

Seminar in Croatia, May 21, 2007

# Nuclear Power in Japan and World Trend

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# Two Major Challenges of Energy Policy

- ◆ Security of Energy Supply
- ◆ Environmental Conservation – Mitigation of Global Warming-

Nuclear Energy Can Contribute for Addressing Both  
But, Nuclear Energy Shares Only 7% of Primary  
Energy

Talking points

- ◆ World nuclear energy trend
- ◆ Japan's nuclear energy policy

# Nuclear Power Growing in Asia

## World wide

- ◆ 442 Nuclear Power Plants in 30 Countries
- ◆ 368GW Generating Capacity Supplying 16% of the World's Electricity
- ◆ Of 28 New NPPs under Construction  
16 in Developing Countries Mostly in Asia

# IAEA Projection

2030: 423 ~ 640 GW

2005: 368 GW

+55 ~ 272GW for 25 years

- Rapidly growing energy demands
- Climate change concern
- Quest for energy independence
- Good economic performance

# Power Demand and Generation Outlook (IEA)

World electricity demand and generation doubled in the next 25 years (2030)

	<u>2005</u>	<u>2030</u>	
Coal	40	44	(%)
Gas	20	25	
Renewable (excl. hydro)	2	7	
Nuclear	16	10	(low case)
Hydro	16	16	1

4

# Nuclear Rapidly Expanding In Asia

**Japan:** 55NPPs in operation (49GW) 30% of electricity  
2NPPs under construction 11NPPs under planning  
(2017)

**China:** 10NPPs in operation(8GW), 5NPPs under  
construction, about 30 new NPPs will be  
completed (total 40 GW, 4% of electricity) and  
18 under construction by 2020

**India:** 15NPPs in operation(3GW), 8NPPs under  
construction 20-40GW in 2015  
500 MW FBR to be completed in 2010

## In Asia(2)

**ROK:** 20NPPs in operation (17GW), (40% of Electricity) 4 NPPs under construction, 4 under planning

**Viet Nam:** The Prime Minister decided in Jan. 2006 2NPPs(2GW)in operation 2020

**Indonesia:** The President decided Jan in2006 2NPPs (2GW) in operation 2018

# Nuclear Renaissance in USA

## USA:

103 NPPs (127 GW) in operation

No new construction after TMI Accident (1979)

Comprehensive Energy Act (2005)

◆ Encouraging NPPs construction by tax exemption, insurance of financing

- Some 27 new NPPs under planning

◆ Proposal of GNEP (Global Nuclear Energy Partnership) (2006) to develop and deploy technology for recycling SF not resulting in separated Pu.



# Nuclear Renaissance in Europe (1)

**France:** 59NPPs(63GW) in operation  
-EPR(1.6GW) to be in operation in 2020  
-Commercial FBR in 2040

**U K :** 23NPPs (11GW) in operation  
No new construction of NPP after 1989  
-The Government announced in July, 2006 the new policy to start construction of NPPs for energy security

**Russia:** 31 NPPs (22GW) in operation, 4 NPPs under construction. Additional 57 NPPs to be in operation by 2030 (nuclear power share to be 25%)

## Nuclear Renaissance in Europe (2)

**Finland:** 4 NPPs (2.7GW) in operation  
EPR (1.6GW) under construction to be in operation 2009

**Poland:** No NPP, 95% electricity by coals  
New Administration announced the policy to start NPP construction to be operated in 2021-2022 (2006)

**Turkey:** Plan to built 5GW NPPs

# Energy Self-Sufficiency Ratio of Japan Only 4% (Hydro-Power)

## Fragile energy security:

Oil	50%
Coal	19%
LNG	13%
Nuclear	14%
Hydro	4%

(2001)

- 85% Oil from Middle East

- Nuclear & LNG have replaced oil,

Oil: '73 77% to '01 50%

Nuclear: '73 1% to '01 14%

- In 2007: 55 NPPs in operation **Total 49GW**

- **2 NPP** under construction, additional **11 units** to be completed by 2017

# Basic Plan and Policy for Energy of Japan (METI, 2006)

1. Active promotion of nuclear power
2. Steady increase in using new types of energy
3. Promotion of saving energy and leading international effort to mitigate the global warming
4. Strengthening international relations to secure energy resource
5. Strengthening development of energy related technology

# Framework for Nuclear Energy Policy of Japan (AEC) 2005

## Major Points -1

- ◆ Increased contribution of nuclear energy to the energy security and the control of CO<sub>2</sub> emission.
- ◆ Through 21st century the ratio of nuclear power should be kept at the current level of 30-40% or higher.
- ◆ The 1st commercial spent fuel reprocessing plant will be in operation in 2007. All of separated Pu will be used for MOX fuels of 16-18 LWRs.

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# Framework for Nuclear Energy Policy (AEC) 2005

## Major Points-2

- ◆ FBR and its fuel cycle should be developed to commercially introduce them around 2050. This contributes the energy security and reduction of long-lived high level radio-active wastes. Prototype FBR "Monju" will be re-started around 2008.
- ◆ R & D on FBR, high temperature gas cooled reactor for hydrogen production and fusion will be strengthened.

# Nuclear Fuel Cycle Policy

## Rationality

- ◆ Better energy security in long term by efficient utilization of Pu and U.
- ◆ Better environmental compatibility by reducing TRU in high level radioactive wastes.
- ◆ Costs of recycling fuel are ¥ 0.5~0.7/kWh (¥ 600~ ¥ 840 per house hold per year)
- ◆ Uranium price has been rapidly increasing from US\$7.1/lbU<sub>3</sub>O<sub>8</sub> in '00 to US \$32.0/lbU<sub>3</sub>O<sub>8</sub> in '05.

# High Level Radioactive Wastes Disposal

- Sub-surface (more than 300m depth) repository
- Preliminary study will be made for sites to be proposed by local governments.
- Disposal (commercial) around 2030

## Research on geological disposal

Two research facilities in sub-surface to improve safety assessment of methodology are under construction.



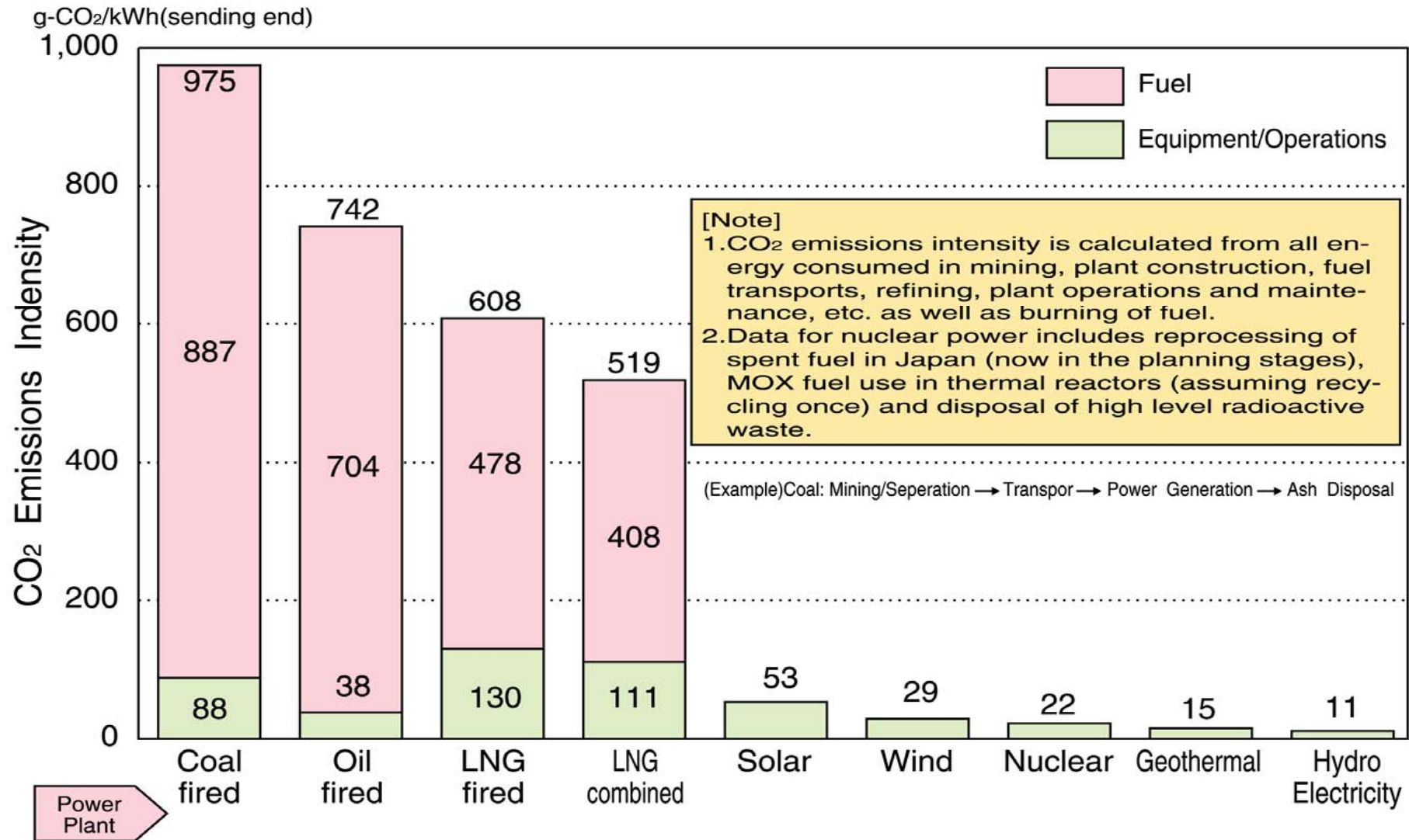


# Fourth Assessment Report of UNIPCC (Feb. '07)

Global Warming is being very likely due to observed increase in anthropogenic GHG concentration

- Past 100 years average temperature has risen 0.74 °C
- By 2100 average temperature will rise by 1.1-6.4°C
- By 2100 sea level will rise by 18-59cm
- CO<sub>2</sub> concentration was 280ppm before the industrial revolution and rose to 379ppm in 2005.
- CO<sub>2</sub> emission will increase by 55% from 2004 in 2030 (IEA)

# Japan's Lifecycle Assessment CO<sub>2</sub> Emissions Intensity by Source



(Source) Central Research Institute of Electric Power Industry Report etc.

# CO<sub>2</sub> Emission in Japan

1990 1.261 billion ton

2004 1.355 billion ton (+7.4%)

2005 1.364 billion ton (+8.1%)

In compliance with Kyoto Protocol: 1.185 billion ton (-6%)

# Japan Achieves High Energy Efficiency by Saving Energy

Produces 14% world GDP with emission of 5% CO2

	CO2 emission per GDP (ton CO2 / us\$1,000)	GDP per capita (us\$1,000 / person)
<b>Japan</b>	<b>0.21</b>	<b>44.8</b>
France	0.20	29.1
Germany	0.31	32.7
<b>USA</b>	<b>0.64</b>	<b>32.6</b>
Mexico	0.99	3.9
India	2.06	0.5
<b>China</b>	<b>2.67</b>	<b>1.0</b>

# Cost Comparison of Nuclear Power by IEA

Nuclear 4.9 – 5.7 cents/kwh

- ◆ Cheaper than gas based power at gas prices above \$4.7- 5.7/MBtu  
(in 2005 international average price \$ 6.13/MBtu)
- ◆ More expensive than coal unless coal price above \$70/ton (\$55/ton in 2005)

# Nuclear Power Economics in Japan (METI/FEPC)

Nuclear 5.3 JPY/kWh

Coal 5.7

LNG 6.2

Oil 10.7

Hydro 11.9

Solar 66 JPY/kWh  
Wind 10-14 (2001)

40-year operation  
Interest rate = 3% / annum

# High Investment Cost (\$/kW) for Nuclear Power (IEA)

Nuclear 2000-2500

Gas 650

Coal 1400

## Plant Life (years)

40 –(60) Nucl.

25 Gas

40 Coal

# Improving Nuclear Power Plants Performance

## - Increases in Average Capacity Factor (%)

	<u>'90-'95</u>		<u>'01-'05</u>	
from	75	to	90	(USA)
	84	to	90	(Korea)
	70	to	80	(World)

◆ Modest capacity increases (USA) = 3GW

- Plant life extensions from 40 to 60 years (USA)



# Non-proliferation of Nuclear Arms

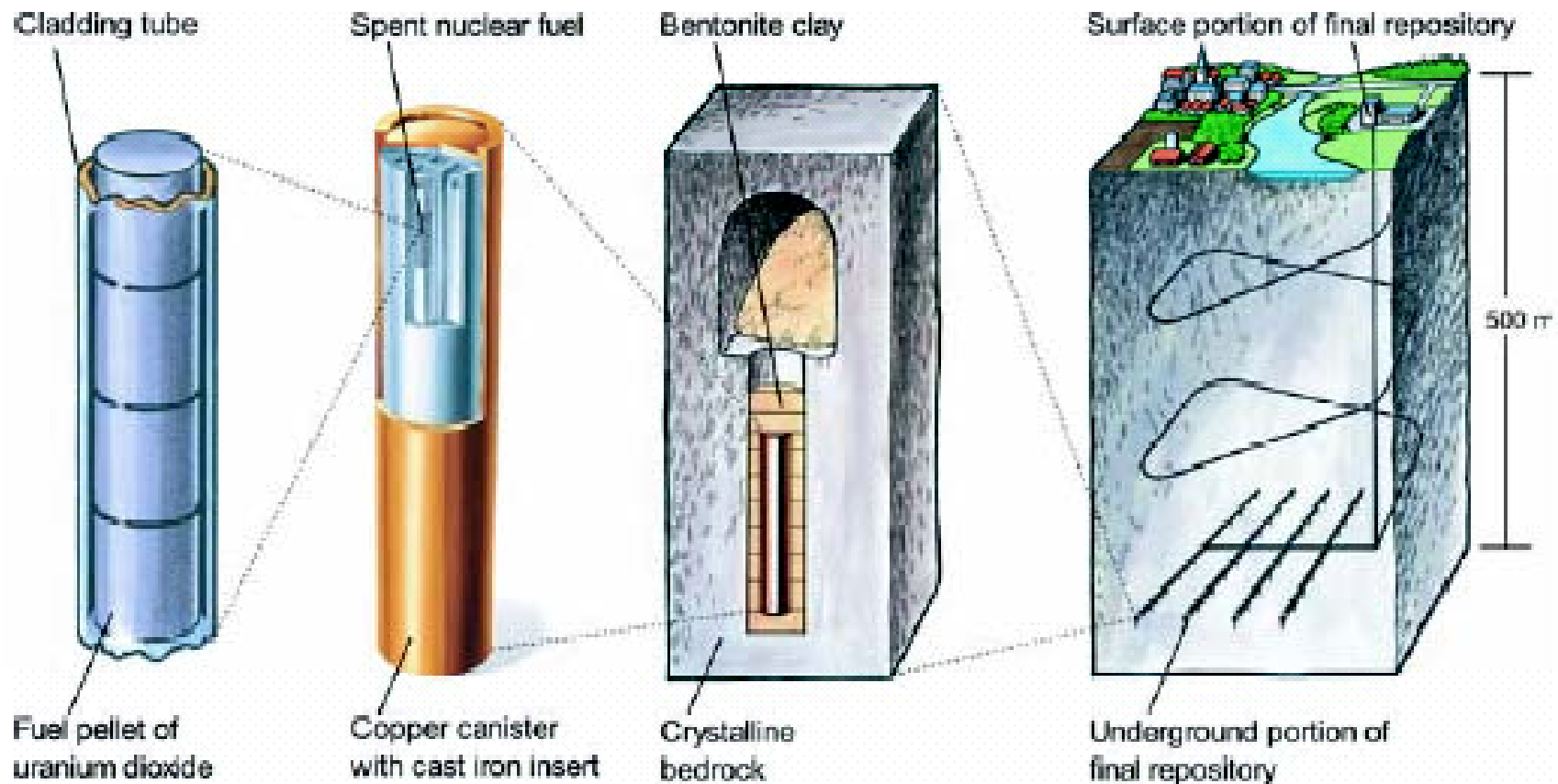
- ◆ NPT: 189 States  
non-NPT States: India, Pakistan, Israel
- ◆ Safeguard Agreement (IAEA) 156 States  
On-site inspection of nuclear materials. Accountancy of nuclear materials
- ◆ Strengthening IAEA SG by **the Additional Protocol (78 States)**
- ◆ El Baradei's proposal for Multi-lateral Nuclear Approach
  - International management of the enrichment and reprocessing plants
  - **Assurance of nuclear fuel supply**

# Public Acceptance of Nuclear Power



*FIG. A-2. Aggregate results of a global public opinion poll. Source: Global Public Opinion on Nuclear Issues and the IAEA: Final Report from 18 Countries, 2005.*

# Geological Disposal of Spent Nuclear Fuels (Sweden)

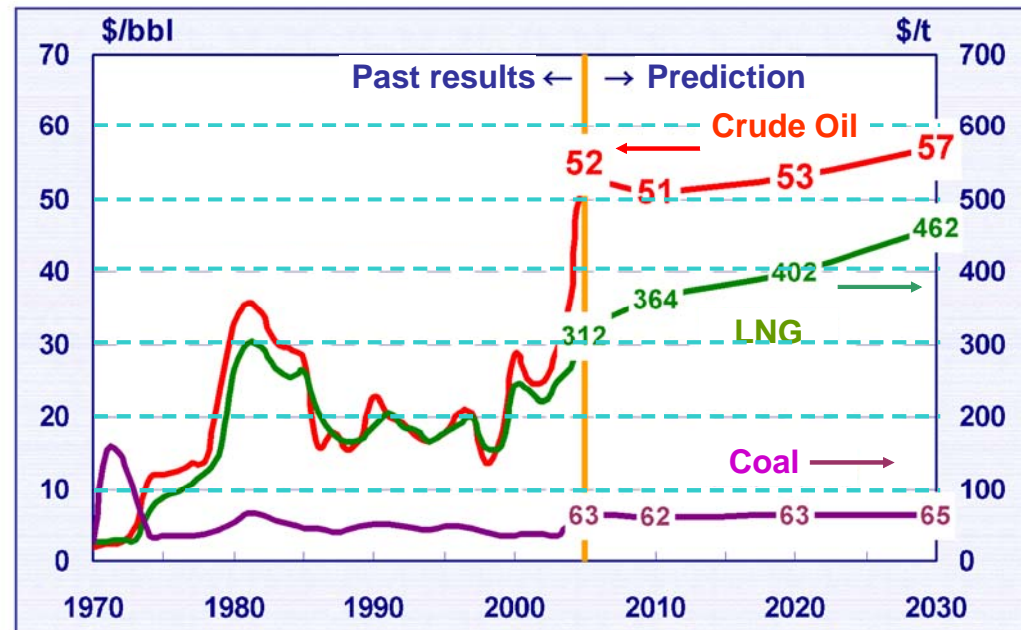


*FIG. 11-5. The Swedish concept for the disposal of spent nuclear fuel as an illustration of the multi-barrier concept.*

# Panel of FNCA (Forum for Nuclear Cooperation in Asia) Noted with Concern (2006)

- ◆ **Rapid increase of energy demand**
- ◆ More than 85% of energy is from fossil fuels
- ◆ **Increasing dependence on oil import and volatile oil price**

**Tremendous increase of oil and gas price**  
(IEEJ)



**Assurance of energy supply to meet development is the most important policy.**

# How to Address Problems (2006)

-Roles of Nuclear Power-

Panel noted:

1. Energy saving and **improving energy efficiency**
2. Energy source diversification and **balanced energy mix ratio**
3. **Introduction and expansion of nuclear power**
4. **Increasing renewable energy** such as hydro, bio-mass, geothermal, wind and solar
5. **Regional energy network** between countries

# Possible Inclusion of Nuclear Power in CDM (2006)

## Panel took note:

(a) Concern about **climate change** caused by CO<sub>2</sub> emission from fossil fuel burning and rapid **increasing of energy demand**

(b) **Nuclear power operation** does not emit CO<sub>2</sub>, SO<sub>2</sub>, and NO<sub>x</sub>

(c) Desirability of **exchanging views in COP** (the Conference of the Parties in the Climate Change Convention) on a possibility of including nuclear power in CDM (Clean Development Mechanism) of Kyoto Protocol

The inclusion of nuclear power in CDM **enhances its introduction and expansion** in developing countries **by fostering investment.**