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# Critique of "The Future of Nuclear Power: An Interdisciplinary MIT Study"

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"The Future of Nuclear Power: An Interdisciplinary MIT Study" (hereafter, the "MIT Study") is the work of nine professors, eight from MIT and one from Harvard. The two principal investigators were former senior officials at the Department of Energy (DOE) managing the department's nuclear energy research and development (R&D) programs, and three other study group members were from MIT's Department of Nuclear Engineering. Most if not all of the study participants were predisposed to support the retention of nuclear power in some capacity. Nuclear power's usefulness as an option for reducing GHG emissions was the rationale for the study and was developed as its central theme.

The MIT Study includes an excellent analysis of the current economic plight of the U.S. nuclear industry. It makes clear that new nuclear plants are not economical and a combination of factors will have to break in nuclear's favor for new nuclear generators to be economically competitive with gas and coal. In the words of the study:

> In deregulated markets, nuclear power is not now competitive with coal and natural gas. However, plausible reductions by industry in capital cost, operation and maintenance costs, and construction time could reduce the gap. Carbon emission credits, if enacted by government, can give nuclear power an advantage. (MIT Study, p. ix)

Favoring nuclear power but recognizing that new nuclear plants are not competitive, the study group recommends that the U.S. government subsidize the technology to "resolve uncertainties about the economics of nuclear power" (MIT Study, p. 77). The recommended subsidies include the government sharing in the cost of obtaining Nuclear Regulatory Commission (NRC) approval for new plant sites, in the fees for NRC certification of new designs and in the fees for NRC construction and operating licenses, and "a production tax credit for up to $200/kWe [i.e., $200 per kilowatt of electric power] of the plants construction tax credit" for ten so-called "first mover" plants (MIT Study, pp. 80-81). This last proposed subsidy is pegged to the 1.7 cent per kilowatt–hour production tax credit for wind energy, and alone represents an additional $2 billion worth of subsidies for nuclear power plants to be constructed in the United States (MIT Study, p. 81). The study group also endorsed DOE's 2010 initiative, under which DOE is subsidizing—to the tune of hundreds of millions of dollars—certification of new reactor designs and early site banking of new nuclear plant sites.

These proposed subsidies are unjustified in my view, promoting both negative economic and environmental consequences relative to more benign renewable energy

generating technologies. Moreover, nuclear power is a mature industry that has already benefited from tens of billions of dollars in government subsidies over many decades and should sink or swim of its own accord without additional taxpayer assistance.

The reactor design certification primarily benefits foreign reactor manufactures since three of five former U.S. reactor vendors are now owned by foreign companies. Moreover, certification by the NRC of new reactor designs is sought by the vendors primarily to aid in selling these designs in foreign markets rather than in the United States. It functions as a "stamp of approval" suggesting that the designs are safe for export.

Under the MIT Study proposal large profitable U.S. nuclear generation companies would receive hundreds of millions of dollars in government subsidies through cost-sharing arrangements to bank sites[1] without being asked to make an upfront commitment to build a new nuclear plant should the sites be approved by the NRC. Moreover, early banking of reactor sites has the detrimental effect of reducing the likelihood that affected citizens can effectively participate in the licensing process.

Most importantly, giving a few large U.S. nuclear energy generating companies $2-3 billion dollars of taxpayer monies is not going to make new nuclear plants economical. It may lead to the subsidized construction of a few new plants, but it does nothing to reduce the real cost of nuclear power plants built in the United States. The study group argues that it will reduce the investor uncertainty in new plant costs. By this logic, the government should subsidize new energy conservation technologies and new pollution control equipment for fossil-fueled power plants.

The study group pegged its recommended production tax credit subsidy to that given to wind power. But the environmental costs of the two technologies are markedly different. While neither wind nor nuclear power contributes significantly to GHG emissions, nuclear power carries considerable baggage that sets it apart from wind power. Nuclear power has unresolved proliferation, safety and waste disposal problems that are unique to the technology. The MIT Study notes key unresolved issues in each of these areas, but instead of calling for their resolution, the pro-nuclear industry study group calls for multi-billion dollar government nuclear subsidies to build new nuclear plants.

Since most *existing* nuclear plants are economically competitive with fossil-fueled plants in terms of forward costs, energy generating companies will continue to extend the licenses and operate the existing U.S. fleet of nuclear plants over the next several decades. Also, since subsidizing a few new plants is not going to make *new* nuclear plants competitive, there are unlikely to be significant additions to the fleet beyond possibly a few heavily subsidized plants. Consequently, over the next fifty years I believe the number of nuclear plants in the United States will be on the order of 80 to 110 plants, where the low end of the range is based on the assumption that some older plants may be shut down and essentially no new plants will be constructed, and the upper end of the range assumes that few of the existing plants will be shut down and the government will subsidized the construction of several new plants.

The MIT Study also recommends that,

> Federal or State portfolio standards should include incremental nuclear power capacity as a carbon free source. (MIT Study, p. x)

I do not support this recommendation because, as noted above, there are serious unresolved safety, nonproliferation and high-level waste disposal problems that are uniquely associated with nuclear power.

Another major disagreement I have with the study group's recommendations is related to fuel cycle research. As before, while the analysis of the problem is correct, the recommendations fall short. The MIT Study correctly notes:

> **. . . over the next 50 years the best choice . . . is the open, once-through fuel cycle.** (MIT Study, p. x, emphasis in the text)

and

> *For the next decades, governments and industry in the U.S. and elsewhere should give priority to the development 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. (MIT Study, p. 5, emphasis in the text)

and

> *We believe that the world-wide supply of uranium ore is sufficient to fuel the development of 1000 reactors over the next half century* and to maintain this level of development over a 40 year lifetime of this fleet. (MIT Study, p. 4, emphasis in the text)

Support for these conclusions can be found in Appendix 5.E at page 154 of the MIT Study where there is a figure that shows that during the 20$^{th}$ century, the constant dollar price of 12 selected minerals went down. This downward trend reflects the fact the efficiencies in extraction ores outpaced the depletion of the higher grades. This trend, which goes unrecognized by most nuclear engineers, is true of virtually all major mineral resources. The fact that it is also true of uranium could be seen more clearly had Figure A-5.E.1 (MIT Study, p. 153) been plotted in constant dollars instead of current dollars.

The MIT Study also recognizes that closed fuel cycles are grossly uneconomical compared to the open cycle.

> The fuel cycle cost model presented in Appendix 5.D shows that the closed cycle PUREX/MOX option fuel costs are roughly 4 times greater than for the open cycle, using estimated costs under U.S. conditions. (MIT Study, p. 44)

In Appendix 5.D the PUREX/MOX option cost was estimated to be $8890/kgHM compared to $2040/kgHM for the open cycle. The open cycle costs in the U.S. are well known based on decades of experience. The closed cycle costs are likely to be

considerably higher than those estimated by the MIT Study, which pegs the reprocessing cost at only $1000/kgHM. Based on European and Japanese experience, this cost is likely to be one or two times higher. The cost estimate of MOX fabrication also appears to be low. Moreover, the advanced closed fuel cycles are likely to be even more economically disadvantageous, as can be deduced from the pilot pyro-processing experience in the United States.

The MIT Study also concludes,

> . . . *we do not believe a convincing case can be made on the basis of waste management considerations alone that the benefits of advanced fuel cycle schemes featuring waste partitioning and transmutation will outweigh the attendant risks and costs.* (MIT Study, p. 60, emphasis in the text)

In addition, the MIT Study recognizes that the closed fuel cycle represents a serious proliferation threat when undertaken in any number of non-weapon states, e.g., Iraq, Iran, North Korea, and even Russia.

Despite the acknowledgement of poor economic prospects, no significant waste management advantages and high proliferation risks associated with closed fuel cycles, the MIT Study unfortunately leaves the door open to develop new reprocessing technologies.

> On the other hand, we [the MIT Study group] support modest laboratory scale research and analysis on new separation methods with the objective to learn about separation methods that are less costly and more proliferation resistant. There has been little exploration in the United States of alternatives to PUREX and pyro-processing since their invention decades ago with entirely different purposes in mind: obtaining weapons usable material and reprocessing metal fuel, respectively. We note however that there is considerable skepticism for even this modest approach, because some see *any* U.S. work on reprocessing sending the wrong signal to other nations about the credibility of our expressed attitude toward the proliferation risks of reprocessing, and the concern that DOE will move from analysis and research to development before the technical basis for such action has been developed. We propose that this program begin at a modest scale, reaching $10 million per year in about five years. (MIT Study, p. 92)

Instead of curbing DOE's appetite for promoting technologies that are both dangerous and uneconomical, this MIT Study recommendation likely will be used by DOE to justify its Advanced Fuel Cycle Initiative (AFCI). The DOE FY 2004 budget for the AFCI is $63 million—over six times what the MIT recommends be spent in five years. The AFCI is coordinated with DOE's Generation IV program to develop new reactor concepts for possible introduction in the 2030 to 2050 time period. Last year DOE organized the Generation-IV International Forum, an effort by 10 countries to jointly develop six nuclear energy systems, including several fast reactor concepts that require closed fuel

cycles. The countries included five non-weapon states that formerly had clandestine nuclear weapon programs, namely, South Africa, Argentina, Brazil, South Korea and Switzerland.

Although the MIT Study recommends that "[t]he DOE R&D program should be realigned to focus on the open, once-through fuel cycle" (MIT Study, p. x), I fear the recommendation to engage in modest R&D on closed fuel cycles will be used to bolster the DOE AFCI effort. This will promote in non-weapon states, including states that in the past had clandestine nuclear weapon programs, the construction of hot cells for reprocessing R&D and training of cadres of experts in plutonium chemistry and metallurgy. This DOE effort is clearly a threat to U.S. national security.

Because closed fuel cycles are so uneconomical, U.S. government sponsored research on closed fuel cycles is not likely to lead to their adoption. Consequently, in the next fifty years I believe U.S. nuclear plants will stick with the open fuel cycle.

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[1] "Site banking" refers to the process of obtaining regulatory approval of a nuclear plant site before construction. See Deutch, John, Ernest J. Moniz, et al. 2003. *The Future of Nuclear Power—An Interdisciplinary MIT Report.* Massachusetts Institute of Technology. See http://web.mit.edu/nuclearpower/, pg. 96.