The Fukushima Nuclear Accident: Lessons learned (so far) and possible implications

Berlin, July 1, 2011

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Note: The views expressed here are of my own and do not necessarily reflect those of the JAEC nor the government.

Summary (1)

- The 3/11 Fukushima nuclear accident triggered by the East Japan Great Earthquake and Tsunami has become one of the worst nuclear accidents (3 core meltdown) not only in Japan but also in the world, and not yet under control.
  - INES level 7, radioactivity discharge(air and the sea) & contaminated land area : 1/5~1/10 of the Chernobyl, It will take at least 6-9 months to stabilize the situation
- Securing safety and welfare of local public is the first priority.
  - Some hot spot area exists beyond evacuation area and careful monitoring is needed.
  - While not all evacuee is likely to be able to return by the end of the year, some may be able to do so after summer.

Summary (2)

- At the same time, assuring safety of existing nuclear power plants, including spent fuel storage, is also critically important.
  - Hamaoka nuclear plant has been shutdown by PM request. 35 units out of 54 units are now shutdown, and more could be shutdown.
- Future nuclear and energy policy will need to be thoroughly discussed with all stakeholders and nationwide pubic debate.
  - Current energy policy (build 14 more reactors, 50% nuclear share by 2030) will be scrapped.
  - More emphasis on new energy sources and conservation is expected, but role of nuclear power has not been denied.
  - Public opinion is shifting towards "reducing dependency" on nuclear energy

Summary (3)

- It is Japan's responsibility to disclose and share the information as much as possible with the public and the rest of the world.
  - The gov't issued report to the IAEA, summarizing 28 lessons learned
  - The gov't has established an independent accident investigation committee
  - IAEA Fact-Finding Team report issued 15 conclusions and 16 lessons
  - IAEA Ministerial Conference on Nuclear Safety issued 25 declarations
- Possible implications for global energy pictures and non-proliferation, nuclear security are still uncertain
  - The world could be divided into "pro-" and "anti-" nations towards nuclear power, which may make global consensus on nuclear issues more difficult.
  - The Fukushima accident proved that common approaches could be effective for enhanced safety and security, especially spent fuel management and emergency response

The Atomic Energy Basic Law (1955)

- Article 1 (Purpose of the Act)
  - The purpose of the Act is to *contribute to the improvement of both welfare of human society and the living standard of the people* through research, development and utilization of atomic energy, *while limiting to peaceful purposes and making it a principle to assure their safety,* making transparent the results, and promoting international cooperation, with a view to securing energy resources for the future, promoting science and industries

Administrative Organizations for Nuclear Energy Policy

Cabinet Office

Atomic Energy Commission (AEC)

- **Formulates the Framework of Nuclear Energy Policy**
- **Outlines the government budget for implementing nuclear energy policy**
- **Review the administrative judgments of other governmental agencies under 'the Law for the Regulation of Nuclear Source Material, Nuclear Fuel Material and Reactors' etc.**

Nuclear Safety Commission (NSC)

- Development of the intellectual infrastructure for ensuring nuclear safety
- Ensuring safety of nuclear facilities
- Nuclear disaster countermeasures
- Promoting dialog on nuclear safety with the general public etc.

Report

Basic policies & Principles

Related Governmental Organizations

Ministry of Foreign Affairs (MOFA)

- Diplomatic policies for peaceful use of Science and Nuclear energy
- Negotiation and cooperation with the foreign government, participation to the international organization for peaceful use of nuclear energy
- Preparation and enforcement for conclusion of nuclear international engagement etc.

Ministry of Education, Sports, Culture, Science and Technology (MEXT)

- Nuclear policies on science and technology
- Nuclear development for the purpose of improving the level of science and technology
- Regulation on use of nuclear reactors for experiment and research, nuclear fuel resource and materials
- Prevention of radioactive hazards etc.

Ministry of Economy, Trade and Industry (METI)

Agency for Natural Resources and Energy

- Nuclear policies for energy use
- Development of nuclear engineering for energy use

Nuclear and Industrial Safety Agency (NISA)

- Regulation on project of nuclear refinement, processing, storage, reprocessing and disposal, and on nuclear power generation facilities etc.

Other related ministries

- Ministry of Internal Affairs and Communications
- Ministry of Health, Labor and Welfare
- Ministry of Agriculture, Forestry and Fisheries
- Ministry of Land, Infrastructure and Transport
- Ministry of the Environment etc

Japan Atomic Energy Commission (JAEC)

○The Role of Japan Atomic Energy Commission

The Japan Atomic Energy Commission is set up in the Cabinet Office and has five commissioners. Its mission is *to conduct planning, deliberations, and decision-making regarding basic policy for research, development, and utilization of nuclear energy, including the formulation of the Framework for Nuclear Energy Policy except matters related to nuclear safety.* When the JAEC deems it necessary as a part of its assigned mandate, *JAEC can recommend and demand reports of the head of relevant administrative organization through the Prime Minister.*

Members: 5 (appointed by the Prime Minister with the consent of the House of Representatives and House of Councilors)

Chairman
Dr. Shunsuke KONDO

Vice Chairman
Dr. Tatsujiro SUZUKI

Commissioner
Ms. Etsuko AKIBA

Commissioner
Dr. Mie OBA

Commissioner
Mr. Akira OMOTO

What Happened (or is happening)?

"*We are gravely concerned about this accident which can fundamentally undermine public trust* in safety measures, not only in Japan but also in other countries" (JAEC, 04/05/11)

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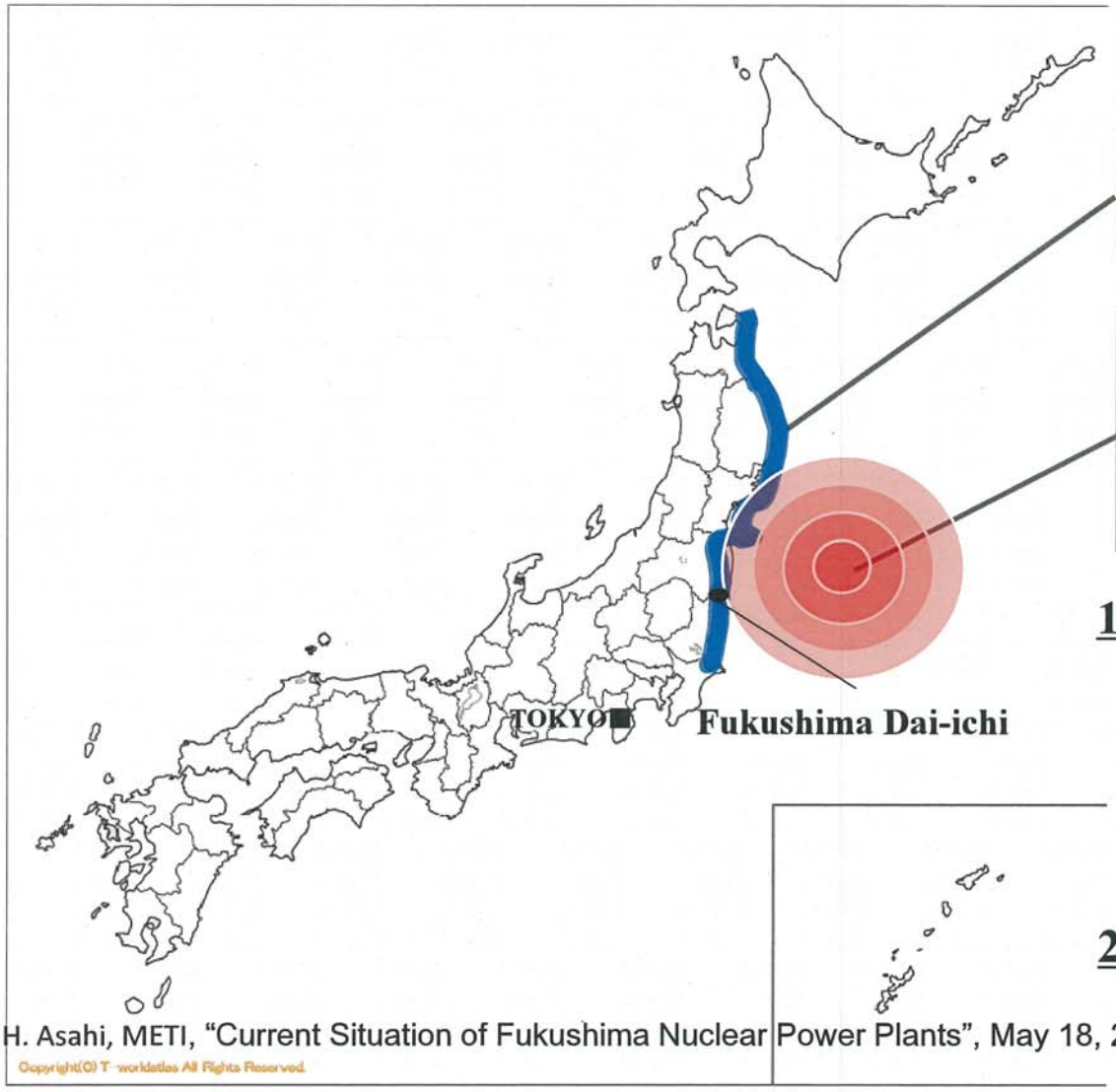
A. Enormous Earthquake, Tsunamis and Nuclear Accident



Tsunamis
14 meters or higher

Earthquakes:
M - 9.0 quake (March 11)
M - 7 class 5 times
M - 6 class 76 times
M - 5 class 452 times

1. Casualties : over 30,000

- Dead over 14,000
- Missing over 9,000
- Injured over 5,000

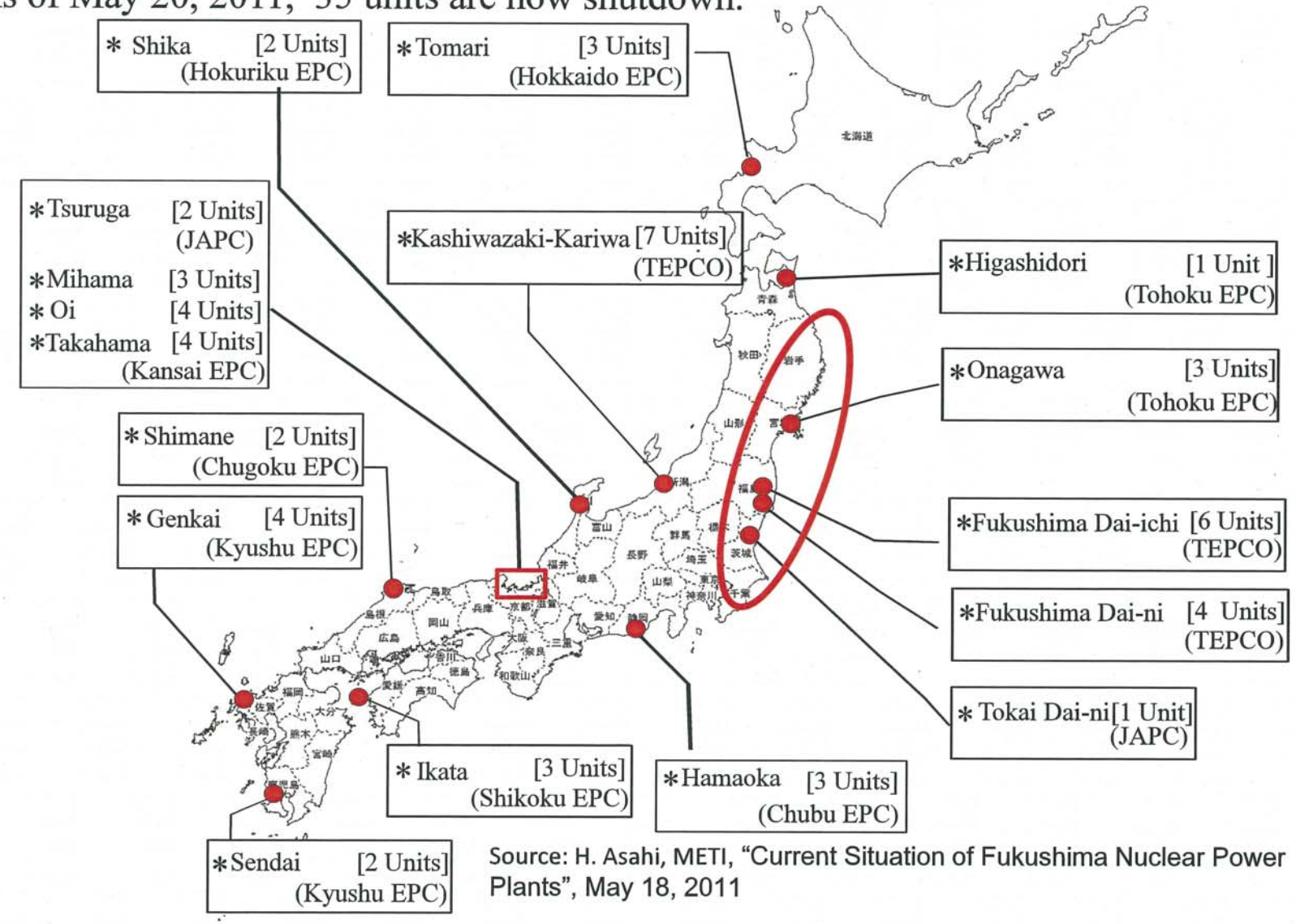
2. Evacuees : over 118,000

(As of May 10th)

Source: H. Asahi, METI, "Current Situation of Fukushima Nuclear Power Plants", May 18, 2011

Location of Nuclear Power Stations in Japan

54 units (30 units of BWR and 24 units of PWR, total 49GW) in 17 sites
As of May 20, 2011, 35 units are now shutdown.



Source: H. Asahi, METI, "Current Situation of Fukushima Nuclear Power Plants", May 18, 2011

Summary of Fukushima Daiichi Nuclear Power Plants

Generation Facilities of Fukushima Dai-ichi NPS

	Unit 1	Unit 2	Unit 3	Unit 4	Unit 5	Unit 6
Electric Output (MWe)	460	784	784	784	784	1100
Commercial Operation	1971/3	1974/7	1976/3	1978/10	1978/4	1979/10
Reactor Model	BWR3	BWR4			BWR5	
PCV Model	Mark-1					Mark-2
Number of Fuel Assembly in the Core	400	548	548	548	548	764

Generation Facilities of Fukushima Dai-ni NPS

	Unit 1	Unit 2	Unit 3	Unit 4
Electric Output (MWe)	1100	1100	1100	1100
Commercial Operation	1982/4	1984/2	1985/6	1987/8
Reactor Model	BWR5			
PCV Model	Mark-2	Mark-2 Advance		
Number of Fuel Assembly in the Core	764	764	764	764

http://www.kantei.go.jp/foreign/kan/topics/201106/iaea_houkokusho_e.html

Earthquake

Design basis earthquake and observed acceleration (Basement of Reactor/B)

Nr.	MWe	3.11 Observed (max. gal)			Design (Ss) (max. gal)		
		N-S	E-W	Vertical	N-S	E-W	Vertical
1Fuku1	460	460	447	258	487	489	412
1Fuku2	784	348	550	302	441	438	420
1Fuku3	784	322	507	231	449	441	429
1Fuku4	784	281	319	200	447	445	422
1Fuku5	784	311	548	256	452	452	427
1Fuku6	1100	298	444	244	445	448	415

Note 1: **Damage by the earthquake**: Not fully inspected but maybe not significant considering the KK earthquake (2007) where no damage to safety functions even though the observed acceleration exceeded design basis by factor 2-3 (Acceleration will not necessarily be damages indicators)

Note 2: **Scram set points** by acceleration (Basement of Reactor Building) Horizontal=135-150 gal, Vertical=100 gal

Note 3: Design means new design basis (2009)

Source: A. Omoto, "Fukushima Accident: Overview," ICAPP 2011, May 3, 2011
https://www.sfen.fr/content/download/30655/1616957/file/1-ICAPP_Omoto2.pdf

Loss of all power sources due to the Earthquake and Tsunami

Note:
- **All operating units when earthquake occurred were automatically shut down.**
- **Emergency D/Gs have worked properly until the Tsunami attack.**

① Loss of offsite power due to the earthquake

Grid Line

Tsunami (estimated more than 10m)

Turbine Building

Reactor Building

D/G

Elevation: about 10m

Seawater level

Seawater Pump

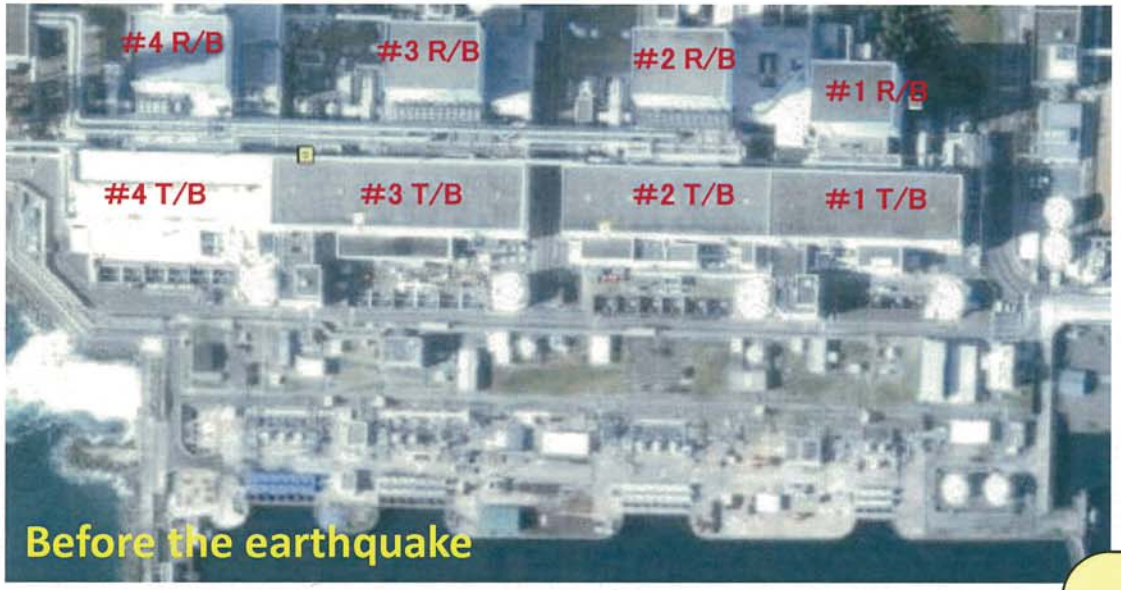
② D/G Inoperable due to Tsunami flood

①+② ⇒ Station Black Out

All Motor Operated pumps (including ECCS pumps) became inoperable

Source: Nuclear and Industry Safety Agency(NISA), April 4, 2011, at IAEA
http://www.nisa.meti.go.jp/english/files/en20110406-1-1.pdf

Satellite view of Fukushima Dai-ichi NPP



Source: Nuclear and Industry Safety Agency(NISA), April 4, 2011, at IAEA
http://www.nisa.meti.go.jp/english/files/en20110406-1-1.pdf

Source: Google Earth

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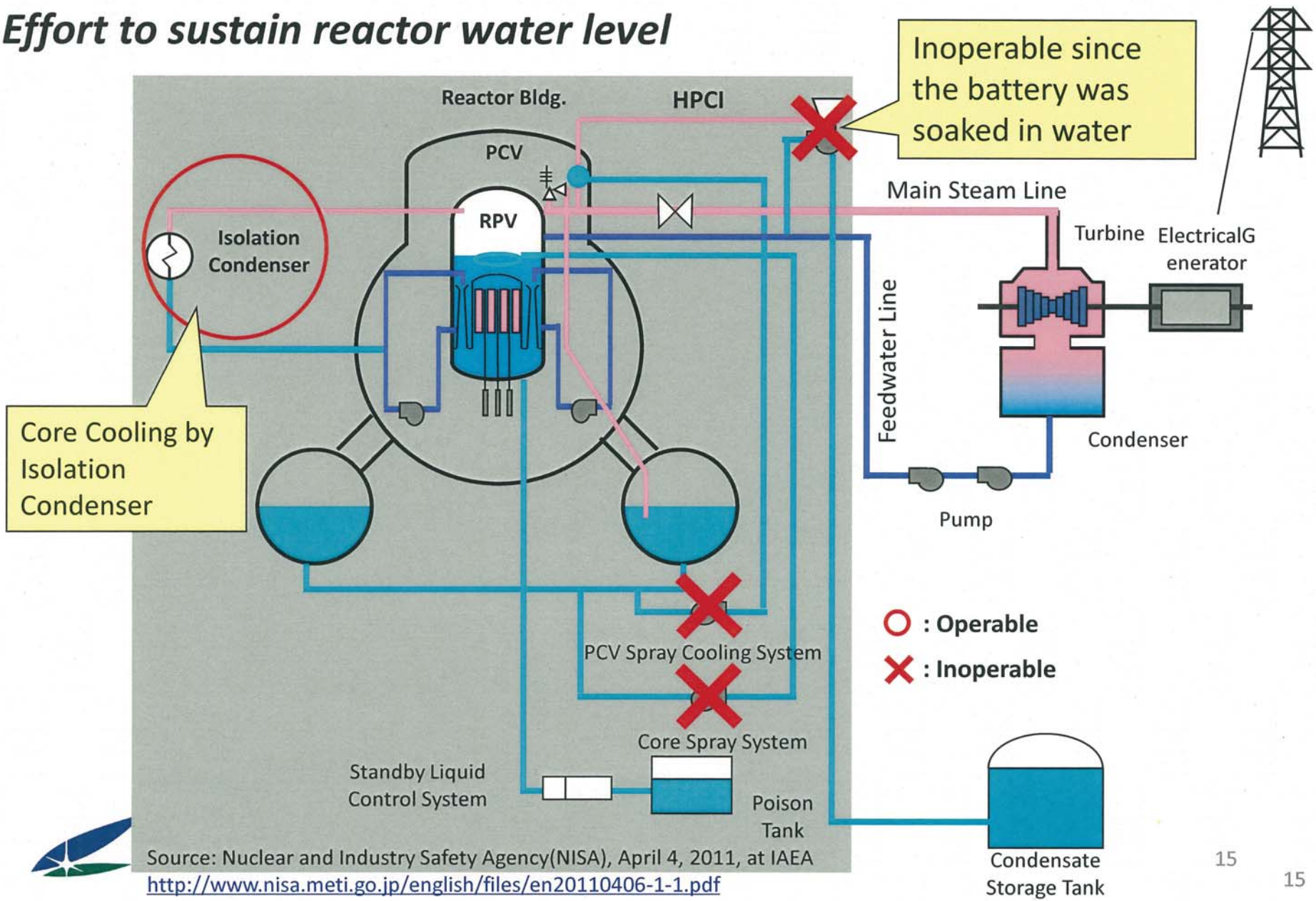
Major event progression at Unit 1 (1/4)

Effort to sustain reactor water level



Source: Nuclear and Industry Safety Agency(NISA), April 4, 2011, at IAEA
http://www.nisa.meti.go.jp/english/files/en20110406-1-1.pdf

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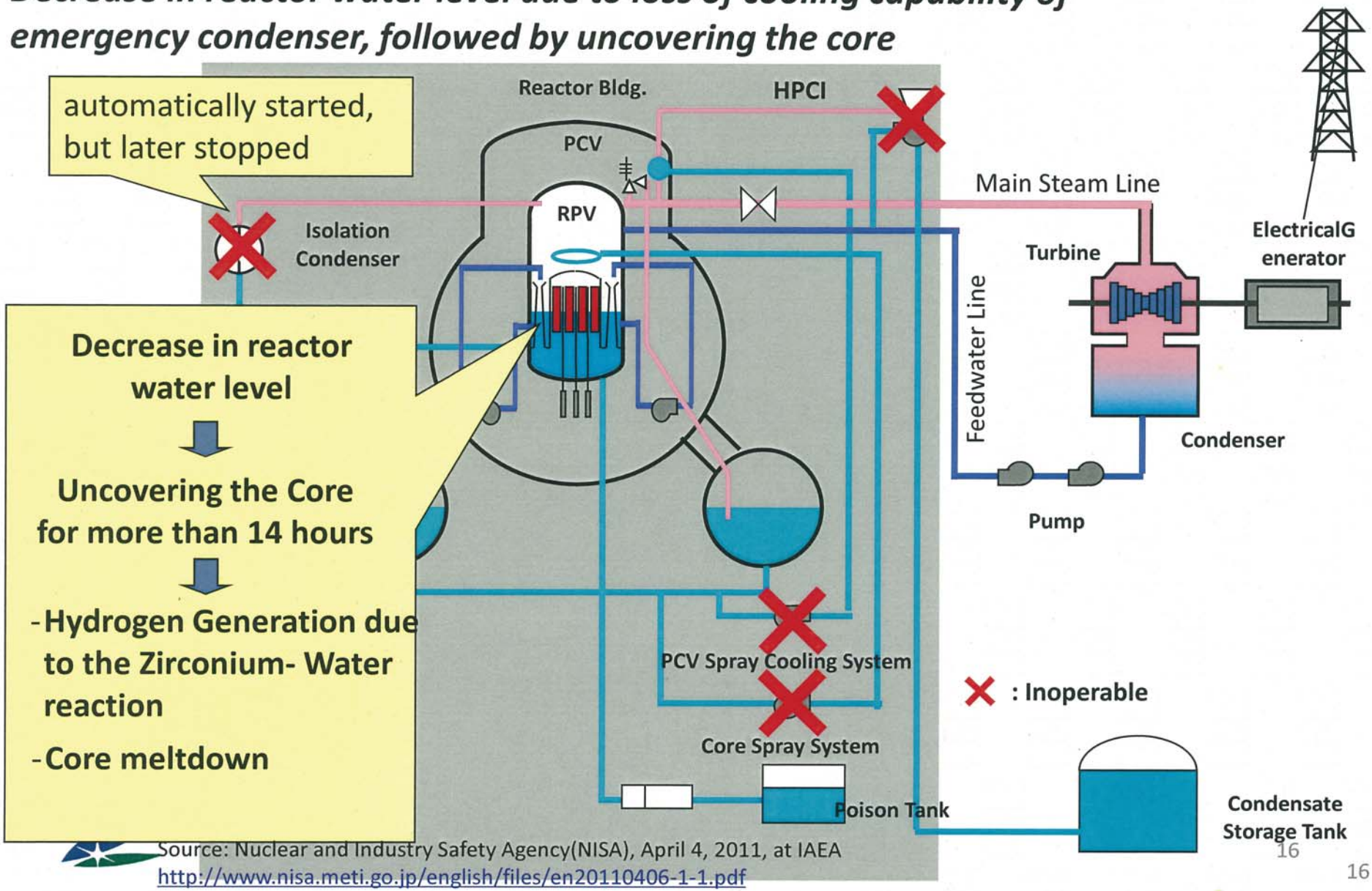
Major event progression at Unit 1 (2/4)

Decrease in reactor water level due to loss of cooling capability of emergency condenser, followed by uncovering the core



Source: Nuclear and Industry Safety Agency(NISA), April 4, 2011, at IAEA
http://www.nisa.meti.go.jp/english/files/en20110406-1-1.pdf

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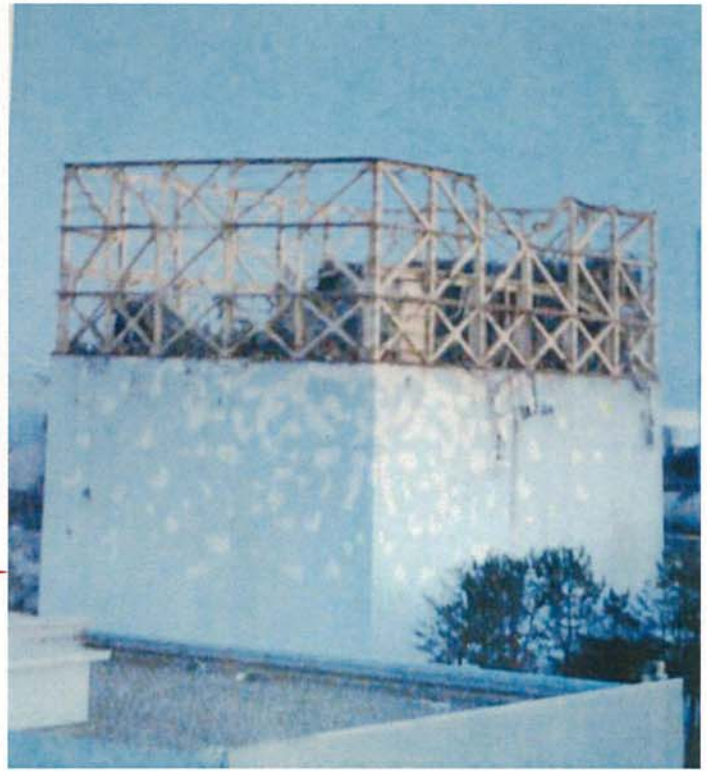
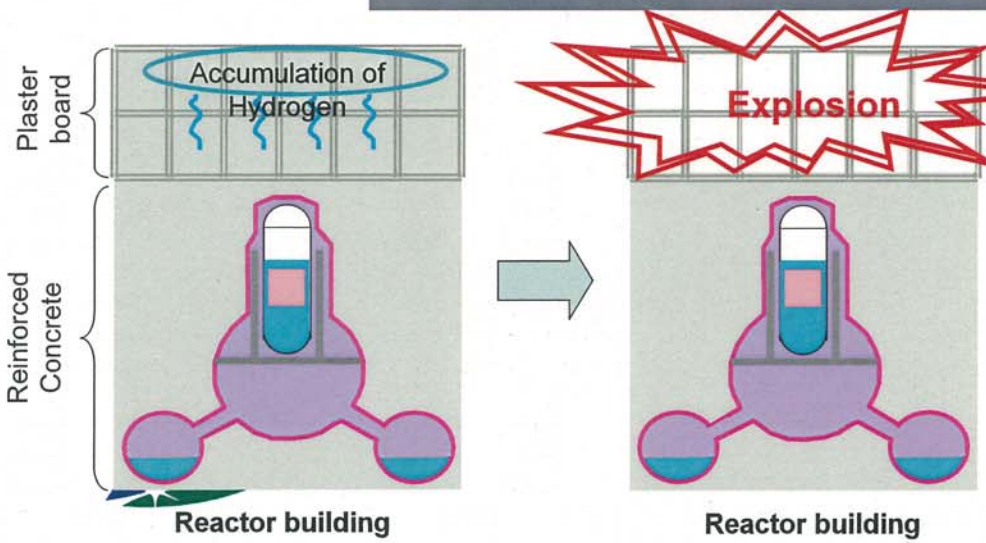
Major event progression at Unit 1 (3/4)

Hydrogen explosion in the operation floor





Source: Nuclear and Industry Safety Agency(NISA), April 4, 2011, at IAEA
http://www.nisa.meti.go.jp/english/files/en20110406-1-1.pdf

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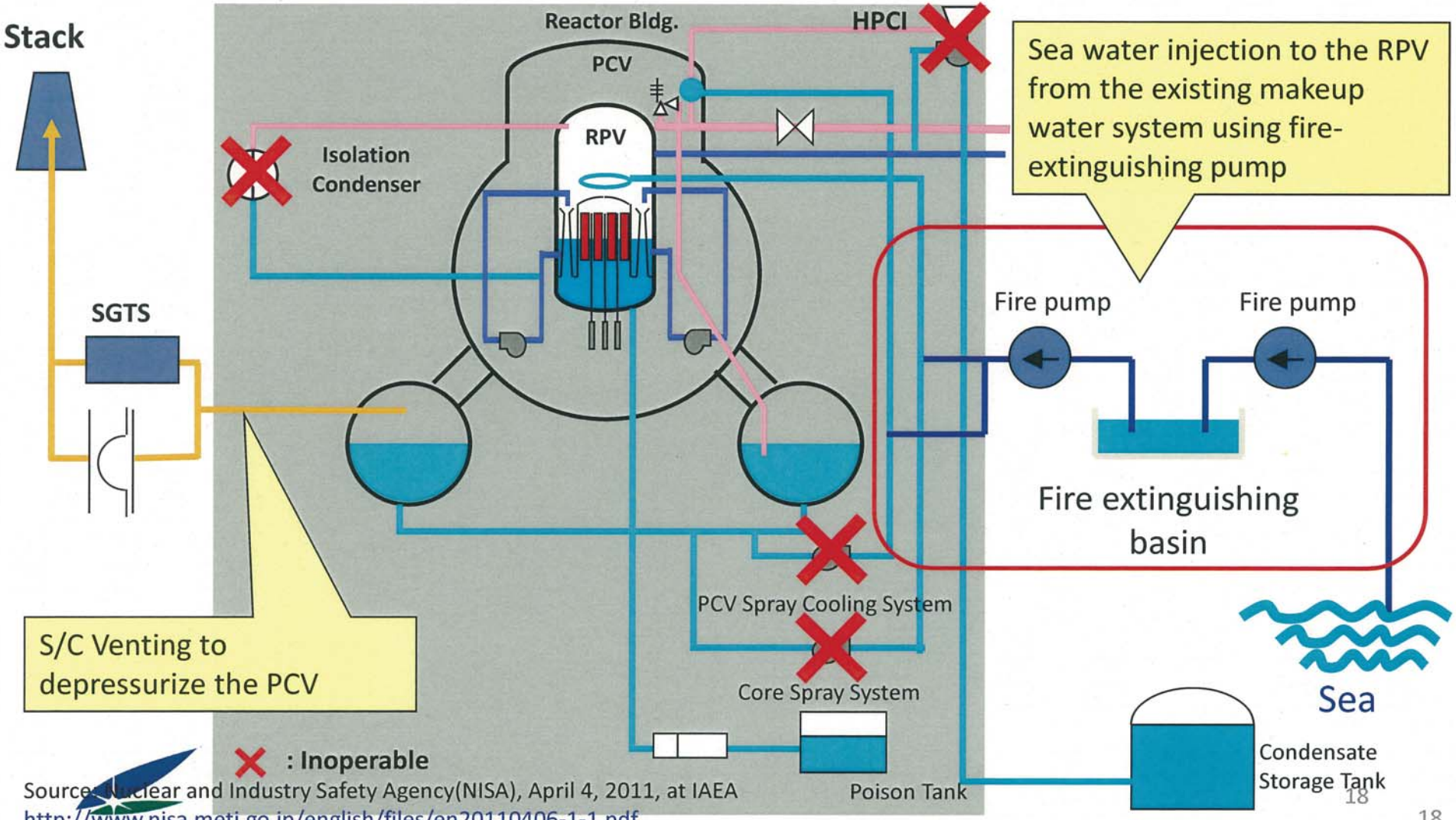
Major event progression at Unit 1 (4/4)

- Sea water injection using fire water pump -
S/C Venting to depressurize the PCV



Source: Nuclear and Industry Safety Agency(NISA), April 4, 2011, at IAEA
http://www.nisa.meti.go.jp/english/files/en20110406-1-1.pdf

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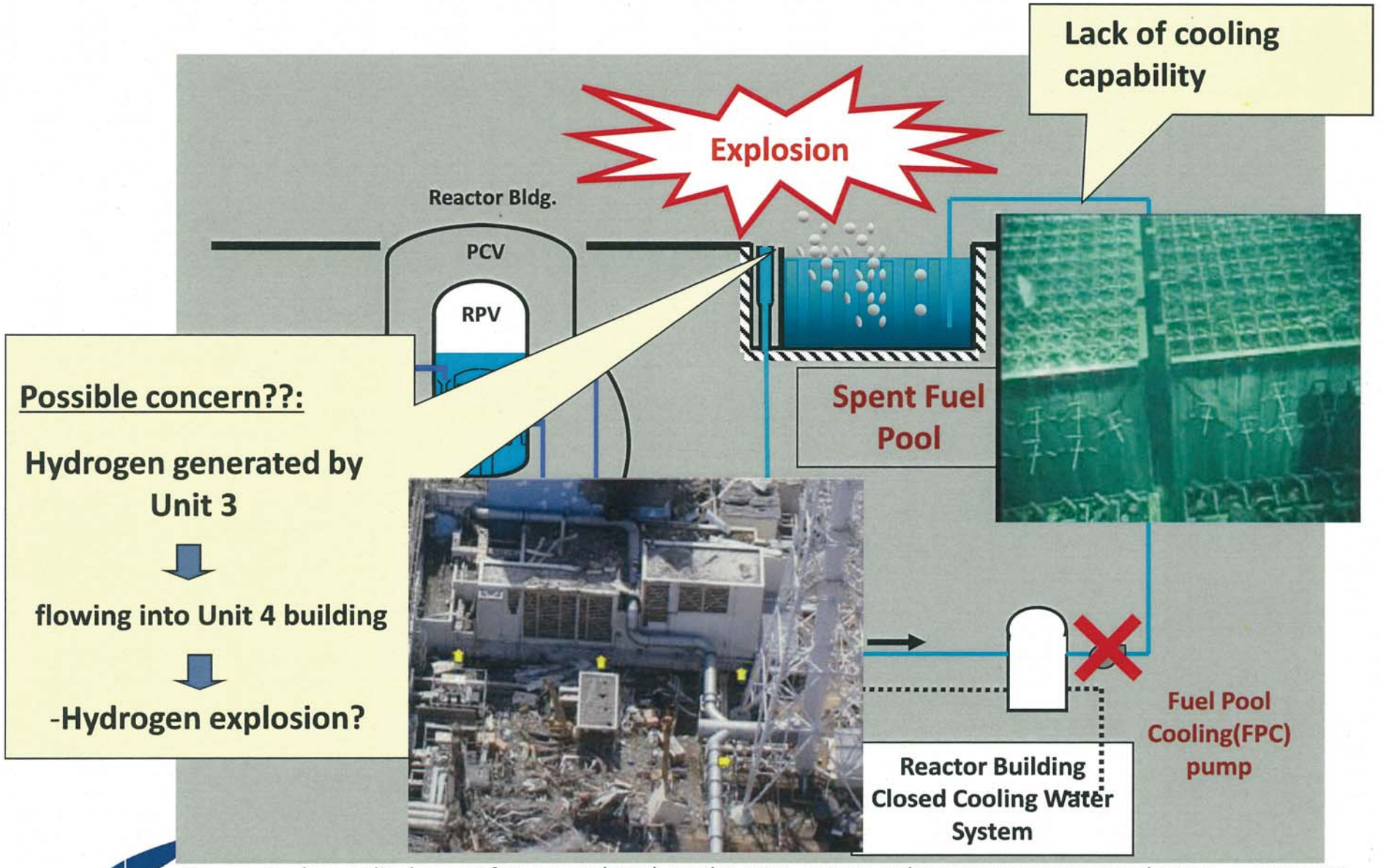
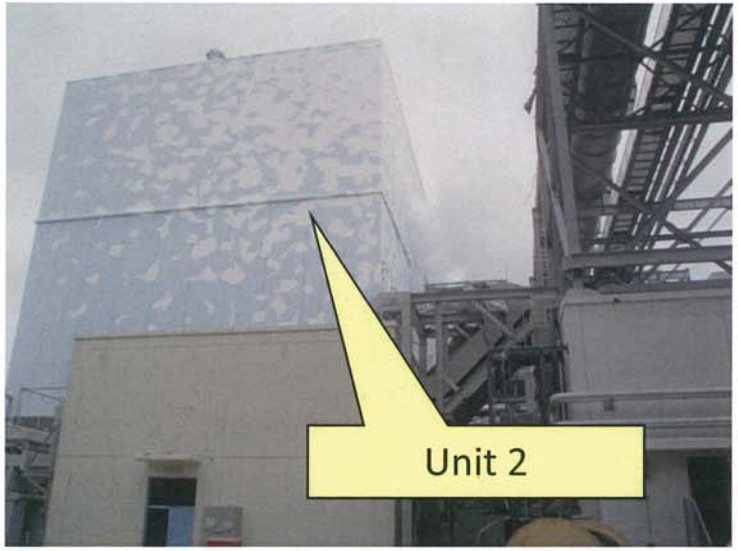
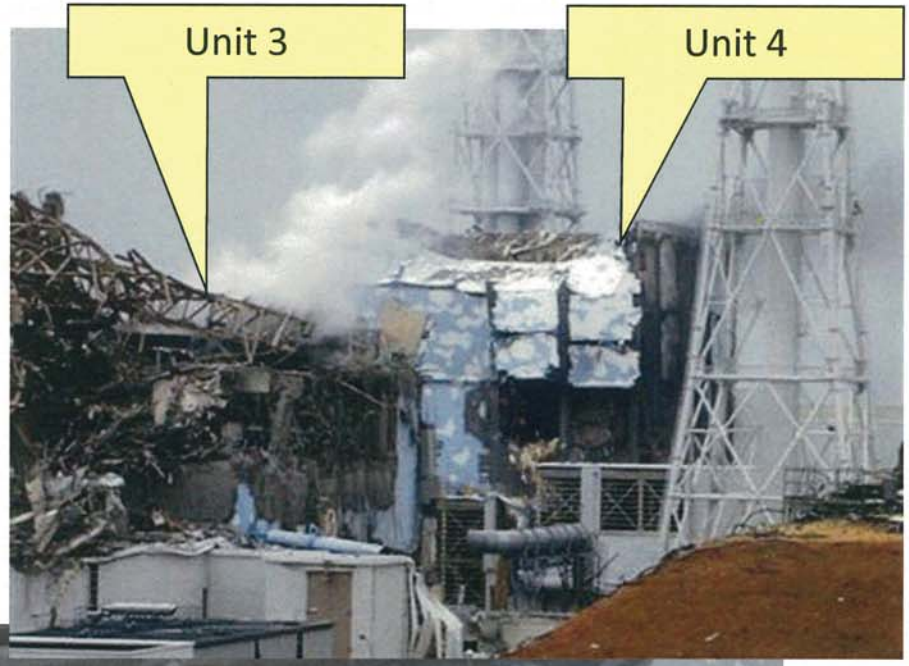
Possible concerns about Spent Fuel Pool



Source: Nuclear and Industry Safety Agency(NISA), April 4, 2011, at IAEA and Government Report to the IAEA, June 7, 2011
http://www.nisa.meti.go.jp/english/files/en20110406-1-1.pdf

Accident Progression at Unit 2 through 4 reactors





Source: Nuclear and Industry Safety Agency(NISA), April 4, 2011, at IAEA
http://www.nisa.meti.go.jp/english/files/en20110406-1-1.pdf

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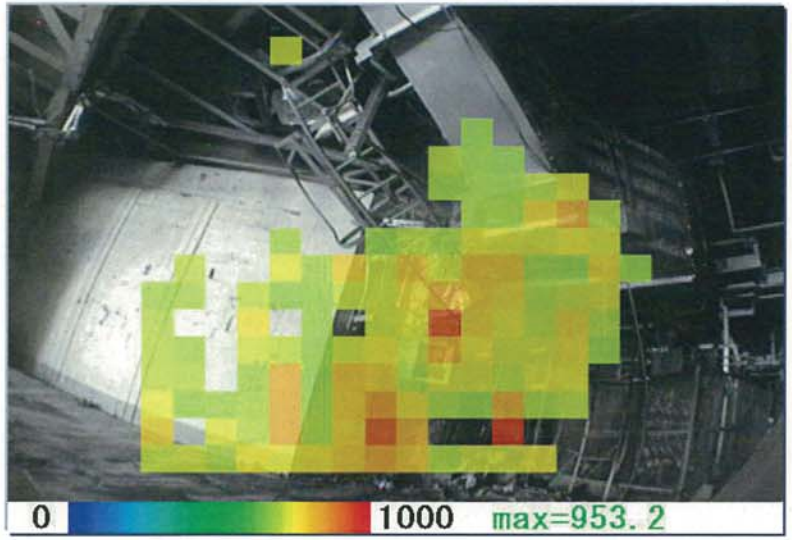
Pictures of Unit 4: http://www.tepco.co.jp/en/news/110311/index-e.html

IAEA mission team visit

Dr. Yoshida, Plant Manager of F-1

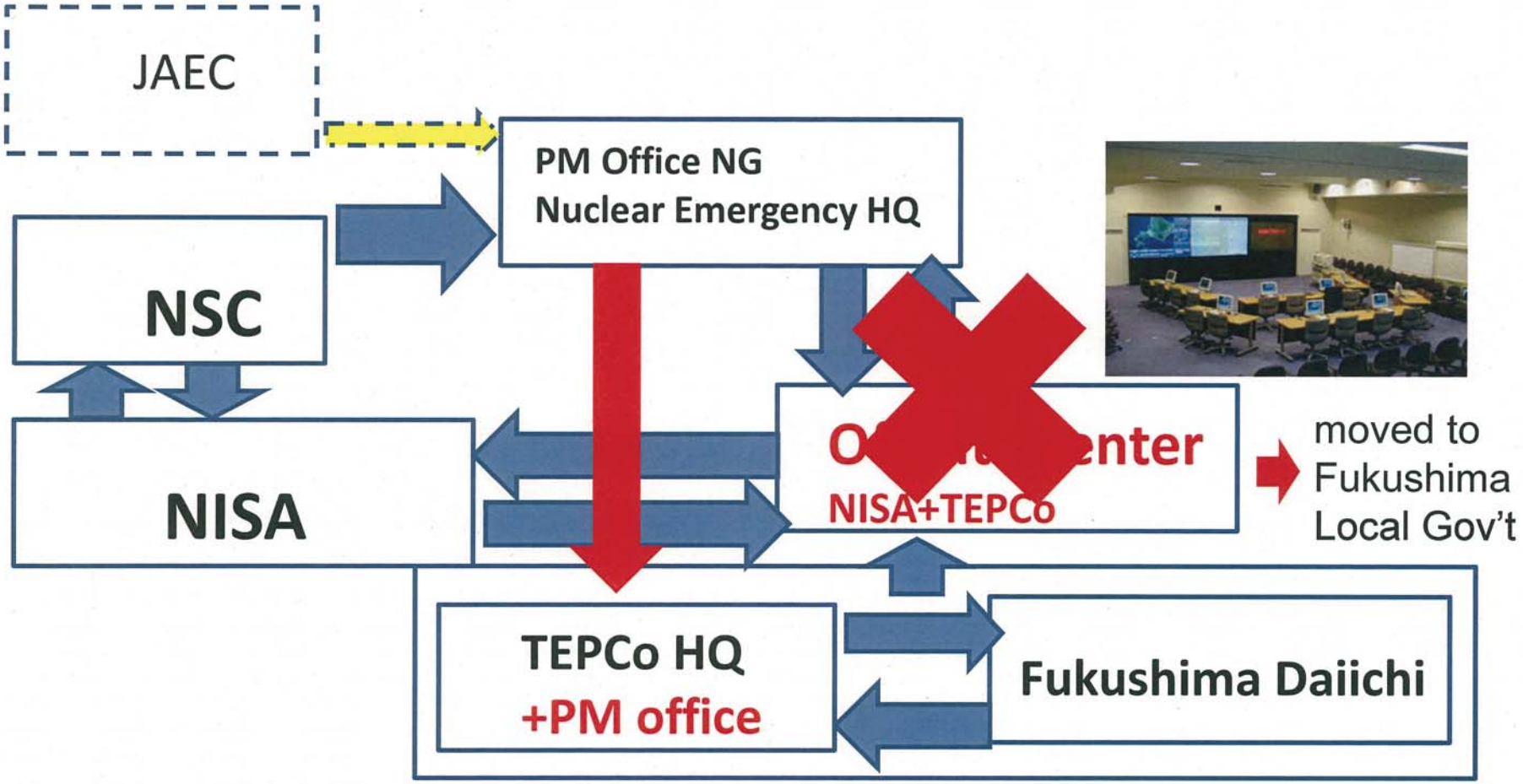


Robot measurement of radioactivity at F-1

Robot investigating inside reactor bldg

http://www.tepco.co.jp/tepconews/pressroom/110311/index-j.html

Nuclear Emergency: Institutional Arrangement under the Law*



*Act on Special Measures Concerning Nuclear Emergency Preparedness (ASMCNE)

Timeline of event: No. 1 unit
- Delay in cooling and venting? -

11th	
14:46	*Earthquake hit the NPP*
15:37	*Tsunami hit, all AV power lost*
16:36	*All cooling capability lost (nuclear emergency declared by TEPCo)*
~17:00	*core exposed, possible meltdown start*
23:00	*Radiation level at control room is reported to be high (0.5~1.2mSV/h)*
12th	
3:15	*METI/TEPCo announced the decision to vent*
5:46	*Started pumping water to the reactor core*
6:50	*METI/NISA ordered TEPCo to vent*
9:04	*TEPCo started venting operation (after confirmation of evacuation)*
14:30	*Confirmed venting*
15:36	*Hydrogen explosion*

14hrs9min

Safety Regulation on Sever Accident

- The Regulatory Guide for Reviewing Safety Design *does not take total AC power loss as a design basis event*.
  - *No particular considerations are necessary against a **long-term** total AC power loss*
  - the assumption of a total AC power loss is not necessary if the emergency AC power system is reliable enough
  - Loss of all seawater cooling system functions is not taken as a design basis event.
- Flammability Control System (FCS) is not aimed at preventing hydrogen combustion *inside the reactor building*
- In Japan, a civil standard on seismic PSA is also established, *while study of PSA related to other external events such as flooding has only started.*
- (Based on NSC decision in 1992).. licensees have taken *voluntary actions (not included in regulatory requirements),* such as measures to prevent accidents from becoming severe accidents

Despite repeated warnings from scientists on earthquake and tsunami…

- "For nuclear power plants, *disaster caused by earthquake can be especially dangerous because it could cause multiple failures at the same time* unlike normal accident"

  – Prof. Katsuhiko Ishibashi, from "Nuclear power disaster with large earthquake", *Kagaku (Science),* Oct., 1997

- "I cannot accept this report because *it does not mention `Jogan-earthquake-tsunami' at all which hit Tohoku area in 869 with huge impacts*"- Dr. Yukinobu Okamura, at NISA expert meeting in June 2009.

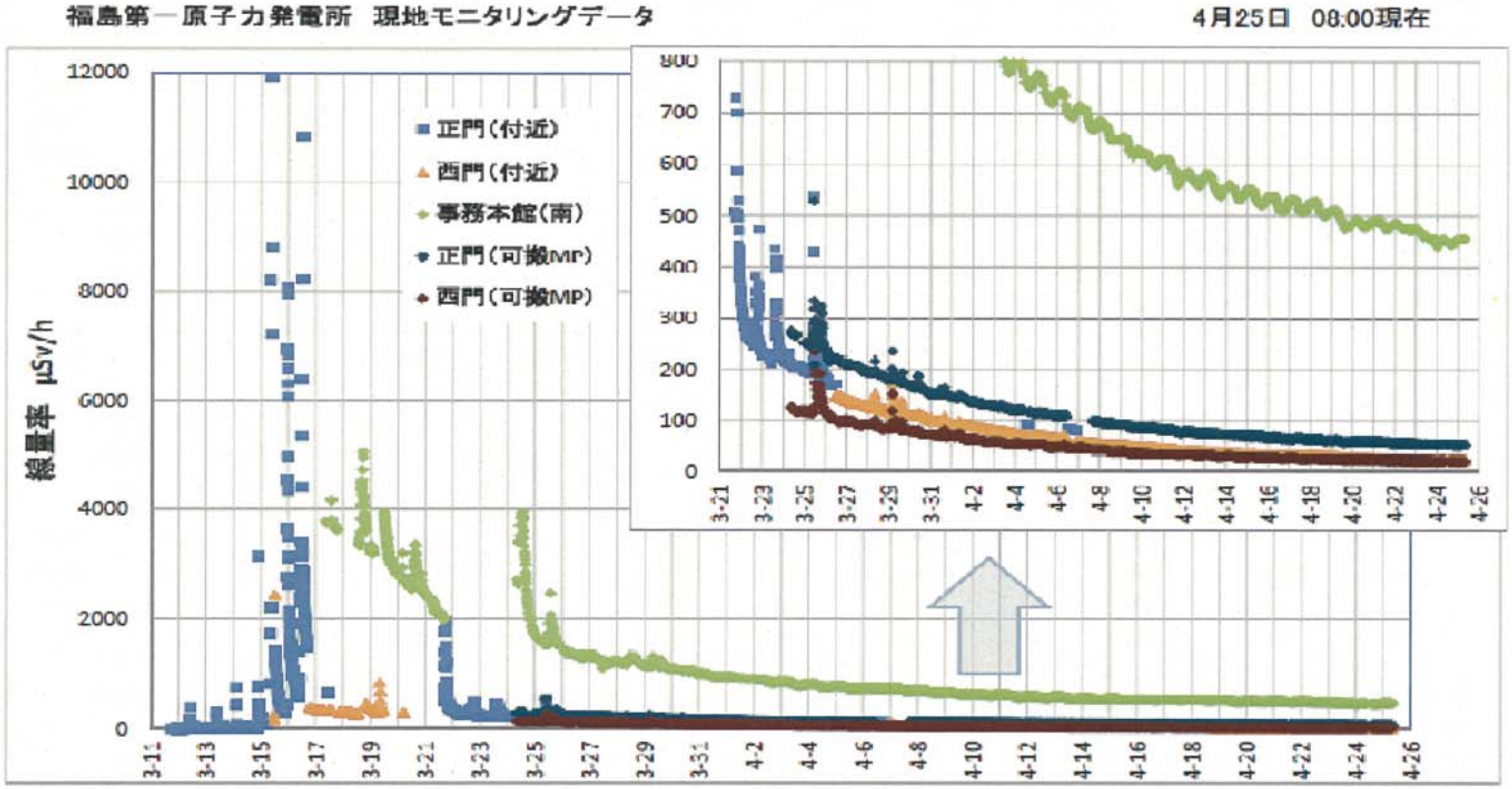
Radiation Exposure to the Workers on site

- As of May 23, total of 7,800 technicians and engineers worked on site (collectively). No radiation-induced illness has not been reported.
- According to the gov't report, average exposure level is 7.7 mSv.
- It is reported that 115 workers were exposed to higher than 100 mSv. 9 workers received more than 250 mSv (as of June 21, 2011.)
  - But, due to lack of availability of WBC (only 4 units), not all workers were tested for internal dose. Besides, TEPCo cannot identify and track the records of 69 workers out of 3726 workers who worked on site during March.

Impact on Public and Environment

"..the monitoring of environmental radiation doses should be continued and dose assessments should be implemented for residents. *The government should* develop an organizational framework to promptly and effectively carry out such emergency measures...it should develop the legal framework required for each measure, and immediately start on such steps *as implementing demonstration tests on effective technology." – JAEC (05/10/11)*

Monitoring Data Trends at Fukushima-1



Source: JAEC based on MEXT data

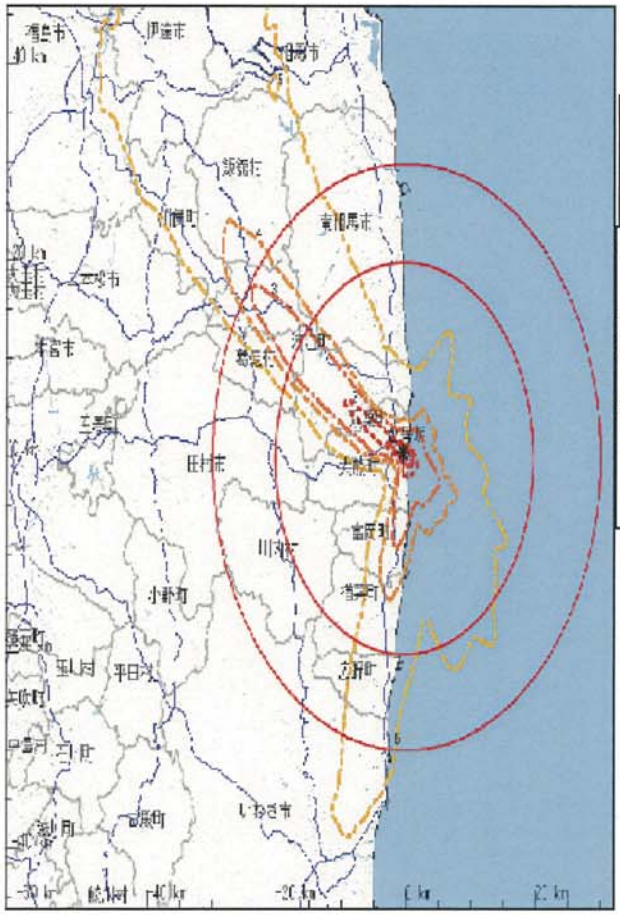
Estimated Exposure by SPEEDI (2011/03/23, 04/05)

内部被ばく臓器等価線量
日時= 2011/03/12 06:00 -
2011/03/24 00:00 の積算値

領域 : 92km X 92km
核種名 = ヨウ素合計
対象年齢 = 1歳児
臓器名 = 甲状腺

【凡例】
線量等価線 (mSv)
1= 10000
2= 5000
3= 1000
4= 500
5= 100

(評価)
本試算は、福島第一原子力発電所の事故発生後、連続して一日中屋外で過ごすという保守的な条件を仮定して、甲状腺の被ばく線量を試算した



第22回原子力安全委員会
資料 第1-3号

外部被ばくの積算線量
(3月12日から4月5日までのSPEEDIによる試算値)

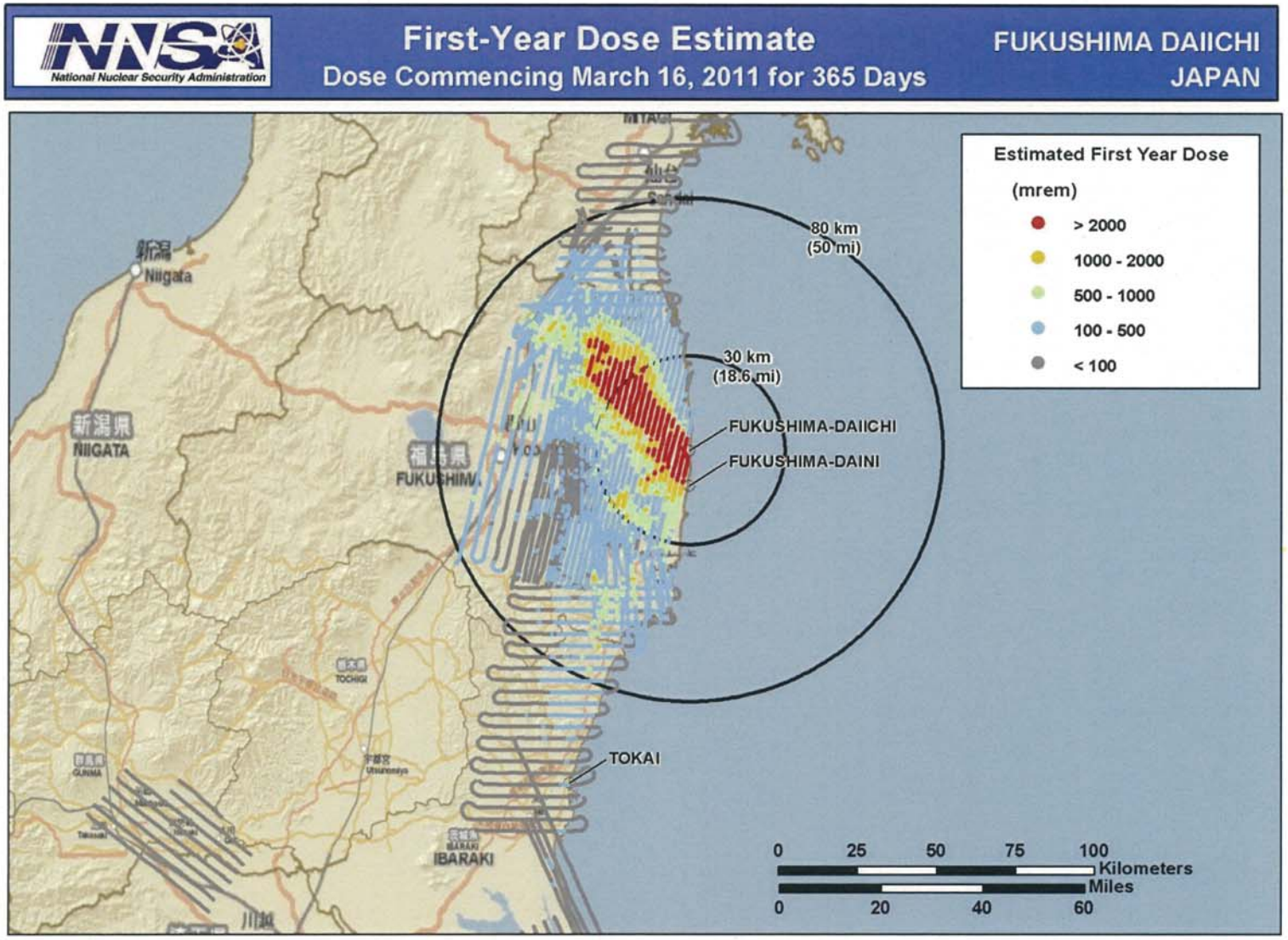
外部被ばくによる実効線量
日時= 2011/03/12 06:00 -
2011/04/06 01:00 の積算値

領域 : 92km X 92km
核種名 = 全核種
対象年齢 = 成人

【凡例】
実効線量等価線 (mSv)
1= 100
2= 50
3= 10 ← 屋内退避レベル
4= 5
5= 1

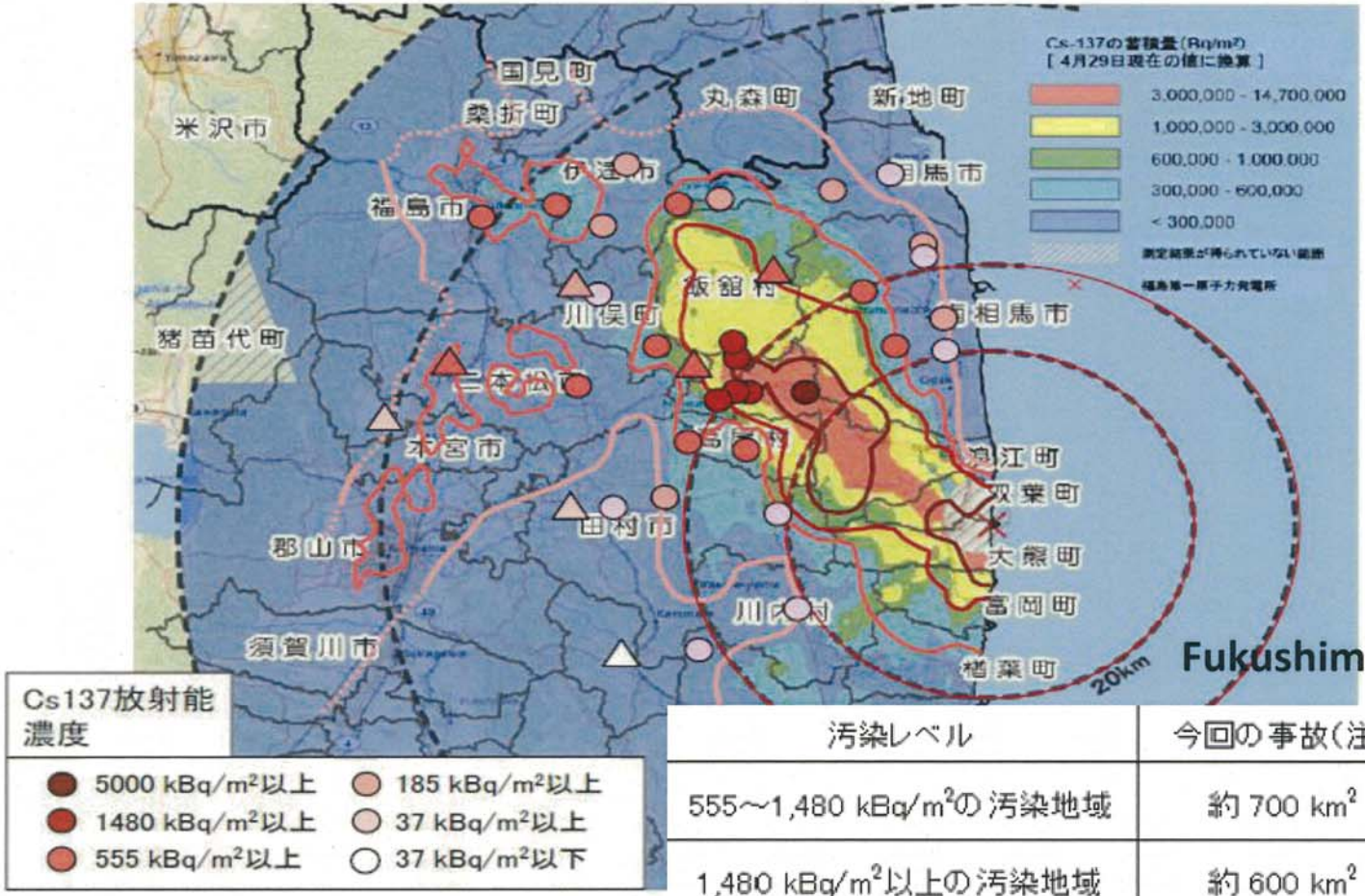
Source: Nuclear Safety Commission, 2011/03/23, http://www.nsc.go.jp/info/110323_top_siryo.pdf
2011/04/10: http://www.nsc.go.jp/anzen/shidai/genan2011/genan022/siryo1-3.pdf

First Year Dose Estimate



Contamination Map by MEXT and DOE
(as of May 6, 2011)

5月6日公表文科省・米国DOE航空機モニタリング結果との重ね合わせ



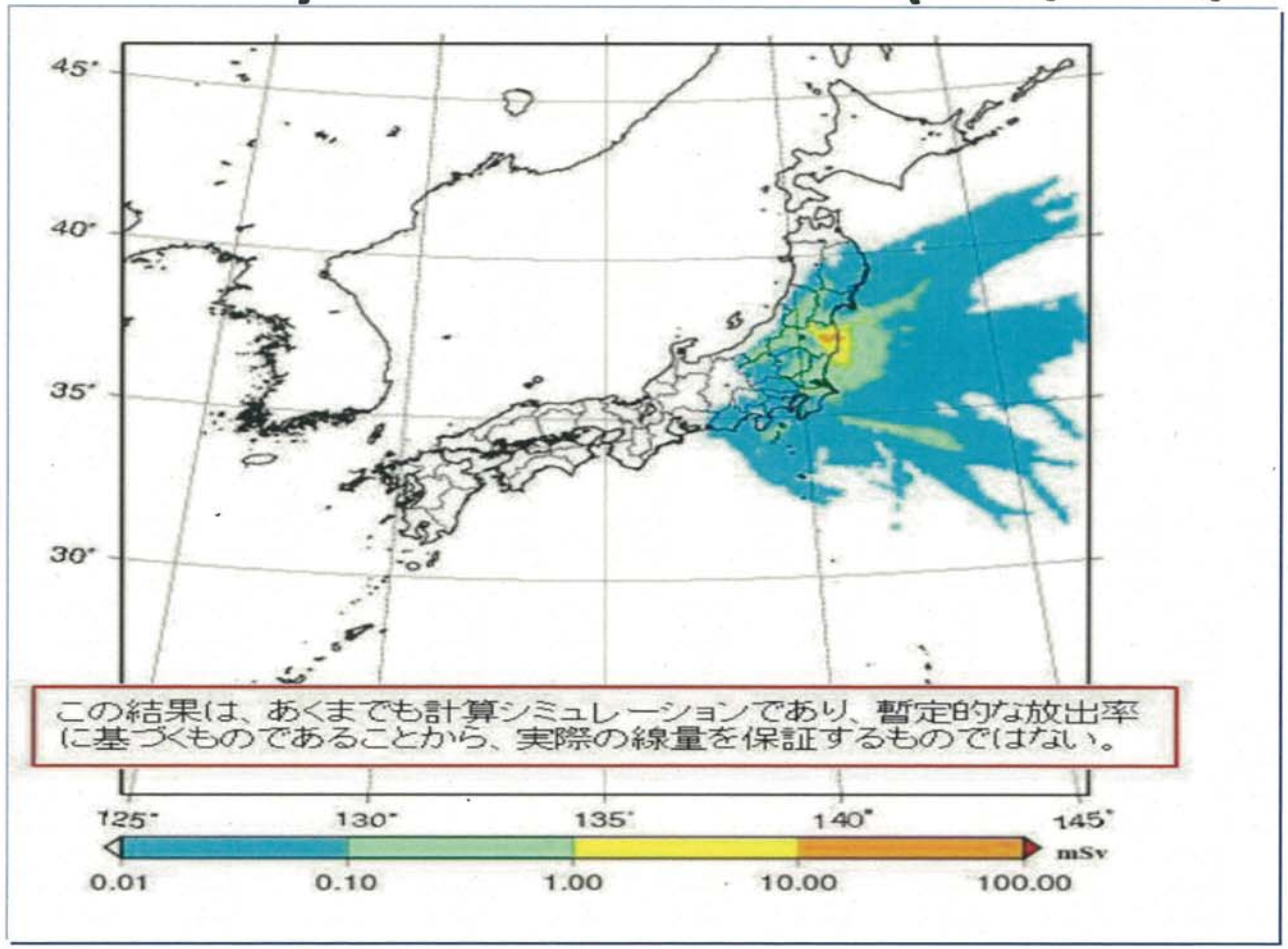
Cs137放射能濃度

- 5000 kBq/m²以上
- 1480 kBq/m²以上
- 555 kBq/m²以上
- 185 kBq/m²以上
- 37 kBq/m²以上
- 37 kBq/m²以下

汚染レベル	今回の事故(注) Fukushima	チェルノブイリ事故 Chernobyl
555～1,480 kBq/m²の汚染地域	約 700 km²	約 7,200 km²
1,480 kBq/m²以上の汚染地域	約 600 km²	約 3,100 km²

Source: T. Kawada, "Current Status of Soil Contamination and how to respond," Presentation at JapanAtomic Energy Commission Meeting, May 24, 2011
http://www.aec.go.jp/jicst/NC/iinkai/teirei/siryo2011/siryo16/siryo2.pdf

Estimated cumulative exposure level by simulation (06/28/11)



Source: M. Chino, presented at JAEC, June 28, 2011.
http://www.aec.go.jp/jicst/NC/iinkai/teirei/siryo2011/siryo23/siryo1-2.pd f

INES Level is now 7

Discharge quantity is roughly 1/5~1/10 of Chernobyl

	Assumed amount of the discharge from Fukushima Dai-ichi NPS		(Reference) Amount of the discharge from the Chernobyl accident
	Estimated by NISA	Announced by NSC	
^{131}I … (a)	1.3×10^{17} Bq	1.5×10^{17} Bq	1.8×10^{18} Bq
^{137}Cs	6.1×10^{15} Bq	1.2×10^{16} Bq	8.5×10^{16} Bq
(Converted value to ^{131}I) … (b)	2.4×10^{17} Bq	4.8×10^{17} Bq	3.4×10^{18} Bq
(a) + (b)	3.7×10^{17} Bq	6.3×10^{17} Bq	5.2×10^{18} Bq

Source: NISA, April 12, 2011 http://www.nisa.meti.go.jp/english/files/en20110412-4.pdf

Contaminated water discharge to the sea (~10,393 tons)

Discharge amount of the stagnant water with low-level radioactivity, etc. from the Fukushima Dai-ichi NPS

< Table 1 >

	Radioactive Concentration (Bq/cm^3)				Discharge Amount (m^3)	Periods of Discharge
	I-131	Cs-134	Cs-137	sum		
Stagnant water in the Radioactive Waste Treatment Facilities	6.3E+00	4.4E+00	4.4E+00	1.5E+01	9,070	4/4 19:03 – 4/6 6:30 4/6 18:00 – 4/8 22:20 4/8 23:45 – 4/10 17:40
Water in the Sub Drain Pit of the Unit 5	1.6E+00	2.5E-01	2.7E-01	2.1E+00	950	4/5 17:20 – 4/8 12:14
Water in the Sub Drain Pit of the Unit 6	2.0E+01	4.7E+00	4.9E+00	3.0E+01	373	4/4 21:00 – 4/9 18:52

※Radioactive Concentration (Bq/cm3) of the stagnant water in the Radioactive Waste Treatment Facilities is assessed by the maximum value of the samples in the two Facilities shown in the following table.

	Radioactive Concentration (Bq/cm3)			
	I-131	Cs-134	Cs-137	Sum
Stagnant water in the Radioactive Waste Treatment Facilities (In the Non-Controlled	6.3E+00	2.7E+00	2.8E+00	1.2E+01
Stagnant water in the Radioactive Waste Treatment Facilities (In the Controlled Area)	8.7E-01	4.4E+00	4.4E+00	9.7E+00

Source: NISA Apil 15, 2011, http://www.nisa.meti.go.jp/english/files/en20110416-10.pdf

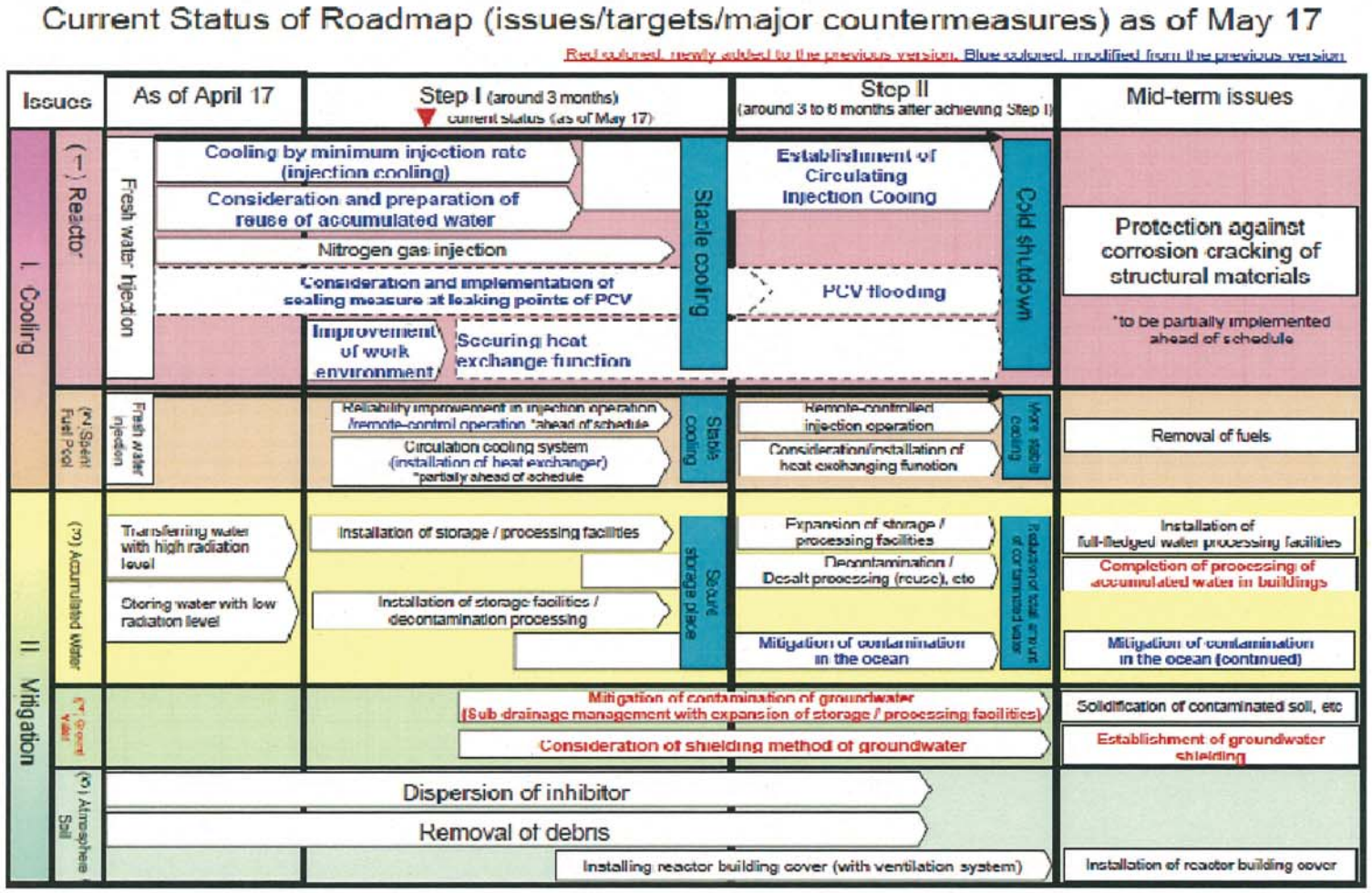
Storage and Treatment of Contaminated Water (>100,000tons?)

Storage tank of contaminated water

Water treatment facility under construction

http://www.tepco.co.jp/tepconews/pressroom/110311/index-j.html

Roadmap to stabilization and cold shutdown（2011/05/17)

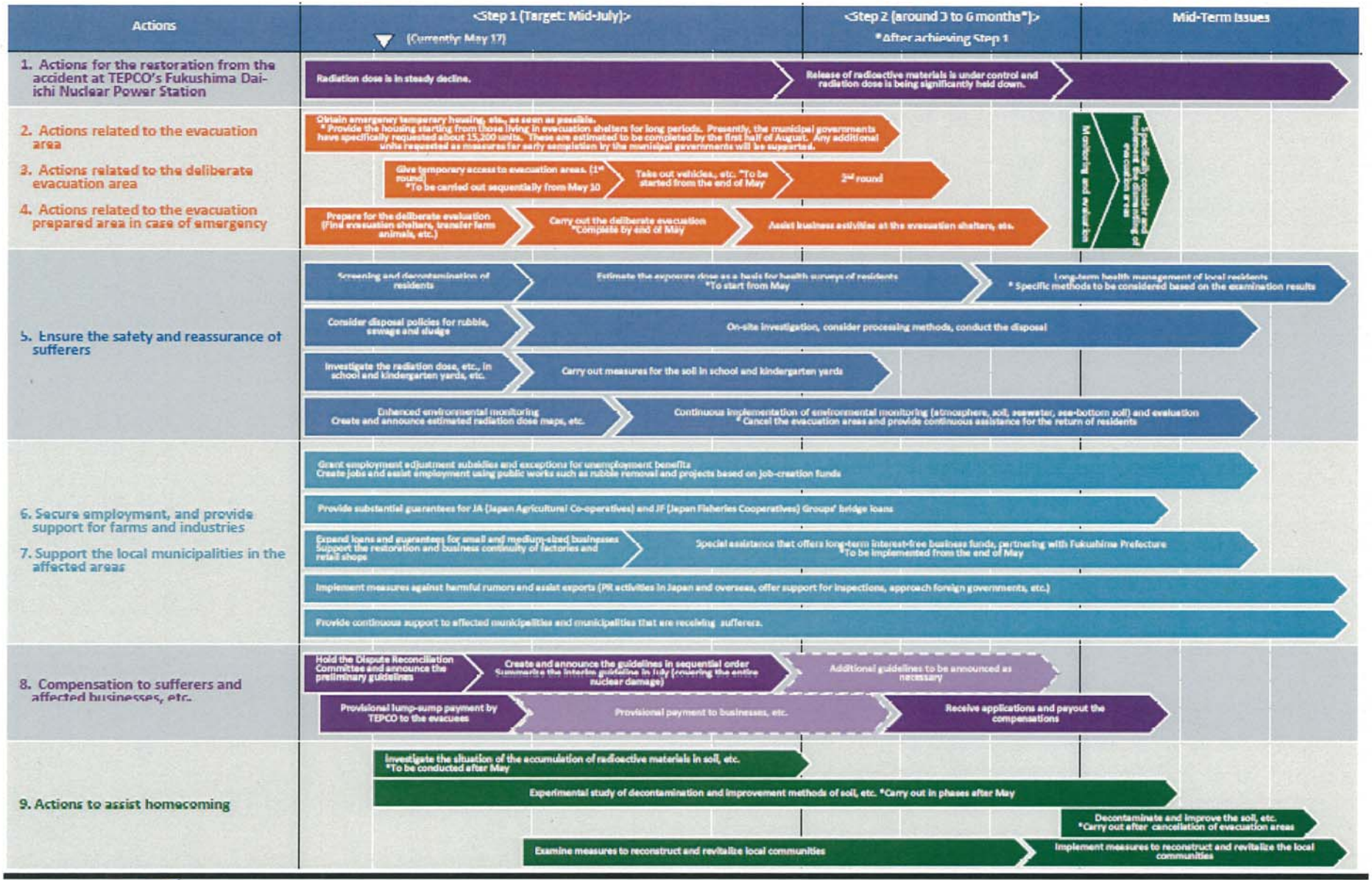


Source: http://www.meti.go.jp/english/earthquake/nuclear/roadmap/pdf/110517TEPCO_status2.pdf

Roadmap for Immediate Actions for the Assistance of Nuclear Sufferers

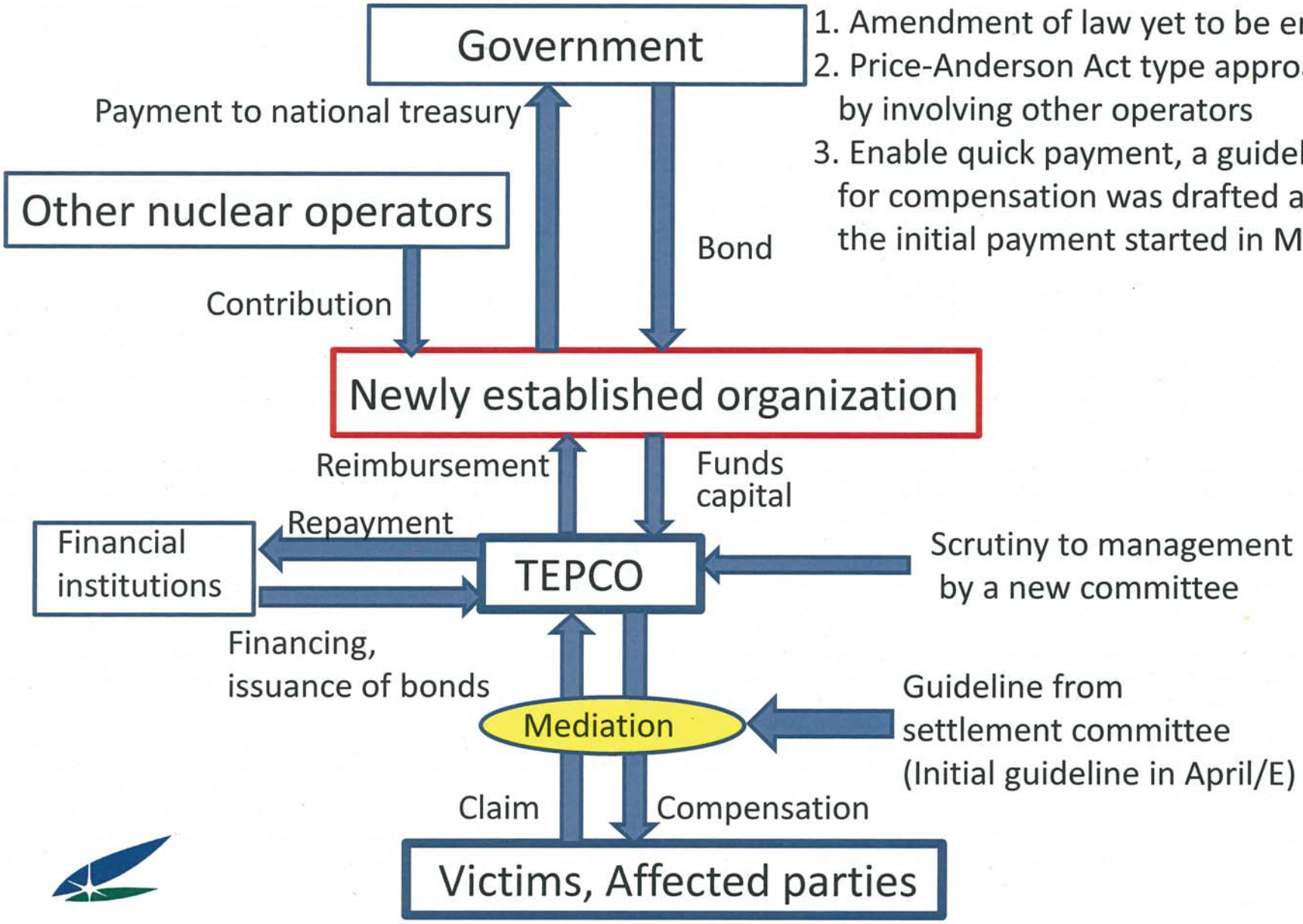
Document 2

May 17, 2011
Nuclear Emergency Response Headquarters



http://www.meti.go.jp/english/earthquake/nuclear/roadmap/pdf/110517roadmap_assistance.pdf

Proposed new compensation scheme



1. Amendment of law yet to be enacted
2. Price-Anderson Act type approach by involving other operators
3. Enable quick payment, a guideline for compensation was drafted and the initial payment started in May

Lessons learned and Possible Implications

"If they (the regulatory authorities) judge that the measures are insufficient, *they should take strict steps, including shutdown*, in accordance with laws and regulations...*It is also Japan's responsibility to share the accident investigation results and the lessons learned with the international community"- JAEC (05/10/11)*

Emergency Safety Measures directed by NISA (2011/03/30)

Short Term Measures (~ within 1 month)

1. Inspection of emergency equipment
2. Inspection of emergency plan and implementation of simulation training
3. Securing emergency power supplies
4. Securing ultimate heat removal capability
5. Securing cooling capability of spent fuel storage pool
6. Measures specific to each site condition

http://www.meti.go.jp/press/20110330004/20110330004.html

PM Kan's request to shutdown all Hamaoka NPPs (May 6, 2011)

- "Today, in my capacity as Prime Minister, I requested .... that Chubu Electric Power Company suspend the operation of all nuclear reactors at Hamaoka Nuclear Power Station. I made this decision, first and foremost, in consideration of the safety and well-being of the public.." (May 6,2011)
  - METI Minister confirms that all other units can operate assuming they satisfy safety requirements issued by METI Nuclear and Industry Safety Agency (NISA)
  - NISA approved short-term measures taken by the all utilities (May 6, 2011)

Additional Measures for Existing Reactors by NISA (06/8/11)

1. Secure the working environment in the Main Control Room
2. Secure the means of communication inside the NPS premises in case of emergency.
3. Secure supplies and equipment such as high-level radiation protective gear, and develop a system for radiation dose management
4. Establish measures to prevent hydrogen explosion
5. Deploy heavy machinery for removing rubble

http://www.nisa.meti.go.jp/english/press/2011/06/en20110615-1.pdf

More nuclear plants may face shutdown

- Out of all 54 units:
  - 14 units are shutdown due to the Earthquake
  - 21 units are shutdown due to maintenance etc.
  - 19 units are now operating, but 9 more units will be shutdown due to maintenance by early next year.
  - All nuclear plants could be shutdown by May, 2012.
- The governor of Fukui said it will not approve the re-startup of nuclear reactors without new safety requirements. (May 20, 2011, Asahi)

Statement by PM Kan on Future Energy Policy : Four Pillars
(May 24, 2011@OECD)

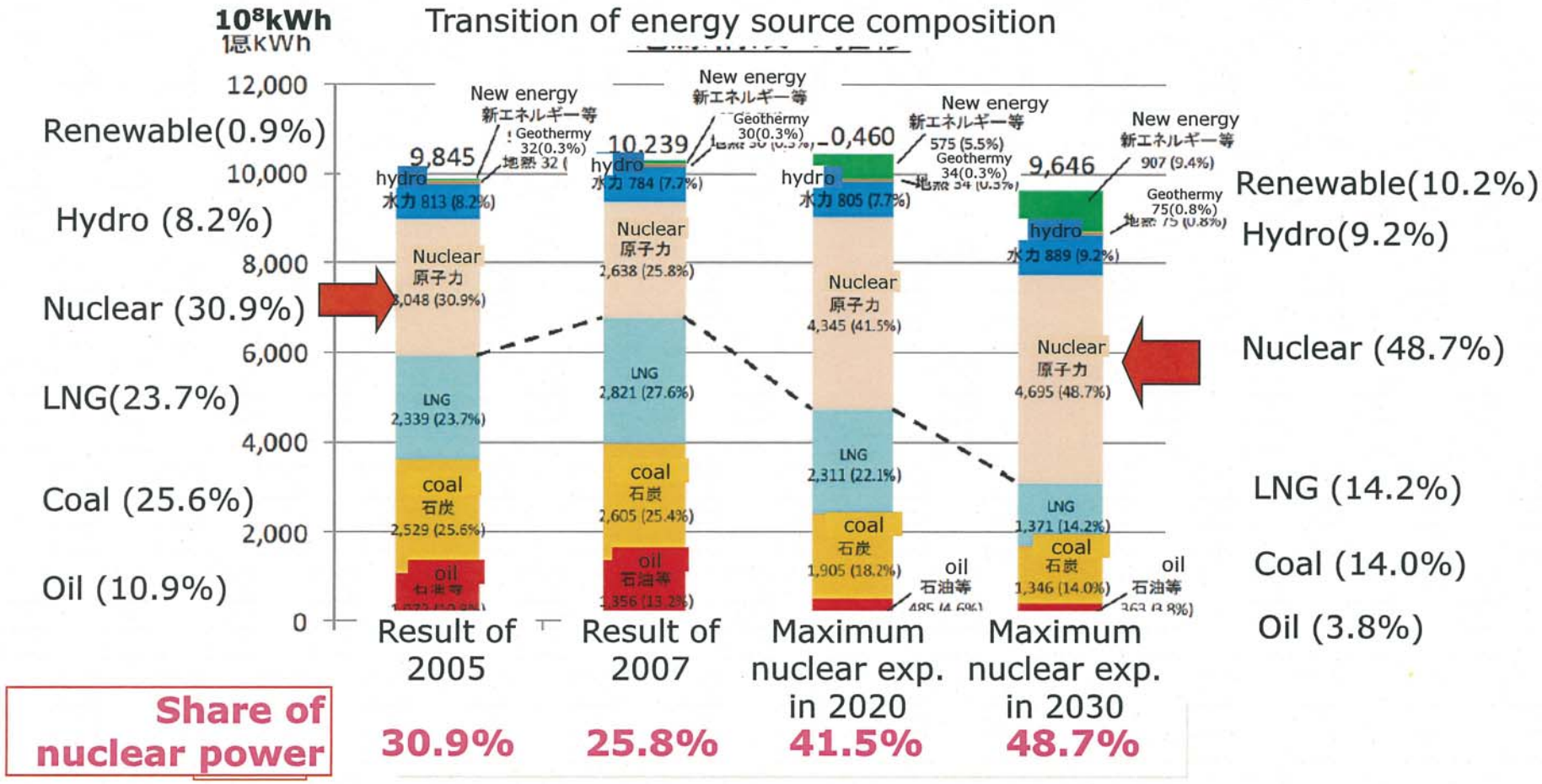
1. Safety of nuclear energy. ...we will achieve the highest standard of nuclear safety.
2. Efficient use of fossil fuel minimizing CO2 emission with advanced technologies
3. Increase the share of renewable energy in total electric power supply to at least go beyond 20 percent by the earliest possible in the 2020s
   - Reduce solar power cost by 1/3 by 2020, 1/6 by 2030
   - Install 10 million solar panels by 2020
4. Achieve energy efficiency without compromising the comfort of life in households and communities.

http://www.kantei.go.jp/foreign/kan/statement/201105/25oecd_e.html

Energy Policy Debate

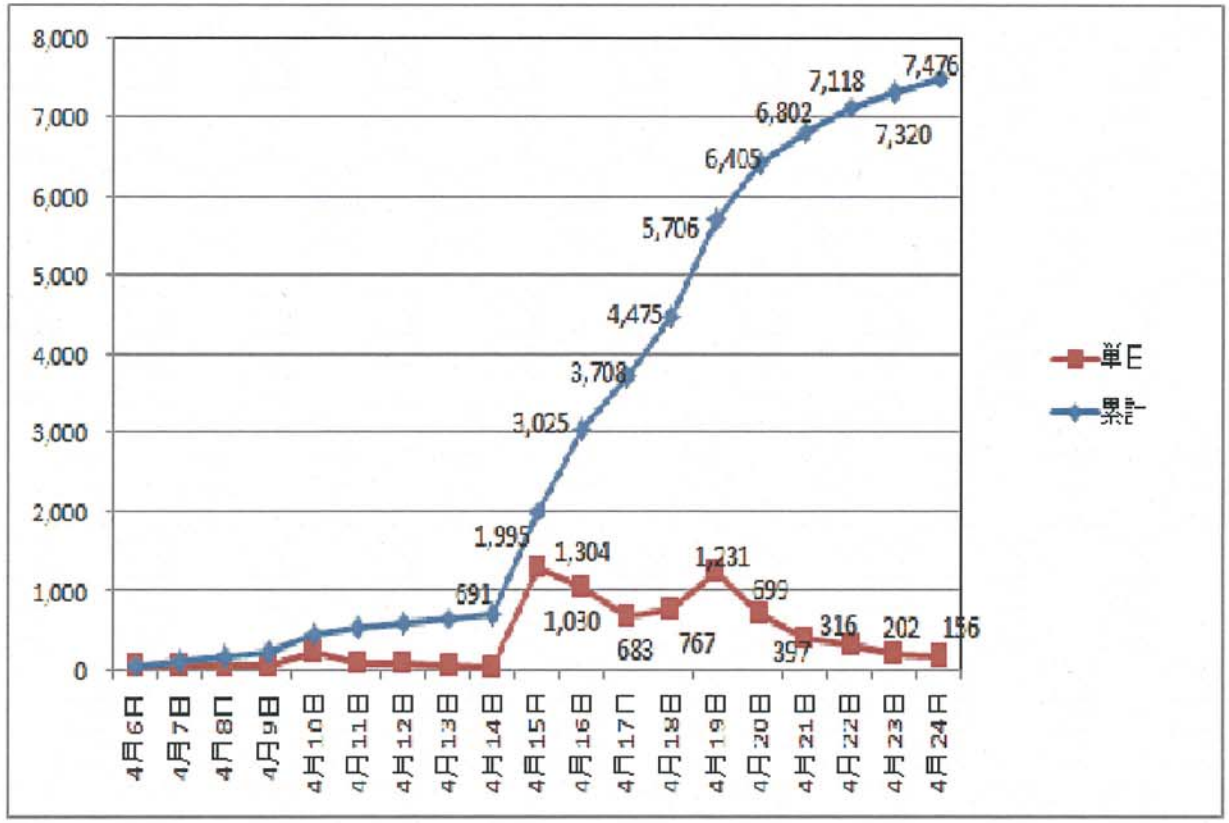
- "Energy Policy Wiseman Council" established by METI Minister as a private advisory organ
  - Headed by Prof. Arima, former Minister of Science and Technology
- National Strategy Office established "Energy and Environmental Policy Council" headed by Minister and METI/Environmental Ministers
  - It will draft outline of energy and nuclear energy policy (including restructuring of power industry)
- METI initiated review process for its "Energy Basic Plan" which was last published in 2010

Goal of Power Production Mix in 2030



Source: Institute of Energy Economics, March 2010

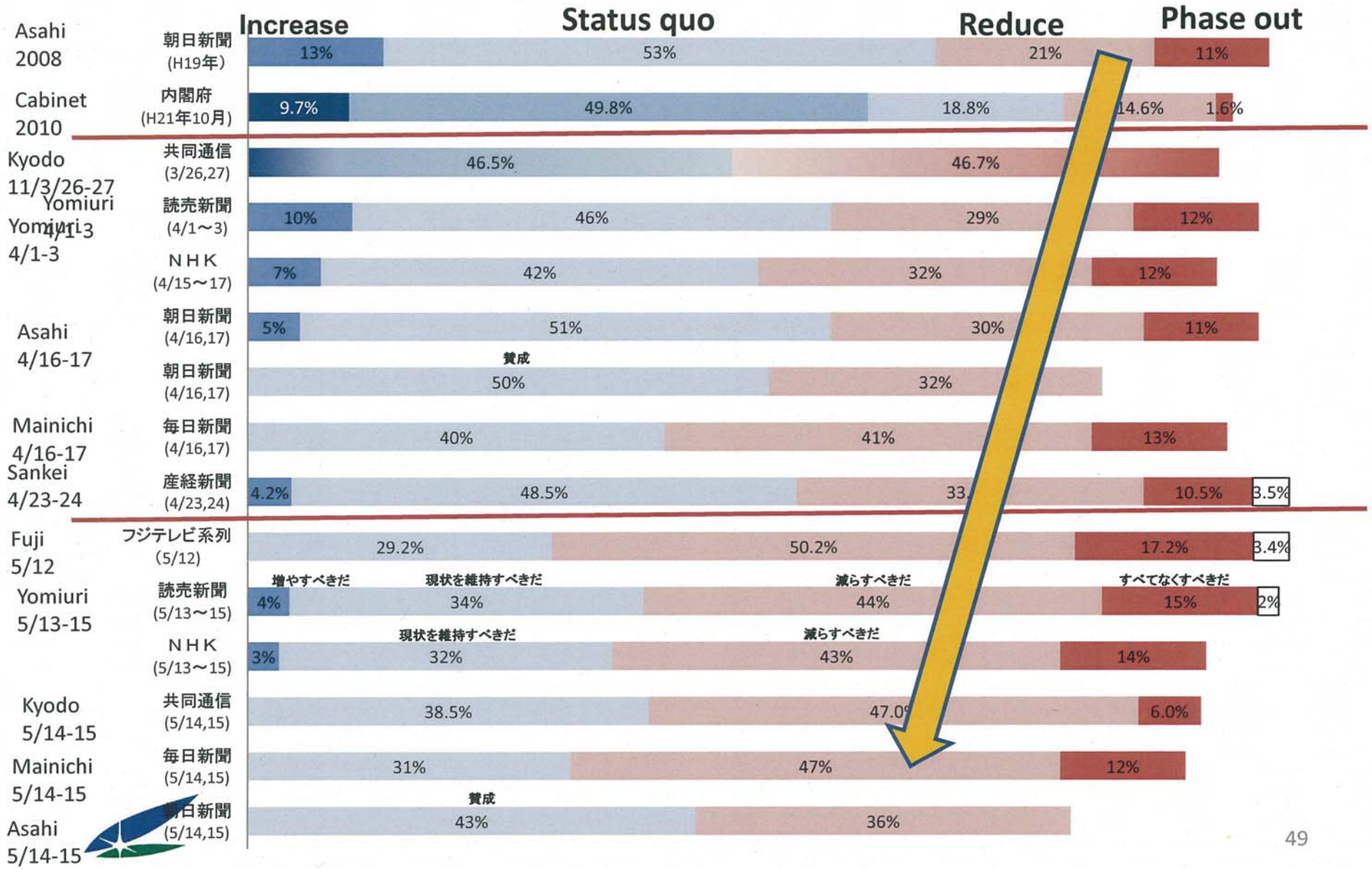
Public Comments Delivered to JAEC



Daily

Cumulative

Public Opinion Shifting to “reduce” and “phase out”

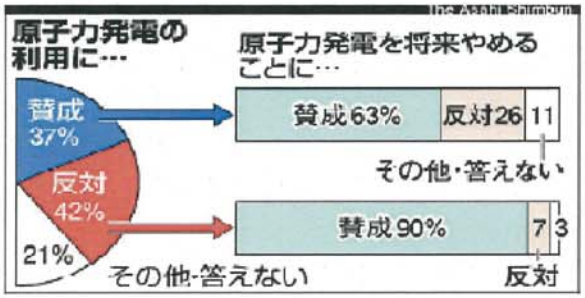


Asahi Poll, 74% says “agree to phase out nuclear power in the future” (06/13/11)

朝日新聞
THE ASAHI SHIMBUN DIGITAL

将来的に「脱原発」賛成７４％　朝日新聞世論調査

２０１１年６月１３日２３時４６分



原発に関する意識

朝日新聞社が１１、１２の両日実施した定例の全国世論調査（電話）によると、「原子力発電を段階的に減らして将来はやめる」ことに７４％が賛成と答えた。反対は１４％だった。東日本大震災の後、「脱原発」にかかわる意識をこうした形で聞いたのは初めて。

原子力発電の利用に賛成という人（全体の３７％）でも、そのうち６割あまりが「段階的に減らして将来はやめる」ことに賛成と答えた。

朝日新聞:http://digital.asahi.com/articles/TKY201106130401.html

World Public Opinion Poll (2011)

Global Views before the Japan Earthquake:

	Globally	Japan
Favorable:	57%	62%
Unfavorable	32%	28%
Net Favor	25%	34%
No Response	11%	10%

Global Views after the Japan Earthquake:

	Globally	Japan
Favorable	49%	39%
Unfavorable	43%	47%
Net Favor	6%	-7%
No Response	8%	14%
Total	100%	100%

Source: WIN/Gallop poll, "JAPAN EARTHQUAKE JOLTS GLOBAL VIEWS ON NUCLEAR ENERGY" April, 19, 2011

Japanese gov't report to the IAEA says "need national discussion"

- At the same time, *it is necessary for Japan to conduct national discussions* on the proper course for nuclear power generation while *disclosing the actual costs of nuclear power generation, including the costs involved in ensuring safety*.

Source: Nuclear Emergency Response Headquarters, Government of Japan,
""Report of Japanese Government to the IAEA Ministerial Conference on Nuclear Safety
-The Accident at TEPCO's Fukushima Nuclear Power Stations -", June 2011.
http://www.kantei.go.jp/foreign/kan/topics/201106/iaea_houkokusho_e.html

Investigation Commission of Fukushima Nuclear Accident

- "Independence, transparency, and comprehensiveness: these are the three principles around which we are preparing the formulation of the Nuclear Incident Investigation Commission."(PM Kan, Press Conference, 2011/05/10)
- Prof. Yotaro Hatamura, expert on human error, is chosen as a head of Gov't investigation commission. (2011/05/24)
  - 1st meeting was held on June 7, 2011

http://www.kantei.go.jp/foreign/kan/statement/201105/10kaiken_e.html
http://english.kyodonews.jp/news/2011/05/92946.html

Report of Japanese Government to the IAEA Ministerial Conference on Nuclear Safety (06/07/2011)

- 5 Categories 28 list of Lessons learned

1. Strengthen preventive measures against a severe accident
2. Enhancement of Responsive measures against a severe accident
3. Emergency responses to nuclear disaster accident
4. Robustness of the safety infrastructure established at the nuclear power station
5. Thoroughness in safety culture while summing up all the lessons.

Source: Nuclear Emergency Response Headquarters, Government of Japan,
""Report of Japanese Government to the IAEA Ministerial Conference on Nuclear Safety
-The Accident at TEPCO's Fukushima Nuclear Power Stations -", June 2011.
http://www.kantei.go.jp/foreign/kan/topics/201106/iaea_houkokusho_e.html

Preventive measures against severe accident

(1) Strengthen measures against earthquakes and tsunamis

(2) Secure power supply

- Secure power supply through *diversification* of power supply sources

(3) Secure robust cooling functions of reactor and PCV

(4) Secure robust cooling functions of spent fuel pools

(5) Thorough accident management (AM) measures

- *Change voluntary efforts to legal requirements, using PSA approach*

(6) Response to issues concerning the siting with more than one reactor

(7) Consideration on placements of NPS in basic design

(8) Ensuring the water tightness of essential equipment facilities

Source: Nuclear Emergency Response Headquarters, Government of Japan,
""Report of Japanese Government to the IAEA Ministerial Conference on Nuclear Safety
-The Accident at TEPCO's Fukushima Nuclear Power Stations -", June 2011.
http://www.kantei.go.jp/foreign/kan/topics/201106/iaea_houkokusho_e.html

Enhancement of response measures against severe accidents

(9) Enhancement of prevention measures of hydrogen explosion

(10) Enhancement of containment venting system

(11) Improvement of accident response environment

(12) Enhancement of the radiation exposure management system at accident

(13) Enhancement of training responding to severe accident

(14) Enhancement of instrumentation to identify the status of reactors and PCVs

(15) Central control of emergency supplies and equipment and setting up rescue team

Source: Nuclear Emergency Response Headquarters, Government of Japan,
""Report of Japanese Government to the IAEA Ministerial Conference on Nuclear Safety
-The Accident at TEPCO's Fukushima Nuclear Power Stations -", June 2011.
http://www.kantei.go.jp/foreign/kan/topics/201106/iaea_houkokusho_e.html

Enhancement of nuclear emergency response

(16) Response to combined emergency of both large-scale natural disaster and prolonged nuclear accident

(17) Reinforcement of environment monitoring

(18) Establishment of clear division of labor between relevant central and local organizations

(19) Enhancement of communication relevant to the accident

(20) Enhancement of response to assistance by other countries and communication to the international community

– Japanese gov't will contribute to developing a global structure for effective response, by cooperating with the international community

(21) Adequate identification and forecast of the effect of released radioactive materials

(22) Clear definition of widespread evacuation area and radiological protection guideline in nuclear emergency

Source: Nuclear Emergency Response Headquarters, Government of Japan,
""Report of Japanese Government to the IAEA Ministerial Conference on Nuclear Safety
-The Accident at TEPCO's Fukushima Nuclear Power Stations -", June 2011.
http://www.kantei.go.jp/foreign/kan/topics/201106/iaea_houkokusho_e.html

Reinforcement of safety infrastructure
&
Raise awareness of safety culture

(23) Reinforcement of safety regulatory bodies

- *the Japanese Government will separate NISA from METI, and starting to review implementing frameworks, including NSC and relevant ministries*

(24) Establishment and reinforcement of legal structure, criteria and guidelines

- *improve the legal structures of nuclear safety and nuclear emergency preparedness and response.*

(25) Human resources for nuclear safety and nuclear emergency preparedness and response

(26) Securing independency and diversity of safety system

(27) Effective use of probabilistic safety assessments (PSA) in risk management

(28) Raise awareness of safety culture

Source: Nuclear Emergency Response Headquarters, Government of Japan,
""Report of Japanese Government to the IAEA Ministerial Conference on Nuclear Safety
-The Accident at TEPCO's Fukushima Nuclear Power Stations -", June 2011.
http://www.kantei.go.jp/foreign/kan/topics/201106/iaea_houkokusho_e.html

Summary of the Final Report by the IAEA Fact Finding Team (06/16/11)

15 Conclusions

- Conclusion 3: There were insufficient defence-in-depth provisions for tsunami hazards.
  - the tsunami hazard was underestimated
  - moreover, those additional protective measures were not reviewed and approved by the regulatory authority;
  - severe accident management provisions were not adequate to cope with multiple plant failures.
- Conclusion 5: An updating of regulatory requirements and guidelines should be performed reflecting the experience and data obtained during the Great East Japan Earthquake and Tsunami
- Conclusion 6: Japan has a well organized emergency preparedness and response system as demonstrated by the handling of the Fukushima accident. Nevertheless, complicated structures and organizations can result in delays in urgent decision making.
- Conclusion 11: There is a need to consider the periodic alignment of national regulations and guidance to internationally established standards and guidance for inclusion in particular of new lessons learned from global experiences of the impact of external hazards.

Source: IAEA International Fact Finding Expert Mission of the Nuclear Accident Following the Great East Japan Earthquake and Tsunami, 16 June, 2011.
http://www-pub.iaea.org/MTCD/Meetings/PDFplus/2011/cn200/documentation/cn200_Final-Fukushima-Mission_Report.pdf

Summary of the Final Report by the IAEA Fact Finding Team (06/16/11)

16 Lessons

- Lesson 1: There is a need to ensure that in considering external natural hazards:
  - common cause failure should be particularly considered for multiple unit sites and multiple sites, and for independent unit recovery options, utilizing all on-site resources should be provided;
- Lesson 8: The risk and implications of hydrogen explosions should be revisited and necessary mitigating systems should be implemented.
- Lesson 9: Particularly in relation to preventing loss of safety functionality, the robustness of defence-in-depth against common cause failure should be based on providing adequate diversity (as well as redundancy and physical separation) for essential safety functions.
- Lesson 16: Nuclear regulatory systems should ensure that regulatory independence and clarity of roles are preserved in all circumstances in line with IAEA Safety Standards.

Source: IAEA International Fact Finding Expert Mission of the Nuclear Accident Following the Great East Japan Earthquake and Tsunami, 16 June, 2011.
http://www-pub.iaea.org/MTCD/Meetings/PDFplus/2011/cn200/documentation/cn200_Final-Fukushima-Mission_Report.pdf

IAEA Ministerial Meeting Declarations (06/20/11)

25 Declarations

3. Recognize that some States consider nuclear power as a viable option in meeting their energy needs, while other States have decided not to use or to phase out nuclear energy;

12. Underline the benefits of strengthened and high quality independent international safety expert assessments...through periodic reviews and evaluation missions assessing national regulatory frameworks, emergency preparedness and response and nuclear power plant operation

19. Emphasize the need to improve national, regional and international emergency preparedness and response to nuclear accidents, including through the possible creation of rapid reaction capacity and the development of training in the field of crisis management at the regional and international levels, ...and call for a strengthened role of the IAEA in emergency preparedness and response by promoting and possibly expanding existing IAEA response and assistance capabilities;

http://www.iaea.org/Publications/Documents/Infcircs/2011/infcirc821.pdf

IAEA Director General's Concluding Remarks (06/24/11)

5 Agreed points

- to strengthen IAEA Safety Standards;
- to systematically review the safety of all nuclear power plants, including by expanding the IAEA's programme of expert peer reviews;
- to enhance the effectiveness of national nuclear regulatory bodies and ensure their independence;
- to strengthen the global emergency preparedness and response system; and
- to expand the Agency's role in receiving and disseminating information.

http://www.iaea.org/newscenter/statements/2011/amsp2011n014.html

Implications for Nuclear Security and Non-Proliferation

- Future of global nuclear power is less certain now.
  - The world could be divided into "pro-" and "anti-" nations towards nuclear power, which may make global consensus on nuclear issues more difficult.
- The Fukushima accident proved that common approaches could be effective for enhanced safety and security
  - Especially, spent fuel management and emergency response have become important subjects for both security and safety.

Final Message

"If we cannot control nuclear power, how can we control nuclear weapons? We should overcome this disaster with humble attitude towards nature and science/technologies"

"As Hiroshima and Nagasaki have become symbol of peace, Fukushima should become a symbol of recovery from nuclear accident"

Thank you very much for your attention!