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Prospect on Chinese Fast Reactor Development and Expectations to MONJU

For the International Conference on Fast Reactors and Related Fuel Cycles: Challenges and Opportunities (FR09)
7-11 December, 2009, Kyoto, Japan

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China Institute of Atomic Energy

1. The status and prospects of fast reactor development in China

- **Introduction**

Recent years the national economy development and the primary energy production increasing have a rather quick speed in China. Their average annual increasing rates are about 10% for more than ten years.

In 2007:

The total primary energy resources production 2.36 Billion tsce

The total primary energy exhausted 2.66 Billion tsce

Ranking the first and second place respectively in the world.

In 2008:

The electricity production per capita only 2500 kWh, less than the average value of 3060 kWh in the world, and only 1/6 of American people.

So, China needs to develop primary energy production continuously.

Up to now, the main energy resources ～70% used for electricity production is coal. In 2007, 856 million tons of coal was consumed for thermal power generation which emitted 20 million tons of SO_2 and 500 million tons of CO_2 (Cited from Mr. Xu Yuming, China power 2009 Tianjing, China, 2009).

The global warming and decreasing the greenhouse gases emission are much concerned by the world.

To develop clean energy is the first thing first.

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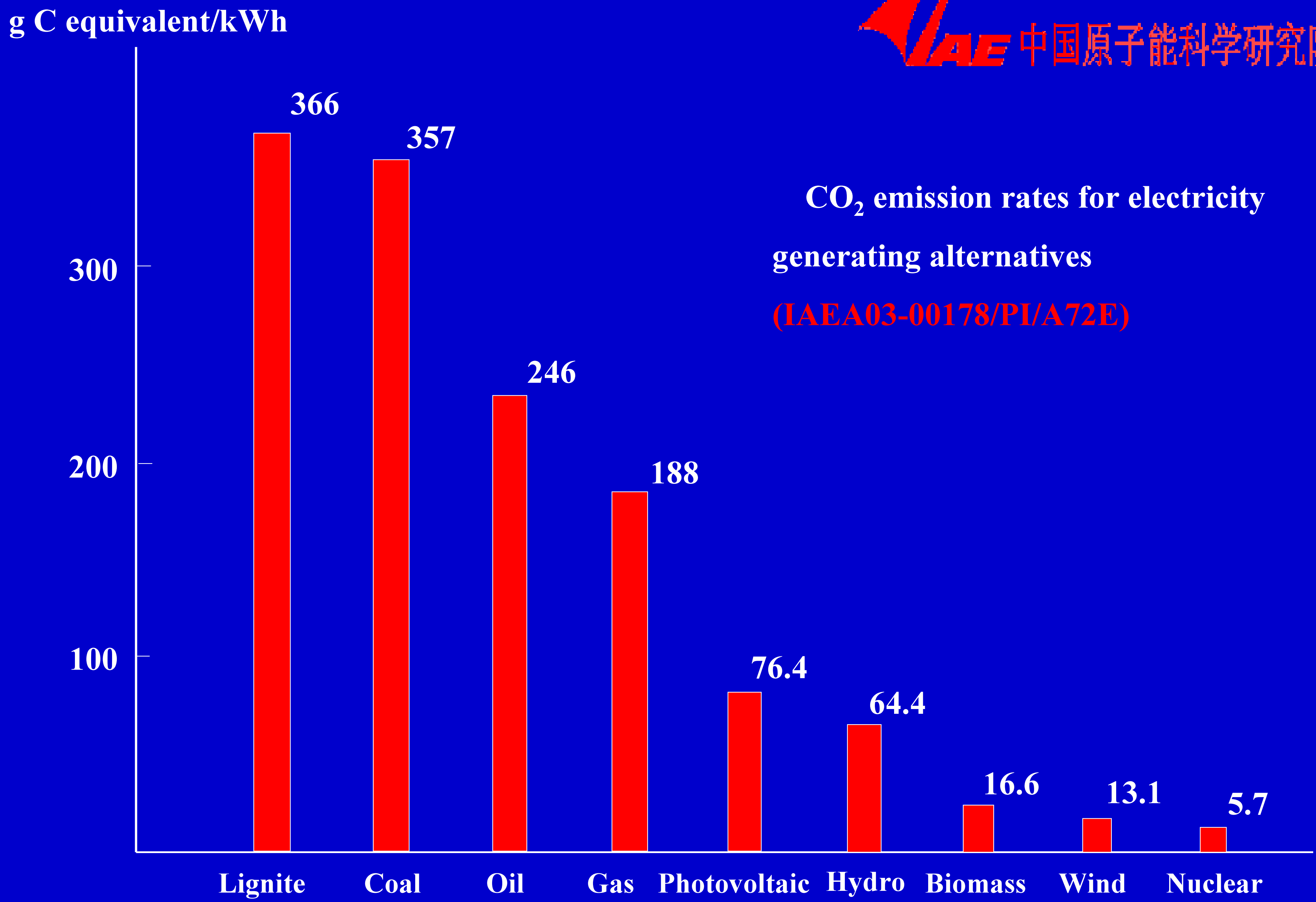
CO$_2$ emission rates for electricity generating alternatives

(IAEA03-00178/PI/A72E)



Zone acreage needed by 1 GWe for alternatives

	Mile square	note
Photovoltaic	40	efficiency 10%
Wind	40-70	Windmill: 3000 sets/1 GW
Bio-gas	2400	60 million pigs
Biomass		6200 km^2 Sugar beet Fields
	12000	30000 km^2 Wood
Bio-alcohol	2800	7400 km^2 Potato
	6200	16100 km^2 Corns
	104000	272000 km^2 Wheat
Bio-oil	9000	24000 Rapeseed
Nuclear	1/3	<1 km^2

(Cited from Mr Samin Anghaic, WGEF 2008, Gyeongsan, Korea.)

Nuclear energy is a new member of the energy resource family in China mainland.

Status of NPPs in China Mainland

Site	Capacity/Type	Grid Date	Load factor (%)								
			2000	2001	2002	2003	2004	2005	2006	2007	2008
Qinshan I	300MW/PWR	1991.12.15	77.2	94.1	66.9	88.6	99.8	86.72	91.44	81.62	96.39
Daya Bay -1	900MW/PWR	1993.08.31	85.2	84.9	89.6	89.6	87.2	99.79	80.31	90.85	99.60
-2	900MW/PWR	1994.02.07	84.9	89.1	81.6	84.5	73.6	79.44	99.68	88.29	86.39
Qinshan II -1	600MW/PWR	2002.02.01			74.9	81.0	82.2	92.76	55.20	65.69	87.38
-2	600MW/PWR	2004.03.11						85.19	90.30	90.70	86.48
Lingao -1	984MW/PWR	2002.04.05			92.0	76.8	87.76	82.69	89.16	82.65	90.79
-2	984MW/PWR	2002.12.15				85.0	79.9	90.57	91.89	87.31	84.56
Qinshan III -1	700MW/PHWR	2002.11.10				90.2	77.3	84.05	98.20	88.35	93.48
-2	700MW/PHWR	2003.06.12				90.4	94.0	81.05	88.70	99.87	89.34
Tianwan -1	1000MW/PWR	2006.06								65.59	74.43
-2	1000MW/PWR	2006.12								78.76	85.50
Total	8.6GWe										

The average load factor over 67 unit ·years is 85.8%.

The 67 reactor · years operation and international experiences of NPPs let the Government and public believe:

Nuclear Energy is a safe, reliable, CO2 free, economically acceptable and could be used as base load and in large scale for the national electrical grid.

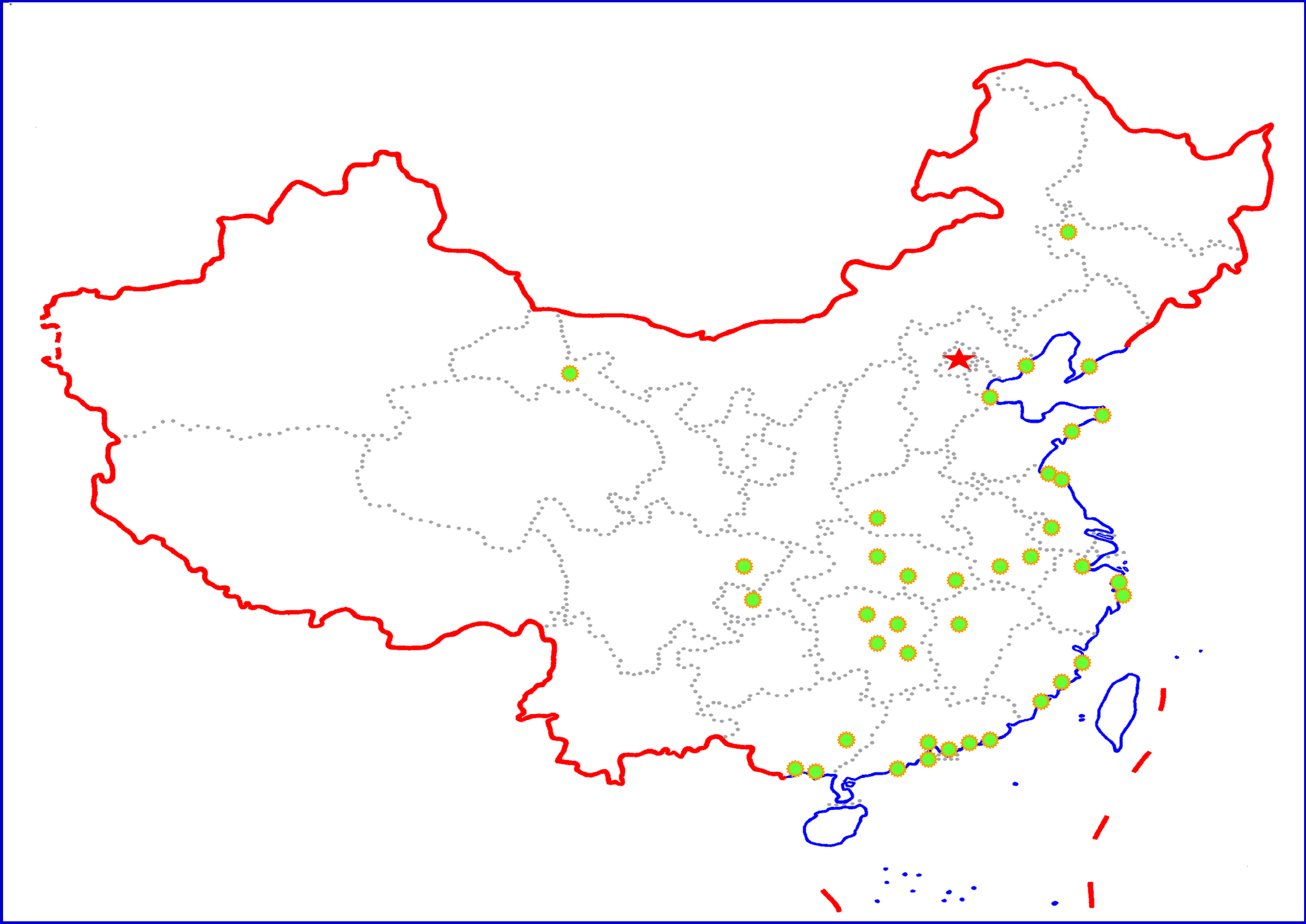
Under the sketch of National Mid-Long Term Science and Technology Development Program (2006～2020) issued by The State Council ,the Government has decided in 2006 to develop continuously nuclear power with a target of 40 GWe in operation and other 18GWe under construction in 2020. The higher capacity targets are under discussion.

Right now:

19 units with ～20GWe under construction.

7 units with ～7GWe under preparing for construction.

And other about 10 units of NPP are waiting approval by the Government for construction.



Envisaged NPP Sites in Future

From Mr. Pan Ziqiang's PPT on 2007 Chinese Nuclear Society Annual Meeting

• The Strategy Study of China FBR Development

Envisaged Primary Energy Production in China for 2050

	1991 Envisaged			2005－2007 Envisaged	
Energy	Exploitable In 2050	Standard Coal Equivalent (billion tsce)	Total Requirement (billion tsce)	Standard Coal Equivalent (billion tsce)	Total Requirement (billion tsce)
Oil	0.1×10^9t	0.45		0.5	
Gas	1500×10^9m^3			0.3	
Hydraulic	260～370GWe	0.65		0.6	
Coal	3.4×10^9t	2.50		2.5	
Nuclear	240GWe	0.60		0.6	
Others		0.30		0.5	
Total		4.5	4.5	5.0	5.0

10,000 t natural uranium is needed to support 1 GWe PWR operating 60 years.

For such huge capacity 240 GWe NPPs it is impossible to use only PWRs due to the Uranium resources technically and economically exploited are limited in China or in the world.

And also considering:

（1）To decrease the quantity of MA and LLFP to be geologically buried, and

（2）To decrease the emission of green-house gases.

The basic strategy of PWR-FBR matched closed fuel cycle is under execution step by step.

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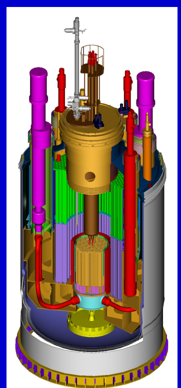
FBR Development Strategy

20 MWe

CEFR

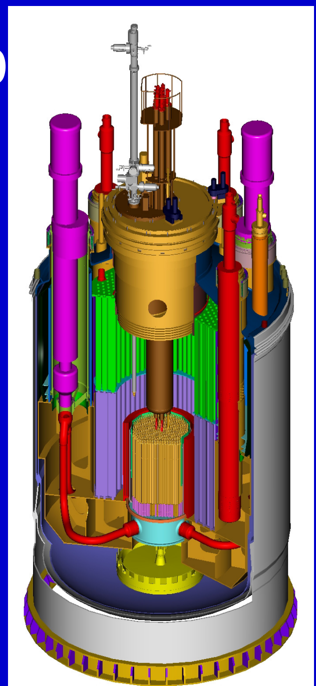


1990

2010

600-900 MWe

CDFR



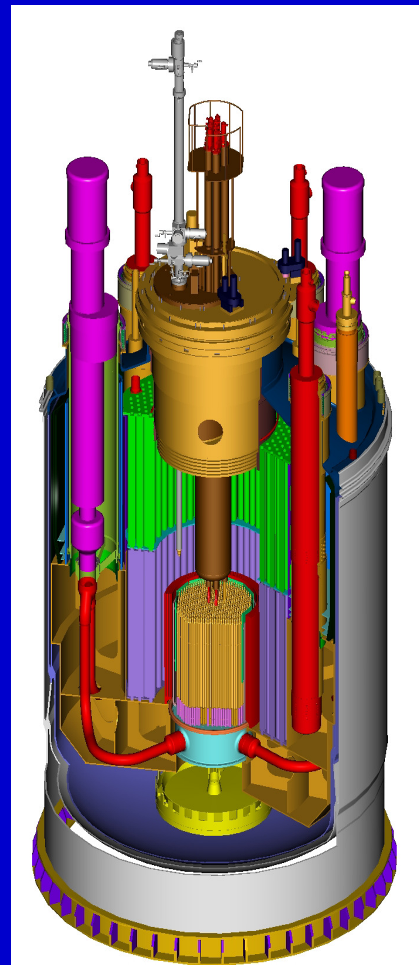
2005-2007

2020

Deployment

1000-1500 MWe

CDFBR



2018

2028

Deployment

R&D of Fast Reactor Technology Since 1965

- **China Experimental Fast Reactor**

In the framework of the National High-Tech Program the China Experimental Fast Reactor CEFR has been executed since 1990.

CEFR is a 65 MWt sodium cooled pool type fast reactor.

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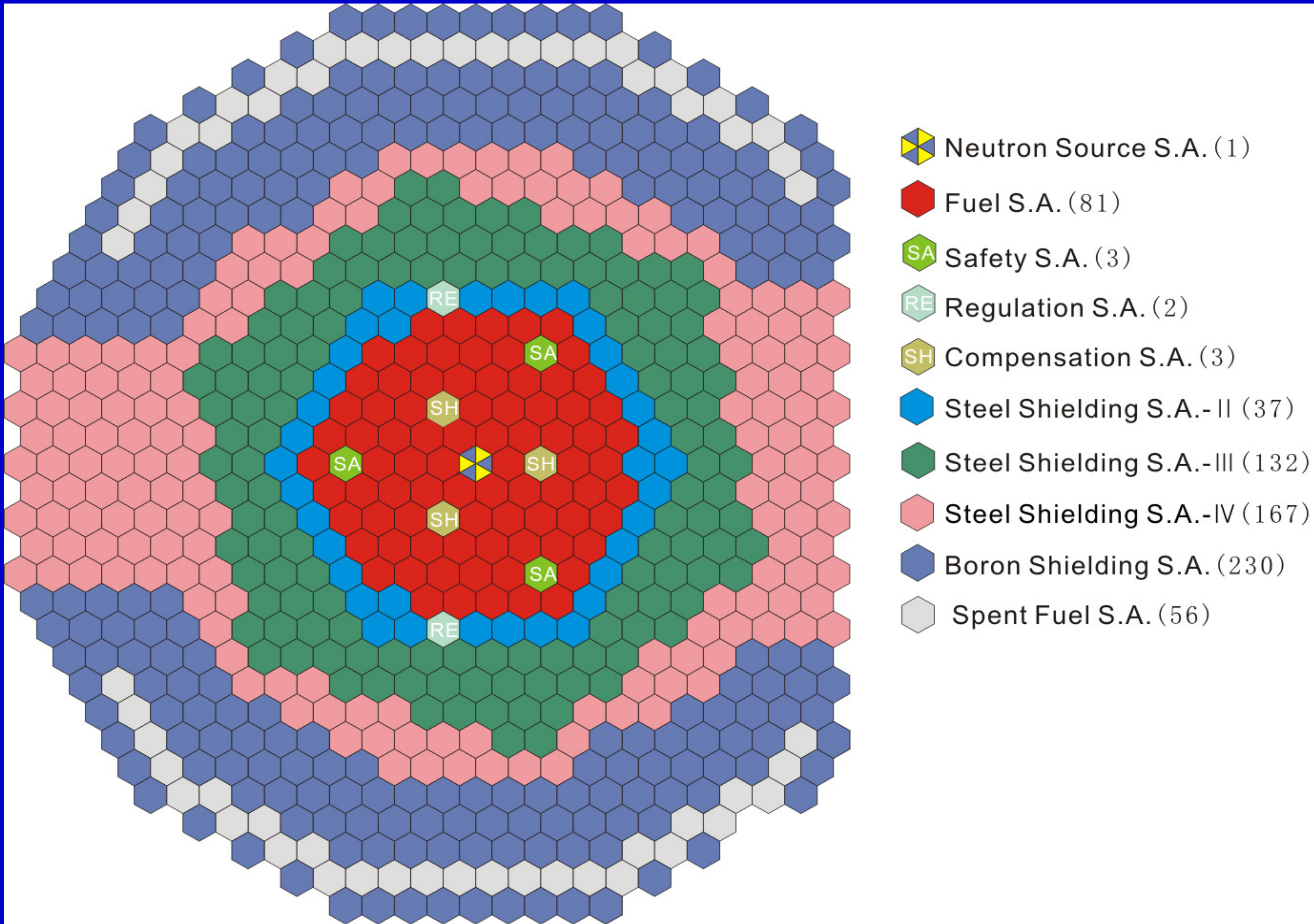
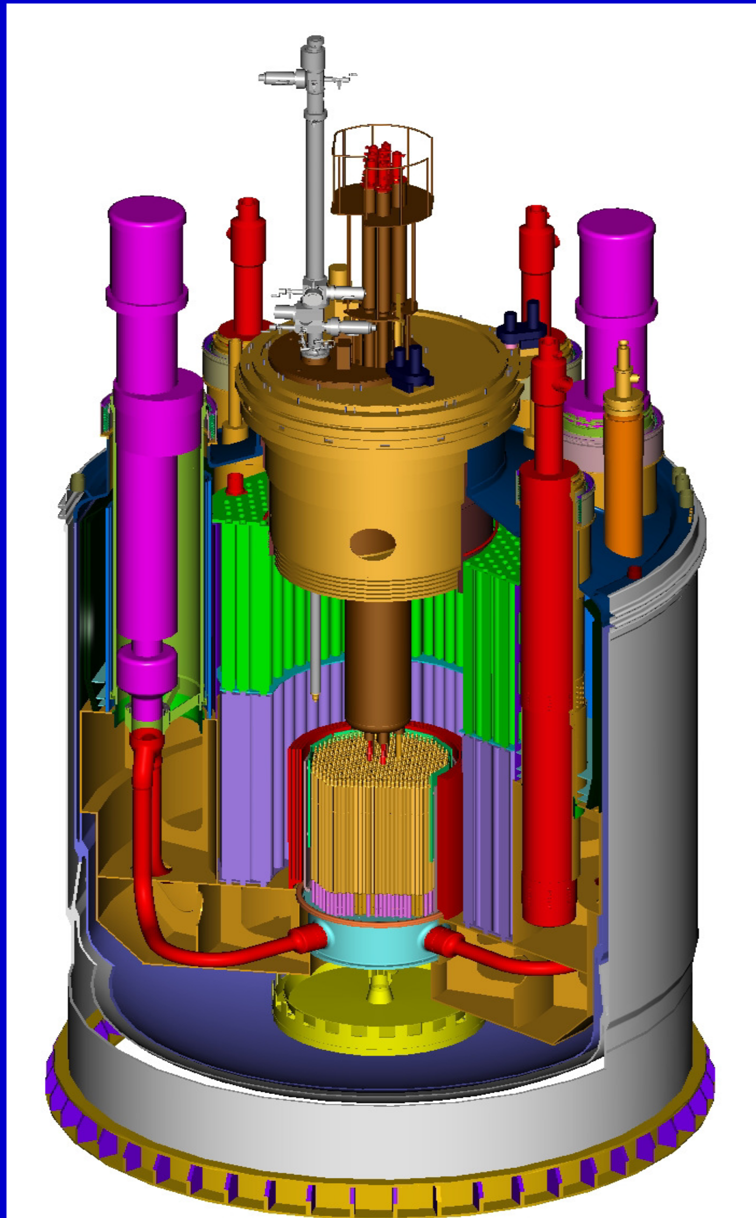
CEFR Introduction



The core of CEFR



CEFR Reactor Block

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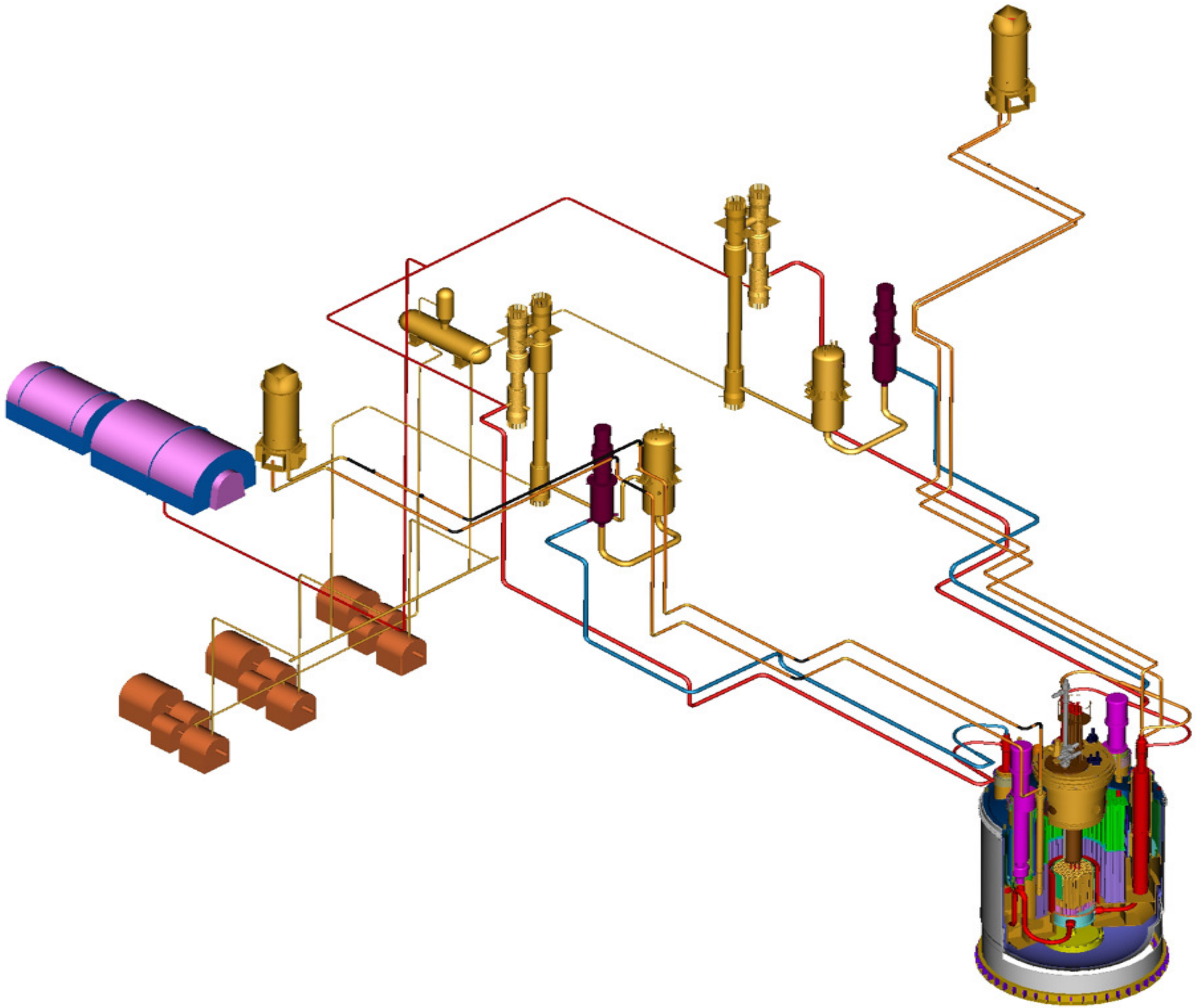

CEFR Main Heat Transfer System

Recent Status of CEFR：

- **Installation is completed.**
- **Pre- operation testing of more than 98% systems has been completed .**
- **336.6t nuclear grade sodium has been transported and filled into reactor block and secondary circuit, purified to about 2 ppm. Their hot testing before fuel loading is finished.**
- **Now the license by NNSA for physical start-up has been issued in 29th, September, but physical start- up was delayed due to a public letter.**

And planned originally that it will incorporated to the grid with 40% full power in June, 2010, may be need 3 months delay.

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CEFR Reactor Building Completion Ceremony (2002.08.15)

Turbine under installation (2005.07.21)

Main control room（2009.01）

CEFR Outside view (2007.10.10)

National Grid comes to the site (2007.01.28)

- **China Demonstration Fast Reactor**

After pre-conceptual design for 600MWe CPFR core it was started to pre- conceptual design for an 800 MWe CDFR in 2007.

The general design demands:

（1）The safety properties should reach the recommendation for SFR design by IAEA-TECDOC-1083;

（2）The reliability should meet commercial nuclear power plants target;

（3）The economy should be acceptable;

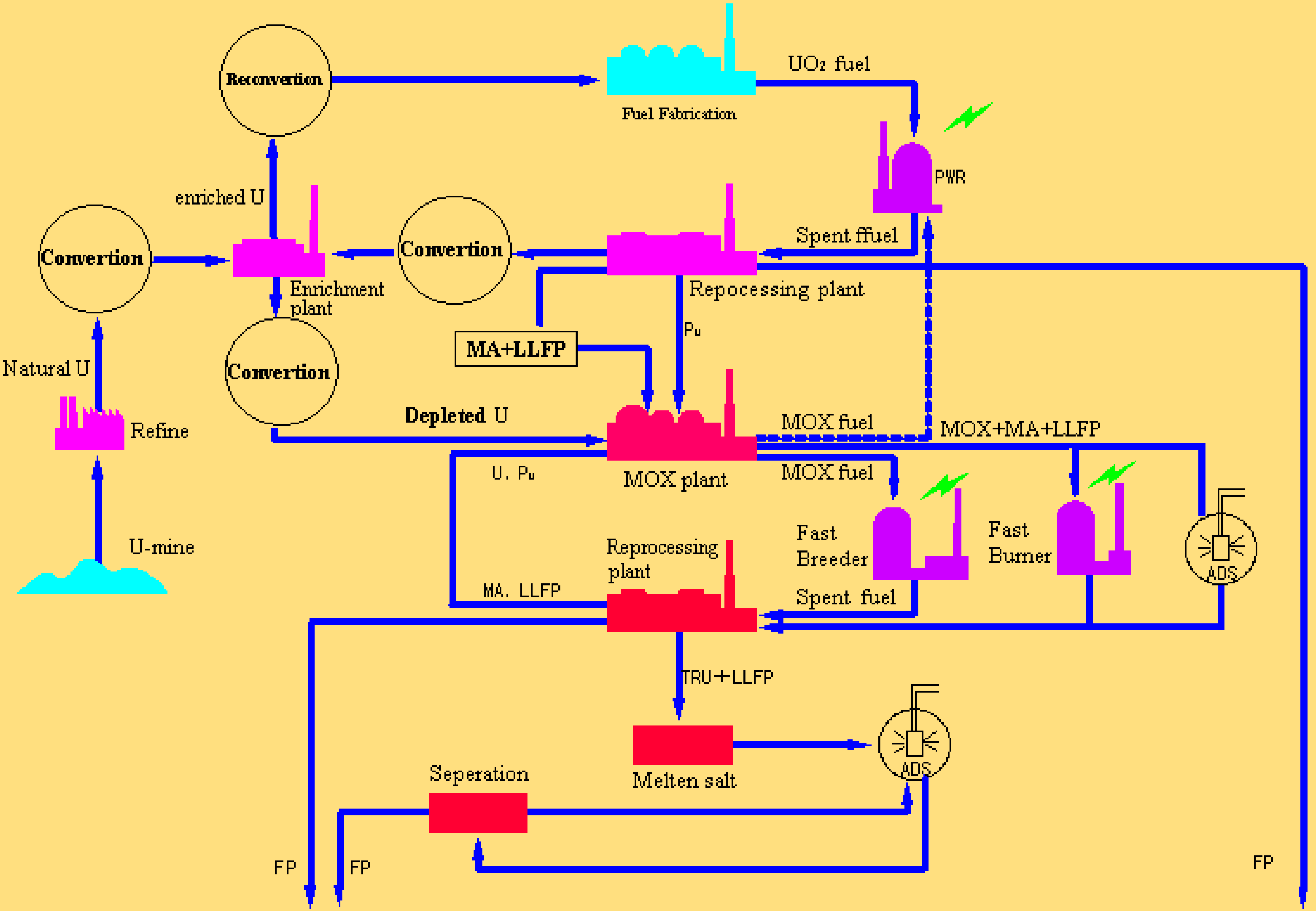
Its site has been selected in Fujian Province.

- **Fast Reactor Fuel Cycle**

Overall Target

Uranium resources should be sufficiently utilized including by-products Pu and MA;

The volume of high radioactive wastes to be geologically buried should be as less as possible.



Closed Fuel Cycle Envisaged

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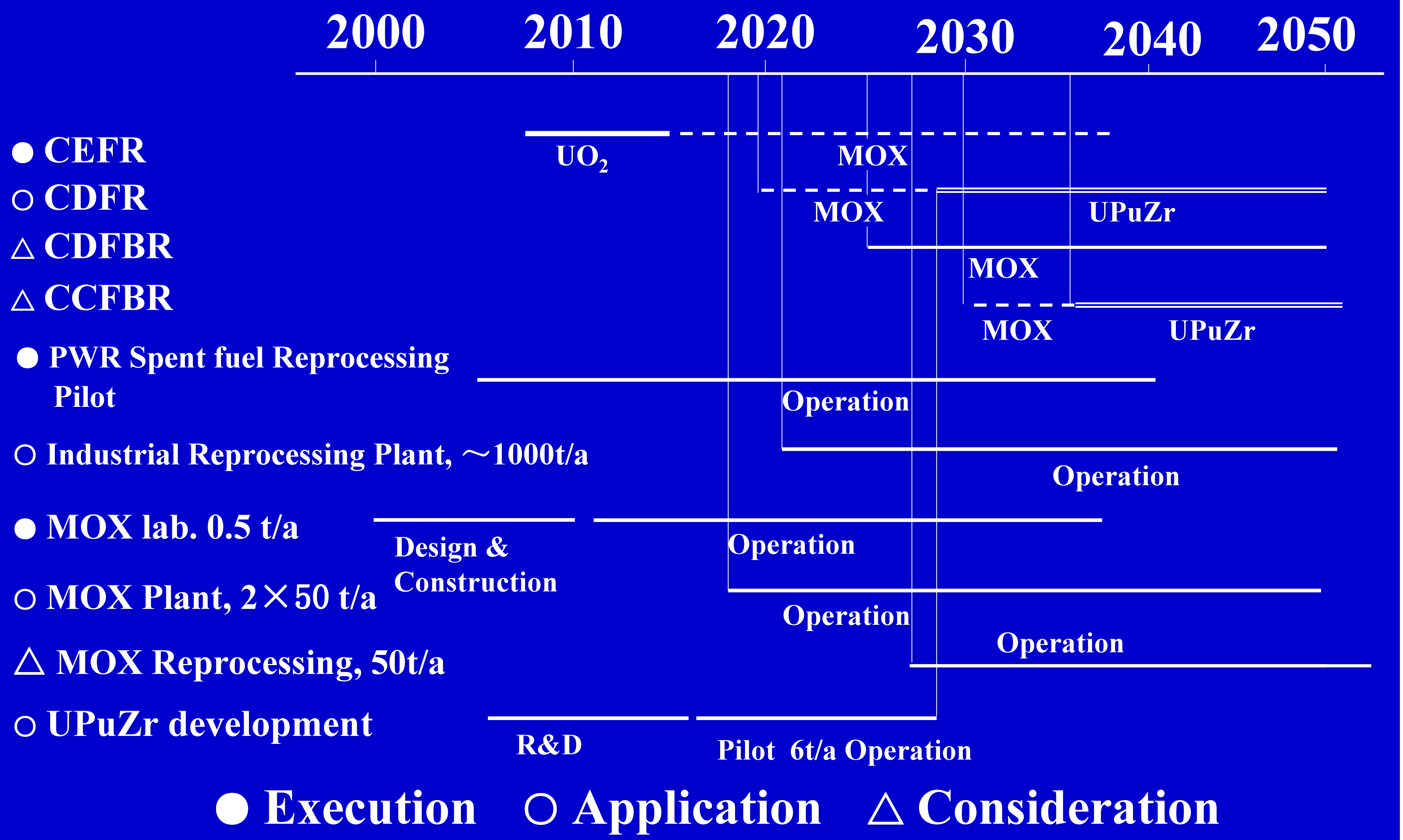

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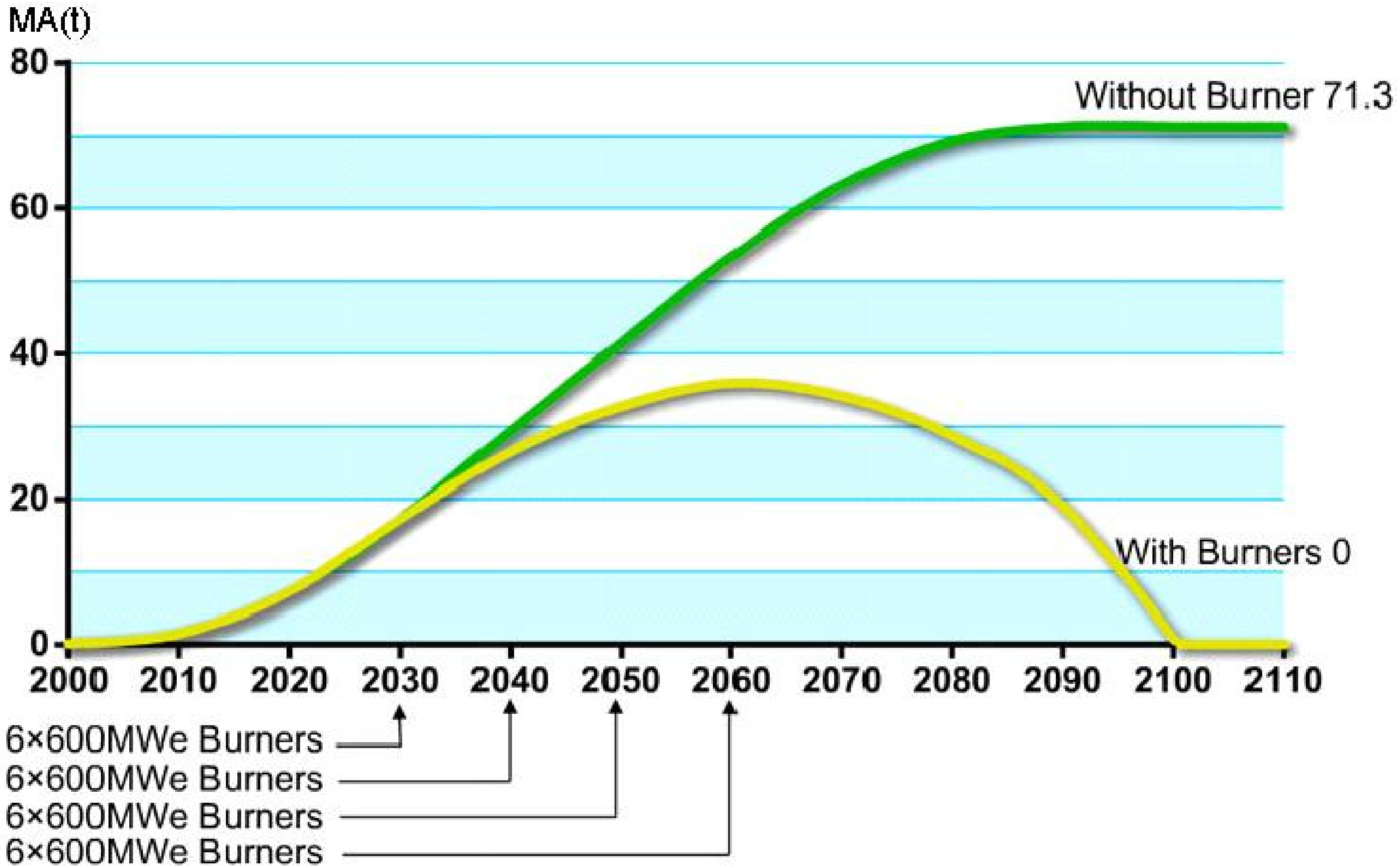

MA Transmutation Strategy

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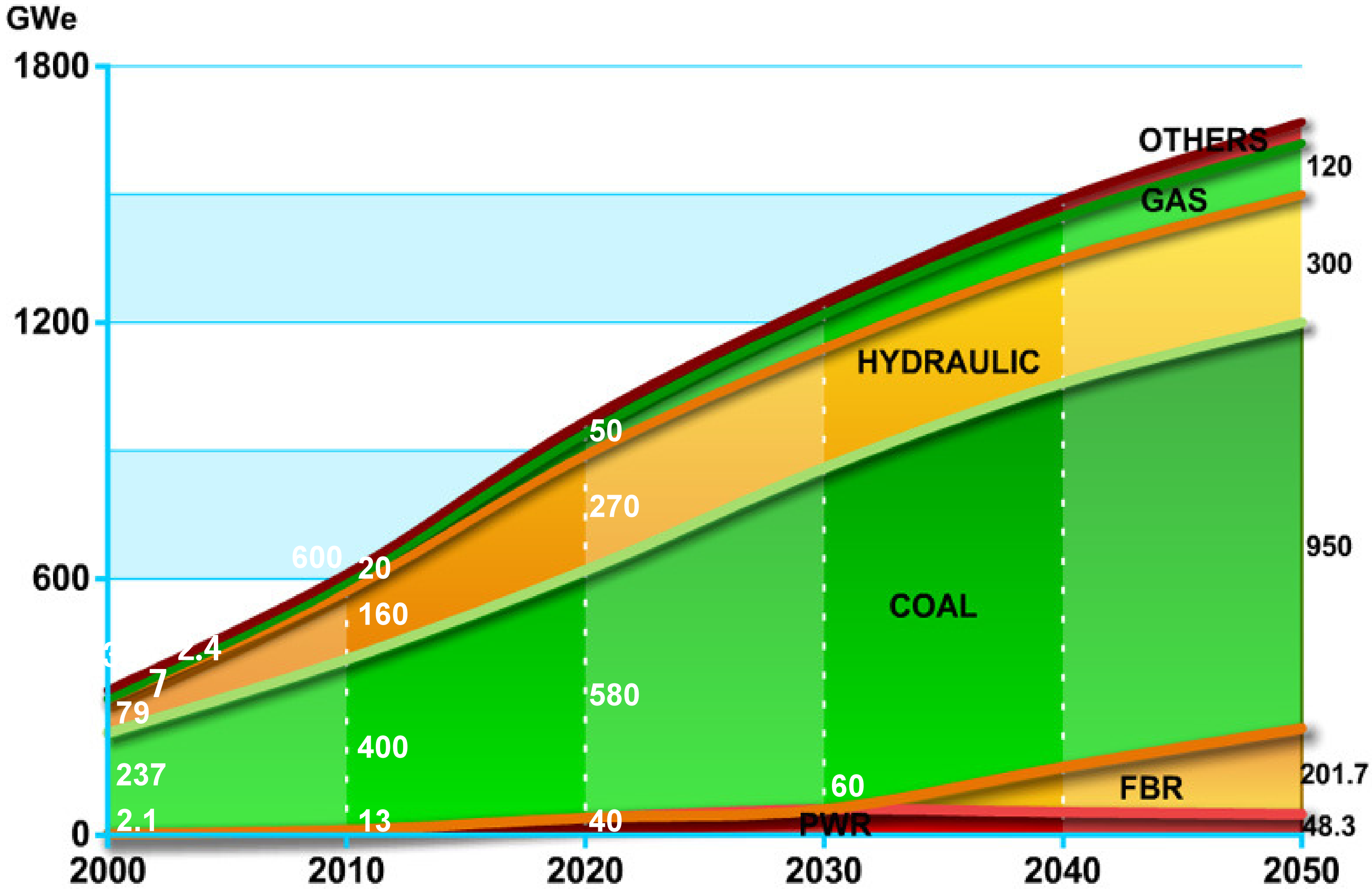
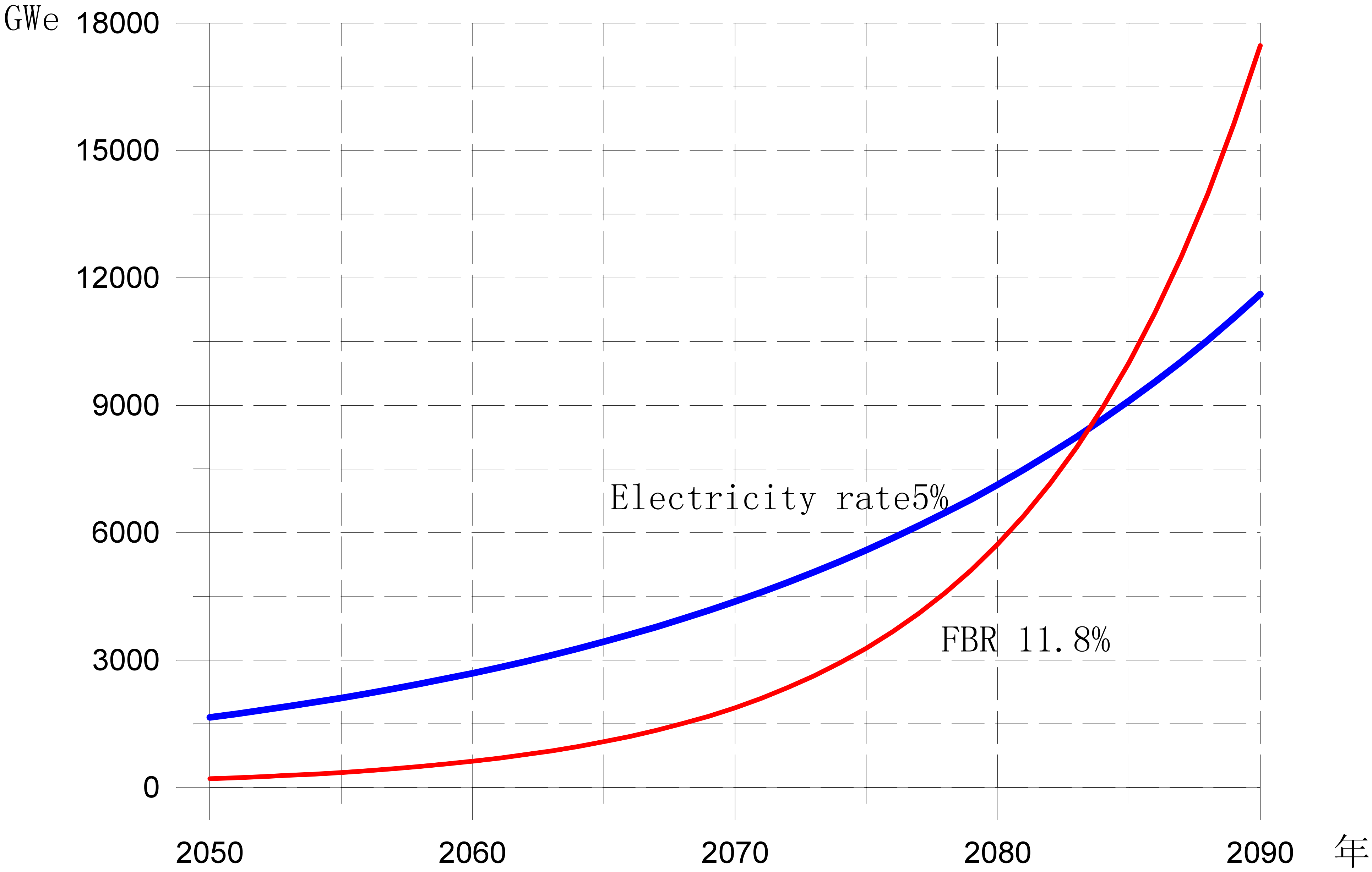


Electric Capacity Development Envisaged In China



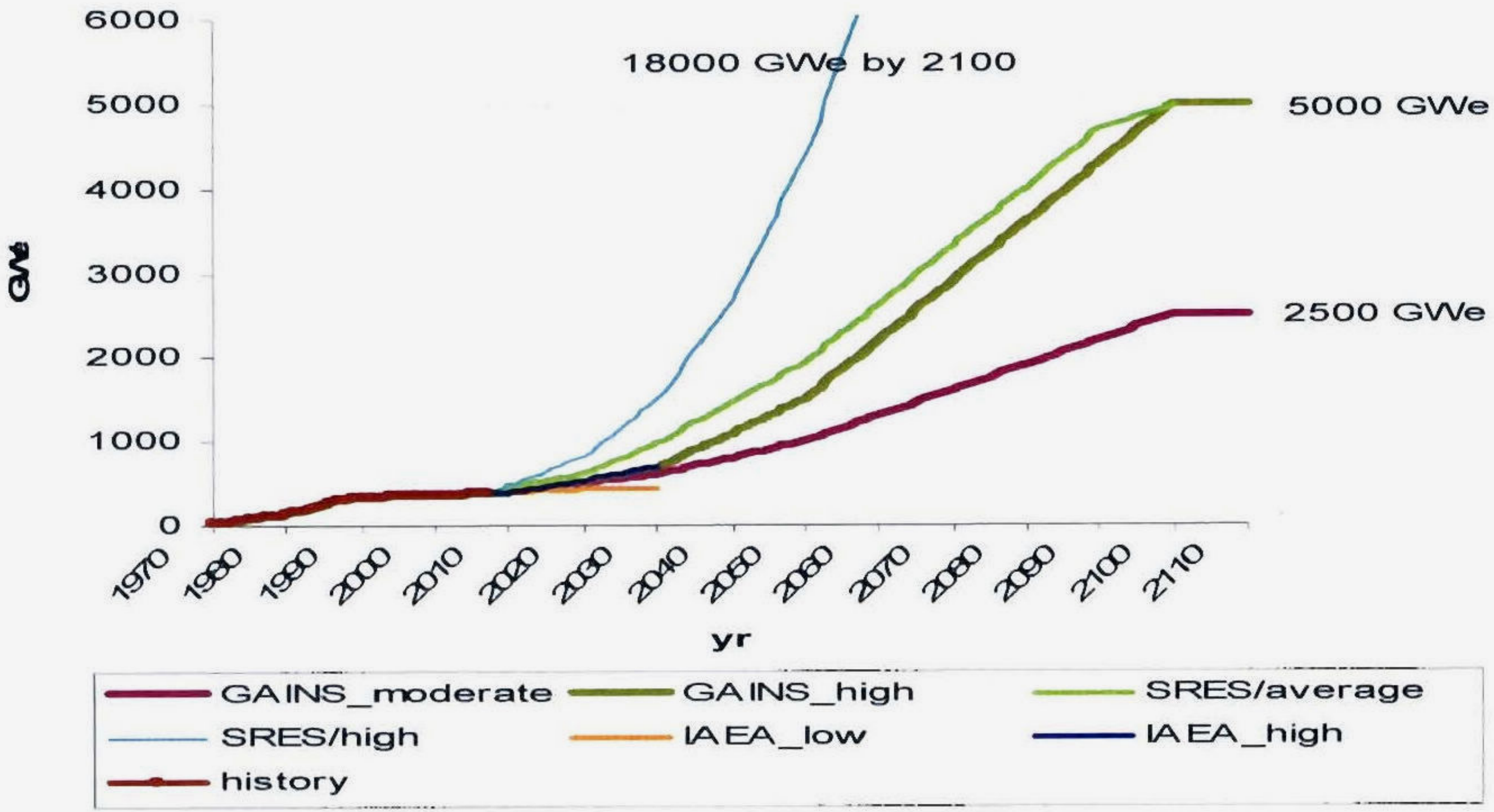
National electricity and FBR annual increasing rate

China needs a huge nuclear power capacity in future. Her first phase of nuclear energy application is rather quick for development with PWRs from now, the second phase, i.e. fast reactor development is still at its experimental stage. China has taken part in the INPRO ,GIF and GNEP, and is willing to have more cooperation with IAEA and other countries to share each other the experiences, and to speed up the national nuclear power development.

2. Expectations to MONJU

- **The world needs Fast Reactors**

As we know that the fossil energy shared about 88% by 2006 in the world. In the global economy and energy development point of view, rather quick development of nuclear power is necessary.



Global scenarios for modelling nuclear power capacities.

(Cited from 2008 Progress Report, INPRO)

It is envisaged that a large scale nuclear power capacity will be needed in the future. Up to now identified uranium resources is about 5.5 million t less than $130/kgU (Cited from Nuclear Technology Review,2009), only could support 550 GWe PWRs operating for 60 years. Any country who will use nuclear energy in large scale should consider uranium supply security.

To develop fast reactors and related closed fuel cycle is the best way, because it provides us the highest efficiency of utilization to uranium resources.

- **Japan Fast Reactor Program has made important contributions to the world**

The fast reactor technology has been developed during past almost 50 years in the world. It could be seen that along with construction and operation of about 20 diversified and different sized sodium fast reactors (SFRs), the SFR engineering technology has been matured which is marked by safe and rather satisfied operation for 350 reactor years. The avant-courier countries including Japan have paved the way to go to the developing phase aimed at higher reliability of components and systems and economical competition of the SFR Plants.

- **Japan Fast Reactor Development needs MONJU**

MONJU Prototype Fast Reactor is an important milestone for fast reactor technology going to its commercial utilization. due to the main physico-thermal parameters is almost same or much closed to those of its following –up commercialized ones and the components and systems with industrial size could extrapolate not so large to commercialized fast reactors.

- **MONJU also is the requirement of nuclear industry section to enlarge its markets**

The restart-up and operation of MONJU will be a very important campaign to demonstrate its safety and reliability properties and to accumulate experiences on design, construction and operation for following-up steps. If so, the suppliers of materials, equipments and components used in MONJU will get competitive profits in the nuclear power markets.

- **MONJU will support to solve our worry about high radioactive wastes**

MONJU will be a powerful irradiation tool for high burn-up fuel of fast reactors and for MA-bearing fuel of fast burners. The complete fuel database will provide important support to economical competitiveness of fast reactors and to decreasing of high radioactive waste volume to be buried geologically.

- **MONJU will give the contribution to important technique selection for fast reactor**

After BN-350 (1973-1999 Kazakhstan) decommissioning, MONJU is a unique loop type fast reactor with prototype scale in operation which will offer more realistic experiences to evaluate safety, reliability, economics and maintenancability for comparison between pool and loop fast reactors.

- **The international cooperation is waiting for the supports from MONJU**

Under the framework of Generation-Ⅳ International Forum the R&D program is recently concentrated on safety, advanced fuels, component design and balance-of-plant study, global actinides cycle and system integration and assessment which reflect SFR developing targets: safety, economical competitiveness, environment consideration and non-proliferation and physical protection. To all these fields as a research platform, MONJU could offer its important contributions.

3. Summary

So the requirement to restart-up and operation of MONJU and hoping it to provide important contributions to fast reactor technology development are not only coming from its native Country Japan, but also from the world.

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