The Fukushima Daiichi Nuclear Accident: Lessons Learned and Policy Implications
福島第一原子力発電所事故:教訓と意味

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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.

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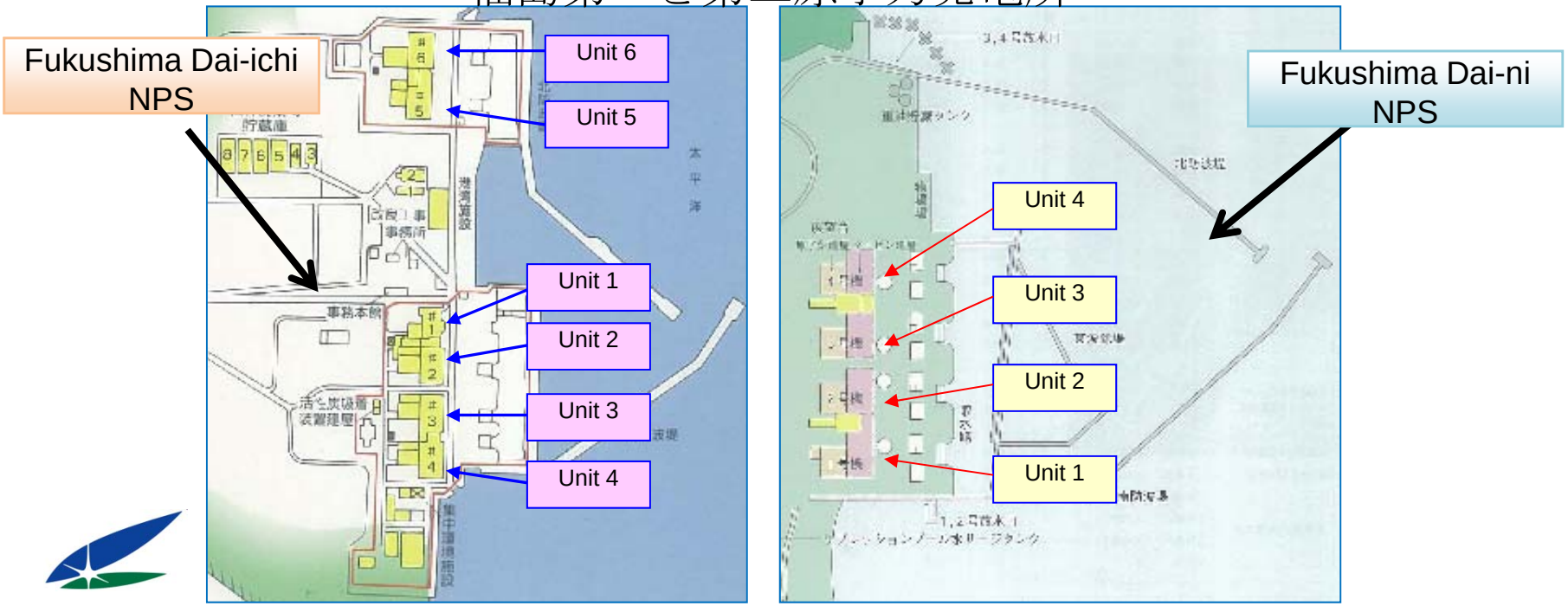
Location of NPSs within Fukushima　福島原子力発電所の場所

Layouts of Fukushima Dai-ichi NPS and Fukushima Dai-ni NPS
福島第一と第二原子力発電所



Loss of all power sources due to the Earthquake and Tsunami :
地震と津波による全電源喪失

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

津波の高さ～15m
Tsunami (estimated more than 10m)

Turbine Building

Reactor Building

D/G

Elevation: about 10m

Seawater level

Seawater Pump

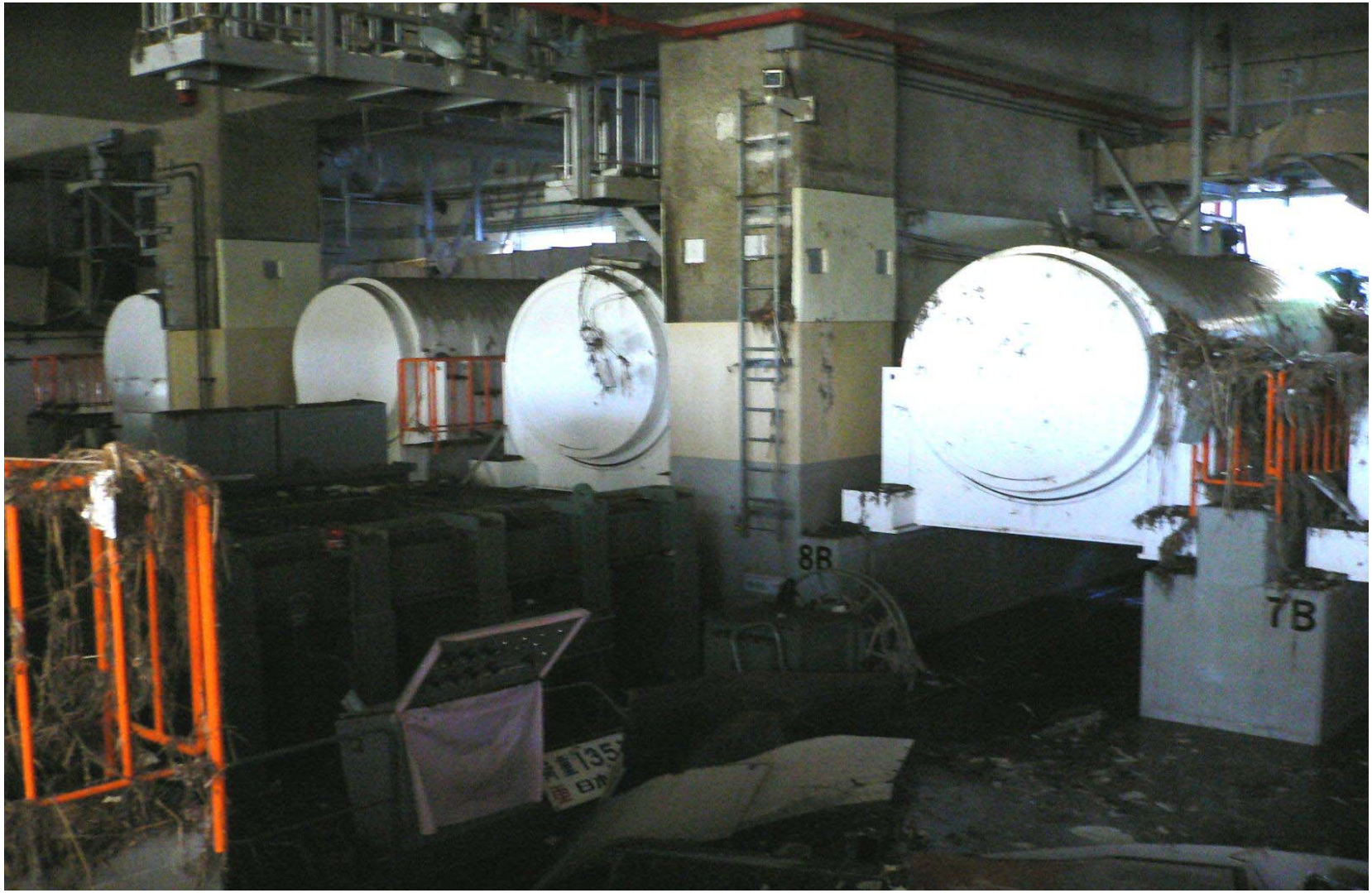
② D/G Inoperable due to Tsunami flood

①+② ⇒ Station Black Out

All Motor Operated pumps (including ECCS pumps) became inoperable

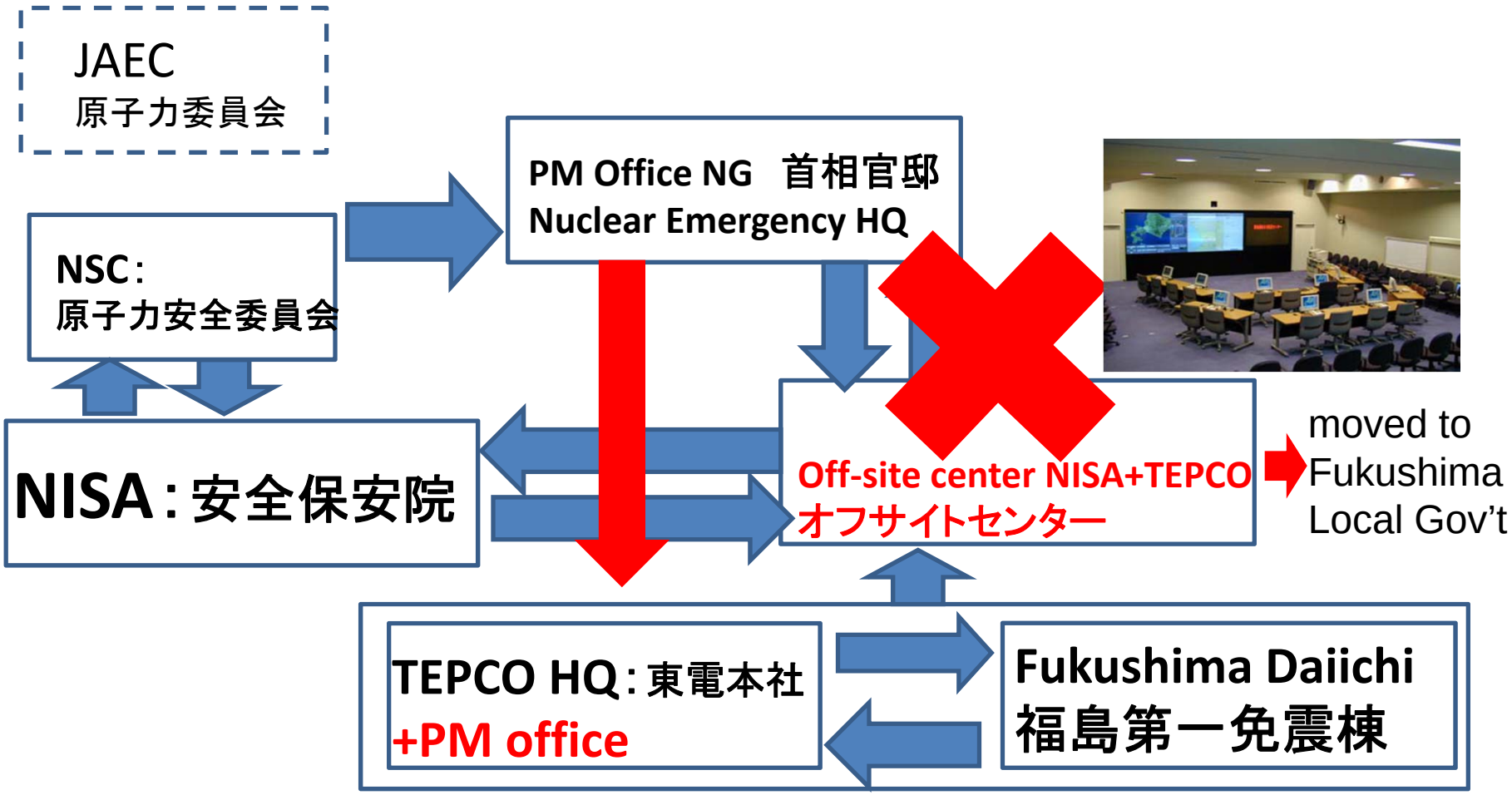
Source: Nuclear and Industry Safety Agency(NISA), April 4, 2011, at IAEA
http://www.nisa.meti.go.jp/english/files/en20110406-1-1.pdf

Dry cask storage after 3.11 (@Fukushima)
津波後の乾式貯蔵キャスク



http://www.tepco.co.jp/en/news/110311/images/110909_69.jpg

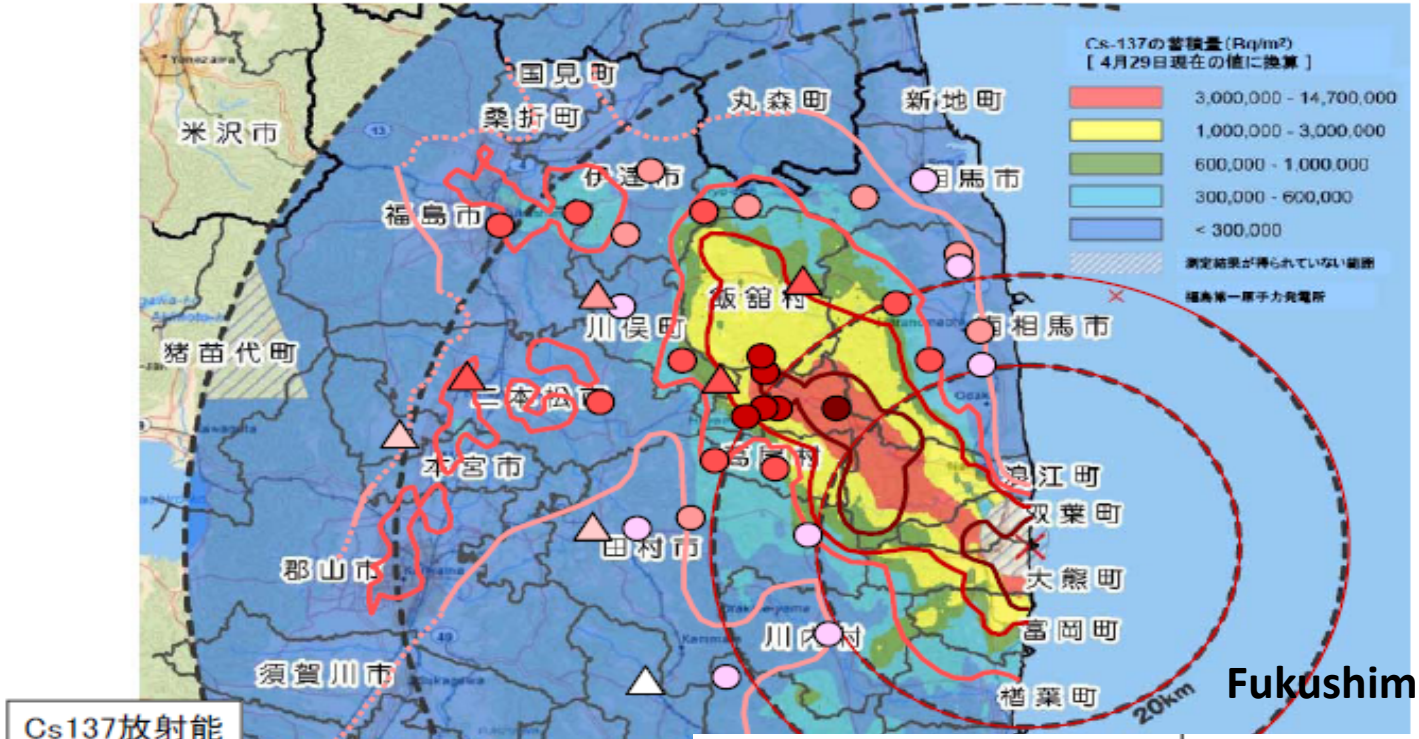
Nuclear Emergency: Institutional Arrangement under the Law*
原子力災害対策特別措置法に基づく防災体制



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

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

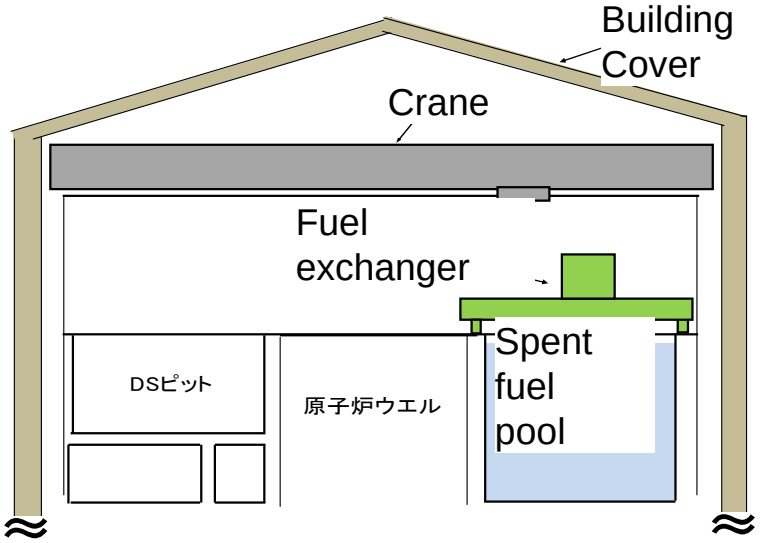
Source: T. Kawada, "Current Status of Soil Contamination and how to respond," Presentation at JapanAtomic Energy Commission Meeting, May 24, 2011
http://www.aec.go.jp/jicst/NC/iinkai/teirei/siryo2011/siryo16/siryo2.pdf

Removal of Spent Fuel (SF) from SF pool
使用済み燃料の取出し

SF remain covered by water during and after the accident: sipping analysis suggests that SF is mostly intact, though some might be damaged by falling objects due to hydrogen explosion

1. Remove rubbles by crane

2. Install refueling machine & overhead crane



3. SF transfer by cask

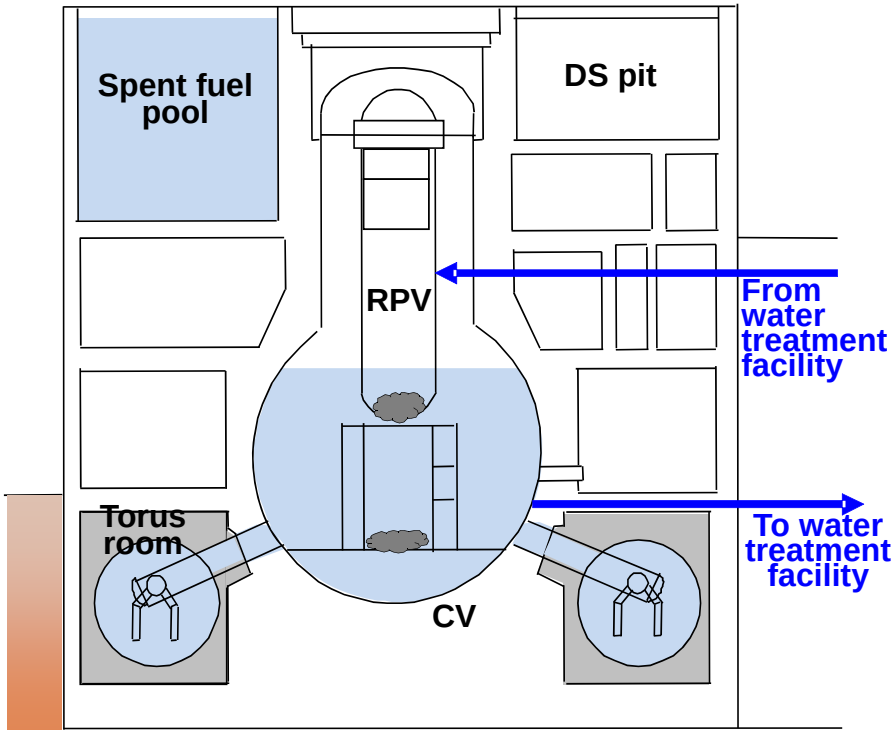
Removal of core debris
破損燃料の取出し

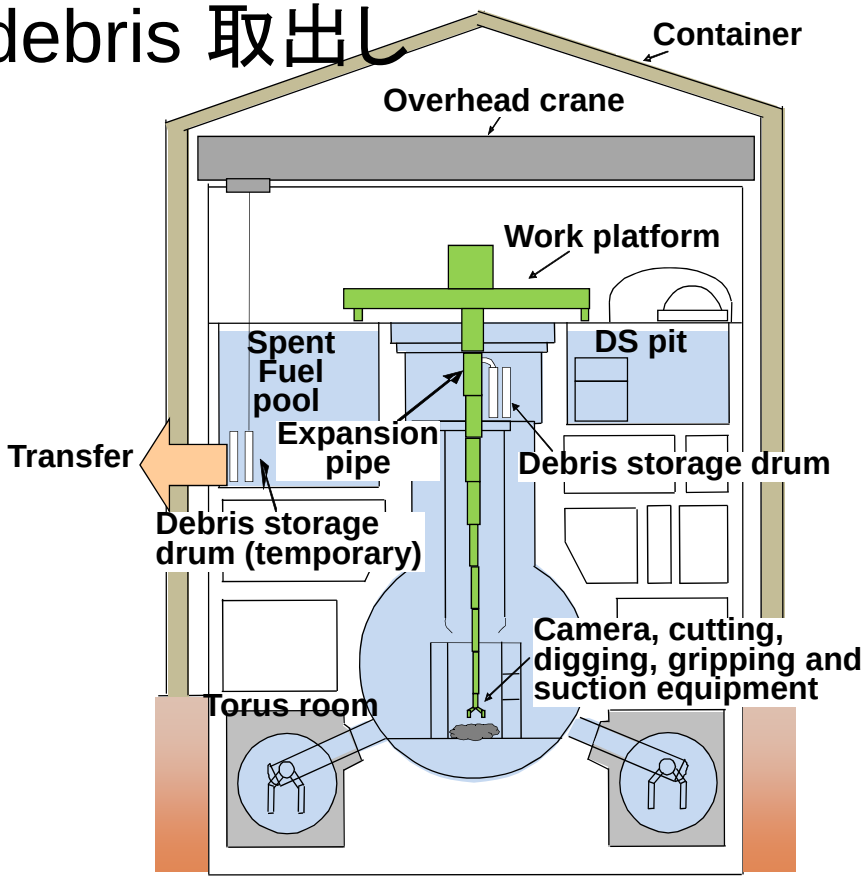
Decontamination (to reduce exposure)除染

→ Plugging the leaky holes　水漏れ修理

→ Flooding the containment 冠水

→ Removal of core debris 取出し





Interim Report of Gov't Accident Investigation Committee (2011/12/26) 政府事故調の中間報告

- Lack of severe accident preparedness for tsunamis

津波と過酷事故に対する準部不足

- Lack of awareness of the ramifications of a complex disaster

複雑な災害に対する対応策への意識欠如

- Lack of an all-encompassing perspective

包括的な視点の欠如

- *The Investigation Committee is convinced of the need of a paradigm shift in the basic principles of disaster prevention programs for such a huge system, whose failure may cause enormous damage.*

巨大システムのリスクを回避する概念にパラダイムシフトが必要

- *It must be recognized that things beyond assumptions may take place. The Fukushima nuclear accident presented us crucial lessons on how we should be prepared for such incidents that we had not accounted for.*

想定外のことが起こりうるとの認識が必要

http://icanps.go.jp/eng/120224SummaryEng.pdf

Five Major Lessons from Gov't Committee* and the Diet Commission** on the Accident
政府事故調、国会事故調報告より5つの教訓

- *Man-made Disaster: 事故は人災であった*
- *Emergency Response: "Unprepared"*
  緊急対策:準備ができていなかった
- *Protecting Public Health: "Communication Failure"*
  住民の保護:コミュニケーションの失敗
- *Regulatory Framework: "Captured by the Nuclear Industry"*
  規制体制:東電・電事連の「虜」
- *International dimension: Importance of information disclosure and sharing 国際的側面:情報公開と共有の重要性*

* Investigation Committee on the Accident at the Fukushima Nuclear Power Stations, Final Report Recommendations, July 2012. http://icanps.go.jp/eng/SaishyuRecommendation.pdf

** The National Diet of Japan Fukushima Nuclear Accident Independent Investigation Commission (NAIIC), Final Report, July 2012. http://naiic.go.jp/en/

“Man-made Disaster”:事故は人災であった

- The accident was *preventable* if the operators and regulators acted properly based on the information available to them (by the Diet Commission)

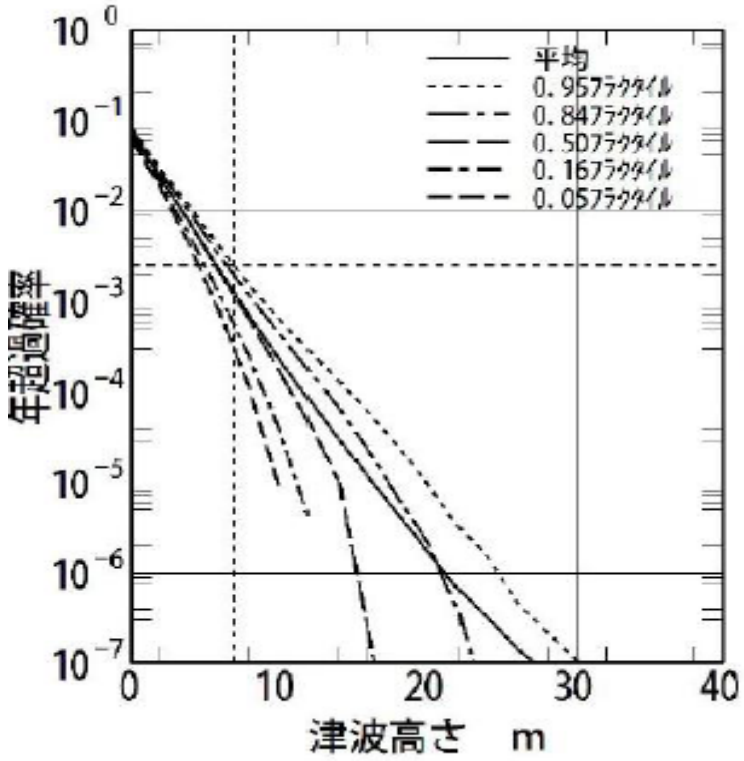
事業者と規制当局が入手した情報に基づき適切な行動をとっていれば事故は防げた

- The scale of tsunami was “beyond imagination” of TEPCO and regulators, but that their preventive measures were insufficient against tsunami and severe accident. (by the Gov’t committee)

津波は東電と規制当局の「想定外」の規模であったが、津波や過酷事故に対する準備は十分でなかったことも事実である

TEPCO Has Evaluated High-Tsunami : 東電、保安院は津波の規模を想定していた

Tsunami Height Analysis（2010）



Tsunami Study has been reported to NISA

- 2008: TEPCO studied Jogan-Tsunami
- June, 2009: TEPCO asked civil engineering society to evaluate their analysis
- June 2009:TEPCO reported to NISA on preliminary results
- March 7, 2011: NISA was briefed on “possible 10m height tsunami at Fukushima.”

http://www.meti.go.jp/earthquake/nuclear/backdrop/20110911.html

Emergency Response: “Unprepared”
緊急対策：準備ができていなかった

- Not only TEPCO and the regulators, but the central government, in particular the Nuclear Emergency Response Headquarters (NERHQs) at the Prime Minister’s office (PM’s office), was not prepared against nuclear emergency.（Gov’t committee and Diet Commission)

東電、規制当局のみならず、首相官邸と緊急対策本部も原子力防災対策の準備が不十分であった。

- Miscommunication and mistrust among regulators, PM’s office and TEPCO were the result of poor crisis management by the government.

コミュニケーションの不足と不信感は政府の危機管理対策が十分でなかったからだ

Protecting Public Health: “Communication Failure”
住民の保護：コミュニケーションの失敗

- The government did not use the System for Prediction of Environmental Emergency Dose Information (SPEEDI) effectively

政府はSPEEDIを効果的に利用しなかった。

- *“The government and the regulator are not fully committed to protecting public health and safety.”(The Diet Commission)*

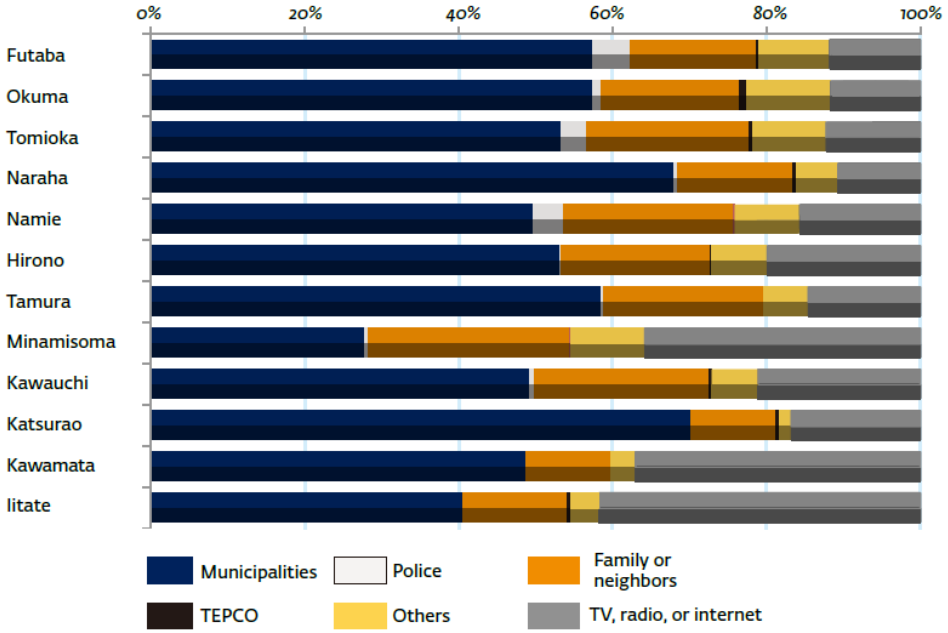
国会事故調は、規制当局が住民の健康と安全を守ることに十分コミットしていなかったと結論づけた。

- *“Nuclear operators and the regulators should establish a systematic activity to identify all risk potentials from the “disaster victims’ standpoint.” (The Gov’t Committee)*

政府事故調は、「被災者の立場」に立ったリスク防護策の立案を提案した。

Survey of Fukushima Residents by the Diet Commission: 国会事故調の福島県住民調査結果

- Within a few hours after the evacuation order was issued, the municipalities communicated the evacuation order to residents, showing that there was a high level of communication between the municipal governments and residents.地方自治体からの情報は十分
- However, as there were areas in which the municipalities did not receive evacuation orders from the government, there were major problems in the transmission process of the evacuation order from the government to the municipalities.政府、東電からの情報は不十分



◀ *Source of Information About the Evacuation Instruction*

http://naiic.go.jp/wp-content/uploads/2012/07/NAIIC_report_lo_res4.pdf

Regulatory Framework: “Captured by the Nuclear Industry”
規制体制：東電・電事連の「虜」

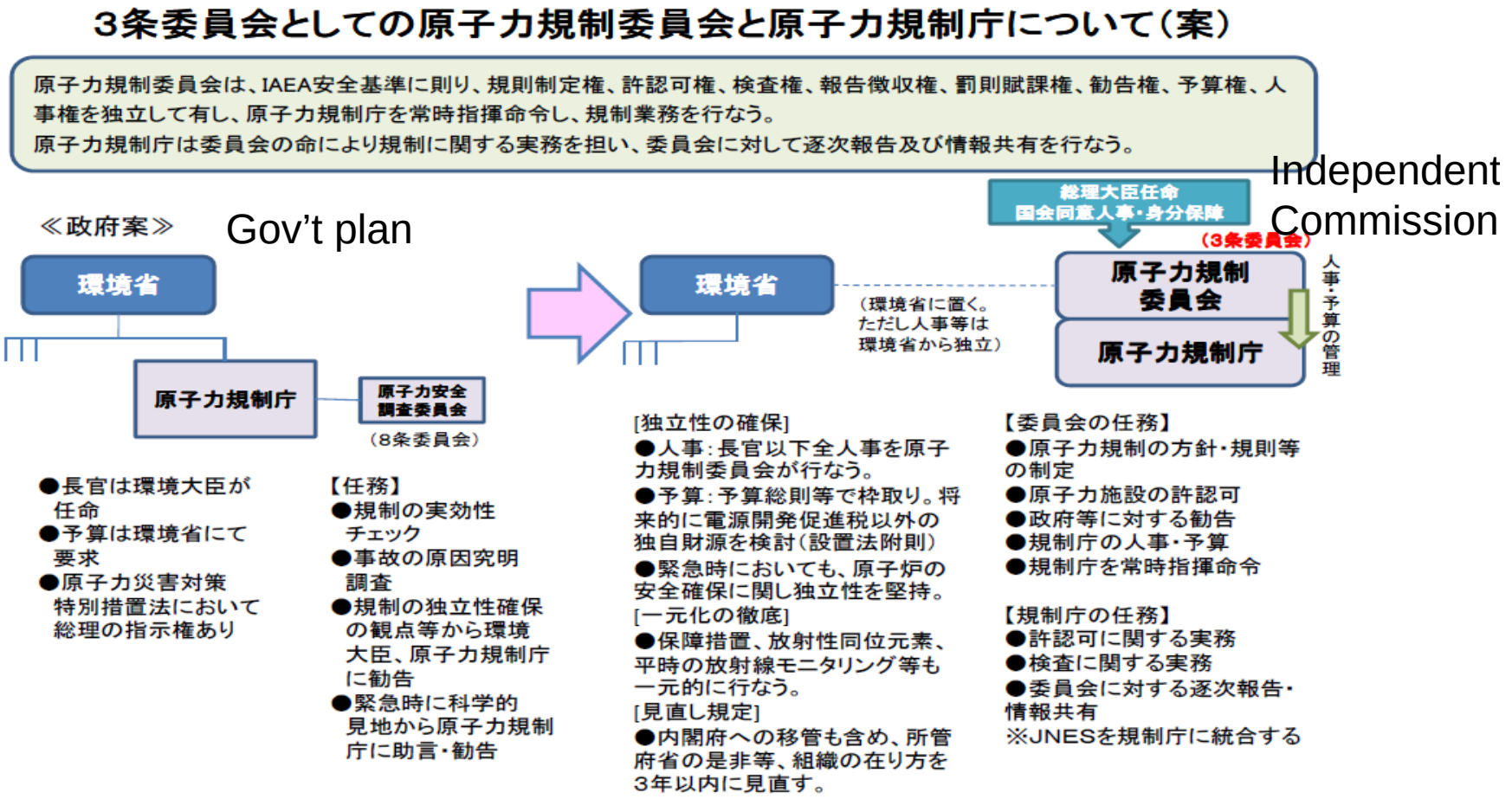
- *“..they (regulators and operators) repeatedly avoided, compromised or postponed any course of action …In fact, it was a typical example of ‘regulatory capture,’ in which the oversight of the industry by regulators effectively ceases. ”*（the Diet Commission)

「規制当局と事業者は妥協と時間稼ぎを繰り返した…これは事業者を規制すべき当局が機能しない、典型的な『規制当局が虜になっている』状況であった」（国会事故調、仮訳）

- Both reports emphasized the importance of the “independence” and “transparency” for newly established regulatory organization

「透明性」と「独立性」をもった新たな規制機関の重要性を指摘

Independent Nuclear Regulatory Commission Proposed by the LDP



http://www.y-shiozaki.or.jp/contribution/pdf/20120416123546_2cfQ.pdf

International dimension: Importance of information disclosure and sharing
国際的側面：情報公開と共有の重要性

- Lack of enough and timely information from Japan after the accident was as one of the reasons for increased concern over the accident.

日本からの十分な情報が不足していたことが、周辺諸国や国際社会の不安を呼んだ。

- *“The new regulatory organization must establish an organizational framework that enables it to provide information in a timely and appropriate manner during an emergency.” (The Gov’t Committee)*

新しい規制機関は、タイムリーで適切な情報提供が緊急事態でもできるような体制を整えるべきだ。

From Fukushima to the World: 福島から世界へ

- We should overcome this man-made disaster with humble attitude towards nature and science/technologies

人類は、この悲劇的な事故・人災を、自然と科学技術リスクへの謙虚な反省を持てば、乗り越えていく事ができる。

- Let's make Fukushima as a symbol of "recovery".

福島を「復興のシンボル」にしよう

- The role of scientists can be extremely important. Closer collaboration between nuclear engineers/scientists and other fields of scientists, especially, social scientists is definitely needed more to improve “safety culture” of nuclear community.

科学者の役割、とくに人文・社会科学者との協力は原子力ムラの安全文化向上に極めて重要である。

From Fukushima to the World:福島から世界へ

I sincerely hope that the lessons learned from the Fukushima accident can be shared by the global community and can be useful for improved safety and better understanding of nuclear technology.

福島事故の教訓を国際社会が共有することにより、原子力技術の更なる理解と安全性向上に役立つことを私は信じています。