Invited testimony to the Select Committee on Energy Independence and Global Warming
United States House of Representatives, Washington, DC
Hearing on "Nuclear Power in a Warming World: Solution or Illusion?"
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Why expanding nuclear power would reduce and retard climate protection and energy security… but can't survive free-market capitalism

I appreciate this opportunity to share with the Committee some recent analysis of whether we need nuclear power, especially to protect the climate.[1] I'll summarize why nuclear power isn't needed for any civilian purpose[2]; how and why it's being dramatically outcompeted in the global marketplace by no- and low-carbon electrical resources that deliver far more climate solution per dollar, far faster; and why nuclear expansion would *inhibit* climate protection, energy security, and reliably powering prosperity. Even if nuclear power could attract private risk capital, it could not in principle deliver its claimed climate and security benefits. But because it's uneconomic and unnecessary, we needn't inquire into its other attributes.

Far from undergoing a renaissance, nuclear power is conspicuously failing in the marketplace, for the same forgotten reason it failed previously: it costs too much and it bears too much financial risk to attract private risk capital, despite federal subsidies now approaching or exceeding its total cost.

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[1] My curriculum vitae is Annex A and my Federal contract/grant disclosure is Annex B. The analysis summarized here is set out in several papers based both on 2004 (Annexes C and D) and on the latest, even stronger, data presented in Annex E, which is the best starting-point. Details and documentation supporting Annex E's summary will be posted shortly at www.rmi.org as a preprint of a major peer-reviewed scholarly article.

[2] A case can be made for nuclear naval propulsion (submarines and carriers), where strategic and operational needs trump economics. Recent claims that nuclear propulsion is also worthwhile for medium surface combatants rely on Navy analyses that improperly assume a zero real discount rate; at even a minimal 3% real discount rate (OMB rules require at least 3% and probably 7%), the breakeven oil price required is a large multiple of the $60/bbl claimed on the House floor last December. Both the JASON senior scientific advisory group to the Secretary of Defense and a Defense Science Board Task Force on military energy strategy on which I recently served (www.acq.osd.mil/dsb/reports/2008-02-ESTF.pdb) pointedly declined to endorse either this naval propulsion concept or the similarly uneconomic—and, for energy security, counterproductive—notion of installing small nuclear power plants on military bases.

Fortunately, its decentralized competitors don't have these problems. Despite much smaller subsidies and often tall barriers, the low- and no-carbon distributed resources dismissed by the nuclear industry as uneconomic, impractical, and trivial are actually producing more electricity worldwide than nuclear, are growing tens of times faster, and have tens of times nuclear's market share. Specifically, "micropower"—cogeneration plus distributed renewables—now produces a sixth of the world's total electricity (more than nuclear), at least a third of the world's new electricity, and from one-sixth to more than half of all electricity in a dozen industrial countries (the U.S. lags with just 4%). "Negawatts"—electricity saved by using it more efficiently or timely—are about as big worldwide as micropower and cost even less.

In 2006, nuclear power added less capacity than photovoltaics added, one-tenth what windpower added, and 30–41 times less than micropower added; its output growth was one-sixth of micropower's. Distributed renewables won $56 billion of private risk capital; nuclear, as usual, got zero—only central planners buy it. China's distributed renewable capacity reached seven times its nuclear capacity and grew seven times faster. These trends are accelerating, especially in developing countries, which have more scope and more need for both micropower and negawatts.

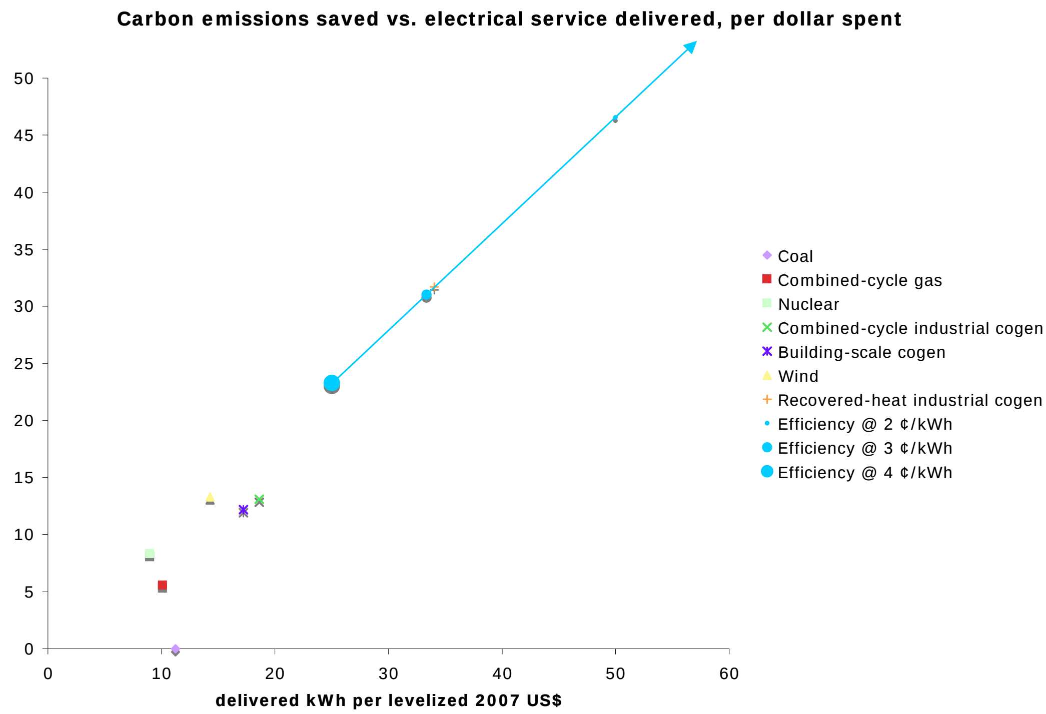
Millions of small resources can be collectively huge, much as networked PCs now provide most of the world's computing capacity. Distributed ways to make or save electricity can spread like PCs and cellphones, not like constructing cathedrals. Capital embraces them. They're quick, agile, rapidly evolving, ever cheaper, and independent of foreign inputs—just the opposite of nuclear power. Moreover, they have such huge potential that just the full economic use of electric efficiency, zero-carbon waste-heat cogeneration, and windpower—with no other renewables—could provide ~13–15× nuclear power's current share of U.S. electric generation, without significant land-use, reliability, or other constraints, and with millions of good new jobs.

Distributed generators are generally more dependable than centralized ones because their many small units won't all fail at once and can bypass the grid, where nearly all power failures originate.[3] Variable renewable resources (sun and wind), even in large amounts, need less backup than we've already bought and built to manage the intermittence of big thermal plants—especially nuclear plants, many of which can fail simultaneously, unpredictably, and for long periods.

The Nuclear Energy Institute says 78% of the new coal plants announced in 2006–07 got cancelled. I expect announced nuclear projects to do worse because they cost more. They've attracted no private risk capital despite U.S. taxpayer subsidies that can now total about $13 billion per new nuclear plant—roughly its entire cost, which exceeds the market cap of any U.S. utility save one. The smart money, led by Warren Buffet, is now heading for the exits, spooked by steeply rising nuclear costs, disappointments in the flagship Finnish project, competition by ever-cheaper micropower and negawatts, and the credit crunch. The U.S. can have only about as many new nuclear plants as taxpayers are forced to buy. Heroic efforts at near- or over-100% subsidization will continue to elicit the same response as defibrillating a corpse: it will jump, but it won't revive.

[3] For fundamental reasons described in my 1982 DoD study *Brittle Power: Energy Strategy for National Security*, www.rmi.org/sitepages/pid114.php, reliable, affordable power supplies must come from efficiently used, diverse, dispersed, mainly renewable resources sited at or near the customer.. The Feb 08 DSB report cited in the previous note strongly reinforces that message. My Senate Energy Committee testimony of 7 Mar 06 provides an overview of the elements of national energy security at www.rmi.org/images/PDFs/Energy/E06-02_SenateTestimony.pdf.

That’s good for climate protection, because nuclear power is so expensive that it buys ~1.5–11+ times less carbon reduction per dollar than competing no-carbon technologies (efficient use, renewables, recovered-heat cogeneration)—or fossil-fueled cogeneration in factories and buildings (adjusted for its modest carbon emissions). This graph, derived in Annex E, summarizes the typical empirical costs today of producing or saving electricity at your meter:



The horizontal axis shows how much new electrical service you get per dollar: cheaper is toward the right. The vertical axis shows how much carbon you save per dollar: more climate-friendly is toward the top. Many “negawatts” are way off the upper-right corner of the chart. Conversely, the least helpful options are toward the lower left corner. Among those losers, nuclear emits less carbon—almost none in operation—than coal power, but it *costs* so much more than competing climate solutions that spending a dollar on nuclear instead of on efficient end-use worsens global warming more than spending the same dollar on new coal power.

Wishing for a nuclear revival will not make it so. After a half-century, nuclear power has irrefutably proven its inability to compete in the marketplace. It’s time to get on with judicious investments that yield the most energy services and climate protection per dollar and per year.

The capital markets are now injecting a welcome realism long absent from Federal policy. The straightest path to American energy security and to a richer, fairer, cooler, safer world is to let all ways to save or produce energy compete fairly, at honest prices, regardless of their type, technology, size, location, and ownership. That’s pretty much the opposite of the Federal energy policy we have.

Annex A: Curriculum vitae of Amory B. Lovins

Birth: 13 November 1947, in Washington DC
Marriage: L. Hunter Lovins 1979–99, Judy Hill Lovins 2007–

Course of Studies and Professional Career:
1964–1967: Undergraduate, Harvard College
1967–1969: Advanced Student, Magdalen College, Oxford
1968– : Consultant to industry and government in ~30 sectors and ~50 countries, chiefly on advanced energy and resource efficiency, integrative design, implementation, strategy, and public policy; clients include scores of major firms; recently redesigned >$30b worth of superefficient facilities
1969–1971: Junior Research Fellow, Merton College, Oxford (MA by Special Resolution, 1971)
1978: Regents' Lecturer in Energy and Resources, University of California at Berkeley
1979–2007: Honorary doctorates of nine US and UK universities
1979: Distinguished Visiting Scholar, University of Oklahoma
1980: Regents' Lecturer in Economics, University of California at Riverside
1980–81: Energy Research Advisory Board, U.S. Department of Energy
1981– : Cofounder, CEO (2002–07), Chairman and Chief Scientist (2007–), Rocky Mountain Institute (independent, nonpartisan, entrepreneurial nonprofit; creates abundance by design; www.rmi.org)
1982: Henry R. Luce Visiting Professor of Environmental Studies, Dartmouth College
1982: Distinguished Visiting Professor of Environmental Design, University of Colorado
1986–92: Cofounder/director, E SOURCE; 1992–99: Board member/Principal Technical Consultant
1999: Oikos Visiting Professor, Business School, University of St. Gallen (Switzerland)
1999–2007: Cofounder and Chairman, Hypercar, Inc. (now Fiberforge Corporation, www.fiberforge.com); Director and Chairman Emeritus, 2007–
1999–2001 and 2006–08: Defense Science Board Task Forces on energy, U.S. Department of Defense
2002: Visiting Lecturer, College of Environmental Engineering, Peking University
2007: MAP/Ming Visiting Professor, School of Engineering, Stanford University

Main Awards:
1982: Mitchell Prize (2nd place)
1983: Right Livelihood Award ("Alternative Nobel Prize")
1984: Fellow, American Association for the Advancement of Science
1988: Fellow, World Academy of Arts and Sciences
1989: Delphi Prize of the Onassis Foundation
1993: Nissan Prize (ISATA); MacArthur Fellow
1997: Heinz Award for the Environment
1999: Lindbergh Award
1999: World Technology Award
2000: Happold Medal of the U.K. Construction Industry Council; *Time* "Hero for the Planet"
2001: Shingo Prize (Research)
2005–6: Benjamin Franklin Medal, Royal Society of Arts (London) (Life Fellow 2007)
2006: Jean Meyer Award
2007: Blue Planet Prize; Volvo Prize; Hon. member, American Institute of Architects; Foreign Member, Royal Swedish Academy of Engineering Sciences; Hon. Senior Fellow, Design Futures Council; *Popular Mechanics* Breakthrough Leadership Award; *Time International* "Hero of the Environment"

29 books and hundreds of papers; the three most recent books are:
- *Natural Capitalism: Creating the Next Industrial Revolution* (with sr. author P.G. Hawken & L.H. Lovins), Little Brown (Boston), 1999 (>12 translations), www.natcap.org
- *Small Is Profitable: The Hidden Economic Benefits of Making Electrical Resources the Right Size* (with six coauthors), Rocky Mountain Institute (Snowmass, Colorado), 2001 (*Economist* book of the year), Japan Energy Conservation Center (Tokyo), 2005, www.smallisprofitable.org

- *Winning the Oil Endgame: Innovation for Profits, Jobs, and Security* (with E.K. Datta, O.-E. Bustnes, J.G. Koomey, & N.J. Glasgow), Rocky Mountain Institute for DoD *et al.*, 2004, www.oilendgame.com

Annex B: Statement of Federal grants and contracts received by myself or by my organization in the current or previous two fiscal years

During 2006–08 I served on the Defense Science Board Task Force on DoD Energy Strategy, cochaired by former SECDEF Dr. James Schlesinger and GEN Mike Carns (USAF Ret.). This service as a Special Government Employee (as I understand it) was noncontractual and uncompensated, but RMI was reimbursed for most of my travel expenses. Since the Task Force's report was briefed to DSB more than a year ago and was released to the public on 13 Feb 08 (www.acq.osd.mil/dsb/reports/2008-02-ESTF.pdb), I presume that my SGE service to DoD has ended., though I received no official notice of entering or leaving SEG status.

For the fiscal year ended 30 Sep 06, my nonprofit employer, Rocky Mountain Institute, held and some of my colleagues partly used a $50,000 contract to support policy research and development on military energy efficiency for the Office of the Secretary of Defense.

I am not currently aware of any other Federal grants or contracts received by Rocky Mountain Institute or by myself during the current or the previous two fiscal years. However, on receiving the Committee's inquiry on this point on 7 Mar 2008, I asked RMI's CFO to research it in case, for example, I might have given a lecture (for which RMI would have been paid) to some Federal entity, as I sometimes do *pro bono*. I shall advise the Committee of any information received.

Annex C: "Mighty mice," from *Nuclear Engineering International*, December 2005, Rocky Mountain Institute Publication #E05-15, www.rmi.org/images/PDFs/Energy/E05-15_MightyMice.pdf,

This article sought to explain to the nuclear industry who its competitors are. The yellow box at the upper right corner of the first page cites an exchange with a critic from the World Nuclear Association.

Annex D: "Nuclear power: Economics and climate-protection potential," Rocky Mountain Institute Publication #E05-14, 6 January 2006, www.rmi.org/images/PDFs/Energy/E05-14_NukePwrEcon.pdf

This more technical paper details and documents the analysis in Annex C. Both are based on the 2004 data then available. Those data are posted at www.rmi.org/sitepages/pid256.php#E05-04, to which 2006–07 updates will shortly be posted. An independent renewable-energy database with very similar figures (but slightly higher due to a wider definition of small hydro) is at www.ren21.net.

Annex E: "Forget nuclear," prepublication draft, *RMI Solutions* (www.rmi.org), Spring 2008; final version to be posted shortly at www.rmi.org, Publications, Energy, Nuclear Energy, and in RMI's Newsletter section, and provided to Committee staff as soon as available

This relatively nontechnical article, currently being edited for the RMI newsletter and hence subject to minor change, draws on a much fuller and heavily documented peer-reviewed analysis to be published in September 2008 by the Royal Swedish Academy of Sciences' journal *Ambio*. A preprint will be posted by permission in spring 2008. The cost analysis in Annex E is updated from that in Annexes C and D chiefly in the following respects:

- The 2004 costs are updated to reflect the best 2006–07 empirical U.S. cost data from industry. Thus we retained the MIT nuclear and combined-cycle costs but added the June 2007 Keystone Center nuclear analysis and more recent estimates from utilities and leading financial houses. We refreshed coal-plant cost escalation with MIT Coal Study and industry estimates. We used the empirical capacity-weighted median windpower prices for 2004–05 US installations (equal to the 1991–2006 average), sensitivity-tested through 2006, and their average O&M costs, plus the mean of nine recent studies of windpower firming and integration costs, all as compiled by Lawrence Berkeley National Laboratory.
- We used the GDP Implicit Price Deflator (1.09) to convert all 2004 $ to 2007 $.
- We added a nominal 0.1¢/kWh cost to the onsite generators as a proxy for any excess of backup costs over distributed benefits to the utility (the actual value may well be negative in most cases), and added similar minor costs for some other resources for which they hadn't previously been explicitly shown.
- We continued to use deliberately low delivery costs for central stations, favoring them over distributed resources.
- We showed an illustrative cost range for electric end-use efficiency. For comparison, national-average program costs are around 2¢/kWh; hundreds of utility programs in industry and commercial buildings have cost less than 1¢/kWh; and the best practitioners routinely achieve costs at or below that level—often even less than zero.