Damages on power plants, lessons learnt ….and what next?

May 27, 2011

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Contents

From Japanese magazine

Where have I been at 14:46 March 11, 2011…

In front of the JR Sendai Station


14:46 March 11, 2011
In front of
JR Sendai Station

1. Damages on Power Plants by Earthquake and Tsunami

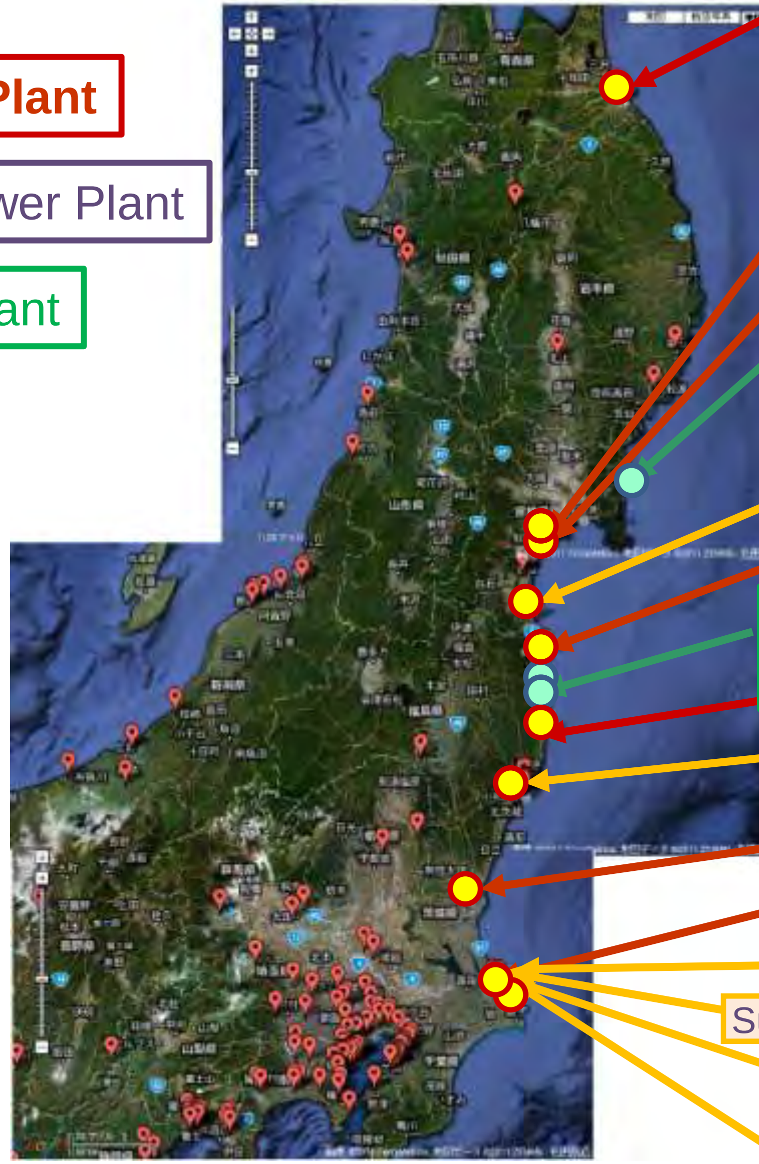
Repair works need 6 months to 2 years!

1-1 Damages on Power Plants

1. Almost all of the power stations(regardless of fossil or nuclear) on the Pacific Coast of Eastern Japan have shutdown by the earthquake
2. Most of the fossil power plants were damaged by tsunami →repair works require 3 months to 2 years
3. Most of the nuclear power plants are under normal cold state shutdown
4. Units Nos. 1 to 4 of Fukushima Daiichi of Tokyo Electric Power suffered reactor core melt down due to all power loss
5. Remedial work is still underway to keep the reactors of the units under normal low temperature condition

Damaged Power Plants in Tohoku & Kanto Districts

- Thermal Power Plant
- Joint Thermal Power Plant
- Nuclear Power Plant



Tohoku/Hatinohe : **250,000 KW**

Tohoku/Sendai : **440,000 KW**

Tohoku/Shinsendai : **950,000 KW**

Tohoku/Onagawa : **2,174,000KW**

Soma Joint/Shinchi : **2,000,000KW**

Tohoku/Haramati : **2,000,000 KW**

Tokyo/Fukushima Daiichi・Daini : **9,096,000 KW**

Joban Joint/Nakoso : **1,625,000KW**

Tokyo/Hitachinaka : **1,000,000 KW**

Tokyo/Kashima : **4,400,000 KW**

Kashima Joint : **1,400,000 KW**

Sumitomo Metal/Kashima : **653,000 KW**

Kashimakita Joint : **650,000 KW**

Kashimaminami Joint : **190,000 KW**

Shutdown Power Plants of Tokyo Electric

(By end of March, 2011)

［Nuclear Power Station］

・Fukushima Daiichi：4700MW ⎫ Total 9100 MKW
・Fukushima Daini： 5500MW ⎭

［Fossil power Station］

・Hirono （Oil/Coal）：3800MW ⎫ Total 9200 MW
・Hitachi-naka（Coal）： 1000MKW ⎬
・kashima （Oil）： 4400MW ⎭ → Recovered to 3800MW by April 20

Nuclear + Fossil total: 18,300 MW

Stopped Nuclear/Fossil＝18300MW/Total capability60000MW ＝ 30%

［Joint Electric power］ Shinchi of Soma J.E.P.Co.（Coal）：2000MW×1/2＝1000MW
Nakoso of Joban J.E.P.Co.（Coal）：1620MW×1/2＝810MW
Clean Coal Power：IGCC（Coal）： 250MW

Total 2060MW

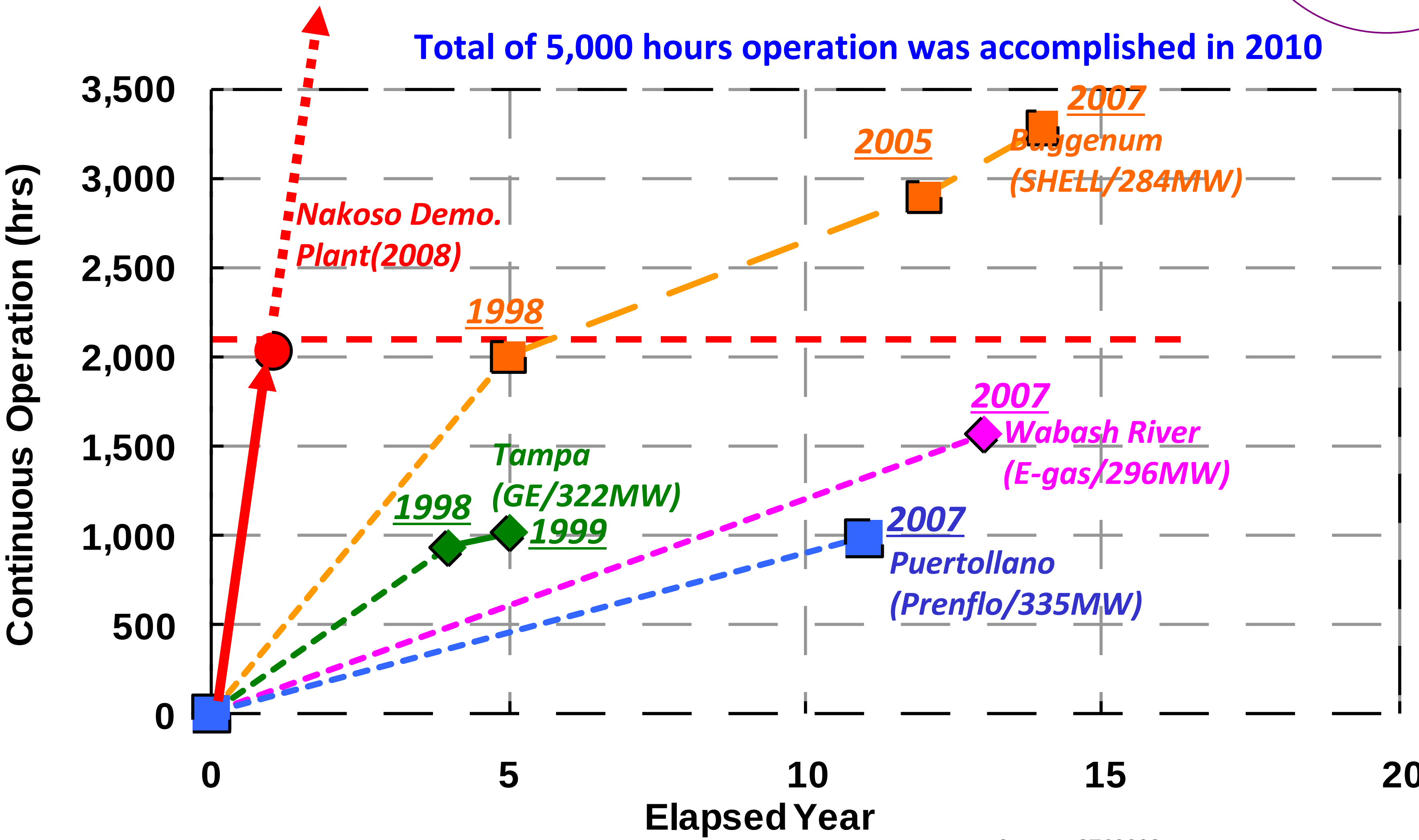
All Total 20,036MW/60,000MW ＝ 33%

Example of Damaged Power Plants :

250 MW IGCC(Integrated coal Gasification Combined Cycle) Demonstration Plant of Clean Coal Power R&D Co.

Result of Demonstration Test

2,000 hours Continuous Operation !



Source : GTC2008

Remarkable operating record after star-up.
2000 hours continuous operation within one year!

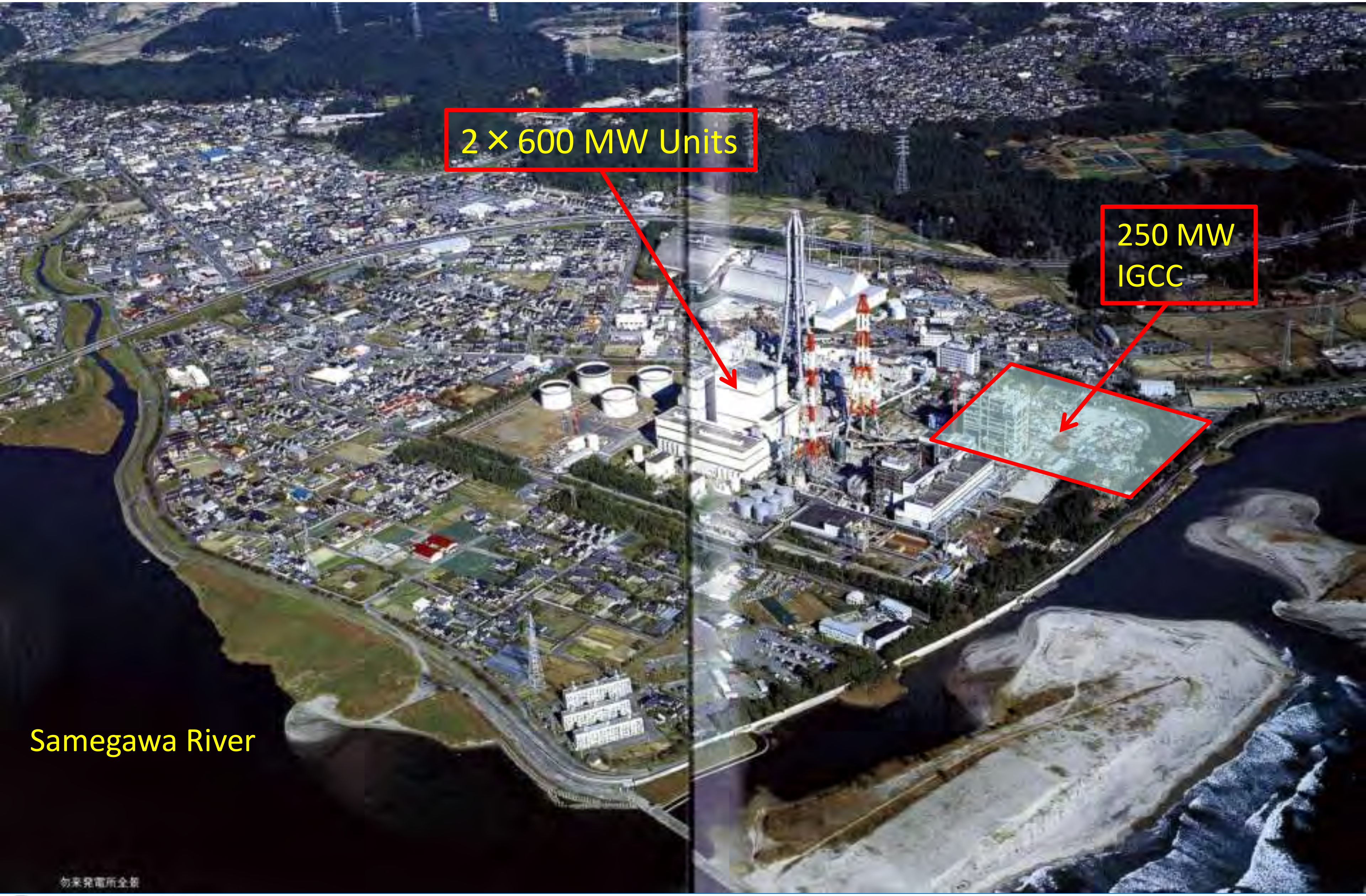
Photo: Courtesy of Clean Coal Power R&D Co.

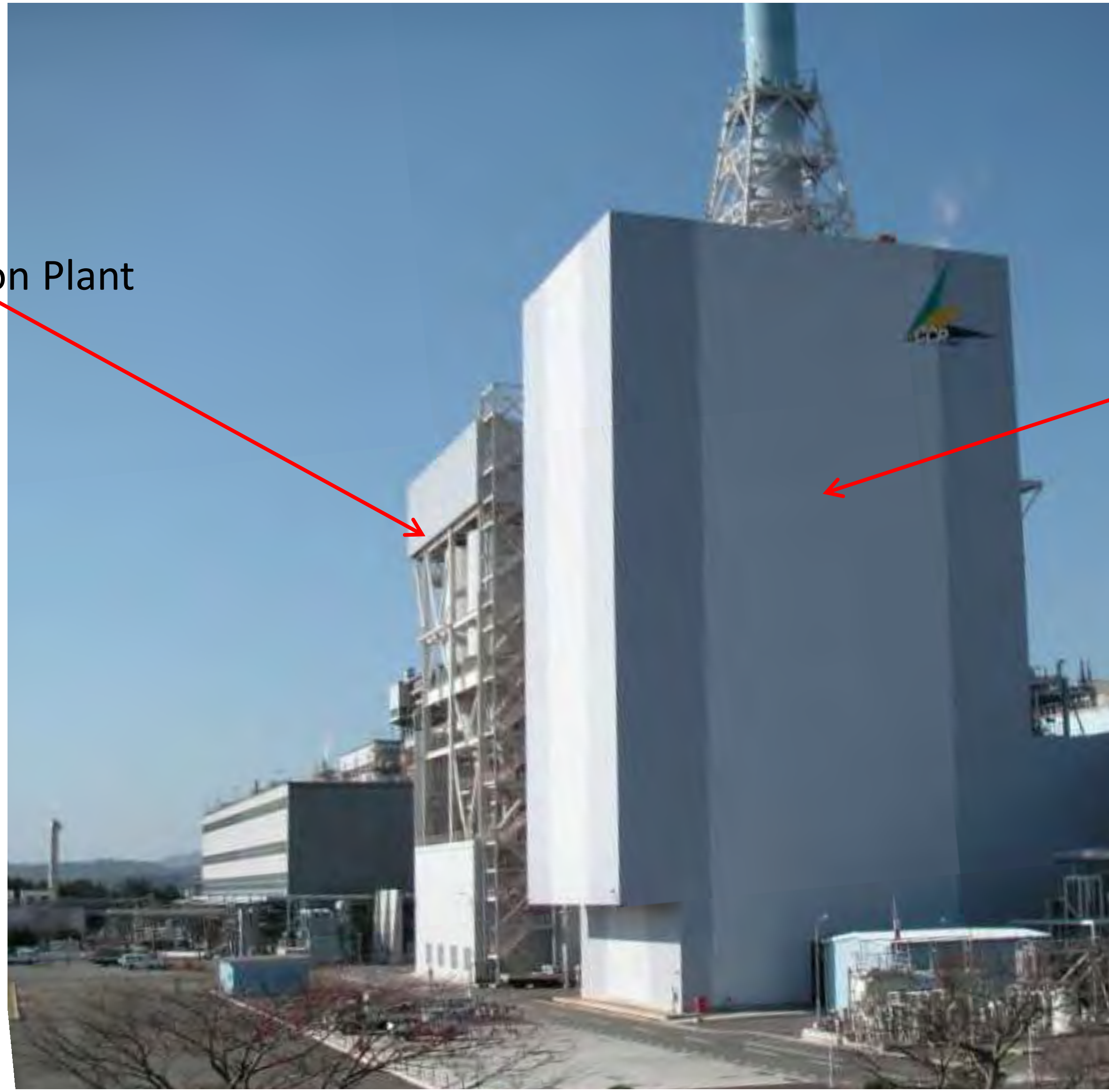
Single digits SOx, NOx and Dust Loading at full load!

Photo: Courtesy of Clean Coal Power R&D Co.


Iwaki City, Fukushima Pref.
Onahama Port
Joban Joint
Elec. Power Co.
IGCC
Samegawa River

Joban Joint Power Co. and IGCC





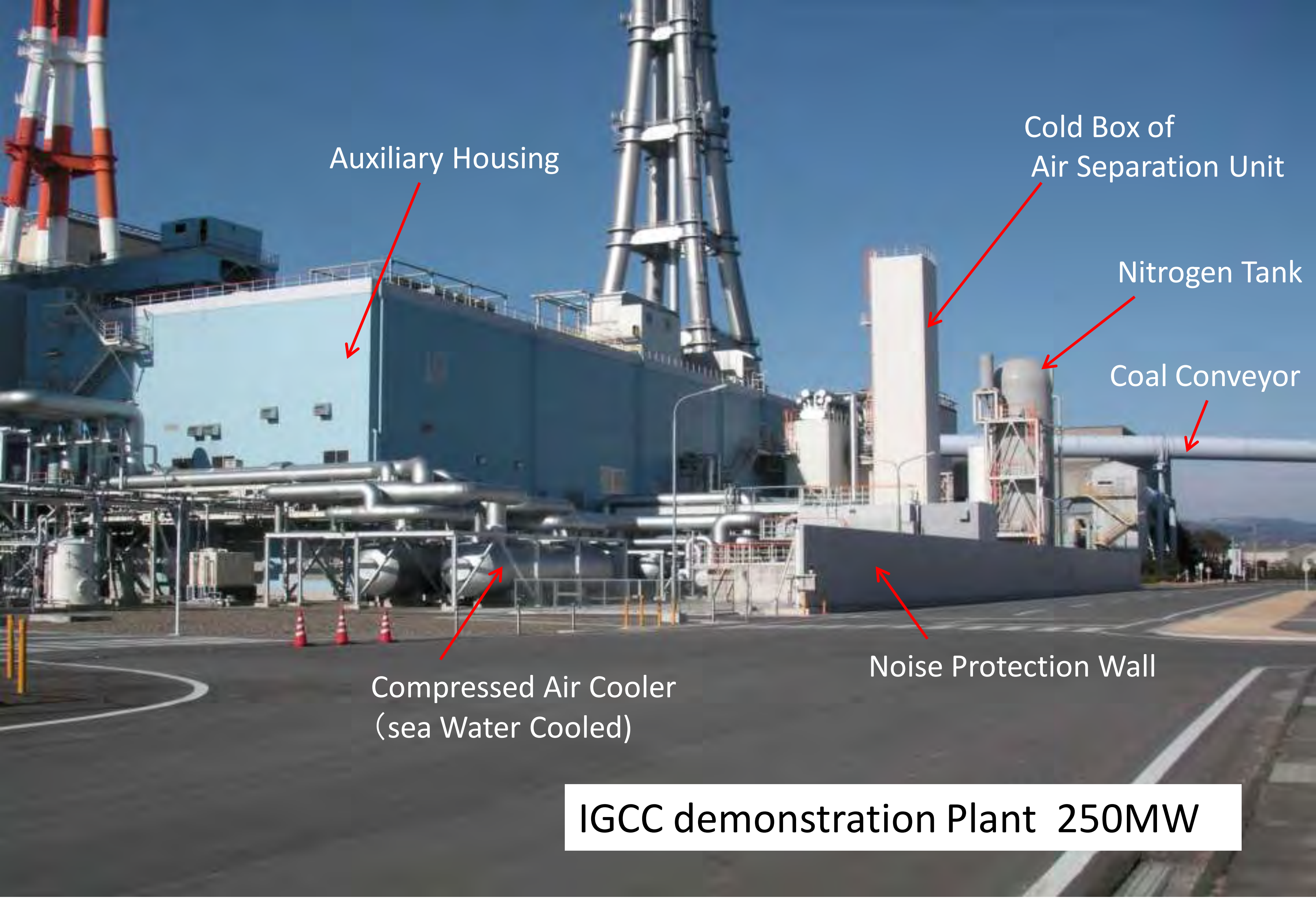
IGCC Demonstration Plant 250 MW

Courtesy of Clean Coal Power R&D Co.

Tsunami is coming !

Courtesy of Clean Coal Power R&D Co.


Just after tsunami
-- mud everywhere
Courtesy of Clean Coal Power R&D Co.



Courtesy of Clean Coal Power R&D Co.

Just after tsunami -- mud and debris everywhere

Courtesy of Clean Coal Power R&D Co.

Just after tsunami
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Courtesy of Clean Coal Power R&D Co.


Just after tsunami
-- debris and mud everywhere
Courtesy of Clean Coal Power R&D Co.


After remedial work
-- Now it is like this…
Courtesy of Clean Coal Power R&D Co.

After remedial work
-- Now it is like this…

Courtesy of Clean Coal Power R&D Co.

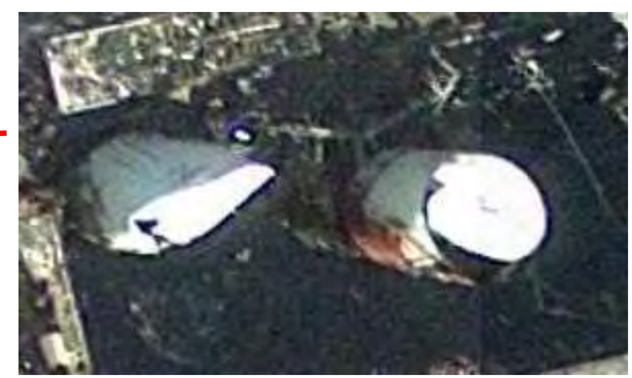
Present condition---IGCC will be in full operation in July!

Courtesy of Clean Coal Power R&D Co.

Tsunami hitting at the Hirono Thermal Power Station of Tokyo Electric Power Co.

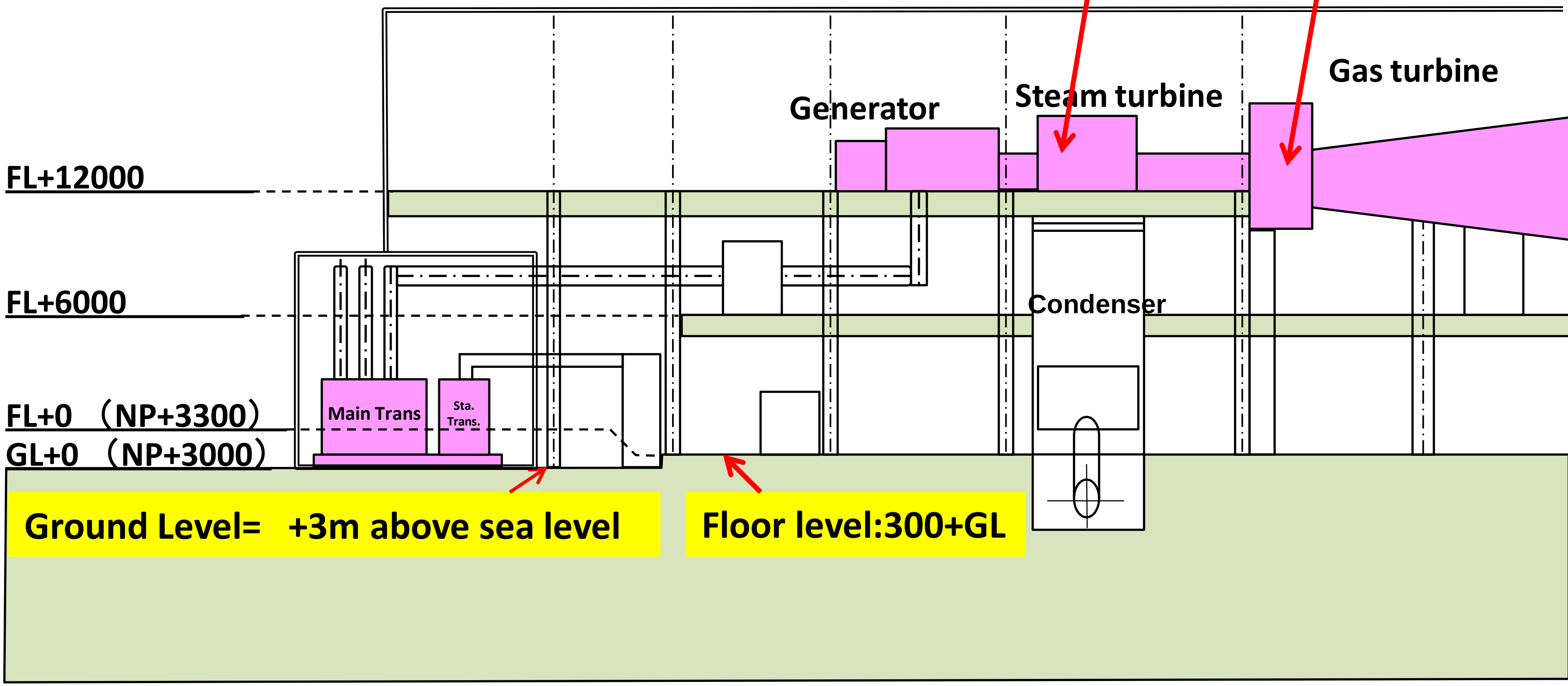
From totallycoolpix.com

Haramachi Power Station of Tohoku Electric Power Co. 2 × 1000MW Coal Units



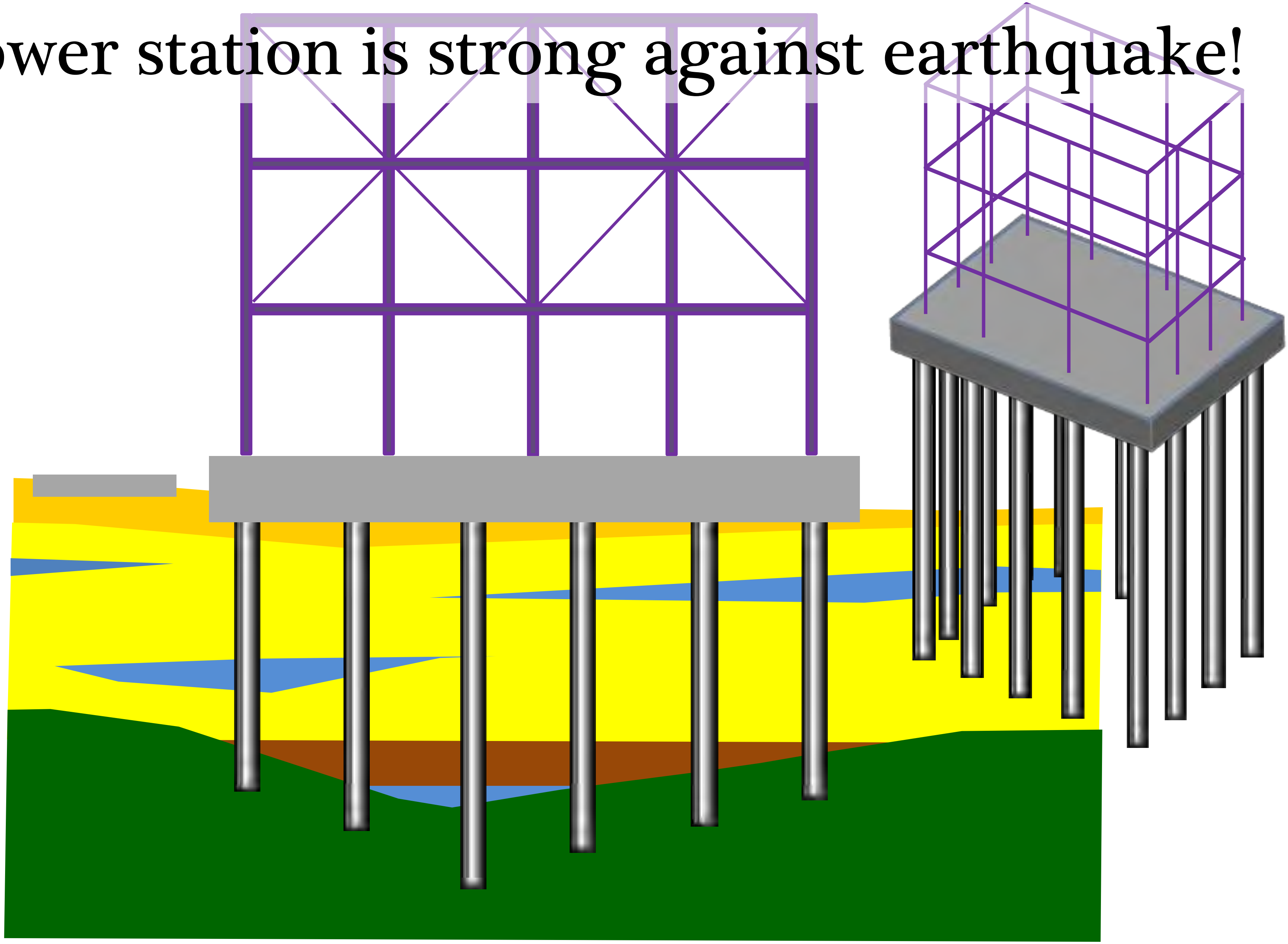
From Google Map

Main components such as gas turbine and steam turbine are mounted on the floor of+12m



Power station ground level is just +3m!

Power station is strong against earthquake!



Ground work at the IGCC

Courtesy of Clean Coal Power R&D Co.

2. Lessons learnt

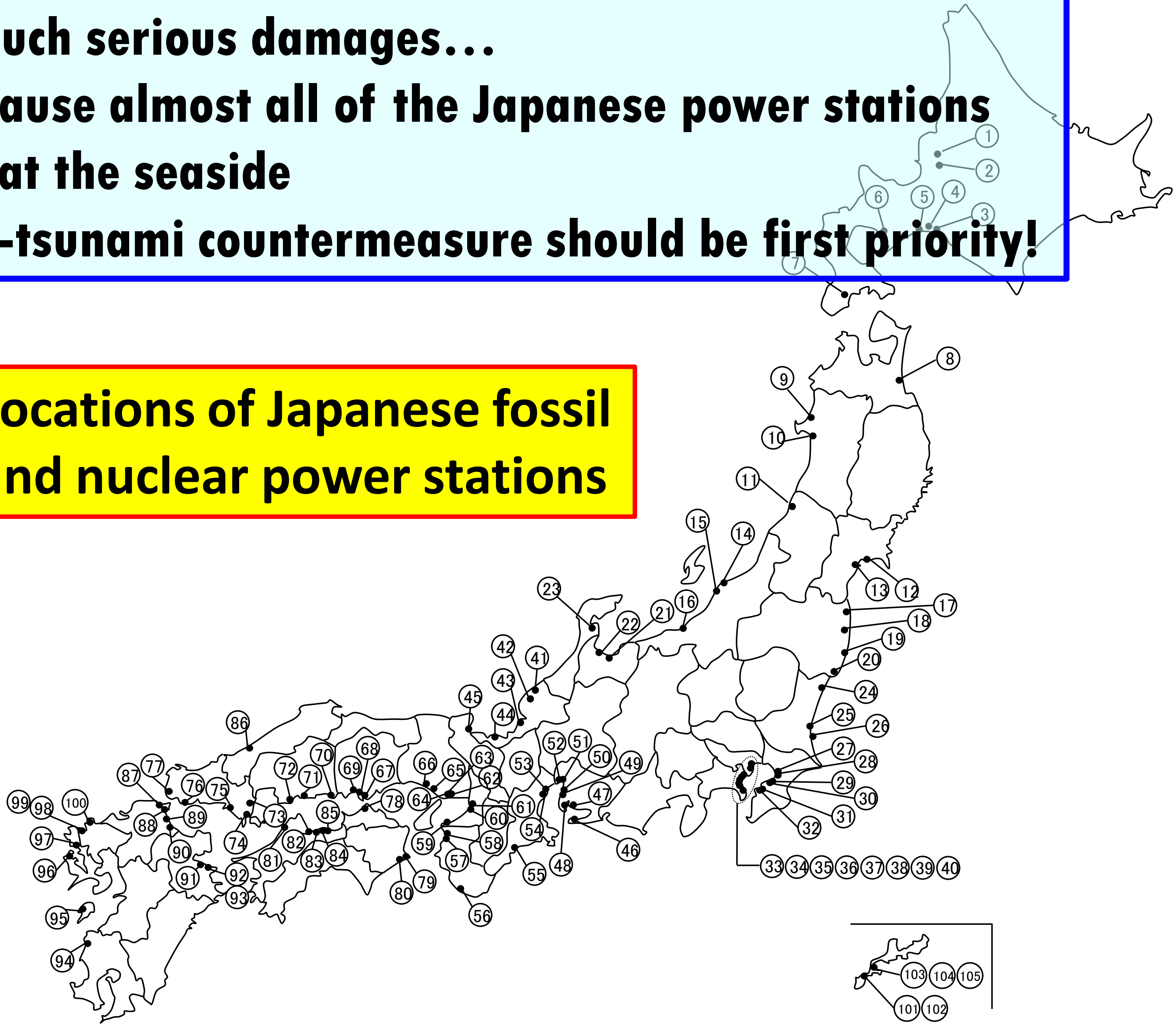
- Most of the damages to the power plants are by tsunami not by earthquake!

Why such serious damages…

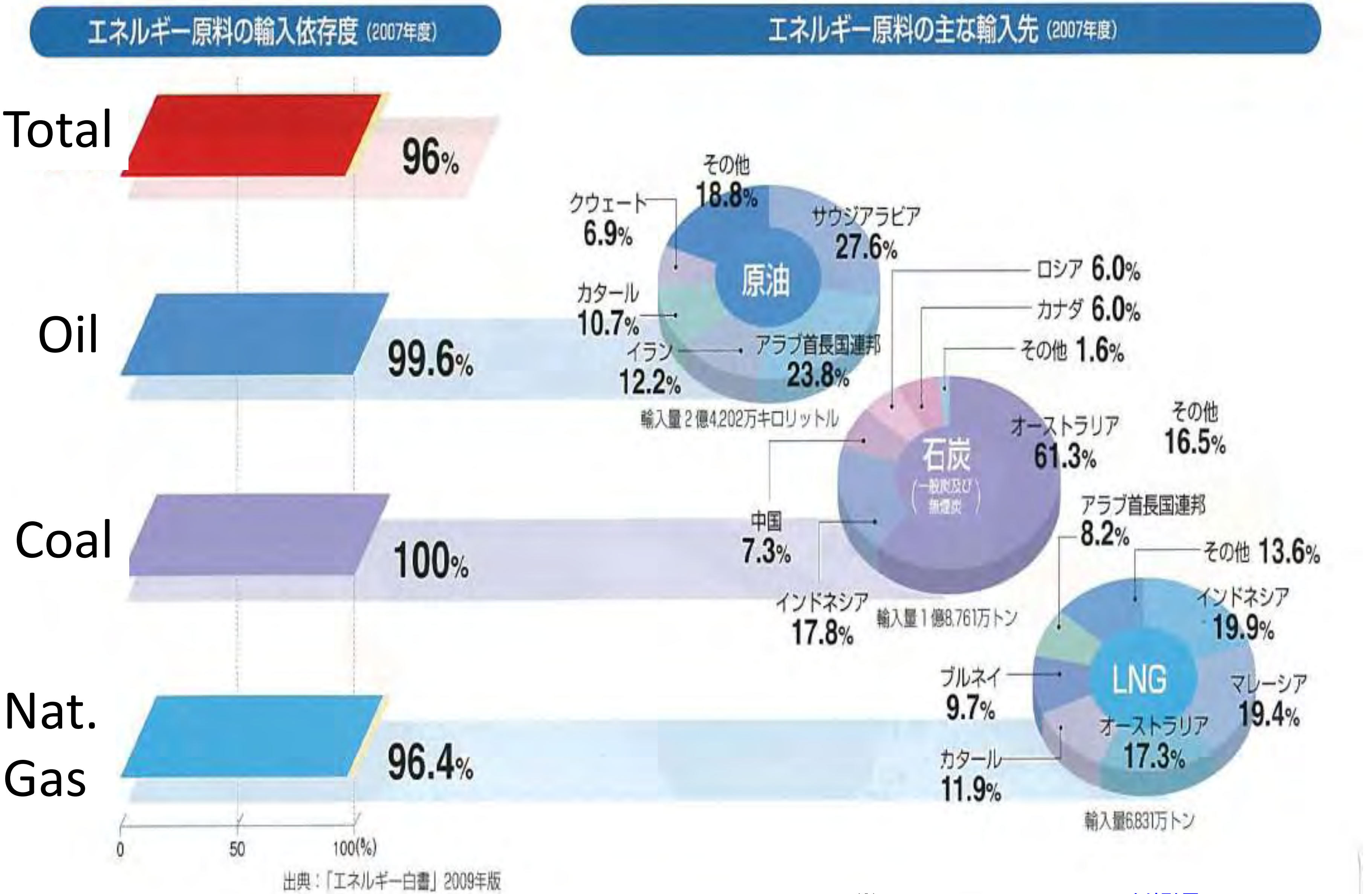
…because almost all of the Japanese power stations are at the seaside

→anti-tsunami countermeasure should be first priority!

Locations of Japanese fossil and nuclear power stations



Almost all of the energy sources are imported in Japan!

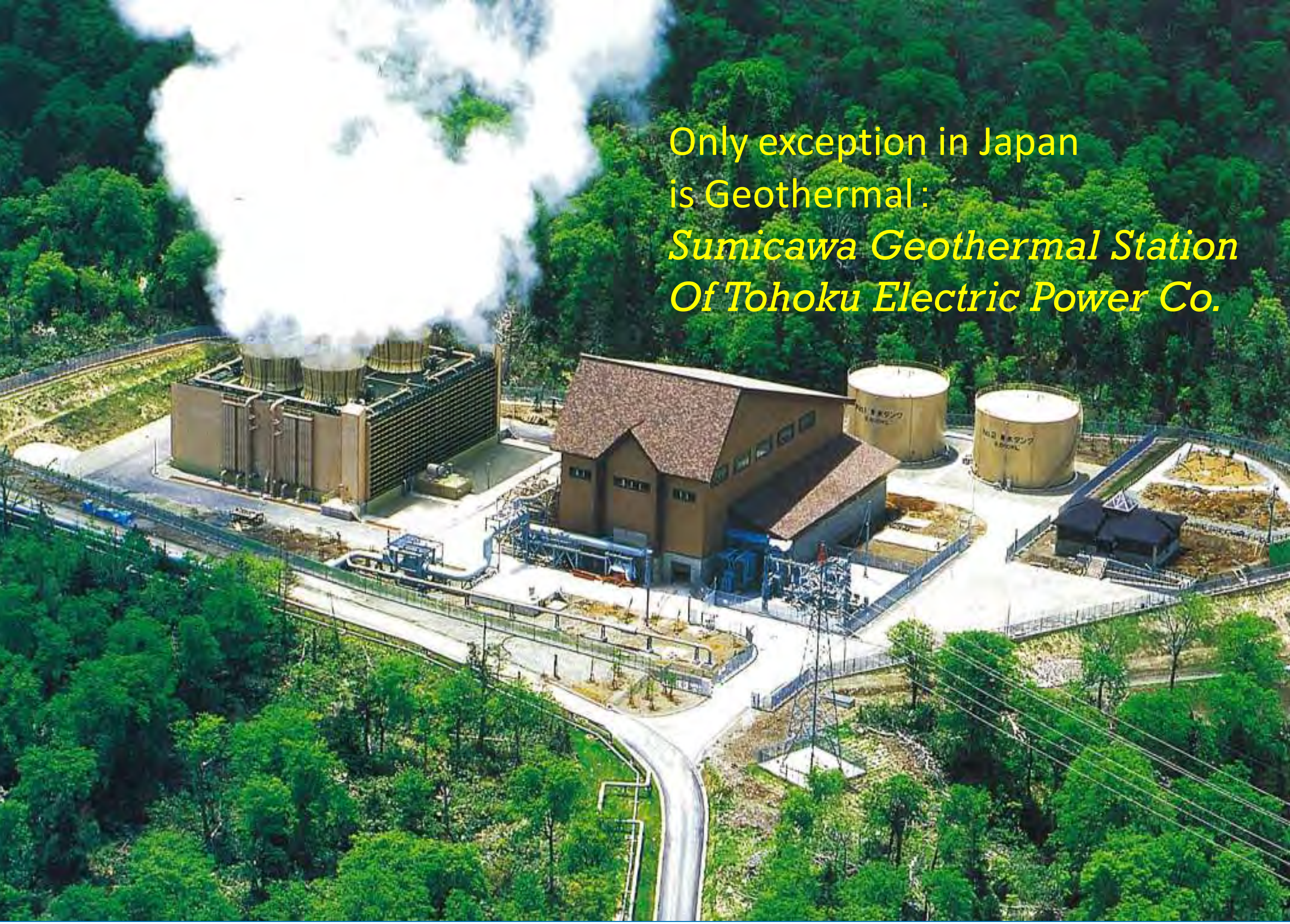


※SHIPPING NOW 2009-2010より引用

All the power stations in Japan are at the seaside---cooled by sea water!

Power stations outside Japan

→Majority is cooled by fresh water in cooling tower



Only exception in Japan
is Geothermal :
Sumicawa Geothermal Station
Of Tohoku Electric Power Co.

Problems at Fukushima Daiichi

1. The most serious problem is loss of cooling media for reactor core.
2. Loss of all three power sources：
   ①All plants were shutdown
   ②Loss of external power supply sources (Damage on Transformer Station)
   ③Loss of emergency back-up power(Diesel generators unable to operate)
3. The differences in destiny:
   Plant location level and the plant layout of auxiliary equipments

Now they are making tremendous efforts at Fukushima

Full support from all sides are required!

Tsunami to the nuclear power stations

Onagawa 13m

Heaven and Hell

What made the difference?

Fukushima No.1—14m

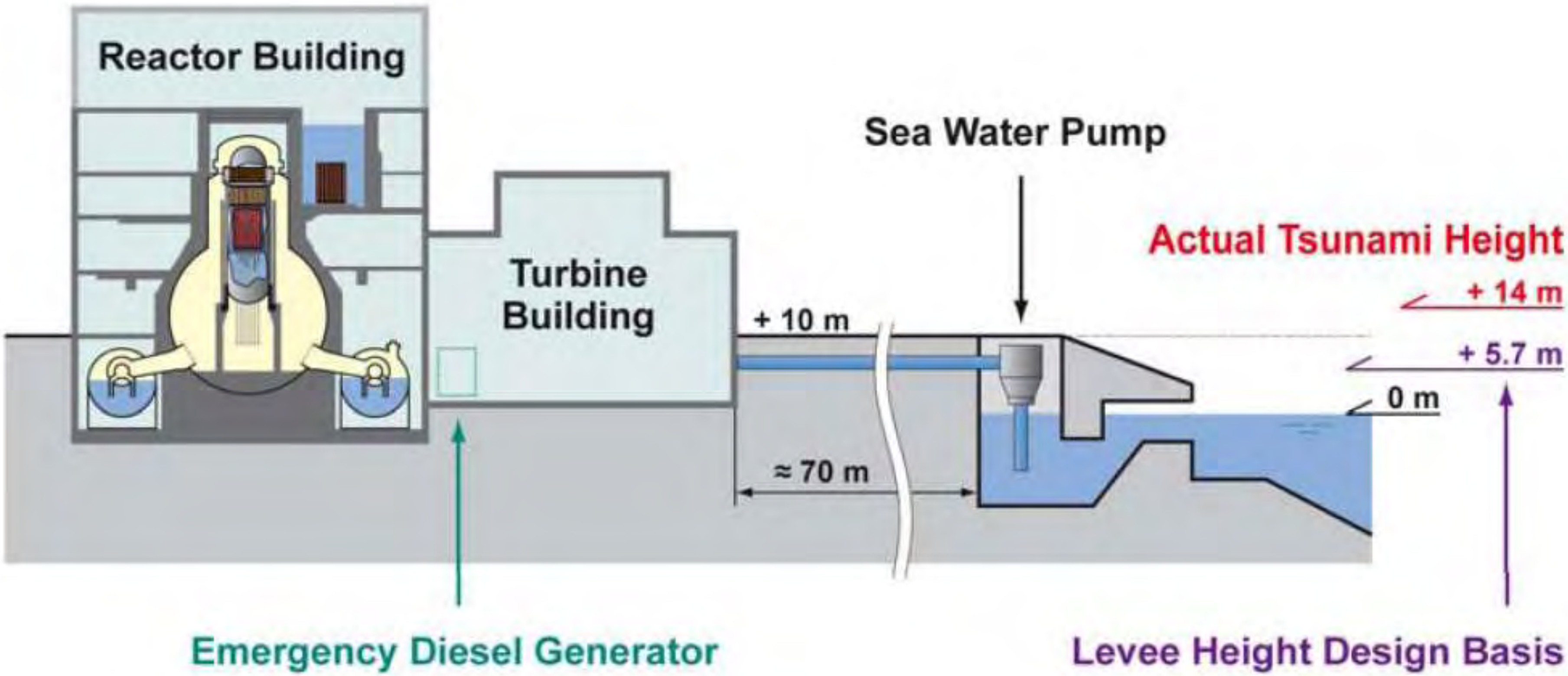
Onagawa Nuclear Power Station of Tohoku Elec.：
Output　2174MW　BWR　(Mark-1)
（Unit 1：524MW, Oper. 1984.6, Unit 2：825MW, Oper. 1995.7, Unit 3：825MW, Oper. 2002.1）

Estimated Height：　7.5m
Location height：　　15m
Actual tsunami height：13m

Fukushima Daiichi of Tokyo Elec.: 4696MW BWR (Mark-1)
(Unit 1: 460MW: Units 2,3,4,5: 4 × 784MW: Unit 6: 1100MW)

Estimated Height: 5.7m
Location height: 10m
Actual tsunami height: 14m

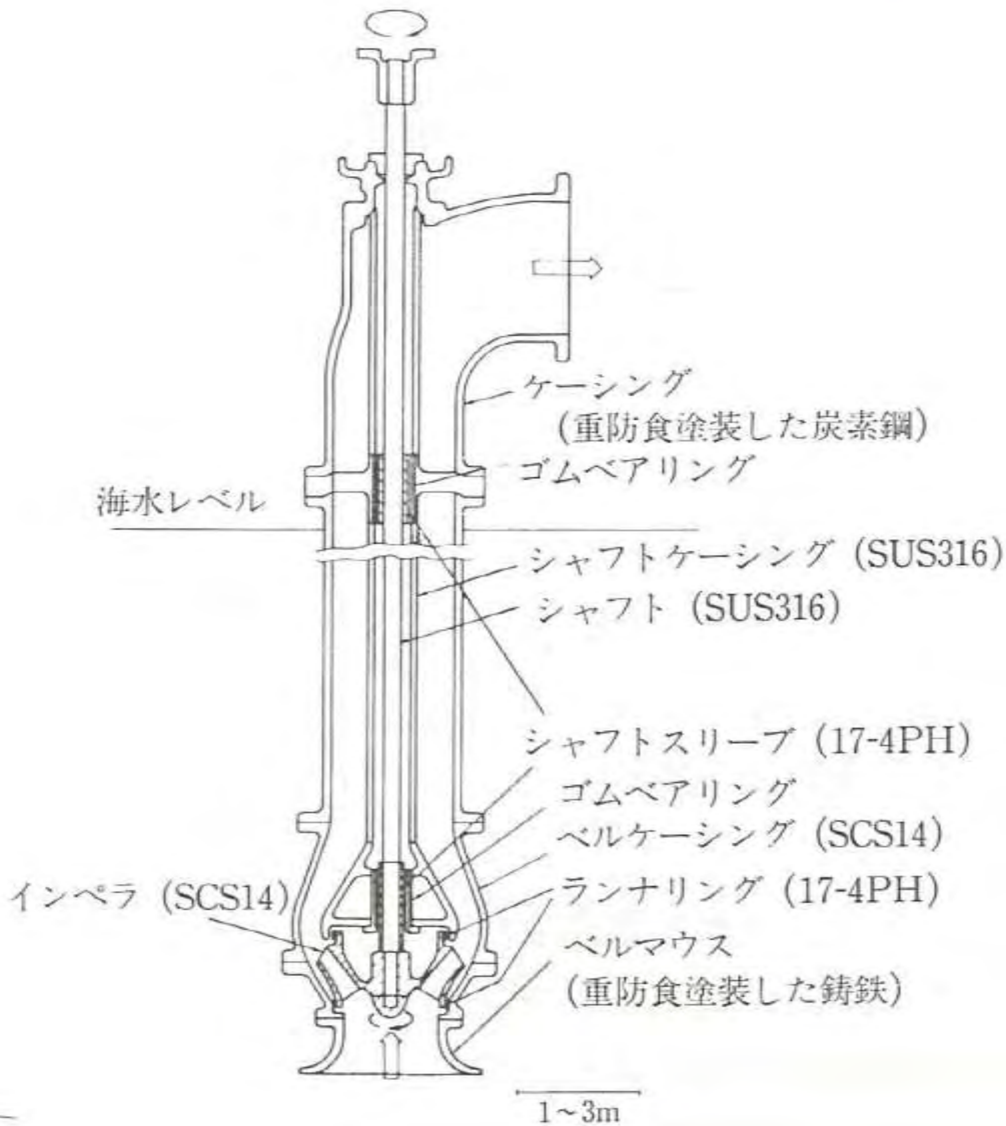

Tsunami
4 to 5 m inundation height across the ocean side of main structures area (reactor and turbine buildings).
From VGB homepage



From VGB homepage

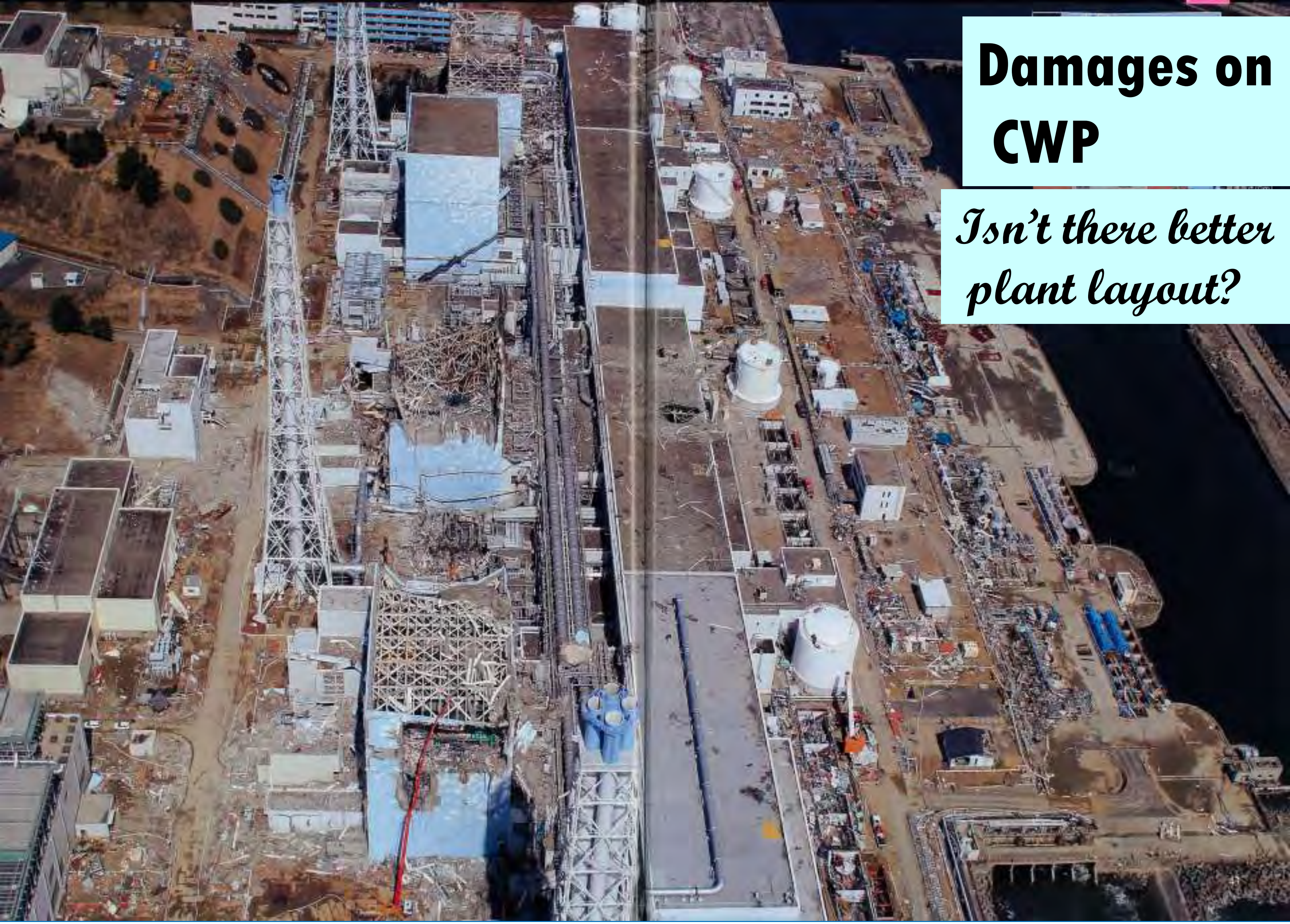
From NHK News

(Sea Water) Circulating Cooling Pump: CWP

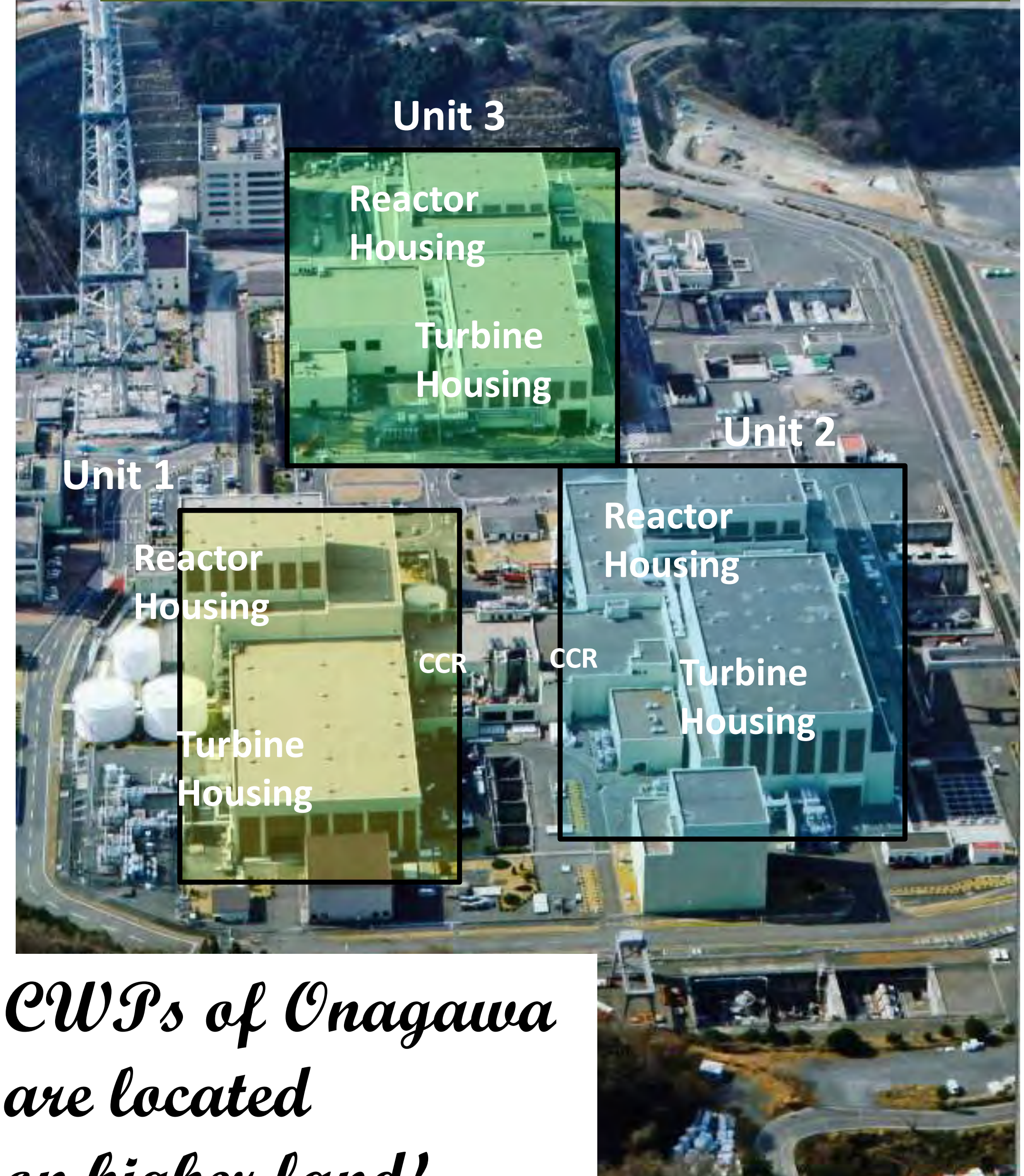


Damages on CWP

Isn't there better plant layout?



Onagawa Nuclear Power Station



CWPs of Onagawa are located on higher land!

Comparison of Onagawa and Fukushima Daiichi

COMPANY	POWER STATION	MAX. OUTPUT (MW)	UNIT No.	OUTPUT (MW)	MAKER	MODEL	START OF COMMERCIAL OPERATION	SUPPLIER							
								MAIN CONTRACTOR	ARCHITECT ENGINEER	NUCLEAR SYSTEM	PRESSURE VESSEL	REACTOR CORE	FUEL	STEAM SYSTEM	TURBINE
Tohoku Electric Power	**Onagawa**	2,174	**1**	**524**	**T**	**BWR-4 /MARK- Ⅰ**	**1984/06**	**T**	**T**	**T**	**IHI**	**T**	**JNF/NFI**	**T**	**T**
			2	825	T	BWR-5 /MARK- Ⅰ Advanced	1995/07	T	T	T	IHI	T	T/JNF	T	T
			3	825	T	BWR-5 /MARK- Ⅰ Advanced	2002/01	T/H	T	T	IHI	T	T/GNF-J	H	H
Tokyo Electric Power	**Fukushima Daiichi**	4,696	**1**	**460**	**GE**	**BWR-3 /MARK- Ⅰ**	**1971/03**	**GE**	**EBASCO**	**GE /GETSCO**	**GE/GETSCO /T/IHI**	**GE /GETSCO**	**GE/JNF**	**GE /GETSCO**	**GE /GETSCO**
			2	784	GE	BWR-4 /MARK- Ⅰ	1974/07	GE/T	EBASCO	GE/T	GE/GETSCO /T/IHI	GE	GE/JNF・NFI	GE/T /GETSCO	GE/T /GETSCO
			3	784	T	BWR-4 /MARK- Ⅰ	1976/03	T	T	T	T/IHI	T	T/JNF・NFI	T	T
			4	784	H	BWR-4/ MARK- Ⅰ	1978/10	H	H	H	H/BH	H	H/JNF・NFI	H	H
			5	784	T	BWR-4/ MARK- Ⅰ	1978/04	T	T	T	T/IHI	T	H/JNF・NFI	T	T
			6	1,100	GE	BWR-5 /MARK- Ⅱ	1979/10	GE/T	EBASCO	GE/T	GE/GETSCO /T/IHI	GE	GE/JNF	GE/T /GETSCO	GE/T /GETSCO

［Note］ Unit 1 of Fukushima Daiichi Nuclear Power Station started design work in 1965, and started construction work in 1967.

T:Toshiba, H:Hitachi, BH:Babcock Hitachi, JNF:Japan Nuclear Fuel, NFI:Nuclear Fuel Industries, GNF-J:Global Nuclear Fuel–Japan

Example of Nuclear Power Station In USA (Pennsylvania)

Example of Nuclear Power Station In USA (East River, New York City, New York)

➢Most important thing at this moment

----Don't spill the contaminated water to the sea again!---

➢First priority technical issue
→Ccooling of reactor core and spent fuel pool
→Continuous cooling water is needed
→Fed water must go somewhere unless evaporated
→Contaminated effluent water may leak …

➢Previous sudden emission of 7,000ton contaminated water caused international reproach regardless of radiation level!

➢Decisive international disqualification may arise if another emission happens!

➢Double or triple layered back-up system is required to be prepared for the worst case!

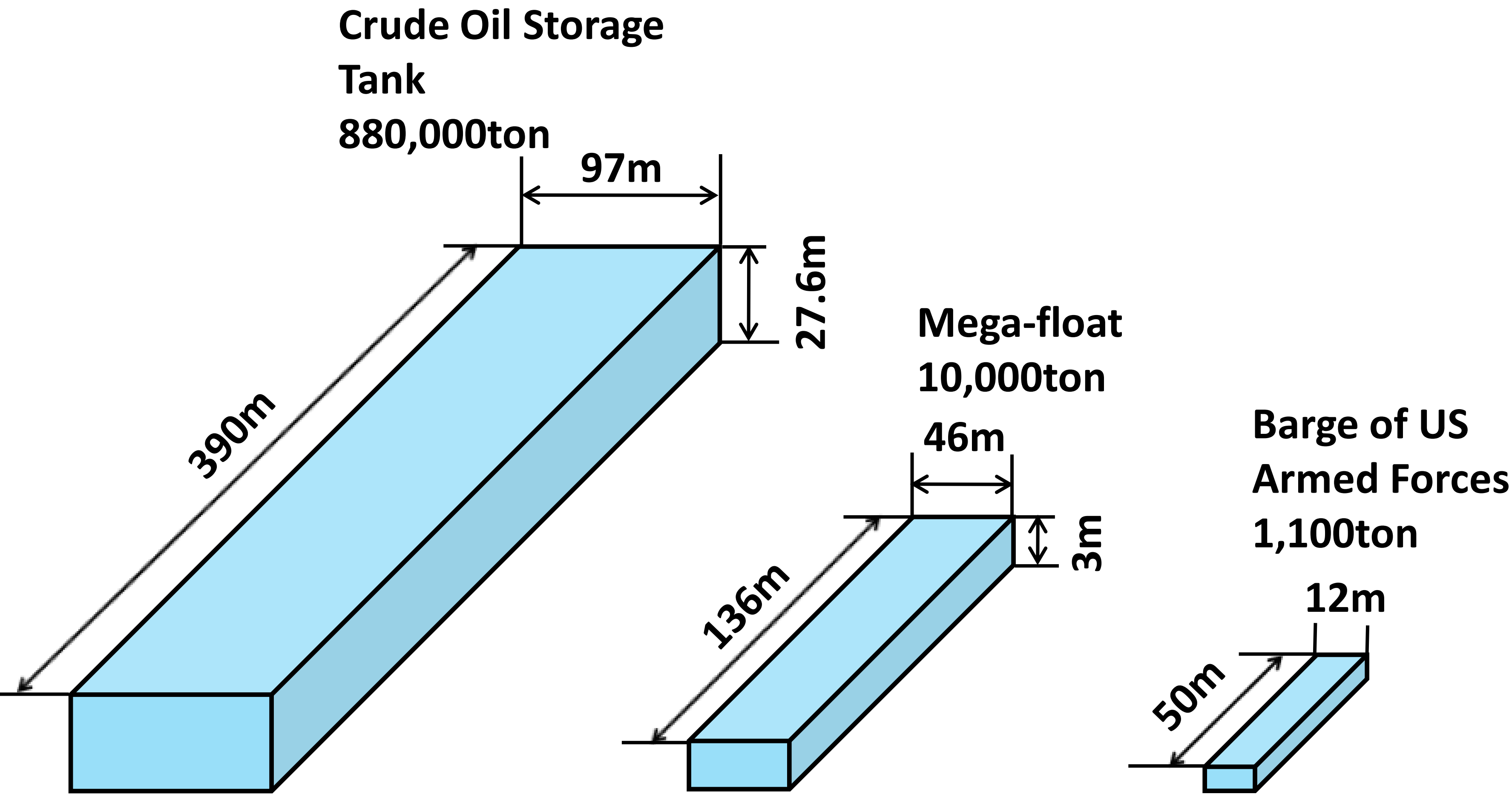
Containment Tank Building of Contaminated Water

- 75,000 ton capacity of Containment Tank Building
- Containment Vessel of Unit 1 will be filled with water in mid-July
- Spilt high level water in turbine Housing of Unit 2 will be sent to the tank building

Other Tanks： Temporary Tank 1000 ton（Already completed)
Ground Tank 57,000 ton（Under construction, expected to be completed by the end of May)

- What Kaneko is proposing is alternative plan of floating tank of sufficient capacity at sea, waiting for just the worst case….

Candidates for Floating Tanks for Contaminated Water



Tank Barge of US Armed Forces

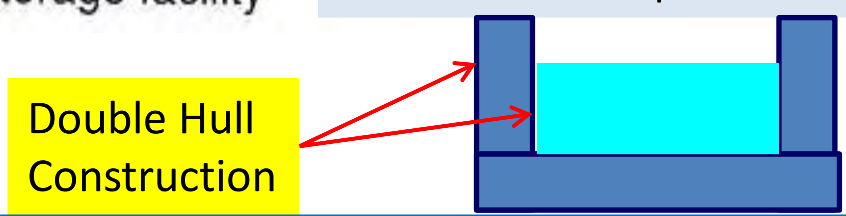
Mega-float

Kami-goto Floating Crude Oil Storage Station

5 tanks are ready to store crude oil since 1988

上五島石油備蓄基地
Kami-goto floating crude oil storage facility

These tanks are of double-hull construction to minimize oil spill to the sea



Floating Crude Oil Storage Facility in Japan

JOGMEC
Japan Oil, Gas and Metals National Corporation

			Kamigoto National Petroleum Storage Station	Shirashima National Petroleum Storage Station
Location			Shinkamigoto, Minami-matuura-county, Nagasaki Prefecture	Shirashima, Wakamatsu-ku, Kitakyusyu City, Fukuoka Prefecture
Area			Land：26ha　Sea：40ha	Land：14ha　Sea：60ha
Storage System			Floating Tank System	Floating Tank System
Facility Capacity			4,400,000 kiloliters（880,000 kiloliters×5）	5,600,000 kiloliters（700,000 kiloliters×8）
Inventory（as of Aug. 2009)			3,425,000 kiloliters（78%）	4,750,000 kiloliters（85%）
Completion Year			1988	1996
Specification	Tank	Capacity	880,000 kiloliters × 5	700,000 kiloliters × 8
		Size	W 390m x D 97m x H 27.6m	W 397m x D 82m x H 25.4m
	Drain System		100 m^3/hr	30 m^3/hr x 2
	Oily Wastewater Tank		9,300 kiloliters x 2	9,700 kiloliters x 2
	Sea Water Pump		1,500 m^3/hr x 3	
	Firefighting boat & Tugboat		1	
	Oil Skimming Boat		1	

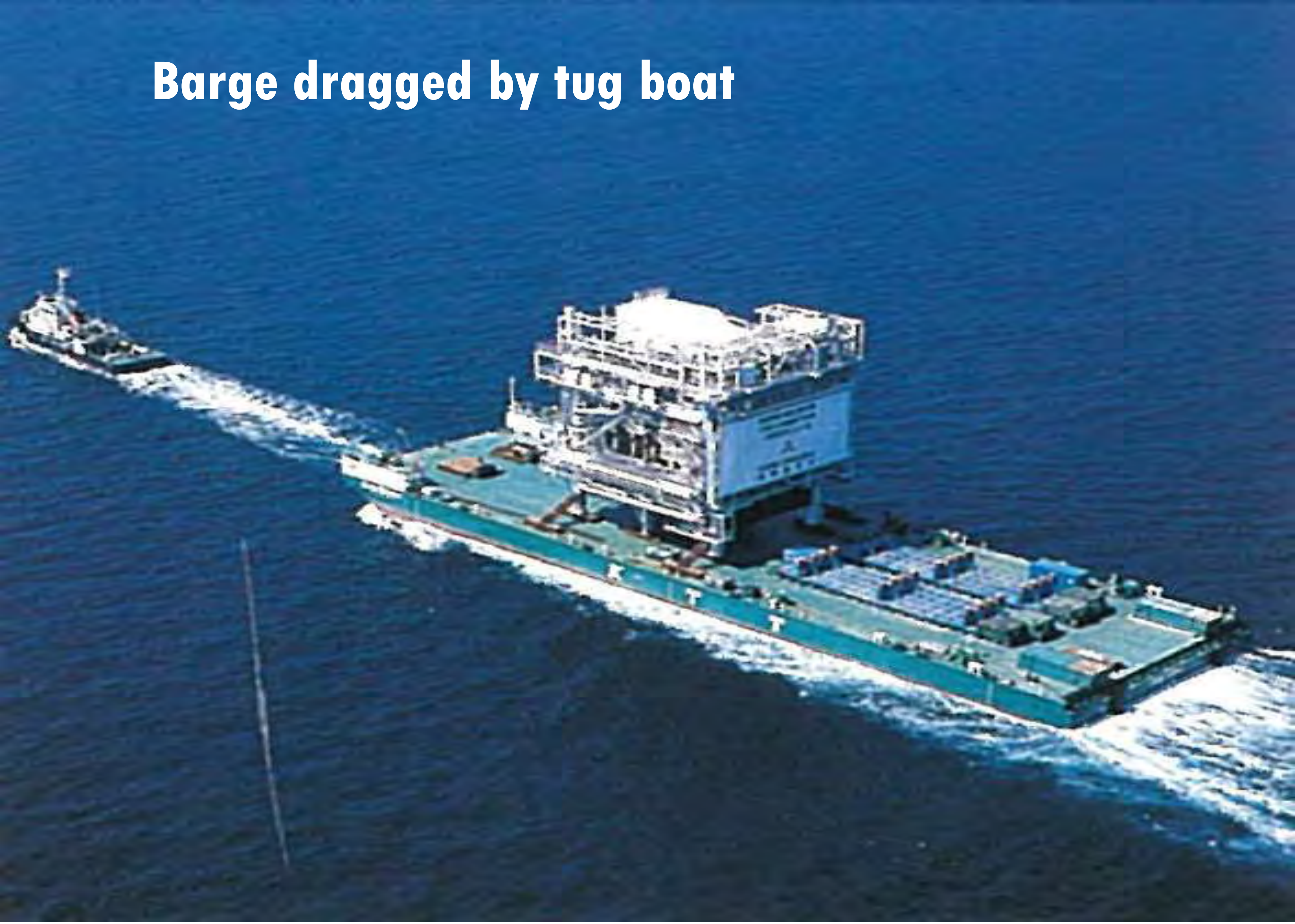
Overview of Crude Oil Storage Facilities in Japan

（　）Inventory as of Aug. 2009

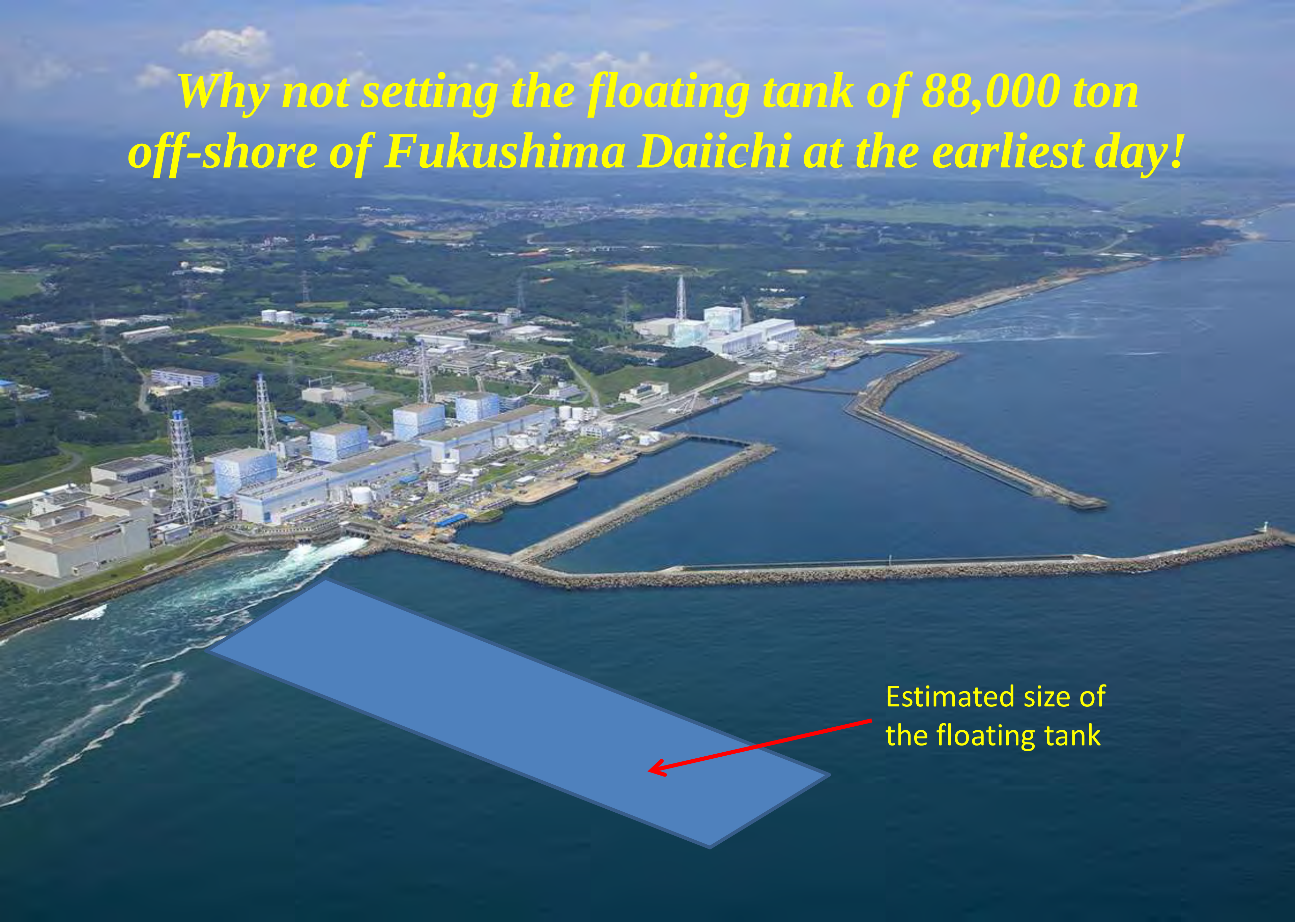
<table>
<tr><td rowspan="3">Government Storage
：51,000,000 kiloliters</td><td rowspan="2">Floating Tank</td><td rowspan="2">10,000,000 kiloliters
（8,170,000 kiloliters）</td><td>Kamigoto</td><td>4,400,000 kiloliters
（3,420,000 kiloliters)</td></tr>
<tr><td>Shirashima</td><td>5,600,000 kiloliters
（4,750,000 kiloliters）</td></tr>
<tr><td>Aboveground Tank</td><td>41,000,000 kiloliters</td><td colspan="2"></td></tr>
<tr><td>Private Sector Storage
：37,000,000 kiloliters</td><td colspan="4" rowspan="2"></td></tr>
<tr><td>Total　88,000,000 kiloliters
（Approx. 194days equivalent）</td></tr>
</table>

［Note］
According to the data as of Aug. 2009（latest data of JOGMEC on homepage）, the stored oil 78% of the rated capacity[342/440=0.78, less than 80%].
This means that the oil quantity of five tanks can be stored in four tanks.
i.e. One tank can be emptied.

Barge dragged by tug boat



Why not setting the floating tank of 88,000 ton off-shore of Fukushima Daiichi at the earliest day!



Other Option: Stand-by of Double Hull Oil Tanker

3. Trend of Energy from now

- Highly efficient fossil power and renewable energy

How to recover loss of power generation by nuclear?

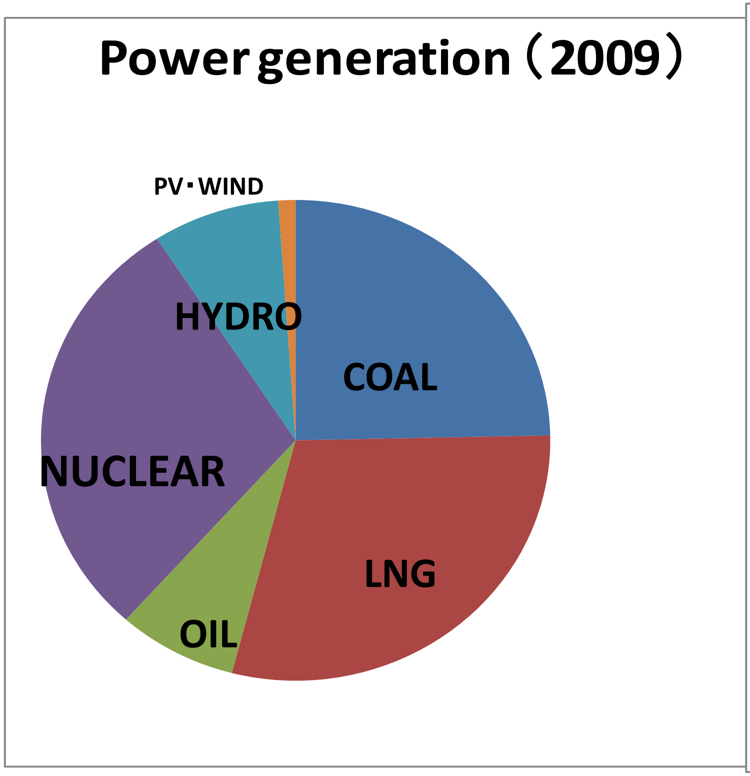
1. Can it be covered by Fossil and renewable power generation?
2. Can Fossil fuels be secured with reasonable price?

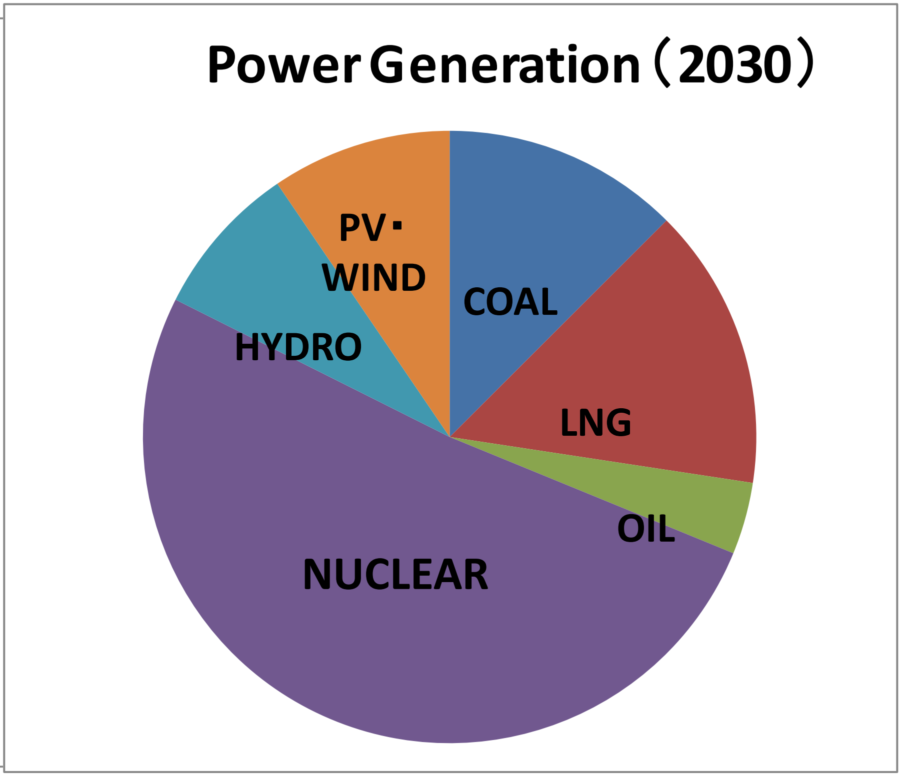
1. To elevate the efficiency to the maximum is absolutely necessary.
2. Both natural gas and coal must be used and interchangeability is preferred for national security.

Why efficiency increase is inevitable?

Projection by the Governmen tPlan of June 18, 2010

Present



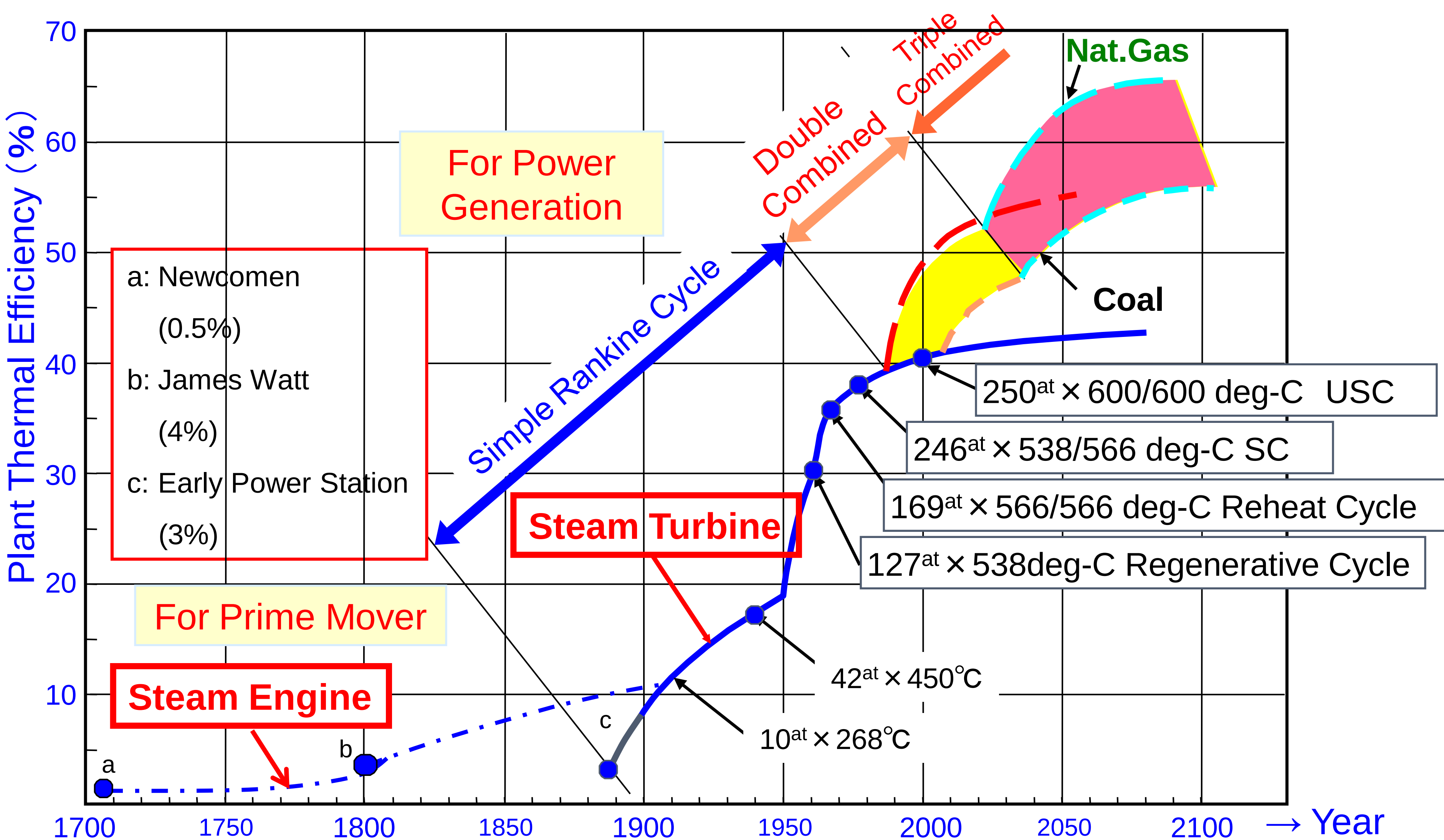


- By the present government plan decided on june 18, 2010, the power generation by nuclear will be 50% in 2030.
- Prime minister Kan said this plan will be revised.

Trend from now and effective solutions

1. No matter how strongly promoted in renewable energy such as solar and wind power, it is impossible to cover the loss of nuclear power.
2. Only fossil power generation can cover the loss of nuclear power. Hence maximum highly efficient fossil power technology is needed.
3. Natural gas combined cycle is most desirable because of cleanness.→But too much dependence on natural gas is risky for security of supply and price-hike. Therefore coal is also very important.
4. High efficiency fossil power generation. It moves from present simple cycle steam turbine (USC or A-USC) to combined cycle both for natural gas and coal.
5. After 2020 triple combined cycle will be the dominant power generation technology.

History of Thermal Efficiencies



Steam Turbine by Parsons

- **Patent in 1884 : multi-stage axial flow steam turbine**
- **Patent in 1896 : Separate production of blades**

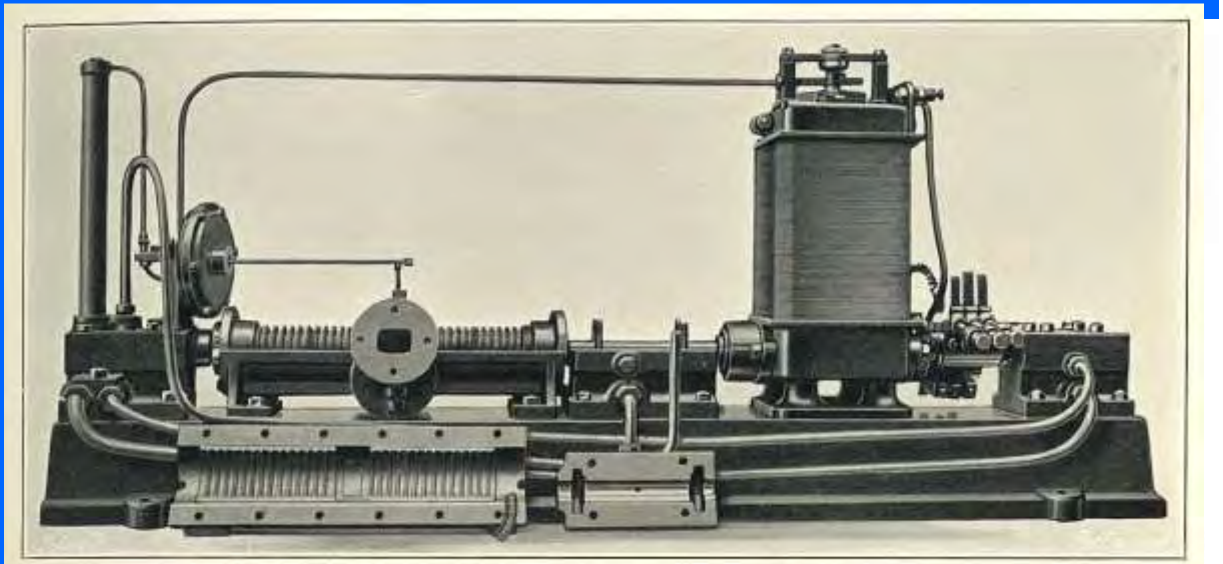


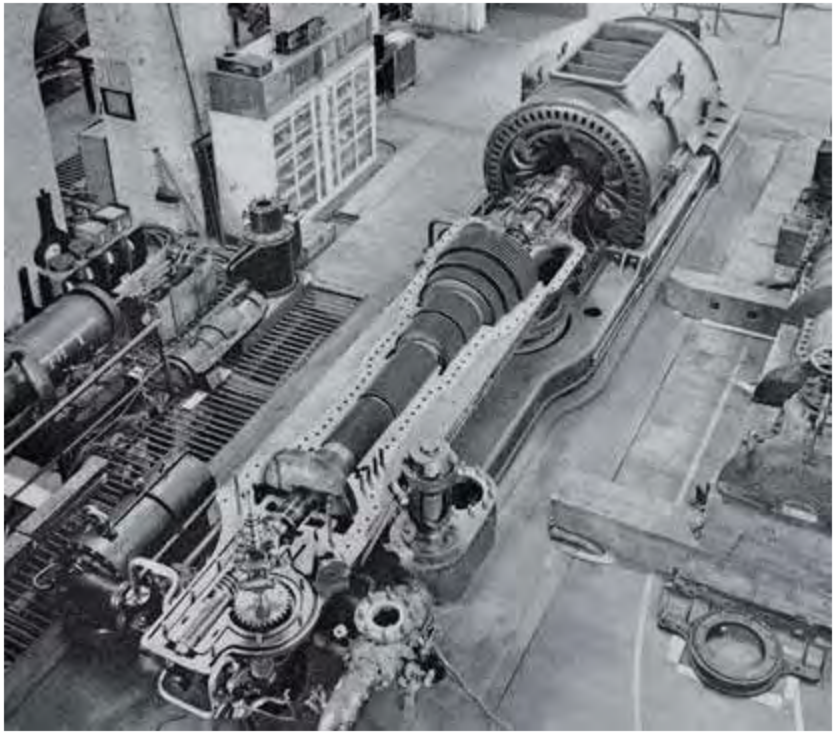
FIG. 1—THE FIRST PARSONS STEAM TURBINE

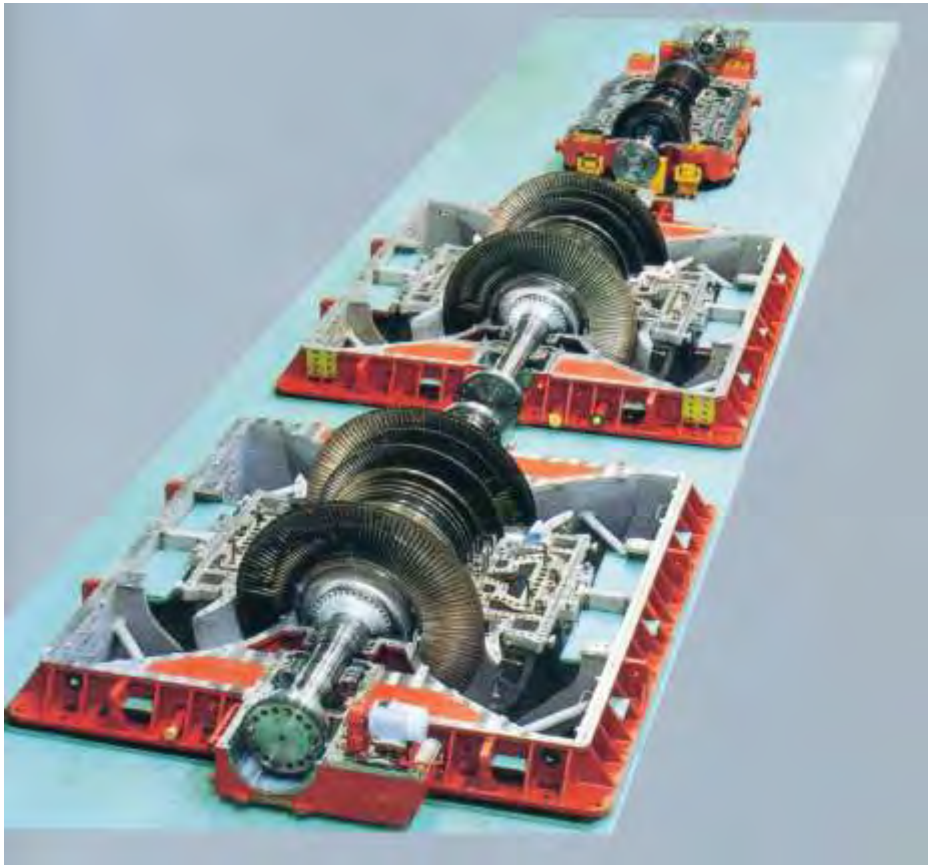
The first steam turbine by Parsons

Charles A. Parsons

Cited from : H.W. Dickinson, " A Short History of Steam Engine "

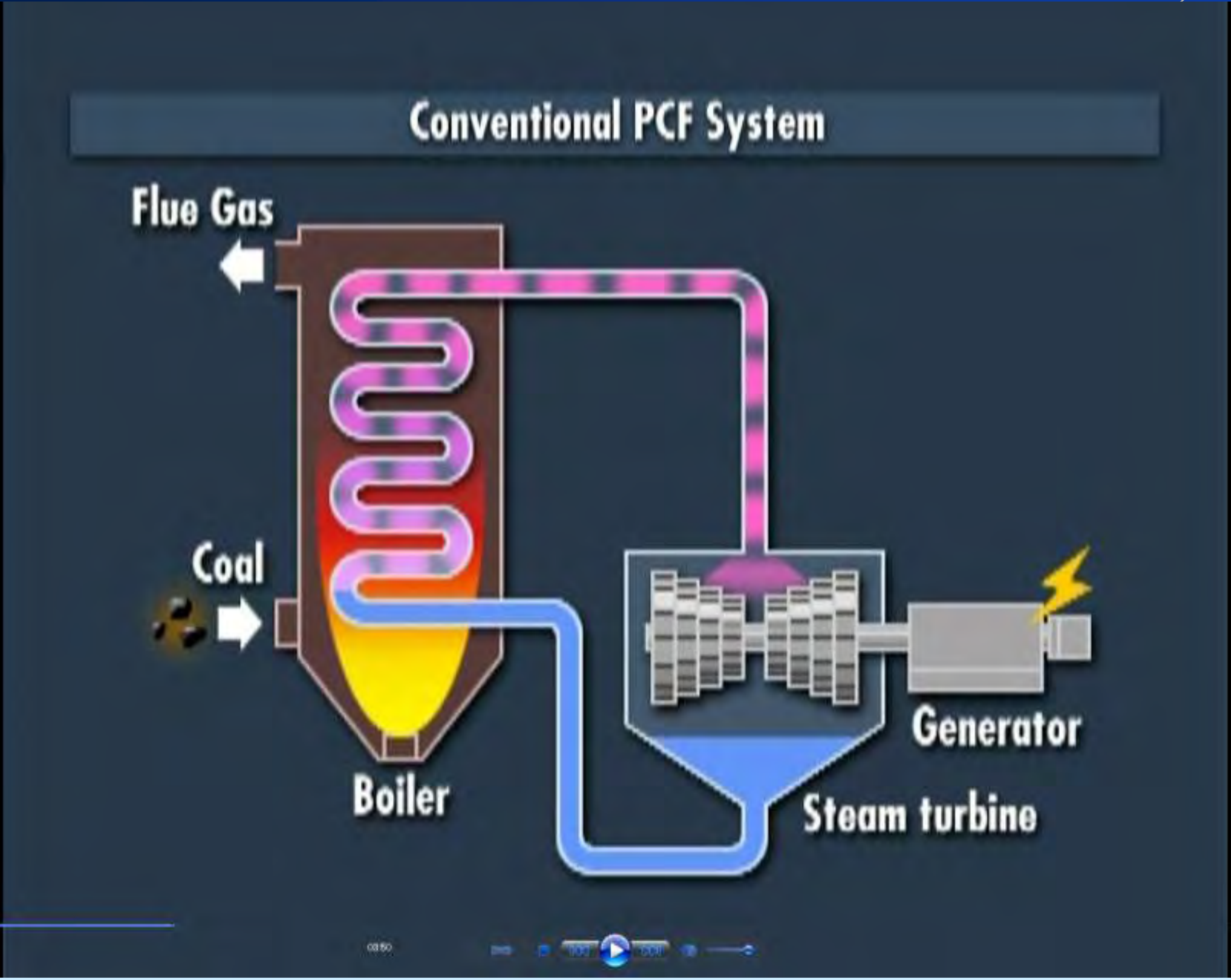
Steam Turbine in Japan





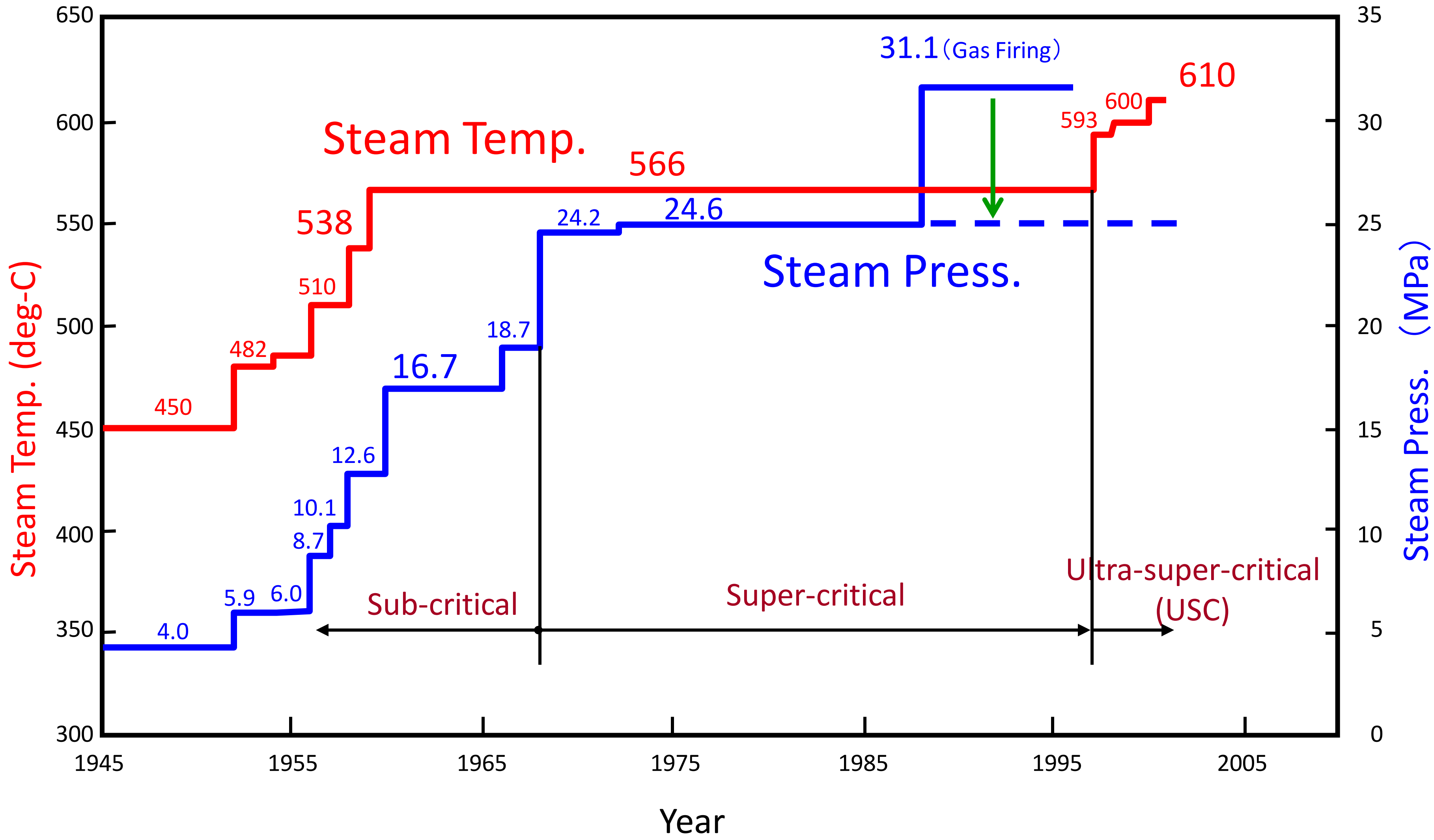
First Steam Turbine for Power Generation：500KW（1905）

Recent Steam Turbine：700,000KW (1995）



Courtesy of Clean Coal Power R&D Co., Ltd.

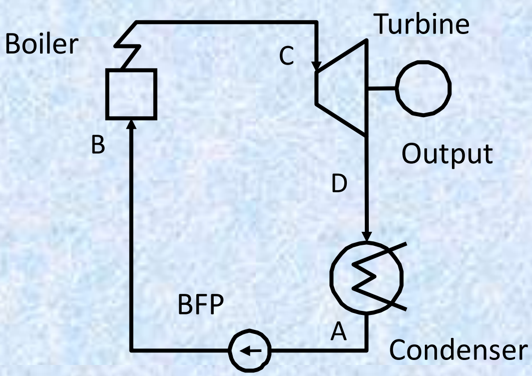
Steam Conditions of Power Plants in Japan



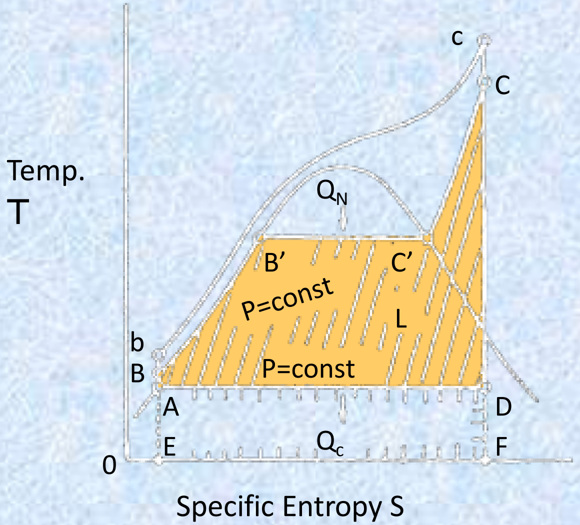
Main Steam Piping at 650 deg-C

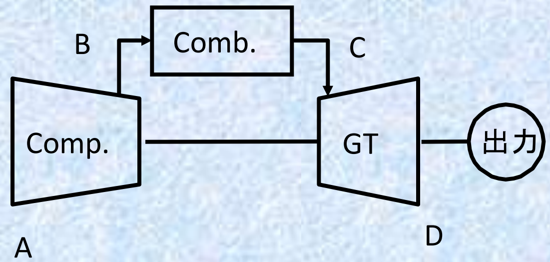
Courtesy of Mitsubishi Heavy Industries, Ltd.

Cycle Diagram of Power Plant

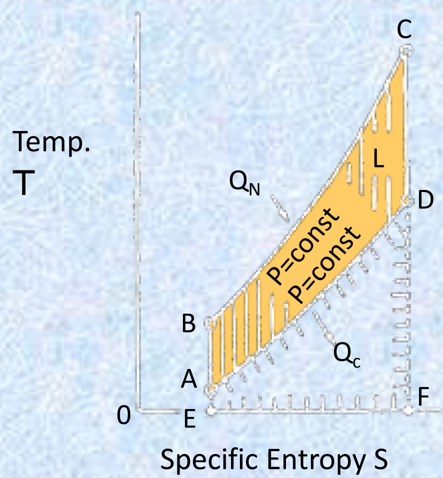


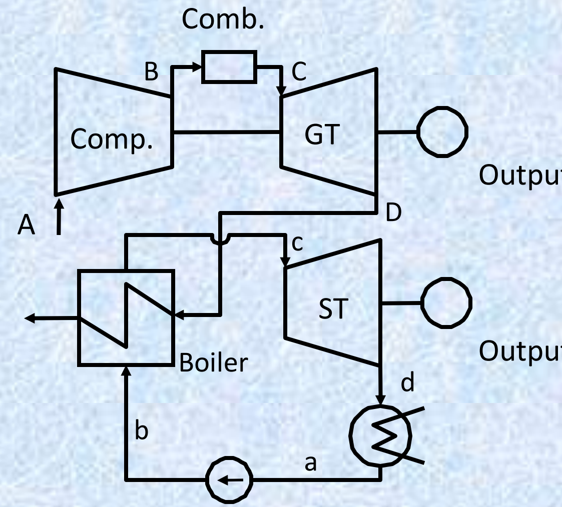
Rankine Cycle



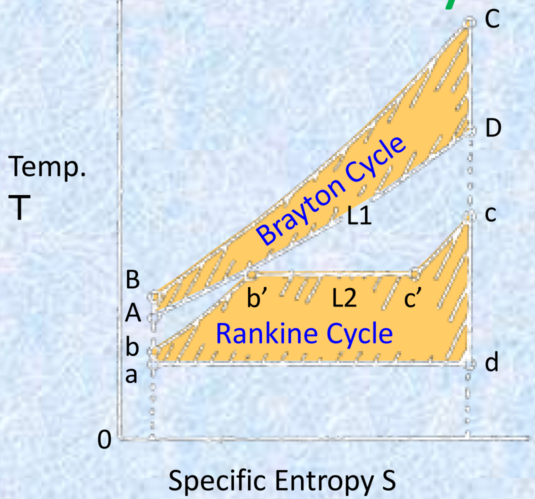


Brayton Cycle





Combined Cycle

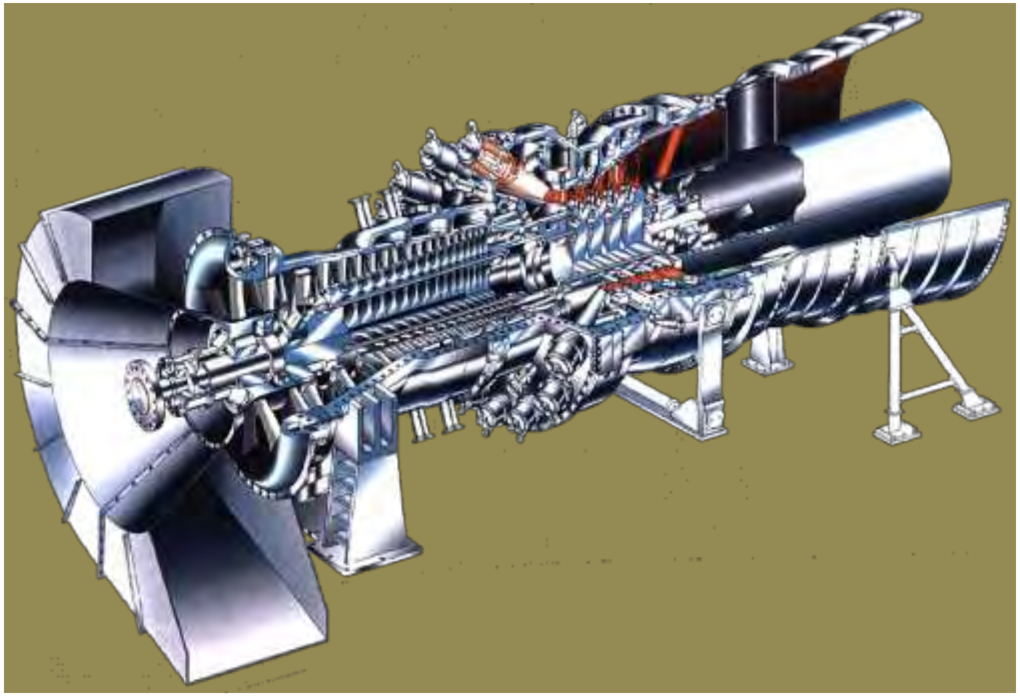


Source : S. Kaneko, "Kagaku-Kougyou" (AUG. 1992), p.32-39

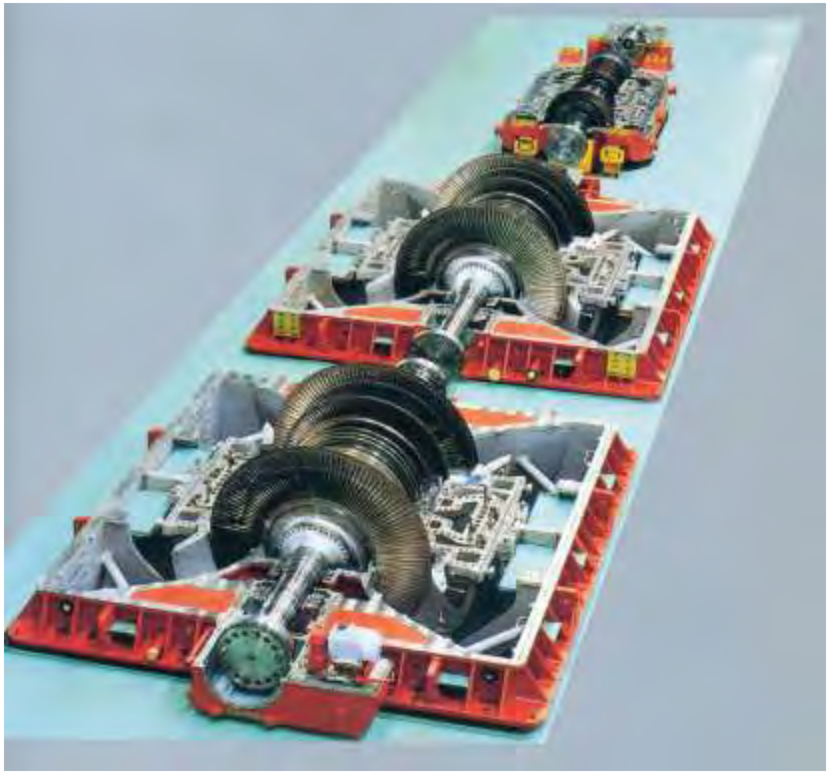
Combined Cycle Plant

- Standard for 21st Century

Gas Turbine

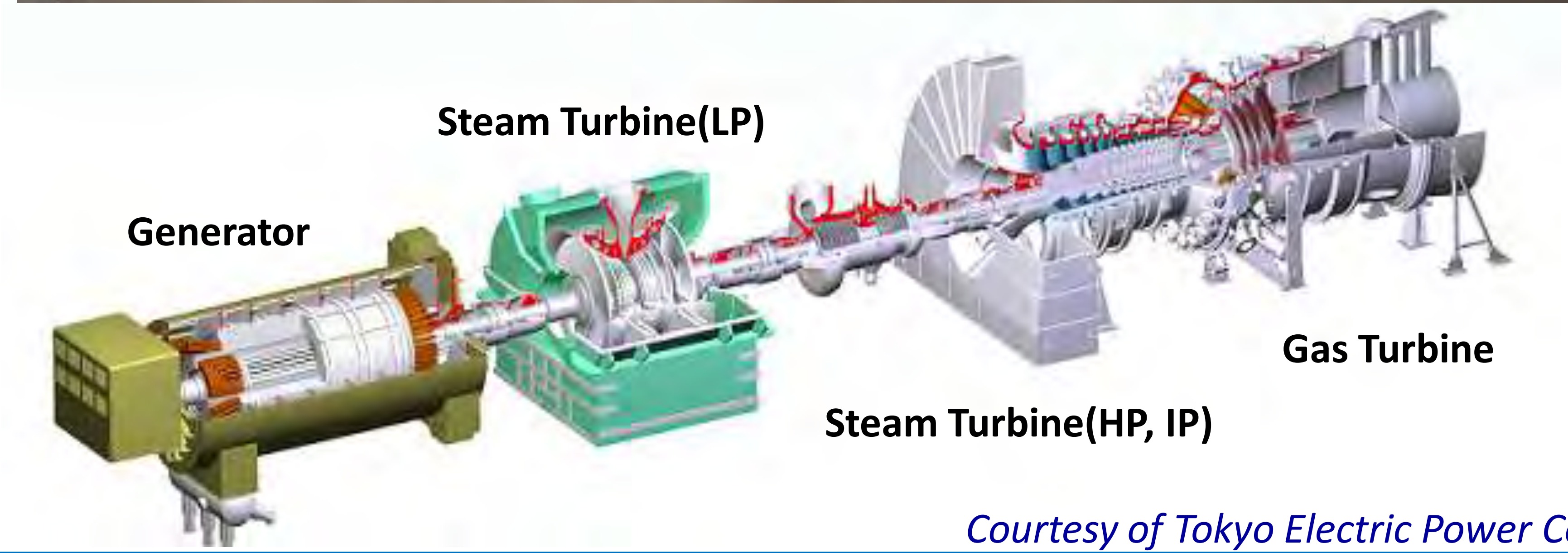


Steam Turbine



Courtesy of Mitsubishi Heavy Industries, Ltd.

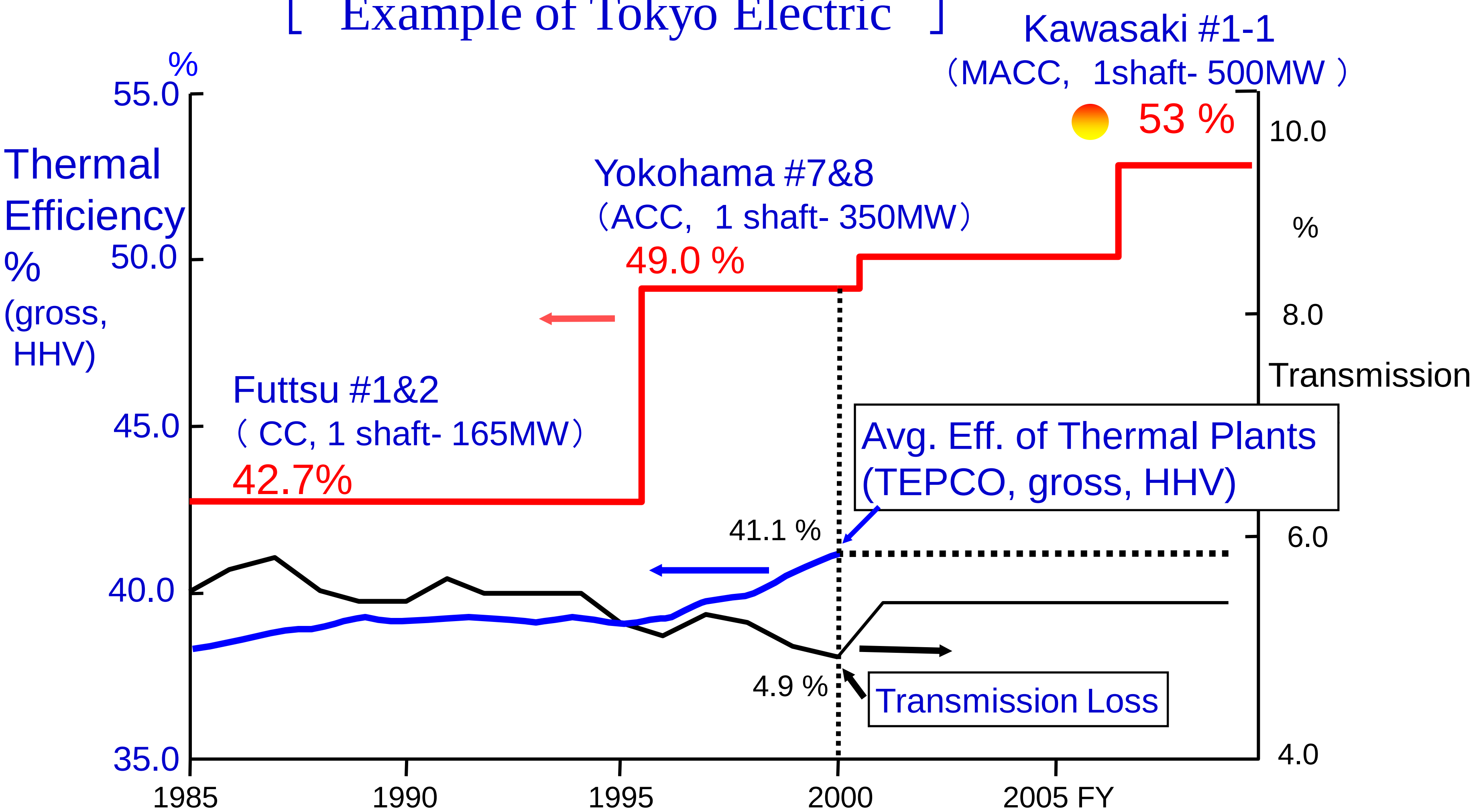
Main Components for Combined Cycle (Gas Turbine with 1,500 deg-C Inlet Gas Temperature)



Courtesy of Tokyo Electric Power Co.

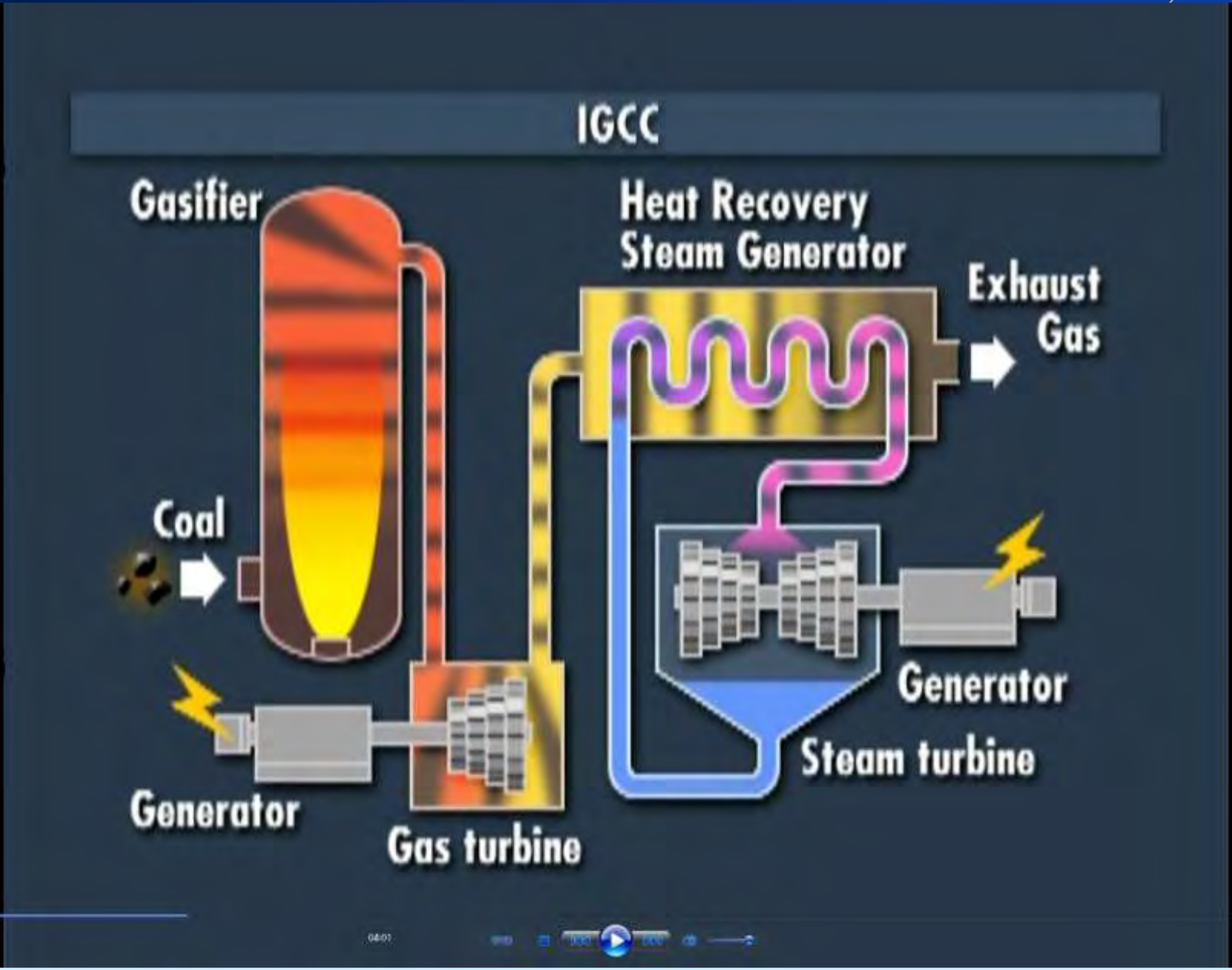
Combined Cycle Plant （Natural Gas)

［ Example of Tokyo Electric ］



Thermal Efficiency(HHV) , Transmission Loss %

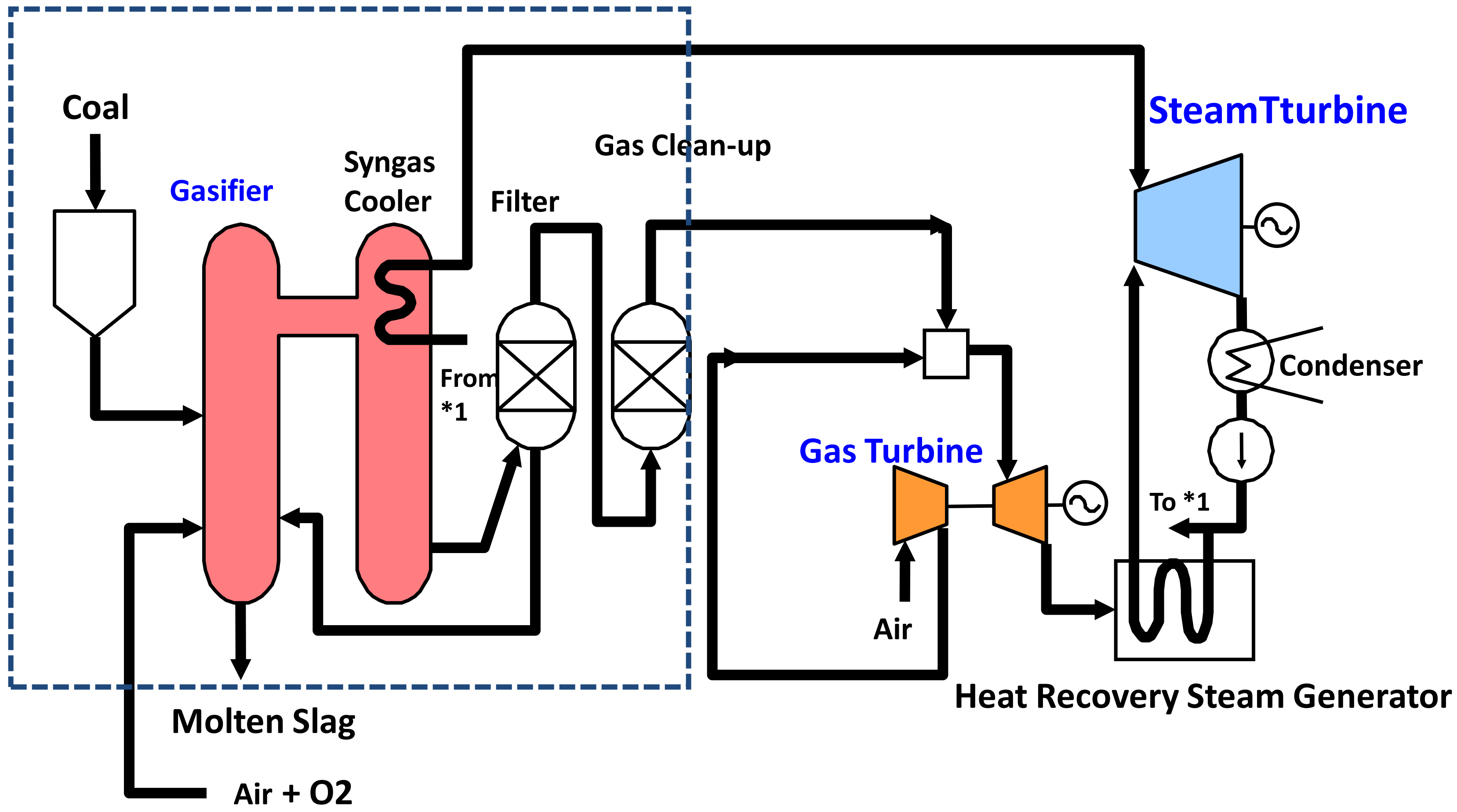
Source: Environmental Action Report of TEPCO, 2001, p.30



Courtesy of Clean Coal Power R&D Co., Ltd.

Integrated coal Gasification Combined cycle（IGCC）

Gasifier and Clean-up System



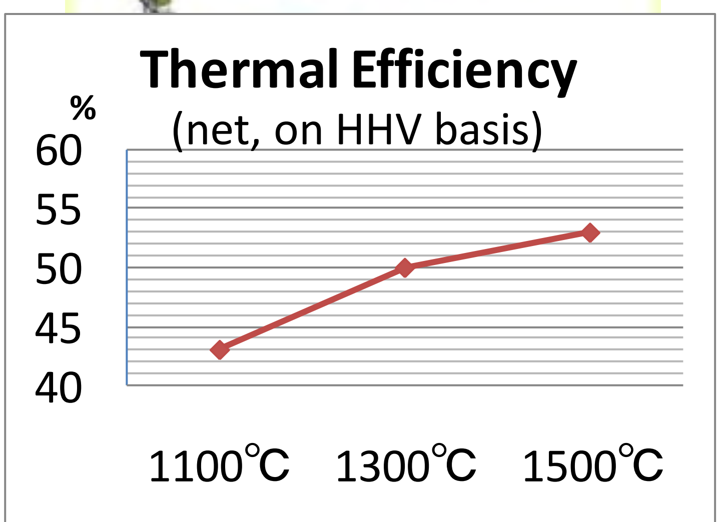
4. Future Trend in Fossil Power Generation

From Double Combined Cycle to Triple Combined Cycle!

Triple Combined Cycle
(Ultimate High Efficiency Power Generation)

Double Combined Cycle

Gas Turbine + Steam Turbine



Triple Combined Cycle

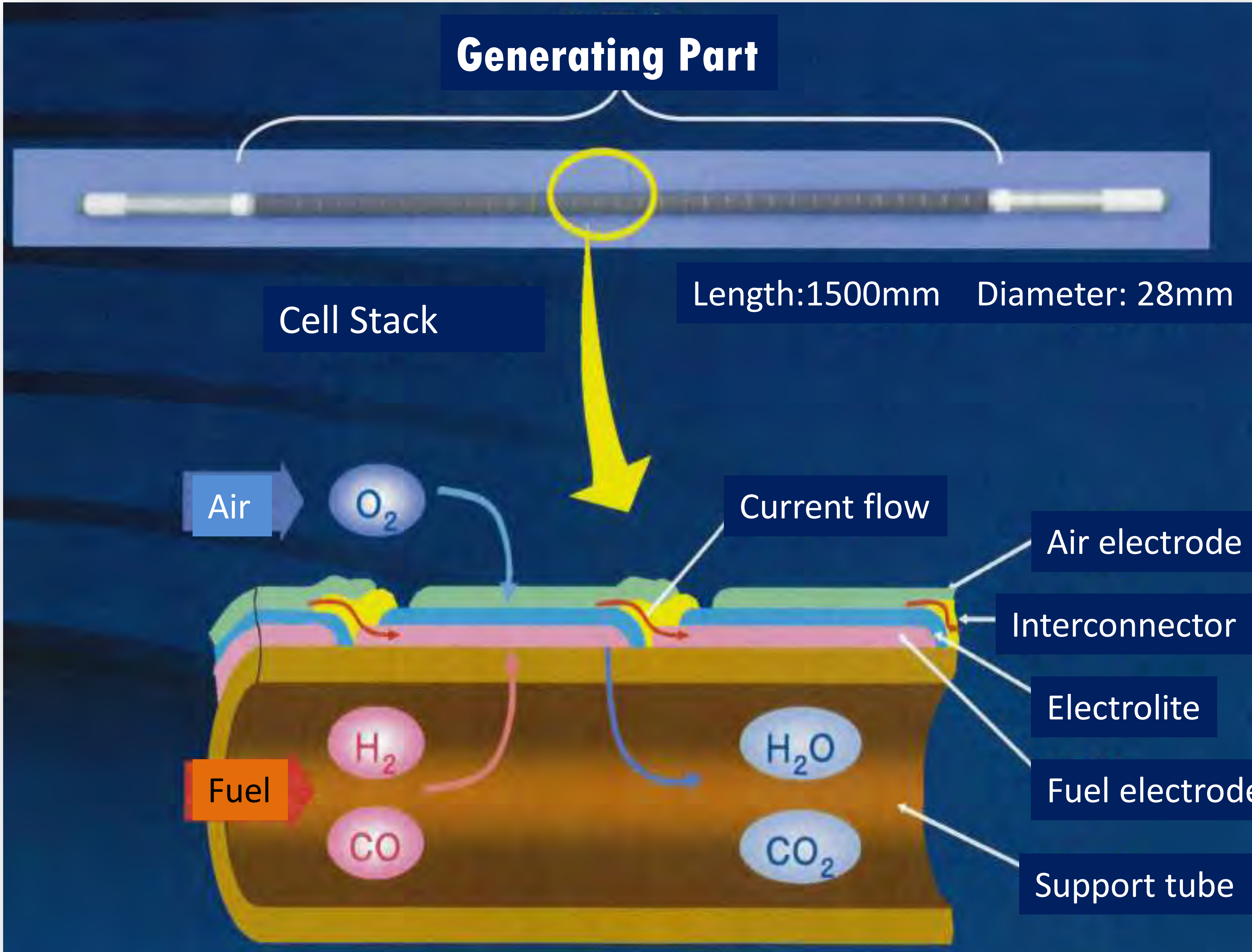
Solid Oxide Fuel Cell + Gas Turbine + Steam Turbine

Courtesy of MHI

Nat. Gas　: 65%
Coal Gas　: 55%
(net, on HHV basis)

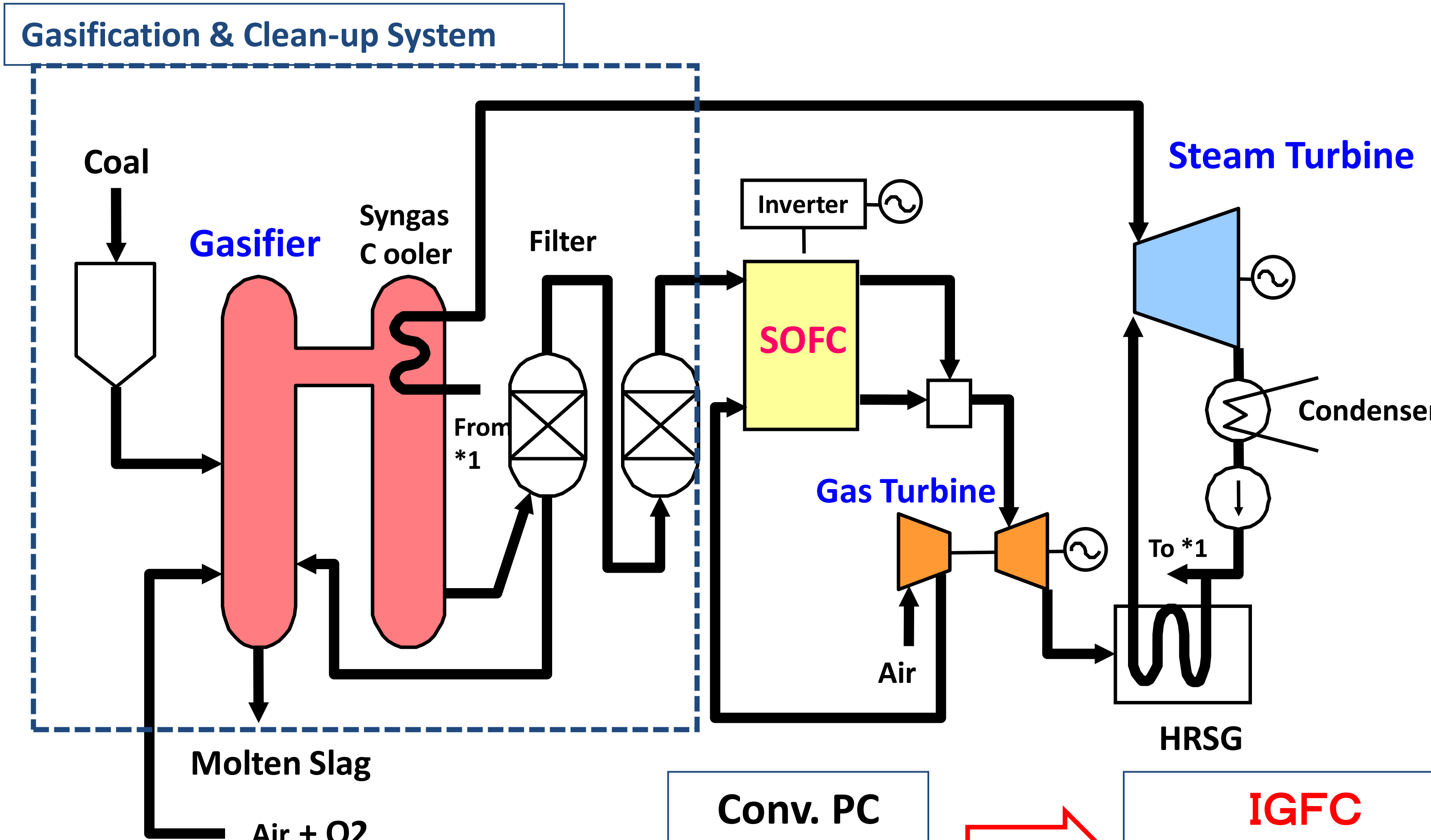
216 million tonnes of CO_2 can be reduced if all the plants are converted to triple cycle

Solid Oxide Fuel Cell (SOFC)



Triple Combined Cycle for Coal（IGFC）

(Coal gasification coupled with SOFC)



Conv. PC Unit 39% (net, HHV) → **IGFC 55%**

→ **30% Reduction in CO_2**

5. Renewable Energy

How to integrate with the renewal and revival of the damaged communities?

- Geothermal
- Biomass for Combustion
- Wave Energy

How to increase in renewable energy?

1. Solar
2. Wind Power
3. Wave energy
4. Geothermal
5. Biomass for combustion

The key is if we can collaborate with the local community!

Tohoku District is most abundant in natural energy sources in Japan!

Source: Japan seen from the Space, Shuuichi Niida, Tokai University Press

Wind Turbine

Off-shore Wind Farm at Middelgrunden, Denmark

Wave Energy


Geothermal

Biomass for Combustion

Source: Associate Professor Nitami, University of Tokyo

6. For Safety and Security

- Cost is needed for better safety and security!
- You must pay for that!

- *Look back the original position!*
- *It is a great chance to change drastically!*
- *Time is now!*

Emergency Power Generation

Battery

It is risky to depend too much on Natural Gas!

Natural gas is like thorough –bred. Clean, efficient and short construction time but weak to price-hike or supply crunch!

Thorough-bred cannot drag cargoes.

The Ants and the Grasshopper

Grasshopper
- Natural Gas?

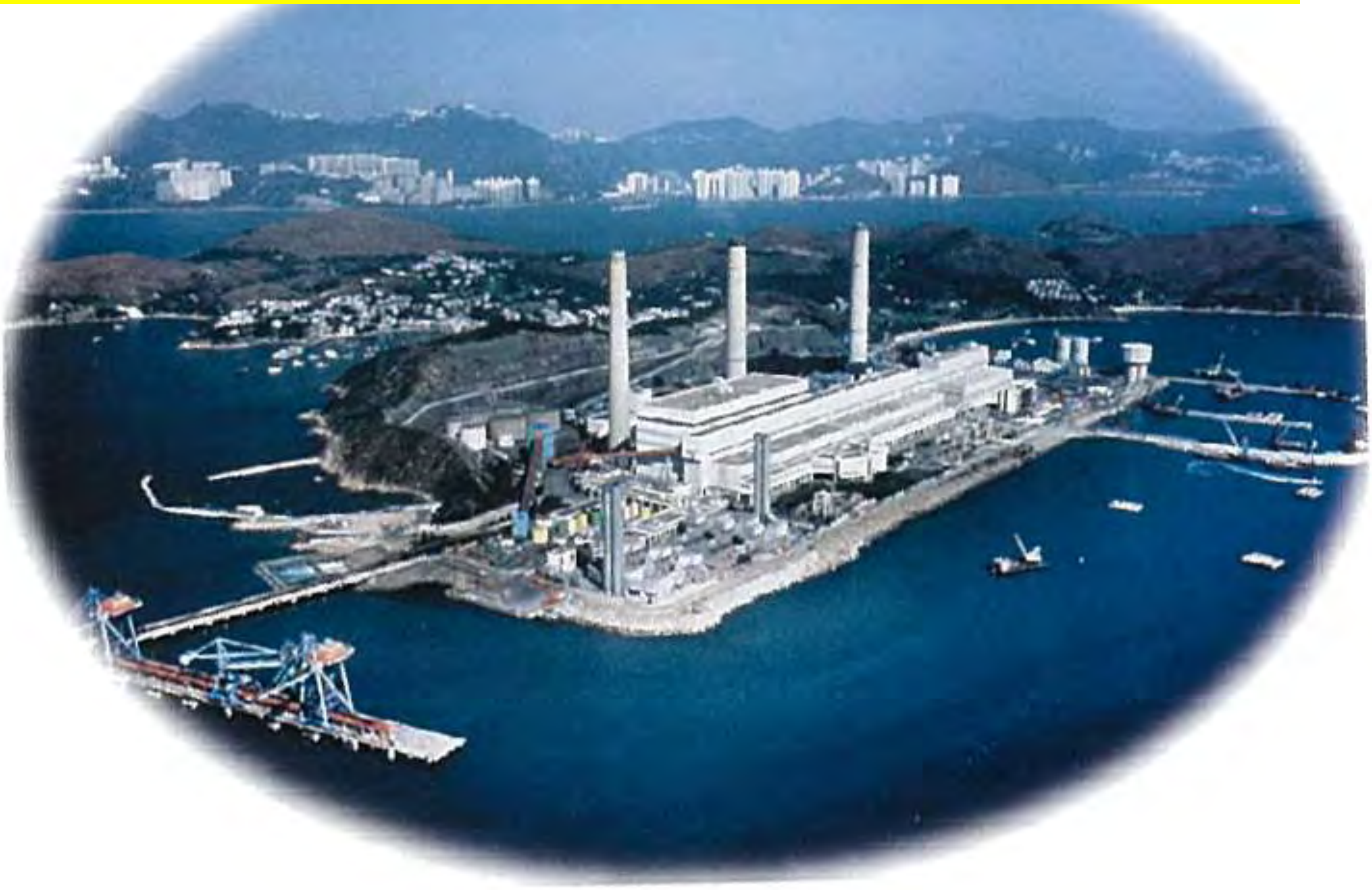
Ants
- Coal?

Why coal gasification is recommended →Interchageability to Natural Gas

- Pressurized
- Air Blown
- Two Stage
- Entrained Flow

Liquid fuel can also be produced by coal gasification!

➢ *We respect UK!*
They are strongly security-minded people!



Guards at the time of
Prince William's wedding Parade


Guard at the gate of Edinburgh Castle


Gorgeous Cruise Ship will be commandeered
by the Government in a day at the time of war!

Risk of Full-turn-key Projects

Greenhouse Gas Reduction Plans for Medium-term (2020)

LDP Gov. Plan : June 10, 2009

Greenhouse Gas Reduction

15% below 2005 levels

8% below 1990 levels

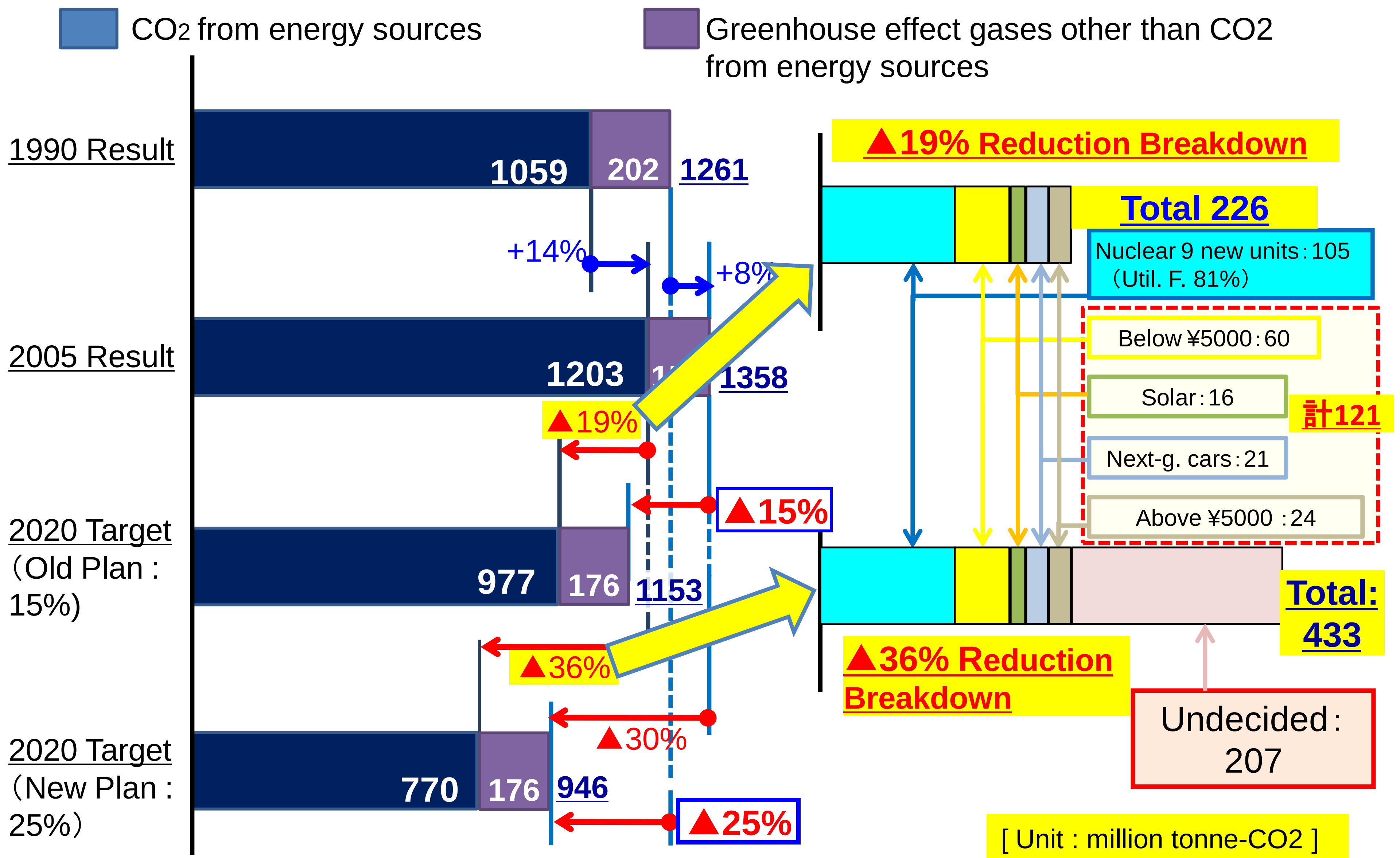
Manifesto by DPJ : August 31, 2009

Greenhouse Gas Reduction

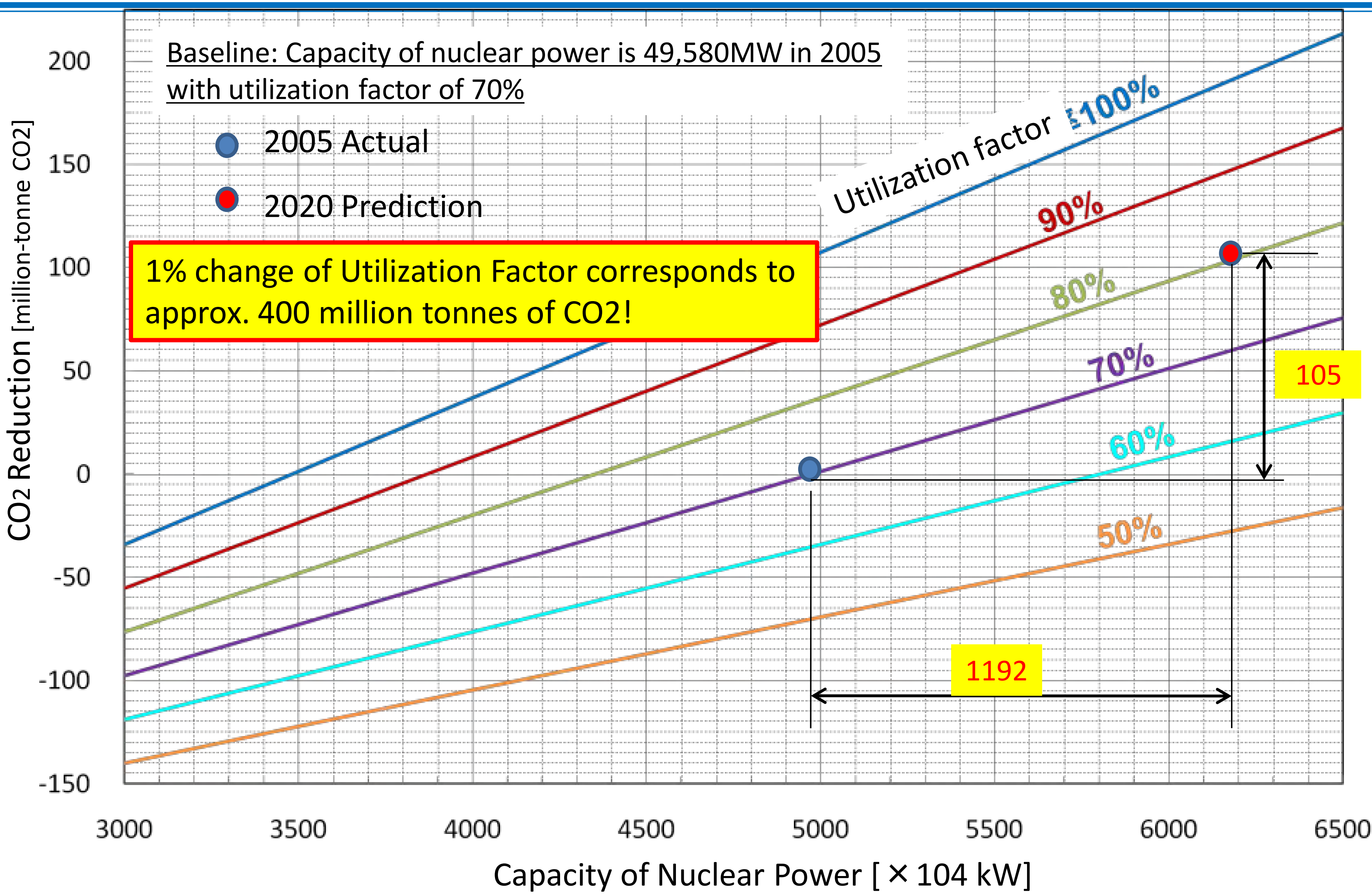
30% below 2005 levels

25% below 1990 levels

Comparison of Old Plan (15% reduction) and New Plan (25% reduction)



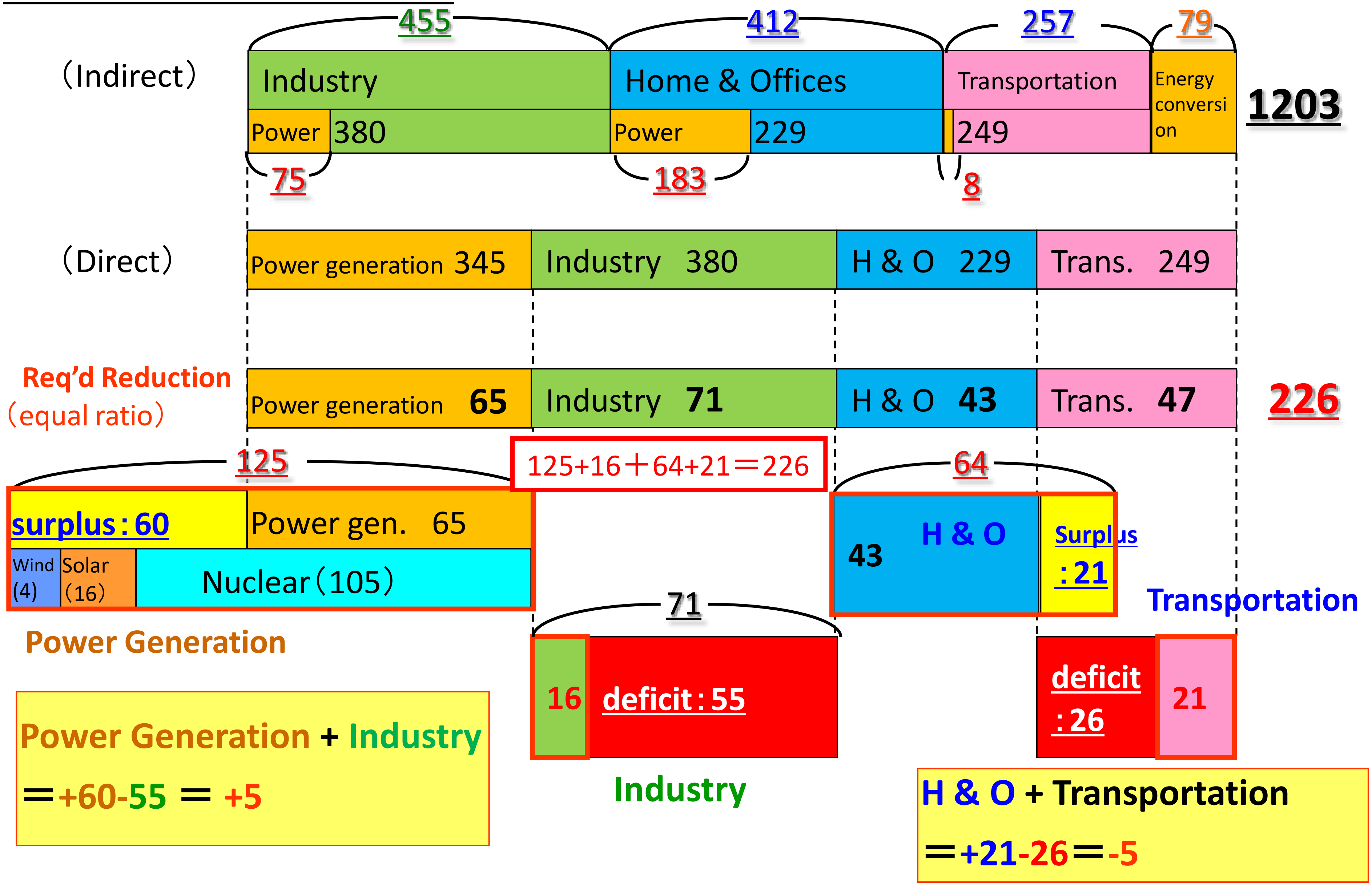
CO2 Reduction by Increase of Nuclear Power



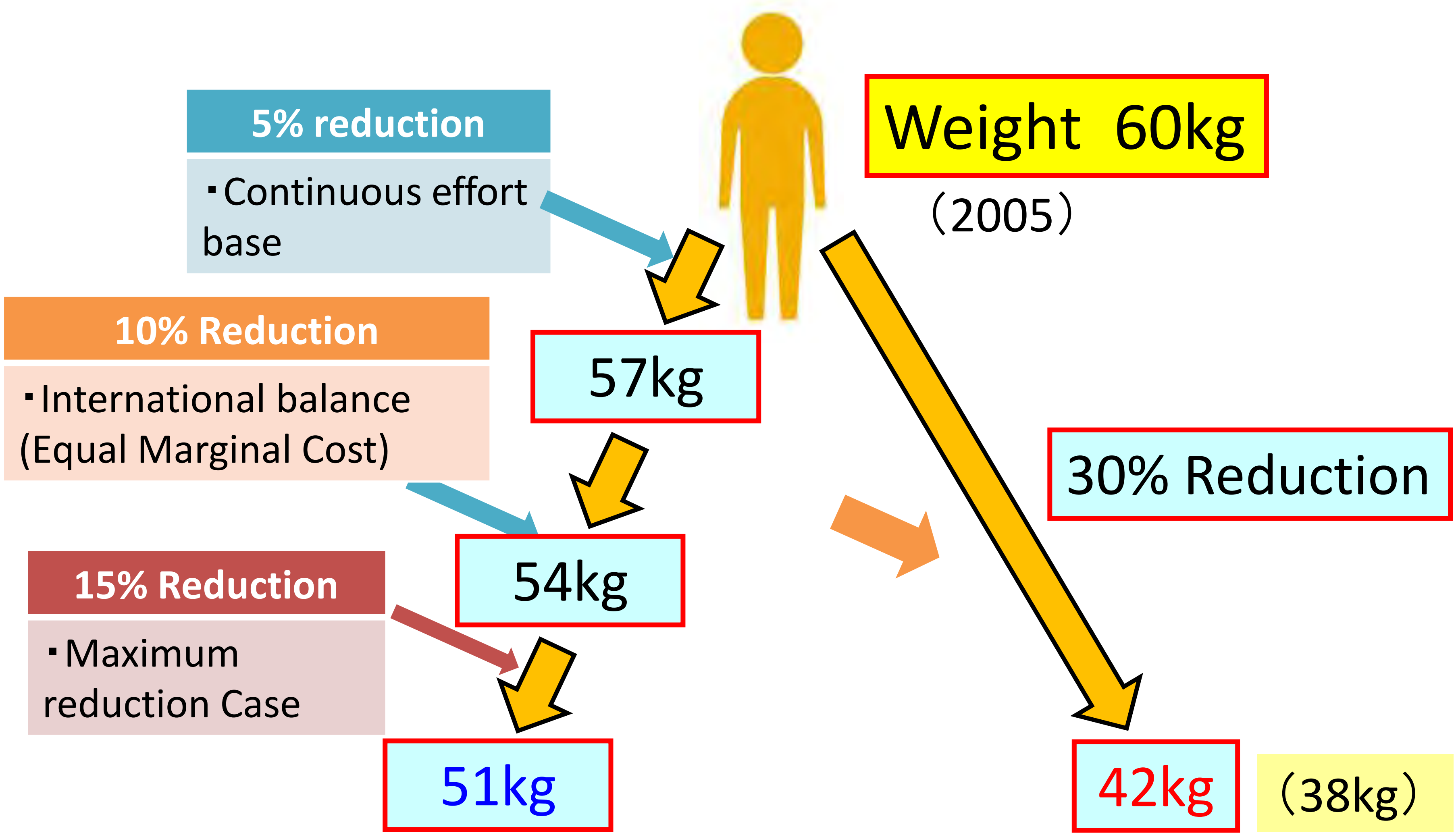
Action Plan for 15% reduction

[Unit : million tonne-CO2]

Results of CO2 emission in 2005



Japanese CO_2 Reduction Plan



It is ridiculous to die because of diet!


2
MFT Button
Is Nuclear OK？
SOS


Thank You!
The End