Nuclear Energy and Nuclear Fuel Cycle Policy Options after the Fukushima Accident

East Asian Alternative Nuclear Weapons Future Conference &
East Asian Alternative Energy Futures Conference

Honolulu, Hawaii,

February 26, 2014

Tatsujiro Suzuki

Vice Chairman, Japan Atomic Energy Commission

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

Summary

- After 3/11, priority of nuclear energy policy has changed significantly. Top priority should be on measures dealing with the Fukushima Daiichi nuclear power plant decommissioning and securing welfare of people affected by the accident.
- Given the uncertainty in future directions of nuclear energy, priority should be on the necessary measures regardless of future of nuclear energy policy.
- Based on the assessments, on economics, safety, and proliferation risks etc., made by the subcommittee, JAEC issued a policy statement that nuclear fuel cycle policy needs to be more flexible in order to cope with future uncertainty.
- Specifically, priority should be on the following measures.
  - Expansion of spent fuel storage (especially dry cask storage)
  - Measures to enable “direct disposal” of spent fuel
  - Plutonium stockpile management

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 regulation.* 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)

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Commissioner
Dr. Mie OBA

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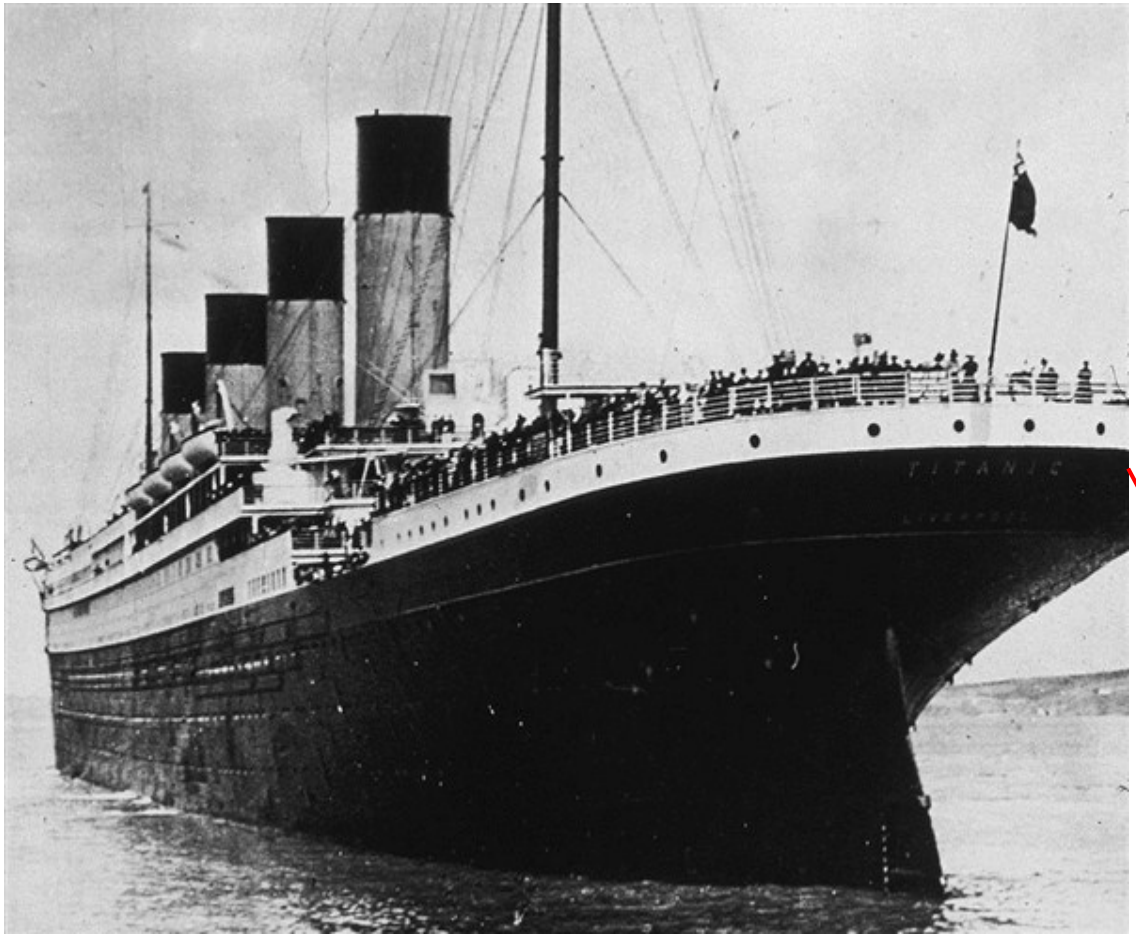
Commissioner
Dr. Akira OMOTO

Role of JAEC (??)
- A small tag-boat for a giant Titanic? –



Expert Panel on Reviewing Role of AEC
2013/12/10

Role of AEC should be fundamentally changed from basic policy maker as a promoter of nuclear energy to act as an advisor for better governance of nuclear energy, while maintaining its neutral positions. Its activities should focus on the following areas:

① Assuring peaceful use of nuclear energy and non-proliferation

② Management and disposal of radioactive waste

③ Other important matters (such as decommissioning of Fukushima nuclear power plants)

http://www.cas.go.jp/jp/seisaku/genshiryoku_kaigi/dai12/siryou2.pdf

Fukushima Daiichi Decommissioning and Restoring life in Fukushima area

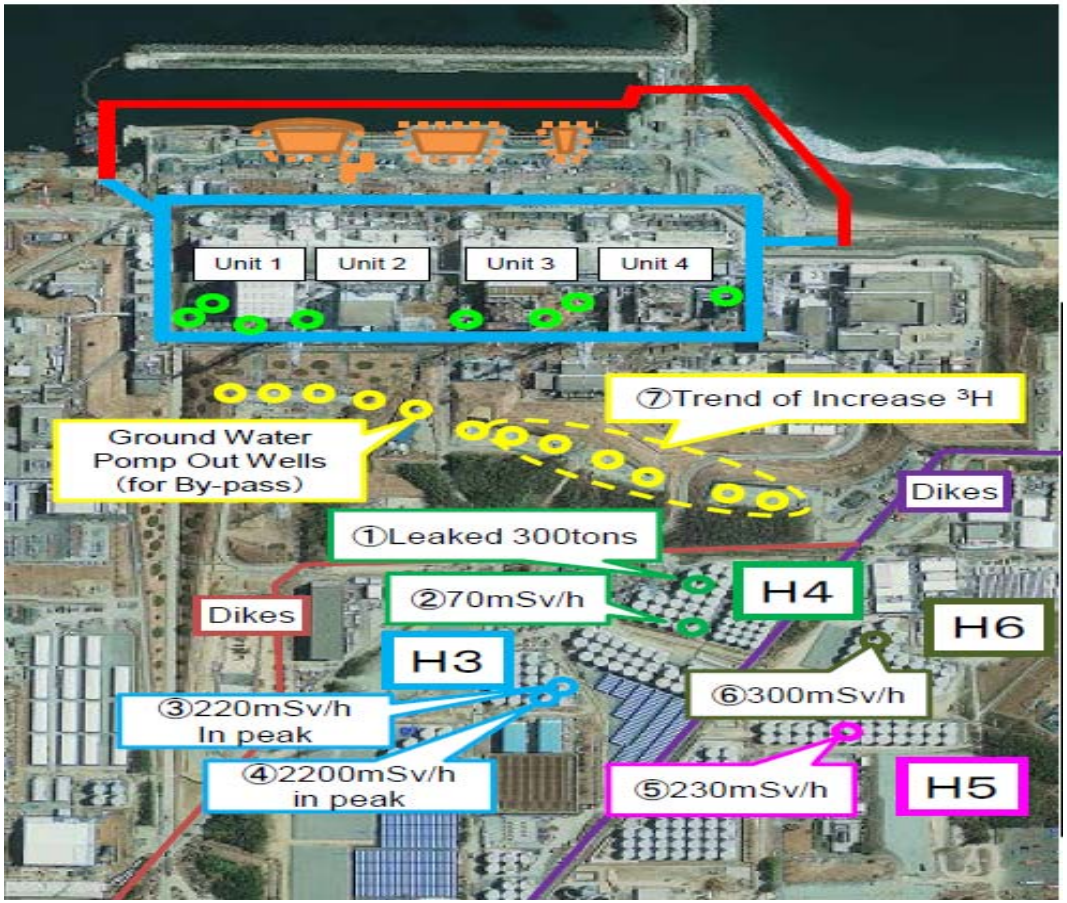
Struggling with contaminated water…during the recent typhoon (Sept. 15, 2013)

http://www.tepco.co.jp/nu/fukushima-np/handouts/2013/images/handouts_130917_01-j.pdf

"I think the current situation is that it is not under control," by a TEPCO official.

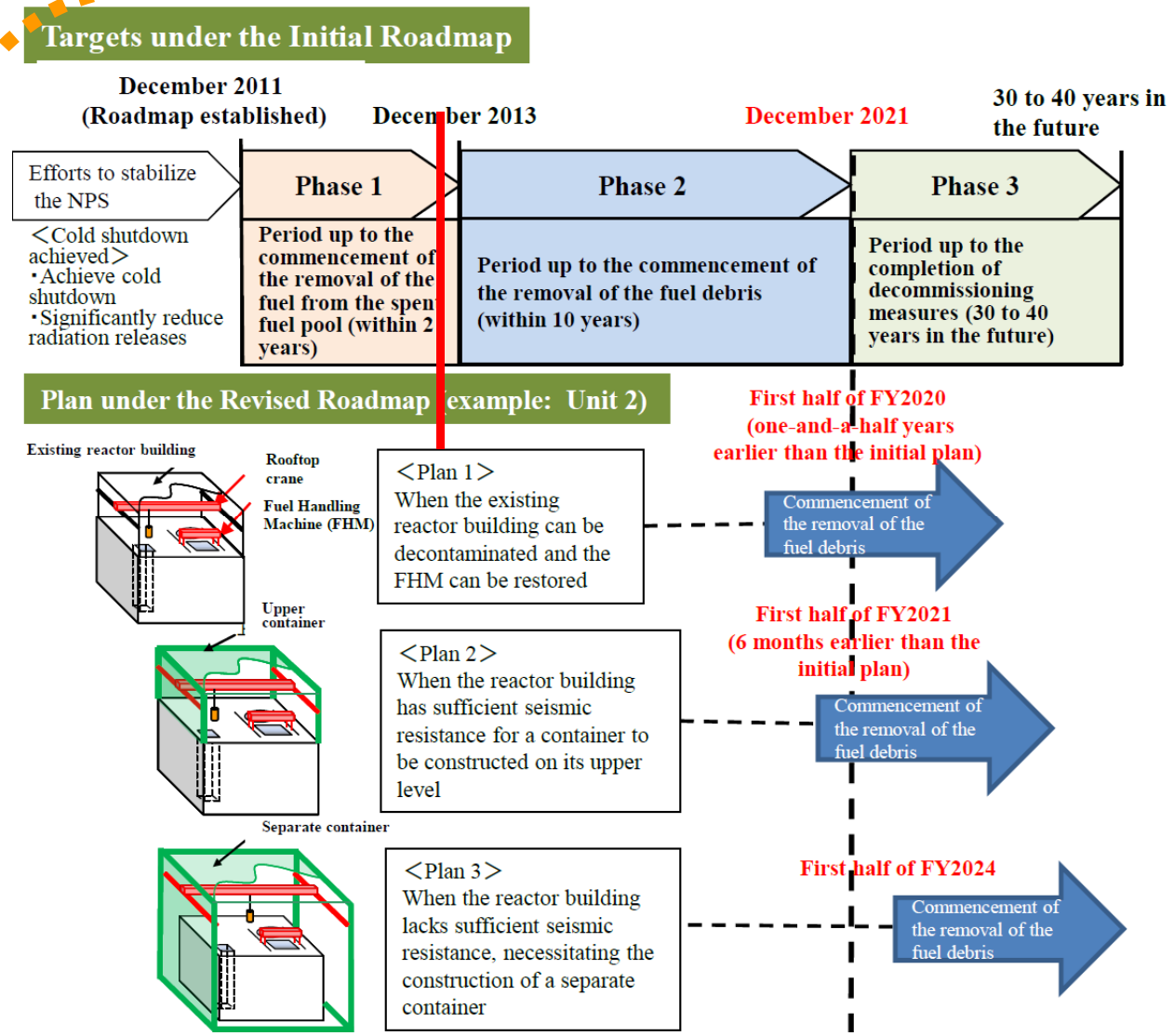
-Fukushima 'not under control' – TEPCO official refutes PM's assurances, Reuter, Sept. 13, 2013

http://rt.com/news/fukushima-under-control-tepco-819/



http://www.meti.go.jp/english/earthquake/nuclear/decommissioning/pdf/20130903_01a.pdf

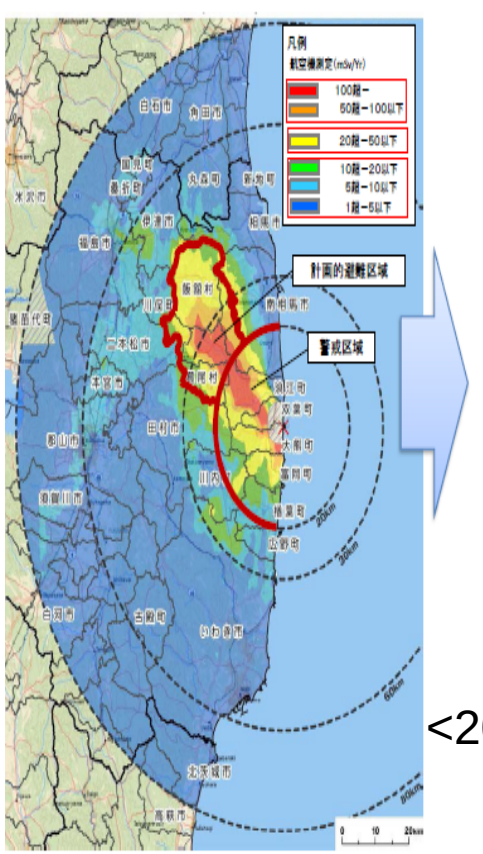
Mid-Long Term Roadmap for Fukushima Dai-ichi



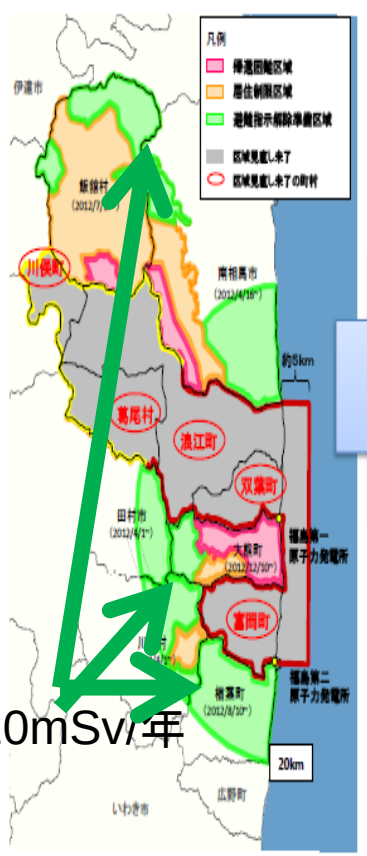
Source: Agency for Natural Resources and Energy, Announcement of the Revised Version of the Mid-and-Long-Term Roadmap towards the Decommissioning of TEPCO's Fukushima Daiichi Nuclear Power Station Units 1-4, June 2013
http://www.meti.go.jp/english/press/2013/0627_01.html

Evacuation Area Amended (13/08/08)

(2012/04/29)

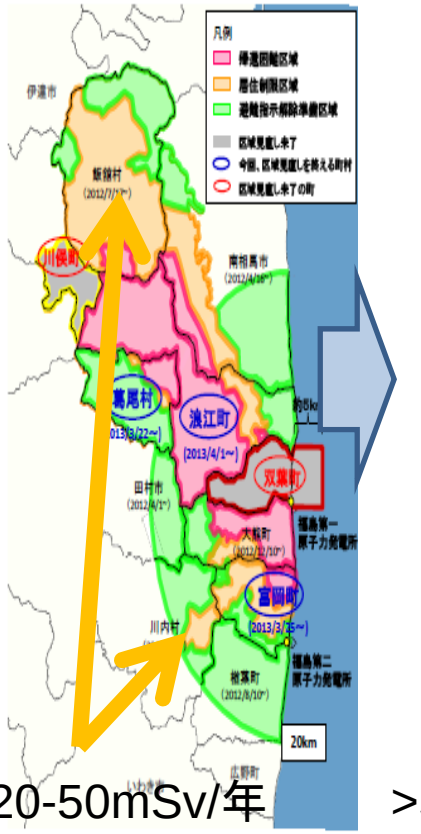


(12/12/10)



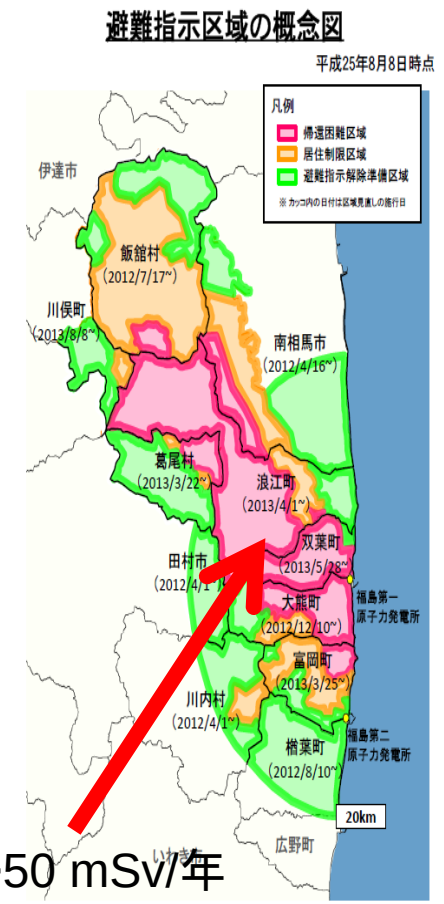
<20mSv/年

(13/04/01)



20-50mSv/年

(13/08/08)



>50 mSv/年

Tomioka

http://www.kantei.go.jp/saigai/pdf/20130307gainenzu.pdf,
http://www.kantei.go.jp/saigai/pdf/20130808gainenzu.pdf

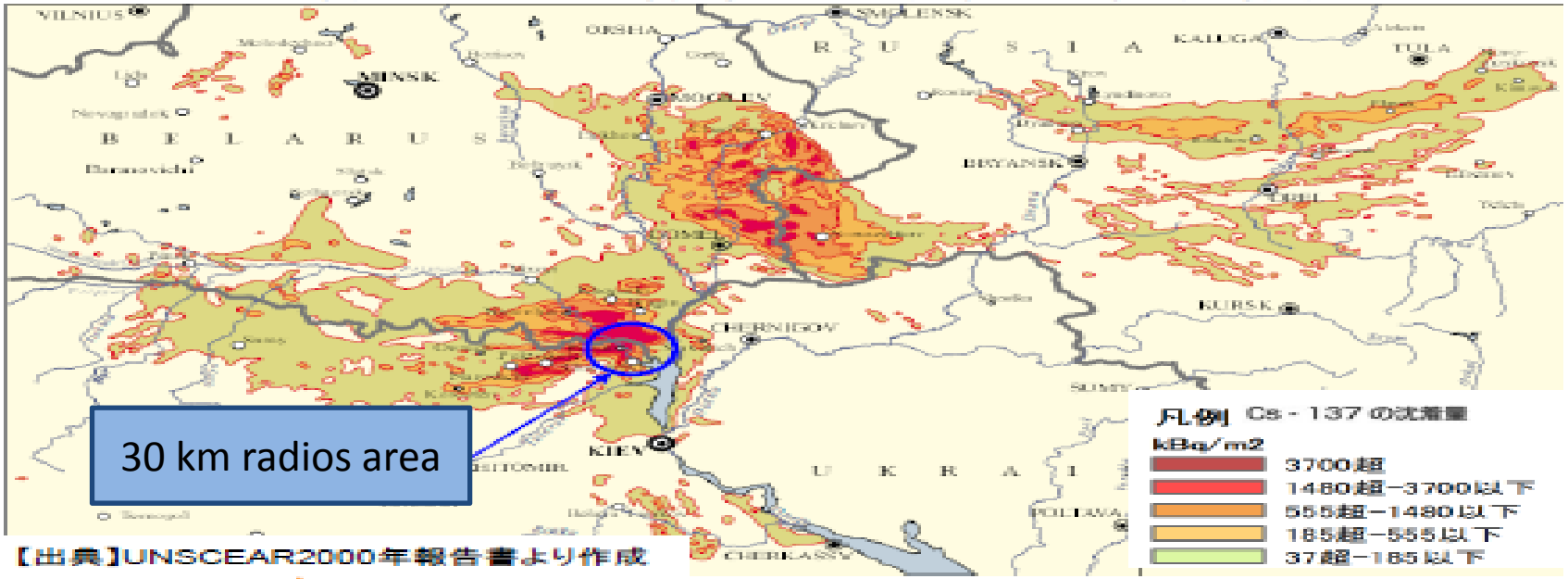
Cherry blossom in Tomioka Town (10 km from Fukushima Daiichi, 2012/04)

http://www.asahi.com/special/10005/images/TKY201204190192.jpg

http://img.47news.jp/PN/201204/PN20120419010011 25.-.-.CI0003.jpg

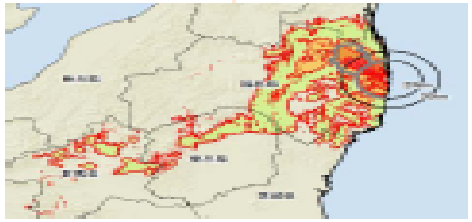
Compared with the Chernobyl accident

図表　チェルノブイリ原発事故による汚染（1989年12月時点）



【出典】UNSCEAR2000年報告書より作成

両図を同縮尺で記載



図表　東電福島第一原発事故による汚染（2011年11月時点）

【出典】文部科学省発表資料（2011年11月）より作成

図表　汚染地域の面積

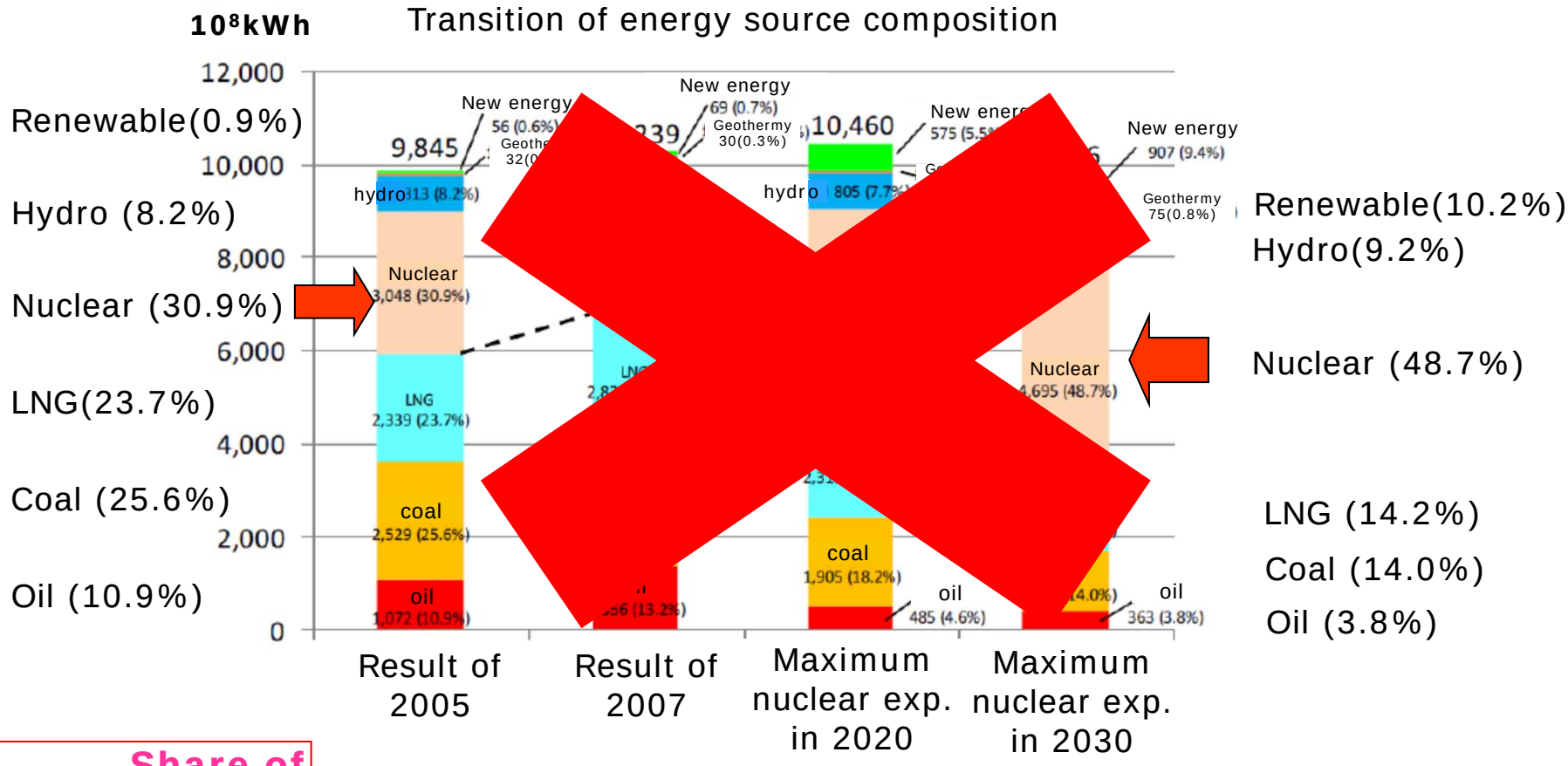
汚染濃度（kBq/㎡）	汚染地域の面積（km²）		
	Chernobyl	Fukushima	F/C
＞ 1,480	3,100	200	6 %
555 － 1,480	7,200	400	6 %
185 － 555	18,900	1,400	7 %
37 －185	116,900	6,900	6 %
合計面積	146,100	8,900	6 %

3

http://www.meti.go.jp/earthquake/nuclear/pdf/130314_01a.pdf

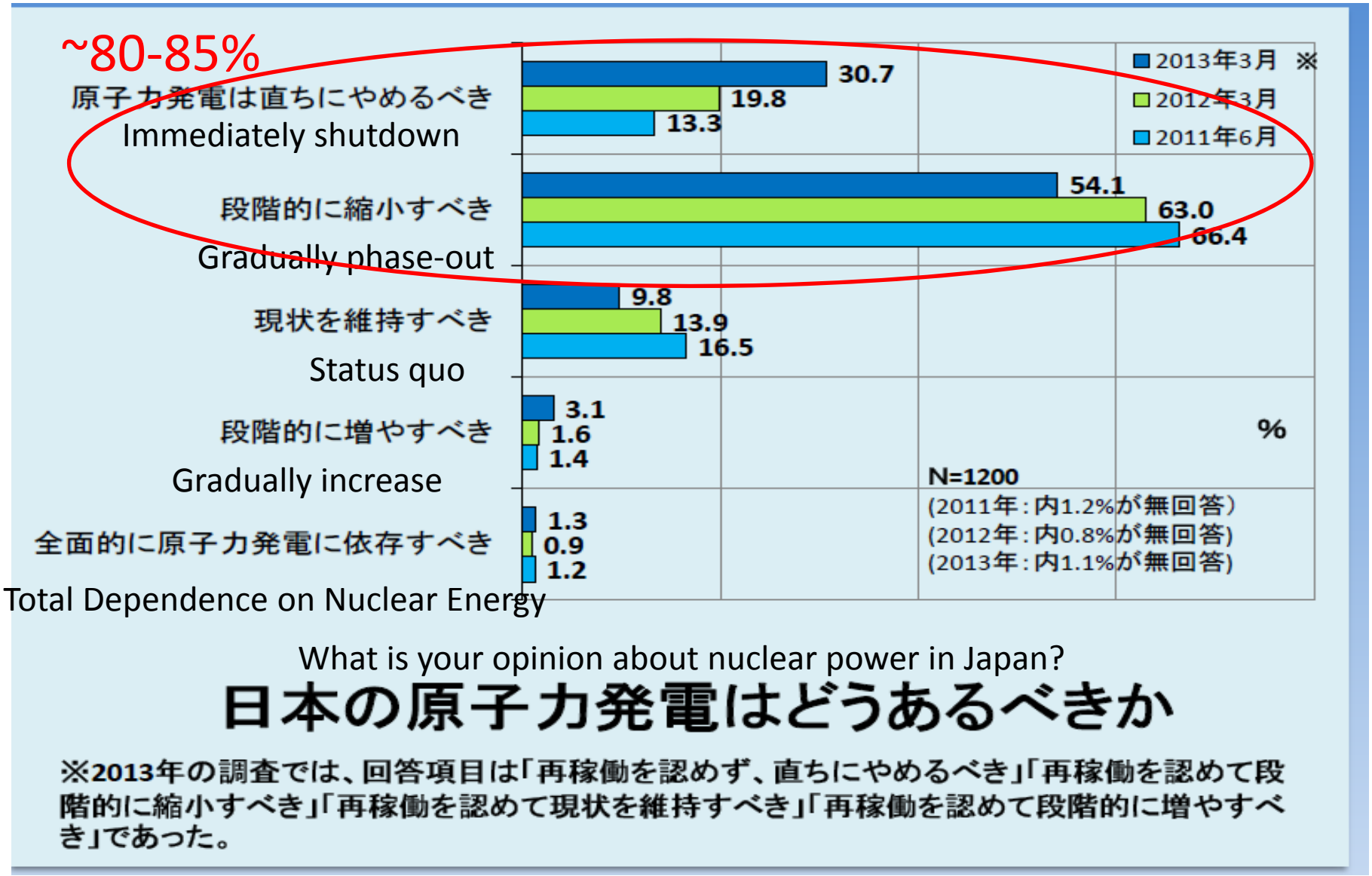
Restoring Public Trust in Nuclear Safety and Energy Policy

Goal of Power Production Mix in 2030 Before 2011/3/11



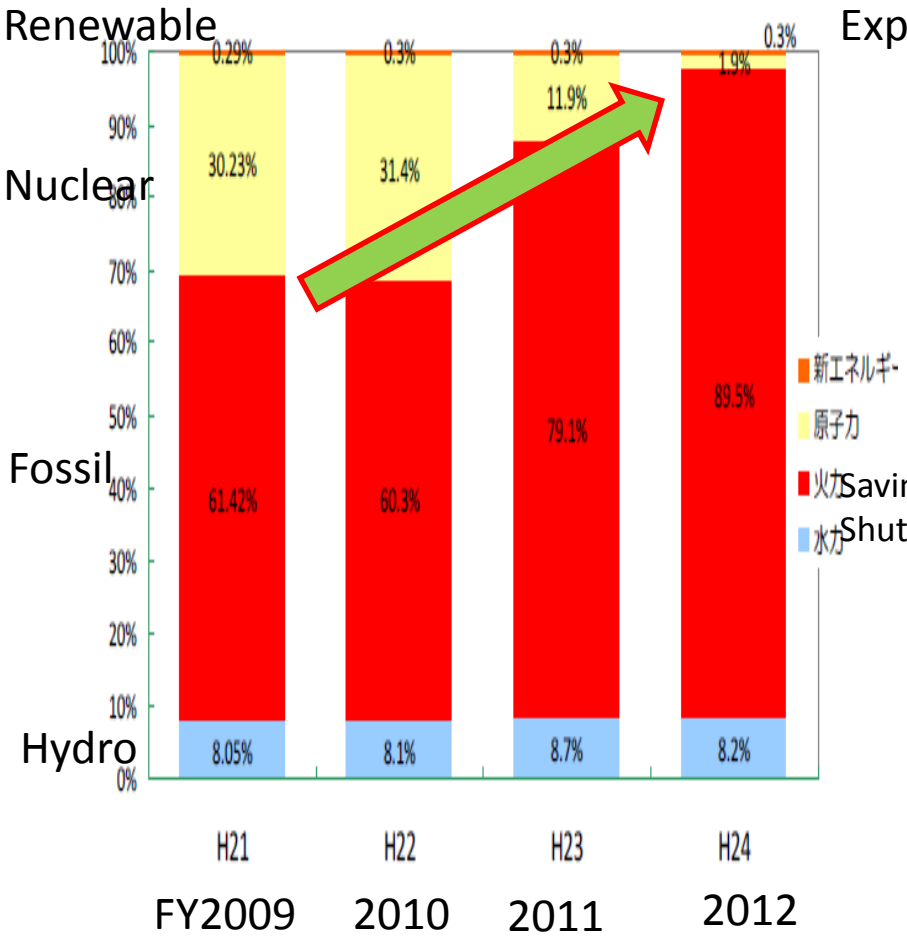
Share of nuclear power	30.9%	25.8%	41.5%	48.7%

Source: Institute of Energy Economics, March 2010

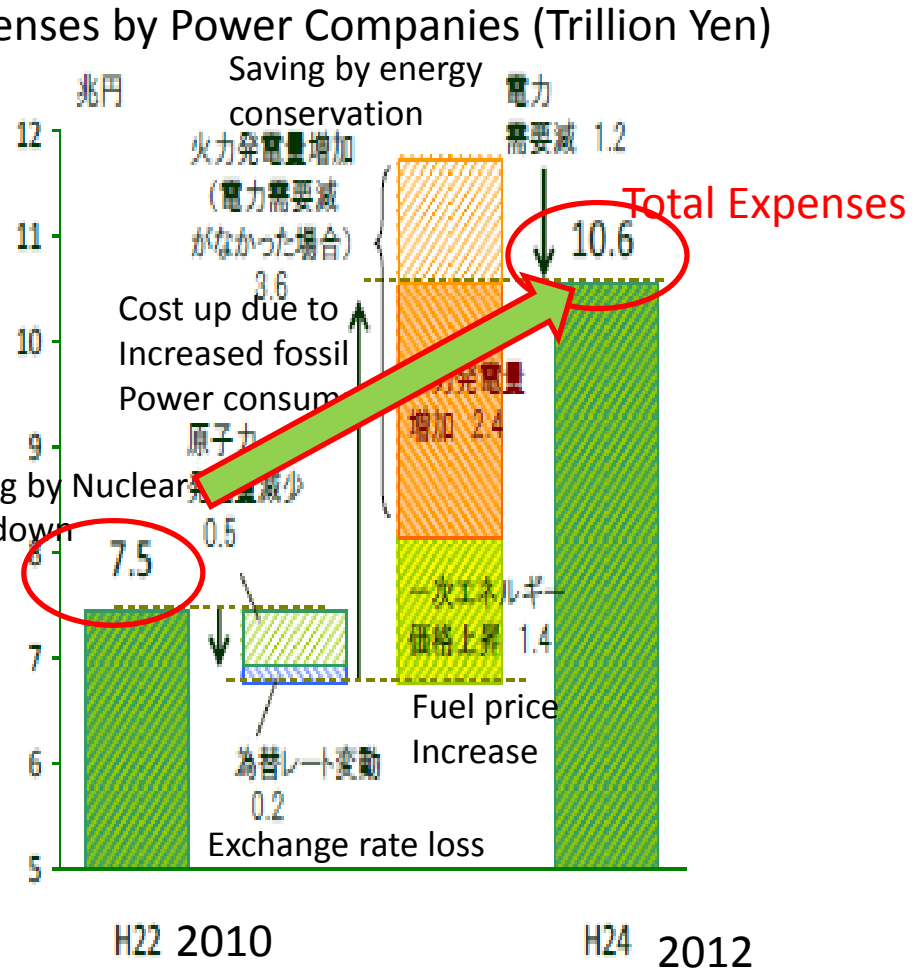


Source: Prof. Hirotada Hirose, “Changes of Public Opinion about Nuclear Power,” Presented at Japan Atomic Energy Commission, July 17, 2013
http://www.aec.go.jp/jicst/NC/iinkai/teirei/siryo2013/siryo27/siryo2.pdf

Impact of Shutdown of Nuclear Power from FY 2010 to FY 2012



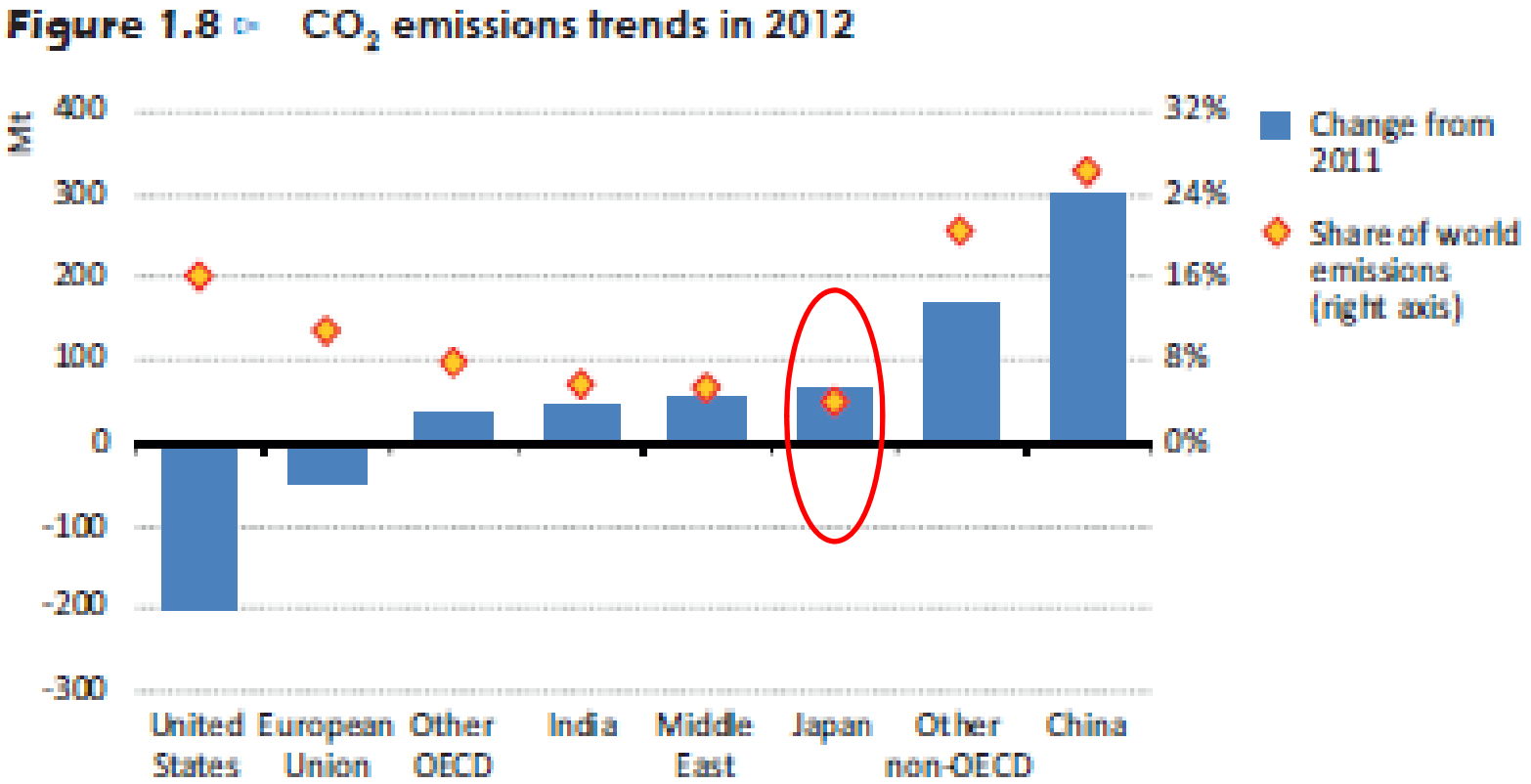
Share of nuclear power down from 31% to 2%



3.1 trillion yen extra expenses due to loss of nuclear power

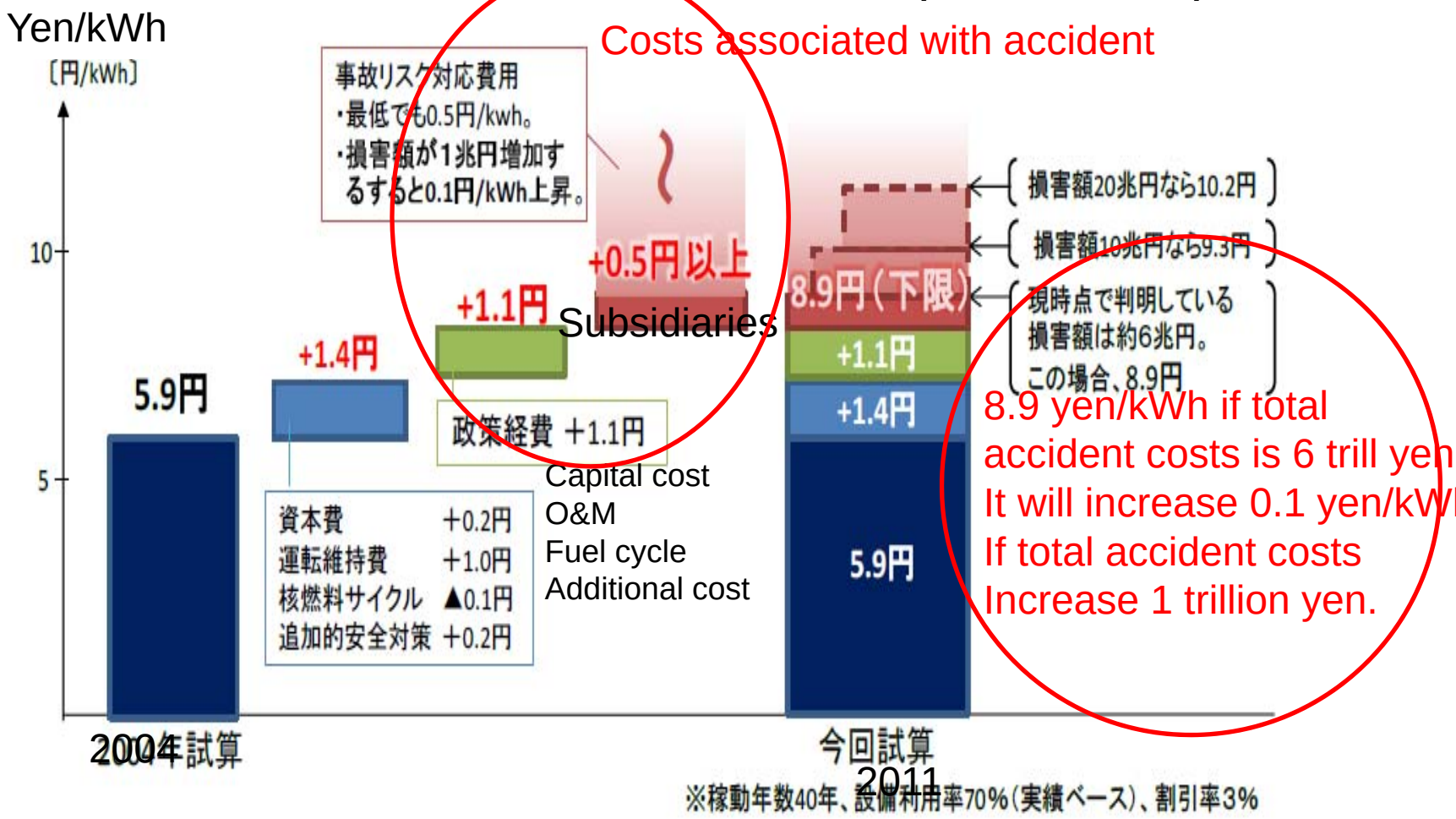
Source: Yuji Yamaguchi, The Institute of Energy Economics, Japan, 2013.
http://www.aec.go.jp/jicst/NC/iinkai/teirei/siryo2013/siryo31/siryo3.pdf

Japan's CO2 emission increased by 70 MT or 5.8% from 2011



Source: International Energy Agency (IEA), "Redrawing Energy Climate Map," 10 June 2013, http://www.worldenergyoutlook.org/media/weowebsite/2013/energyclimatemap/RedrawingEnergyClimateMap.pdf

Nuclear Power Generation Costs (2004, 2011)

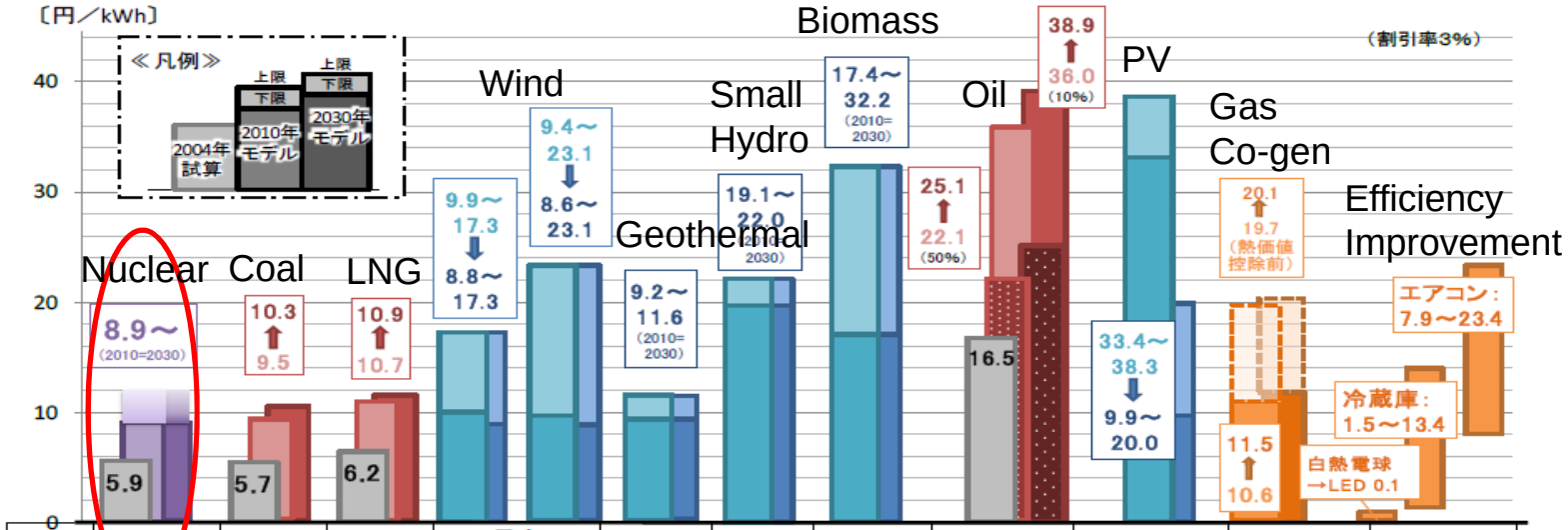


（図 ２０）原子力の発電コスト（2004 年試算と今回試算）

出所：コスト等検証委員会報告書、2011年12月19日
http://www.npu.go.jp/policy/policy09/pdf/20111221/siryo3.pdf

Nuclear power can be competitive, but social costs can be high…

【コスト試算のポイント】
○モデルプラント形式（最近7年間の稼働開始プラント、最近3年間の補助実績等を基に設定）
○CO2対策費用、原子力の事故リスク対応費用、政策経費等の社会的費用も加算。
○2020年、2030年モデルは燃料費・CO2対策費の上昇、技術革新等による価格低減を見込んで試算。



	原子力	石炭火力	LNG火力	風力 陸上	風力 洋上着床式	地熱	小水力	バイオマス（木質専焼）	石油火力	太陽光（住宅用）	ガスコジェネ	省エネ
シナリオ等	核燃料サイクル現状モデル	新政策シナリオ	新政策シナリオ	横ばい～低減	横ばい～低減	—	—	—	新政策シナリオ	参照～パラダイムシフト	新政策シナリオ	—
設備利用率	70%	80%	80%	20%	30%	80%	60%	80%	50%・10%	12%	70%	—
稼働年数（2030年モデル）	40年	40年	40年	20年	20年	40年	40年	40年	40年	20年（35年）	30年	—
留意点・ポイント 赤：増加要因 青：低減要因 黒：その他（導入ポテンシャルに関する記述を含む。）	8.9円は下限。事故の損害額が5.8兆円から1兆円増えるごとに0.1円増。次世代軽水炉による合理化は、定量的には見込まず。	燃料費・CO2対策費用上昇。発電効率向上。	燃料費のウェイト大。発電効率向上。シェールガスのメリットは資源戦略が鍵。	量産効果でコスト低減の可能性あり。立地の拡大には、規制・制度改革、系統強化等が必要。		安定電源として有望。電源線のコストの問題がある導入可能量拡大には、立地に係る課題の解決などが必要。	安定的な発電が可能。多くの場所で可能性あり。	未利用間伐材の収集・運搬距離等により燃料費が変動。	主に燃料費が上昇。	量産効果でコスト半減の可能性あり。次世代太陽電池が実現すれば、コストはさらに下がる可能性あり。大量導入には、系統対策が必要。	熱の利用を勘案すると大規模集中電源並み。電気代（業務・産業：13.7円）の節約を考慮すると需要家のメリット大。	機器によって幅あり電気代（家庭：20.4円）の節約を考慮するとメリット大。
今後の対応	○原子力の事故費用：最新の情報が得られ次第、数字を見直し。　○技術革新や量産効果によるコスト低下：技術革新の進歩や普及の動向に応じて、試算結果の見直しや試算への組込み。 ○系統安定化対策：エネルギーミックスのシナリオが固まった段階でシナリオ毎に試算。　○経済効果：エネルギーミックスのシナリオが決まった段階でマクロ的な効果として分析・試算。											

（図　３６）主な電源の発電コスト（2004 年試算／2010 年・2030 年モデルプラント）

出所：コスト等検証委員会報告書、2011年12月19日
http://www.npu.go.jp/policy/policy09/pdf/20111221/siryo3.pdf

PM Abe's Statement at Diet on Energy Policy (2013/02/28)

- Reflecting on the accident at Tokyo Electric Power Company's Fukushima Daiichi Nuclear Power Station, under the Nuclear Regulation Authority, we will foster a new culture of safety that will uncompromisingly enhance the degree of safety. After doing so we will restart nuclear power plants where safety has been confirmed.
- We will promote the introduction of energy conservation and renewable energies to the greatest possible extent to reduce our degree of dependency on nuclear power as much as possible. At the same time, we will begin a fundamental reform of the electric system.

http://www.kantei.go.jp/foreign/96_abe/statement/201302/28siseuhousin_e.html

Recommendations to the Energy Basic Plan (Draft) by METI's Advisory Council on Energy - For Nuclear Energy Policy（2013/12/06）

- We continue to use nuclear energy as an important base-load energy source to support stable energy supply
- We reduce dependence on nuclear energy as much as possible by expanding renewable energy, energy efficiency and more efficient fossil power plants.
- Under this basic policy, considering the constraints of energy resource situations, we maintain the necessary level of nuclear power from the viewpoints of energy supply stability, cost reduction, climate change, human resources to maintain the safety.

http://www.enecho.meti.go.jp/info/committee/kihonseisaku/12th/12th1-2.pdf

Recommendations to the Energy Basic Plan (Draft) by METI's Advisory Council on Energy - For Nuclear Energy Policy（2013/12/06）

(1) Measures to recover and revitalize Fukushima

(2) Enhance safety constantly and establish environment for stable nuclear business operations

(3) Steady progress in measures without delay

① Comprehensive and enhanced measures to deal with spent nuclear fuel

- Strengthen measures for final disposal of HLW
- Expansion of spent fuel storage capacity
- R&D on reduction of toxicity/volume of radioactive waste

②Steady progress in nuclear fuel cycle

- Important to increase flexibility of nuclear fuel cycle

(4) Building confidence with citizens, local governments and international society

①Public communication after Fukushima accident

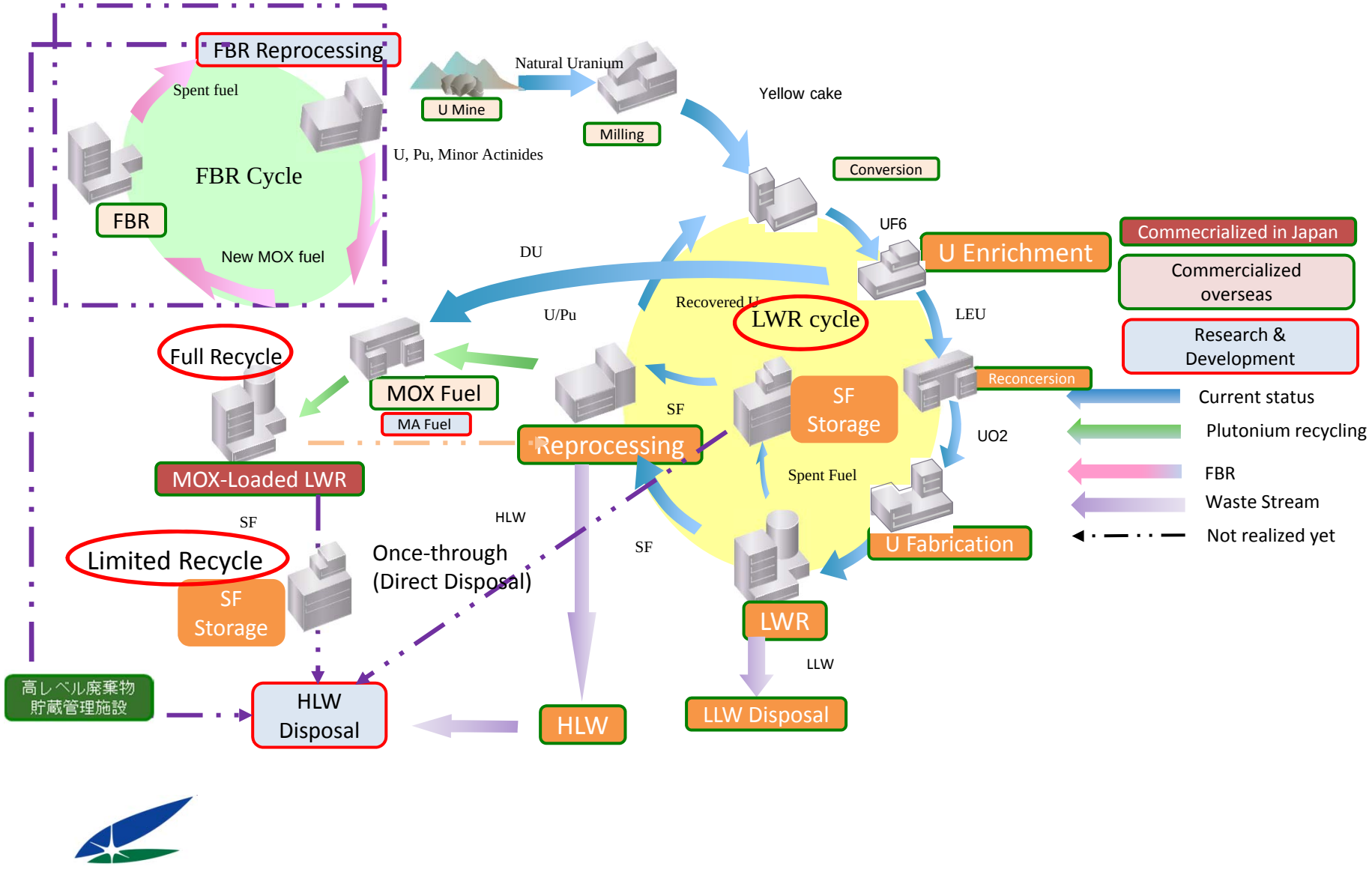
②Building confidence with local siting community

③Contribution to peaceful use of nuclear energy in the world and non-proliferation

http://www.enecho.meti.go.jp/info/committee/kihonseisaku/12th/12th1-2.pdf

Nuclear Fuel Cycle Options

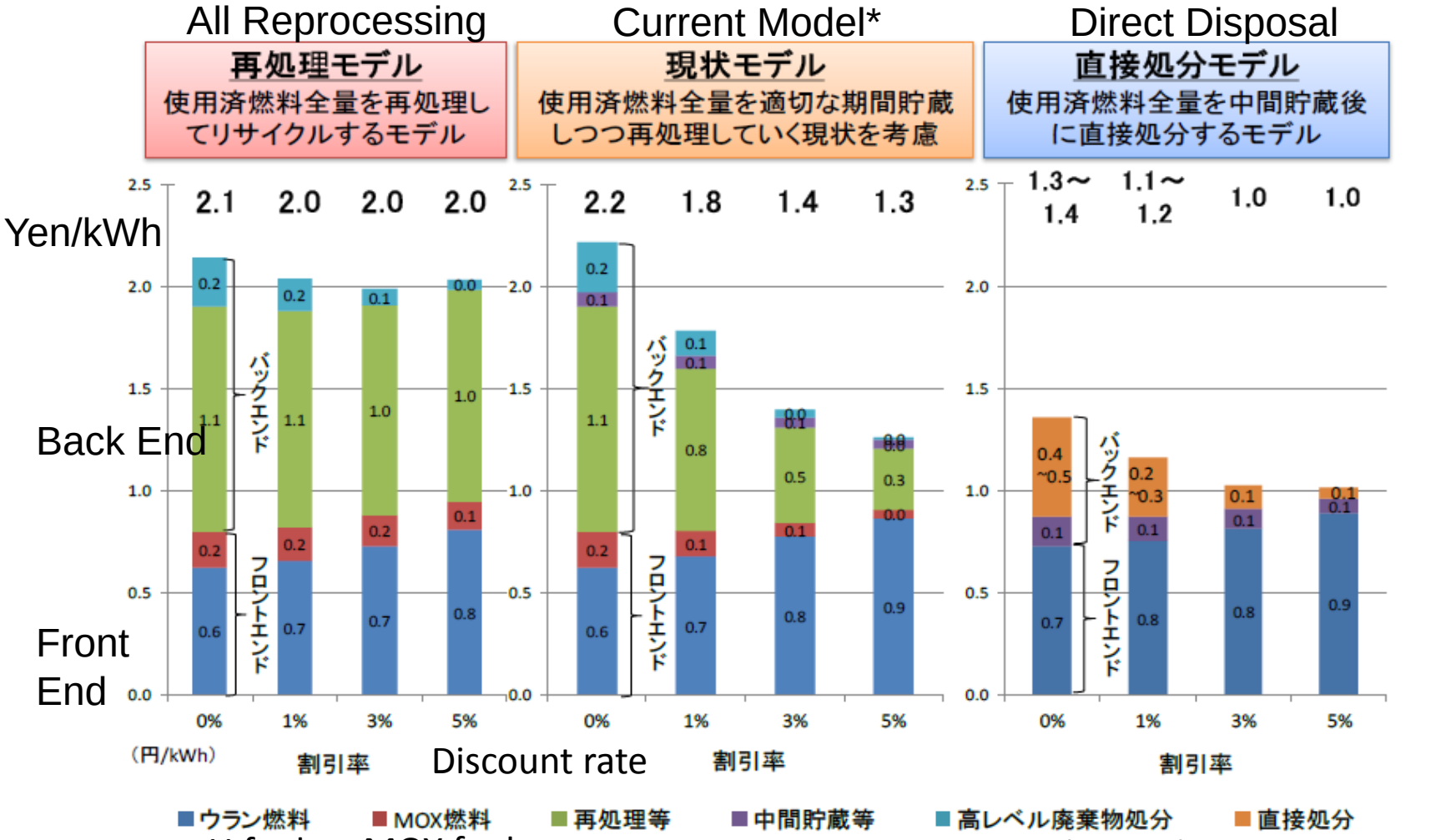
Nuclear Fuel Cycle Technology Options



Major Findings of JAEC subcommittee on nuclear power and fuel cycle (12/06/05)

- For the next 20~30 years, “MOX recycling” and “Once-through” fuel cycle are the only commercially available options.
  - “Once-through” is more desirable from economic and nuclear proliferation/security standpoints, but “MOX recycling” is more desirable from resource efficiency standpoint.
  - No significant difference in terms of safety and waste management.

Source: Chairman’s report on Subcommittee on nuclear power and fuel cycle technologies, June 5, 2012. (in Japanese) http://www.aec.go.jp/jicst/NC/iinkai/teirei/siryo2012/siryo22/siryo1-1.pdf



（図　１７）核燃料サイクル費用の比較

（再処理モデルと現状モデルと直接処分モデル）

*50% immediate reprocessing and 50% reprocessing after long term storage

Source: National Policy Unit, Energy and Environmental Council, Cost etc. Verification Committee.
http://www.npu.go.jp/policy/policy09/pdf/20111221/siryo3.pdf

Fuel Cycle Economics in Variation of Options (Summary)

～3 Fuel Cycle Options～	～4 Nuclear Share Options～
1. Total reprocessing	1. Nuclear share: 35 % (Installed capacity: 50 GW)
2. Mixed option	2. Nuclear share: 20 % (Installed capacity: 30 GW)
3. Total disposal	3. Nuclear share: 15 % (Installed capacity: 20 GW)
	4. Nuclear share: 0 %

○For all nuclear share option, **total expense of F.C. option 3 is less than the other F.C. options**.

○As for F.C. option 3, SF stored in Aomori pref. may have to be sent back and under the worst case, **nuclear power operation could be suspended if new SF storage capacity is not available**.

Total Expense of Fuel Cycle (Unit: trillion yen) <Discount rate: 0 %>

	F.C. Option 1 Total reprocessing	F.C. Option 2 Coexistence of reprocessing/disposal	F.C. Option 3 Total disposal
Nuclear Share Option I: 35 %	18.4	17.3～18.4	13.9～14.8
Nuclear Share Option II: 20 %	15.4	15.3～15.4	12.0～12.8
Nuclear Share Option III: 15 %	14.4	14.4	10.9～11.6
Nuclear Share Option IV: 0 %	—	—	8.1～8.7

Ref. : http://www.aec.go.jp/jicst/NC/tyoki/hatukaku/siryo/siryo15/index.htm
16 May 2012 Technical Subcommittee on Nuclear Power, Nuclear Fuel Cycle, etc., Material No. 1-1, No. 1-2, No. 1-3, No. 1-4 (Japanese)

Assessment of Nuclear Fuel Cycle Policy Options by Subcommittee (June, 2012)

- "All reprocessing" option: Most desirable when nuclear power will expand or stay as it is
- "Co-existing of reprocessing/direct disposal" option : Most desirable when future of nuclear energy is uncertain
- "All direct disposal" option: Most desirable when nuclear energy will be phased out

Source: Chairman's report on Subcommittee on nuclear power and fuel cycle technologies, June 5, 2012. (in Japanese) http://www.aec.go.jp/jicst/NC/iinkai/teirei/siryo2012/siryo22/siryo1-1.pdf

JAEC's Decision on Nuclear Fuel Cycle Policy Options (2012/06/21)

- As recommended by the technical subcommittee, regardless of the policy choice, it is vital to build a system ready to cope with future policy changes

http://www.aec.go.jp/jicst/NC/about/kettei/kettei120621_2.pdf

Three types of spent fuel storage capacity

(As of September 2013, total of 17,335 tons are in storage)

At-reactor storage

Storage capacity: 20,640 tU/17 sites (as of Sept. 2013, 14,340tons ~70% full)

On-site dry cask storage is not allowed by local governments (Fukushima-1 & Tokai-2 was allowed).

If Rokkasho was cancelled...

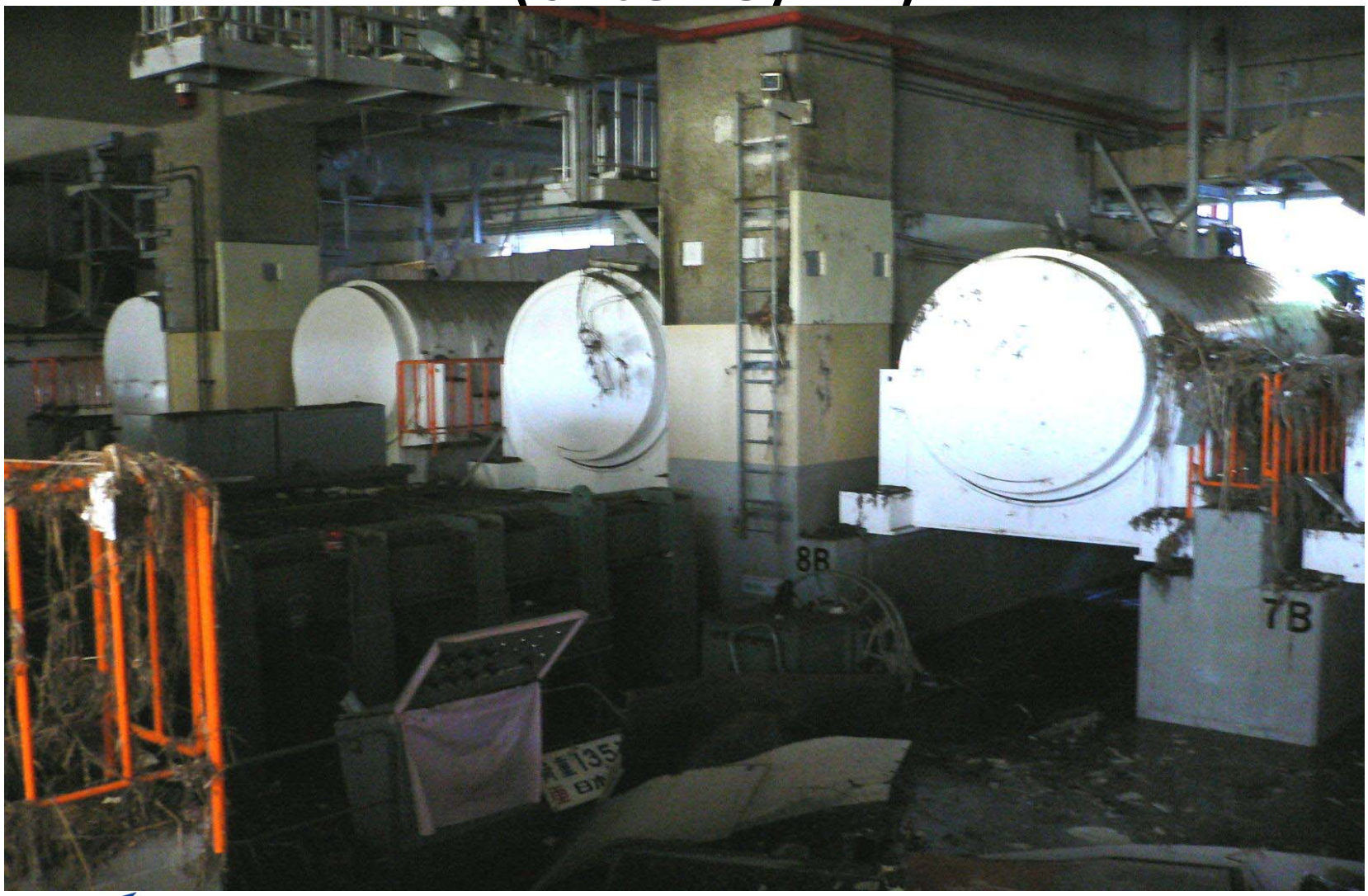
Rokkasho reprocessing plant

Storage capacity:**3,000tU**
(storage **2,945 tU** as of Sept. 2013)
Construction cost: ¥2.14Trillion
Commission date: not known

Mutsu Interim storage site

Dry Cask storage type
Capacity : totally 5,000 tU
1st 3,000 tU, add 2,000tU in future
Operation: October 2013 (postponed)
(Status : under construction)
Construction cost: ¥0.1Trillion
(including dry casks)

Dry Cask Storage at Fukushima Daiichi (after 3/11)



http://photo.tepco.co.jp/library/110909_2/110909_69.jpg

Basic Policy for FY 2014 Nuclear Energy Budget
(2013/07/17)

- On nuclear fuel cycle policy, there are measures which are necessary regardless of future of nuclear energy policy. Parties should promote such measures with increased flexibility as JAEC decision on June 21, 2013.
- Especially, government should take more active leadership in expanding storage capacity of spent fuel, measures to enable direct disposal and final disposal of high-level radioactive waste.
- Especially, on plutonium management, principle of "no plutonium surplus policy" should be strictly followed, with enhanced transparency and more persuasive programs than the current measures.

http://www.aec.go.jp/jicst/NC/about/kettei/kettei130717.pdf

JAEC's "No Pu surplus policy"

- Since 1991, Japan stick to a principle of "no plutonium surplus policy" , i.e. Japan does not have any plutonium which does not have specific purposes to use.
- In August 2003, JAEC announced its new guideline for plutonium management preparing for commissioning of the first commercial reprocessing plant.
  - Utilities are expected to submit **its plutonium usage plan annually *before* separation of plutonium**.

But, Japan now has 44 tons (35 tons in Europe, 9 tons in Japan) of stockpile.

"Plutonium stockpile should be reduced regardless of fuel cycle options chosen in the future"

(Statement in JAEC Subcommittee on Nuclear Power/Nuclear Fuel cycle technologies)
http://www.aec.go.jp/jicst/NC/iinkai/teirei/siryo2012/siryo22/siryo1-1.pdf (in Japanese)

Pu Use Plan for Rokkasho (FY2010)

	Pu stock (End of FY 2009)	Pu recovered (FY2010)	Pu stock (End of FY2010)	Reactors for Pu use	Pu use per year	Planned period
Hokkaido	72kgfis	0	72kgfis	Tomari#3	0.2tonfis/y	FY2015~
Tohoku	78	0	78	Onagawa#3	0.2	FY2015~
TEPCO	748	0	748	3～4 unit include Fukushima-1#3 (planned)	0.9~1.6	FY2015~
Chubu	182	0	18	Hamaoka#4	0.4	FY2015~
Hokuriku	9	0	9	Shika #1	0.1	FY2015~
Kansai	556	0	556	Takahama#3,4 1～2 unit in Ohi	1.1~1.4	FY2015~
Chugoku	84	0	84	Shimane#2	0.2	FY2015~
Shikoku	133	0	133	Ikata #3	0.4	FY2015~
Kyushu	315	0	315	Genkai #3	0.4	FY2015~
JAPCO	140	0	140	Tsuruga#2. Tokai#2	0.5	FY2015~
J-Power	(purchase from others)			Ohma	1.1	NA
Total	2,317	0	2,317	--	5.5~6.5	--

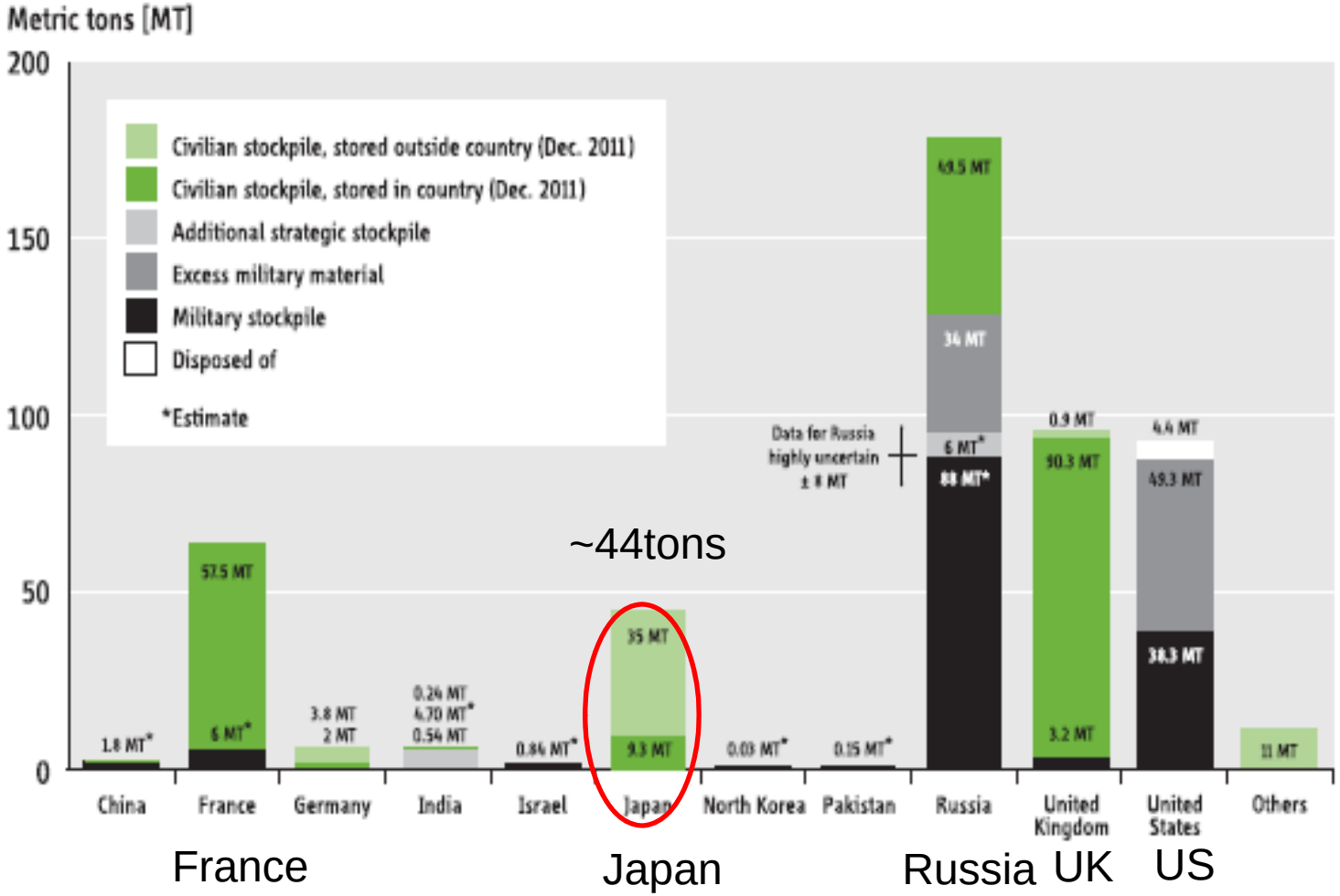
Source: Federation of Electric Power Cos, Sept. 17, 2010, http://www.aec.go.jp/jicst/NC/iinkai/teirei/siryo2010/siryo51/siryo1.pdf

Plutonium Stockpile in Japan (as of the end of 2012)

	2012 (kg)	2011 (kg)
Stock in Japan (Pu total)		
Reprocessing Plants	4,363	4,364
MOX Fuel Plant	3,364	3,363
Stored at Reactors	1,568	1,568
Sub-total (Pu fissile)	9,295(6,315)	9,295 (6,316)
Stocks in Europe (Pu total)		
UK	17,052	17,028
France	17,895	17,931
Sub-total :Pu total(Pu fissile)	34,946 (23,277)	34,959(23,308)
Total (Pu fissile)	44,241(29,592)	44,254(29,624)

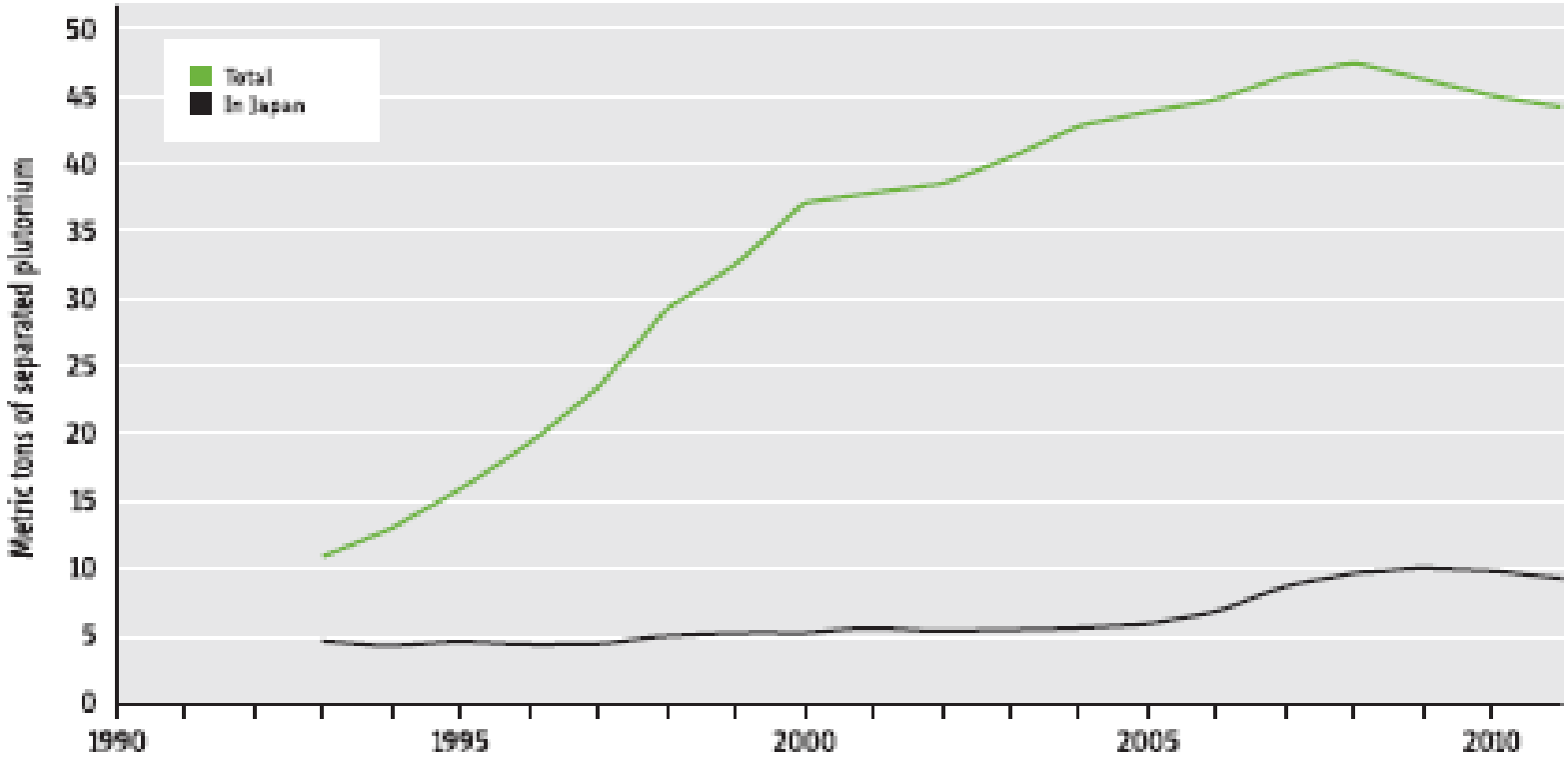
Source: Japan Atomic Energy Commission (2013, 2012) http://www.aec.go.jp/jicst/NC/sitemap/pdf/130911e.pdf

Global Civilian Plutonium Stockpile (2011)
- Reprocessing has international security implications -



Source: International Panel on Fissile Material (IPFM), Global Fissile Material Report 2013, http://fissilematerials.org/library/gfmr13.pdf

Japan's Plutonium Stockpile



Source: International Panel on Fissile Material (IPFM), Global Fissile Material Report 2013, http://fissilematerials.org/library/gfmr13.pdf

Second Meeting of the Japan-United States Bilateral Commission on Civil Nuclear Cooperation

（2013/11/4）

- “On nuclear security, Japan and the United States committed to continue to strengthen the nuclear security posture of both countries and to fundamentally reduce the threat that terrorists could acquire nuclear material. Key steps towards these goals include the following:
  - Reducing the quantities and attractiveness of weapons-usable nuclear material;”

http://www.mofa.go.jp/mofaj/files/000018671.pdf

http://www.aec.go.jp/jicst/NC/iinkai/teirei/siryo2013/siryo41/siryo2-2.pdf

A Proposal for Plutonium Use Policy - personal opinion (2013/03/26)

1. Demand comes first: Reprocessing should take place only when plutonium demand(use) is specified. In order to achieve this goal, spent fuel storage capacity must be expanded.
2. Stockpile reduction: Matching demand/supply is not good enough. Existing stockpile should be reduced before further reprocessing.
3. Flexible plan: Current Pu use plan (MOX recycling in 16~18 units) is no longer certain. Other options (Pu ownership transfer, disposition as waste etc.) need to be pursued. With minimizing cost, transportation and time required to dispose.

REFERENCE

安全性：ライフサイクルでの被ばくリスク(2/3)

Life cycle analysis of exposure risk

核燃料サイクルの主要工程毎の被ばく量概算値について

核燃料サイクル工程	操業後500年間にわたるヨーロッパの一般公衆の集団被ばく線量 解析値 (manSv/GWe-year)		作業従事者の集団被ばく線量 (manSv/GWe-year)	
	ワンスルー	リサイクル	ワンスルー	リサイクル
採掘、精錬	1	0.79 (1)	0.7	0.55 (1)
転換、濃縮	0 (2)	0 (2)	0.02	0.016
燃料成形加工	0.0009 (4)	0.0007 (3)	0.00657 (5)	0.0941 (3)
発電	0.65 (6)	0.65 (6)	2.7 (7)	2.7 (7)
再処理、ガラス固化、中間貯蔵	0	1.534 (8)	0	0.012 (9)
合計	1.65	2.97	3.43	3.37

Once-through Recycle Once-through Recycle

U mine

Reprocessing

注釈
(1) 天然ウラン必要量に基づいて算出、作業従事者の線量はUNSCEAR88による
(2) 燃料成形加工による影響に合算した
(3) UO_2とMOX燃料の重量(21.1t、5.5t)で重み付けして算出
(4) 一般公衆：解析結果：Romans 3.21×10^{-4}、 Melox 2.51×10^{-3}
(5) 作業従事者：Romans 6.57×10^{-3}、 Melox 4.3×10^{-1}
(6) 一般公衆：海岸 0.54、 内陸 0.65
(7) 作業従事者：フランス 900MW(e)プラントの平均
(8) 一般公衆：サイトを特定しない一般的な評価
(9) 作業従事者：La Hagueにおけるデータ

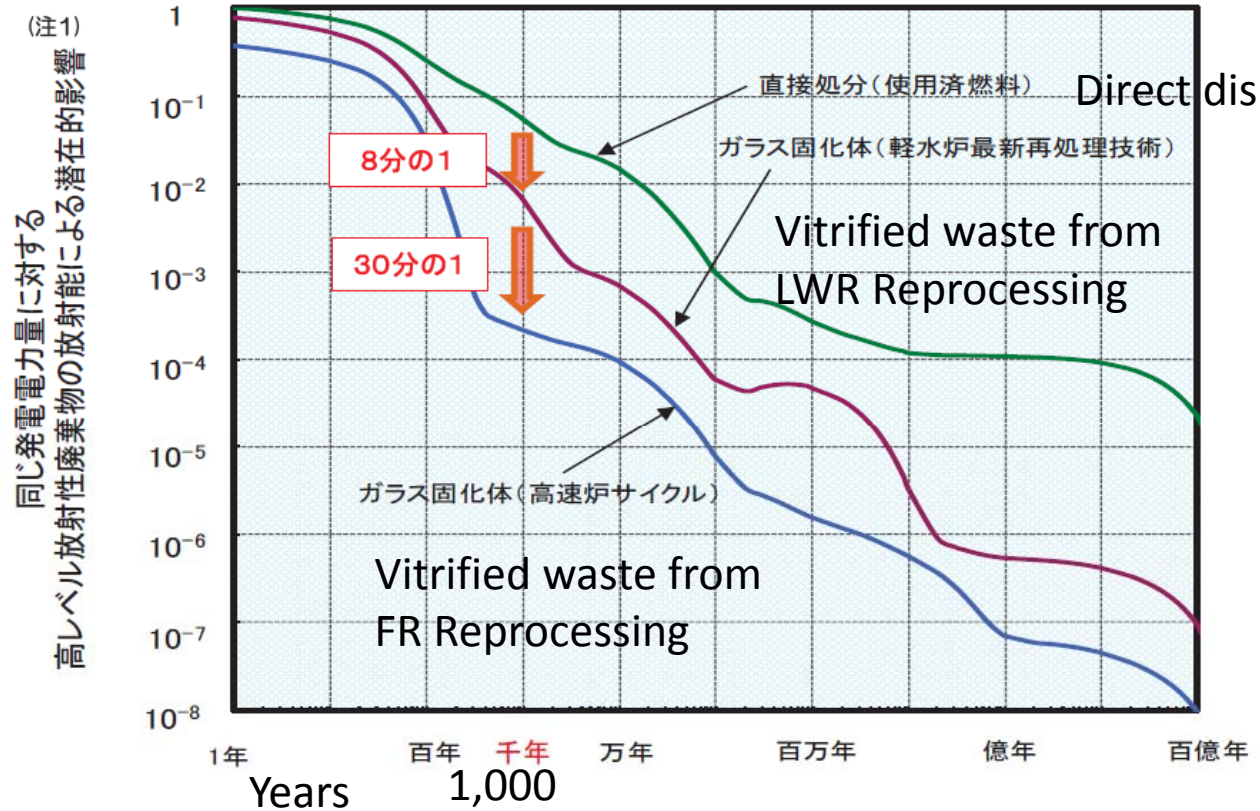
出典：
・OECD/NEA, "Trends in the Nuclear Fuel Cycle: Economic, Environmental and Social Aspects" (2001).

参考文献：
・UNSCEAR88, United Nations Scientific Committee on the Effects of Atomic Radiation(UNSCEAR): "Sources, Effects and Risks of Ionizing Radiation, 1988, Report to the General Assembly, with annexes", United Nations, New York, 1988.

2012/3/1 原子力発電・核燃料サイクル技術等検討小委員会（第9回） 27

http://www.aec.go.jp/jicst/NC/iinkai/teirei/siryo2012/siryo22/siryo1-2.pdf

廃棄物：Potential Hazard of HLW by form 高レベル放射性廃棄物の潜在的有害度（毒性）(2/2)



（注1）高レベル放射性廃棄物と人間との間の障壁は考慮されておらず、高レベル放射性廃棄物の実際の危険性ではなく、潜在的な有害度（経口摂取による年摂取限度で規格化）を示している。使用済燃料取り出し直後の潜在的影響を1とした相対値。

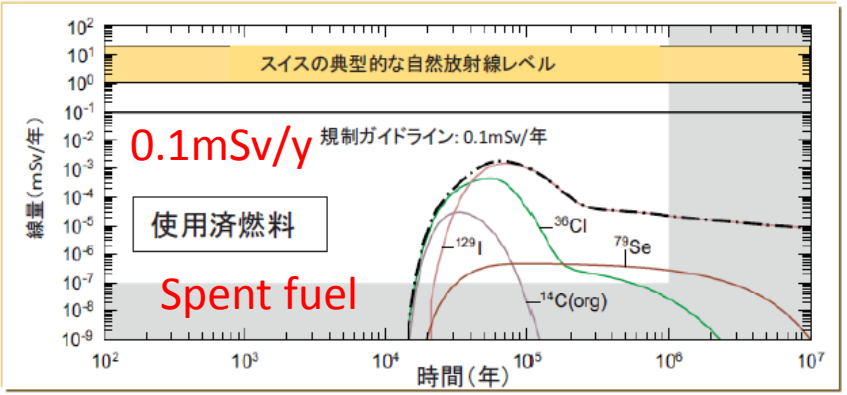
出典：原子力委員会 原子力政策大綱（平成17年）を基に編集

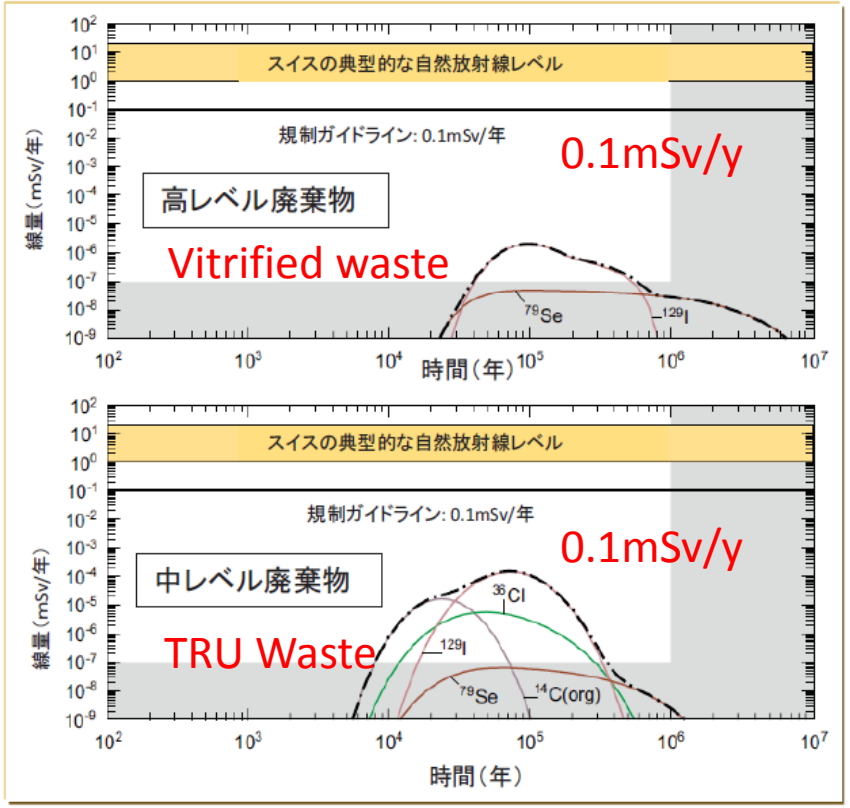
http://www.aec.go.jp/jicst/NC/iinkai/teirei/siryo2012/siryo22/siryo1-2.pdf

Potential Exposure Risk from HLW
廃棄物：高レベル放射性廃棄物の被ばくリスク(2/2)

“What if” case studies in Switzerland assuming 100 times speed of underground flow

スイスの解析例
“what if”ケースとして、地下水の流量をリファレンスケースの100倍と仮定した場合の放射線量





直接処分の場合（左上図）及び再処理を行った場合（右上＋右下図）のいずれも、廃棄物からの被ばく線量は、諸外国で提案されている安全基準（0.1～0.3mSv/年）に比べて十分低い

出典：Nagra Technical Report NTB 02-05(2002)より事務局作成

http://www.aec.go.jp/jicst/NC/iinkai/teirei/siryo2012/siryo22/siryo1-2.pdf