

What should be the criteria to discuss the safety of nuclear energy?

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Private Sector Independent Investigation

Committee on Fukushima Nuclear Accident

Science Council of Japan, energy policy options

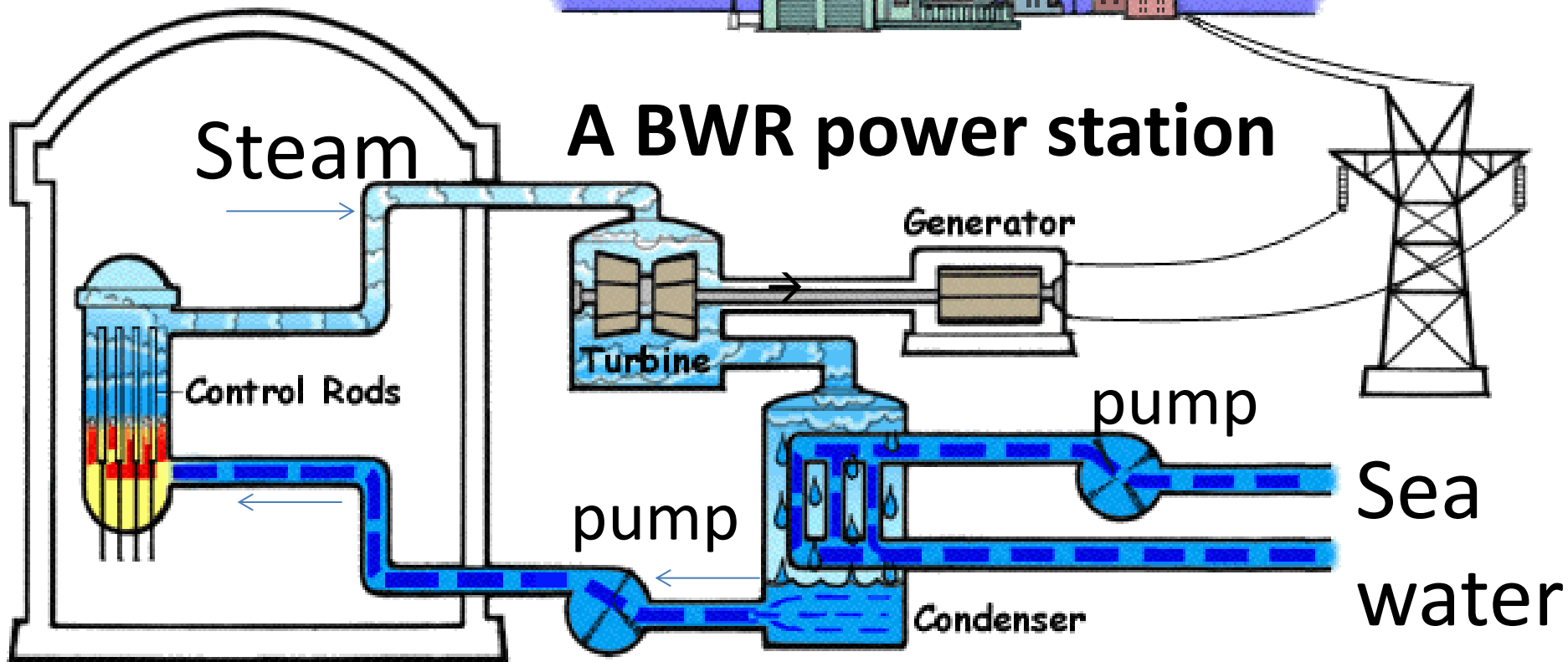
Follow-up committee on NRA, Cabinet Office

President, Tokyo City University

container



A BWR power station



Steam

Generator

Turbine

pump

Sea water

pump

Condenser

Control Rods

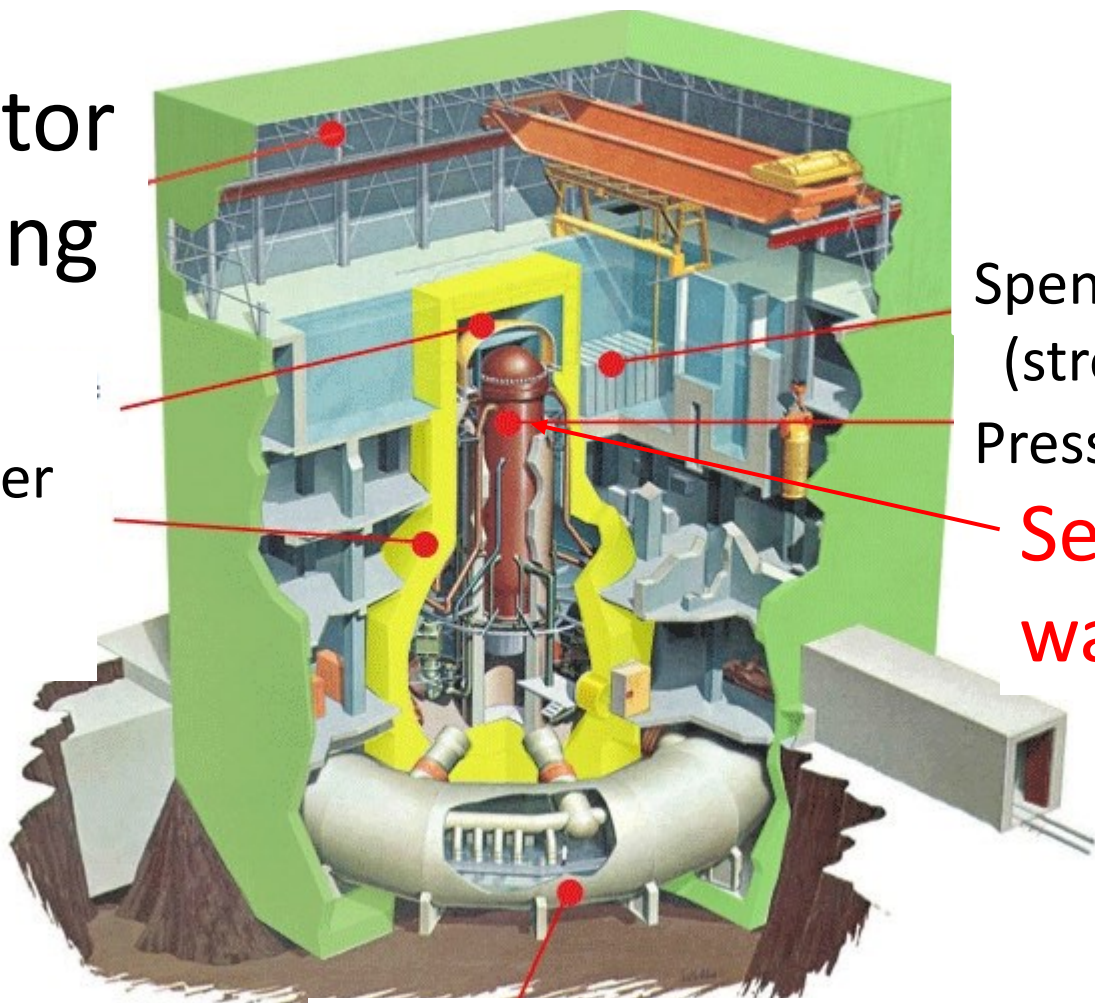
Pressure vessel

Water circulation

#1 BWR unit of Fukushima Daiichi

Reactor
bldng

container



Spent fuel pool
(strongest radioactivity)

Pressure vessel: boiler

**Several tons/h
water must!!**

Suppression chamber

Why severe accident?

- Commercial nuclear plants--not “fail safe”
- → fuel rods overheated on loss of water even
- → melt-down → leak of radioactive substance
- → melt-through bottoms of pressure vessel and container vessel → leak of radio-active substance into environments
- Early as possible water injection into the reactor core is the must!

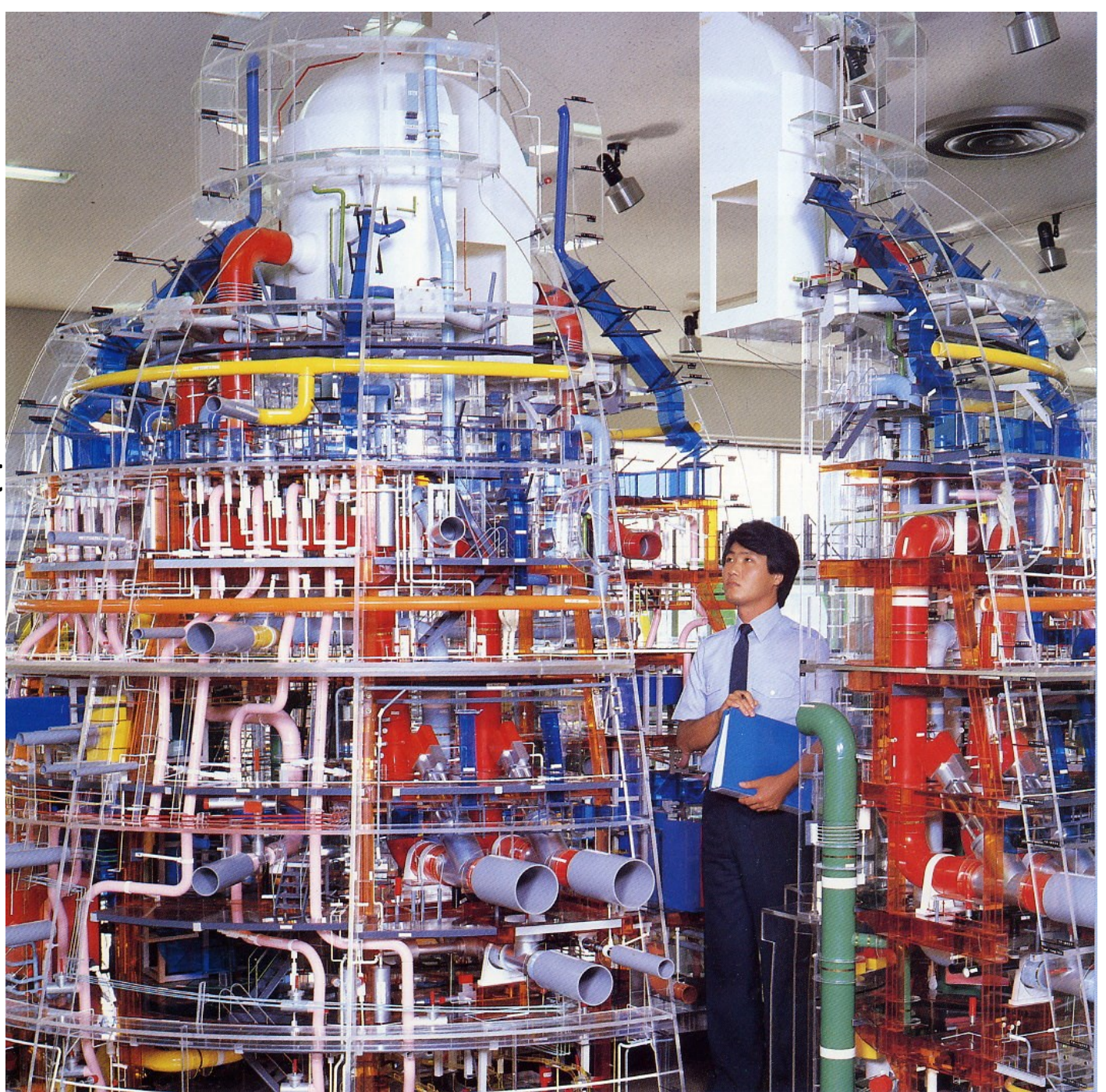
Fukushima: “Water! Water! Water!”

- **Station black out → pumps disabled**
- **→ fuel rods overheated on loss of water**
- **→ melt-down → leak of radioactive substance**
- **→ melt-through bottoms of pressure vessel and container vessel → radioactive leak into environments**
- **Water injection into the reactor core is essential.**

Cause of the severe accident

- ***Accident expands with time, as the fuel rods are left self-heated without water. Fuel rods are strongly radioactive to give heat after operation.***
- ***Poor back-ups for electric power in Fukushima***
- ***Poor precautions against loss of water***
- ***Poor level exercise for accident management***
- ***Poor level preparedness in accident management***
- ***too late decision to introduce sea water***
 - ← ***Sea water saves people but damages reactors.***
- ***The other countries were better prepared in 2011.***

BWR
scale model
Inside the
Containment
vessel

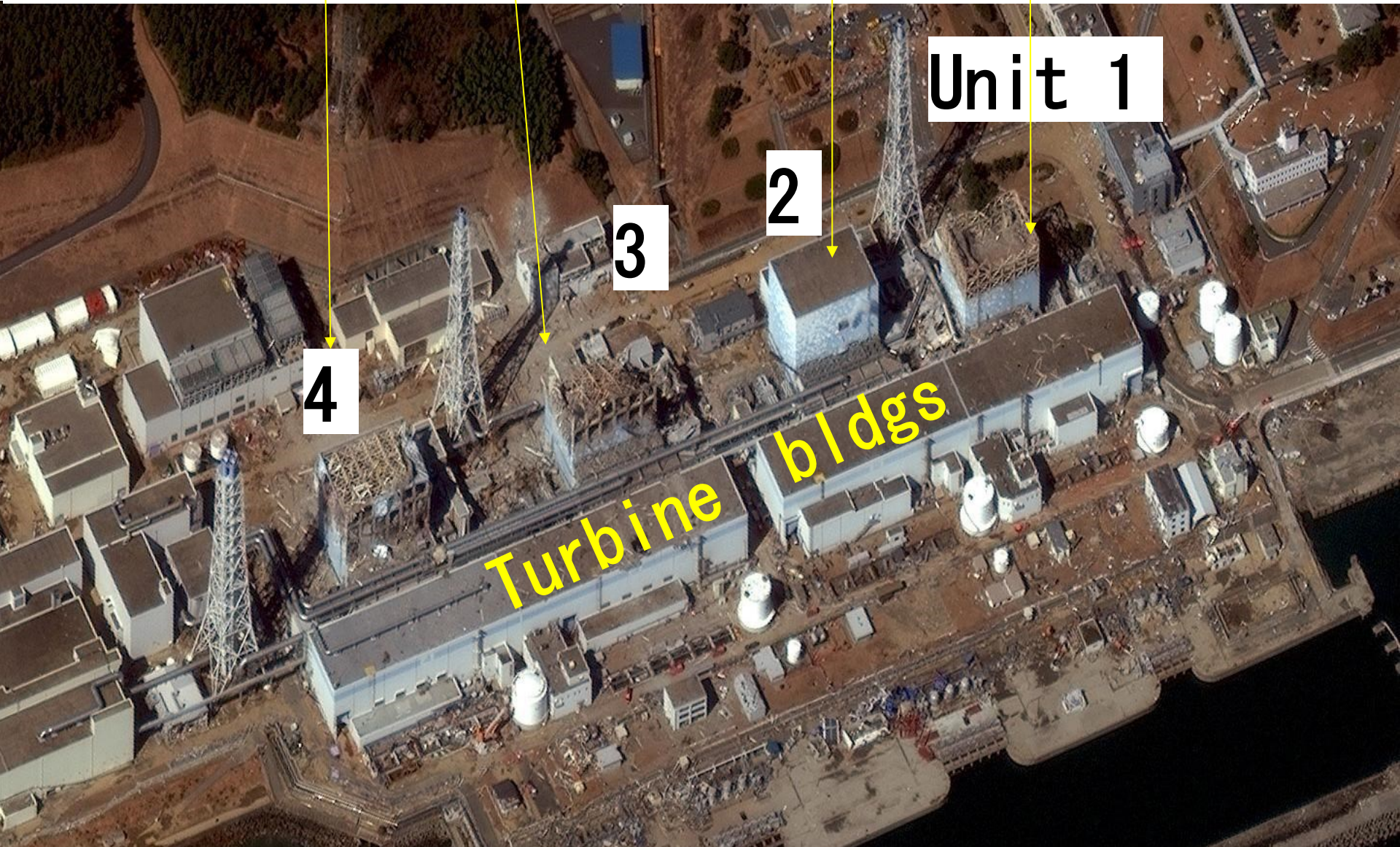


Pipings:
Too
complicated
to
remember!

Background of the unpreparedness

- *State-planned private-management system*
 - too strong promotion body*
 - nobody could speak up*
- *“Myth of Safety” 100% safe*
 - overwhelming for these 30 yrs*
 - logical consequence: no need to improve!*
- *“Wise-men committee” for decision making*
 - “secretary office” to choose the members*
 - secretary office members: two-year rotaters*
 - and those dispatched from power companies*

H2 leak to #4 from #3 largest leak of radioactivity H2 explosion



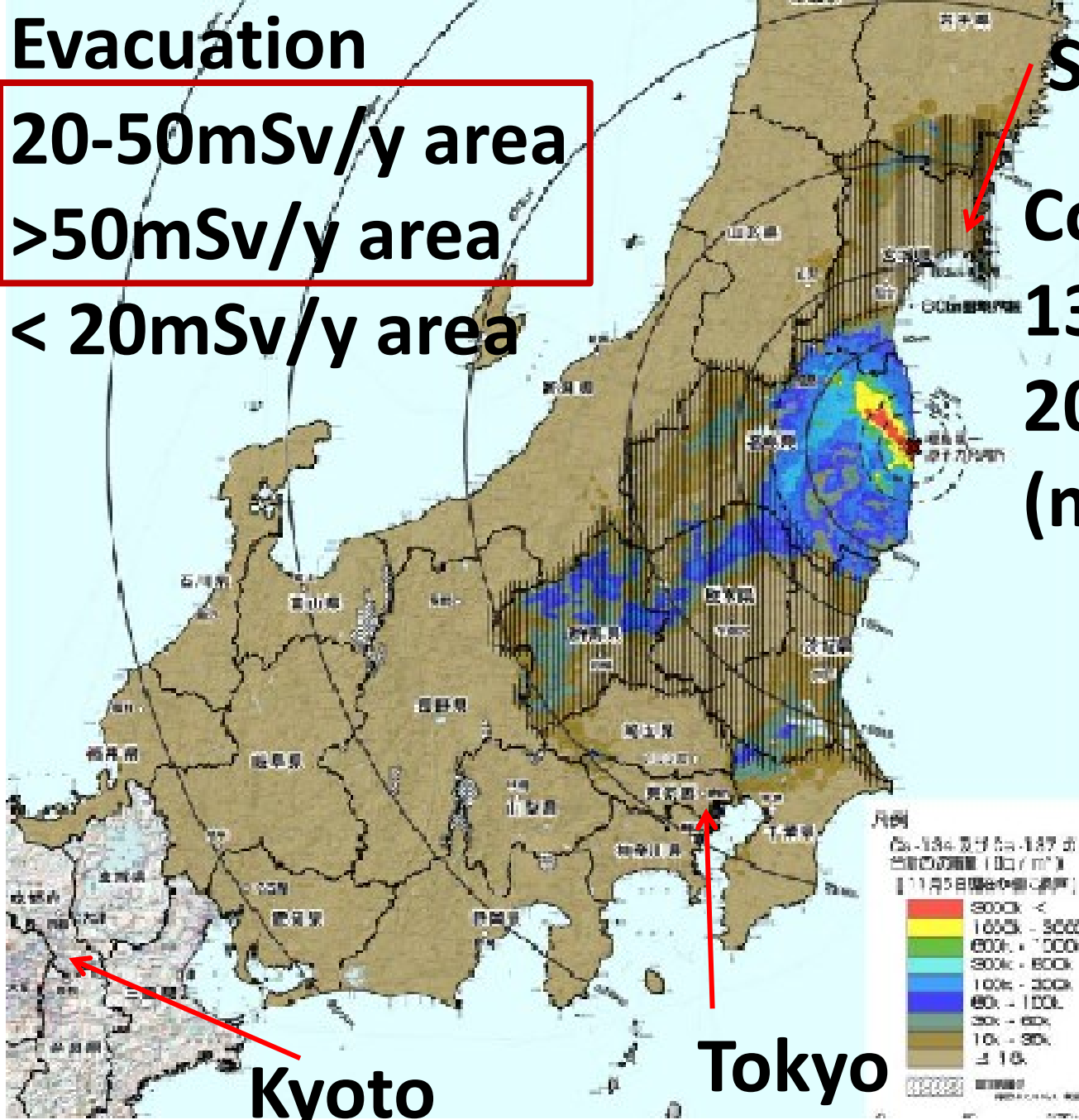
Fukushima Dai-ichi Nuclear Power Station

Evacuation

20-50mSv/y area

>50mSv/y area

< 20mSv/y area



Sendai

Contamination
 ^{134}Cs & ^{137}Cs
2011 Mar.15
(meas.)

2012 Nov. 5)

80,000
evacuated
additional
75,000 on
own will

Kyoto

Tokyo

Discharge of Radioactive Substances from the Fukushima Dai-ichi NPS

- ***The second worst in the world history. The third of the severe accidents since 1979.***
 - ***Level 7, the worst level (INES)***
 - ***1/7 of contaminant of Chernobyl***
- Myth of safety shattered.**

The possible “worst-case scenario”

- Reactor unit #4(not on operation) lost the roof←
H₂ explosion of the building ← H₂ leaked from #3
 - If the spent fuel pool (sfp) loses water →overheat to release radioactivity directly to the environment
 - The sfp contained more radioactive substance.
 - 1)after shock feared ← sfp poorly supported in attic
 - 2)#2 reactor feared of explosion of containment vessel
- evacuation of metropolitan area 30M people feared
- ☆ ***Unexpected water leak to sfp saved Japan from the worst scenario.***

Smaller countries than Japan, if economically developed, choose de-nuclear path.

Kitazawa's Empirical Rule (2011)

big countries >(Chile)>Ukrain>

France>Spain>Sweden> Norway

Japan>Germany>Italy>UK>Korea>Austria>

Switzerland>Taiwan>Belgium

“We may lose our country by a single accident”

○: de-nuclear

On the other hand, big countries think:

“Some residents may have to be relocated for a few hundred years. But the major activities of the country can remain unchanged”

Nuclear power plants are not
designed “fail safe”.

A certain risk does remain.

← lack of water supply ← terror, error

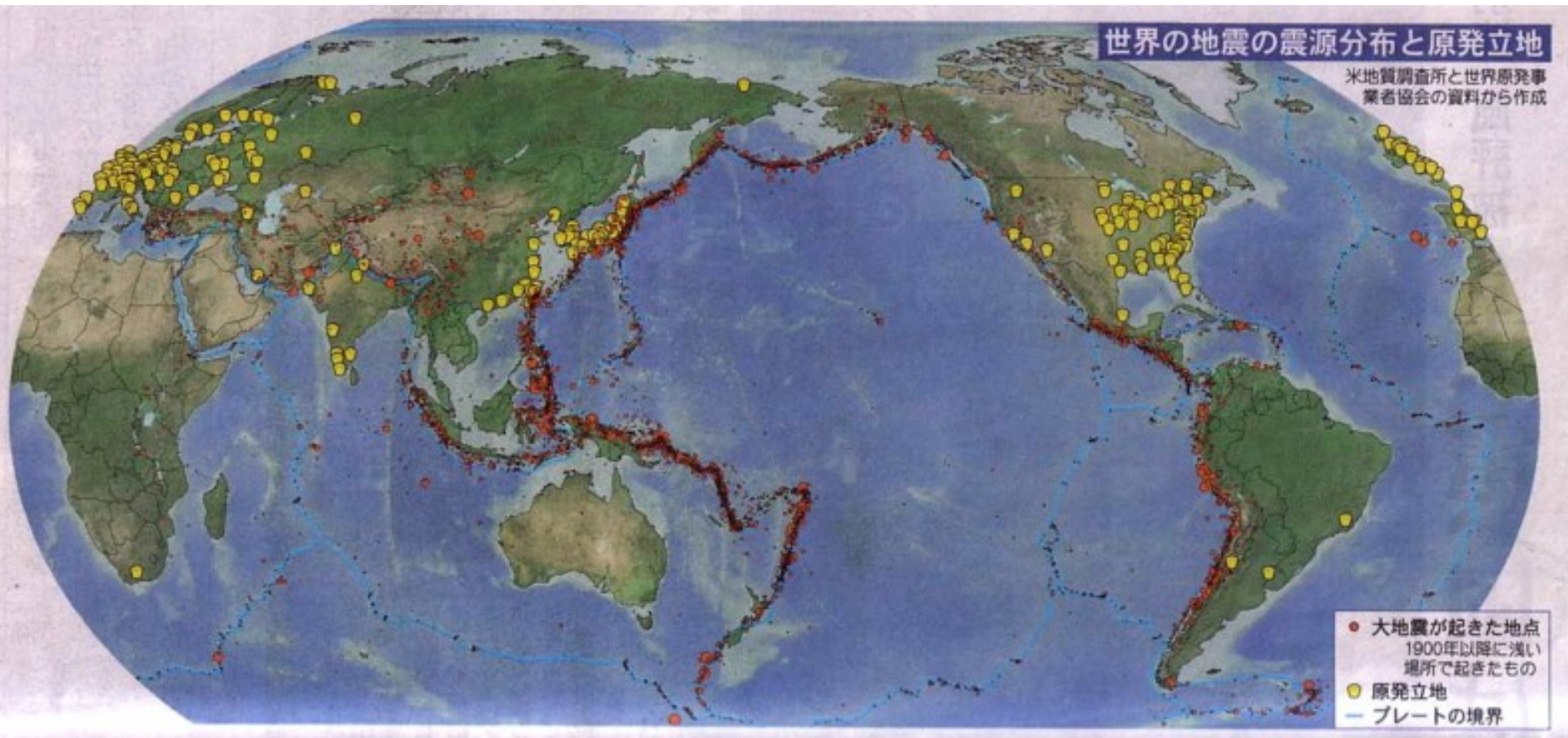
Non-zero risk of nuclear plant N

v.s. Risk of alternative energy sources A

“N” depends much on the size and population
density of a country.

“A” needs considerations of time scale.

Additional factors to consider for some countries
Location of earthquakes bigger than mag 6.0 ●
20% in Japan (50 times more frequent)



● : Nuclear reactors

Risks with Alternative Energy Sources

Energy Saving: always welcomed and effective

Fossil Fuel : global warming

→ higher efficiency conversion within 10 yrs
from coal to gas (50% of CO₂) within 20 yrs
long term → non-fossil fuel 30-50 yrs

Renewable Energy Sources: coming rapidly

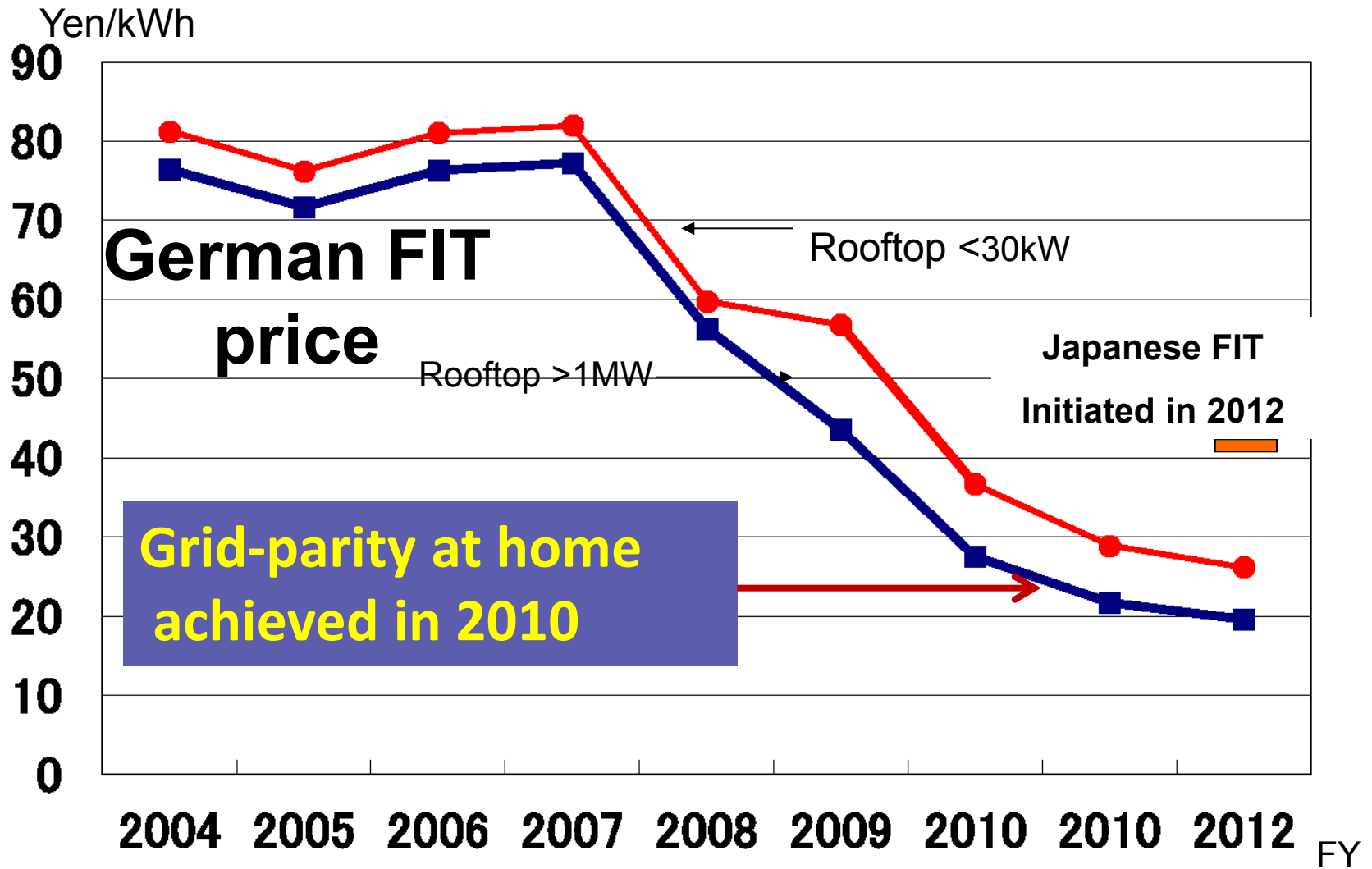
Price has come down rapidly.

Grid parity is attained with wind.

Peak power grid parity attained with solar.

grid compatibility ← smart grid, batteries

Price of electricity by solar cells in Germany



solar sharing: agri-friendly



Half of the light is enough to grow plants

friendly wind mills



Wind mills with lens
Prof. Ohya & Kyojuka
Kyushu Univ.
no bird strike
lower noise by 10 dB
intensified output
by 2.5 times
peaceful looking?

Fishery-friendly Off-shore Floating Windmill



fish culture
pond
Solar cells

Kyushu Univ.
Prof. Kyozuka

- Central supply v.s. Regional supply
key: grid parity → Elec power companies need care.

Future of elec power companies?

- Technology
 - Electric steel industry, chemical industry.....
 - Electric vehicles
 - Electric energy to chemical energy conversion
 - Electrochemical power stations or batteries?
 - Wide area energy sharing to stabilize grid

Which direction to go?

GDP/person \$50,000/y

- Japanese import of fossil fuel
max in 2008 \$2,000/y/person
- Electric power total sales \$1,300y (2010)
Nuclear energy share (30% in 2011) \$400
- Investment needed for REN \$500/y fastest case
- Elec saving by 15% + REN 50% → 30% up in elec bill
Estimated by SCJ to \$1,700/y (2022)

Cf.

- Total expenditure for amusement \$8,000/y
- For education of children \$500/y

Are people ready to pay for energy more?

New regulations in the area of contamination

- Areas $>50\text{mSv/y}$: “no-return area” within 5 yrs
- $50\text{-}20\text{mSv/y}$ areas: clean the area for early return
- $<20\text{mSv/y}$ areas: gov. has requested for return
decontamination efforts paid till 1mSv/y