WHAT REALLY HAPPEND IN FUKUSHIMA

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THE FUTURE OF NUCLEAR ENERGY

Did the Fukushima disaster change the game?

The Tsunami and subsequent nuclear incident at Fukushima in Japan brought to the fore once again the potential dangers of nuclear power. Everyone knows that nuclear energy involves hazards but we tend to assume they are under control and manageable. Three-mile Island, Chernobyl and now Fukushima might suggest otherwise.

So what is the future for nuclear power after this latest disaster? Opinion is still divided despite the consequences of the Fukushima accident and its implications for nuclear energy production worldwide. Surprisingly it has been countries like China who have led the way in questioning the nuclear power option and beginning to scrutinize their program. Within a few days of the accident the Chinese had suspended approvals for new plants and put construction of existing plants on hold pending a comprehensive review of procedures.

Germany has already started making noises about abandoning nuclear power altogether and other countries are looking again at their programs amid growing concerns about whether the safety of plants can be maintained. Many international pressure groups are also pushing the claim that the only type of safe nuclear power is no nuclear power and the argument is beginning to find traction among influential people in government and beyond.

But on the other side of the argument there are many who insist that nuclear power is still the only feasible green option and, that if we wish to maintain some balance in environmental terms there is no alternative. Fossil fuels are too expensive and dirty and other alternative sources like wind, water and solar are taking too long to develop and anyway can only ever account for a very small proportion of the overall energy needs of a world hungry for consumption. Whether these arguments are genuine and defensible is debatable but there is still a huge lobby for nuclear power and it is difficult to imagine that countries like India and China, with massive (and quickly expanding) energy needs, will be able to substitute any other form of power generation in the near future.

This compilation looks at the question from a number of angles and viewpoints and considers the impact of Fukushima and the state of nuclear energy production throughout the world.

Which side will win the argument is still far from clear and probably a long time off. Nuclear disasters are not containable within national boundaries and we are all potentially affected by their consequences but whether a global concensus can be reached on their regulation and management is still a massive question to be answered.

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AFTER FUKUSHIMA, JAPAN DIVIDED OVER FUTURE OF NUCLEAR ENERGY

John C.K. Daly, guest blogger

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As Japan moves forward with its energy future after the Fukushima disaster, it tries to balance stable electricity with public safety. Will Japan return to nuclear energy?

The steel structure for the use of the spent fuel removal from the cooling pool is seen at the Unit 4 of the Fukushima Daiichi nuclear plant at Okuma in Fukushima prefecture, Japan.

Two and a half years after a tsunami devastated Tokyo Electric Power Company's six reactor Fukushima Daiichi nuclear power plant, Japan's political establishment is divided over the country's nuclear future. Prior to the March 2011 Fukushima Daiichi nuclear catastrophe Japan was the world's third largest producer of nuclear power after the U.S. and France. Japan is now the world's largest importer of LNG, second largest importer of coal and the third largest net importer of oil.

An opinion poll conducted by NHK earlier this month found that nearly half of those responding were against the Nuclear Regulation Authority's plan to allow the restart of closed NPPs after safety checks. Only 19 percent of those polls approved of the plan, 32 percent were undecided, and 45 percent were against it. When a second question asked if those polled approved or disapproved of TEPCO's handling of Fukushima Daiichi of leaks of radioactive wastewater from the crippled nuclear complex, 68 percent of responders said they disapproved, only 27 percent approved.

RECOMMENDED: Fracking. Tight oil. Do you know your energy vocabulary?

If there is good news for TEPCO, the figures are better than those from a September 2011 poll by the Japanese newspaper Mainichi Shimbun, which found that as many as 70 percent of respondents to an opinion poll called for a quick or gradual decrease in the number of NPPs. (Related article: Nuclear Power Gets Hope from New Radiation Data)

The debate is ongoing, as on 24 October Japanese Prime Minister Shinzo Abe disagreed with his earlier mentor, former Prime Minister Junichiro Koizumi, who supports the closure of Japan's nuclear power industry, labeling the suggestion as "irresponsible."

Abe's reason?

Financial. Abe commented that Japan is still not ready to totally rely on thermal power generation as it is still too "expensive."

Abe added that Japan is losing roughly $41 billion in national wealth annually because all 48 of 50 of Japan's NPPs nuclear reactors are currently offline, noting, "We will be in big trouble if this continues." The same day, during an Upper House budget committee meeting, Social Democratic Party leader Tadatomo Yoshida again urged Abe to reject the current administration's promotion of nuclear power generation and even showed photos of Koizumi and Abe's wife Akie Abe, who is vocal about her opposition to nuclear power. Other Japanese politicians supporting Koizumi's call include Your Party chief Yoshimi Watanabe, Ichiro Ozawa, leader of the People's Life First Party, and former Prime Minister Naoto Kan of the Democratic Party of Japan. (Related article: Despite Fukushima, Global Nuclear Power on the Rise).

In the meantime, the Japanese economy is scrambling to replace the electricity lost from the shutdown of the nation's NPPs. The U.S. government's Energy Information Agency notes, "The Japanese government and electric utilities have taken several steps to ensure power supply meets demand following the Fukushima crisis. Some of these measures for thermal power stations include restoring some of the disaster-affected plants, relaxed regulations on inspections of the stations, and restarting mothballed oil-fueled stations. Also, the government promoted power restraints for consumers in the disaster-affected areas throughout 2011, invoking a 15-percent power reduction on all consumer groups."

And the future? Richard J. Samuels, Ford International Professor of Political Science, director of the Center for International Studies at MIT and Japan expert at the National Bureau of Asian Research in a 22 October 22 report said that Japan could pursue nukes using North Korea and China as a pretext, writing, "Most of the Japanese people are still against having nuclear weapons. However, due to recent developments in the domestic and international arena, they might rethink the issue. Japan's biggest concern is North Korea. If the North Korean regime collapses or is attacked by outside forces, it is possible that Pyongyang will launch a nuclear attack on Tokyo with the nothing-to-lose mentality. On top of that, it's doubtful whether the North can control its own nuclear arsenal."

It will be interesting to see what a poll of the Japanese people makes of Professor Samuels' observations.

Original article: **http://oilprice.com/Alternative-Energy/Nuclear-Power/Japanese-Political-Elite-Divided-over-Countrys-Nuclear-Future.html**

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THE FUTURE OF NUCLEAR POWER — OVERVIEW AND CONCLUSIONS

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The generation of electricity from fossil fuels, notably natural gas and coal, is a major and growing contributor to the emission of carbon dioxide – a green-house gas that contributes significantly to global warming. We share the scientific consensus that these emissions must be reduced and believe that the U.S. will eventually join with other nations in the effort to do so.

At least for the next few decades, there are only a few realistic options for reducing carbon dioxide emissions from electricity generation:

- increase efficiency in electricity generation and use;

- expand use of renewable energy sources such as wind, solar, biomass, and geothermal;

- capture carbon dioxide emissions at fossil-fueled (especially coal) electric generating plants and permanently sequester the carbon; and

- increase use of nuclear power.

The goal of this interdisciplinary MIT study is not to predict which of these options will prevail or to argue for their comparative advantages. *In our view, it is likely that we shall need all of these options and accordingly it would be a mistake at this time to exclude any of these four options from an overall carbon emissions management strategy.* Rather we seek to explore and evaluate actions that could be taken to maintain nuclear power as one of the significant options for meeting future world energy needs at low cost and in an environmentally acceptable manner.

In 2002, nuclear power supplied 20% of United States and 17% of world electricity consumption. Experts project worldwide electricity consumption will increase substantially in the coming decades, especially in the developing world, accompanying economic growth and social progress. However, official forecasts call for a mere 5% increase in nuclear electricity generating capacity worldwide by 2020 (and even this is questionable), while electricity use could grow by as much as 75%. These projections entail little new nuclear plant construction and reflect both economic considerations and growing anti-nuclear sentiment in key countries. The limited prospects for nuclear power today are attributable, ultimately, to four unresolved problems:

- *Costs: nuclear power has higher overall lifetime costs* compared to natural gas with combined cycle turbine technology (CCGT) and coal, at least in the absence of a carbon tax or an equivalent “cap and trade” mechanism for reducing carbon emissions;

- *Safety: nuclear power has perceived adverse safety, environmental, and health effects,* heightened by the 1979 Three Mile Island and 1986 Chernobyl reactor accidents, but also by accidents at fuel cycle facilities in the United States, Russia, and Japan. There is also growing concern about the safe and secure transportation of nuclear materials and the security of nuclear facilities from terrorist attack;

- *Proliferation: nuclear power entails potential security risks,* notably the possible misuse of commercial or associated nuclear facilities and operations to acquire technology or materials as a precursor to the acquisition of a nuclear weapons capability. Fuel cycles that involve the chemical reprocessing of spent fuel to separate weapons-usable plutonium and uranium enrichment technologies are of special concern, especially as nuclear power spreads around the world;

- *Waste: nuclear power has unresolved challenges in long-term management of radioactive wastes.* The United States and other countries have yet to implement final disposition of spent fuel or high level radioactive waste streams created at various stages of the nuclear fuel cycle. Since these radioactive wastes present some danger to present and future generations, the public and its elected representatives, as well as prospective investors in nuclear power plants, properly expect continuing and substantial progress towards solution to the waste disposal problem. Successful operation of the planned disposal facility at Yucca Mountain would ease, but not solve, the waste issue for the U.S. and other countries if nuclear power expands substantially.

We believe the nuclear option should be retained, precisely because it is an important carbon-free source of power.

Today, nuclear power is not an economically competitive choice. Moreover, unlike other energy technologies, nuclear power requires significant government involvement because of safety, proliferation, and waste concerns. If in the future carbon dioxide emissions carry a significant “price,” however, nuclear energy could be an important — indeed vital — option for generating electricity. We do not know whether this will occur. But *we believe the nuclear option should be retained, precisely because it is an important carbon-free source of power that can potentially make a significant contribution to future electricity supply.*

To preserve the nuclear option for the future requires overcoming the four challenges described above—costs, safety, proliferation, and wastes. These challenges will escalate if a significant number of new nuclear generating plants are built in a growing number of countries. The effort to overcome these challenges, however, is justified only if nuclear power can potentially contribute significantly to reducing global warming, which entails major expansion of nuclear power. In effect, preserving the nuclear option for the future means planning for growth, as well as for a future in which nuclear energy is a competitive, safer, and more secure source of power.

To explore these issues, our study postulates a *global growth scenario* that by mid-century would see 1000 to 1500 reactors of 1000 megawatt-electric (MWe) capacity each deployed worldwide, compared to a capacity equivalent to 366 such reactors now in service. Nuclear power expansion on this scale requires U.S. leadership, continued commitment by Japan, Korea, and Taiwan, a renewal of European activity, and wider deployment of nuclear power around the world. An illustrative deployment of 1000 reactors, each 1000 MWe in size, under this scenario is given in following table. This scenario would displace a significant amount of carbon-emitting fossil fuel generation. In 2002, carbon equivalent emission from human activity was about 6,500 million tonnes per year; these emissions will probably more than double by 2050. The 1000 GWe of nuclear power postulated here would avoid annually about 800 million tonnes of carbon equivalent if the electricity generation displaced was gas-fired and 1,800 million tonnes if the generation was coal-fired, assuming no capture and sequestration of carbon dioxide from combustion sources.

Global Growth Scenario

REGION	PROJECTED 2050 GWe CAPACITY	NUCLEAR ELECTRICITY MARKET SHARE 2000	NUCLEAR ELECTRICITY MARKET SHARE 2050
Total World	1,000	17%	19%
Developed world	625	23%	29%
U.S.	300		
Europe & Canada	210		
Developed East Asia	115		
FSU	50	16%	23%
Developing world	325	2%	11%
China, India, Pakistan	200		
Indonesia, Brazil, Mexico	75		
Other developing countries	50		

Projected capacity comes from the global electricity demand scenario in Appendix 2, which entails growth in global electricity consumption from 13.6 to 38.7 trillion kWhe, 2000 to 2050 (2.1% annual growth). The market share in 2050 is predicated on 85% capacity factor for nuclear power reactors. Note that China, India, and Pakistan are nuclear weapons capable states. Other developing countries includes as leading contributors Iran, South Africa, Egypt, Thailand, Philippines, and Vietnam.

We believe that the world-wide supply of uranium ore is sufficient to fuel the deployment of 1,000 reactors over the next half century.

A critical factor for the future of an expanded nuclear power industry is the choice of the fuel cycle — what type of fuel is used, what types of reactors "burn" the fuel, and the method of disposal of the spent fuel. This choice affects all four key problems that confront nuclear power — costs, safety, proliferation risk, and waste disposal. For this study, we examined three representative nuclear fuel cycle deployments:

- *conventional thermal reactors operating in a "once-through" mode,* in which discharged spent fuel is sent directly to disposal;

- *thermal reactors with reprocessing in a "closed" fuel cycle,* which means that waste products are separated from unused fissionable material that is re-cycled as fuel into reactors. This includes the fuel cycle currently used in some countries in which plutonium is separated from spent fuel, fabricated into a mixed plutonium and uranium oxide fuel, and recycled to reactors for one pass[1];

- *fast reactors*[2] *with reprocessing in a balanced "closed" fuel* cycle, which means thermal reactors operated world-wide in "once-through" mode and a balanced number of fast reactors that destroy the actinides separated from thermal reactor spent fuel. The fast reactors, reprocessing, and fuel fabrication facilities would be co-located in secure nuclear energy "parks" in industrial countries.

Closed fuel cycles extend fuel supplies. The viability of the once-through alternative in a global growth scenario depends upon the amount of uranium resource that is available at economically attractive prices. *We believe that the world-wide supply of uranium ore is sufficient to fuel the deployment of 1000 reactors over the next half century* and to maintain this level of deployment over a 40 year lifetime of this fleet. This is an important foundation of our study, based upon currently available information and the history of natural resource supply.

The result of our detailed analysis of the relative merits of these representative fuel cycles with respect to key evaluation criteria can be summarized as fol-lows: *The once through cycle has advantages in cost, proliferation, and fuel cycle safety,* and is disadvantageous only in respect to long-term waste disposal; the two closed cycles have clear advantages only in long-term aspects of waste disposal, and disadvantages in cost, short-term waste issues, proliferation risk, and fuel cycle safety. (See Table.) Cost and waste criteria are likely to be the most crucial for deter-mining nuclear power's future.

We have not found, and based on current knowledge do not believe it is realistic to expect, that there are new reactor and fuel cycle technologies that simultaneously overcome the problems of cost, safety, waste, and proliferation.

Fuel Cycle Types and Ratings

	ECONOMICS	WASTE	PROLIFERATION	SAFETY Reactor	SAFETY Fuel Cycle
Once through	+	x short term – long term	+	x	+
Closed thermal	–	– short term + long term	–	x	–
Closed fast	–	– short term + long term	–	+ to –	–

+ means relatively advantageous; x means relatively neutral; – means relatively disadvantageous

This table indicates broadly the relative advantage and disadvantage among the different type of nuclear fuel cycles. It does not indicate relative standing with respect to other electricity-generating technologies, where the criteria might be quite different (for example, the nonproliferation criterion applies only to nuclear).

Our analysis leads to a significant conclusion: *The once-through fuel cycle best meets the criteria of low costs and proliferation resistance.* Closed fuel cycles may have an advantage from the point of view of long-term waste disposal and, if it ever becomes relevant, resource extension. But closed fuel cycles will be more expensive than once-through cycles**,** until ore resources become very scarce. This is unlikely to happen, even with significant growth in nuclear power, until at least the second half of this century, and probably considerably later still. Thus our most important recommendation is:

For the next decades, government and industry in the U.S. and elsewhere should give priority to the deployment of the once-through fuel cycle, rather than the development of more expensive closed fuel cycle technology involving reprocessing and new advanced thermal or fast reactor technologies.

This recommendation implies a major re-ordering of priorities of the U.S. Department of Energy nuclear R&D programs.

PUBLIC ATTITUDES TOWARD NUCLEAR POWER

Expanded deployment of nuclear power requires public acceptance of this energy source. Our review of survey results shows that a majority of Americans and Europeans oppose building new nuclear power plants to meet future energy needs. To understand why, we surveyed 1350 adults in the US about their attitudes toward energy in general and nuclear power in particular. Three important and unexpected results emerged from that survey:

The U.S. public's attitudes are informed almost entirely by their perceptions of the technology, rather than by politics or by demographics such as income, education, and gender.

The U.S. public's views on nuclear waste, safety, and costs are critical to their judgments about the future deployment of this technology. Technological improvements that lower **costs** and improve safety and waste problems can increase public support substantially.

In the United States, people do not connect concern about global warming with carbon-free nuclear power. There is no difference in support for building more nuclear power plants between those who are very concerned about global warming and those who are not. Public education may help improve understanding about the link between global warming, fossil fuel usage, and the need for low-carbon energy sources.

There are two implications of these findings for our study: first, the U.S. public is unlikely to support nuclear power expansion without substantial improvements in costs and technology. Second, the carbon-free character of nuclear power, the major motivation for our study, does not appear to motivate the U.S. general public to prefer expansion of the nuclear option.

The U.S. public is unlikely to support nuclear power expansion without substantial improvements in costs and technology.

ECONOMICS

Nuclear power will succeed in the long run only if it has a lower cost than competing technologies. This is especially true as electricity markets become progressively less subject to economic regulation in many parts of the world. We constructed a model to evaluate the real cost of electricity from nuclear power versus pulverized coal plants and natural gas combined cycle plants (at various projected levels of real lifetime prices for natural gas), over their economic lives. These technologies are most widely used today and, absent a car-to use today, with parameters based on actual experience rather than engineering estimates of what might be achieved under ideal conditions; it compares the constant or “levelized” price of electricity over the life of a power plant that would be necessary to cover all operating expenses and taxes and provide an acceptable return to investors. The comparative figures given below assume 85% capacity factor and a 40-year economic life for the nuclear plant, reflect economic conditions in the U.S, and consider a range of projected improvements in nuclear cost factors.

Comparative Power Costs

CASE	REAL LEVELIZED COST [illegible]
Nuclear (LWR)	6.7
+ Reduce construction cost 25%	5.5
+ Reduce construction time 5 to 4 years +	5.3
Further reduce O&M to 13 mills/kWe-hr +	5.1
Reduce cost of capital to gas/coal	4.2
Pulverized Coal	4.2
CCGT[a] (low gas prices, $3.77/MCF) CCGT	3.8
(moderate gas prices, $4.42/MCF) CCGT	4.1
(high gas prices, $6.72/MCF)	5.6

a. Gas costs reflect real, levelized acquisition cost per thousand cubic feet (MCF) over the economic life of the project.

We judge the indicated cost improvements for nuclear power to be plausible, but not proven. The model results make clear why electricity produced from new nuclear power plants today is not competitive with electricity produced from coal or natural gas-fueled CCGT plants with low or moderate gas prices, unless all cost improvements for nuclear power are realized. The cost comparison becomes worse for nuclear if the capacity factor falls. It is also important to emphasize that the nuclear cost structure is driven by high up-front capital costs, while the natural gas cost driver is the fuel cost; coal lies in between nuclear and natural gas with respect to both fuel and capital costs.

Nuclear does become more competitive by comparison if the social cost of carbon emissions is internalized, for example through a carbon tax or an equivalent “cap and trade” system. Under the assumption that the costs of carbon emissions are imposed, the accompanying table illustrates the impact on the competitive costs for different power sources, for emission costs in the range of $50 to $200/tonne carbon. (See Table.) The ultimate cost will depend on both societal choices (such as how much carbon dioxide emission to permit) and technology developments, such as the cost and feasibility of large-scale carbon capture and long-term sequestration. Clearly, costs in the range of $100 to $200/tonne C would significantly affect the relative cost competitiveness of coal, natural gas, and nuclear electricity generation.

The carbon-free nature of nuclear power argues for government action to encourage maintenance of the nuclear option, particularly in light of the regulatory uncertainties facing the use of nuclear power and the unwillingness of investors to bear the risk of introducing a new generation of nuclear facilities with their high capital costs.

We recommend three actions to improve the economic viability of nuclear power:

The government should cost share for site banking for a number of plants, certification of new plant designs by the Nuclear Regulatory Commission, and combined construction and operating licenses for plants built immediately or in the *future; we support U.S. Department of Energy initiatives on these subjects.*

The government should recognize nuclear as carbon-free and include new nuclear plants as an eligible option in any federal or state mandatory renewable energy portfolio (i.e., a "carbon-free" portfolio) standard.

The government should provide a modest subsidy for a small set of "first mover" commercial nuclear plants to demonstrate cost and regulatory feasibility in the form of a production tax credit.

We propose a production tax credit of up to $200 per kWe of the construction cost of up to 10 "first mover" plants. This benefit might be paid out at about 1.7 cents per kWe-hr, over a year and a half of full-power plant operation. We prefer the production tax credit mechanism because it offers the greatest incentive for projects to be completed and because it can be extended to other carbon free electricity technologies, for example renewables, (wind currently enjoys a 1.7 cents per kWe-hr tax credit for ten years) and coal with carbon capture and sequestration. The credit of 1.7 cents per kWe-hr is equivalent to a credit of $70 per avoided metric ton of carbon if the electricity were to have come from coal plants (or $160 from natural gas plants). Of course, the carbon emission reduction would then continue without public assistance for the plant life (perhaps 60 years for nuclear). If no new nuclear plant is built, the government will not pay a subsidy. These actions will be effective in stimulating additional investment in nuclear generating capacity if, and only if, the industry can live up to its own expectations of being able to reduce considerably capital costs for new plants.