The impacts of Fukushima Dai-ichi nuclear power plant accident on the global nuclear power industry

October 16-17, 2012
The World Green Energy Forum 2012

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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.

Summery

- Fukushima Dai-ichi nuclear power accident has become one of the worst in nuclear history and it is not completely over yet. This has serious implications for not only Japan but also global nuclear energy development.
- The most serious issue is loss of public trust which has been affecting national policy debate on overall energy policy.
- The Japanese government recently published “Innovative strategy for Energy and Environment” aiming at “society not dependent on nuclear power” in earliest possible future. This means complete U-turn of nuclear energy policy for Japan. In order to realize such policy, “transition period” is necessary.
- Especially nuclear fuel cycle policy requires a transition period and also needs policies with careful attention on international implications and the government should have a stronger responsibility.

The Fukushima accident and Lessons learned

Five Major Lessons from Gov't Committee* and the Diet Commission** on the Accident

- *Man-made Disaster*
- *Emergency Response: "Unprepared"*
- *Protecting Public Health: "Communication Failure"*
- *Regulatory Framework: "Captured by the Nuclear Industry"*
- *International dimension: Importance of information disclosure and sharing*

* 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”

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

Emergency Response: “Unprepared”

- 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)

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

Protecting Public Health: “Communication Failure”

- The government did not use the System for Prediction of Environmental Emergency Dose Information (SPEEDI) effectively
- *“The government and the regulator are not fully committed to protecting public health and safety.”(The Diet Commission)*
- *“Nuclear operators and the regulators should establish a systematic activity to identify all risk potentials from the “disaster victims’ standpoint.” (The Gov’t Committee)*

Regulatory Framework: “Captured by the Nuclear Industry”

- *“..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)

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

International dimension: Importance of information disclosure and sharing

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

- *“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)*

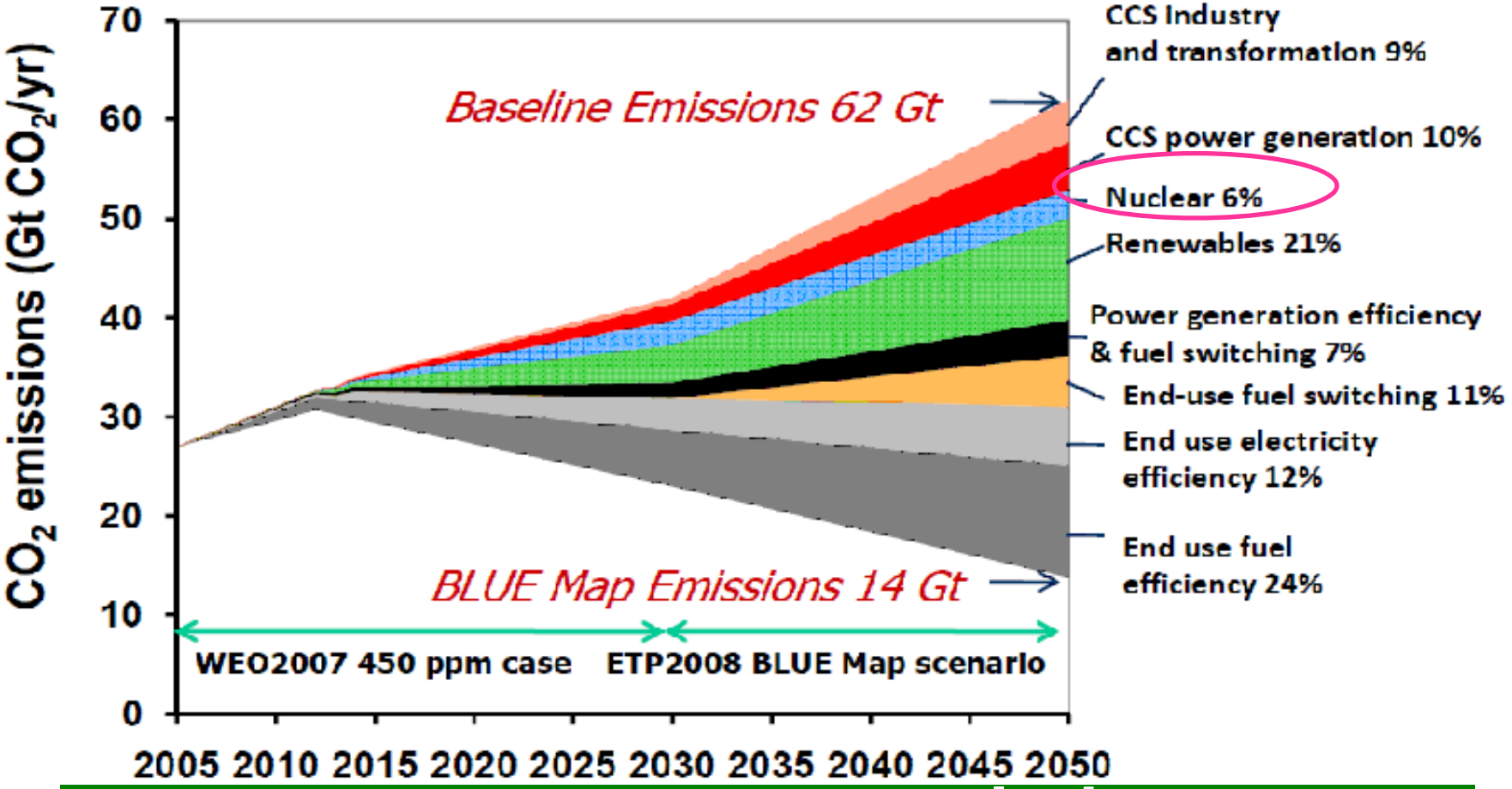
Global Energy/Nuclear Energy Policy

Global energy policy challenge

- 80% of global energy supply comes from fossil fuel, and global energy demand is expected to grow 50% more by 2030
- Most of such growth comes from developing countries which are most likely to depend on fossil fuel (as cheaper energy source)
- We need to reduce CO2 by more than 50% by 2050

How can we shift from “fossil-dependent society” to “low-carbon society”?

A Cutting Energy Scenario to 2050 by IEA



A New Energy Revolution : Cutting Energy Related CO2 Emissions

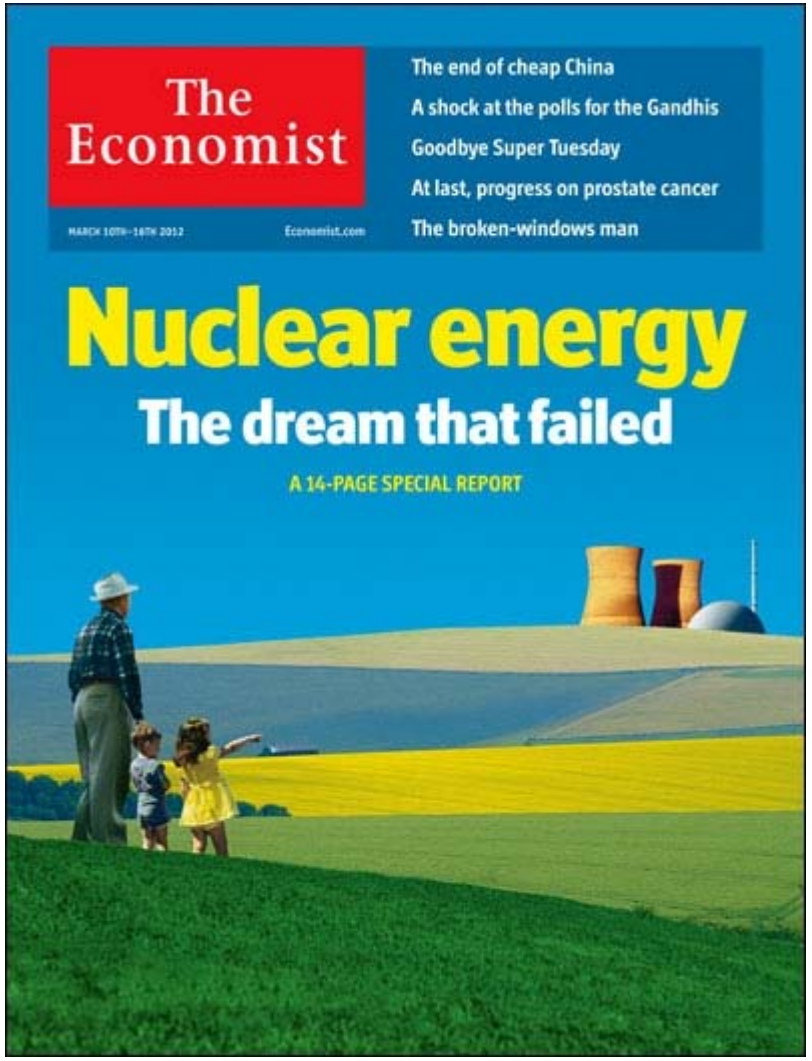
Resource: Energy Technology Perspectives 2008, IEA, June 2008

Nuclear Renaissance?

"A nuclear revival is welcome so long as the industry does not repeat its old mistakes"

--*The Economist*, September 8, 2007

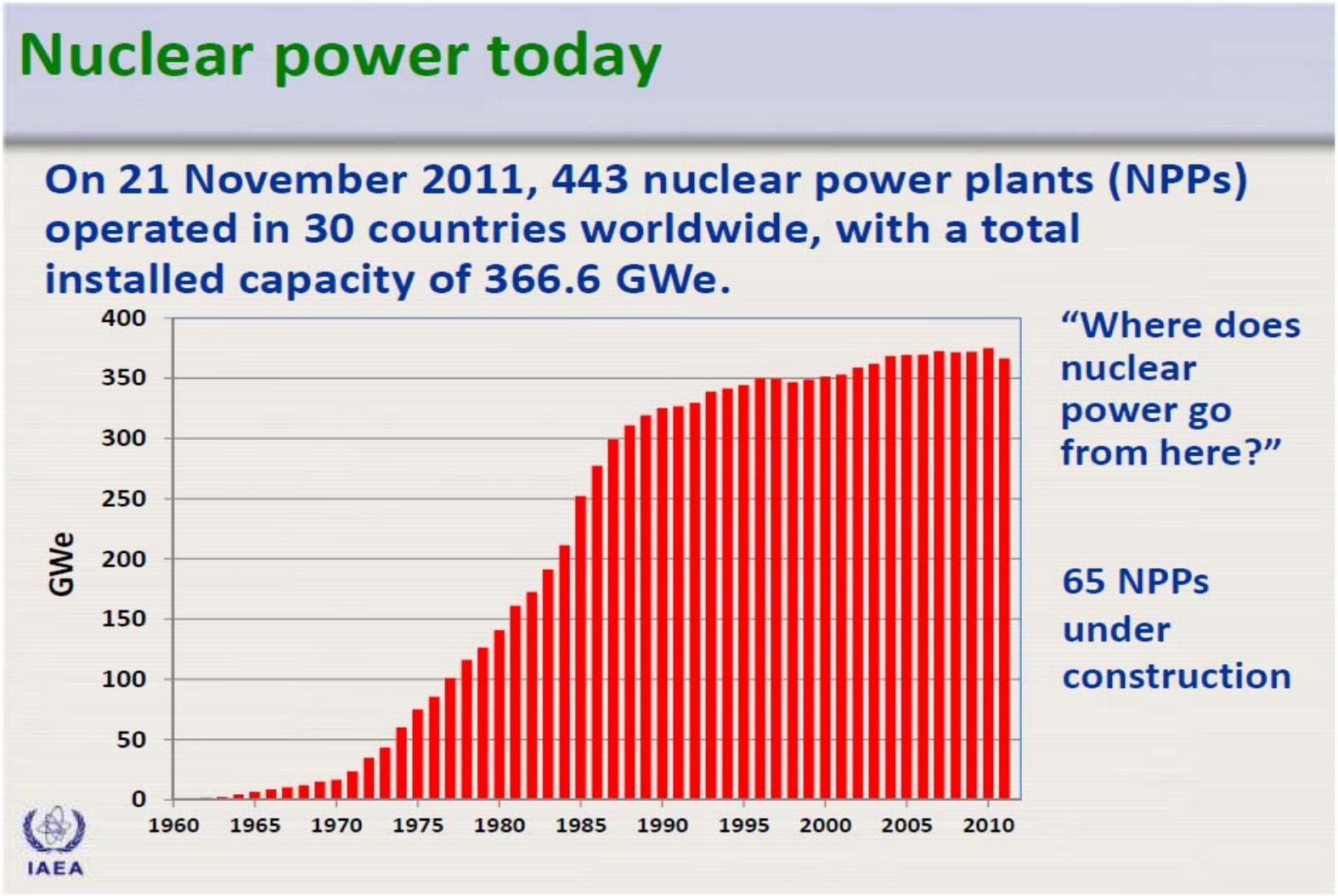
Has its dream failed? (The Economist, March 10, 2012)



- *"For nuclear to play a greater role, either it must get cheaper or other ways of generating electricity must get more expensive."*
- *"Nuclear innovation is still possible, but it will not happen apace…This does not mean nuclear power will suddenly go away…But the promise of a global transformation is gone."*

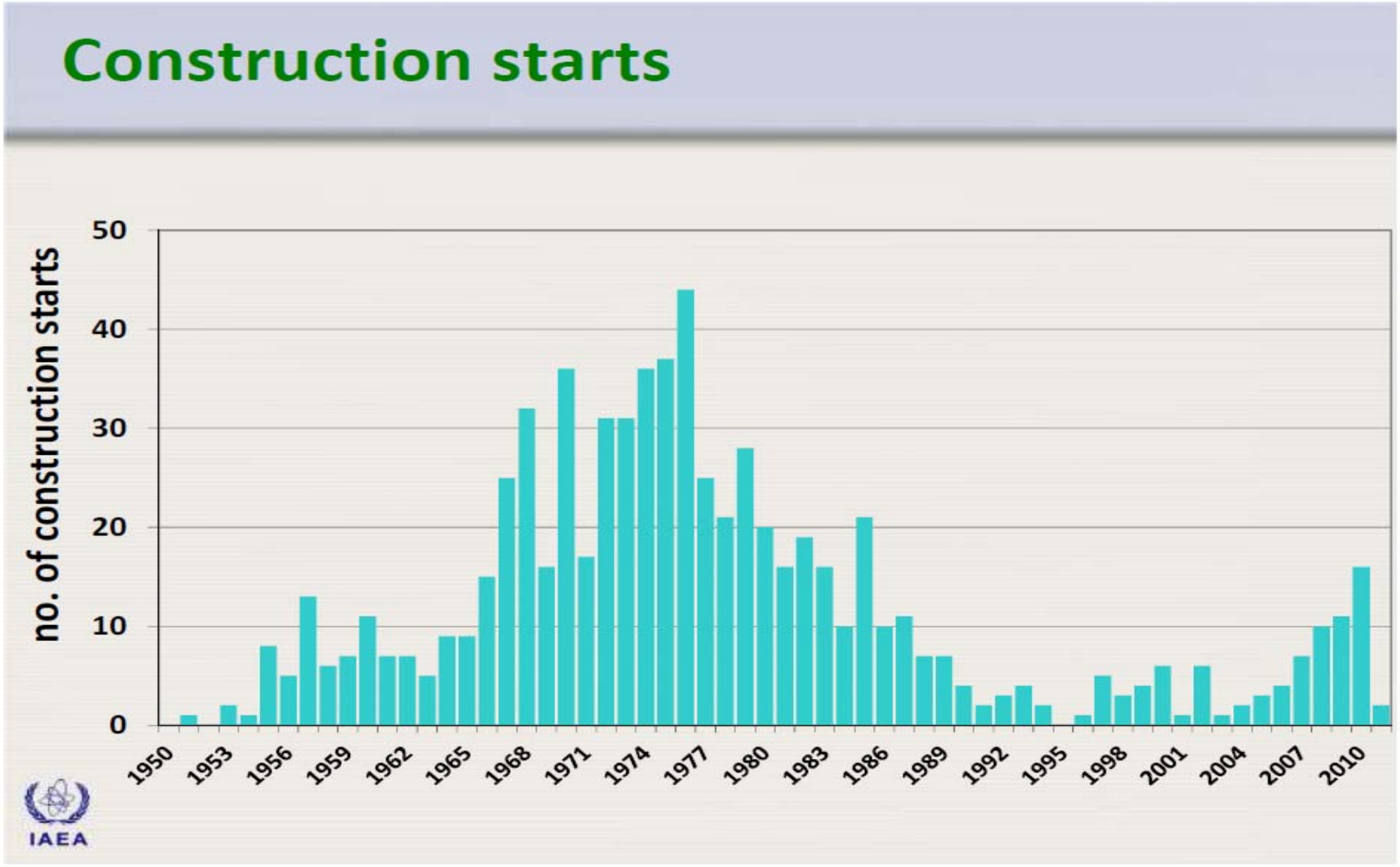
http://www.economist.com/node/21549936

Global Nuclear Power Development (IAEA)



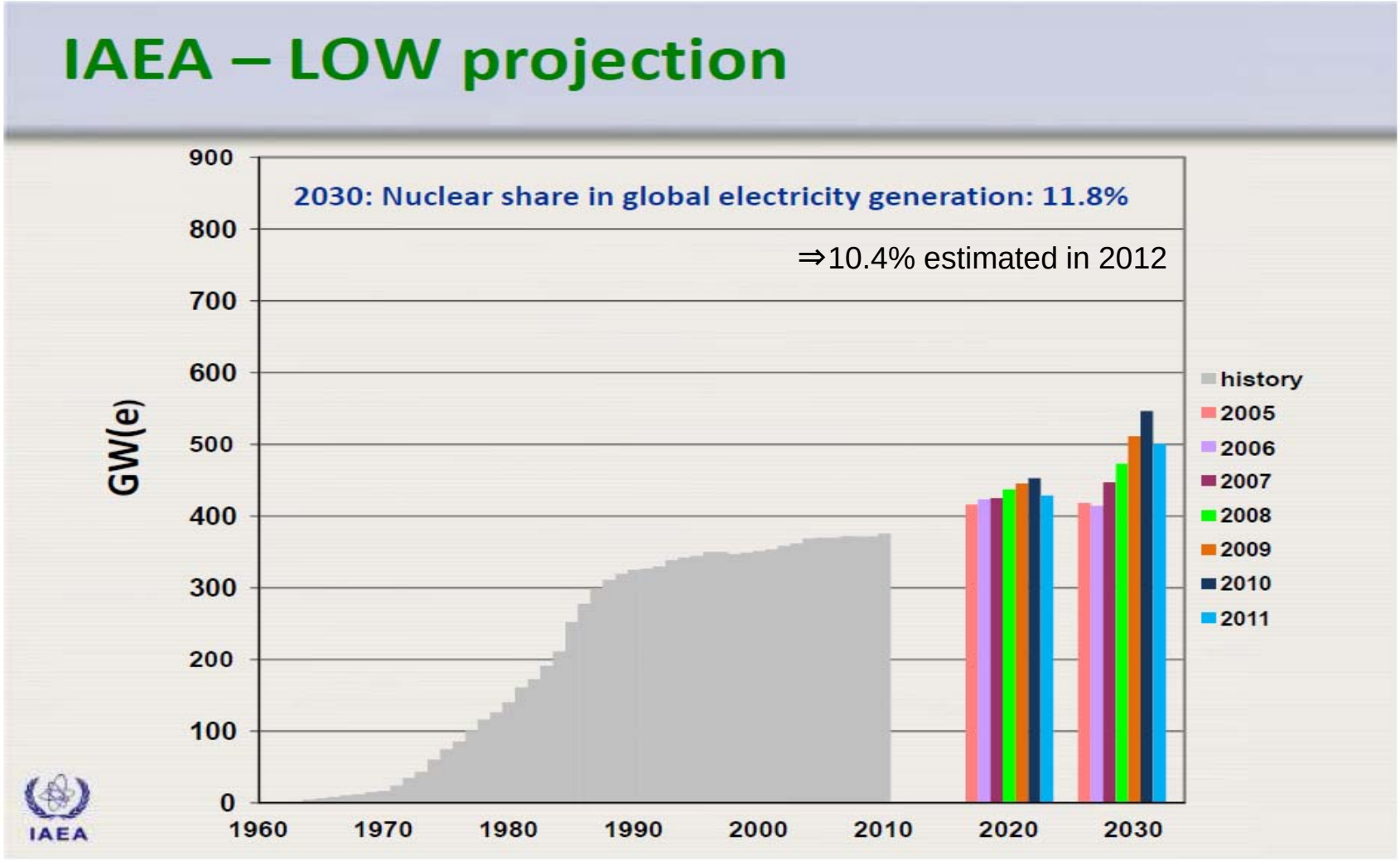
Source: H-HolgerRogner, Head, Planning & Economic Studies Section (PESS)Department of Nuclear Energy, International Atomic Energy Agency, "Energy, Electricity and Nuclear Power Estimates for the Period up to 2030," November 2011.

Global Nuclear Power Plant Construction (IAEA)
: Replacement of old reactors are coming….



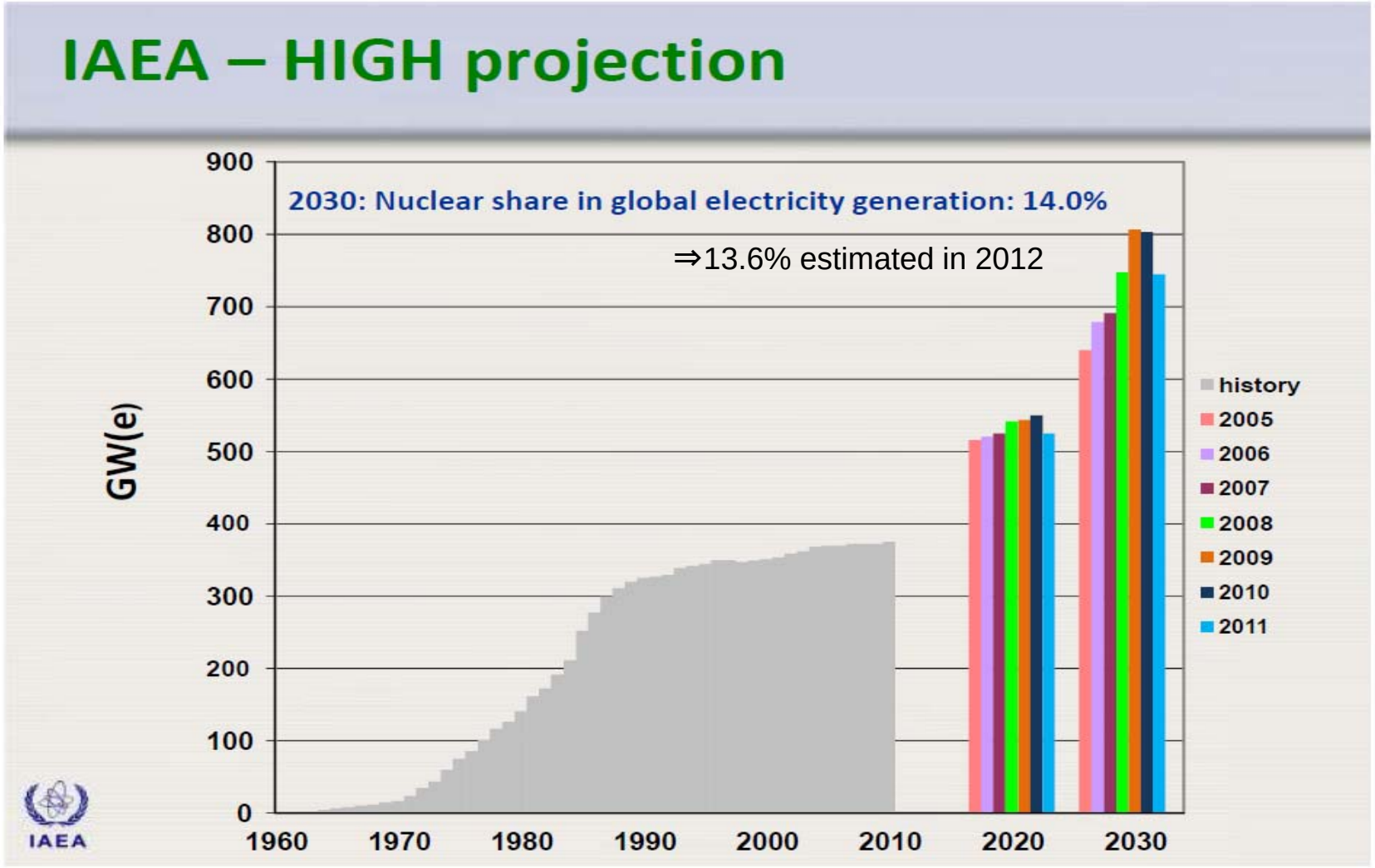
Source: H-HolgerRogner, Head, Planning & Economic Studies Section (PESS)Department of Nuclear Energy,
International Atomic Energy Agency, "Energy, Electricity and Nuclear Power Estimates for the Period up to 2030," November 2011.

Global Nuclear Power Projection up to 2030 (IAEA)



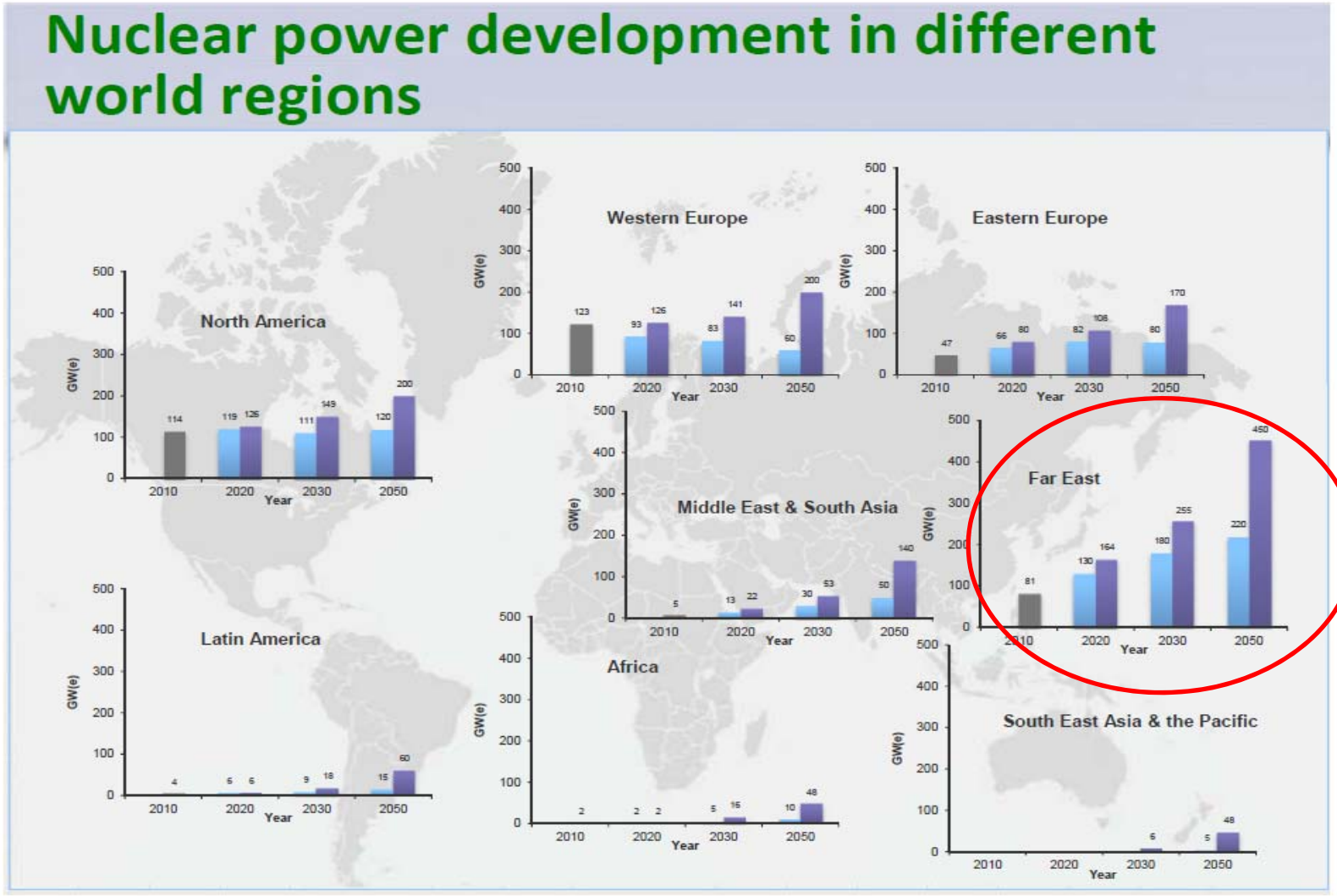
Source: H-HolgerRogner, Head, Planning & Economic Studies Section (PESS)Department of Nuclear Energy, International Atomic Energy Agency, "Energy, Electricity and Nuclear Power Estimates for the Period up to 2030," November 2011.

Global Nuclear Power Projection up to 2030 (IAEA)



Source: H-HolgerRogner, Head, Planning & Economic Studies Section (PESS)Department of Nuclear Energy, International Atomic Energy Agency, "Energy, Electricity and Nuclear Power Estimates for the Period up to 2030," November 2011.

Global Nuclear Power Projection up to 2030 (IAEA): Asia is most important



Source: H-HolgerRogner, Head, Planning & Economic Studies Section (PESS)Department of Nuclear Energy, International Atomic Energy Agency, "Energy, Electricity and Nuclear Power Estimates for the Period up to 2030," November 2011.

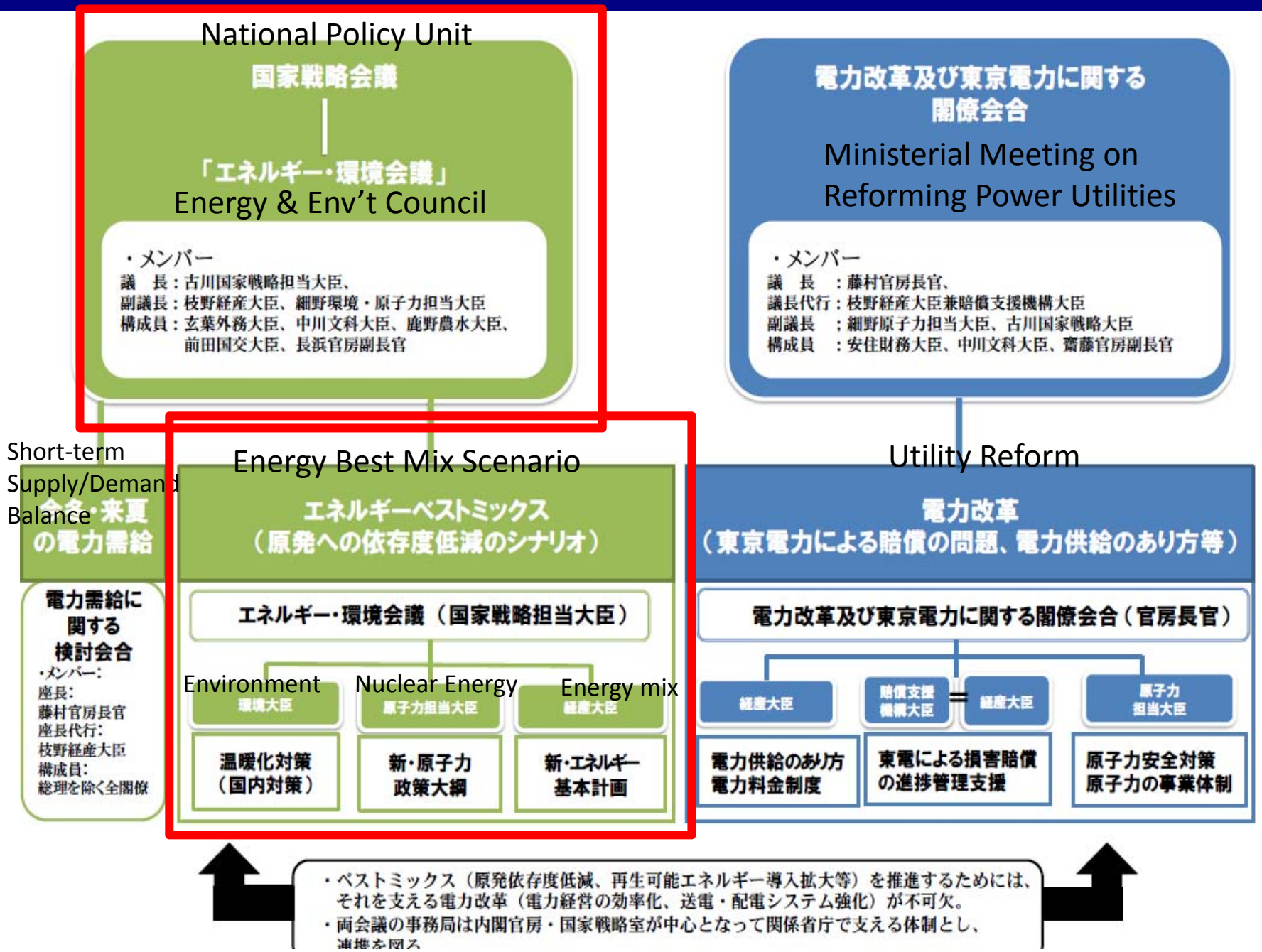
Estimates of Nuclear Electrical Generating Capacity : Comparison of estimates in 2012 and 2011

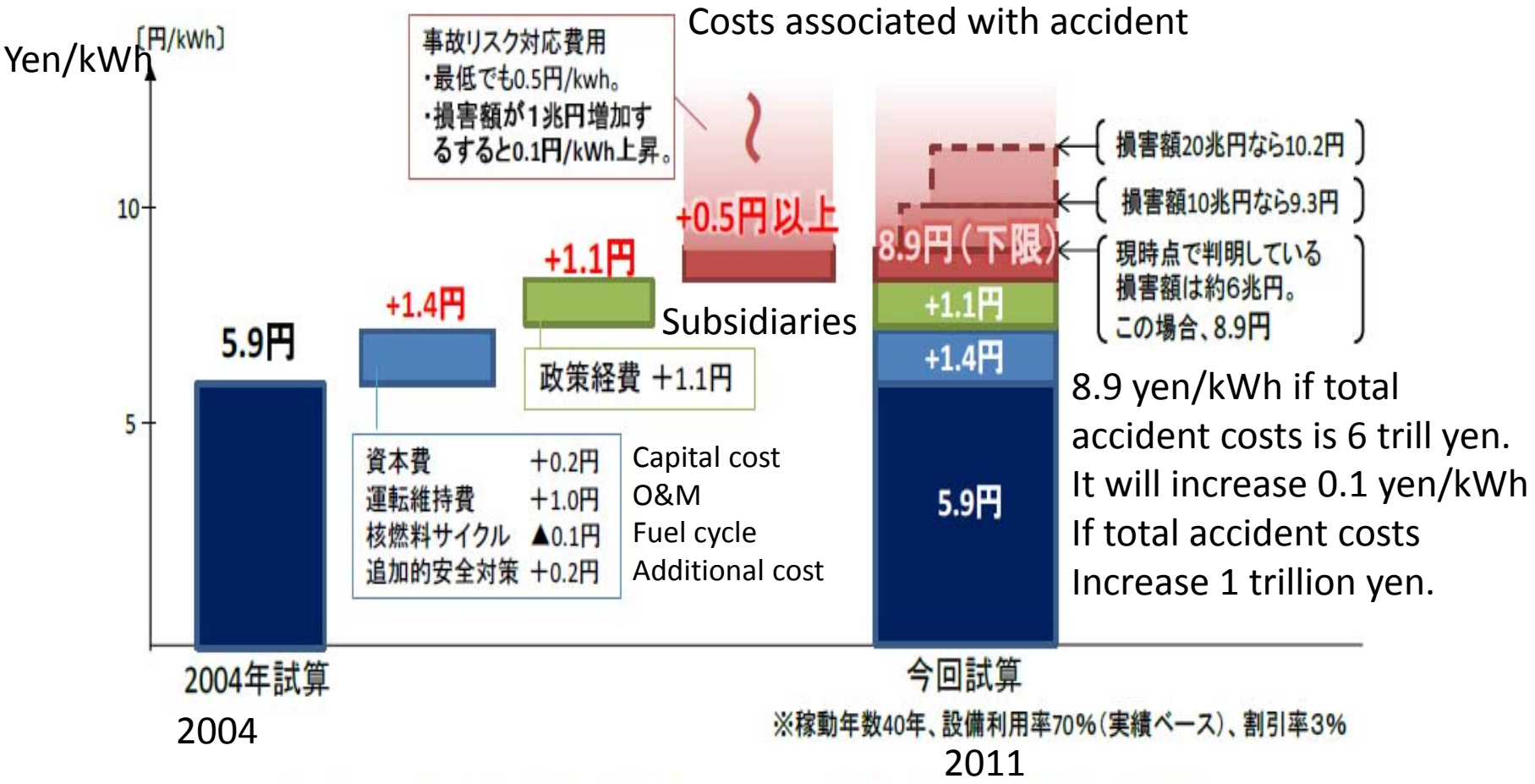
	Actual in 2011	Estimates for 2030 Estimated		Estimates for 2050 Estimated	
		in 2011	in 2012	in 2011	in 2012
World Total			-9%		-16%
Nucl. Capacity (GWe)					
Low Estimate	368.8	501	456	560	469
High Estimate		746	740	1228	1137
			+1%		-7%
Share (%)					
Low Estimate	7.1	5.2	4.7	2.7	2.3
High Estimate		6.2	6.2	6.0	5.7
Far East			-15%		-13%
Nucl. Capacity (GWe)					
Low Estimate	79.8	180	153	220	191
High Estimate		255	274	450	417
			+7%		-7%
Share (%)					
Low Estimate	5.0	6.4	5.5	4.2	3.7
High Estimate		7.5	8.2	8.6	8.1

Source: International Atomic Energy Agency, "Energy, Electricity and Nuclear Power Estimates for the Period up to 2050,"
2011 Edition http://www-pub.iaea.org/MTCD/Publications/PDF/RDS1_31.pdf
2012 Edition http://www-pub.iaea.org/MTCD/Publications/PDF/IAEA-RDS-1-32_web.pdf

Japan’s energy and nuclear energy policy

New Framework for Energy and Environmental Policy





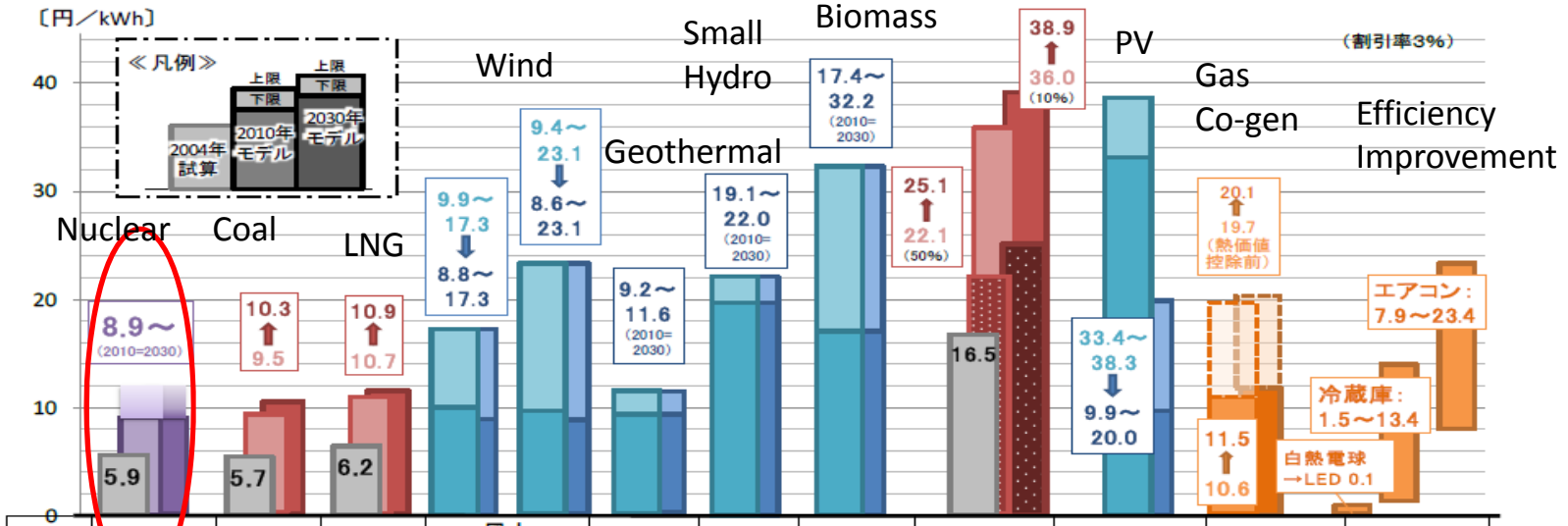
（図 ２０）原子力の発電コスト（2004 年試算と今回試算）

Nuclear Power Generation Costs (2004, 2011)

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織込んで試算。



	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

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)

Important issues on fuel cycle policy (by JAEC)

1. Expansion of the storage capacity of spent fuel on-site and off-site of nuclear power plants, including dry storage, finding final disposal site for high-level radioactive waste, and the development of technology enabling direct disposal and the required measures and regulations.
2. A comprehensive assessment of nuclear fuel cycle business operations focused on the performance of plant operation at the Rokkasho Reprocessing Plant, progress of plutonium utilization and international perspective (in several years).
3. Construction of an effective check-and-review system for R&D of FBRs, an R&D system to produce innovative and competitive advanced reactors, and effective and efficient R&D utilizing international cooperation without insisting on finalizing the domestic R&D.
4. Establishment of nuclear fuel cycle policy which takes sufficient account of the increased safety of nuclear power generation worldwide, reducing nuclear nonproliferation and the nuclear security risk.
5. The government is responsible for deciding nuclear policies, with the more explicit assignment of responsibilities to government and private utilities, and enhanced trust via sincere communications with people, and ensuring transparency.

http://www.aec.go.jp/jicst/NC/about/kettei/kettei120718_e.pdf

Three types of spent fuel storage capacity

At-reactor storage

Storage capacity: 19,420 tU/17 sites

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

Rokkasho reprocessing plant

Storage capacity:**3,000tU**

(storage **2,834 tU** as of March 2010)

Construction cost: ¥2.14Trillion

Mutsu Interim storage site

Dry Cask storage type

Capacity : totally 5,000 tU

1st 3,000 tU, add 2,000tU in future

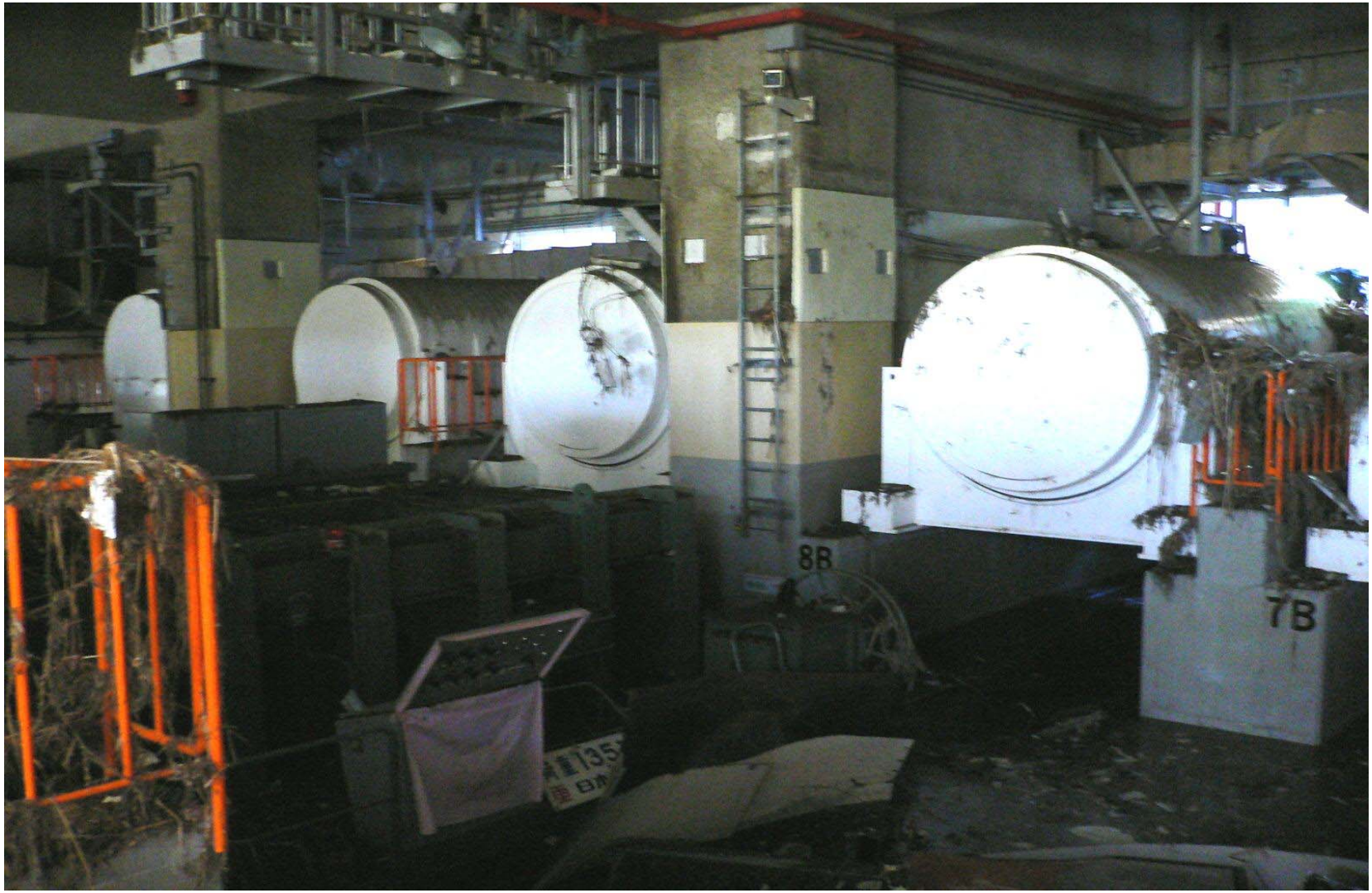
Operation: July 2013 (or later)

(Status : under construction)

Construction cost: ¥0.1Trillion

(including dry casks)

Dry Cask Storage at Fukushima Dai-ichi (after 3/11)



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

Anti-nuclear demonstration triggered by Social Network Service

- Largest ever anti-nuclear demonstration organized by SNS and general citizens: 20,000 ~100,000 (or more?) participants.
- It is taking place every Friday evening (since June) surrounding the PM's office.

Confusing Public Polling Results

- NHK Poll(2012/8/12)

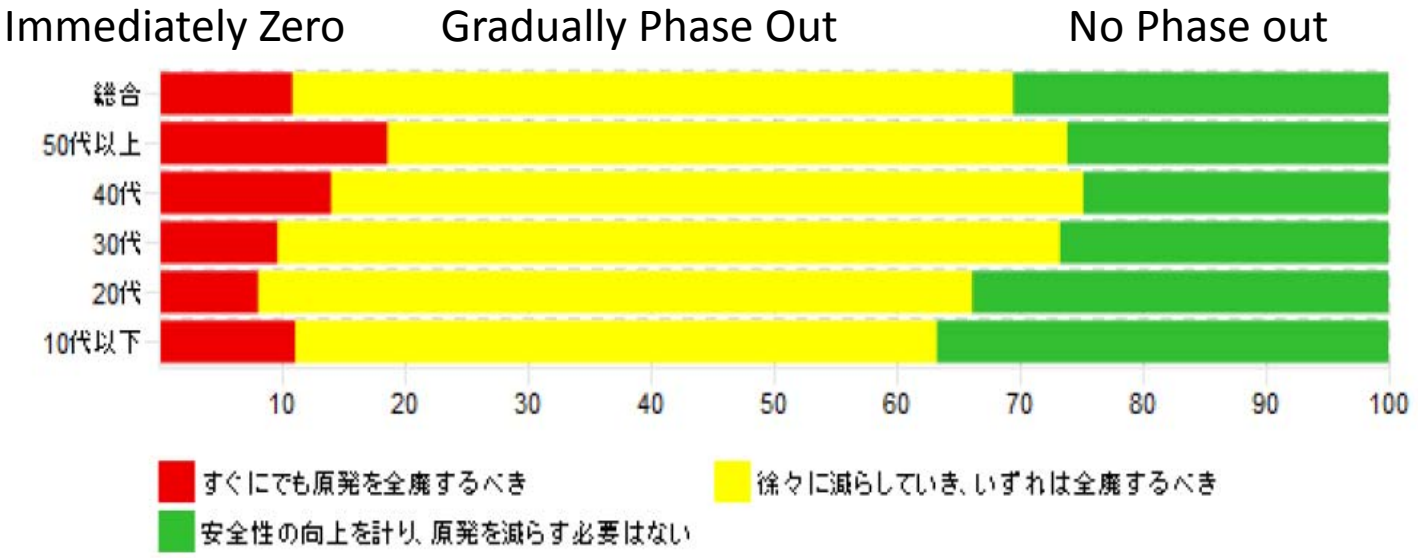
- Asahi Poll (2012/8/4~5)

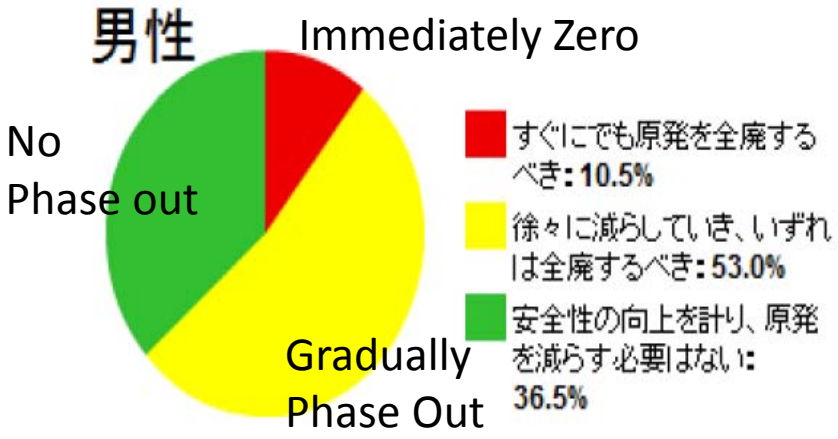
Nuclear

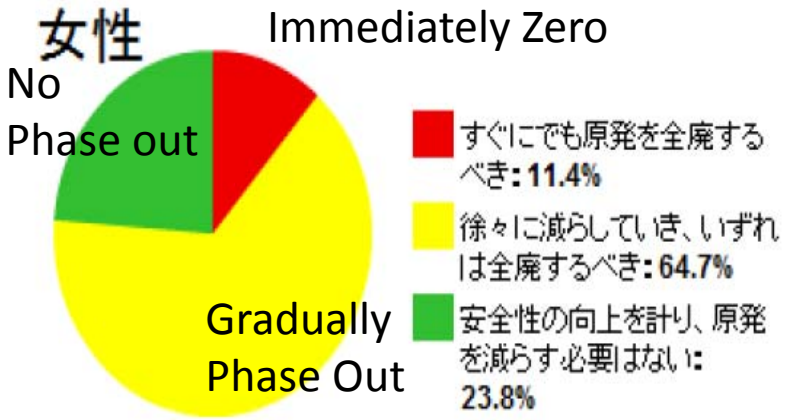
Share	Support
0%	43%
15%	31%
20~25%	11%

Internet Polling Results (2012/08)

- Sample of more than 1 million people -







http://info.nicovideo.jp/enquete/special/genpatsu/201208/index.html

Summery of New Energy and Environmental Strategy（2012/09/14)

1. Realization of a society not dependent on nuclear power in earliest possible future (see the next pages)
2. Realization of a green energy revolution
   - Compose the “Framework for Green Development Policy” by the end of this year
   (1) Power saving: more than 110 billion kWh (~10%) by 2030
   (2) Energy saving: more than 77 million kl (~19%) by 2030
   (3) Renewable energy: more than 300 billion kWh (three times) by 2030
3. Stable supply of energy
   (1) Intensive use of thermal generation
   (2) Intensive use of heat, including cogeneration
   (3) Technologies related to the next generation energy
   (4) Stable and inexpensive securement and supply of fossil fuels
4. Reform of the electric power system
5. Steady implementation of measures against global warming

Source: The Energy and Environment Council, “Innovative Strategy for Energy and Environment,” September 14, 2012. http://www.npu.go.jp/en/policy/policy06/pdf/20120924/20120924_en.pdf

Summery of New Energy and Environmental Strategy (2012/09/14)（on nuclear energy policy）

Realization of “Society not dependent on nuclear power” in earliest possible future

：Mobilize all possible policy resources to such a level as to even enable zero operation of nuclear power plants in the 2030s.

（1）3 Principe guidelines

- Strictly apply 40-year limitation of reactor operation
- Restart the operation of nuclear power plants once the Nuclear Regulation Authority gives safety assurance
- Not to plan the new and additional construction of a nuclear power plant

（2）5 policies to achieve society without dependent on nuclear power (later)

（3）Review and constantly re-examine the path towards realization of a society not dependent on nuclear power

Source: The Energy and Environment Council, “Innovative Strategy for Energy and Environment,” September 14, 2012. http://www.npu.go.jp/en/policy/policy06/pdf/20120924/20120924_en.pdf

5 policies towards realization of a society not dependent on nuclear power

1. The Nuclear Fuel Cycle policy
   - Engage in reprocessing projects with assuming responsibility for the international community
   - Have discussions with related local governments and with the int'l communisty responsibly
     - Launch R&D on direct disposal
     - For "Monju", develop the time-bound research and after harvesting its outcomes, finalize it. Promote R&D on waste treatment (including "burner reactors" and others)
     - The government should also take responsibility on back-end of fuel cycle
     - The gov't will set up a forum with local gov'ts including consumer gov'ts
2. Maintaining and strengthening human resources and technology
   - Develop policies by the end of this year
3. Cooperation with the international community
4. Strengthening measures for local areas with nuclear power facilities
5. Systems of nuclear power projects and the liability system for nuclear-related damages

Armitage/Nye report (CSIS)（2012.8）

- A permanent shutdown will also stymie responsible international nuclear development, as developing countries will continue to build nuclear …Japan cannot afford to fall behind if the world is to benefit from efficient, reliable, and safe reactors and nuclear services.
- Tokyo and Washington must revitalize their alliance in this area…Safe, clean, responsibly developed and utilized nuclear power constitutes an essential element in Japan's comprehensive security. In this regard, U.S.-Japan cooperation on nuclear research and development is essential.

Source: R. Armitage and J. Nye, "The US-Japan Alliance: Anchoring Stability in Asia," A Report of the CSIS Japan Chair. August 2012.

http://csis.org/event/us-japan-alliance-anchoring-stability-asia

Complete U-turn of Nuclear Energy Policy: Need "transition period" (personal view)

- Can achieve "society not dependent on nuclear power" earlier than achieving "nuclear zero"
  - This policy is "reversible" (i.e. keeping the option alive)
- But "nuclear zero" can be "irreversible" policy
  - Need constant review
- "Reprocessing/direct disposal co-existing policy" is appropriate during the transition period.
  - Can maintain flexibility for future uncertainties.
    - UK, Belgium and Switzerland, who withdrew from commercial reprocessing, also adopted such policy
  - "No reprocessing without specific plutonium use plan" should be followed
  - Comprehensive review of Rokkasho project
  - Check and review of Fast Reactor R&D programs, while maintaining basic R&D and international cooperation