

# Important matters in realizing commercial FBR cycle

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International Conference on Fast Reactors  
and Related Fuel Cycles

Young Generation Event

**Takahiko Ito**  
**Japan Atomic Energy Commission**



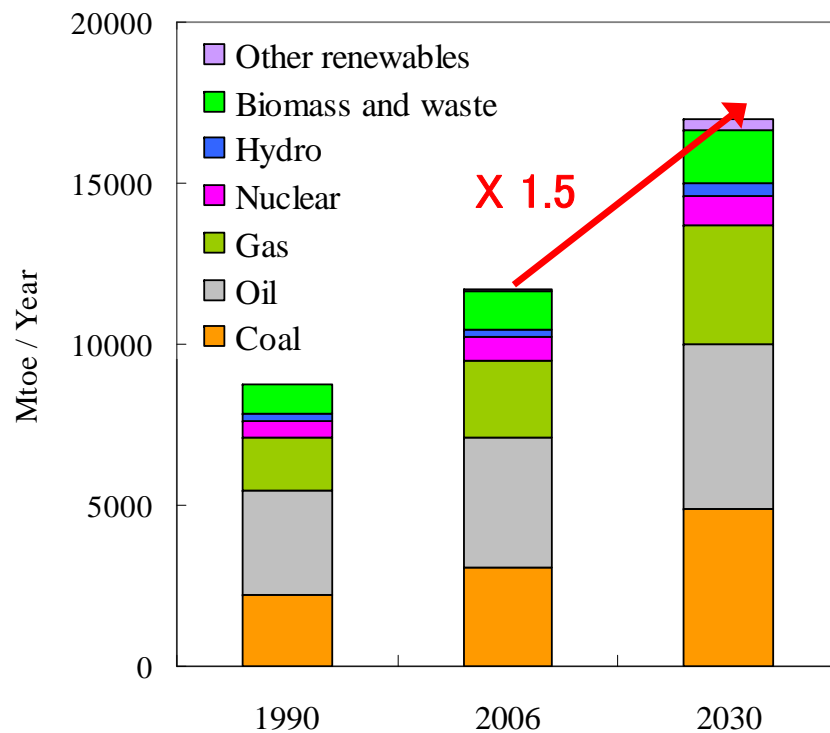
# Preface

- ❁ In realizing commercial Fast Breeder Reactor Cycle, research and development of innovative technologies, conceptual design of commercial and demonstration FBR and cycle facilities, and construction and operation of the facilities are essential. I sincerely hope that you, young generation will work hard on these field passionately and succeed in commercializing FBR cycle.
- ❁ Today, assuming that these activities would have done successfully, I'd like to show you what I recognize very important things in realizing commercial FBR cycle except for the above mentioned research and development activities, as a person who spent many years in the fields of nuclear power generation.

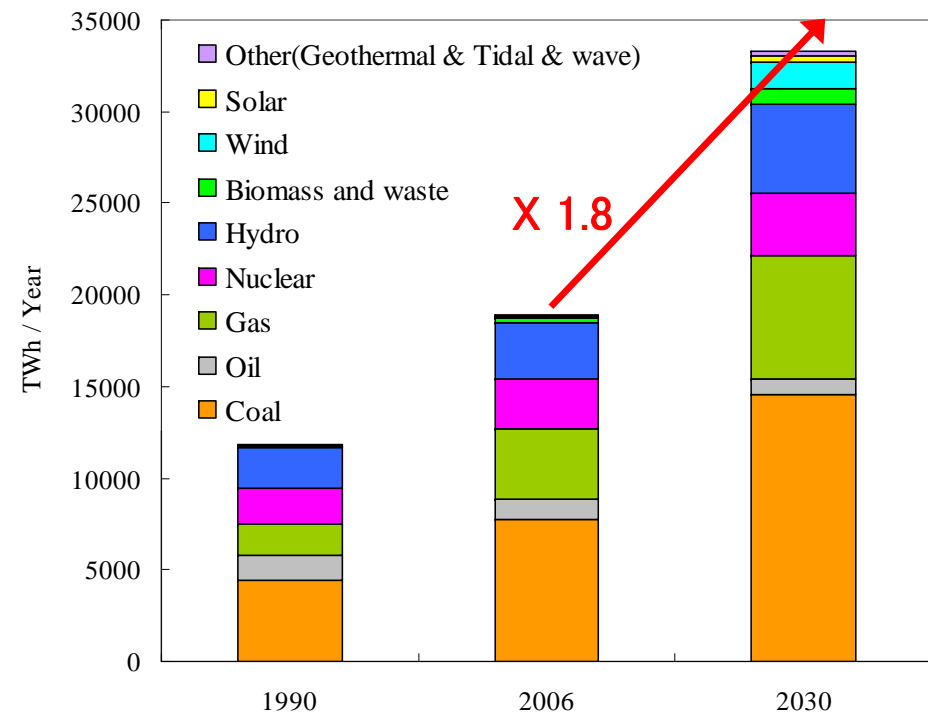
# Primary Energy and Electric Production in the World

- International Energy Agency expected primary energy demand and electric production increase 1.5 and 1.8 times each in 2030.
- Nuclear Energy contribute constantly (Primary Energy Supply 5%, Electric Production 10%)

## Primary Energy Supply

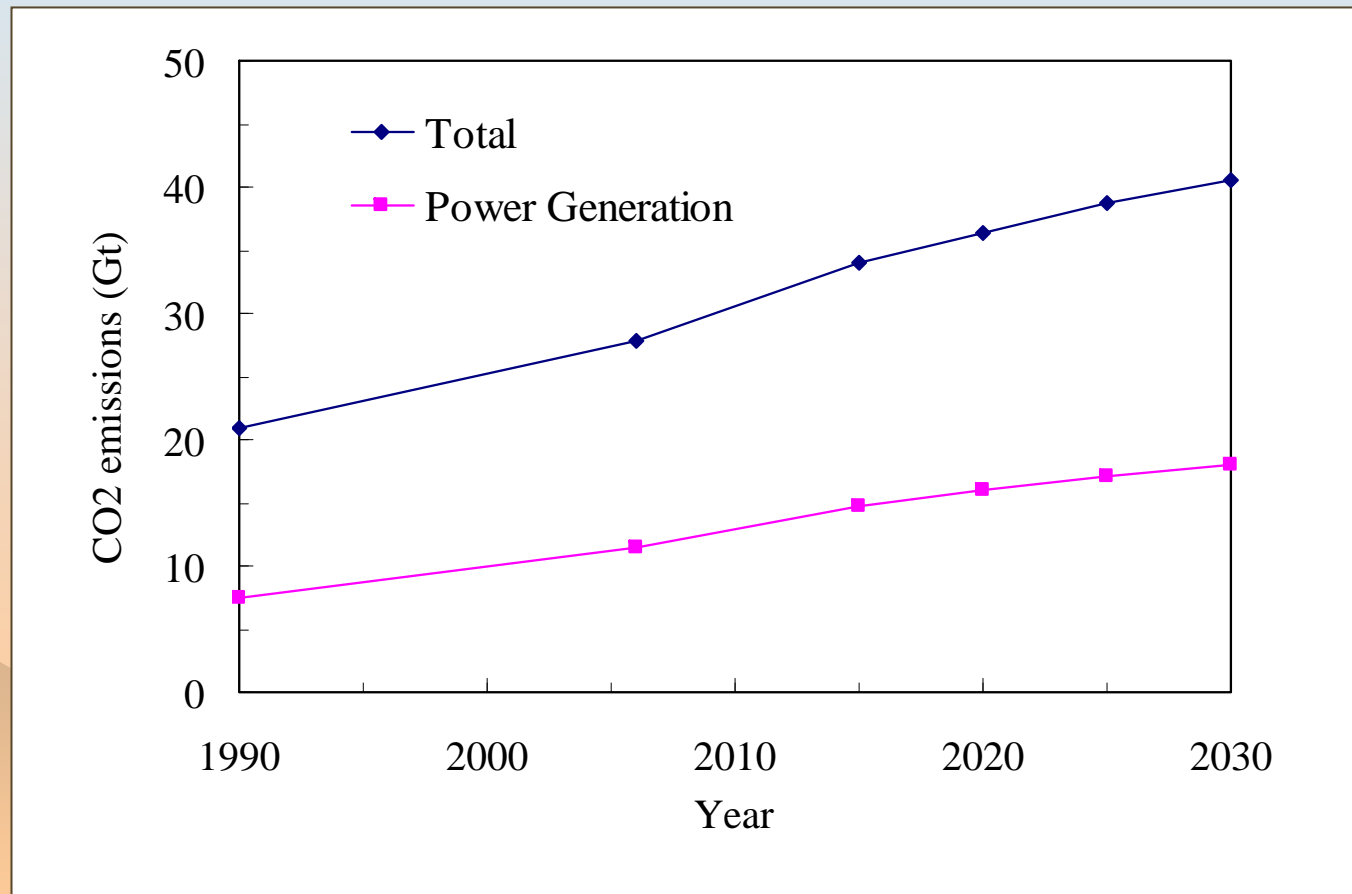


## Electric Production



# World CO2 emissions

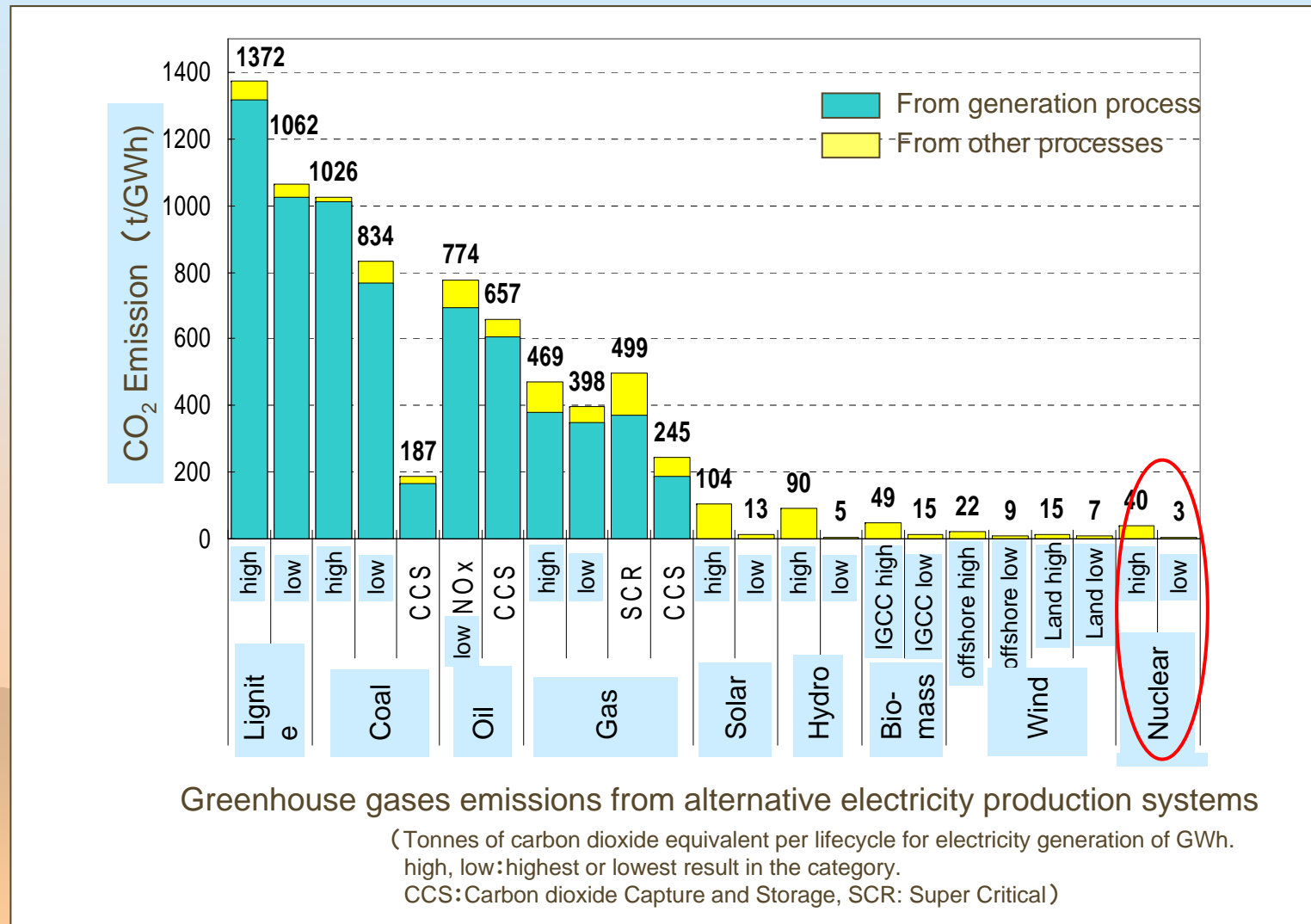
- Emission of carbon dioxide in the world is increasing.
- Measures to reduce emission should be taken to prevent the global warming.



Source: World Energy Outlook 2008

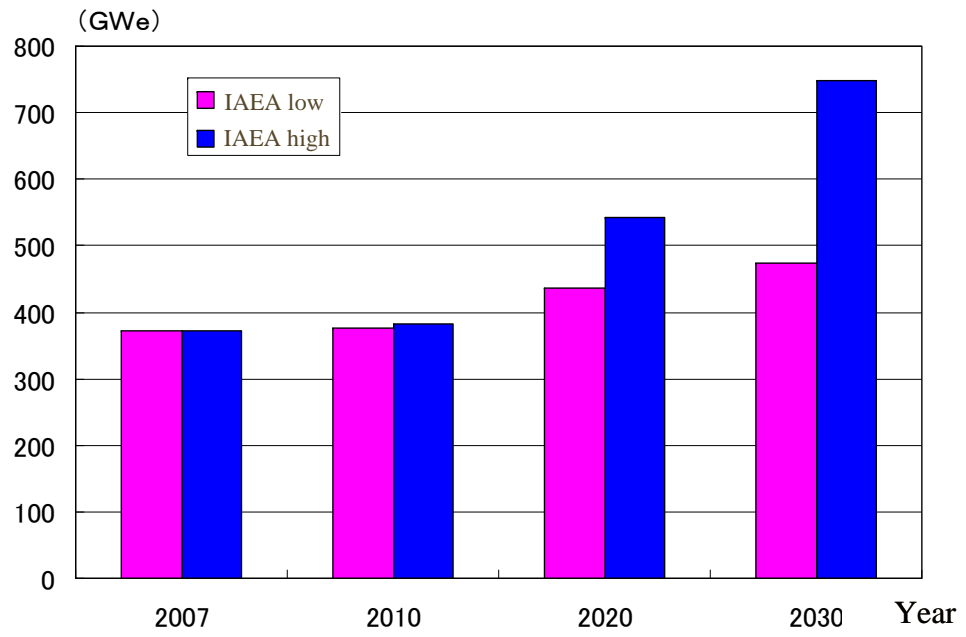
# Lifecycle CO<sub>2</sub> Emission from Alternative Electricity Sources

Nuclear energy is expected as a low carbon dioxide electric power generation, which is essential as a measure for global warming.

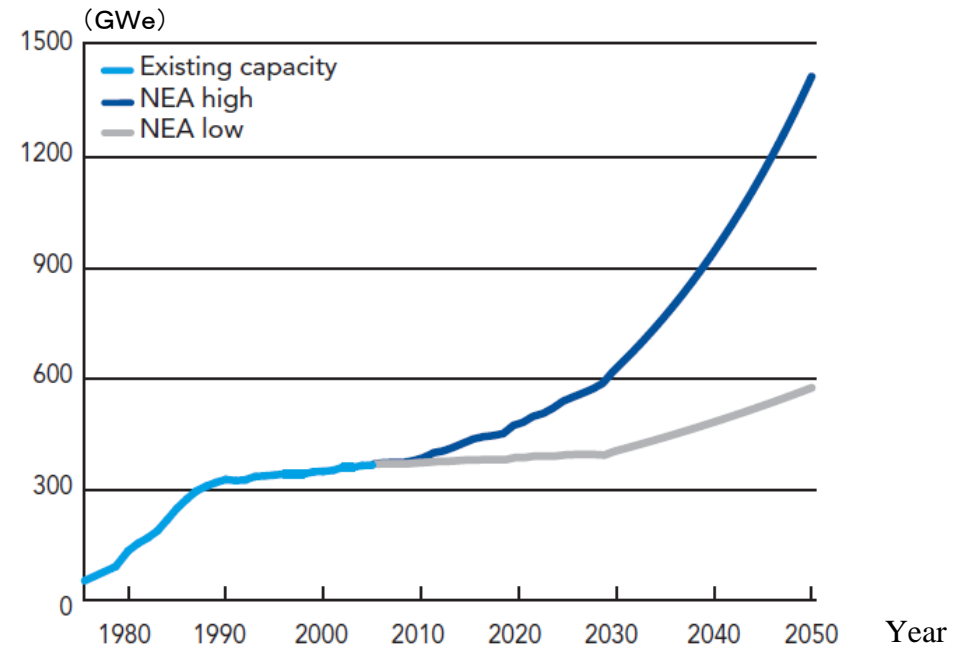


# Expectation of Nuclear electricity power generation

Nuclear electricity power generation is expected to increase.



Source: Energy, Electricity and Nuclear Power Estimates for the Period up to 2030, 2008 Edition, IAEA RDS-1



Source: Nuclear Energy Outlook 2008, OECD/NEA



# Limit of Energy Resources

- Most of energy resources is expected to dry up by the end of this century, unless additional resources are found.
- Innovative technologies including Fast Breeder Reactor cycle, Thorium cycle, Recovery of uranium from seawater have possibility to expand utilization of energy resources drastically.

	Coal *1	Oil *1	Gas *1	Nuclear *2				
				Once-through	MOX recycle in LWRs	FBR cycle	Thorium cycle	
Reserve-production ratio (Year)	122	42	68	100	130	> 3000	-	
Reserve	909 bt	165 bt	181 tm <sup>3</sup>	5400 kt				2.5 Mt
Production (/Year)	6.2 bt	3.9 bt	2.87 tm <sup>3</sup>	40 kt				-
Note	-	-	Research of Recovery technology of Uranium in seawater (4.5 bt) is being performed in the Japan Atomic Energy Agency. *3	The resource can be extended by about 30% by reprocessing fuel and recycling fissile material as mixed oxide fuel (MOX) in LWRs.	-	-	-	

\*1 BP statistics 2009 (As of the end of 2008)

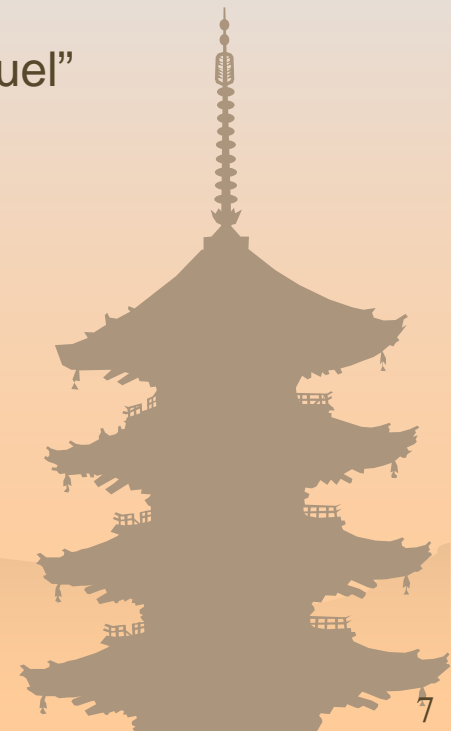
\*2 OECD/NEA, Nuclear Energy Outlook 2008

\*3 Masao Tamada, Recovery of uranium from seawater by graft-adsorbent, Japan Atomic Energy Commission 20<sup>th</sup> Commissioners' meeting in 2009 (Japanese).

# Recent Proposals on Multi-lateralization of Nuclear Fuel Cycle

## 12 Proposals on Assurance of Fuel Supply (AOS):

- U.S. Proposal on a Reserve of Nuclear Fuel (2005)
- Nuclear Threat Initiative (NTI) Fuel Bank (2006)\*
- Global Nuclear Energy Partnership (2006)
- Global Nuclear Power Infrastructure (2006)
- World Nuclear Association (WNA) Proposal (2006)
- Six-Country Proposal (2006) – “Reliable Access to Nuclear Fuel”
- IAEA Standby Arrangement System (2006)
- UK Nuclear Fuel Assurance Proposal(2007)
- International Uranium Enrichment Centre (2007)
- Multilateral Enrichment Sanctuary Project (2007)
- Multilateralisation of the Nuclear Fuel Cycle (2007)
- Russian LEU Reserve Proposal (2009)



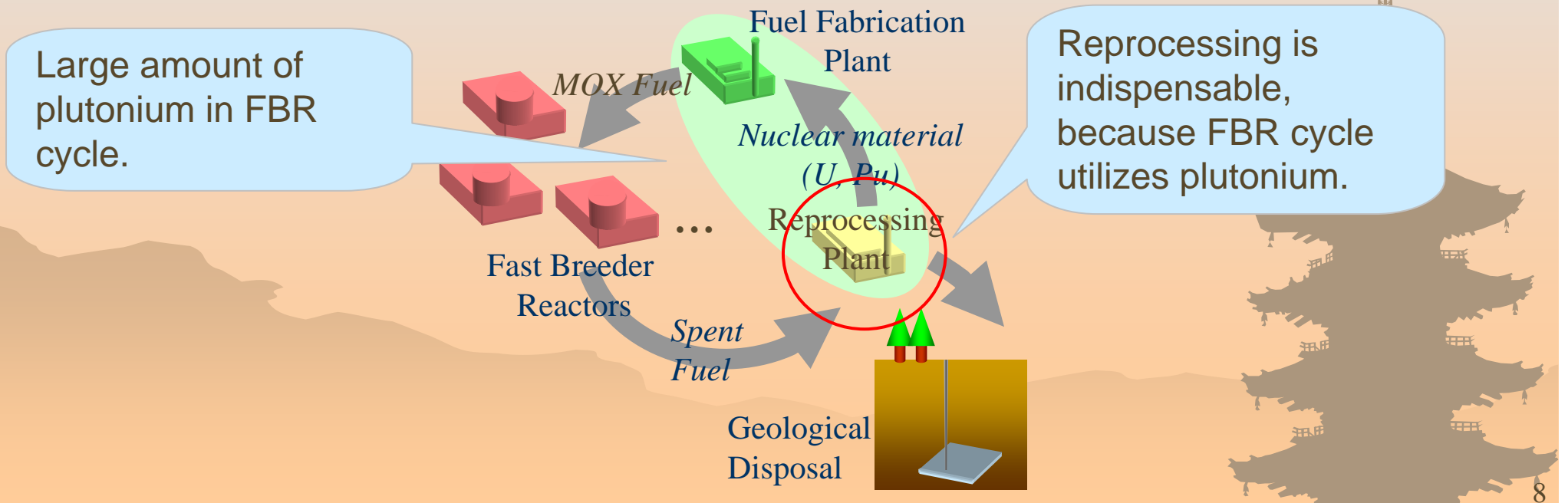


# Commercial FBR Cycle - Characteristics -

- ❁ Large amount of plutonium is utilized.
- ❁ Reprocessing is indispensable.

Ex) If world nuclear generation capacity (372GW in 2009) is replaced by FBRs, about 450t plutonium fissile is utilized all over the world in equilibrium period. The amount is 60 times larger than the amount to be recovered at the Rokkasho Reprocessing Plant (800 tHM UOX).

\* Recovered plutonium at a reprocessing plant, high enriched uranium and U-233 is more sensitive nuclear material and required more strict management in safeguards and security than low enriched uranium or used nuclear fuel.



# Amount of Plutonium in commercial FBR cycle in equilibrium period

	1 GW FBR	Replacing existing nuclear energy capacity into FBRs	
		Japan's Nuclear energy capacity in 2009 (48GW *2)	World Nuclear energy capacity in 2009 (372GW *2)
Pu in new MOX Fuel (tPuf/year)	0.7 *1	34	260
Compared with Recovery Pu in Rokkasho Reprocessing Plant (800tHM) (4 - 5 tPuf/year) *3 (-)	0.2 times	8 times	58 times
Compared with Plutonium held in Japan in 2009 (UK: 11.4, France: 13.8, Japan: 6.6, Total 31.8 tPuf) (-)	0.02 times	1.1 times	8.2 times

\*1 Future perspective in nuclear fuel cycle (Technical Review), Japan Atomic Energy Commission 28th Commissioners' meeting in 2009 (Japanese).

\*2 [http://www.jaif.or.jp/ja/news/2009/ichiran2009\\_data.pdf](http://www.jaif.or.jp/ja/news/2009/ichiran2009_data.pdf)

\*3 Estimated from "Current situation of Rokkasho Reprocessing Plant and MOX fuel fabrication Plant", Japan Atomic Energy Commission 9th Commissioners' meeting in 2009 (Japanese).

# Commercial FBR Cycle - Challenges -

## Challenges

Plutonium management measures including safeguards and security, and public acceptance are essential, because of large amount of plutonium utilization.

### 1. Plutonium management (Nonproliferation: Safeguards and Security)

Commercial FBR cycle have to handle greater amount of plutonium than exist cycle facilities. In light of this matter, efficient safeguards and security measures should be taken. Otherwise economical operation of FBR cycle could be difficult because of safeguards and security burden.

### 2. Public Acceptance

In early stage of research and development of FBR cycle, efforts to explain and share goals and challenges of FBR cycle should be taken. It is vital to explain to public that large amount of plutonium is utilized in the FBR cycle and appropriate measures are to be taken for FBRs and related cycle facilities.



# Nonproliferation

## Issues

### (Safeguards)

- ❁ Commercial FBR cycle is required huge number of safeguards inspections, if conventional safeguards methods are applied.
- ❁ Under the circumstances that we have to handle large amount plutonium, development of advanced safeguards is important.

### (Security)

- ❁ Large number of reprocessing plants, MOX fuel fabrication plants and FBRs that handle large amount of plutonium and require high level security measures will be deployed in many countries. And in transportation among them if necessary, security measures are also needed.

# Nonproliferation

## Challenges

- ❁ Development of advanced safeguards technologies and “Safeguard by Design” concept is needed taking the large burden and requirement of safeguards caused by the increased fuel cycle facilities and amount of plutonium into account.
- ❁ Recently, there are many activities concerning nuclear security. The International Atomic Energy Agency has been preparing standard documents. Nuclear security summit will be held in next march. Taking this opportunity, nuclear security measures should be strengthened.
- ❁ In realizing commercial FBR cycle, nonproliferation measures including safeguards and security should be considered to meet not only these requirement but also economic reasonability.
- ❁ Proliferation resistance technology is difficult to ensure nonproliferation by itself so far. But, it is still important to develop these technologies to strengthen nonproliferation as a supplementary measure.
- ❁ Collocation of a reactor and cycle facility like Integral Fast Reactor (IFR) concept by the USA might be one of ideas to solve this issue.
- ❁ Multilateral approach of fuel cycle would be helpful to enhance its regime. Second track discussion to seek the feasibility should be taken.

# Public Acceptance

## Issues

- ❁ Public must be well informed challenges associated with the development and operation of commercial FBR cycle.

## Challenges

- ❁ Goals and challenges of FBR cycle should be shared through dialogue with public in early stage of research and development for accountability.
- ❁ It should be explained to public that large amount of plutonium is utilized in the FBR cycle and appropriate measures are to be taken for FBRs and related cycle facilities.
- ❁ International dialogue is also important to keep transparency of utilization of large amount of plutonium.
- ❁ Solutions for the challenges, which are hopefully easy-to-understand, must be explained to public.

# Message to young generation

- ❁ Big challenges for future commercial FBR cycle I showed here do not mean that it's impossible, as long as we have confidence that we can do it. I would rather say I believe FBR cycle is essential for human future.
- ❁ I expect that young generation in the world cooperates and competes keeping these important matters in mind and having a big dream and passion in realizing commercial FBR cycle.
- ❁ I'd ask young participants in the young generation session to express and exchange opinions actively using this opportunity.

**Thank you for your kind attention!**

