Soft Energy Paths for the 21st Century

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The Fukushima disaster has added great suffering to a nation for which I feel strong affection and sympathy—especially the heroic workers and soldiers who risked their lives to contain the accident. It saddens me that much of this suffering was avoidable by means that were not and still are not being properly considered in Japan.

The Fukushima disaster was not a surprise. Since the 1960s, reactor meltdowns caused by power failures have been understood and feared. The US Nuclear Regulatory Commission task force now examining this accident—America has six identical and 17 very similar plants—already found the backup power supplies inadequate. Many of us have been saying so for decades.

More broadly, it was unwise to put 54 reactors in an earthquake-and-tsunami zone crowded with 127 million people, and to pack many reactors together at one site so failure can cascade from one to the rest. I discussed these concerns with TEPCO officials when advising the company decades ago. This tsunami is now called unimaginably [*sotegai*] huge, but a 2007 paper coauthored by two TEPCO employees said it was about time for another like the similar Jogan tsunami 1,142 years earlier (or, another paper found, two others before that). Nothing was done.

In neither Japan nor the US have the decisions, attitudes, and governance of nuclear technology matched its uniquely unforgiving nature, which Swedish Nobel physicist Hannes Alfvén summarized as "No acts of God can be permitted." He added: "If a problem is too difficult to solve, one cannot claim that it is solved by pointing all the efforts made to solve it."

Nuclear regulation has long been about as undemanding in Japan as in the US and most other countries. Its promotional policy context is also widespread. Strong pro-nuclear-power policies in Japan, France, and Russia have long discouraged inquiry, dissent, and promotion of alternatives: criticizing nuclear power harms careers. Even in less-conformist America, many Presidents' pro-nuclear-power attitudes have tended, over the long run, to harm the nuclear industry by making regulation less strict, operators more complacent, and hence accidents more likely.

Japan's more rigid bureaucratic structures, reluctance to send bad news upwards, need to save face, weak development of policy alternatives, eagerness to preserve nuclear power's public acceptance (indoctrinated since childhood[1]), and politically fragile government, along with TEPCO's very hierarchical management culture, also contributed to the way the accident unfolded. Moreover, the information Japanese people receive about nuclear energy and its alternatives has long been tightly controlled by both TEPCO and the government. As the accident evolved, the mainstream media were full of reassurances from prominent pro-nuclear professors, but other views were absent. This has been true for decades. Two prominent Japanese broadcasters have told me of longstanding pressures not to air nuclear information contrary to the official

line. Such constrained public information and discourse cannot lead to healthy policy choices.

The accident information presented, too, was often unreliable. Trying to advise Japanese friends, I had to use independent U.S. and European fallout data because the official Japanese data seemed inconsistent with reported events. April "letters of request" from the Japanese government apparently told telecommunications companies to instruct webmasters to erase posted content that conflicted with official information and to monitor email communications to stop false rumors.[2] Delays and discrepancies further damaged public confidence—and mine.

Reputable Western media reported that radiation exposure standards for some Japanese schoolchildren had been raised to those of nuclear workers. This is contrary to accepted international norms of public health protection. As a scientist, therefore, if I were visiting potentially exposed areas, I would study the official data, but I would also bring my own monitoring equipment. In four decades, I have also found other official nuclear sources not always reliable: the International Atomic Energy Agency estimates hundreds of times fewer Chernobyl deaths[3] than an authoritative analysis[4] based on 5,000 mainly Slavic-language scientific papers the IAEA had overlooked, and an eminent nuclear physicist who served on the official inquiry into the Three Mile Island accident told me he felt an official coverup had greatly understated its release too.

If I were Japanese, I would want independent validation of official statements about releases and exposures.[5] Fukushima I-4's spent fuel alone, while in the reactor, had produced (over years, not in an instant) more than a hundred times more fission energy and hence radioactivity than both 1945 atomic bombs. Even a small fraction of its persistent isotopes, such as cesium-137, is thus a big long-term problem. Had the wind during the peak releases been blowing toward Tôkyô, Japan would have faced evacuation of 35 million people—and centuries of contamination of the land whose value underpins the nation's balance sheet. Luckily, the winds blew out to sea most of the time, yet some areas were significantly contaminated. The severely contaminated and cooling-challenged plant site will remain very risky for many years. And Asia's biggest private utility, its balance sheet vaporized, has been nationalized in all but name: TEPCO, just recovering from $10–20 billion in 2007 earthquake costs at Kashiwazaki-karima, just booked a $14-billion initial loss from Fukushima, whose ultimate bill could be tenfold more.

Nuclear power is the only energy source where mishap or malice can destroy so much value or kill many faraway people; the only one whose materials, technologies, and skills can help make and hide nuclear weapons[6]; the only proposed climate solution that substitutes proliferation, major accidents, and radioactive-waste dangers. Yet nuclear plants are so costly and slow to build that they actually reduce and retard climate protection. That's because each yen spent on a new reactor buys about 2–10 times less carbon savings, 20–40 times slower, than spending the same yen on the cheaper, faster, safer solutions that make nuclear power unnecessary and uneconomic: efficient use of electricity, cogenerating electricity and useful heat together in factories or buildings, and renewable energy.[7] Cogeneration and renewables, except big hydro dams, made 18% of the world's 2009 electricity (while nuclear made 13%, more than reversing their 2000 shares), and made over 90% of the 2007–08 increase in global electricity production.[8]

These smarter, faster, cheaper choices are sweeping the global market. Half the world's new generating capacity in 2008–10 was renewable. In 2010, renewables, excluding big hydro dams, surpassed nuclear power's global installed capacity, won $151 billion of private investment, and added 52 GW (52 billion watts) while nuclear got zero private investment and gained 6 GW, mostly by uprating old units. For the previous two years, nuclear power lost global capacity, as it

will again in 2011 and in most future years (new construction can't offset retirements). Windpower, supposedly unreliable and unimportant, made 43–52% of four German states' total 2010 electricity. The conservative government of non-nuclear Denmark, 32% renewably powered, plans to get entirely off fossil fuels by 2050. Non-nuclear Portugal in 2005–10 went from 17% to 45% renewable electricity while the US went from 9.2% to just 10.5%—but Hawai'i plans 70% renewables by 2025.

The nuclear industry claims its U.S. market was flourishing until Three Mile Island; actually, orders had already stopped due to poor economics. Now it claims a vibrant global renaissance until Fukushima; actually, orders from the world's market-driven electricity systems stopped years ago. Of the 66 nuclear units officially listed as "under construction" worldwide at the end of 2010, 12 had been so listed for over 20 years, 45 had no official startup date, half were late, all 66 were in centrally planned power system (50 in just four—China, India, Russia, South Korea), and none were free-market purchases fairly competed against or compared with available alternatives.

Fukushima will further raise nuclear construction costs, complicate siting, and erode public support. But nuclear capital costs were already soaring, mainly due to bottlenecked and atrophied supply chains, while competitors' costs plummeted. Long before Fukushima, the nuclear enterprise was collapsing[9], displaced by competitors it doesn't even acknowledge.[10]

Since 2007, nuclear growth has added less annual generation than just the costliest renewable—solar power—and will probably never catch up. By the end of 2011, the world will probably be able to make about 50 GW of solar cells each year—enough to match the peak output of those 66 under-construction nuclear plants every 15 months or their annual output every five years, before one reactor begun now could be built. While nuclear power stagnates, the solar power industry sustains 65% annual growth. California's private utilities just bought 4.4 GW of photovoltaics at below the auction's benchmark wholesale electricity price. Four fast-growing US firms even install solar cells on your roof at no up-front cost to you, and your electric bill decreases.

Pro-nuclear Chancellor Merkel was so shocked by Fukushima that that she turned Germany's energy focus from nuclear (of which she closed 41% and will close the rest within a decade) to efficiency and renewables. That's supported by three-fourths of Germans and opposed by no political party. Switzerland has accelerated its nuclear exit. Nearly 95% of Italian voters rejected a nuclear revival. Siemens, now a leader in solar and wind, is leaving the nuclear market; General Electric will probably do so in due course; Westinghouse already sold out to Toshiba; and France's 93%-state-owned AREVA is in trouble. Nuclear power is increasingly made by and sold only to obsolescent state-owned enterprises. Even France is emphasizing growth not in nuclear power but in renewables.[11]

Cloudy Germany added 8 GW of solar power in 2010 alone, and recently installed 2 GW in a single month—more than Japan's total through 2009. Windpower in 2010 was a $96-billion global industry adding 40 GW, but Japan targets only 5 GW through 2020. Japanese solar and windpower manufacturers are active and capable—Toshiba in 2010 installed an integrated solar-and-wind power plant at Miyakojima in just five months—and Masayoshi Son, the richest man in Japan, has proposed to jumpstart Japan's renewable power revolution, with support from 36 of the 47 prefectures. But Japanese renewable suppliers are limited in their home market by utility restrictions based on fear of competition and myths about variability. (Properly diversified,

forecast, and integrated into existing grids, 80–90%+ variable renewables can match or beat thermal plants' reliability and electricity cost.)

With Japanese manufacturers still held back by outmoded domestic energy policy, China has soared to #1 in those and three other renewable energy technologies. China halved its net additions of coal capacity during 2006–10 (two-thirds of the new coal plants in 2005–07 were unauthorized by Beijing); in 2010 its net capacity additions were only 59% coal, 38% renewable, and 2% nuclear. In 2006, China's renewables (excluding big hydro) had seven times its nuclear capacity and were growing seven times faster, but by 2010, despite the world's most ambitious nuclear program, that gap had widened. China in 2010 invested 60% more in clean energy than the US did, or 139% more in proportion to GDP. In 2011, China suspended nuclear approvals and construction but accelerated efficiency and renewables.

India is also in the world's renewable Top Ten, just quadrupled its renewables target, and aims to install 20 GW of photovoltaics by 2022—nearly Japan's 28-GW target for 2020.[12] Asia's renewable investments passed the Americas' in 2009 and Europe's in 2010. With half the world's coal burn and three-fourths of the world's planned new coal plants in China and India, these are encouraging signs. Yet Japan's 2009 clean-energy investment of $0.8 billion ranked only 15th in the world, and just 1.3% of its 2009 capacity was new renewables.

US energy policy, too, remains stuck between two worlds. President Obama and Energy Secretary Chu strongly support efficiency and renewables, with encouraging results. But opponents in Congress, which is more fractious and less functional than the Diet, keep blocking White House policy, halving 2010 windpower additions. Secretary Chu is also pro-nuclear, as his Department of Energy (which includes the powerful nuclear-weapons establishment) has always been. President Obama has supported nuclear power rhetorically and sought $36 billion more in nuclear loan guarantees. But it doesn't matter, because new nuclear plants are clearly uneconomic, and in America, policymakers can't make utilities buy nor markets finance them. Of the $18.5 billion of federal loan guarantees authorized in 2007, only $8.3 billion has been conditionally offered—to a one two-unit plant in Georgia, directly financed by the Treasury. Despite extraordinary federal and state support, the Georgia plant's licensing, construction, and operation are not assured, it's in political trouble, and its economics are dismal. The two other leading candidates for loan guarantees collapsed (one was hoping TEPCO would bail it out), and other options are disappearing.

For the past six years, new U.S. reactors (if any) have been 100+% subsidized[13]—yet they couldn't raise a cent of private capital[14], because they have no business case.[15] They cost 2–4 times as much as new firmed windpower. By the time you could build a reactor, it couldn't even beat solar power. Renewables, cogeneration, and efficient use can cost-effectively displace all US coal *and* nuclear power more than 16 times over, but once suffices. While Washington dithers, state governments and private firms steadily switch from nuclear and coal to efficiency and renewables.

The US Nuclear Regulatory Commission, under withering criticism for complacency despite worrisome near-misses, seems likely to tighten scrutiny and enforcement.[16] The long-festering US nuclear waste problem won't be solved soon—least of all by reprocessing, which all its practitioners except Japan realize will make waste management more costly and difficult while raising grave safety and proliferation concerns. Secretary Chu has funded some smaller, more modular reactor developments, but these all have problems broadly similar to today's, with probably

even worse economics, so they won't forestall nuclear collapse. This future technology whose time has passed has died of an incurable attack of market forces, lacks only an orderly terminal phase, yet continues to distract policymakers and citizens from the market winners.

In autumn 2011 in English and soon thereafter in Japanese, my team will publish a business book[17] explaining how the US could fuel and power a 158%-bigger 2050 economy with no oil, no coal, no nuclear energy, and one-third less natural gas. This would cost $5 trillion less (in 2010 net present value) than the officially forecast future, assuming that carbon and all other externalities are valued at zero. The business logic is so compelling that no Act of Congress is needed. Innovative policies, like size- and revenue-neutral "feebates" for new autos, and rewarding electric utilities for cutting your bills rather than for selling you more energy, would unlock or speed this transition to efficiency and renewables, but can be implemented at a state level (as most energy policy always has been), avoiding federal gridlock.

Japan has similar potential, perhaps greater. Japan leads the world in efficient cars and trains, industrial processes, smart controls, miniaturization, carbon fiber, solar-cell technology. Its "Top-Runner" appliance-efficiency policy is the world's best. Japan can profitably at least triple its energy efficiency.[18] For its size, Japan is even richer than America in clean, ample, resilient, but long-neglected renewable energy options. Japan is also wonderfully rich in human energy, speed, ingenuity, courage, social cohesion and endurance (so inspiringly displayed after the earthquake and tsunami), and traditional wisdom.

Exploiting these advantages could return Japan to global energy leadership. Perhaps Prime Minister Kan's announcement of a new energy policy could be the first step. While people everywhere pray for the best in Japan today, we hope her sacrifice will help speed the world to a safer, more competitive energy future.

In 2007, I had the great honor to accept the Blue Planet Prize from Their Imperial Highnesses Prince and Princess Akishino. My remarks then express my high hopes for Japan's energy choice:

> This precious award honors decades of collaboration with my colleagues at Rocky Mountain Institute and around the world, including Japan. Special meaning comes from this Prize's roots in Japan—the world leader in eliminating waste [*muda*], in beautifully simple design that harmoniously integrates people within nature[19], and in social ability to form and quickly adopt a new consensus. These attributes can uniquely equip Japan—*if* the Japanese people choose to accept this mission—to lead the world on the historic shift to benign, secure, and affordable energy, for all, for ever.
>
> This leadership will challenge the Japanese people to make four changes:

1. Japan's extraordinary gains in energy efficiency after the 1970s oil shocks have faded into complacency. Japan, once the pioneer of energy efficiency, now has passenger vehicles scarcely more efficient, and buildings less efficient, than in America. The average person uses more electricity in Japan than in California or New York, and that use is growing as fast as in Texas. Some Japanese firms do keep getting more efficient, but few Japanese people pay much attention. Too many think climate protection means cost, burden, and sacrifice—not profit, competitive advan-

tage, and higher quality of life. Today's techniques can profitably at least *triple* Japanese energy efficiency[20], enhance security, and help protect our blue planet—*if* Japanese people realize this is possible and insist that it happen.

2. Japan is poor in *fuels*, but is the richest of all major industrial countries in renewable *energy*[21] that can meet the entire long-term energy needs of an energy-efficient Japan, at lower cost and risk than current plans. Japanese industry can do it faster than anyone—*if* Japanese policymakers acknowledge and allow it.
3. The old idea that a big industrial economy requires giant, vulnerable power plants is now obsolete. The revolutions in miniaturization and information make millions of smart distributed electric generators cheaper[22], faster to build, and more reliable than a few big plants—*if* old institutions and habits stop favoring central plants.
4. Today's fast-moving energy technologies and markets make old bureaucratic and monopolistic habits no longer in the national interest. Japanese energy policy needs to become more diverse, agile, and open. Japan's technological and commercial genius will best flower *if* all ways to save or produce energy can compete fairly, at honest prices—no matter which kind they are, what technology they use, where they are, how big they are, or who owns them.

   Japan's energy future and the world's depend on these four big *if*s. Each is a big challenge —and a huge opportunity. So let me end with a fifth *if:*

   If the nation with the sacred sun on its flag now turns these potentials into reality, and by its example, leadership, and investment quickly shares them with its neighbors, then Japan's highest purpose in history will be achieved; your country will have led the whole world to be healthier, safer, richer, fairer, and cooler; and all beings everywhere will be as happy and grateful as I am today.

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[1] N. Onishi, "'Safety Myth' Left Japan Ripe for Nuclear Crisis,' *New York Times*, 24 June 2011, www.nytimes.com/2011/06/25/world/asia/25myth.html.
[2] The link is posted at www.soumu.go.jp/menu_news/s-news/01kiban08_01000023.html.
[3] "Chernobyl Forum" report, www.iaea.org/Publications/Booklets/Chernobyl/chernobyl.pdf.
[4] A.V. Yablokov, V.B. Nesterenko, & A.V. Nesterenko, *Chernobyl: Consequences of the Catrastrophe for People and the Environment*, *Annals of the New York Academy of Sciences* **1181** (2009), 343 pp., www.strahlentelex.de/Yablokov%20Chernobyl%20book.pdf.
[5] Some is starting to appear, such as the "citizens' map" at www.nnistar.com/gmap/fukushima.html, which shows exposures several times legal limits in certain "hot spots" in northeast Tôkyô, Kashiwa-shi, and nearby cities in Chiba Prefecture.
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[16] UCS, *The NRC and Nuclear Power Plant Safety in 2010*, Union of Concerned Scientists, 2011, www.ucsusa.org/nuclear_power/nuclear_power_risk/safety/nrc-and-nuclear-power-2010.html, J. Donn, "US nuke regulators weaken safety rules, 20 June 2011, http://news.yahoo.com/s/ap/20110620/ap_on_re_us/us_aging_nukes_part1, and numerous 2011 *New York Times* stories on failures of NRC regulation. Interim recommendations call for "redefining the level of protection that is regarded as adequate": M.L. Wald, "Task Force Recommends Improvements for Nuclear Plants," *N.Y. Times*, 12 July 2011.
[17] A.B. Lovins and Rocky Mountain Institute, *Reinventing Fire: Bold Business Solutions for the New Energy Era*, Chelsea Green (Vermont, USA), autumn 2011.

[18] Based on the excellent analyses by Japan's National Environmental Policy Institute since 2005. Their expert team found that "Japan has the technological potential to reduce its CO_2 emissions by 70% compared to the 1990 level, while satisfying the expected demand for energy services in 2050," at an extra cost around 0.1% of 2050 GDP. I consider the NIES analysis technically and economically conservative, especially in omitting integrative design (www.di.net/videos/3314/, www.rmi.org/stanford, www.rmi.org/rmi/Library/2010-09_IntegrativeDesign, www.rmi.org/rmi/Library/2010-10_10xEPrinciples).

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[20] Based on the excellent analyses by Japan's National Environmental Policy Institute since 2005. Their expert team found that "Japan has the technological potential to reduce its CO_2 emissions by 70% compared to the 1990 level, while satisfying the expected demand for energy services in 2050," at an extra cost around 0.1% of 2050 GDP. I consider the NIES analysis technically and economically conservative, especially in omitting integrative design (www.di.net/videos/3314/, www.rmi.org/stanford, www.rmi.org/rmi/Library/2010-09_IntegrativeDesign, www.rmi.org/rmi/Library/2010-10_10xEPrinciples).

[21] Such pioneering Japanese analysts as Dr Haruki TSUCHIYA have been showing this for decades. Please see also my Blue Planet Prize lecture at www.af-info.or.jp/en/blueplanet/doc/list/2007lect-lovins.pdf and www.af-info.or.jp/en/blueplanet/doc/slide/2007slide-lovins.pdf.

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