RESPONSE TO FUKUSHIMA ARTICLE COMMENTS

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I am quite concerned about the present and projected effects of climate change and our national failure to integrate three essential actions into a cohesive energy plan: greater use of renewable energy, improved energy efficiency, and significant expansion of nuclear energy. Fukushima was a huge economic setback, but with very small health consequences. It is essential to understand this if nuclear energy is to fully participate in preventing far greater economic and health risks from climate change.

The Fukushima accident was a very rare event which exposed both strengths and weaknesses in nuclear power plant designs. The March, 2011 magnitude 9 earthquake was the largest earthquake to ever strike Japan. Yet all the important passive safety structures at Fukushima, like the containment buildings and spent fuel pools, withstood the direct effects of this earthquake even though it was far beyond the size of the earthquake these plants were designed for. The important safety structures at other Japanese nuclear power plants, even those near the Fukushima plants, not only survived the earthquake and tsunamis, so did all of their active safety equipment like pumps, valves, and the emergency electric diesel generators. The emergency diesel generators at the Fukushima plants also survived the earthquake and worked for about a half hour until the tsunami struck. Nuclear power plants in the United States have also demonstrated their ability to safely withstand large natural phenomena such as Category 5 hurricanes, severe tornadoes, and beyond design basis earthquakes.

It was the extreme tsunami, not the huge earthquake, that led to the meltdowns at Fukushima. Possible tsunamis at Fukushima had been the subject of numerous studies prior to this accident. The actual tsunami differed from previous tsunamis that have struck Japan and exceeded the predictions from a variety of computer models based on different tsunami theories. In short, in spite of the Fukushima operators providing adequate tsunami protection consistent with the state of knowledge at the time, the Fukushima power plants were struck by a very rare and extreme tsunami of an unpredicted magnitude.

Should we rule out nuclear power because of this exceedingly rare natural event, an extreme tsunami, which caused three simultaneous core meltdowns, yet had near zero radiation caused health effects? If we apply such reasoning about the risks of rare natural events we would have to stop expanding renewable energy too. In April, 1815 Mount Tambor erupted. The ash particles released into the atmosphere caused, in 1816, “the year without a summer”, with worldwide crop failures. It has been reported that there wasn’t even enough hay to feed horses. A similar natural event could have severe consequences in energy systems that are highly dependent on renewable energy. Nature teaches us that a key survival strategy is diversity. We need the diversity of greater energy efficiency, along with more renewable energy and more nuclear power if we are to cope with climate change and other large human-caused and nature-caused events.

To put things into perspective I use the 80-80-36 “rule”. In the United States about 80% of our energy comes from fossil fuels, about 80% of our greenhouse gases (GHG) come from burning these fossil fuels, and we are only 36 years away from 2050. The 2050 date is derived from the International Panel on Climate Change’s studies which support an 80% reduction in GHG by 2050 to avoid/lessen severe environmental consequences. So how are we doing in terms of reducing our GHG emissions? In the short term the US looks like it is making progress, partly brought about by a weakened economy, more fuel efficient cars, and with new natural gas power plants displacing many coal power plants. Per kilowatt- hour, gas plants produce about half the GHG as coal plants.

However, this reduction in GHG emissions is likely to be temporary. Many projections of our energy future conclude that there will need to be a significant increase in the amount of energy we will use and an especially large increase in our use of electricity. However, in the short term very low natural gas prices are also causing the shutdown of some GHG-free nuclear power plants. When nuclear plants have been shut down they usually are not replaced by renewable energy, but have been replaced by increased burning of fossil fuels. Here the replacement fossil fuel is natural gas. In Germany it is dirty brown coal. Germany, with all of its push towards a renewable energy future, is building new coal plants. In Japan the shutdown of its nuclear plants has come at great expense as large amounts of fossil fuel have to be imported. Japan, well known for its Kyoto climate change protocol, has had to announce that it will now not be able to meet its GHG reduction goals because of burning all this imported fossil fuel.

The much touted Ivanpah solar thermal plant in the Mohave Desert, the world’s largest, was supposed to be the prototype of many more to come. Repower America[1], which promoted an all renewable energy future, called for a 3300 fold increase in electricity by 2020 from such solar thermal plants, relative to their output in 2007. Now the New York Times[2] and others[3] report that this could also be the last of its kind. This seems obvious in retrospect. Thermal electric plants, be they gas, coal, nuclear, or solar, need to be located next to large bodies of water which they use as their ultimate heat sinks. There is not too much water in the deserts.

Even smaller renewable energy systems appear to be running into economic barriers. Great progress has been made in reducing the cost of photovoltaic panels. However, the rest of these smaller renewable energy systems is comprised of batteries, inverters, charge controllers, wires, and cables. These components come from mature industries and significant further cost reductions will be difficult to achieve. The dominant cost for these smaller systems is shifting towards these conventional components. Without subsidies, many renewable energy systems may not be competitive against low natural gas prices.

[1] “A Sustainable U.S. Energy Plan”, Table 2, H. Specter, Natural Resources Research, Volume 18, No.4, 12/2009

[2] “A Huge Solar Plant Opens, Facing Doubts About Its Future”, D. Cardwell and M. Wald, NY Times, February 13, 2014

[3] “Massive desert solar plant opens, already a threatened species”, Energy Central, March 5, 2014

Some renewable energy systems, like wind energy, may not be very effective today in reducing GHG emissions. The intermittent and variable nature of wind energy means that fossil based electric power systems, like gas and coal, must be ready to rapidly step in when wind energy decreases. As long as wind power needs fossil fuels to overcome its production shortfalls, it is not a totally effective means of reducing the release of GHG. It is doubtful that wind power's dependence for fossil fuel backup systems to ensure grid reliability could be economically replaced by greatly overbuilding other renewable energy systems, such as with enormous numbers of solar photovoltaic systems, which themselves are variable output systems. Not only does the sun not shine at night, there are seasonal variations where, in winter, only half or so of the solar energy is available. A reliable electric grid based just on wind energy and solar systems that could meet electricity demands in the winter would require a staggering amount of energy storage.

Large amounts of wind energy on the electric grid may introduce grid instabilities. An electric grid wind energy limit of about 20% is often referred to. Research conducted by the National Renewable Energy Laboratory (NREL) points to a related issue. The US electric grid is an engineering marvel with a 99% reliability. However, according to NREL, the remaining one percent of the time when there is poor power quality or power outages is extremely costly, about $119 billion to $188 billion dollars annually. To have a large wind energy contribution while maintaining a 99% grid reliability would require massive amounts of energy storage systems and many new transmission lines and these systems have their own costs too.

To put this into perspective, preventing wind energy from causing another one percent decrease in grid reliability would prevent the loss of an additional $119 billion to $188 billion dollars annually. This would be enough to build 24 to 38 large nuclear power plants every year, even if these nuclear plants cost $5 billion dollars each. Grid reliability is a problem for developed economies. Large rural areas in many poorer countries, have millions of people living beyond the electric grid. These people deal with renewable energy shortages by cutting down the few remaining trees which causes greater land erosion, deadly mud slides, and the spread of cholera.

This brings up a critical point about comparing risks of one energy source to another. Some have compared the risks from events like Fukushima to the risks of someone falling off of a wind turbine. Clearly, from a societal point of view, the risks of falling off of a wind turbine are insignificant. This type of risk-to-risk comparison, however, is misleading. The risks associated with fossil fuels and nuclear power (and hydropower) come from the production of energy and from failures in these systems, like the recent gas explosion in New York City. The risks from renewable energy systems mainly comes from insufficient energy production, such as large economic penalties from a less reliable electric grid, from not producing enough energy to meet demands, or the environmental impact of cutting down of trees, as mentioned above, when there isn't enough renewable energy. Both energy production and insufficient energy production produce consequences.

Renewable energy systems are not alone in terms of economic challenges. Today US nuclear power plants are very expensive to build. However, other countries, like China and South Korea, produce new economical nuclear plants, some of which are just modern versions of earlier US designs, but at a fraction of the costs we incur. Part of these lower costs is due to using modern factories to build major sections of these plants from standardized designs and part of the lower costs is due to advanced construction technology. However, much of the cost reduction in these highly capital intensive power plants comes from better financing. The 2010 OECD[4] lifetime levelized cost comparisons, in US dollars per megawatt-hour, make this clear:

Country, reactor type	Cost of investment money-5%	Cost of investment money-10%
S. Korea, APR-1400	29.05	42.09
China, AP-1000	36.31	54.61
US, Adv. Gen III	48.73	77.39

The decrease in levelized costs for nuclear power plants due to low interest money is profound. The US had $50 billion dollars set aside to provide loans to encourage the construction of new energy sources. This program seems to be a failure. As utilities discovered this loan program is so cumbersome that the few utilities building new nuclear plants have largely turned away from it, at an eventual greater cost to rate payers. If this program had been effective and interest rates were, say, 5% instead of 10%, US customers could get 1600 megawatts of nuclear capacity for each 1000 Megawatts they paid for.

China and Korea have improved on earlier US designs, while we have languished. A new nuclear plant, at a 10 % interest rate and using US outdated manufacturing and construction technology, is 266 % more expensive than a similar plant built and constructed by South Koreans. The result is that South Korea, Russia, and now China, are offering nuclear plants for sale worldwide. South Korean leaders have predicted that their nuclear sales will eventually bring in more money than the sale of their cars. In spite of Chernobyl, Russia is successful in the international nuclear power plant market, by offering attractive financial arrangements to its customers. Perhaps we should encourage the South Koreans to build nuclear power plant factories in the United States, much like they build Korean cars here, employing American workers. With a standard design and a set sales price, it should be possible to attract investment dollars at low interest rates.

What is clear from the above, the two main sources of GHG free energy, renewable energy and nuclear energy, are far from where they need to be if we are serious about reducing the release of greenhouse gases.

Two of the "greenest" states in the USA, Massachusetts and California, have taken important steps in dealing with the challenge of climate change. Massachusetts

[4] "Projected Costs of Generating Electricity: 2010 Edition", Table 3.7a, OECD

regulators recently approved a gas-fired power plant[5], but require it to emit less and less carbon dioxide starting in 2026 until it is closed by 2049. If supplying natural gas to this plant also releases methane, as some claim, this new gas plant might have to be phased out even more quickly. As we get closer to 2050 and GHG emission allowances get less and less, the allowable energy production and lifetimes of new gas plants may get so short it would be uneconomical to build such new plants. With a growing demand for electricity, such as for electrified transportation and a larger population, and with first coal and then gas power plants phased out, the challenge for renewable energy, nuclear, and greater efficiency to meet future demands for electricity will be huge. Further, between now and 2050 all the licenses on existing nuclear plants, except for a few under construction outside of Massachusetts, will expire. Unless further license extensions beyond 60 years of operation are approved for existing nuclear plants and/or unless there are significant increases in the construction of new nuclear plants, Massachusetts and similar states would become totally reliant on electricity from renewable energy. While such a renewable energy future appeals to some, it is in direct conflict with detailed studies conducted in California, discussed below, which showed that no single energy source is sufficient to meet 2050 GHG goals. Without more nuclear power, it would also make Massachusetts completely dependent on renewable energy sources, increasing its risks due to a loss of diversity.

California already is a leader in reducing GHG emissions with about half the carbon dioxide emissions per capita than the US average. California has studied the climate change issue comprehensively, as described in CEF, " California's Energy Future- the view to 2050", now in the OEPF library. This CEF report concludes " The most robust, and thus most desirable, electricity system will not rely on a single generation technology." Even with significant gains in efficiency, CEF projects electricity increases from California's 270 Twh/year today to 510 Twh/yr by 2050 if California is to meet its climate change goals. CEF has concluded that a large fraction of California's energy future would have to come from nuclear power. Although CEF calls for large gains in energy efficiency and increased renewable and nuclear energy contributions, CEF could only identify about a 60%, not 80%, reduction in GHG by 2050. To achieve the last 20% reduction there would have to be technical breakthroughs.

If one assumes that fears about climate change force greater harmony and synergy among renewable and nuclear energy and that great progress in energy conservation so that all sources of energy are carbon free, it would not be enough. Such an improvement would only affect the sources of energy whereas our total energy system consists of end use devices that use energy and multiple distribution systems to connect energy sources to these end use devices. Many end use devices like gas ranges, gas hot water systems, gas home and industry heating systems and several hundred million vehicles all depend on fossil fuels. Our energy distribution systems, from gas pipelines to coal trains to oil delivery trucks, are part of our largely fossil-fueled energy system. How do we replace several hundred million fossil fueled vehicles and perhaps a billion fossil fueled home appliances and simultaneously build all of the non-carbon distribution systems they

[5] "Massachusetts Regulators Approve a Gas-Fired Power Plant With an Expiration Date", M. Wald, NY Times, February 20, 2014

would need, between now and 2050? As large as the Fukushima economic impact is, it pales by comparison to the magnitude of what lies ahead to reach a fossil free energy future.

Part of the post Fukushima problem is misinformation. In their “fact” sheet on Fukushima, Physicians for Social Responsibility claims that the incidence of thyroid cancer for Fukushima children was 22.3 per 100,000 people, based on ultrasound examinations first taken in October, 2011. They compare this to an earlier pre-Fukushima thyroid incidence rate of 0.1 to 0.9 in 2007. These examinations began in October, 2011 only 7 months after the Fukushima accident. Yet, the latency period for thyroid cancers due to exposure to radiation has a mean value of 20.5 years or longer, depending on the type of cancer[6] with the minimal latent period for thyroid cancer development after exposure at four years. Even now it hasn’t been four years since the Fukushima accident. Shouldn’t physicians be aware of this latency period? Are the Physicians for Social Responsibility being responsible?

There have been other scare stories about Fukushima, such as an increased number of baby deaths in the Pacific Northeast. This has been debunked in an article[7] in Scientific American. Some have expressed concerns that the actual releases of radioactive material might be larger than what has been reported. Even if this were so, it would not affect the World Health Organization’s conclusion that early health effects from the release of radioactive material is essentially zero. The range of such early health effects is typically less than two miles. As reported before, some 13 hours passed between the time of the earthquake and the first release of radioactive material into the environment from a core melt. Long before any release occurred, people close to the plant were evacuated. A larger release would not cause early health effects because, by then people would be too far away.

Others have raised questions about the impact of Fukushima on sea life, human food chains, and possible effects of Fukushima along the Canadian and American Pacific shorelines. One can rely upon anecdotal statements or sensationalized articles often found in the media. However, if one wants competent and unbiased information, these issues have been extensively investigated by scientists from Woods Hole Oceanographic Institute and their findings are available on their web site. Claims that radiation from the wrecked Japanese nuclear plants are contaminating U.S. waters are simply not correct[8], according to U.S. Nuclear Regulatory Commission Chairman, Dr. Allison Macfarlane.

Some leading environmentalists who once were opposed to nuclear energy have reversed their positions after they studied the risks and benefits in the context of the threats from climate change. It is my hope that more people who care about the environment and all of

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[6] “ Latency period of thyroid neoplasia after radiation exposure”, S. Kikuchi et al, Ann Surg 2004 Apr:239(4):536-43, “Radiation-induced thyroid cancer: what we have learned from Chernobyl”, Nikiforov, YE, Endocr. Pathol. 2006 Winter :17(4): 307-17.

[7] “Are Babies Dying in the Pacific Northwest Due to Fukushima? A Look at the Numbers.”, Michael Moyer, Scientific American, June 21, 2011

[8] “Fukushima Contamination in U.S. Waters Refuted by NRC”, Bloomberg News, March 11, 2014

its living species will follow in their lead. Any debate between renewable energy and nuclear energy is worse than folly, it is dangerous. We will need both sources of energy and even then the challenges are daunting. The job ahead is enormous and the clock is ticking.