31st WNA Symposium
September 6-8, 2006

Session III
National Perspectives

Current State and Future of Japan's Nuclear Power Program

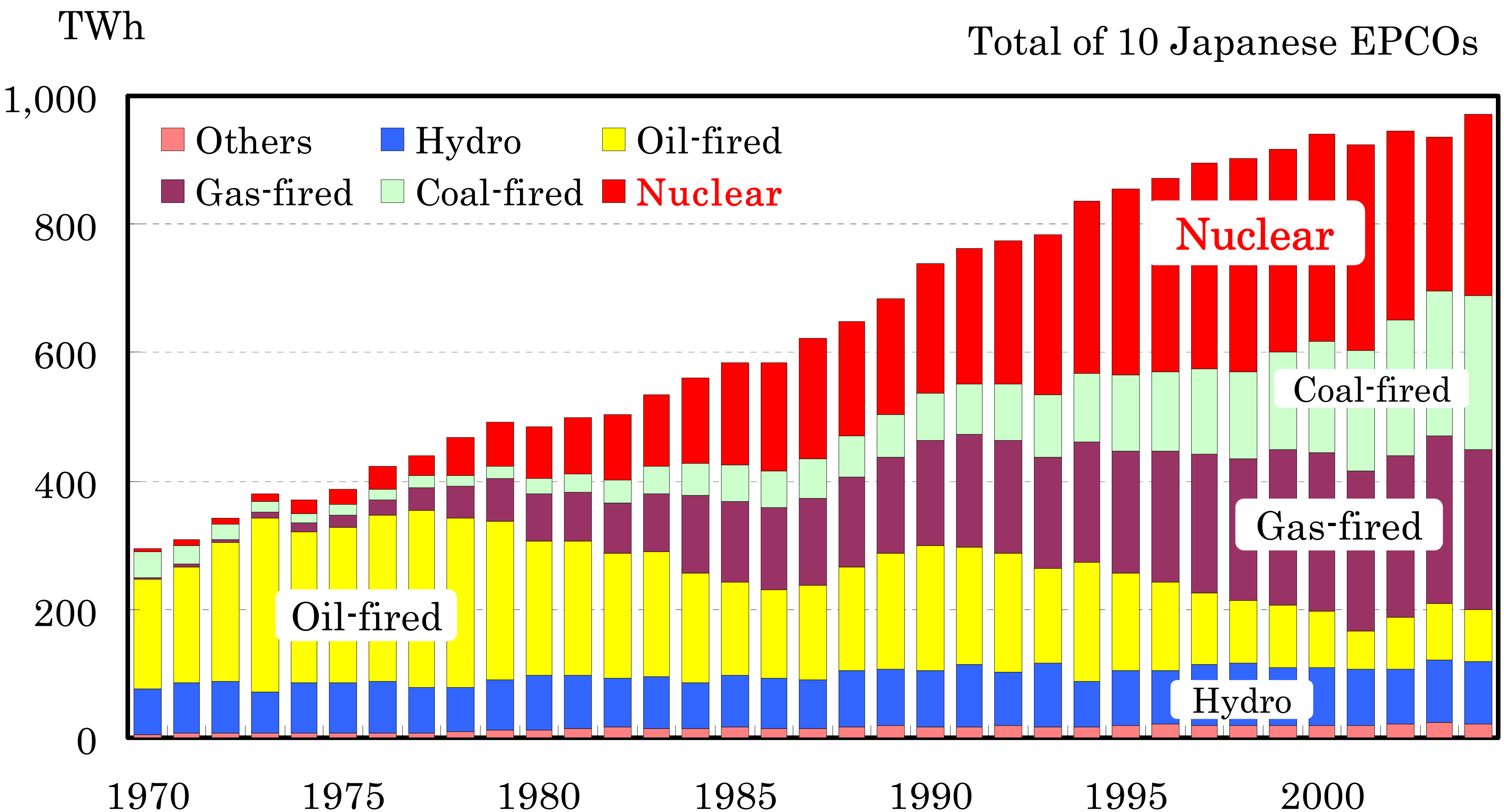
Harukuni TANAKA
General Manager, Nuclear Power Dept.
Federation of Electric Power Companies of Japan

Contents

- Share of nuclear power in Japan
- Competitiveness of nuclear power
- Need of higher capacity factor
- Continuing construction of new NPP
- R&D for Gen III+
- Fuel cycle facilities for Pu recycling
- R&D for FBR

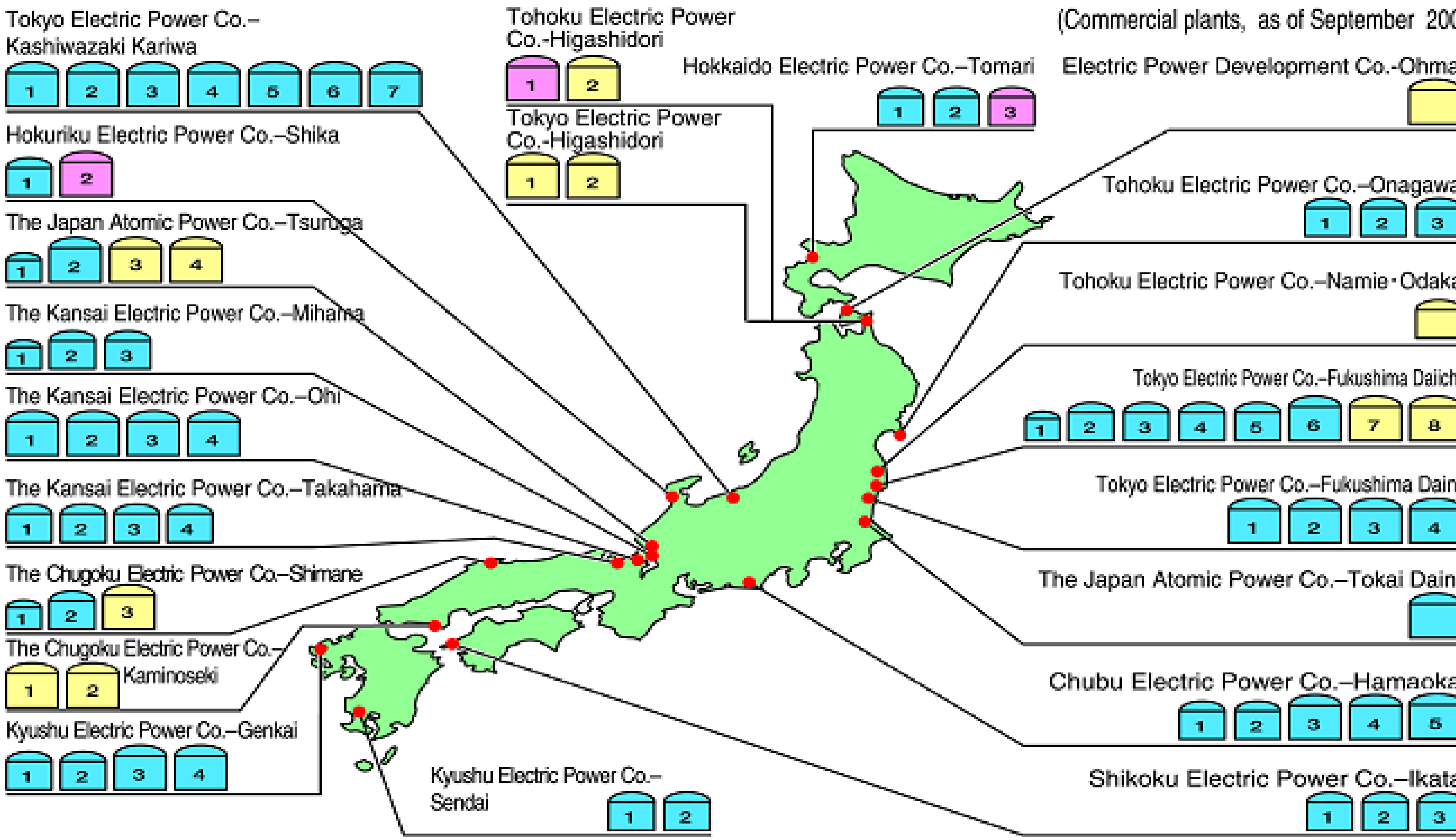
Increase of Nuclear Power Generation

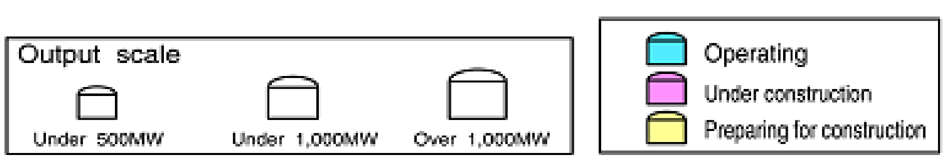
FEPC, JAPAN



Nuclear Power Plants in Japan

FEPC, JAPAN

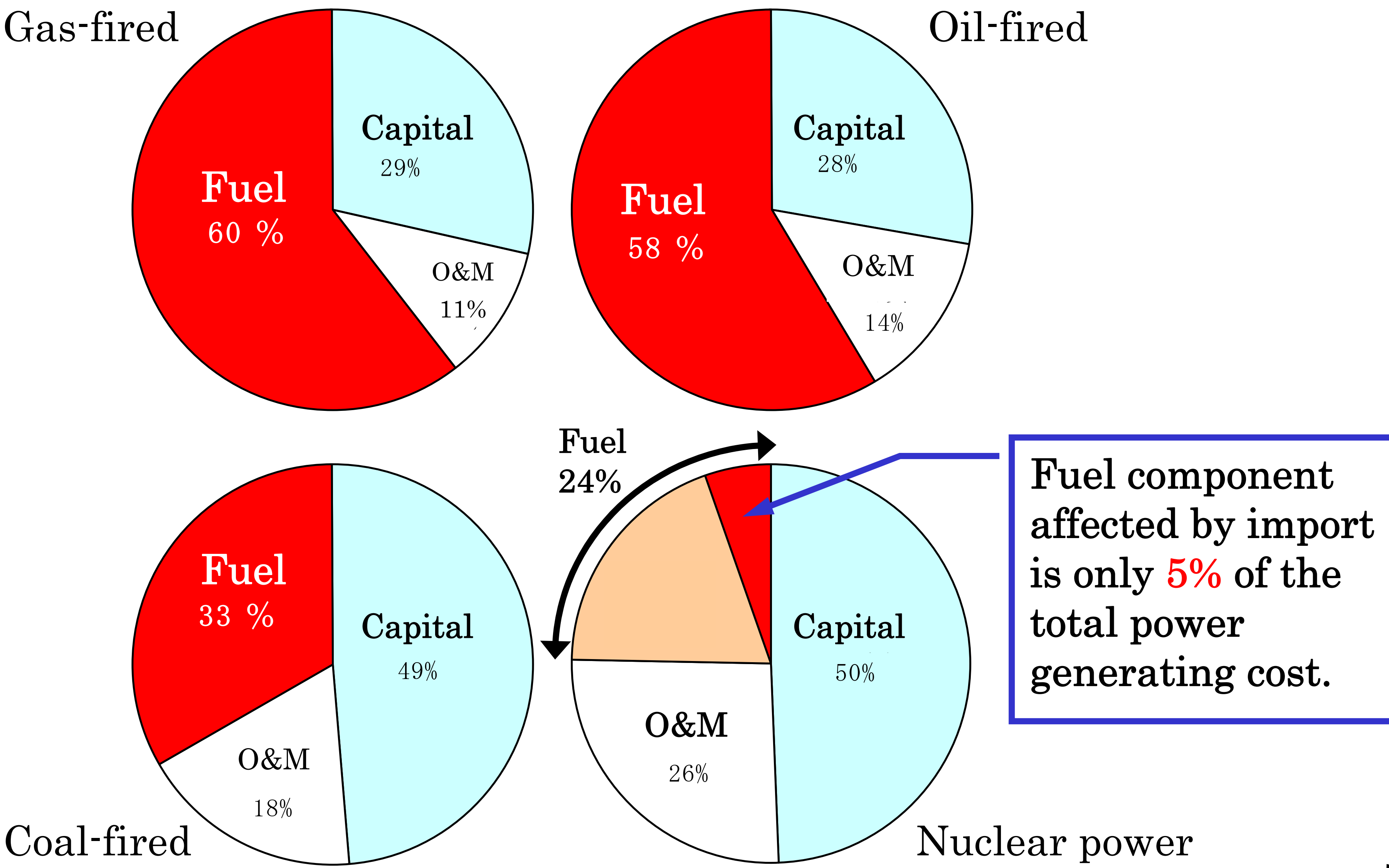




	# of reactors	Total Power
Operational	55	49.580 GWe
Under Const.	2	2.285 GWe
Planned	11	14.945 GWe
Total	68	66.810 GWe

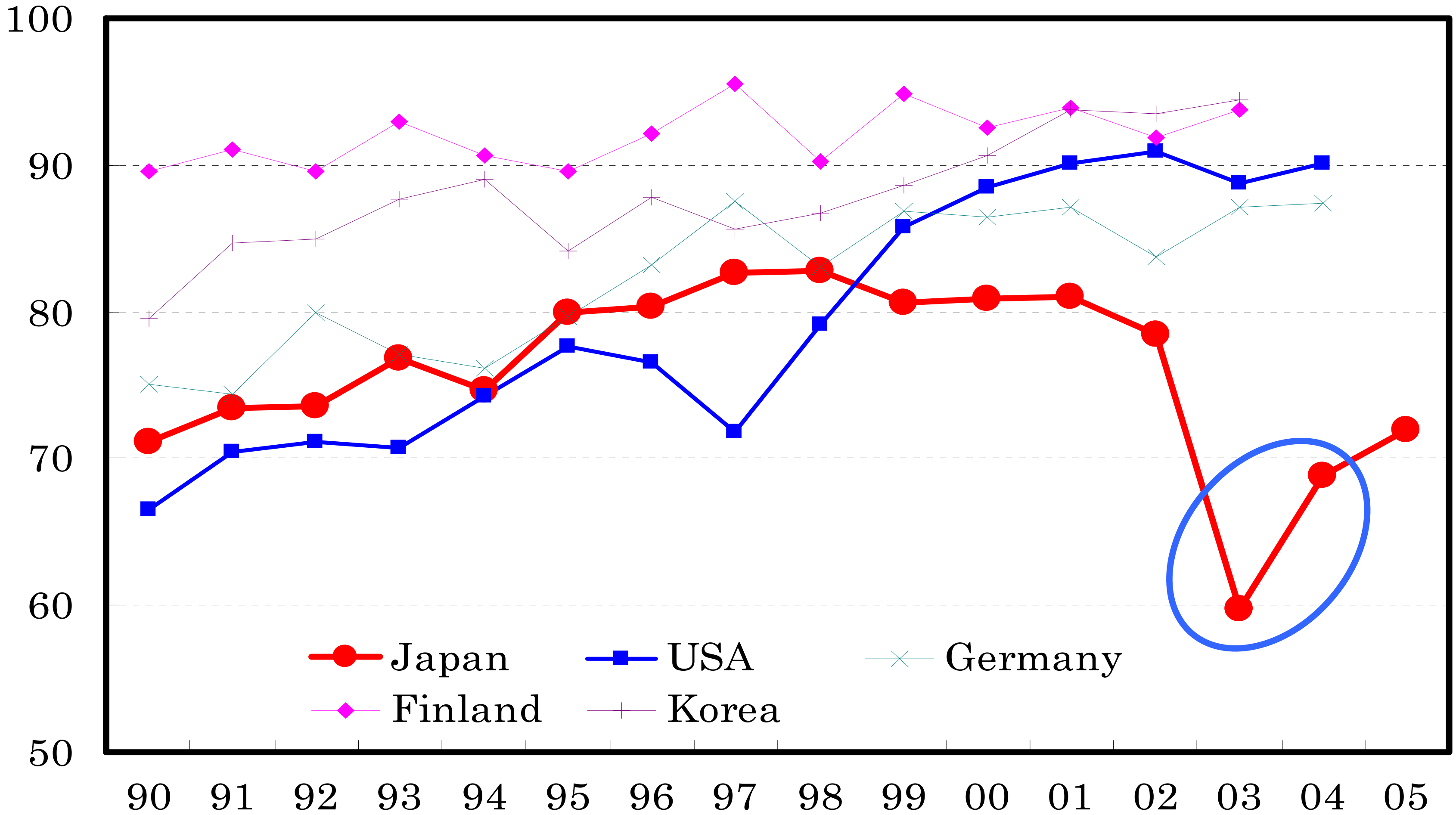
All NPPs are located on the seacoast.

Cost components for power generation



Comparison of Capacity Factor

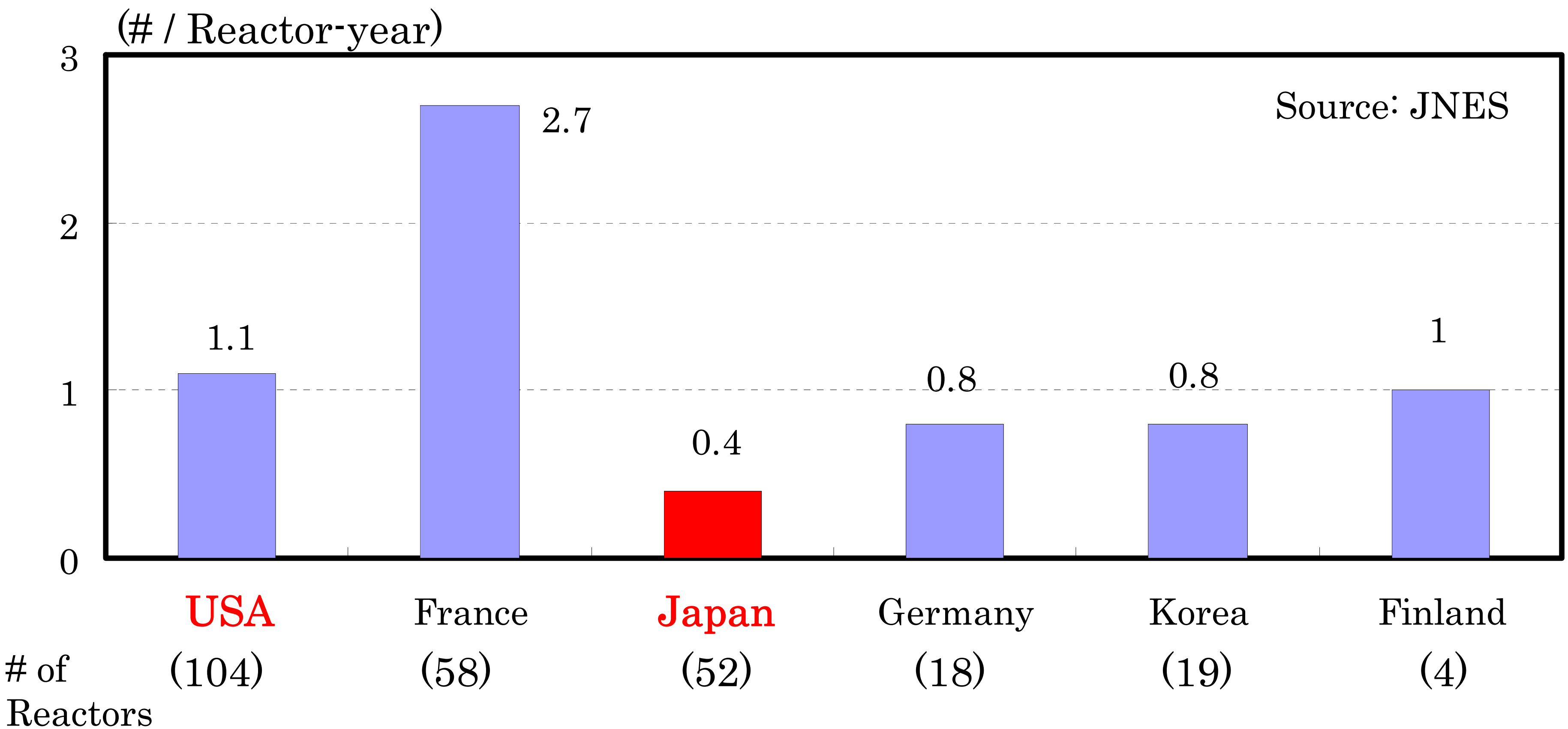
- Japan's highest capacity factor is 83%, in 1997.
- Significantly lower than 90% which has been achieved by many countries.



Unscheduled Shut-downs (2004)

FEPC, JAPAN

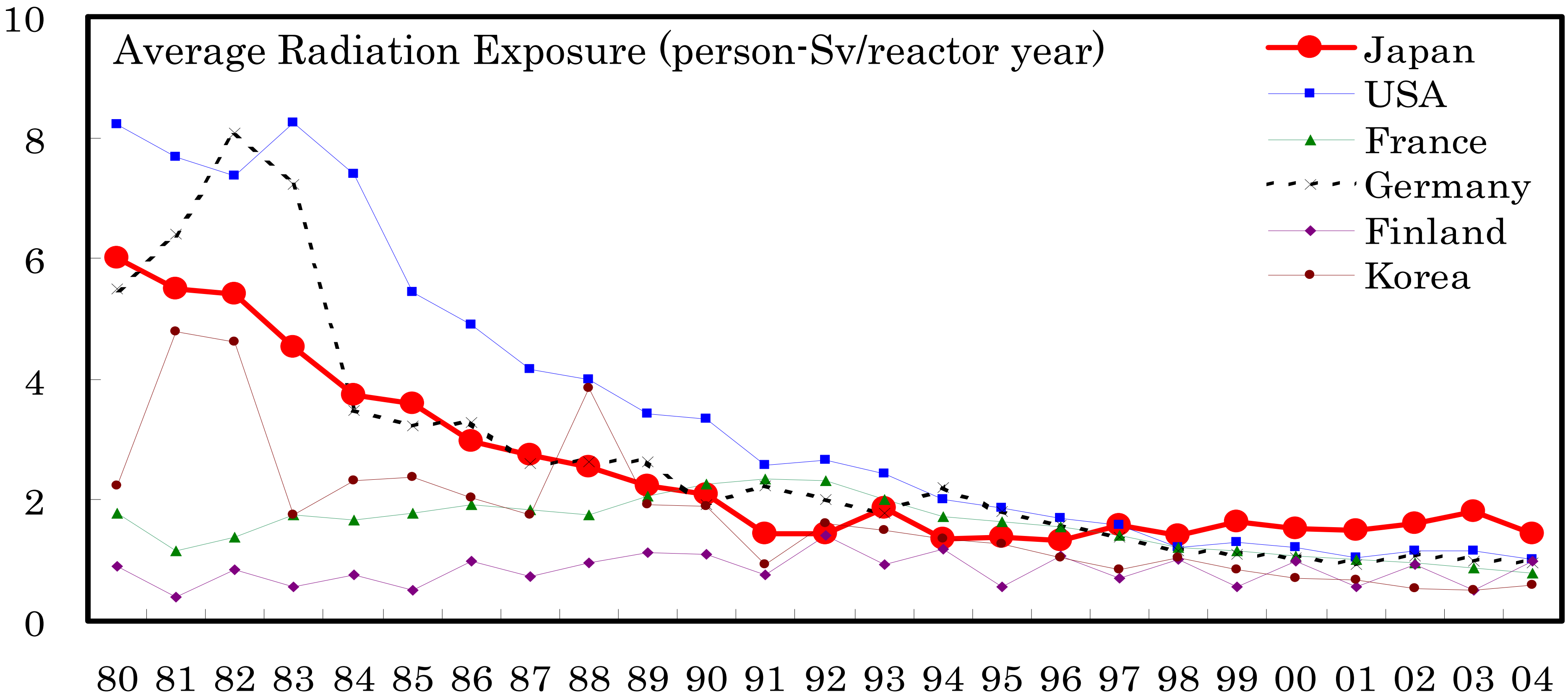
- Unscheduled reactor shut-down frequency of Japanese nuclear power reactors is very low, compared to that of other countries.



Radiation Exposure of Workers at NPP

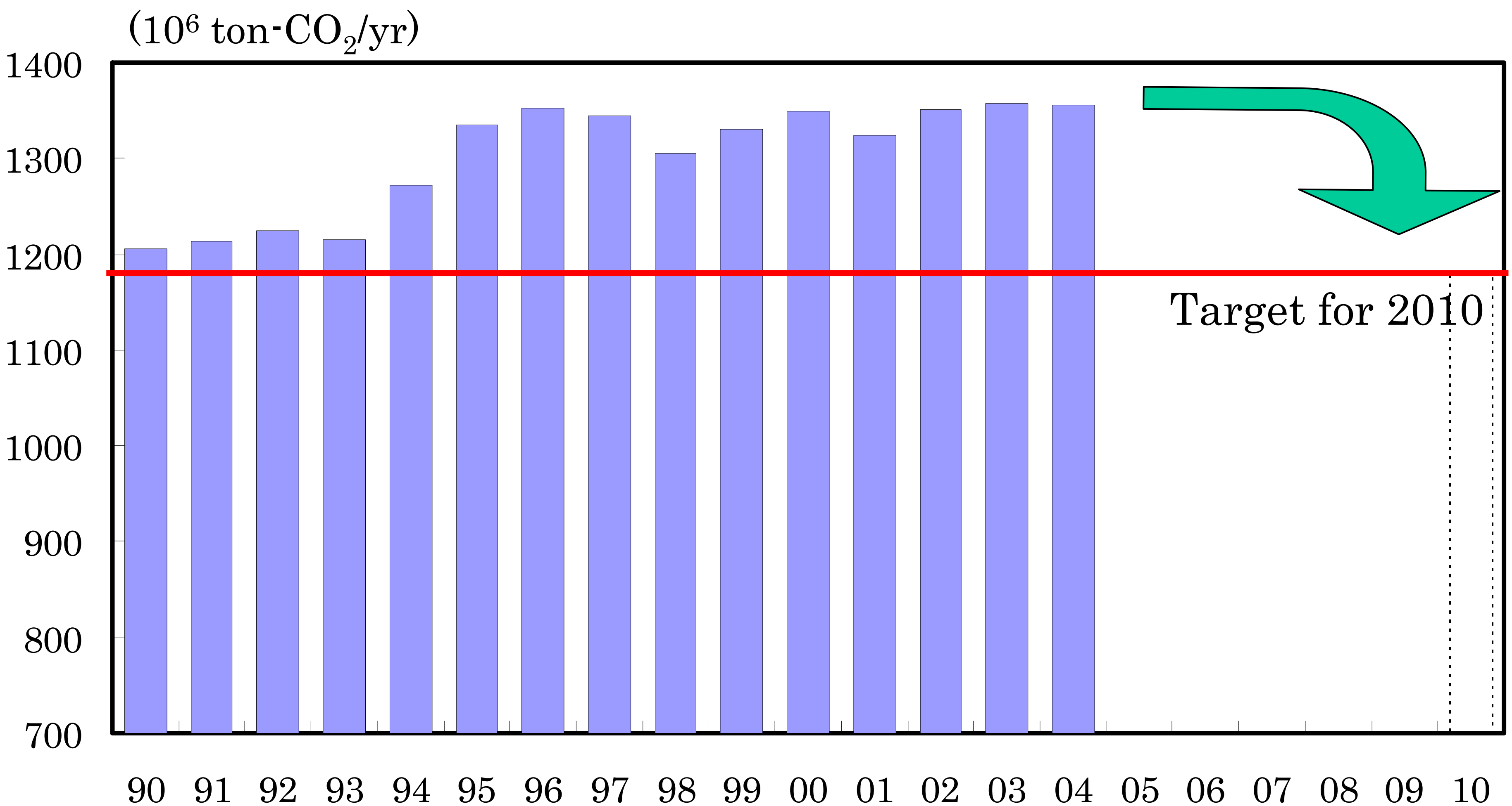
FEPC, JAPAN

- In recent years, workers' radiation exposure in Japan is higher than that in other countries.
- This trend is related to the frequency and length of planned outages for periodic inspections.



Japan's Greenhouse Gas Emission

■ Japan's target for 2008 through 2012 in Kyoto-protocol is 6% reduction of the base emission in 1990.



Nuclear safety and trustworthiness

- Public acceptance is absolutely essential for the industrial use of nuclear power.
- In order to gain trust from the public people and especially from the local societies around NPPs, presidents of Japanese EPCOs are;

  giving top priority to the safety of and

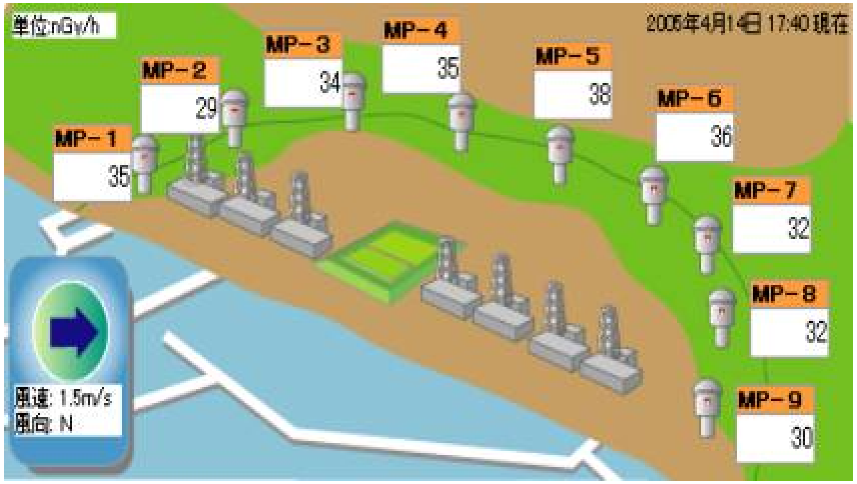
  making efforts to keep transparency of the nuclear power generation.

Transparency for Public Acceptance

FEPC, JAPAN

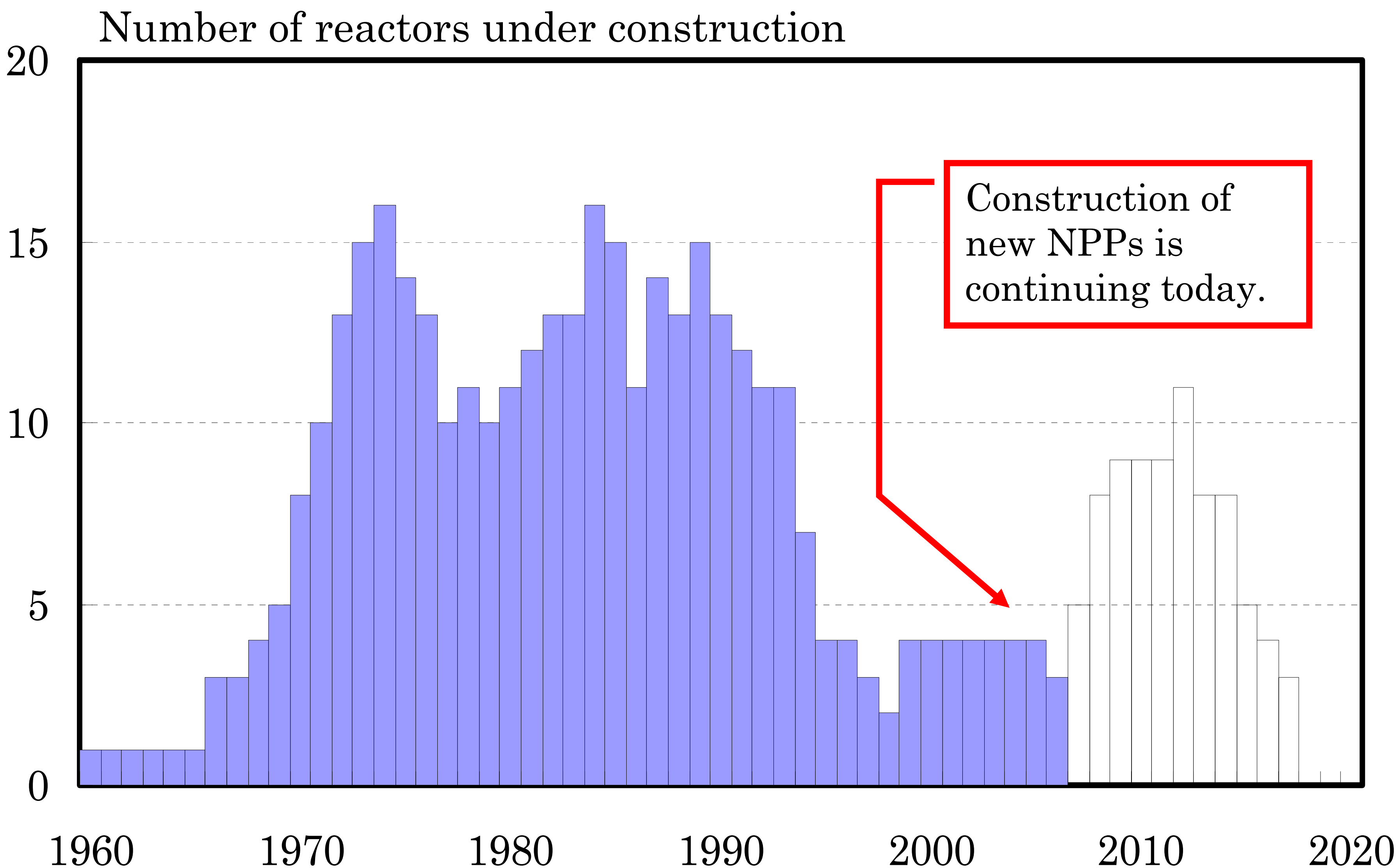
Every NPS is trying to disclose as much information as possible in order to make plant operation transparent to the public.

- Data important to public health can be accessed through web on the real time basis;
  - Reactor power.
  - Radioactivity contained in the air flow at the stack outlet.
  - Radiation level on the site boundary.
- Occurrence of any plant trouble is publicized immediately.
- Meeting with the representatives of local residents.



Number of NPPs under Construction

FEPC, JAPAN



Coming LWRs

- **2 NPPs under construction** (2.285 GWe)

Hokkaido EPCO	Tomari-3	PWR	912 MWe	(Dec., 2009)
Chugoku EPCO	Shimane-3	ABWR	1373 MWe	(Dec., 2011)

- **3 NPPs being reviewed by regulatory authority** (4.459 GWe)

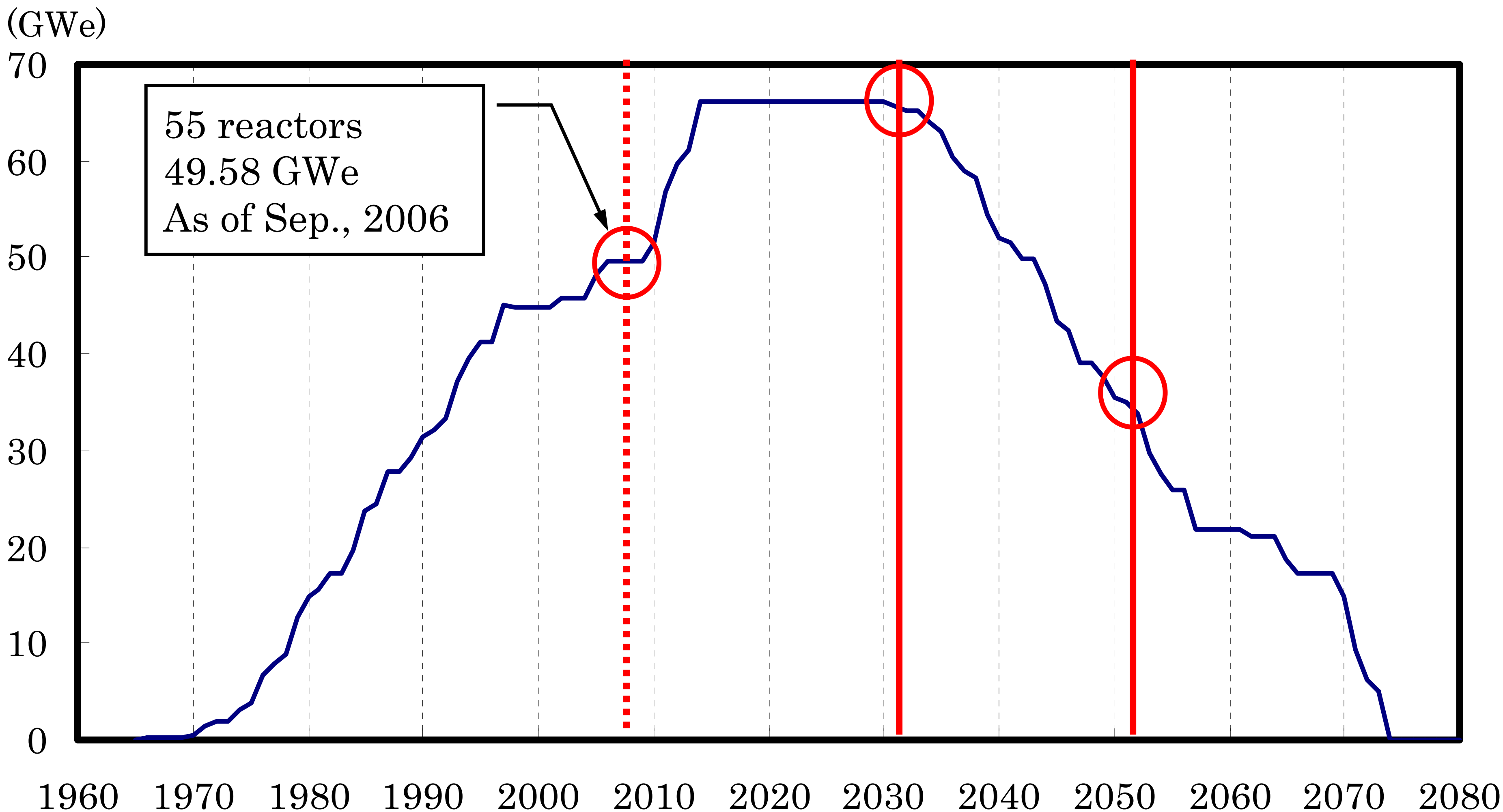
J-Power	Ohma	ABWR	1383 MWe	(Mar., 2012)
JAPCO	Tsuruga-3 & 4	APWR	1538 MWe	(Mar., 2014 / Mar., 2015)

- **9 NPPs planned and/or invited** (10.486 GWe)

Chugoku EPCO	Kaminoseki-1 & 2	ABWR	1373 MWe	(2014 / 2017)
Tokyo EPCO	Higashidori-1 & 2	ABWR	1385 MWe	(2014 / 2016 --)
Tokyo EPCO	Fukushima Daiichi-7 & 8	ABWR	1380 MWe	(2012 / 2013)
Tohoku EPCO	Hgiashidori-2	ABWR	1385 MWe	(2017 --)
Tohoku EPCO	Namie-Odaka	BWR	825 MWe	(2017)
Kyushu EPCO	Sendai-3	invited by the local community		

Nuclear Generating Capacity in Japan

- Service period of 60 years will need start of replacement in 2030s.
- 30 GWe for 2030 to 2050, i.e., 1.5 GWe per a year.

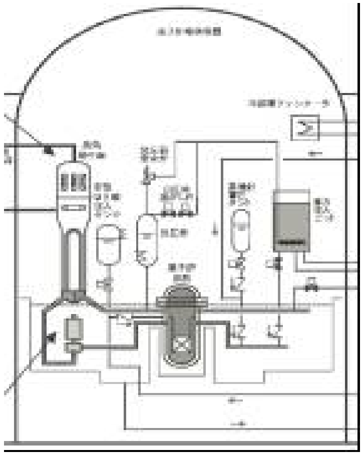


Modification to ABWR & APWR

ABWR-II (Toshiba & Hitachi)

- 1.717 GWe
- Large K-lattice core
- Large capacity SRV
- Low DP MSIV
- Active safety features
  4-ECCS, ARCIC
- Passive safety features
  PCCS, PRCS
- Emergency power
  D/G, GTG

APWR+ (Mitsubishi)

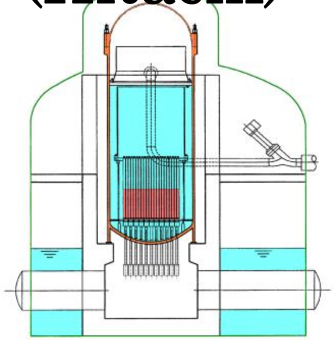


- 1.75 GWe
- Longer fuel assembly
- In-core instrument from top
- Full core MOX loading
- Active safety features
  4-ECCS
- Passive safety features
  HP boron injection
- Emergency Power
  D/G, GTG

Innovative Small Reactor Designs

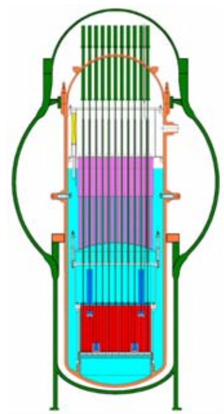
FEPC, JAPAN

DMS (Hitachi)



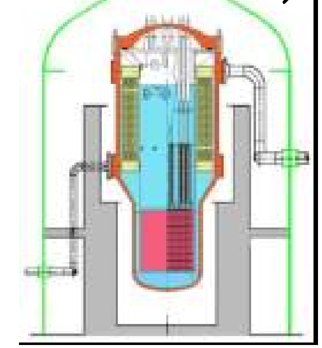
- 428 MWe
- Short fuel assembly
- Natural circulation
- No steam separator
- No steam dryer
- Active safety features
  - LPFL
  - Hybrid RCIC
- Passive safety
  - Pressure injection

CCR (Toshiba)



- 428 MWe
- Short fuel assembly
- Natural circulation
- Compact PCV
- Gravity driven CR
- Passive safety
  - Isolation condenser

IMR (Mitsubishi)



- 350 MWe
- Natural circulation
- In-vessel SG
- In-vessel CRD
- Boiling at TAF
- Passive safety
  - SG
- SG feed pumps
  - Diesel driven
  - GT driven

Nuclear program based on recycling

FEPC, JAPAN

from 1966 to 2005: 22,000 t

- 2,900 t — Reprocessed in France.
- 4,200 t — Reprocessed in UK.
- 1,000 t — Reprocessed at Tokai, Japan.
- 14,000 t

Today

from 2006 in 40 yrs: 45,000 t

- 18,000 t
- 27,000 t — Stored and reprocessed in the further future.

14,000 t + 18,000 t: 32,000 t of spent fuel to be reprocessed at Rokkasho, Japan in 40 years.

Rokkasho Reprocessing Plant (RRP)

- Operated by JNFL
- Rated spent fuel reprocessing capacity; 800 tU/yr.
  - Apr. 2001 Water-flow test started.
  - Dec. 2004 Uranium test using fresh fuel started.
  - Mar. 2006 Active test using spent fuel started.
  - May 2007 Expected completion of construction.
- 97% completed as of today.

- More than 30 tU reprocessed.
- No separate pure Pu exists in RRP.
- PuO2 is recovered as a mixture with UO2.

JNFL MOX Fuel Plant (JMOX)

- Commercial MOX fuel fabrication plant in Japan.
- Under safety evaluation by the regulatory authority since April, 2005.
- Located adjacent to Rokkasho Reprocessing Plant (RRP).
- MOX powder to be transferred through an underground tunnel from RRP to JMOX.
- Expected start of operation； April 2012
- Maximum capacity； 130 tHM/year

MOX fuel to be utilized by NPPs

FEPC, JAPAN

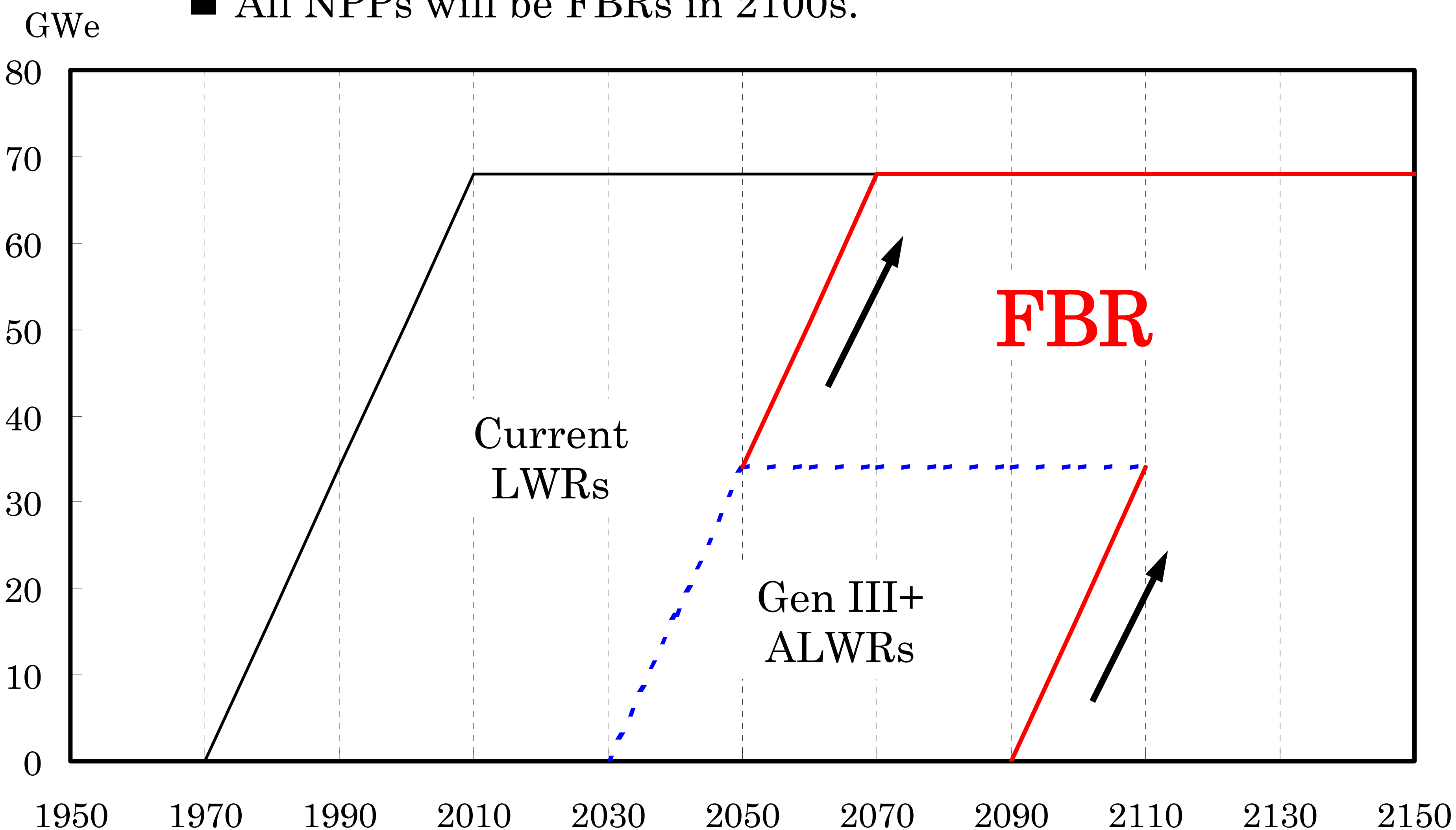
- <u>Licensed by the regulatory authority</u> ;
  - Kansai EPCO's PWRs Takahama #3 and #4 for 1/4 core MOX loading ; contracted with a French fuel vendor.
  - Kyushu EPCO's PWR Genkai #3 for 1/4 core MOX fuel loading.
  - Shikoku EPCO's PWR Ikata #3 for 1/4 core MOX loading.
  - Tokyo EPCO stores 32 fresh MOX fuel assemblies at the BWR Fukushima Daiichi #3 and 28 fresh MOX assemblies at the BWR Kashiwazaki-Kariwa #3.
- <u>Under safety review by the regulatory authority</u> ;
  - J-POWER's ABWR Ohma for full core MOX fuel loading.
  - Chubu EPCO's BWR Hamaoka #4 for 1/3 core MOX loading.
- <u>Requesting agreement of the local government</u> ;
  - Chugoku EPCO's BWR Shimane #2 for 1/3 core MOX loading.

Production and consumption of Pu

- Fissile plutonium recovered at Rokkasho reprocessing plant will be **4 tPuf / yr**.
- Fissile plutonium loaded onto the nuclear power reactors as MOX fuel assemblies will be **6 tPuf / yr**.
  - 1/3 of the operating commercial nuclear power reactors including a full-MOX ABWR and,
  - prototype FBR MONJU.
- Due to the difference between the above two rates, Japan's plutonium in Europe will be consumed in about **15 years** while domestic Pu-recycling proceeds through Rokkasho (RRP and JMOX).

Introduction of FBRs in Japan

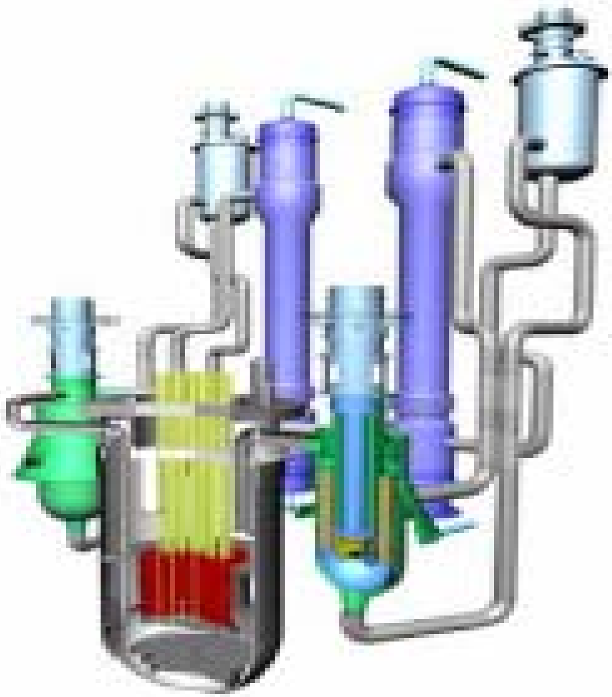
- LWRs with age 60 will be replaced by FBRs from 2050s.
- All NPPs will be FBRs in 2100s.

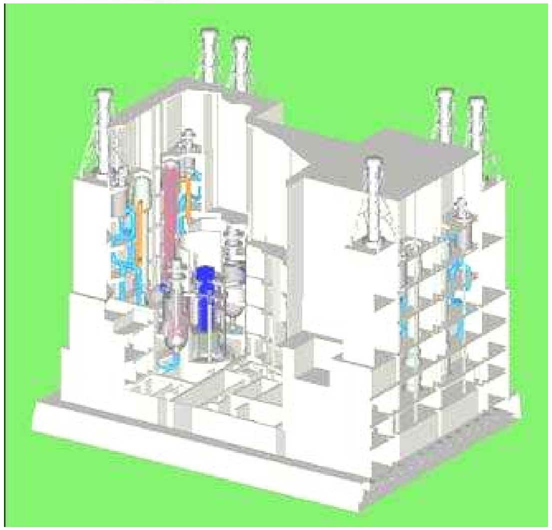


Japanese FBR design

FEPC, JAPAN

- 1.5 GWe with only two loops.
- Reactor vessel and building smaller than that of MONJU.
- Na-cooled MOX fuel.
- 12 Cr steel for shorter piping.
- IHX combined with primary pump.
- Double tube SG.
- ODS ferrite steel cladding for high burn-up.
- Demonstration with smaller size in 2025.
- Feedback from MONJU & JOYO.
- More competitive than ALWR.





Japanese fast breeder fuel cycle design

FEPC, JAPAN

Advanced and simplified aqueous reprocessing and fuel manufacturing technology include:

- Aqueous method based.
- Crystallization for U recovery.
- U, Pu, Np extracted at the same time.
- Lower DF without purification.
- MA recovered for burning in the FBR core.
- U-Pu content ratio adjusted in the nitric acid.
- MA added to the MOX pellet.
- More competitive than PRUEX for ALWRs.

Concluding Remarks

- From the viewpoints of energy security and the prevention of global warming, the peaceful use of nuclear power has been and will continue to be very important.
- Electric power companies in Japan, country with almost no energy resources, will make every effort to fully utilize the potential of nuclear power and its capability of fuel recycling.
- Japanese nuclear reactor operators will continue to give the largest consideration to transparency, safety, security and non-proliferation.

Thank you for your attention.