IUGG2003 Sappro
JSP11
Geophysical Risk and Vulnerability: The Population-Hazard Interaction
July 7, Mon.,14:30 Site A, Room 10

Genpatsu-Shinsai:

Catastrophic Multiple Disaster of Earthquake and Quake-induced Nuclear Accident Anticipated in the Japanese Islands

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Genpatsu-Shinsai Japanese new word coined by Ishibashi (1997)

Nuclear power plant Earthquake disaster
原子力発電所 地震災害

Complex of an earthquake disaster and radioactive disaster due to a severe accident of a nuclear power plant caused by the earthquake

- Quake-induced nuke accident magnifies quake disaster.
- Earthquake damage magnifies radioactive disaster.

Entirely new type of natural + manmade disaster that the human beings have never encountered

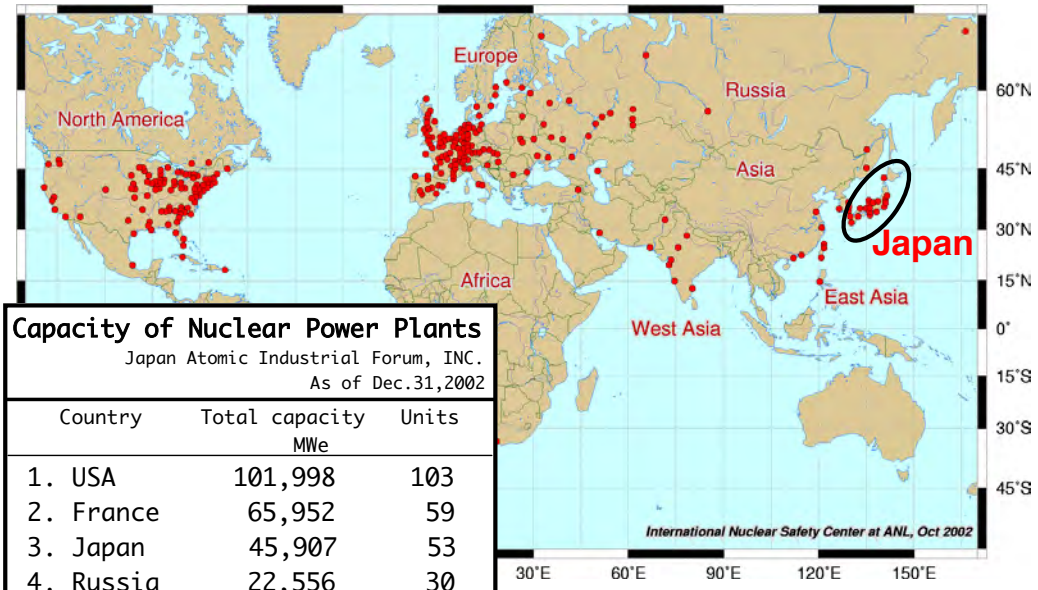
Japan may well cause Genpatsu-Shinsai ruining itself and changing the world.

This grave problem is not restricted in Japan.

World Map of Nuclear Power Reactors

International Nuclear Safety Center at Argonne National Laboratory, U.S. Department of Energy

http://www.insc.anl.gov/pwrmaps/map/world_map.php



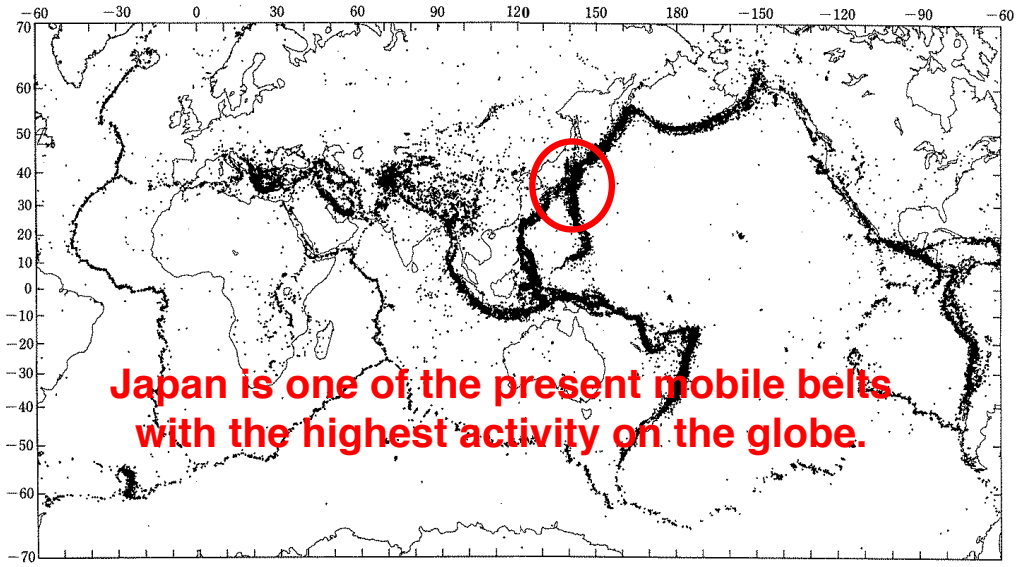
Capacity of Nuclear Power Plants

Japan Atomic Industrial Forum, INC.
As of Dec.31,2002

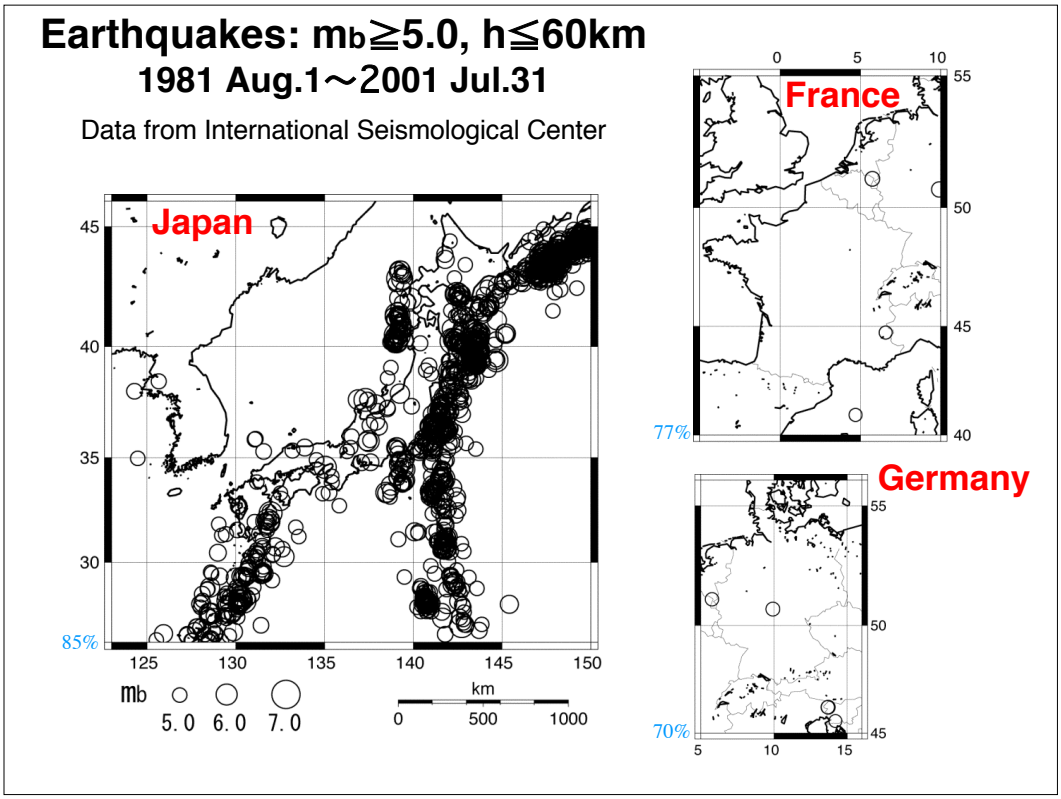
Country	Total capacity MWe	Units
1. USA	101,998	103
2. France	65,952	59
3. Japan	45,907	53
4. Russia	22,556	30
5. Germany	22,365	19

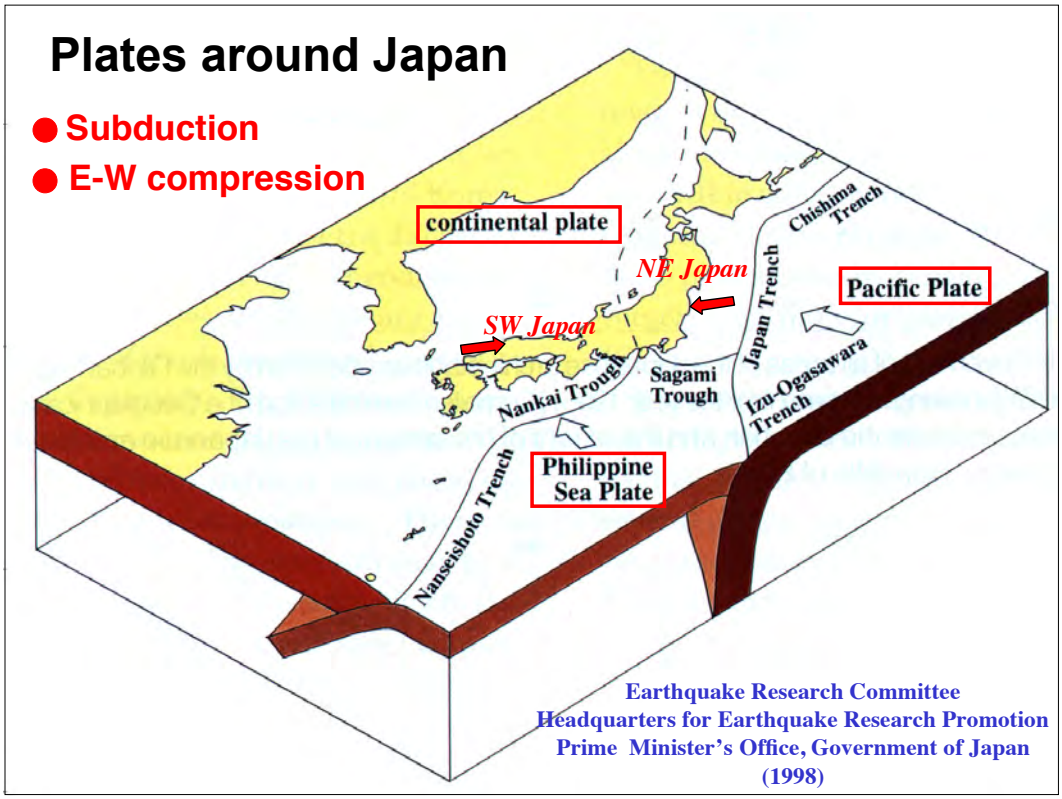
World Seismicity: 1975～1994, $M \geqq 4.0$, depth $\leqq$ 100km

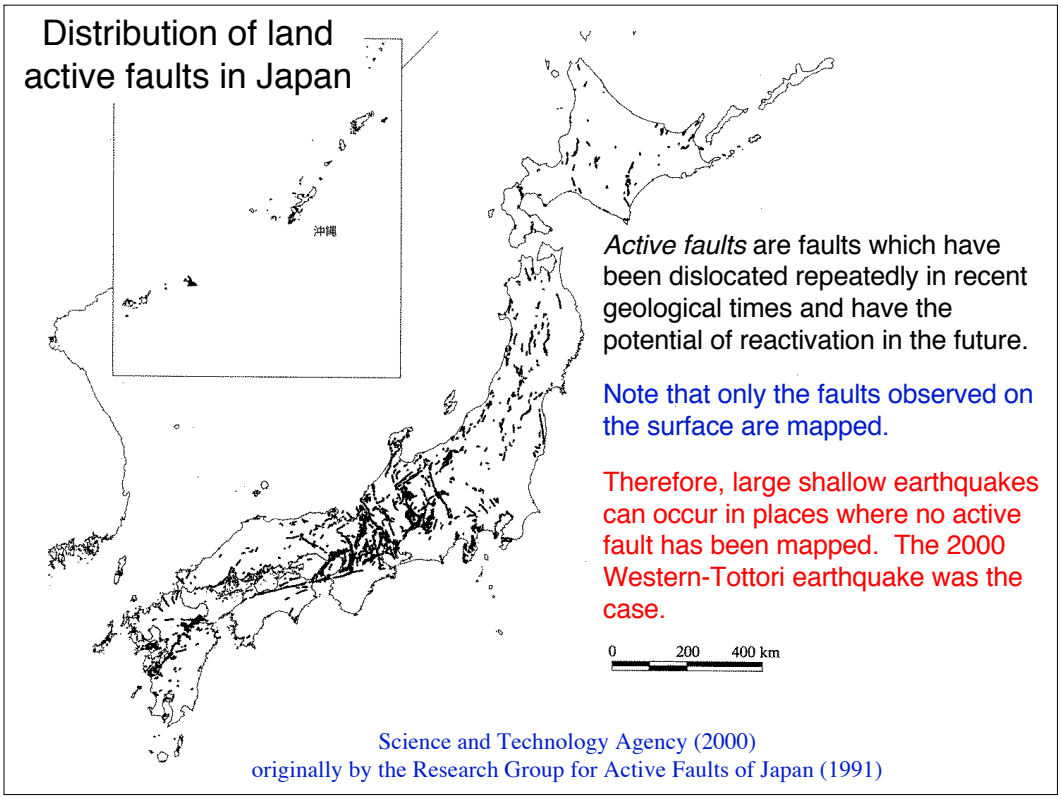
Data from International Seismological Center

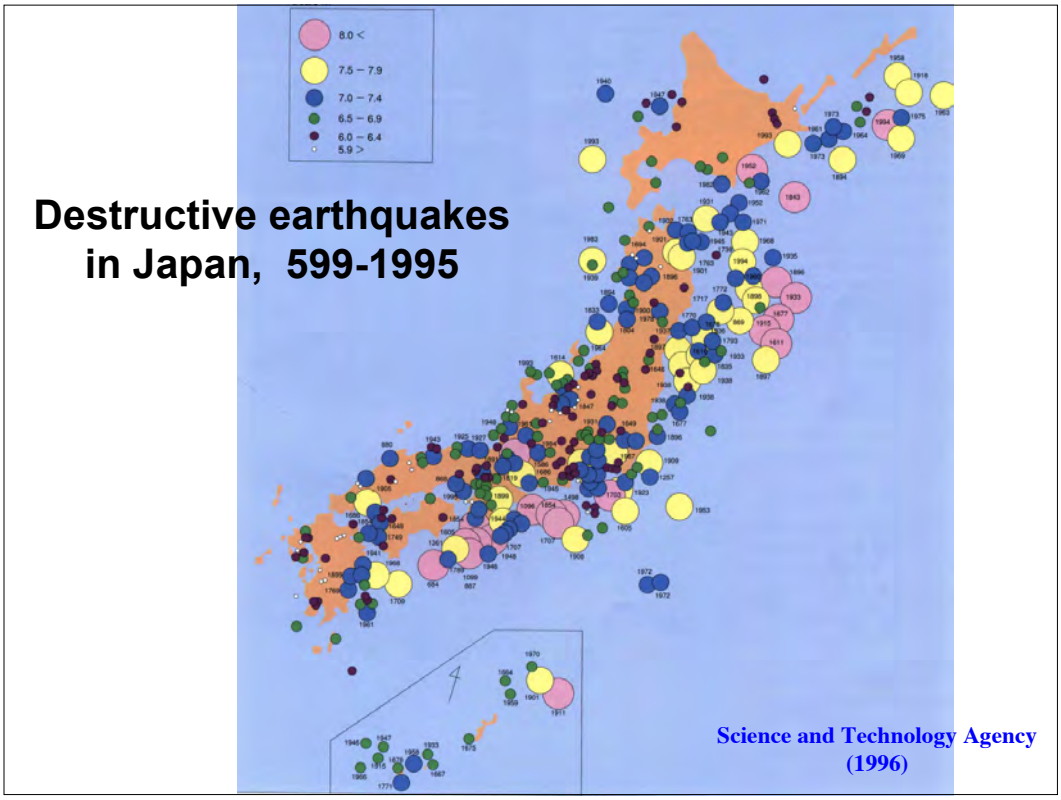


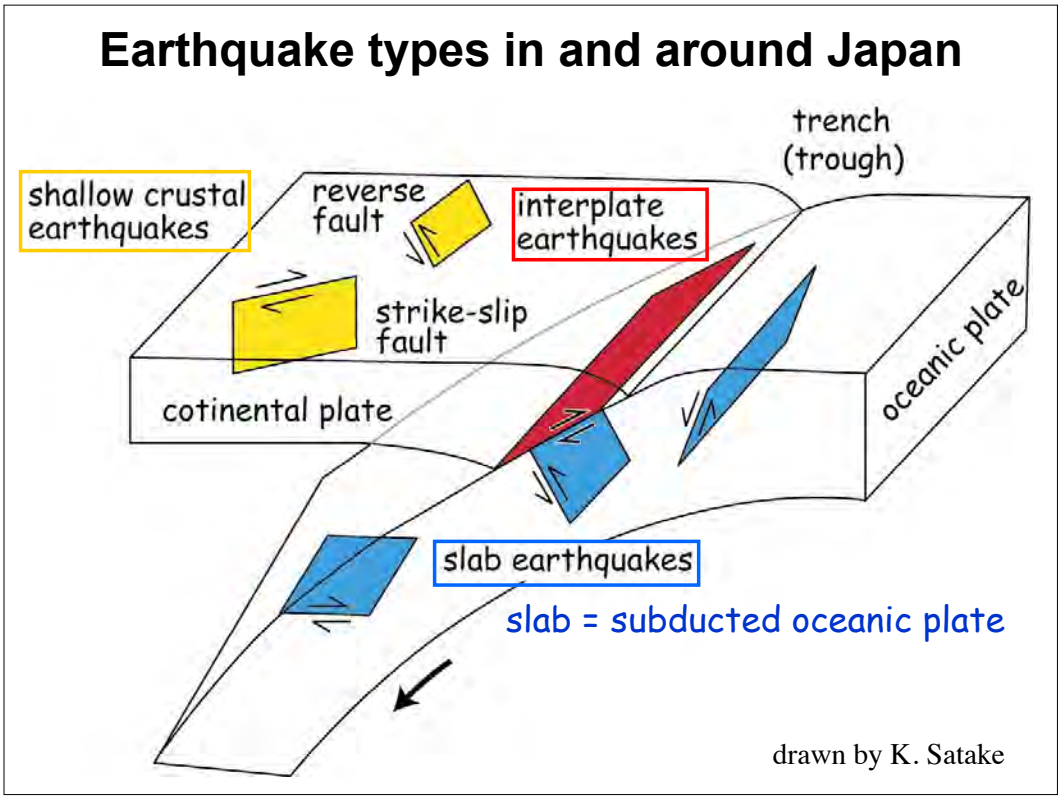
Rika nenpyo 2003 (Chronological Scientific Tables), Nat. Astro. Obs. (ed.), Maruzen Co., Ltd., 2002

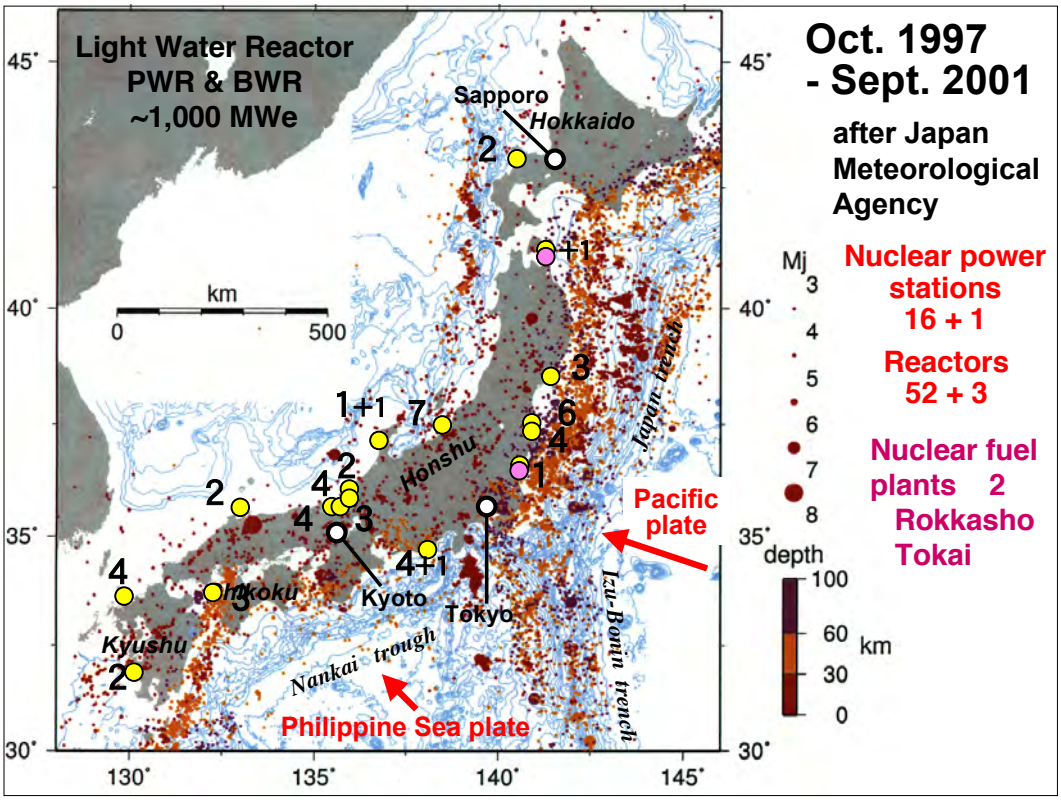

Earthquakes: mb≧5.0, h≦60km
1981 Aug.1～2001 Jul.31
Data from International Seismological Center
Japan
France
Germany
85%
77%
70%
mb
5.0 6.0 7.0
km
0 500 1000


Plates around Japan
● Subduction
● E-W compression
continental plate
NE Japan
SW Japan
Pacific Plate
Philippine Sea Plate
Chishima Trench
Japan Trench
Izu-Ogasawara Trench
Sagami Trough
Nankai Trough
Nanseishoto Trench
Earthquake Research Committee
Headquarters for Earthquake Research Promotion
Prime Minister's Office, Government of Japan
(1998)


Distribution of land active faults in Japan
沖縄
Active faults are faults which have been dislocated repeatedly in recent geological times and have the potential of reactivation in the future.
Note that only the faults observed on the surface are mapped.
Therefore, large shallow earthquakes can occur in places where no active fault has been mapped. The 2000 Western-Tottori earthquake was the case.
0 200 400 km
Science and Technology Agency (2000)
originally by the Research Group for Active Faults of Japan (1991)


Destructive earthquakes in Japan, 599-1995
8.0 <
7.5 – 7.9
7.0 – 7.4
6.5 – 6.9
6.0 – 6.4
5.9 >
Science and Technology Agency (1996)


Earthquake types in and around Japan
trench
(trough)
shallow crustal
earthquakes
reverse
fault
interplate
earthquakes
strike-slip
fault
cotinental plate
oceanic plate
slab earthquakes
slab = subducted oceanic plate
drawn by K. Satake


Light Water Reactor
PWR & BWR
~1,000 MWe
Oct. 1997
- Sept. 2001
after Japan
Meteorological
Agency
Nuclear power
stations
16 + 1
Reactors
52 + 3
Nuclear fuel
plants 2
Rokkasho
Tokai
Sapporo
Hokkaido
Honshu
Kyoto
Tokyo
Shikoku
Kyushu
Pacific
plate
Philippine Sea plate
Nankai trough
Japan trench
Izu-Bonin trench
km
0
500
Mj
depth
km
45°
40°
35°
30°
130°
135°
140°
145°

Safety of NPPs from earthquakes

According to the Agency for Natural Resources and Energy (1999)

For NPPs, sufficient earthquake countermeasures are made from construction till operation.

1. Avoiding active faults in site selection.

Actually, many plants have active faults very close to them.
Large earthquakes can occur even if active faults haven't been observed.

2. Construction of reactor buildings directly on solid rock beds.

Actually, many plants are situated on young soft rocks.

3. Seismic design assuming violent earthquakes.

Actually, in most cases largest earthquakes are not considered.

4. Safety confirmed by computing earthquake behaviors.

Unknown factors of earthquake phenomena can't be covered by computer programs.

5. Emergency shutdown system for strong earthquake motions.

There remains possibility of failing in shutdown.
Moreover, shutdown is not enough to prevent severe accident.

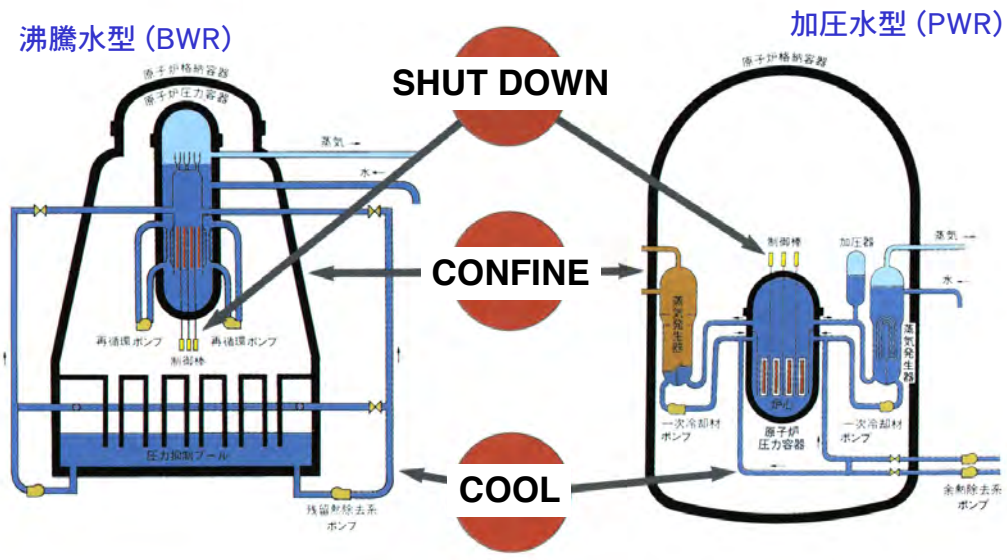
6. Actual proof by a large-scale shaking table experiment.

Full-size shaking test of aged plant system as a whole has not been performed.

7. Countermeasures against tsunamis.

We don't know completely all possible tsunamis.

In order to prevent a severe accident with large-scale release of fission products outside, three functions are essential.



According to the Agency for Natural Resources and Energy (1999)

Existing Procedure of Seismic Design of NPPs

"Shut Down, Cool, Confine" Functions Should Be Kept
For a Much Severe Earthquake than the Biggest One in the Past

Seismic Classification of Importance (As, A, B, C)

1. Assumption of Two Kinds of Earthquakes (Underground Sources)

Maximum design earthquake

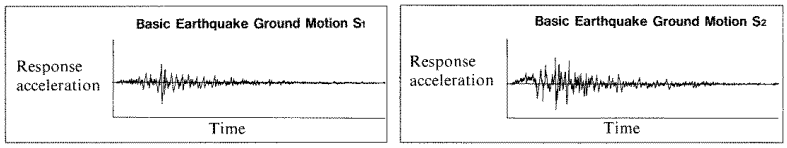
The biggest earthquake assumed based on past large earthquakes around the site and expected earthquakes originated from nearby active faults

Extreme design earthquake

A stronger earthquake than maximum one (M6.5 nearby earthquake included)

2. Determination of Basic Earthquake Ground Motion S1 & S2

Artificial seismic waves for S1 & S2



3. Structure Seismic Analysis & Ground Stability Analysis by Computer

"Guidelines for Examining Seismic Design of Nuclear Power Plants"
Drawn up in 1978, Revised in 1981

Important Points

Construction of NPPs was started before the birth and spread of **fault model of earthquakes** and **plate tectonics**.

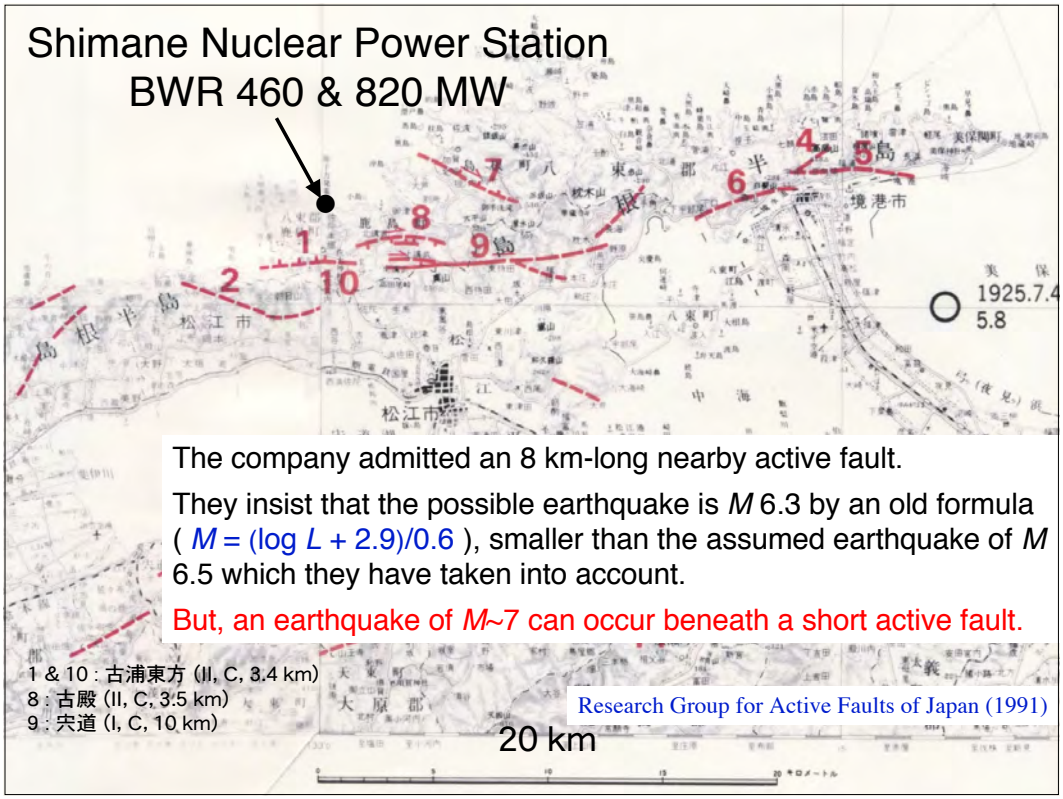
Almost the whole Japanese Islands are expected to enter the seismically active period.
Large earthquakes in APEMMB, M8 Tokai & Nankai earthquakes, etc.
Large/great slab earthquakes are very difficult to tell where and when.

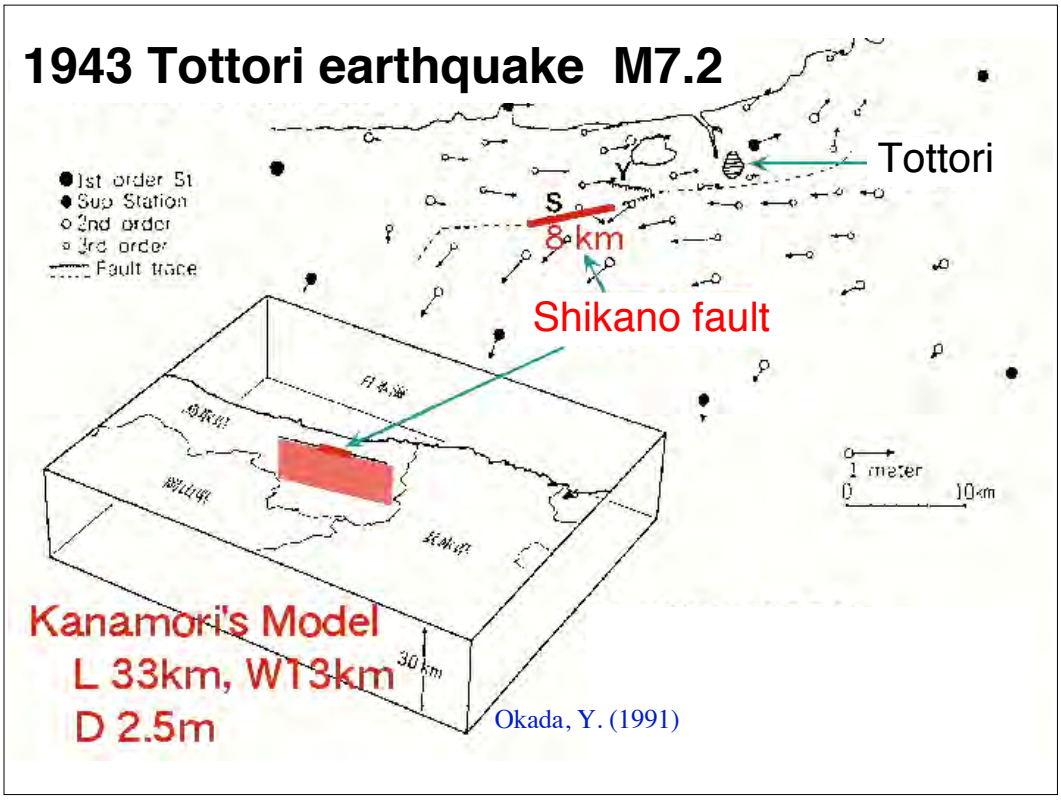
Serious mistakes in assuming earthquakes

- Ignorance of large/great slab earthquakes: Only interplate earthquakes and active faults have been considered.
- Possibility of large earthquakes in places without active faults has been ignored: Maximum nearby earthquake is only M6.5.
- Evaluation of active faults is inadequate: Ignorance of active fault system and grouping; underestimation of M.
- Ignorance of the concept of seismic gap: Danger of places where historical earthquakes are unknown has been ignored.

Determination method of basic earthquake ground motion is very old in view of modern earthquake science and strong motion seismology:
Tendancy of underestimation of S1 & S2.

Effect of large aftershocks is not taken into account.


Shimane Nuclear Power Station
BWR 460 & 820 MW
1925.7.4
5.8
The company admitted an 8 km-long nearby active fault.
They insist that the possible earthquake is M 6.3 by an old formula (M = (log L + 2.9)/0.6), smaller than the assumed earthquake of M 6.5 which they have taken into account.
But, an earthquake of M~7 can occur beneath a short active fault.
1 & 10 : 古浦東方 (II, C, 3.4 km)
8 : 古殿 (II, C, 3.5 km)
9 : 宍道 (I, C, 10 km)
Research Group for Active Faults of Japan (1991)
20 km


1943 Tottori earthquake M7.2
Tottori
1st order St
Sup Station
2nd order
3rd order
Fault trace
8 km
Shikano fault
1 meter
0
10km
Kanamori's Model
L 33km, W13km
D 2.5m
30 km
Okada, Y. (1991)

What happen?

Any of Japanese NPPs and NFPs could be attacked
by an unexpected large earthquakes nearby.
Probably the strong ground motion exceeds S2 at each plant.

Many devices and piping systems get in trouble all at once.
Multiple defense systems lose their function simultaneously.
Aging and defects in construction and maintenance are severe background problem.
Successive large aftershocks are also serious.
Violent shaking may affect operators physically and mentally.

Loss of AC power, fail in control rods inserting, runaway
Pipe rupture accidents, loss of coolant, fail in ECCS, meltdown
Steam explosion, hydrogen explosion, nuclear explosioon
Release of huge amount of fission products outside the reactor

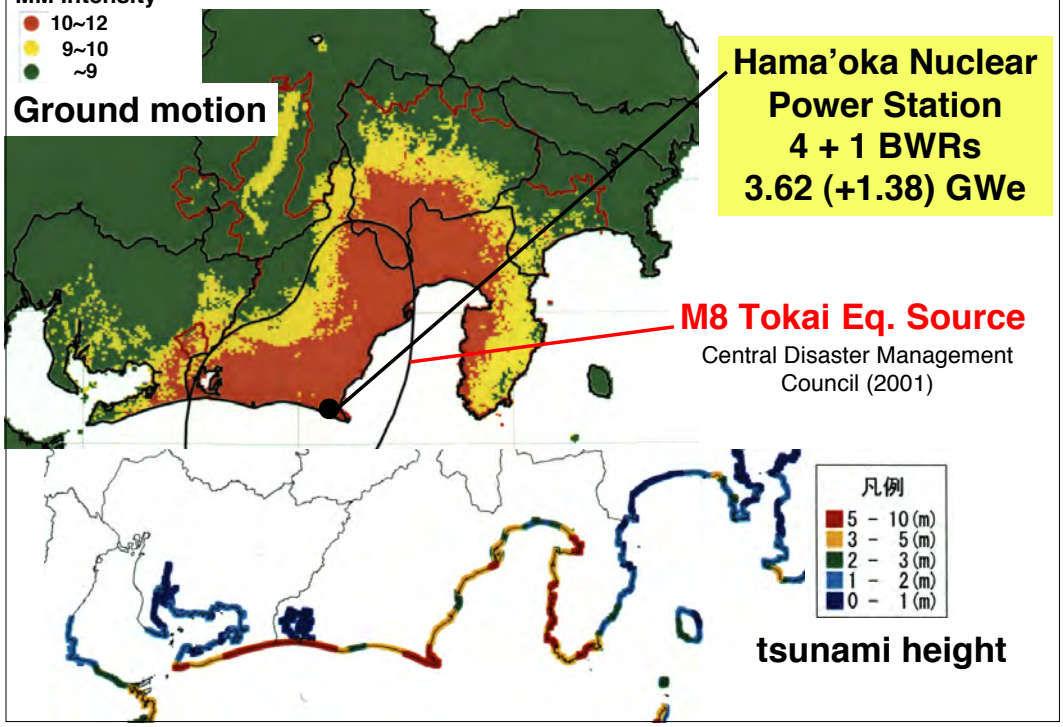
Due to the severe earthquake damage, management of the nuke accident and evacuation of inhabitants from radioactivity become extremely difficult, The nuke accident would be left to expand to the maximum scale.

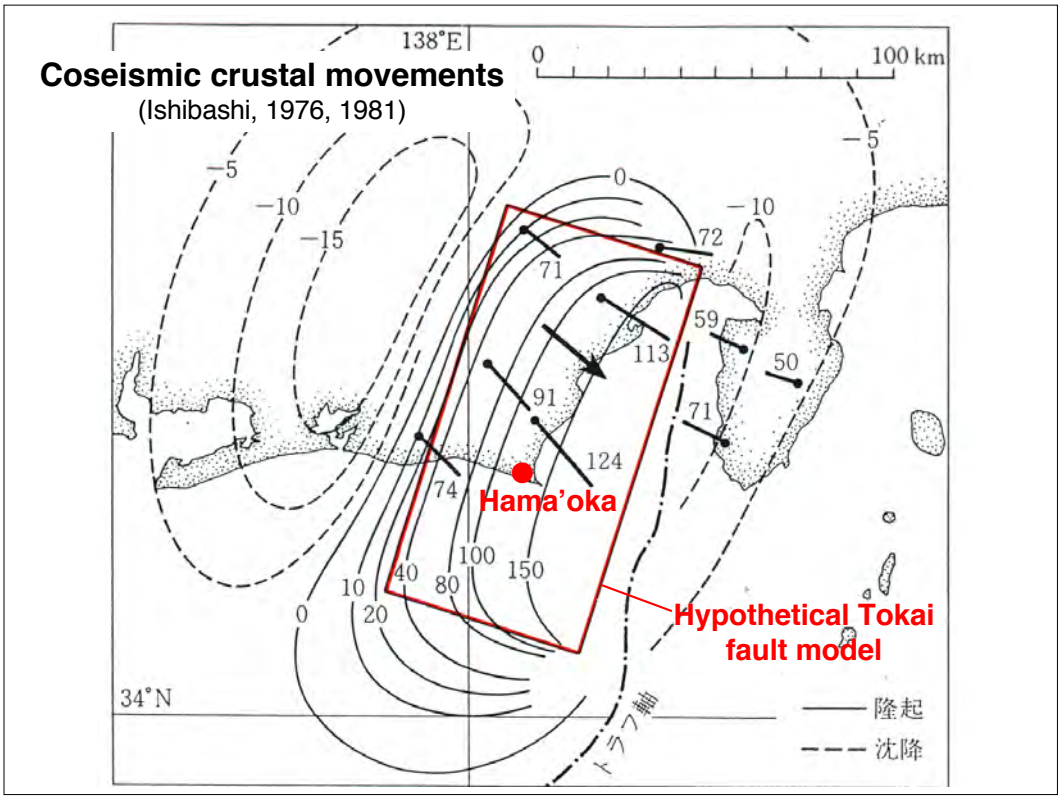
Strong radioactivity prohibit rescue works in the earthquake disaster area, and cause evacuation of numerous people in a very wide area.

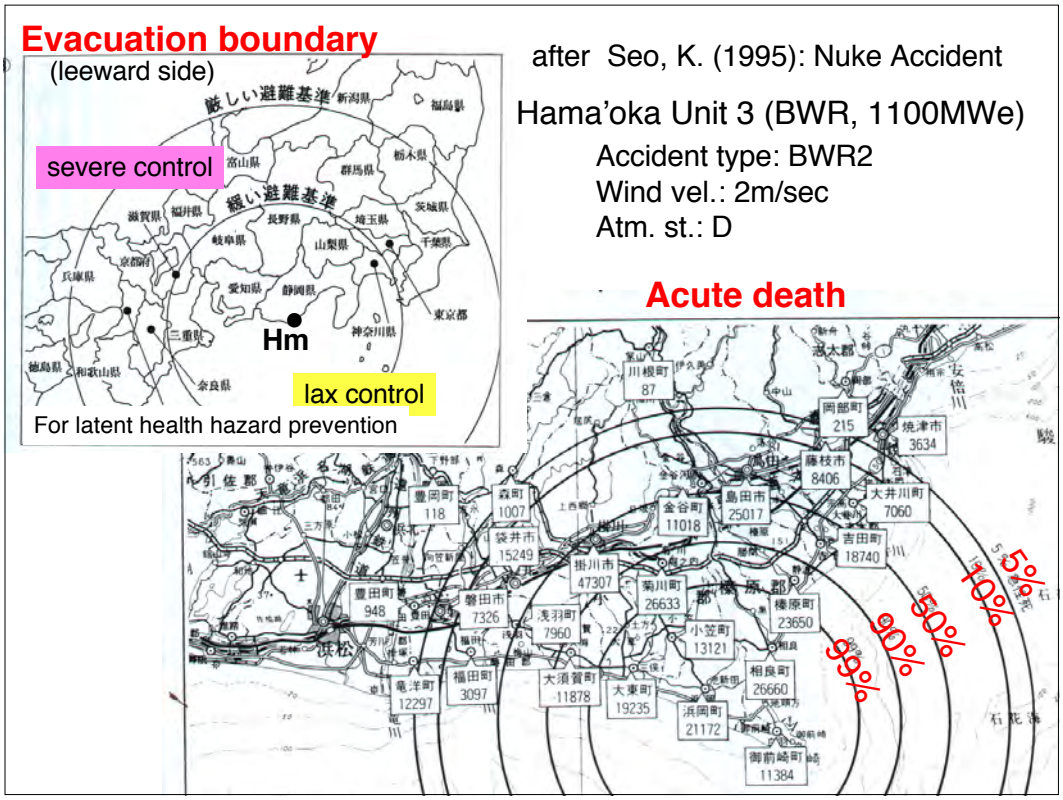
Victims of radiation exposure and ordinary quake disaster becomes uncountable.

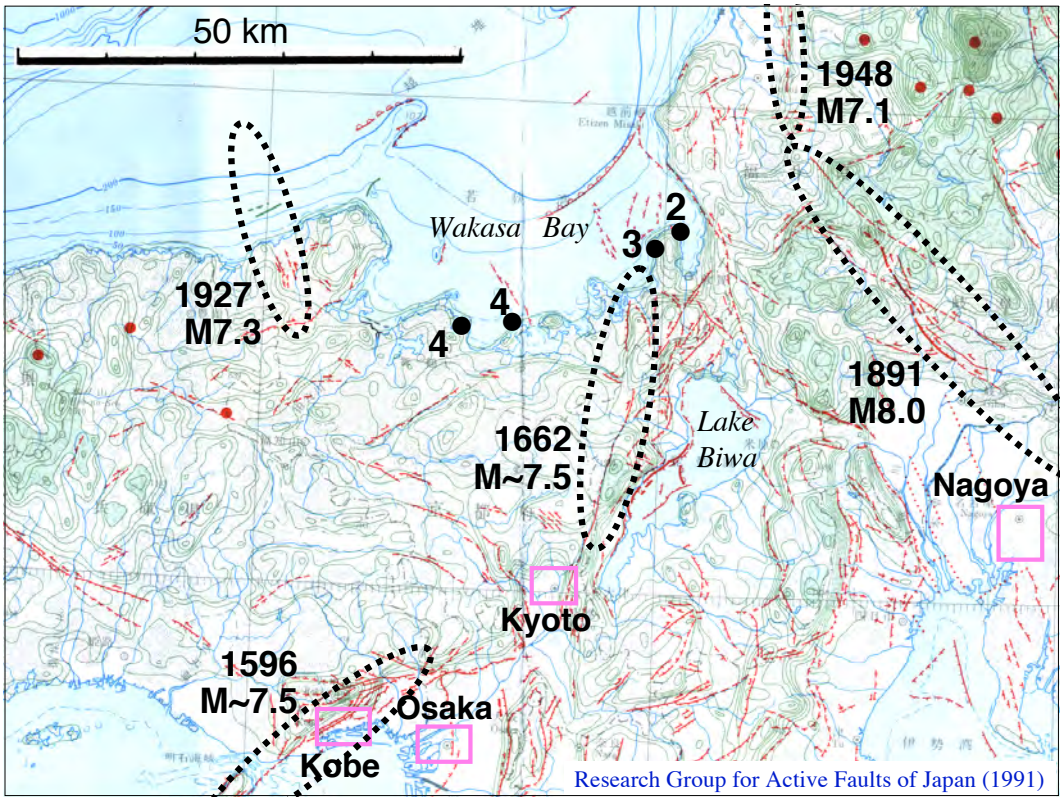
The final result is global as well as a fatal blow to Japan, and affect deeply future generations.

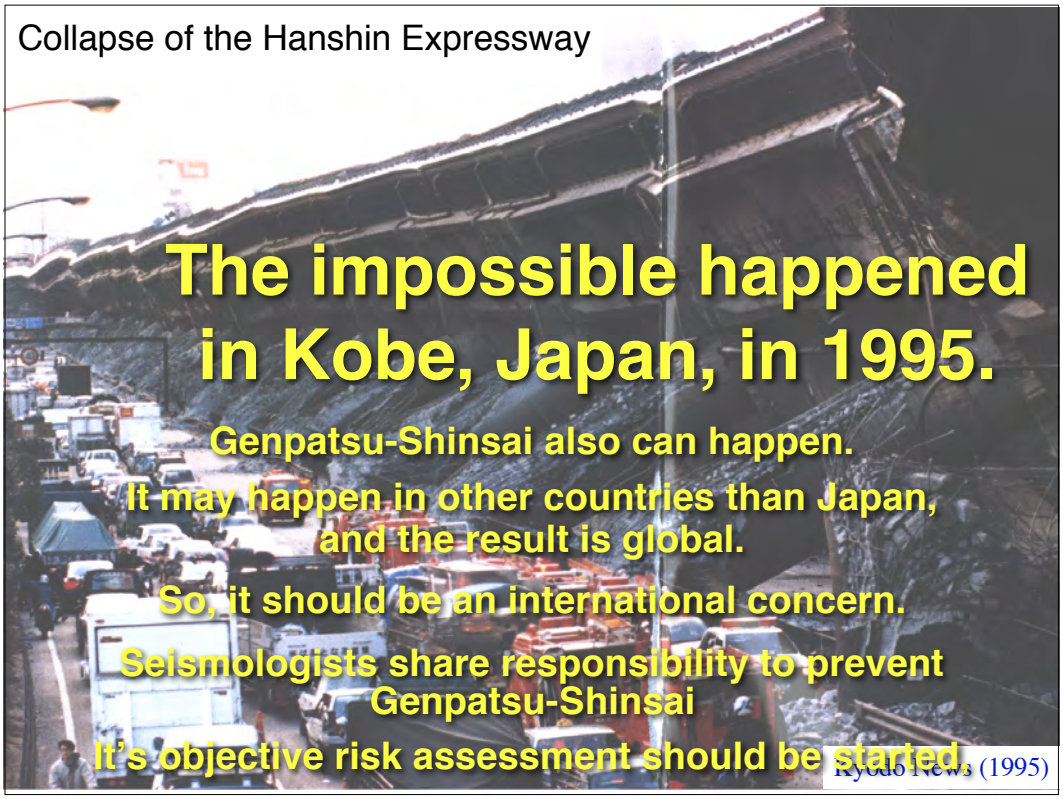
Impending Tokai earthquake




Coseismic crustal movements
(Ishibashi, 1976, 1981)
138°E
0
100 km
34°N
Hama'oka
Hypothetical Tokai
fault model
隆起
沈降


Evacuation boundary
(leeward side)
severe control
lax control
Hm
For latent health hazard prevention
after Seo, K. (1995): Nuke Accident
Hama'oka Unit 3 (BWR, 1100MWe)
Accident type: BWR2
Wind vel.: 2m/sec
Atm. st.: D
Acute death
5%
10%
50%
90%
99%


50 km
1948
M7.1
Wakasa Bay
2
3
4
4
1927
M7.3
1891
M8.0
Lake
Biwa
1662
M~7.5
Nagoya
Kyoto
1596
M~7.5
Osaka
Kobe
Research Group for Active Faults of Japan (1991)


Collapse of the Hanshin Expressway
The impossible happened in Kobe, Japan, in 1995.
Genpatsu-Shinsai also can happen.
It may happen in other countries than Japan, and the result is global.
So, it should be an international concern.
Seismologists share responsibility to prevent Genpatsu-Shinsai
It's objective risk assessment should be started.
Kyodo News (1995)