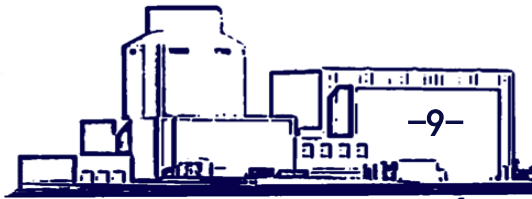
WHO limitation: 50 μg/m3

1.2 Significant roles of WCR NPPs in China

1.2.1 Significance to energy security

Energy security is related to the national security, economic development and social stability, and is closely related to people's life. To deal with above mentioned 3 inconsistencies, China must pay more attention to energy saving, and take positive measures to open up new growth point in the energy supply. There is an old Chinese proverb- "opening the stream source, while cutting down the flow". According to the reality of China's per capita energy resource deficiency, saving energy consumption should be committed, while developing and deploying new increasing point of energy sources, such as nuclear energy and non-water renewable energy.

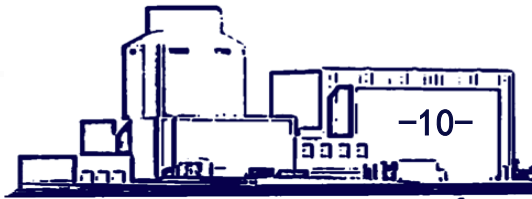
In addition, nuclear energy could loose the heavy burden to the national transportation systems, because of considerable less fuel transportation requirements, compared with those for fossil power plants. WCR technology is mature in the world and in China as well. At present, it is the most practicable choice, which can replace the fossil energy on a large scale, and speeding up its development has been an ongoing pathway in China to cope with the aspiration demands for energy supply and environment protection.



1.2.2 Significance to environment safety

China has set the policy to accelerate the development of nuclear power as the most realistic and effective way out to reduce CO_2/SO_2 emission. The State Council principally approved a clear medium and long-term nuclear power development plan – in 2020 China's nuclear power installed capacity should reach 40 GWe. If there will be operating WCR NPP of 40GW in 2020 (It is foreseeable to have an upward adjustment of this goal), the reduced amount of CO_2 emission would be 3×10^8 ton each year in China. Considering the much large scale NPP development after 2020, as a responsible large country, China will surely made the great contribution to the world conspired emission reduction goal in proper time.

WCR power plant development in China has shown its excellent way ahead within foreseeable 30-40 years, and its significant role to realize Chinese top leader's commitment to CO_2 emission reduction during last month's UN Summit Meeting.



2. Challenges

2.1 To improve safety and economics

2.2 To gain the domestic capability of design and manufacture

2.3 To push forward the plant life management (PLiM)

2.4 To improve fuel utilization rate

2.5 To prove up more uranium resource

2.1 To improve safety and economics

China has caught the favorable chance to import advanced 3rd generation AP1000 technology from abroad, and will build up the domestic innovation capability through its digestion. It is expected to complete the first AP1000 plant around 2013, and to realize its batch and standardized construction immediately.

Distinctly, the passive system application in AP1000 NPPs could obviously improve the safety performance and simplify the system, and consequently have better economical competitiveness. Of cause, the first batch construction of AP1000 NPPs in the world will be a challenge, and of cause, will finally be an achievement.

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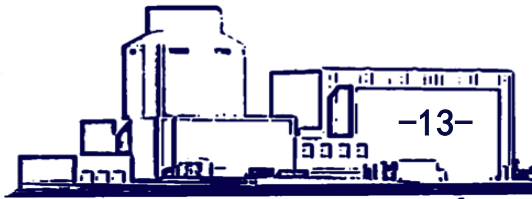
2.2 To gain the domestic capability of design and manufacture

For the safe and economical reasons China's large scale development of WCR/NPP must rely on our own capability of design and manufacture. The available 2nd generation PWR technology foundation is easy to be upgraded to 3rd generation PWR, based on the digestion of imported AP1000 technology. A special national R&D key project has been approved partly for this purpose. All designated design institutes and manufacturers are acting as the transferred technologies users to carry out the task for localization through 4 units' self-reliance support AP1000 projects, and to have enough financial support for gaining their capabilities of self-relied design and manufacture. Then the following standardized AP1000 batch construction could be relied mainly on our own.



2.2 To gain the domestic capability of design and manufacture

NI equipments' localization for Sanmen & Haiyang AP1000 projects

设备名称 Equipments	SM Unit 1	HY Unit 1	SM Unit 2	HY Unit 2
屏蔽电机主泵 RCP	WEC	WEC	WEC	WEC/Chinese Side
爆破阀 Squib Valve	WEC	WEC	WEC	WEC/Chinese Side
反应堆压力容器 RV	WEC	WEC	Chinese Side	Chinese Side
蒸汽发生器 SG	WEC	WEC	Chinese Side	Chinese Side
堆内构件 Internals	WEC	WEC	Chinese Side	Chinese Side
控制棒驱动机构 CRDM	WEC	WEC	Chinese Side	Chinese Side
装卸料机 Fuel Handling Equipment	WEC	Chinese Side	Chinese Side	Chinese Side
钢制安全壳 CV	WEC	Chinese Side	Chinese Side	Chinese Side
主管道 Primary Pipe	Chinese Side	Chinese Side	Chinese Side	Chinese Side
稳压器 Pressurizer	Chinese Side	Chinese Side	Chinese Side	Chinese Side

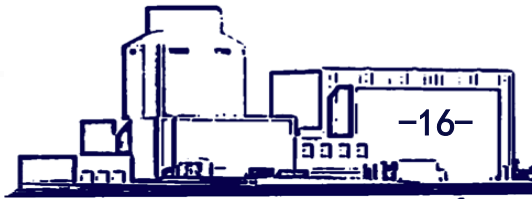
2.3 To push forward the plant life management

China has paid more attention to the R&D on ageing and life management. Qinshan Phase 1 is the first NPP in China. It is at the middle age of its 30 years' design life, and the ageing management and life extension R&D activities have been carried out for many years. These activities would surely gain some preliminary experiences, which are not enough for so many operating NPPs requirements. Anyhow, most of NPPs in China is still quite young, and much more WCR NPPs are under construction within coming 30-40 years with their design life as long as 60 years and possible life extension of a few decades through the effort of PLiM. It is quite sure that WCR will be the domain type of NPPs and last its viability for the whole 21 century, as well as the early stage of next century in China.

2.4 To improve utilization rate of nuclear fuel

Nuclear energy is not renewable. Attentions have to be paid to the improvement of fuel utilization rate. The 3rd generation NPPs could use MOX fuel with full core loading, which will increase uranium utilization rate and partly ease up the uranium resource supply before the fast spectrum reactor and relevant fuel cycle technologies get maturated and commercialized in China.

Regarding the 4th generation nuclear technologies, most reactor types adopt fast spectrum core. Then, discovered uranium resources will be able to support thousand years nuclear energy development, even if its uranium utilization rate reaches 10% (it is much higher by theoretical estimation). But, a few decades' efforts have to be made for their commercial deployment.



2.5 To prove up more uranium resource

The potential uranium resource in China is comparative ample. The natural uranium supply would not become a unconquered restrict factor, but to compare with the long term demand of nuclear energy development the amount of discovered uranium resource remaining still retains large differences. In order to ensure the enough uranium resource supply for the speeding up nuclear energy development, the parallel utilization of domestic and overseas uranium resources has to be considered.

Regarding the domestic activities, the research on uranium geological proving up technology and mine formation theory should be emphasized, and the support to the geology prospect for uranium resource should be promoted, so as to improve the capability to prove up more uranium mines.

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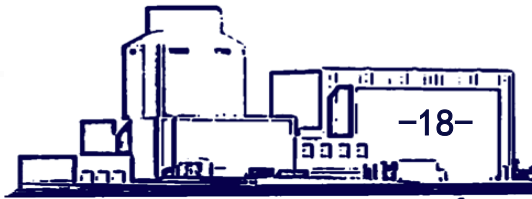
2.6 Some more Challenges

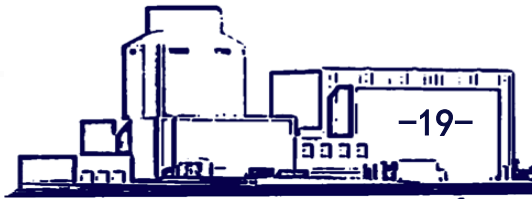
In addition to above challenges, the human resource preparedness is also an important issue in China, which has been well described by keynote speaker, Dr. Zheng Minguang this morning.

And, another challenge to be faced in this century is WCR/NPP's decommissioning. The relevant experience has been accumulated for some experimental WCRs in China. Of cause, it is not enough for NPPs. That's why the international cooperation in this area should be encouraged, I think.



Summary of above chapters

In summary of abovementioned opportunities and challenges, in order to meet the demand of country's economy and society development, the realization of China's energy sustainability needs to optimize the national energy structure, by means of seeking new increasing point of energy resource. Thus, WCR nuclear power must be the most reasonable practicable pathway, and doubtless posses the irreplaceable strategic position in this century. Meanwhile, considering its own sustainability challenges, the proper arrangement of medium and long term's development program is of more strategic significance.



3. Strategic Arrangement

NPP Sites Distribution

- Operating 运行中 11 (9078MW)
- Constructing 建设中 14 (14350MW)
- Approved 已核准 10 (11050MW)
- Programmed 规划中

红沿河
海阳
田湾
秦山1, 2, 3
秦山2+
三门
福清/宁德
台山
大亚湾/岭澳/岭东
阳江
昌江
防城港
湖北
江西
湖南
方家山
Harbin
Dunhuang
Beijing
Xian
Lasa
Chengdu
Haikou

3. Strategic Arrangement

3.1 Speeding up 3rd generation technology deployment and its self–reliance

3.2 Initiating inland NPP construction at the earliest

3.3 Paying attentions to 4th generation WCR—SCWR

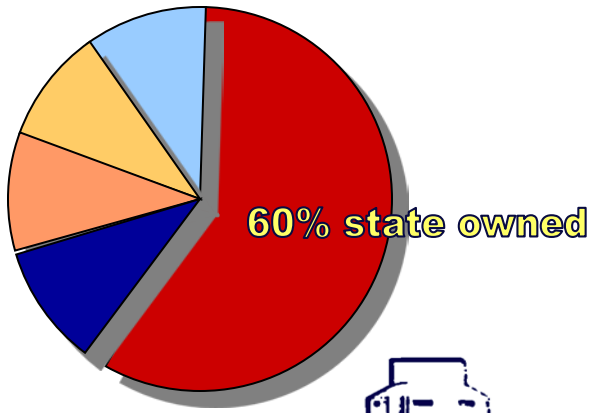
3.4 Following the trend of non-electrical applications

3.1 Speeding up 3rd generation technology deployment and its self–reliance

Generally, the 3rd generation PWR will become the main stream NPPs for the coming 30-40 years in China, with their designed life time as long as 60 years. To fulfill this task, our SNPTC was established on May 22, 2007, and is a state-owned corporation with 3 government authorized responsibilities:

- ***To sign the contract of introducing AP1000 technology from U.S. on behalf of the state owned-share***

The Contract was signed on July 24, 2007, and put into effective on Sept. 24, 2007 after both sides government approval.



3.1 Speeding up 3rd generation technology deployment and its self–reliance

To organize the construction of first batch of 4 units AP1000 NPPs, as the self-reliance supporting projects

- **2X1250MW for both Sanmen and Haiyang projects**

Sanmen Unit 1: FCD on March 31, 2009
COD in August 2013

Haiyang Unit 1: FCD in September 2009
COD in February 2014

3.1 Speeding up 3rd generation technology deployment and its self–reliance

Sanmen Unit 1 completed first concrete pouring on March 31, 2009, and Haiyang Unit 1 had that on Sept. 26, 2009, both in schedule.

The largest module CA20 assembling in Sanmen site

72 structure parts pre-fabricated in SNPEMC machineshop

4 sub-module assemblyies welded on site

CA20 module consisting of 4 sub-modules with total weight of 840 tons

Integrated CA20 module to be placed in fuel building on schedule

Lifting No.3 sub-module in place on CA20

Lifting the largest No.4 sub-module in place on CA20

3.1 Speeding up 3rd generation technology deployment and its self-reliance

CA20 module installation in place at end of last June

Transport by truck to lifting point

Lifting started near unit 1 NI

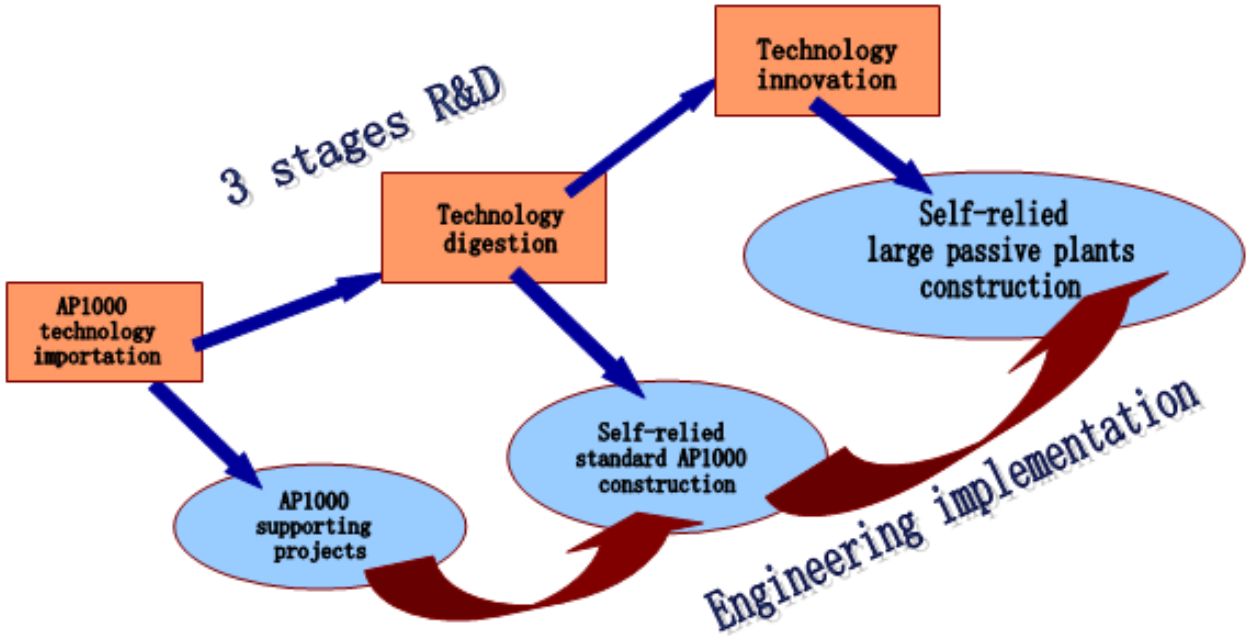
Arriving at position above nuclear island

Well installed in place of fuel building

Overview of Sanmen site

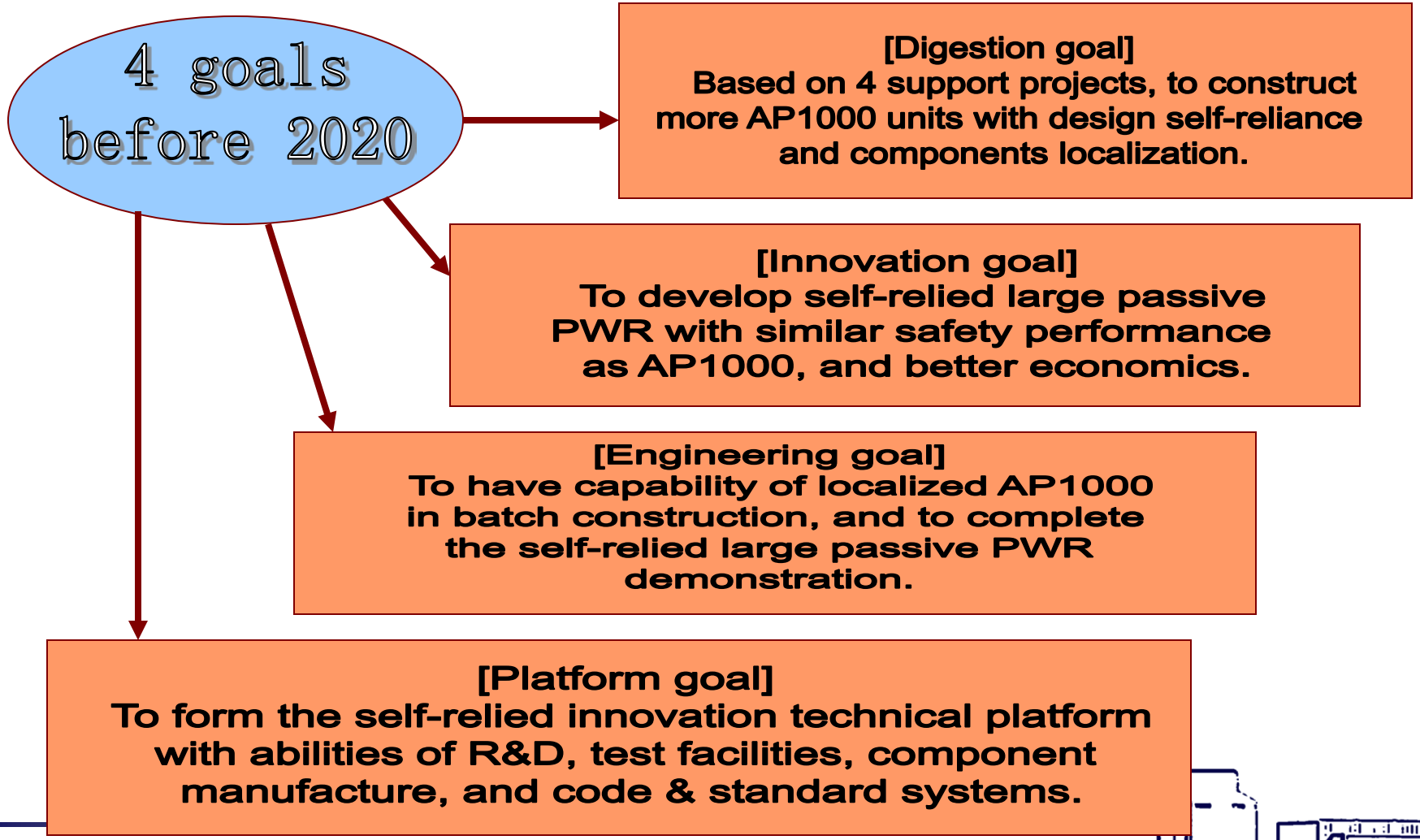
To act as the implementation organization of National Key Project on large advanced PWR R&D for AP1000 technology digestion, assimilation, and its innovation

The three stages of National Key Project on large APWR



Site view of CAP1400 demonstration plant in Shidaowan, (Shandong province)

3.1 Speeding up 3rd generation technology deployment and its self–reliance



3.2 Initiating inland NPP construction at the earliest

Some southern-middle inland provinces are also lack of coal, which is even more difficult and expensive to transport to inland by railroad than to coastal areas by ocean shipping. Therefore, to develop inland NPPs could not only ensure the energy demand for the regional economical and social development, but also reduce the regional strength of acid rain, the pressure to environment protection, and the heavy burden to railway for coal transportation.

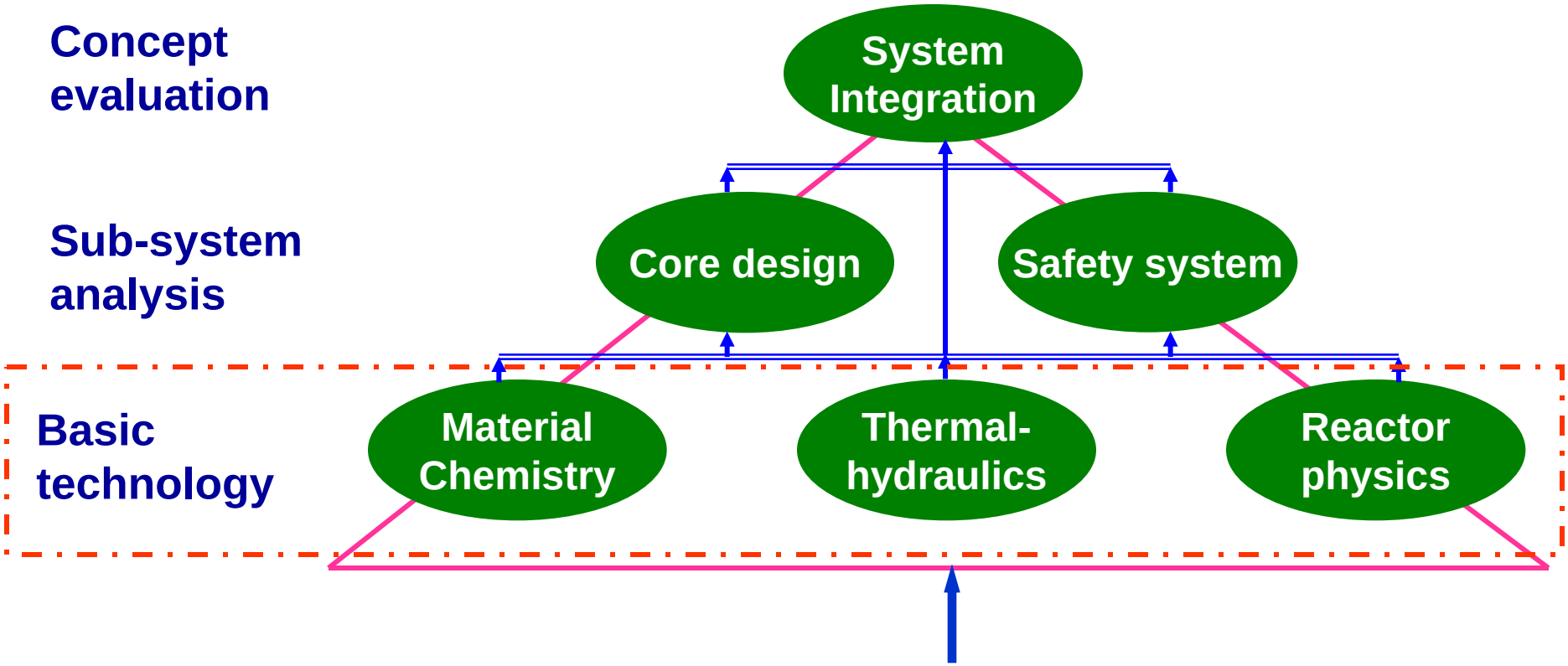
3.3 Paying attentions to 4th generation WCR—SCWR

SCWR is the sole WCR technology in GIF R&D frame, and is hopeful to be the future option of nuclear electricity generation. China has taken part in this international coordination research plan of SCWR which is organized by IAEA and started from 2006, and has been the new member of Generation 4 International Forum (GIF) from 2007, not only to participate the activities in the frame of VHTR and SFR System Steering Committees (SSC), but also to be the observer in SCWR SSC.

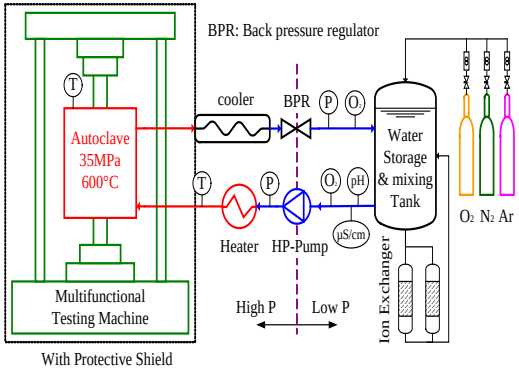
A National Research Program on SCWR supported by Government organization has launched in 2007. Some basic research projects on reactor physics, thermo-hydraulics, and materials have been ongoing, and a few innovative reactor design concepts are proposed and have got reputably evaluation.

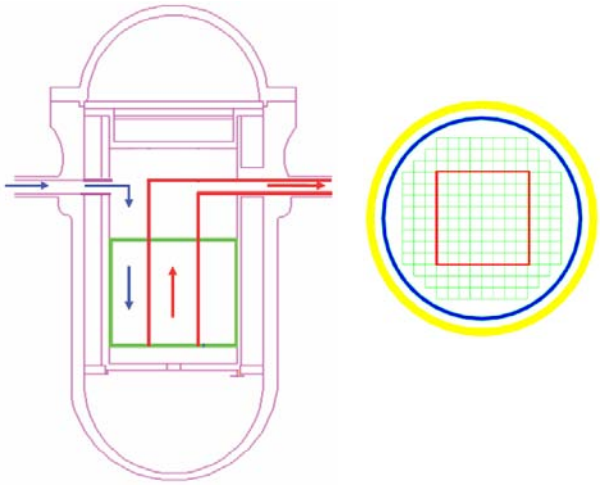
3.3 Paying attentions to 4th generation WCR—SCWR

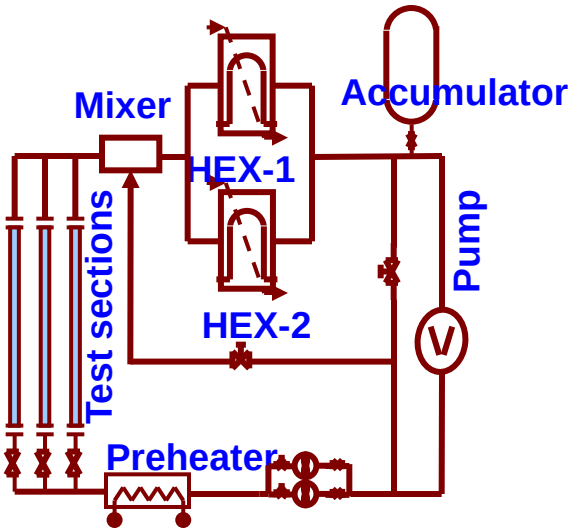
A National Research Project on SCWR supported by MOST and hosted by SJTU launched in 2007



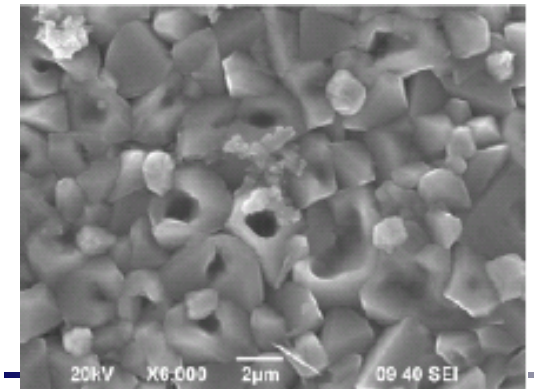
3.3 Paying attentions to 4th generation WCR—SCWR



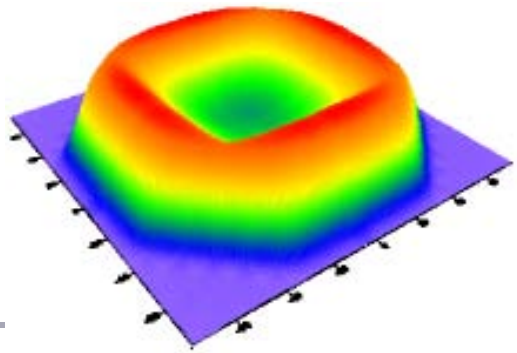




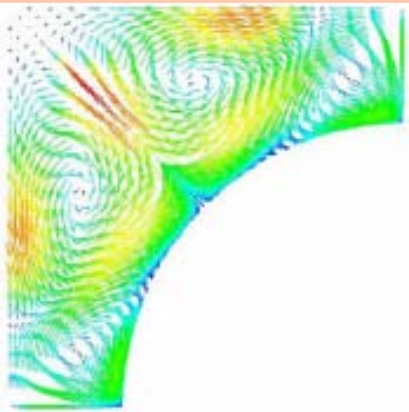
Material corrosion



Reactor physics



Thermal-hydraulics



3.4 Following the trend of non-electrical applications

The small and medium reactors (SMR) are characteristics in its own safety and economy especially have well adaptability in non-electric application, lower one-time investment, and more component in-machine shop manufacturing. They are easy to realize modularization and to be built in outlying area. Based on the modular design, manufacturing and installment technology, the site selection and unit-capacity of nuclear power plant can be more flexible.

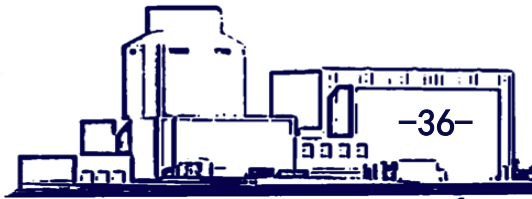
The SM-WCRs for heating, seawater desalination, commercial ship, and isotope production are under R&D, in order to broaden the potential non-electrical applications in China.

Postscript

For WCR sustainable development in China, two countermeasures have been taken:

The first is to introduce generation III PWR technologies for the current large-scale commercial applications, since GIII PWR technologies have considerable risk reduction comparing to generation II technologies. The more capacity scale, the more attention has to be taken to the single unit risk reduction. And, the possibility of full core loading with MOX fuel is another advantage of GIII PWR for improving fuel resource utilization rate.

The second is to join GIF activities, including SFR, VHTR, and SCWR, in order to follow up the world technology advancement and make joint effort in some common interested R&D projects, so as not only to catch up with the world advanced level in proper time, but also to have the great stamina for the long term sustainability of nuclear power in China.



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THANK YOU!

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