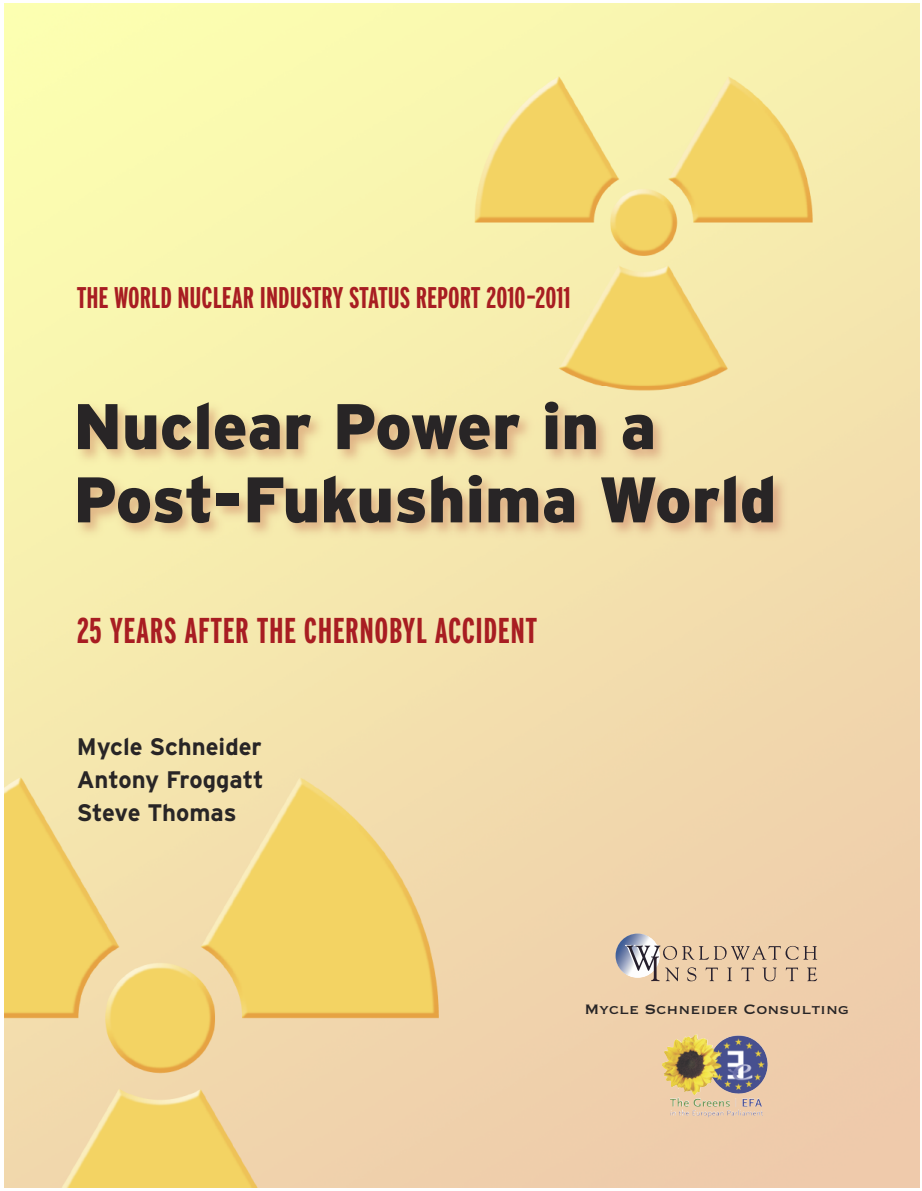
Our Energy Future: Exploring Safe and Sustainable Options

July14,2011

“What role will nuclear power play in our energy future?”

Aileen Mioko Smith (Green Action)

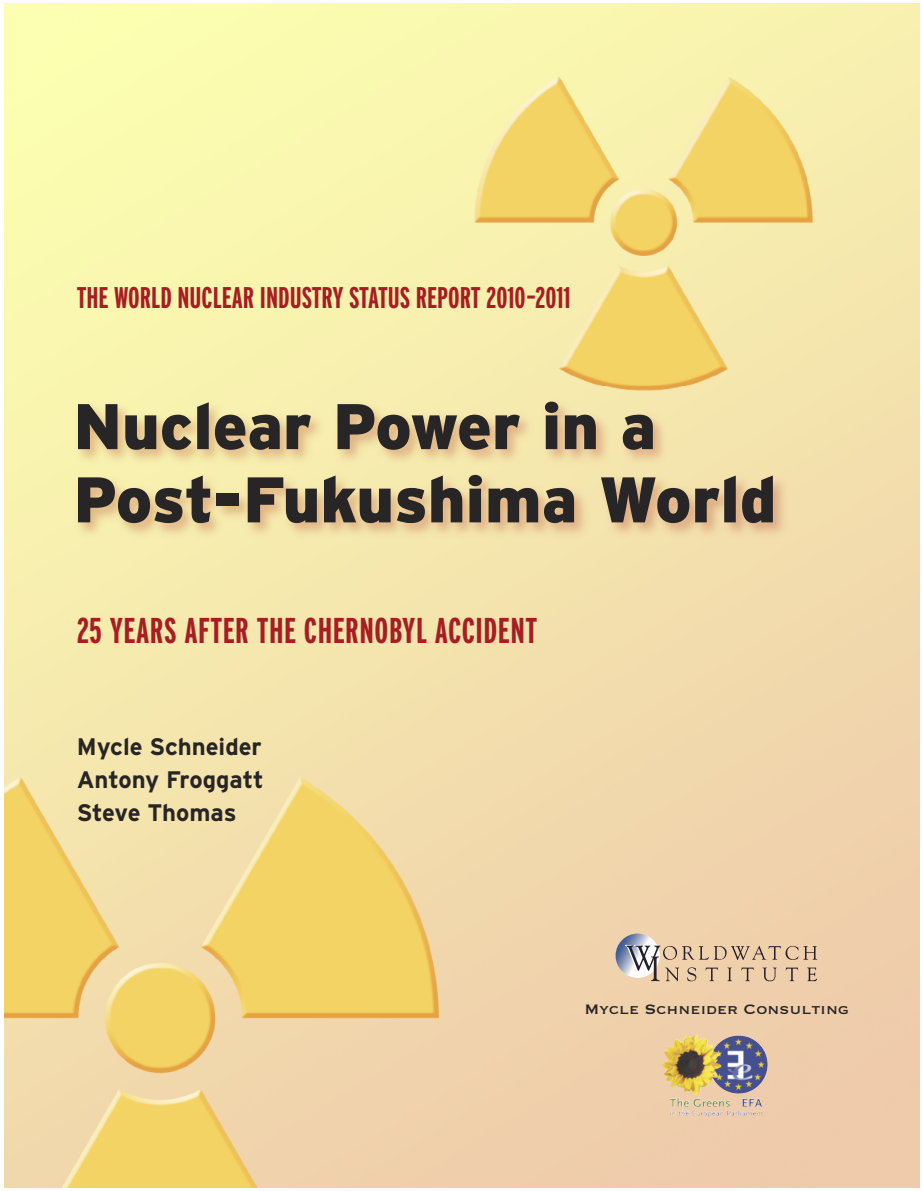


"The role of nuclear power is declining steadily and now accounts for about 13 percent of the world's electricity generation and 5.5 percent of the commercial primary energy."

"In 2009, nuclear power plants generated 2,558 terawatt-hours (TWh) of electricity, about 2 percent less than the previous year."

"The industry's lobby organization the World Nuclear Association headlined 'another drop in nuclear generation'—the fourth year in a row."

"The World Nuclear Industry Status Report 2010-2011 Nuclear Power in a Post-Fukushima World 25 Years After the Chernobyl Accident



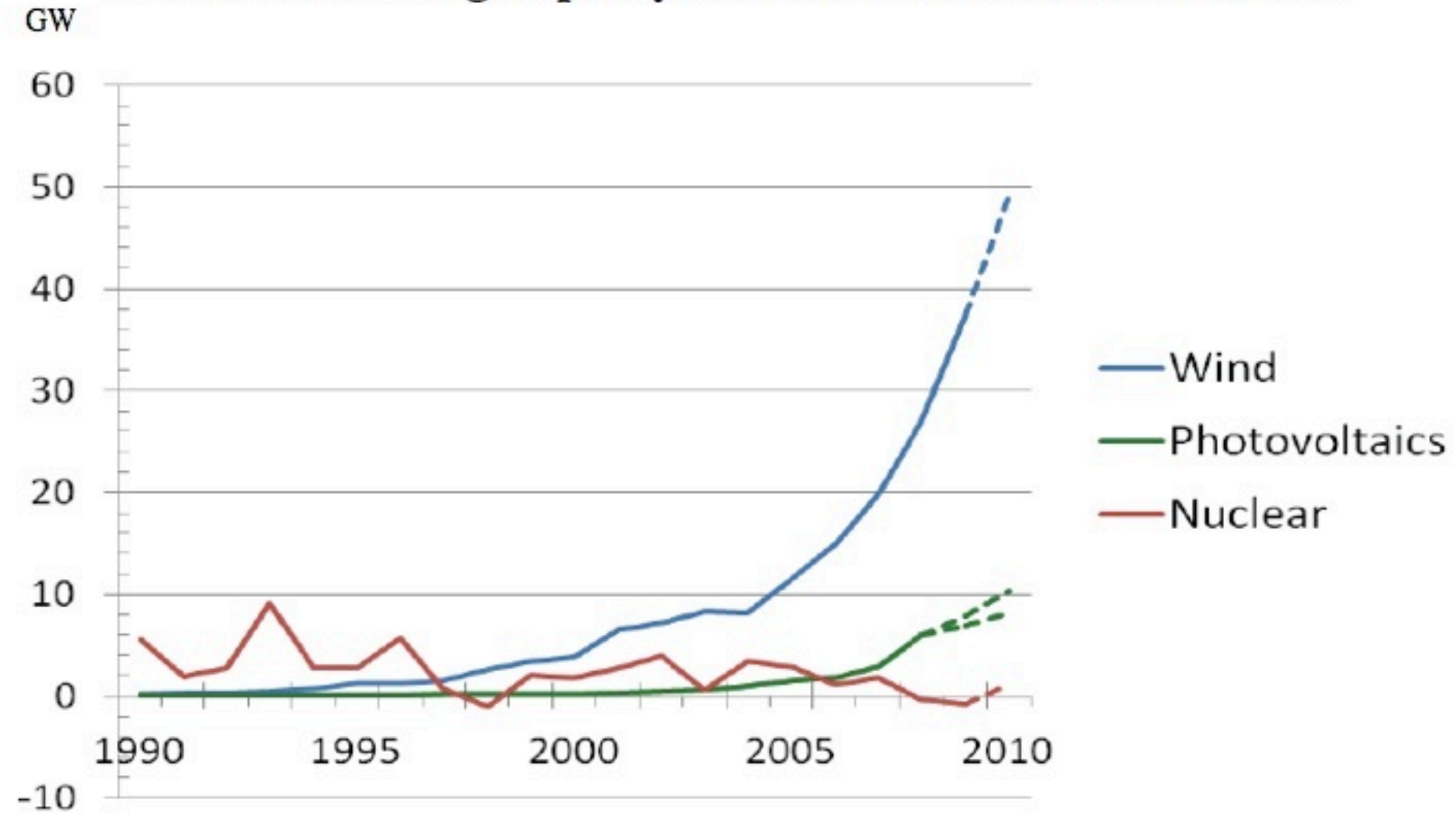
"Annual renewables capacity additions have been outpacing nuclear start-ups for 15 years."

"In 2010, for the first time, worldwide cumulated installed capacity of wind turbines (193 gigawatts), biomass and waste-to-energy plants (65 GW), and solar power (43 GW) reached 381 GW, outpacing the installed nuclear capacity of 375 GW prior to the Fukushima disaster."

"As of April 1, 2011, there were 437 nuclear reactors operating in the world—seven fewer than in 2002."

"The World Nuclear Industry Status Report 2010-2011 Nuclear Power in a Post-Fukushima World 25 Years After the Chernobyl Accident

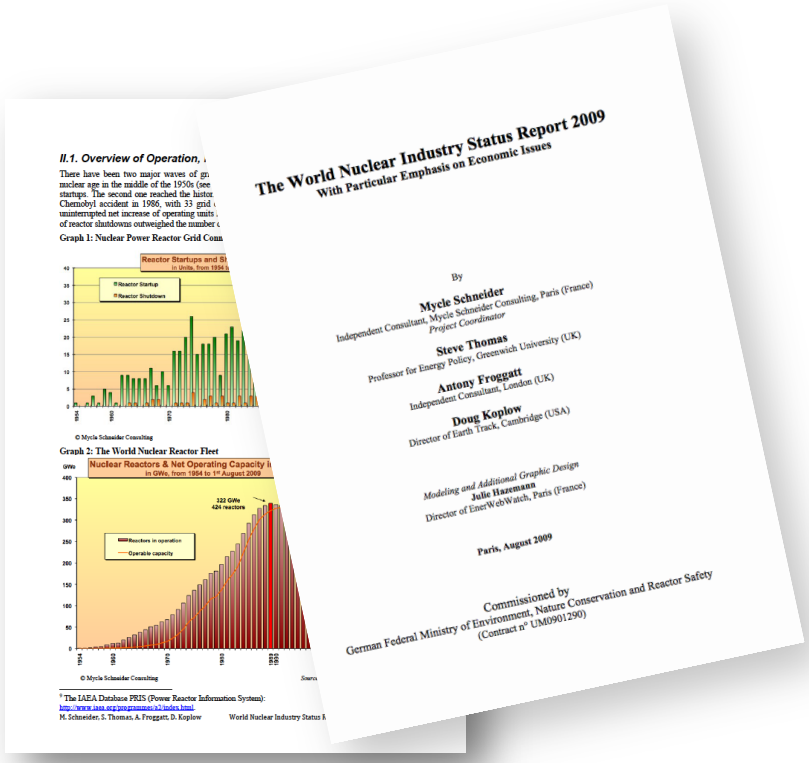
Annual Generating Capacity Additions in the World 1990-2010



Source: Amory Lovins, RMI, personal communication, 2010

German Government Report on Status of Nuclear Industry ---- with Emphasis on Economics

[Excerpt from "Executive Summary and Conclusions" of "The World Nuclear Industry Status Report 2009 -- With Particular Emphasis on Economic Issues"]



"With extremely long lead times of 10 years and more, it will be practically impossible to maintain, let alone increase the number of operating nuclear power plants over the next 20 years."

"The one exception to this outcome would be if operating lifetimes could be substantially increased beyond 40 years *on average* ; there is currently no basis for such an assumption."

"The World Nuclear Industry Status Report 2009 With Particular Emphasis on Economic Issues", SCHNEIDER, THOMAS, FROGGATT, KOPLOW
Commissioned by: German Federal Ministry of Environment, Nature Conservation and Reactor Safety (Contract n° UM0901290) 119 pages.

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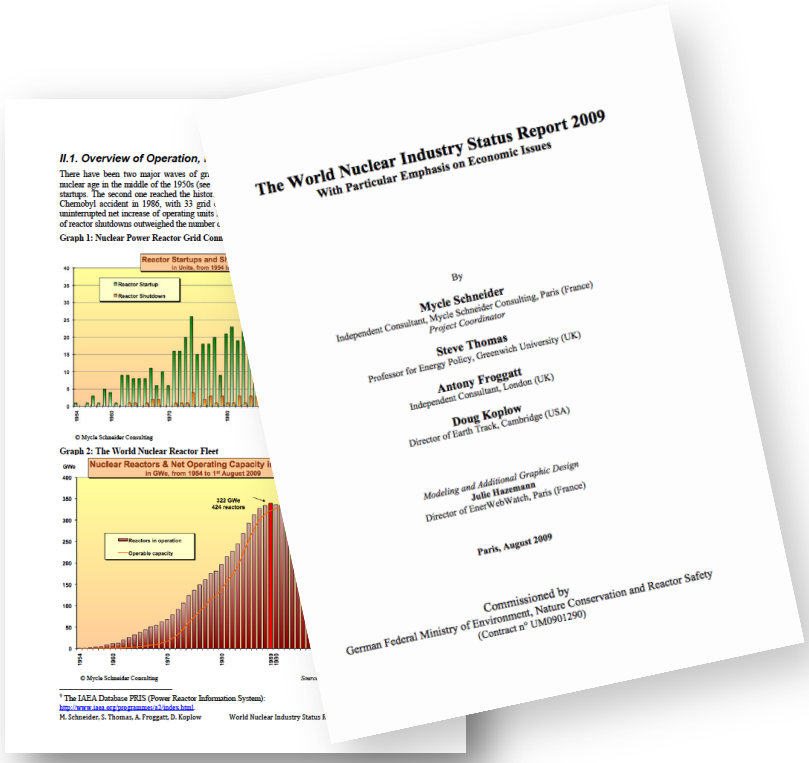


"Lack of a trained workforce and massive loss of competence are probably the most difficult challenges for proponents of nuclear expansion to overcome."

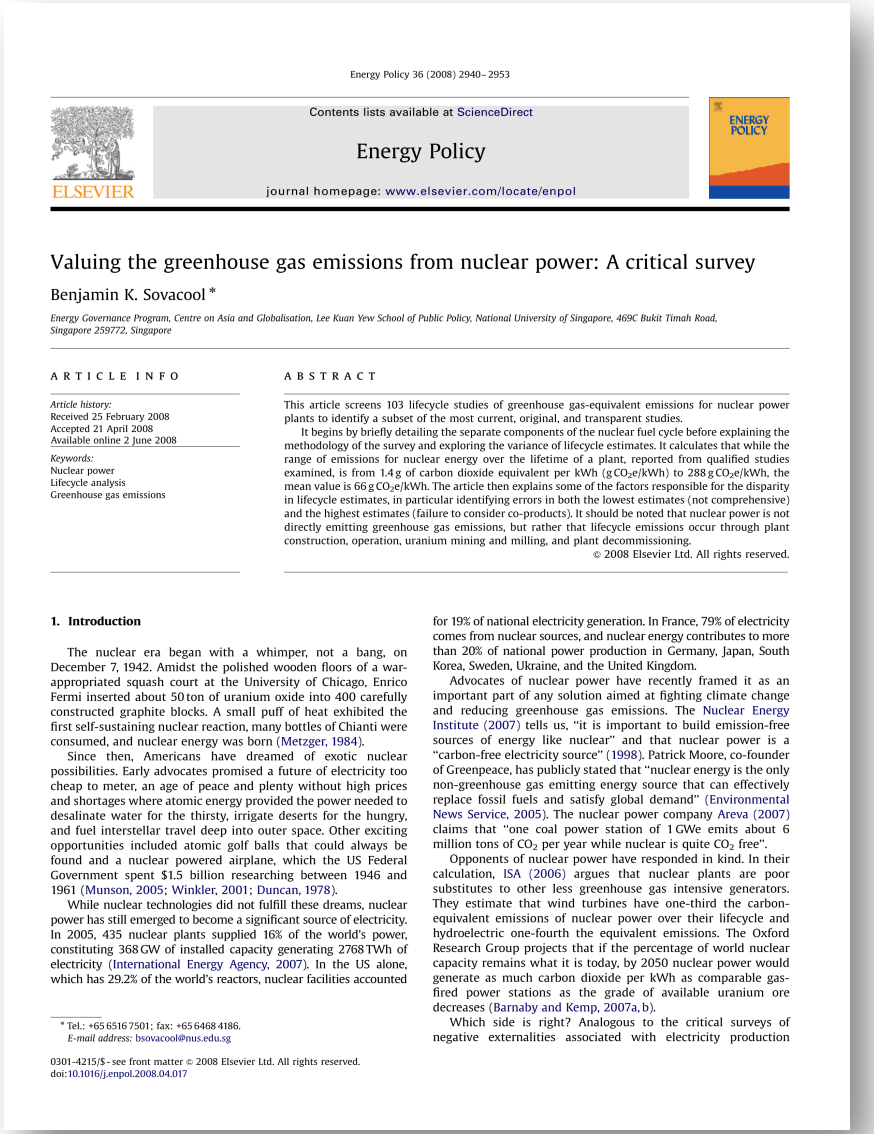
"While many industries experience declining costs as they move out their technological learning curve, the nuclear industry continues to face steadily increasing costs on existing construction and future cost estimates."

"The World Nuclear Industry Status Report 2009 With Particular Emphasis on Economic Issues", SCHNEIDER, THOMAS, FROGGATT, KOPLOW
Commissioned by: German Federal Ministry of Environment, Nature Conservation and Reactor Safety (Contract n° UM0901290) 119 pages.

[This study screened 103 lifecycle studies of greenhouse gas-equivalent emissions for nuclear power plants, identifying a subset of the most current, original, and transparent studies.]

"...the mean value of emissions over the course of the lifetime of a nuclear reactor (reported from qualified studies) is 66g CO_2e/kWh..."

"...nuclear energy is in no way 'carbon free' or 'emissions free,' even though it is much better (from purely a carbon-equivalent emissions standpoint) than coal, oil, and natural gas electricity generators, but worse than renewable and small scale distributed generators."



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Valuing the greenhouse gas emissions from nuclear power: A critical survey

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ABSTRACT

This article screens 103 lifecycle studies of greenhouse gas-equivalent emissions for nuclear power plants to identify a subset of the most current, original, and transparent studies.

It begins by briefly detailing the separate components of the nuclear fuel cycle before explaining the methodology of the survey and exploring the variance of lifecycle estimates. It calculates that while the range of emissions for nuclear energy over the lifetime of a plant, reported from qualified studies examined, is from 1.4 g of carbon dioxide equivalent per kWh (g CO_2e/kWh) to 288 g CO_2e/kWh, the mean value is 66 g CO_2e/kWh. The article then explains some of the factors responsible for the disparity in lifecycle estimates, in particular identifying errors in both the lowest estimates (not comprehensive) and the highest estimates (failure to consider co-products). It should be noted that nuclear power is not directly emitting greenhouse gas emissions, but rather that lifecycle emissions occur through plant construction, operation, uranium mining and milling, and plant decommissioning.

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1. Introduction

The nuclear era began with a whimper, not a bang, on December 7, 1942. Amidst the polished wooden floors of a war-appropriated squash court at the University of Chicago, Enrico Fermi inserted about 50 ton of uranium oxide into 400 carefully constructed graphite blocks. A small puff of heat exhibited the first self-sustaining nuclear reaction, many bottles of Chianti were consumed, and nuclear energy was born (Metzger, 1984).

Since then, Americans have dreamed of exotic nuclear possibilities. Early advocates promised a future of electricity too cheap to meter, an age of peace and plenty without high prices and shortages where atomic energy provided the power needed to desalinate water for the thirsty, irrigate deserts for the hungry, and fuel interstellar travel deep into outer space. Other exciting opportunities included atomic golf balls that could always be found and a nuclear powered airplane, which the US Federal Government spent $1.5 billion researching between 1946 and 1961 (Munson, 2005; Winkler, 2001; Duncan, 1978).

While nuclear technologies did not fulfill these dreams, nuclear power has still emerged to become a significant source of electricity. In 2005, 435 nuclear plants supplied 16% of the world's power, constituting 368 GW of installed capacity generating 2768 TWh of electricity (International Energy Agency, 2007). In the US alone, which has 29.2% of the world's reactors, nuclear facilities accounted for 19% of national electricity generation. In France, 79% of electricity comes from nuclear sources, and nuclear energy contributes to more than 20% of national power production in Germany, Japan, South Korea, Sweden, Ukraine, and the United Kingdom.

Advocates of nuclear power have recently framed it as an important part of any solution aimed at fighting climate change and reducing greenhouse gas emissions. The Nuclear Energy Institute (2007) tells us, "it is important to build emission-free sources of energy like nuclear" and that nuclear power is a "carbon-free electricity source" (1998). Patrick Moore, co-founder of Greenpeace, has publicly stated that "nuclear energy is the only non-greenhouse gas emitting energy source that can effectively replace fossil fuels and satisfy global demand" (Environmental News Service, 2005). The nuclear power company Areva (2007) claims that "one coal power station of 1 GWe emits about 6 million tons of CO_2 per year while nuclear is quite CO_2 free".

Opponents of nuclear power have responded in kind. In their calculation, ISA (2006) argues that nuclear plants are poor substitutes to other less greenhouse gas intensive generators. They estimate that wind turbines have one-third the carbon-equivalent emissions of nuclear power over their lifecycle and hydroelectric one-fourth the equivalent emissions. The Oxford Research Group projects that if the percentage of world nuclear capacity remains what it is today, by 2050 nuclear power would generate as much carbon dioxide per kWh as comparable gas-fired power stations as the grade of available uranium ore decreases (Barnaby and Kemp, 2007a, b).

Which side is right? Analogous to the critical surveys of negative externalities associated with electricity production

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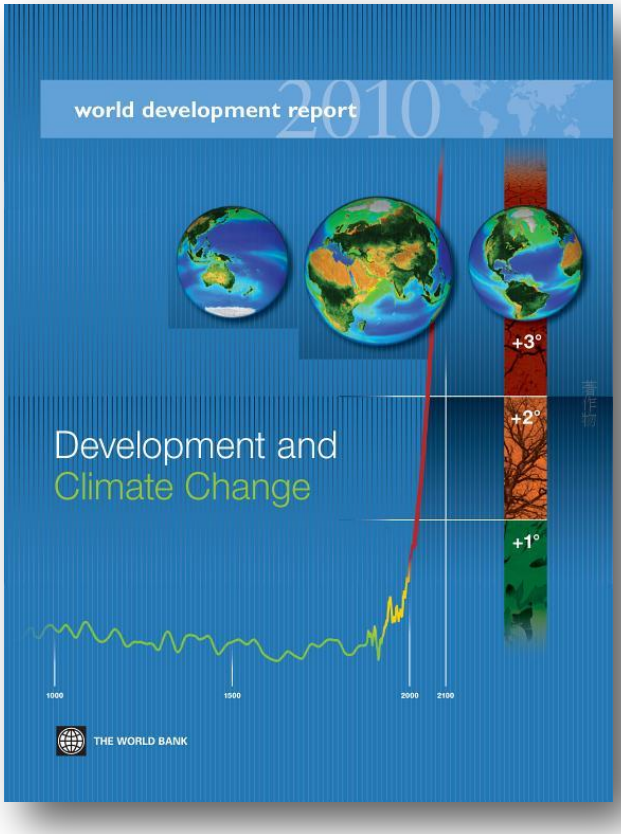
doi:10.1016/j.enpol.2008.04.017

"Valuing the greenhouse gas emissions from nuclear power: A critical survey", Benjamin K. Sovacool, National University of Singapore, Energy Policy 36 (2008) 2940 – 2953, 2June 2008. 14 pages

The World Bank:

Nuclear Power's Limited Short-Term Potential

"Nuclear power has large requirements for capital and highly trained personnel, with long lead times before it comes on line, thus reducing its potential for reducing carbon emissions in the short term."



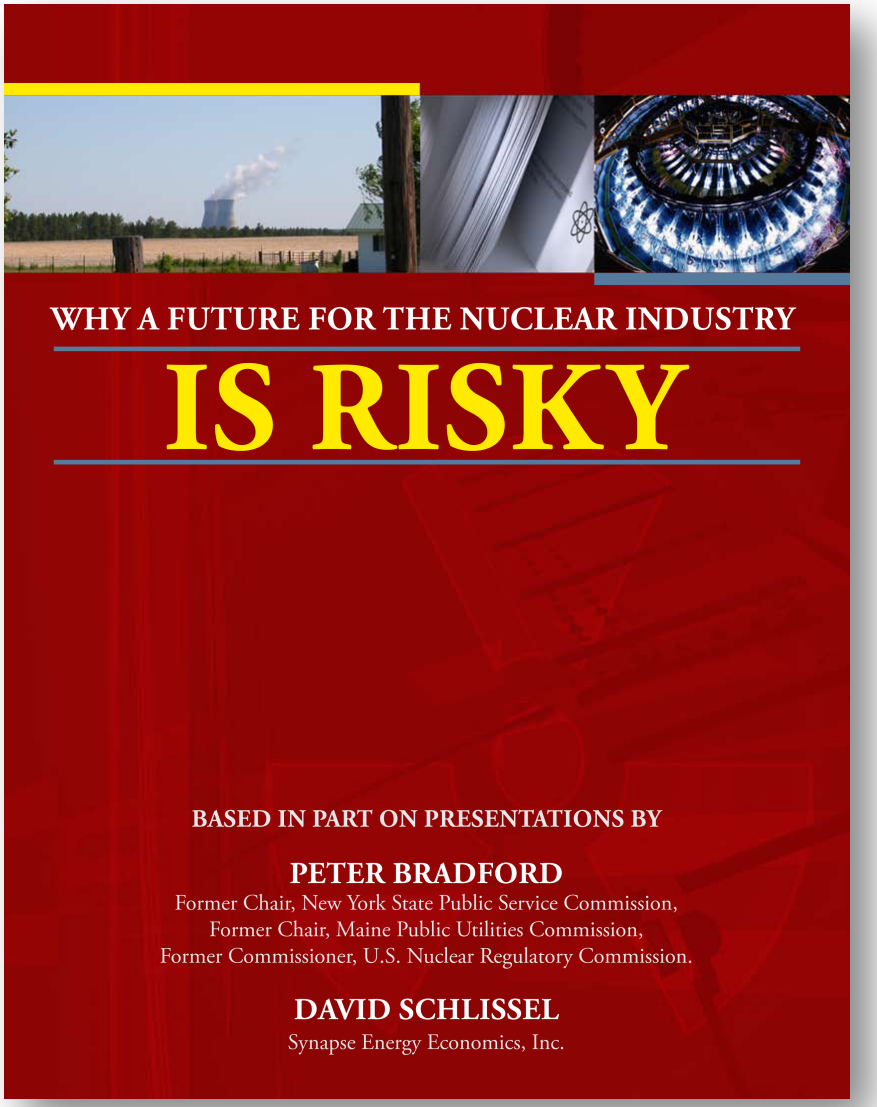
"...the world has limited capacity to manufacture many of the critical components of nuclear plants, and rebuilding that capacity will take at least a decade."

World Development Report 2010—Development and Climate Change (October 2009), World Bank Group ISBN: 978-0-8213-7987-5 p.220.

Former US NRC Commissioner:

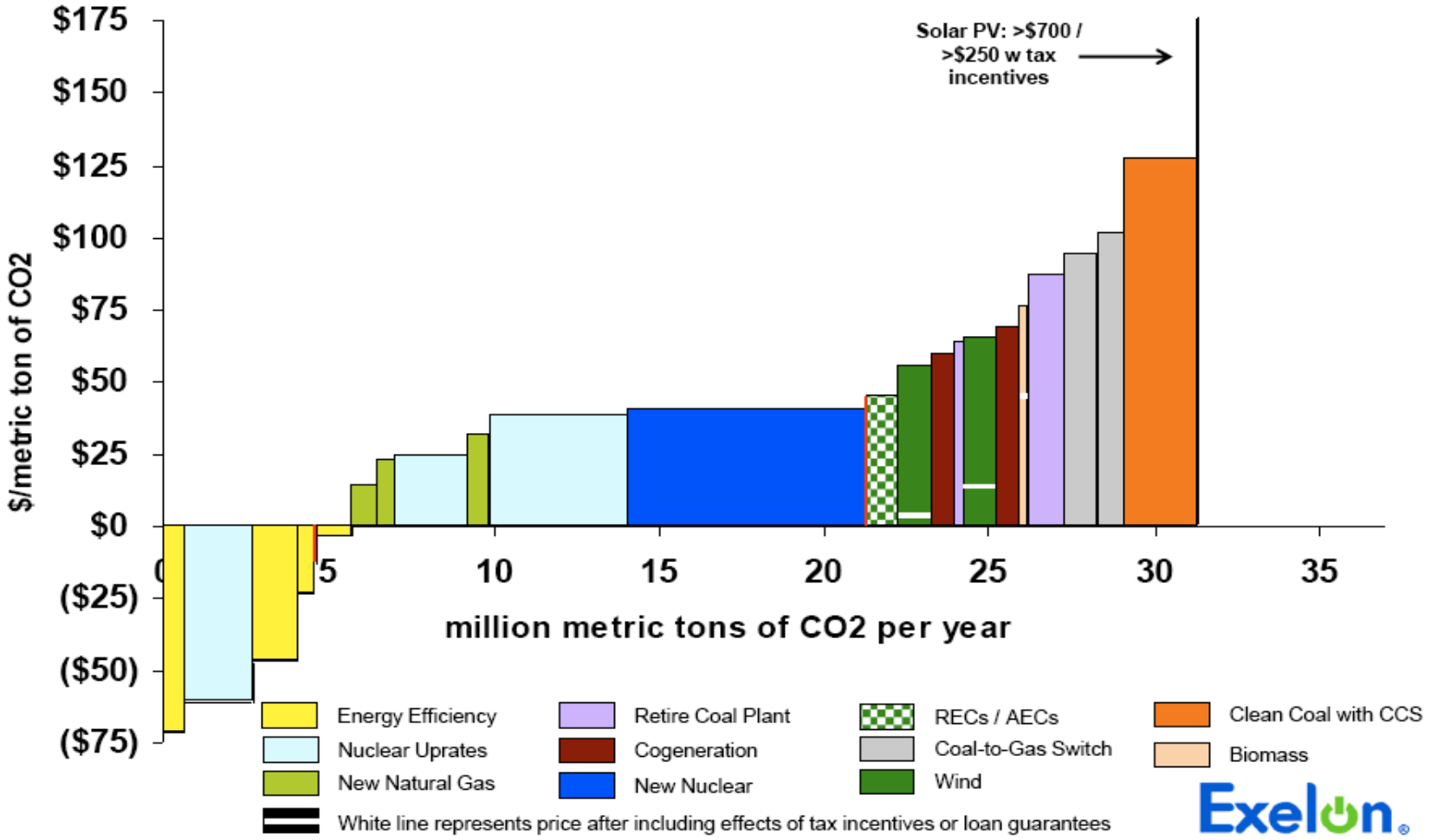
"Building Expensive New Nuclear Power will Divert Private and Public Investment from Options Needed to Protect Our Climate"

"Further investment in nuclear power would squander the limited financial resources that are available to implement meaningful climate change mitigation policies."



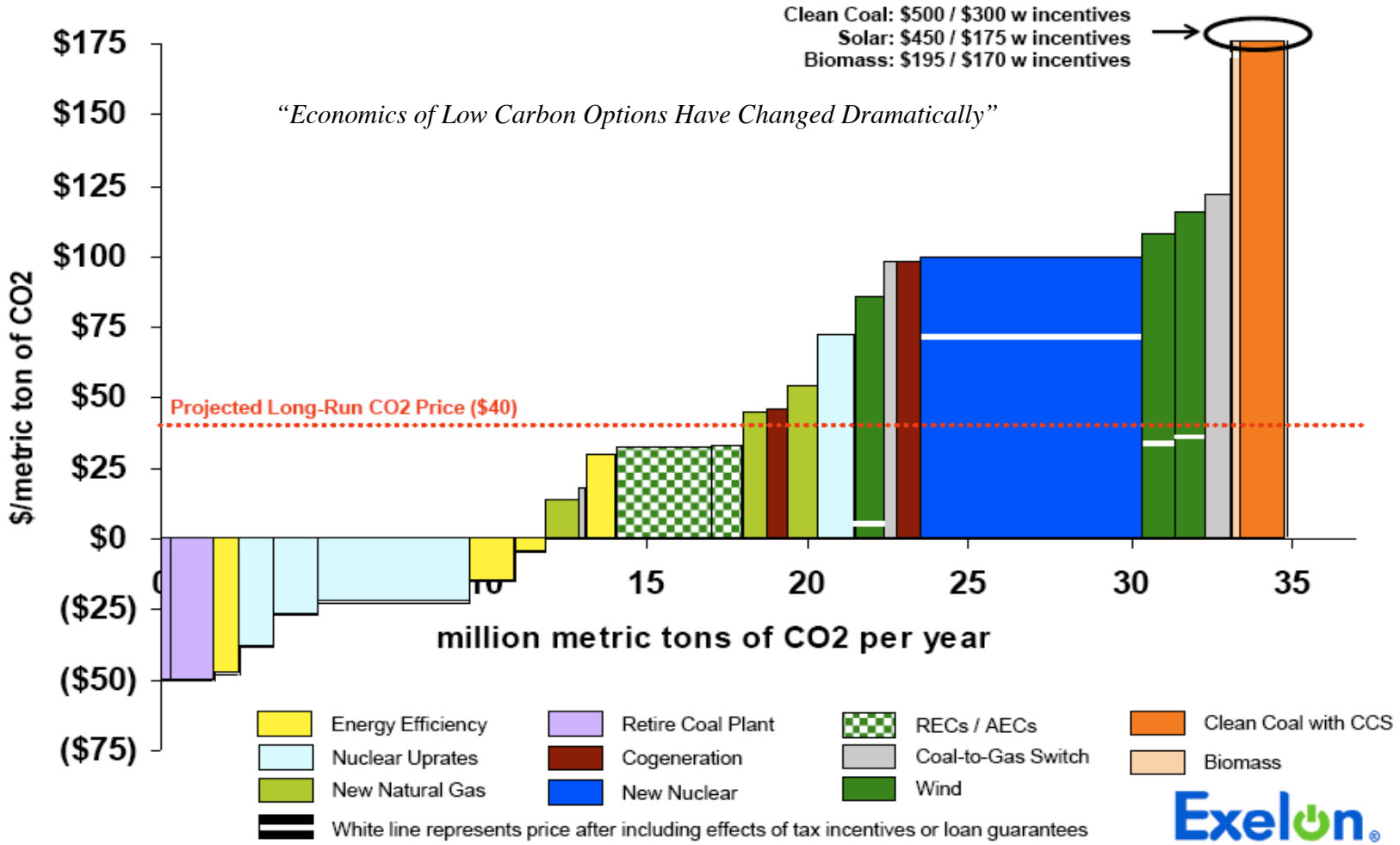
"Why a Future for the Nuclear Industry is Risky". Interfaith Center on Corporate Responsibility (ICCR), etc. Based in part on Presentations by: Peter Bradford (Former Commissioner, U.S. Nuclear Regulatory Commission) David Schlissel (Synapse Energy Economics, Inc.), January 2007. 9 pages.

Exelon's View of Carbon Abatement Options in 2008



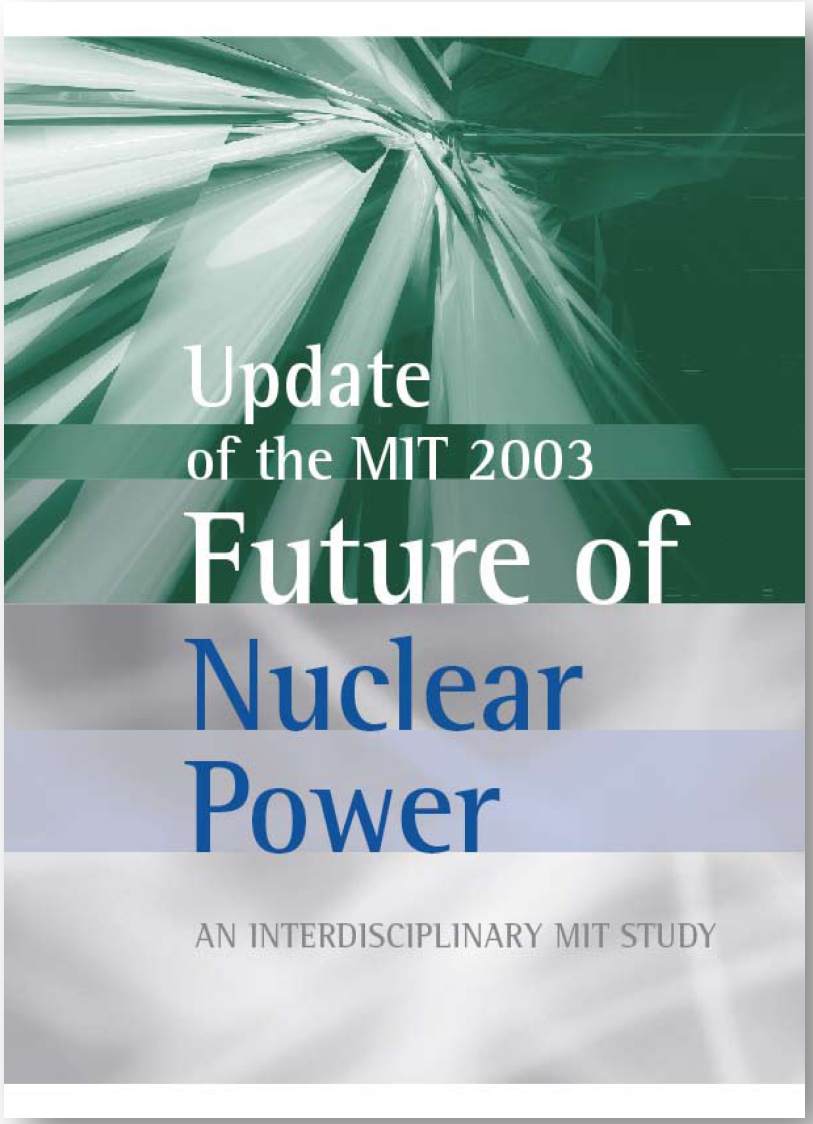
Source: John Rowe, Exelon

Exelon's View of Carbon Abatement Options in 2010



Source: John Rowe, Exelon

MIT on the Future of Nuclear Power



Nuclear investment cost estimate update by the Massachusetts Institute of Technology (MIT) doubled an earlier estimate.

According to the report, the estimated cost of constructing a nuclear power plant has increased at a rate of 15% per year heading into the current economic downturn.

This is based both on the cost of actual builds in Japan and South Korea and on the projected cost of new plants planned for in the United States.

May 2009

"The Future of Nuclear Power" An Interdisciplinary MIT Study---2009 Update to the 2003 Report, Massachusetts Institute of Technology
DEUTCH, FORSBERG, KADAK, KAZIMI, MONIZ, PARSONS, 18 pages / (Original report: 29 July 2003. 170 pages)

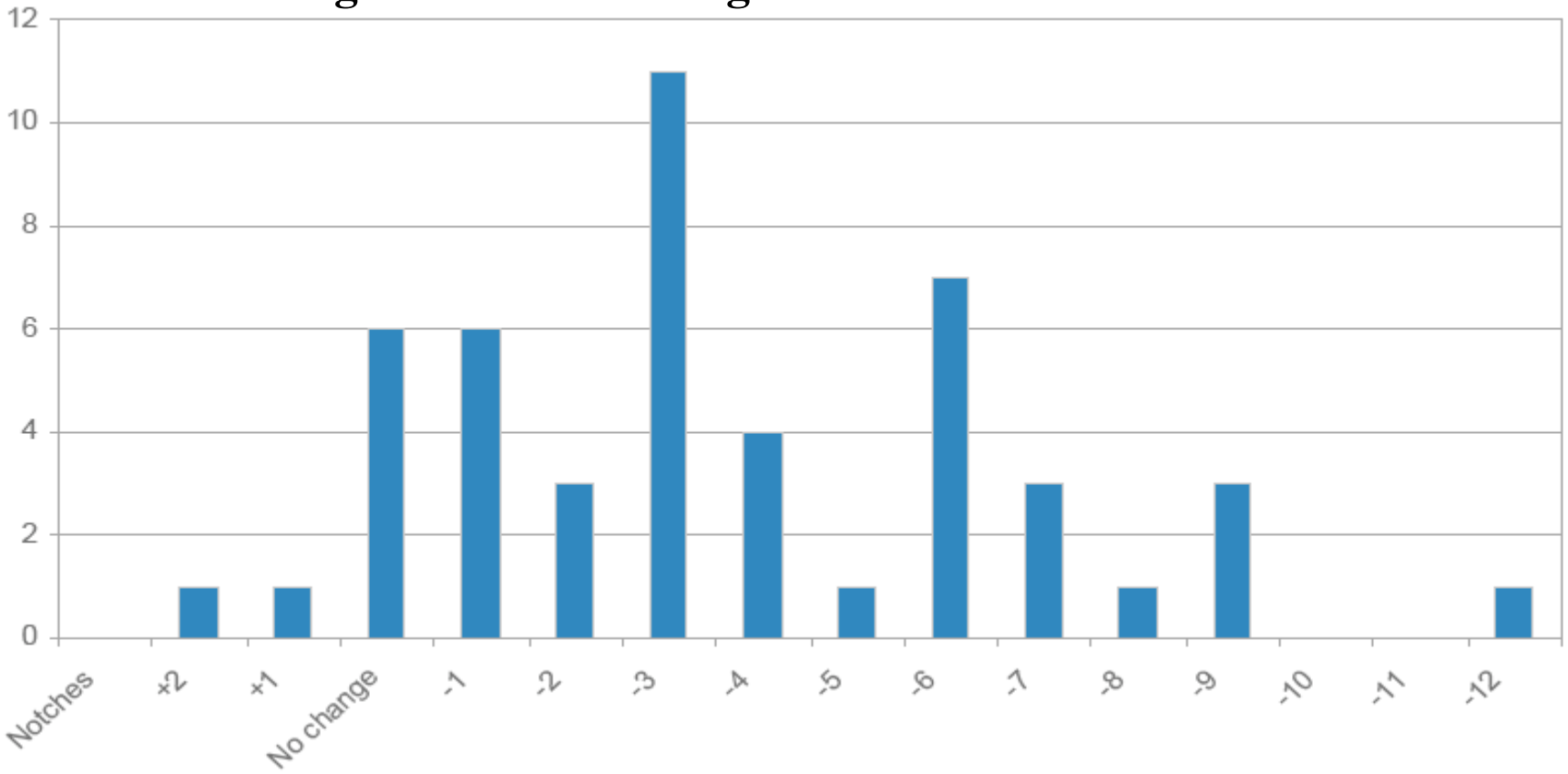
"What is clear is that it is completely impossible to produce definite estimates for new nuclear costs at this time."

Steve Kidd,
Director of Strategy & Research,
World Nuclear Association.

August 2008.

"Comment: Escalating costs of new build: what does it mean?", Nuclear Engineering International, 22 August 2008.

Changes in Credit Rating of 48 US Nuclear Utilities



"Moody's is considering applying a more negative view for issuers that are actively pursuing new nuclear generation."

Source: Moody's, "New Nuclear Generation: Ratings Pressure Increasing", 2009

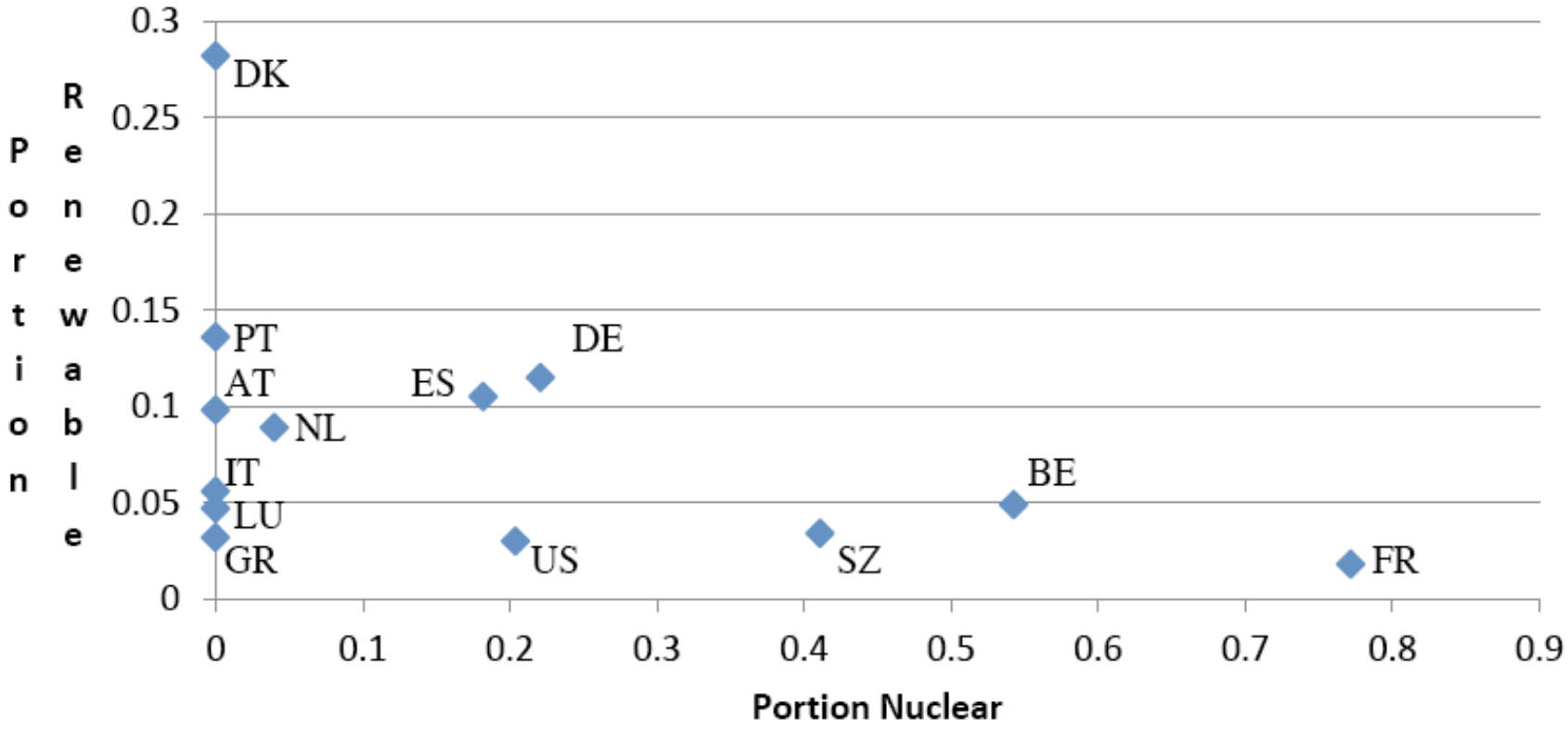
STANDARD &POOR'S

Rating Companies Raise Serious Concerns About Creditworthiness of Companies that Pursue Nuclear Power Plants

"... an electric utility with a nuclear exposure has weaker credit than one without and can expect to pay more on the margin for credit. Federal support of construction costs will do little to change that reality. Therefore, were a utility to embark on a new or expanded nuclear endeavor, Standard & Poor's would likely revisit its rating on the utility."

"Credit Aspects of North American and European Nuclear Power," Standard & Poor's, January 9, 2006.

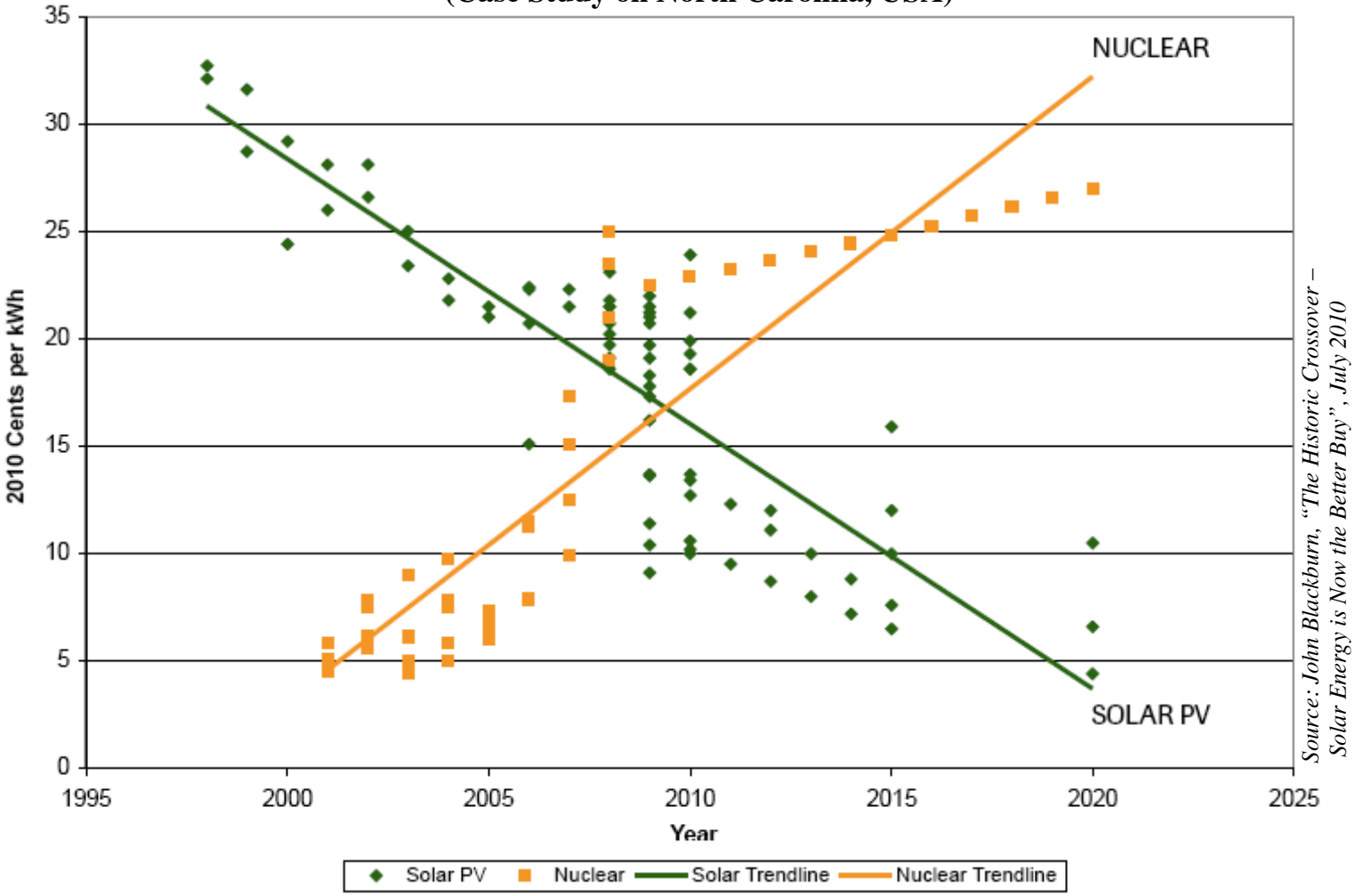
Crowding-out Renewables: Non-Hydro Renewables vs. Nuclear Share



Source: Mark Cooper, "POLICY CHALLENGES OF NUCLEAR REACTOR CONSTRUCTION, COST ESCALATION AND CROWDING OUT ALTERNATIVES", September 2010

Historic Generation Cost Crossover in 2010: Solar PV / New Nuclear

(Case Study on North Carolina, USA)



Source: John Blackburn, "The Historic Crossover – Solar Energy is Now the Better Buy", July 2010

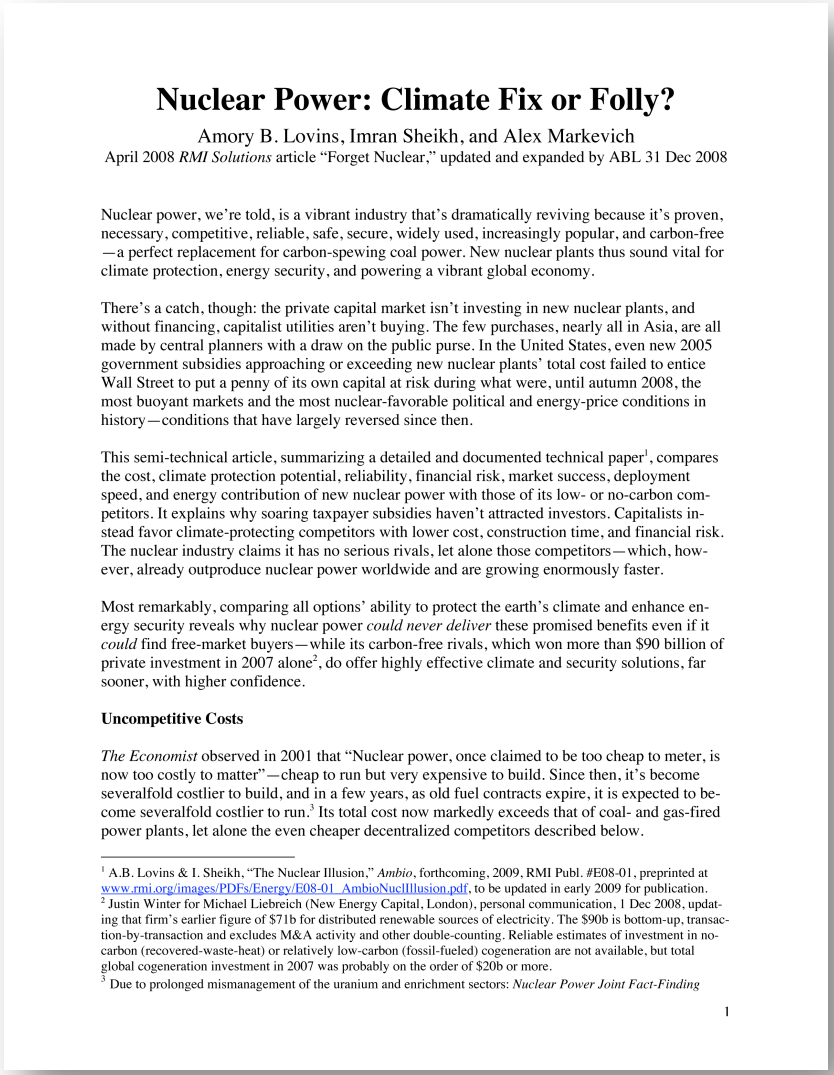
Nuclear Power: Climate Fix or Folly?

Amory B. Lovins

"New nuclear power is so costly that shifting a dollar of spending from nuclear to efficiency protects the climate severalfold more than shifting a dollar of spending from coal to nuclear."

"Indeed, under plausible assumptions, spending a dollar on new nuclear power instead of on efficient use of electricity has a worse climate effect than spending that dollar on new coal power!"

"After more than half a century of devoted effort and a half-trillion dollars of public subsidies, nuclear power still can't make its way in the market."



Nuclear Power: Climate Fix or Folly?

Amory B. Lovins, Imran Sheikh, and Alex Markevich

April 2008 *RMI Solutions* article "Forget Nuclear," updated and expanded by ABL 31 Dec 2008

Nuclear power, we're told, is a vibrant industry that's dramatically reviving because it's proven, necessary, competitive, reliable, safe, secure, widely used, increasingly popular, and carbon-free—a perfect replacement for carbon-spewing coal power. New nuclear plants thus sound vital for climate protection, energy security, and powering a vibrant global economy.

There's a catch, though: the private capital market isn't investing in new nuclear plants, and without financing, capitalist utilities aren't buying. The few purchases, nearly all in Asia, are all made by central planners with a draw on the public purse. In the United States, even new 2005 government subsidies approaching or exceeding new nuclear plants' total cost failed to entice Wall Street to put a penny of its own capital at risk during what were, until autumn 2008, the most buoyant markets and the most nuclear-favorable political and energy-price conditions in history—conditions that have largely reversed since then.

This semi-technical article, summarizing a detailed and documented technical paper[1], compares the cost, climate protection potential, reliability, financial risk, market success, deployment speed, and energy contribution of new nuclear power with those of its low- or no-carbon competitors. It explains why soaring taxpayer subsidies haven't attracted investors. Capitalists instead favor climate-protecting competitors with lower cost, construction time, and financial risk. The nuclear industry claims it has no serious rivals, let alone those competitors—which, however, already outproduce nuclear power worldwide and are growing enormously faster.

Most remarkably, comparing all options' ability to protect the earth's climate and enhance energy security reveals why nuclear power *could never deliver* these promised benefits even if it *could* find free-market buyers—while its carbon-free rivals, which won more than $90 billion of private investment in 2007 alone[2], do offer highly effective climate and security solutions, far sooner, with higher confidence.

Uncompetitive Costs

The Economist observed in 2001 that "Nuclear power, once claimed to be too cheap to meter, is now too costly to matter"—cheap to run but very expensive to build. Since then, it's become severalfold costlier to build, and in a few years, as old fuel contracts expire, it is expected to become severalfold costlier to run.[3] Its total cost now markedly exceeds that of coal- and gas-fired power plants, let alone the even cheaper decentralized competitors described below.

[1] A.B. Lovins & I. Sheikh, "The Nuclear Illusion," *Ambio*, forthcoming, 2009, RMI Publ. #E08-01, preprinted at www.rmi.org/images/PDFs/Energy/E08-01_AmbioNuclIllusion.pdf, to be updated in early 2009 for publication.
[2] Justin Winter for Michael Liebreich (New Energy Capital, London), personal communication, 1 Dec 2008, updating that firm's earlier figure of $71b for distributed renewable sources of electricity. The $90b is bottom-up, transaction-by-transaction and excludes M&A activity and other double-counting. Reliable estimates of investment in no-carbon (recovered-waste-heat) or relatively low-carbon (fossil-fueled) cogeneration are not available, but total global cogeneration investment in 2007 was probably on the order of $20b or more.
[3] Due to prolonged mismanagement of the uranium and enrichment sectors: *Nuclear Power Joint Fact-Finding*

1

"Nuclear Power: Climate Fix or Folly?", RMI Solutions article "Forget Nuclear" updated and expanded by ABL 31 Dec 2008.
LOVINS, SHEIKH, MARKEVICH, Rocky Mountain Institute. 15 pages.

Amory Lovins, Chair & Chief Scientist, Rocky Mountain Institute, Testimony before the Select Committee on Energy Independence and Global Warming, March 12, 2008

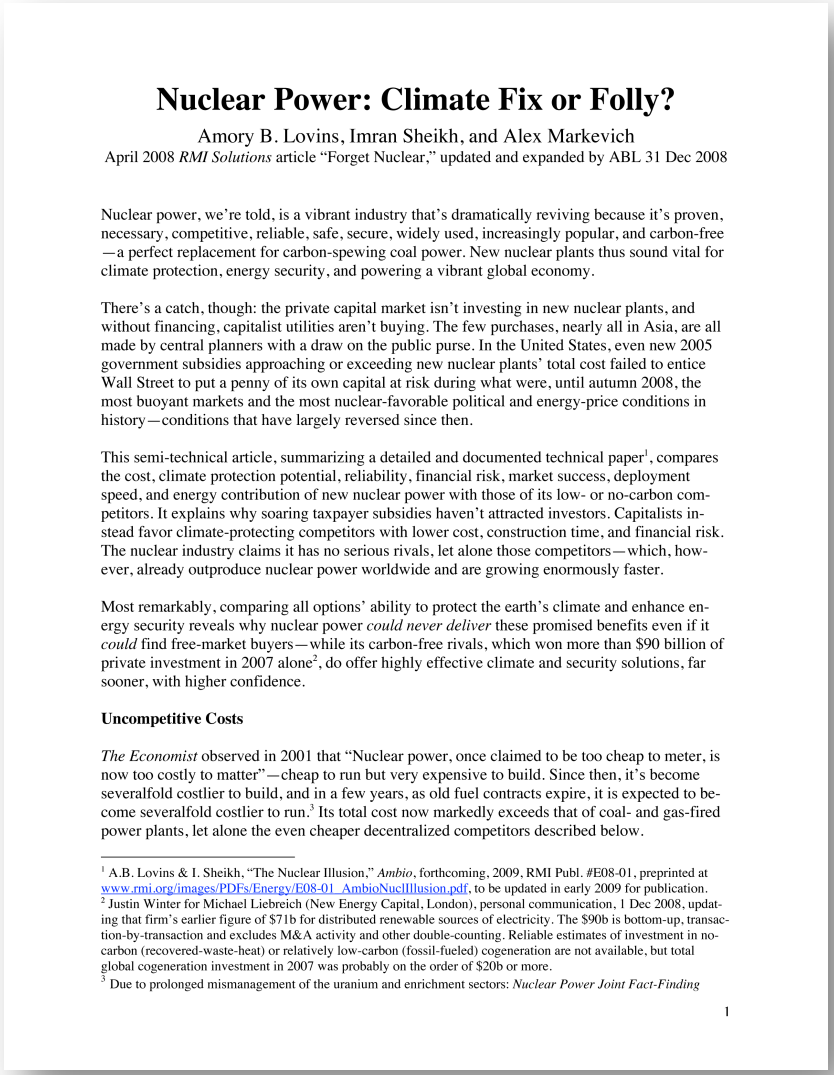
http://www.youtube.com/watch?v=2JkrvSaL7-w

Nuclear Power: Climate Fix or Folly?

Amory B. Lovins

“Saving electricity costs far less than producing and delivering it, even from existing plants.”

“A kilowatt-hour of nuclear power does displace nearly all the 0.9-plus kilograms of CO_2 emitted by producing a kilowatt-hour from coal. But so does a kilowatt-hour from wind, a kilowatt-hour from recovered-heat industrial cogeneration, or a kilowatt- hour saved by end-use efficiency. And all three of these carbon-free resources cost far less than nuclear power per kilowatt-hour, so they save far more carbon per dollar.”



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LOVINS, SHEIKH, MARKEVICH, Rocky Mountain Institute. 15 pages.

Nuclear power: economics and climate-protection potential

AMORY B. LOVINS, CEO, ROCKY MOUNTAIN INSTITUTE, WWW.RMI.ORG

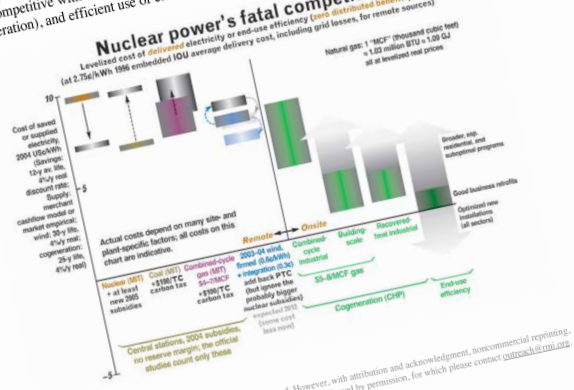
11 September 2005, updated 6 January 2006

Copyright © Rocky Mountain Institute 2005. All rights reserved. Posted at www.rmi.org/sitepages/pid171.php#E05-14.

Abstract

Nuclear power is often described as a big, fast, and vital energy option—the only practical and proven source big and fast enough to do much to abate climate change. Yet industry and government data tell the opposite story. Nuclear power worldwide has less installed capacity and generates less electricity than its decentralized no- and low-carbon competitors—one-third renewables (excluding big hydroelectric dams), two-thirds fossil-fueled combined-heat-and power. In 2004, these rivals added nearly three times as much output and six times as much capacity as nuclear power added; by 2010, industry forecasts this sixfold ratio to widen to 136–184 as nuclear orders fade, then nuclear capacity gradually disappears as aging reactors retire. These comparisons don't count more efficient use of electricity, which isn't being tracked, but efficiency gains *plus* decentralized sources now add at least ten times as much capacity per year as nuclear power.

All the meager nuclear orders nowadays come from centrally planned electricity systems, because despite strong official support and greatly increased U.S. subsidies, nuclear power's bad economics make it unfinanceable in the private capital market. Official studies compare new nuclear plants only with coal- or gas-fired central stations. But all three kinds of central stations are uncompetitive with windpower and some other renewables, combined-heat-and power (cogeneration), and efficient use of electricity, all compared on a consistent accounting basis:



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Highlights Series from RMI2009: From Ideas to Solutions

(Use the arrows on either side to navigate through all the RMI2009 videos.)


MONJU

19 June 2010

[APEC 9th Energy Ministerial Meeting. Fukui, Japan. June 18 - 20, 2010]

Has the "fast breeder" nuclear reactor been good for Japan's energy?

Monju, Japan's prototype fast breeder reactor (280 MWe). Fukui,Japan

Monju was restarted May 6, 2010, after being closed for 14 years 5 months.

Q: What is this? **9,054 yen/kWh**

A: It is the cost of electricity produced at "Monju".

Monju has cost 926.5 billion yen so far (June 2010)* and produced 102,325 MWh of electricity.

[Production of electricity occurred in 1995 only.]

*926.5 billion yen is equivalent to US$10.2 billion, or, 8.3 billion Euros. (Exchange rate: 17 June 2010)

The cost of electricity produced at Monju comes to 9054 yen per kilowatt - hour. (926.5 billion yen / 102,325 MWh)

This is equivalent to $99 per kilowatt - hour, or, 81 Euros per kilowatt - hour.

(Data for calculation provided by Japan Atomic Energy Agency (JAEA), owner-operator of "Monju".)

Commercialization of the FBR postponed 8 times.

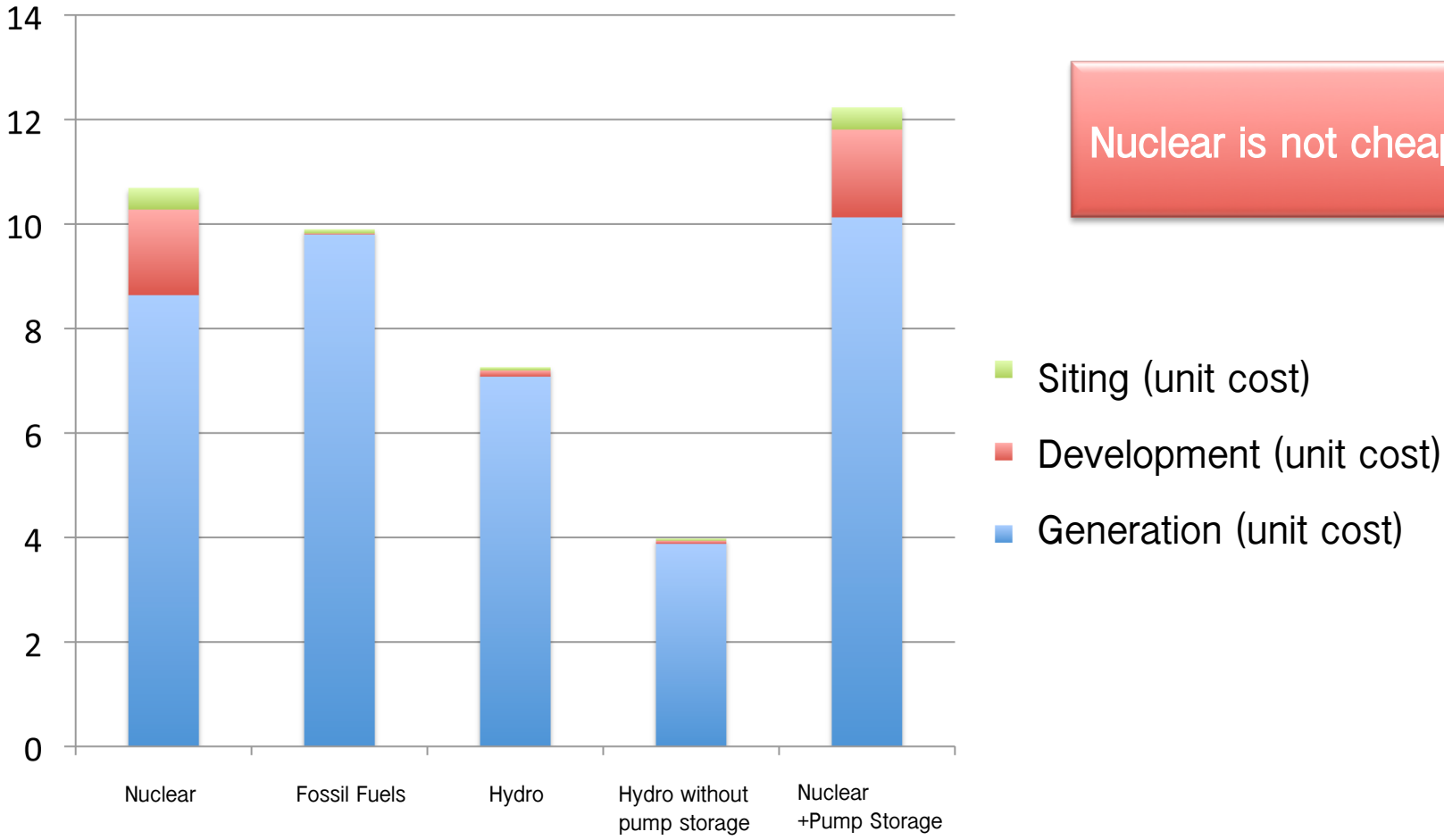
Original date of commercialization: “by around 1970”
Current date of commercialization: “by around 2050”

Year of Plan	Date for Commercialization
1961	By around 1970
1967	No date
1973	1985~95
1978	1995-2005
1982	During the 2010’s
1987	During the 2020’s
1994	Around 2030
2000	No date
2006	By around 2050

In June 2010, Shunsuke Kondo, chair of the Japan Atomic Energy Commission on commercialization of the FBR:

"It's not as though it (the date) has been decided.”

Actual Costs of Electricity Generation (fiscal years 1970 - 2007)



Nuclear is not cheap.

Table compiled by: Kenichi Oshima, College of International Relations, Ritsumeikan University

Public Funding (Unit Costs: Development/Siting)

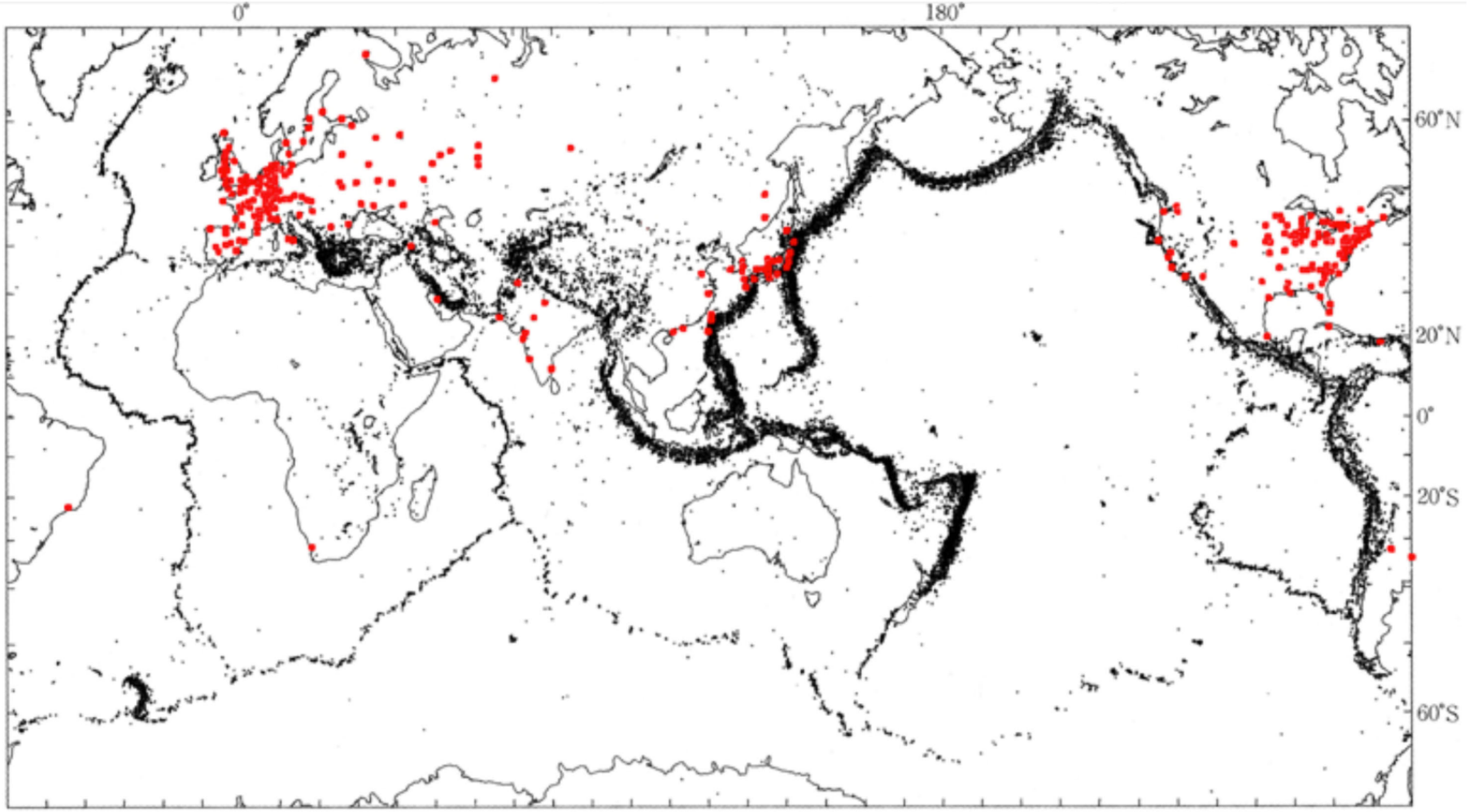
		Nuclear	Fossil Fuels	Hydro	Hydro without pump storage	Pump Storage	Nuclear +Pump Storage
1970年代	Development	4.19	0.00	0.00	0.00	0.00	4.31
	Siting	0.53	0.03	0.02	0.01	0.36	0.54
1980年代	Development	2.26	0.02	0.14	0.08	1.52	2.31
	Siting	0.37	0.06	0.04	0.03	0.35	0.38
1990年代	Development	1.49	0.02	0.22	0.11	1.16	1.54
	Siting	0.38	0.10	0.08	0.06	0.29	0.39
2000年代	Development	1.18	0.01	0.10	0.05	0.60	1.21
	Siting	0.46	0.11	0.10	0.07	0.38	0.47
1970-2007年	Development	1.64	0.02	0.12	0.06	0.94	1.68
	Siting	0.41	0.08	0.06	0.04	0.34	0.42

Unite: Yen/kWh

Table compiled by: Kenichi Oshima, College of International Relations, Ritsumeikan University

Worldwide Distribution of Earthquakes (black dots) and Nuclear Power Plants (red dots)

Graph: Nobuo Kasai, http://sites.google.com/site/hamaokareport/earth

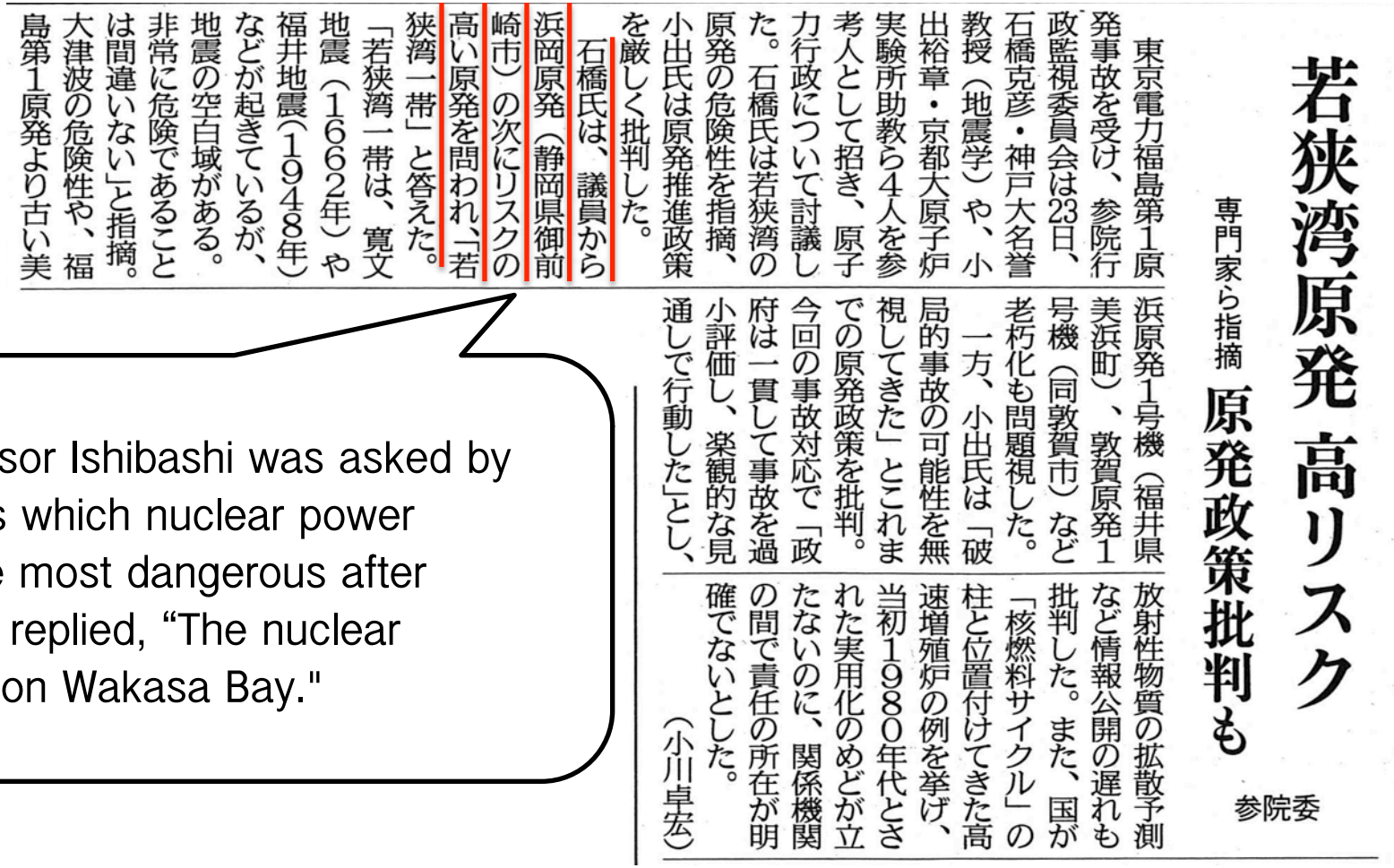


Nuclear power plant locations: International Nuclear Safety Center

Wakasa Bay Nuclear Power Plants at High Risk

Experts Point Out---Also Criticize Nuclear Power Policy

At Diet, House of Councillors



若狭湾原発 高リスク

専門家ら指摘 原発政策批判も

参院委

東京電力福島第1原発事故を受け、参院行政監視委員会は23日、石橋克彦・神戸大名誉教授（地震学）や、小出裕章・京都大原子炉実験所助教ら4人を参考人として招き、原子力行政について討議した。石橋氏は若狭湾の原発の危険性を指摘、小出氏は原発推進政策を厳しく批判した。

石橋氏は、議員から浜岡原発（静岡県御前崎市）の次にリスクの高い原発を問われ、「若狭湾一帯」と答えた。「若狭湾一帯は、寛文地震（1662年）や福井地震（1948年）などが起きているが、地震の空白域がある。非常に危険であることは間違いない」と指摘。大津波の危険性や、福島第1原発より古い美浜原発1号機（福井県美浜町）、敦賀原発1号機（同敦賀市）など老朽化も問題視した。

一方、小出氏は「破局的事故の可能性を無視してきた」とこれまでの原発政策を批判。今回の事故対応で「政府は一貫して事故を過小評価し、楽観的な見通しで行動した」とし、放射性物質の拡散予測など情報公開の遅れも批判した。また、国が「核燃料サイクル」の柱と位置付けてきた高速増殖炉の例を挙げ、当初1980年代とされた実用化のめどが立たないのに、関係機関の間で責任の所在が明確でないとした。（小川卓宏）

"When Professor Ishibashi was asked by Diet members which nuclear power plants are the most dangerous after Hamaoka, he replied, “The nuclear power plants on Wakasa Bay."

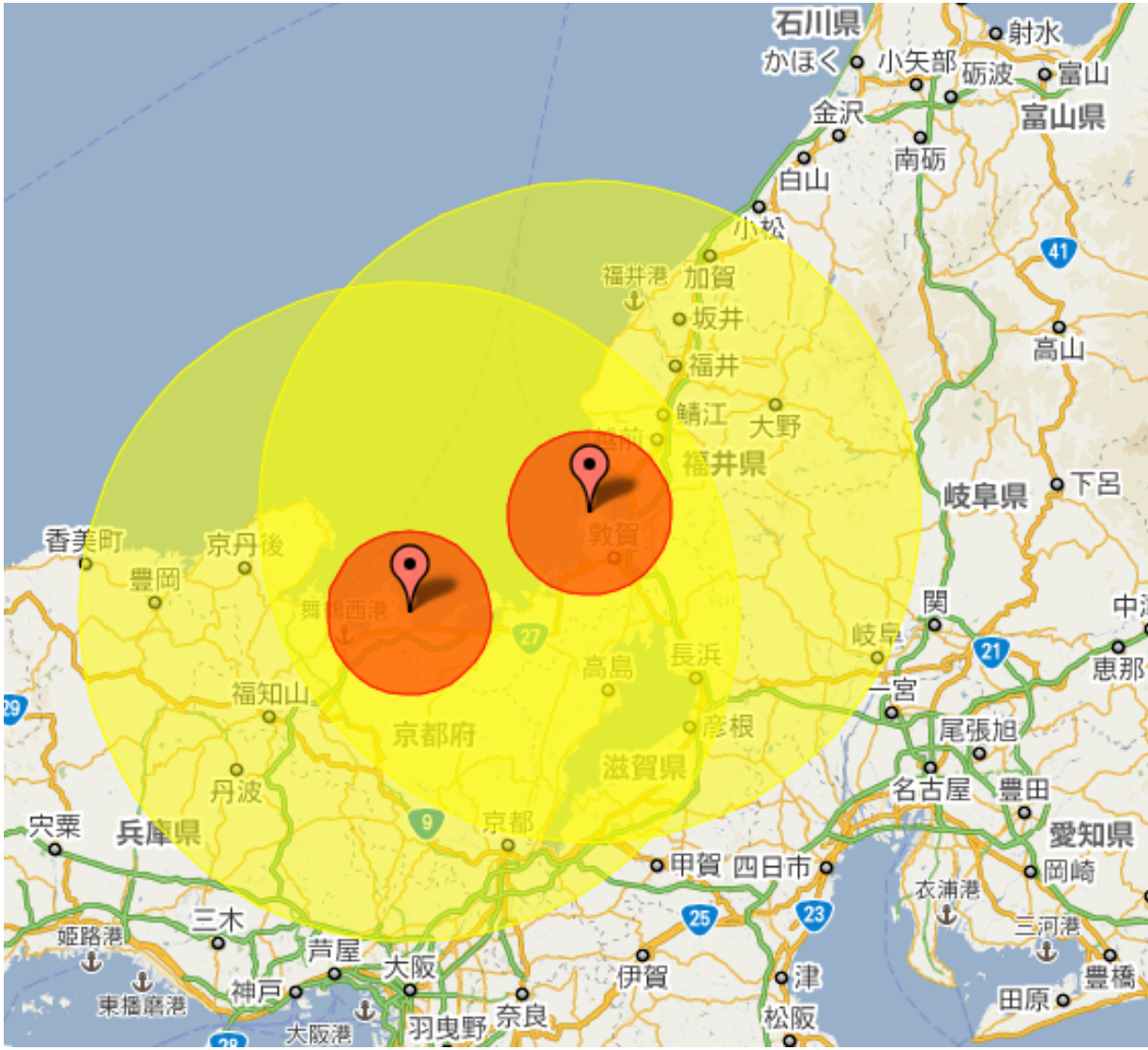
Kyoto Shimbun 24 May 2011

Overlay of Fukushima evacuation zone and US Government No-Go Zone

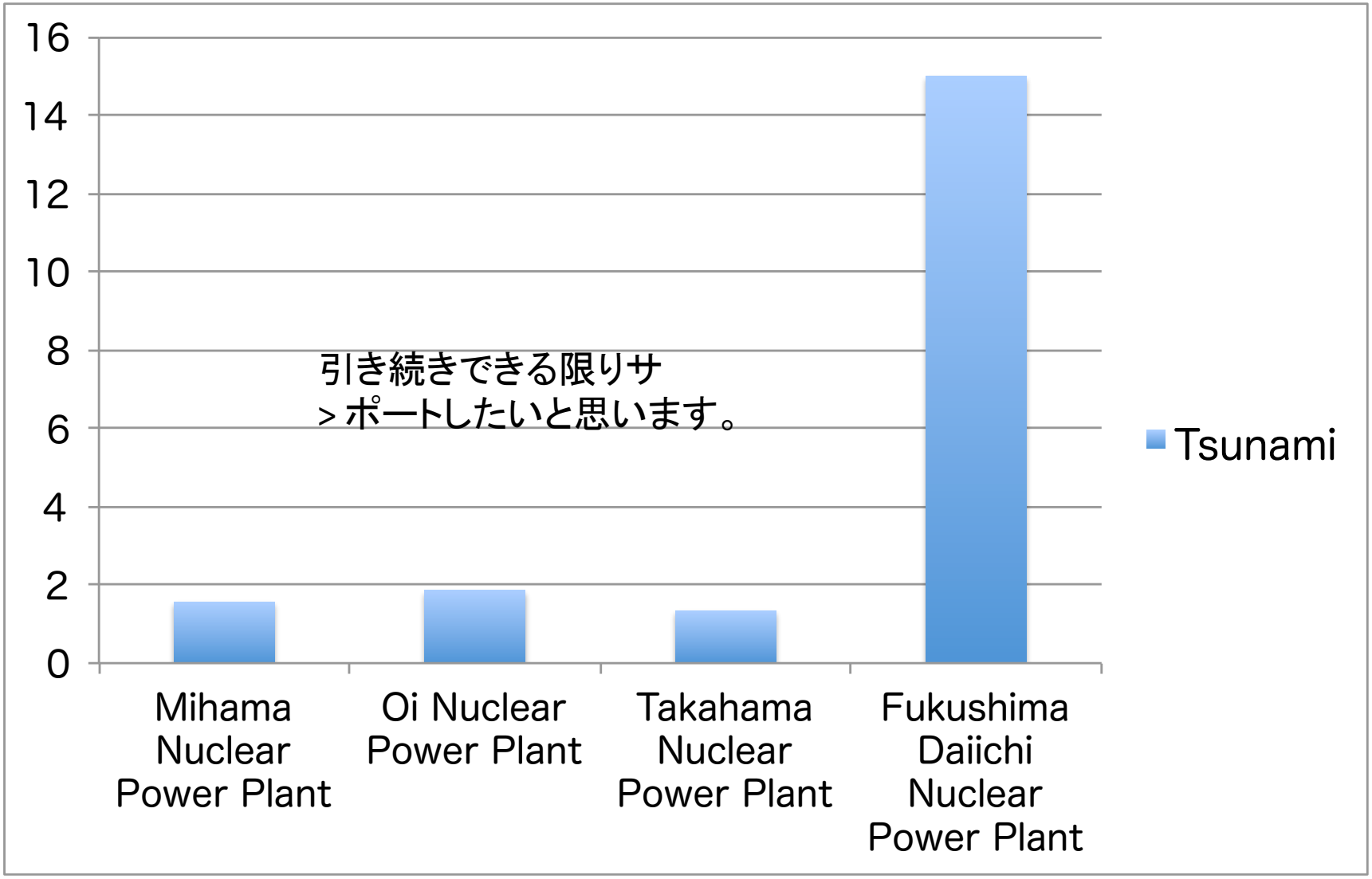
Orange is Fukushima evacuation zone

Yellow is US Nuclear Regulatory Commission recommendation zone: 50miles (80 kilometers)

The Yellow Zone extends to cover Lake Biwa

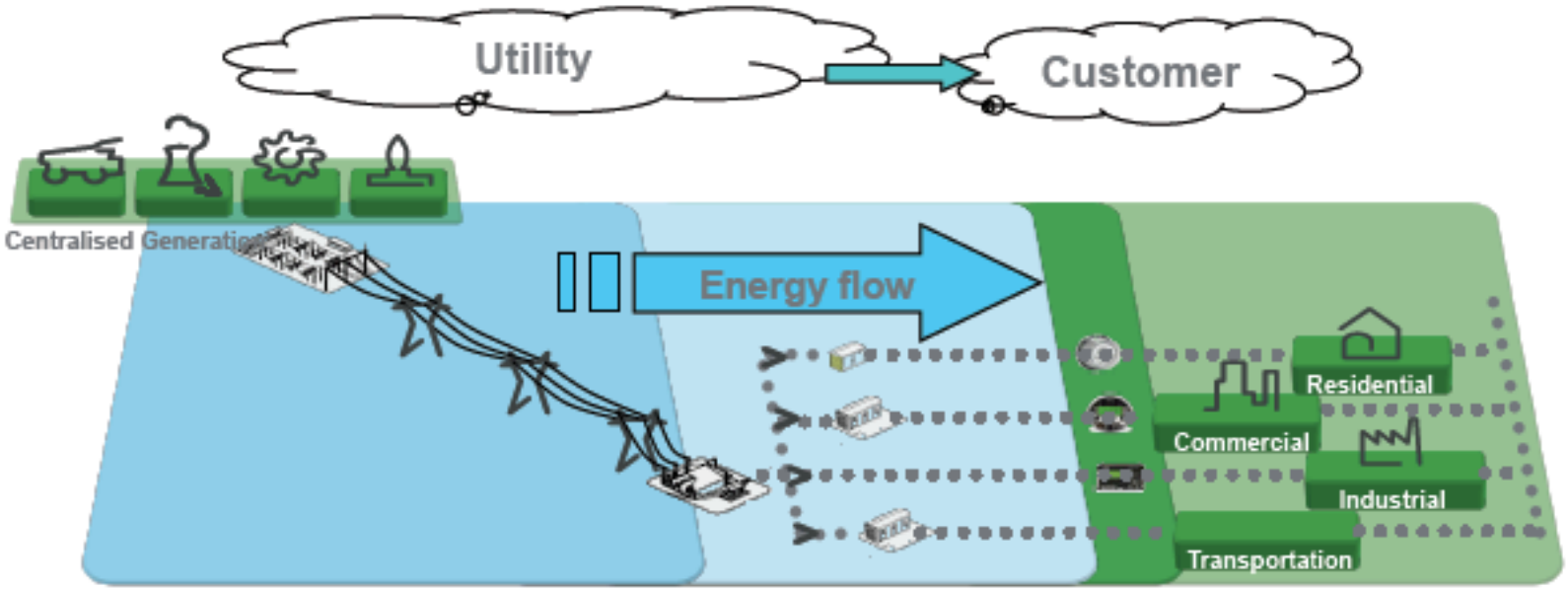


Tsunami Estimates and Actual Tsunami that Hit Fukushima Daiichi



The Traditional Electricity Grid

- **Central production** adapting to demand variation
- **Top-down** energy flow
- Production / consumption balance done by **integrated utility companies**
- Rather **passive users**



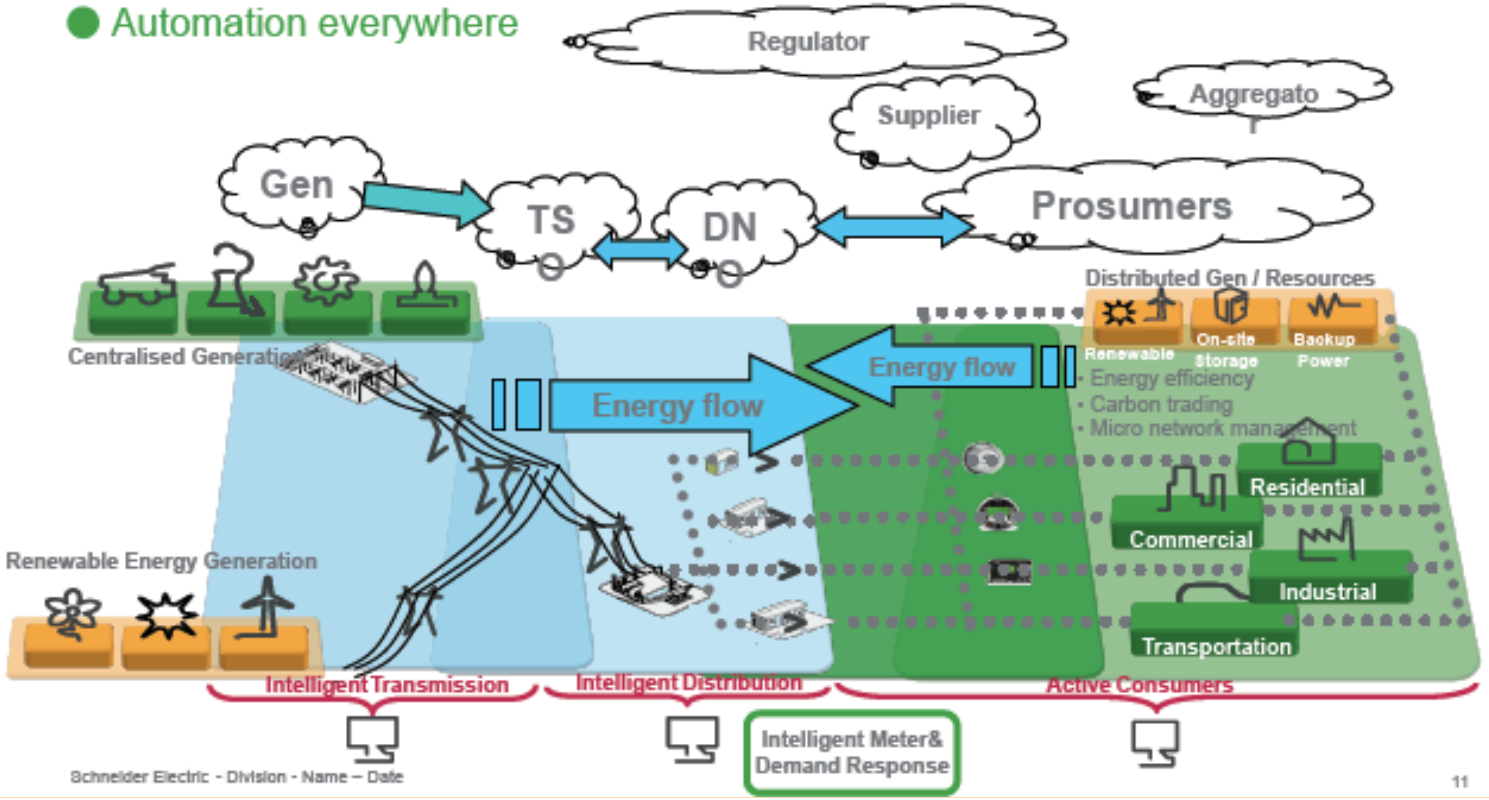
Source: Sanjay Verma, Manila, June 2010

The Smarter Grid with New Requirements

- New roles and contribution (Prosumers ….)
- Behavioural changes
- Best use of communication technologies
- Real time & visibility
- Automation everywhere

But also

- Energy Efficiency
- Renewable decentralized sources
- Energy storage



Source: Sanjay Verma, Manila, June 2010

The energy future lies in affordable, distributed, superefficient technologies, smart grids and sustainable urbanism. Nuclear policy – centralized, inflexible and generally autocratic – symbolizes the opposite.

The perpetuation of nuclear energy will massively hinder rather than favour the urgent implementation of reliable, sustainable energy policies.

Lessons from System Analysis of Energy Policy in the US, France and Germany

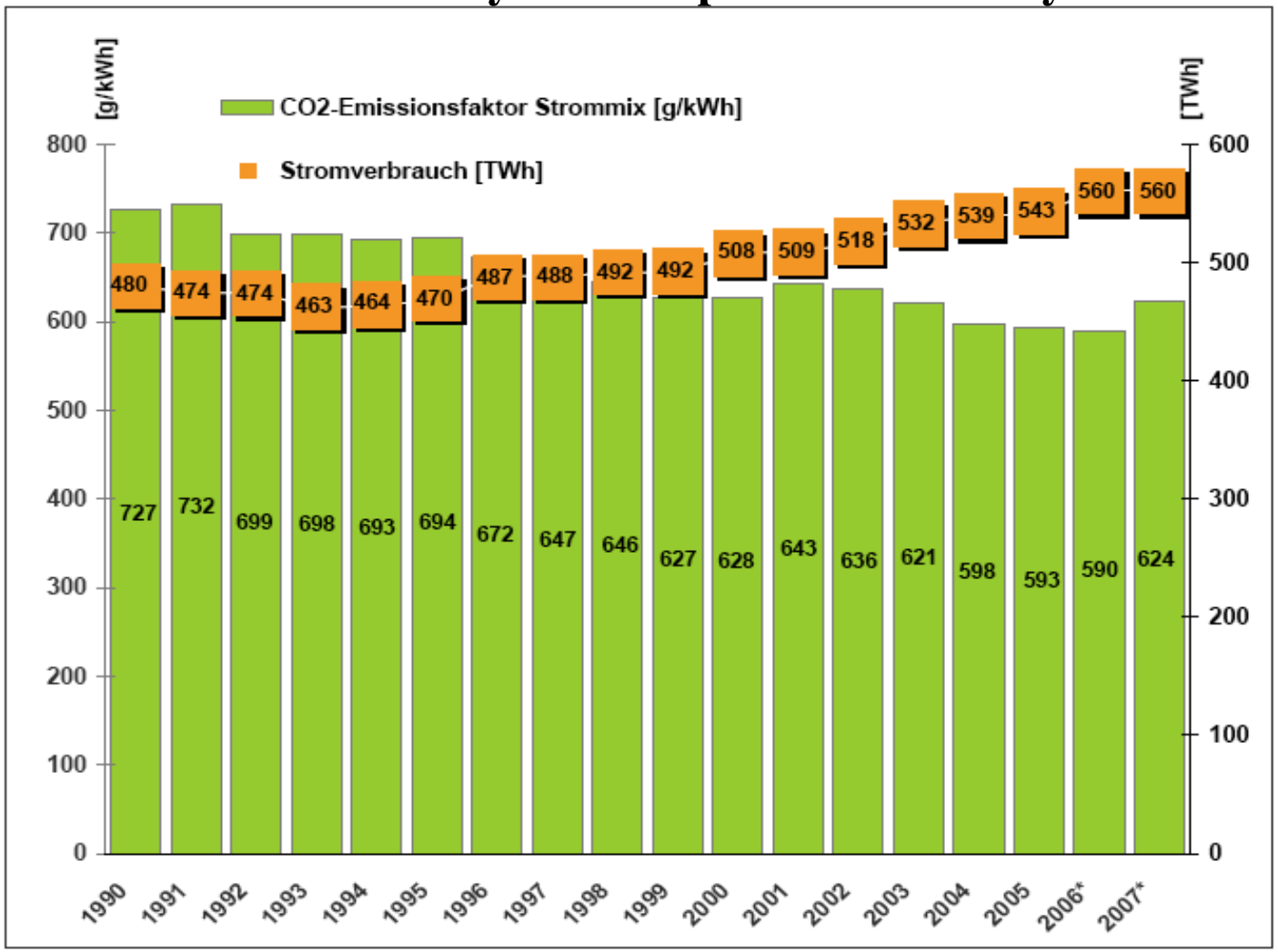
Is Pursuing both Renewables *and* Nuclear Feasible?

Briefing at Diet of Japan, Tokyo, 13 October 2010

Mycle Schneider

International Consultant on Energy and Nuclear Policy, Paris, France

CO2-Emissions and Electricity Consumption in Germany 1990-2007



Source: Umweltbundesamt, 2009

これで安全ですか？給食大丈夫ですか？

飲み物の基準値

Bq/L

食べ物の基準値

Bq/Kg

※コーデックスは５核種合計値

世界もおどろく日本の基準値2000ベクレル
http://kingo999.web.fc2.com/kizyun.html