Why Nuclear Power's Failure in the Marketplace Is Irreversible (Fortunately for Nonproliferation and Climate Protection)

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Nuclear Power and Nuclear Weapons: Can We Have One Without the Other?

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Scorecard: competitors pulling ahead

- World primary energy output 1998 (BP)
  - Nuclear 6.3%; all renewables without traditional biofuels 8.8%, or with biofuels 20.3%
- US energy output '98–2000 (hydro varies)
  - Nuclear = 1.02–1.17× renewables' pri. energy, ~1.8× renewable kWh, same el. gen. capacity
- 1990–99 av. %/y growth in global capacity
  - Nuclear 1, photovoltaics 17, windpower 24
- 1998–99 change in global capacity
  - Nuclear –1.4% (–5 GW to 354 GW: IAEA)
  - Windpower +37% (+3½ GW to 17 GW at end 2000; + 5 GW to ~22 GW expected in 2001; cf. world nucl. starts avgd. 3.1 GW/y 1990–99)

Typical el. competition: conclusions

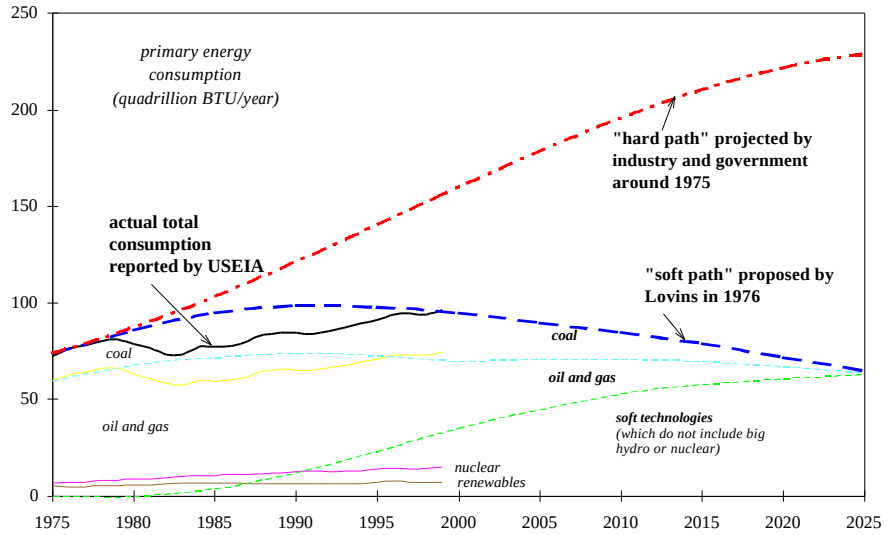
- Three abundant resources—efficient end-use, efficiently used gas (especially when thermally integrated), and windpower — easily beat new (even old!) nuclear plants
  - DOE 12/00 projects US c-c gas 126 GW in 2010, vs. nuclear power's 97 GW in 2000
  - Gas rather ubiquitous / abundant (>200 years)
  - Rhodes's claim of "the decline and fall of the renewables": cf. current Eur. Fortune cover!
  - The case strengthens in developing countries
- Any one of these three makes nuclear power unnecessary and uneconomic
- Fuel cells & PVs will raise that 3 to 4–5
- "Distributed benefits" seal the argument

Is efficient end-use important?

[US energy efficiency improvements] "contribute only marginally to US energy supplies"

— Richard Rhodes & Denis Beller, "The Need for Nuclear Power," Foreign Affairs, Jan.–Feb. 2000

US energy use/$ GDP already cut 40%, to very nearly the 1976 "Soft Energy Path"



By 2000, the reduction in US E/GDP (compared with 1975) was:

- The nation's largest energy "supply," providing 40% of all US energy services
  - >5 times US domestic oil output
  - >2 times total US oil imports
  - >12 times Persian Gulf imports
- The fastest-growing US energy "source"
- At least 2/3 due to technical efficiency

The US has doubled its oil productivity in the past quarter-century — yet barely scratched the surface of how much efficiency is available and worth buying

A new wave of US energy efficiency

- 1979–86: real GDP +20%, pri. energy –5%
- 1986 price crash, "period of stagnation"
- Calif. led in el. eff.: –10 GW_p by early '90s
- 1996–2000: U.S. neared record for speed of cutting primary energy/GDP (–3.1%/ y)
  - Despite record-low / falling prices 1996–99
  - Perhaps 1/3 due to E-commerce-related structural changes: www.cool-companies.org
  - Mostly technical gains in end-use efficiency
  - Driven by competition, fashion, side-benefits
- Savings keep getting bigger and cheaper
- Electrical savings are the most lucrative
  - Enthalpically, 1¢/kWh = $17/bbl-equivalent

Vast unbought efficiency potential

- US could save ≥3/4 of its electric use (1/4 lights, 1/4 motors, ≥1/4 others) by fully retrofitting best existing technologies at below short-run marginal supply cost — ~4× nuclear output, cheaper than op. cost
- Tech details available: www.esource.com
- 60–80 market failures in buying efficiency offer attractive business opportunities*
- *"Climate: Making Sense and Making Money," www.rmi.org, at pp. 11–20
- Side-benefits worth far more than kWh
  - ~6–16% higher labor productivity, 40% more retail sales, ~20–26% higher school test scores, more/better industrial production,…

Efficiency can work quickly

- *In 1983–85, 10 million people served by Southern California Edison Co. were cutting its 10-y-ahead forecast peak load by 8½%* per year*, at ~1% of marginal supply cost*
- *In 1990, NEES got 90% of a small-business retrofit pilot program's market in 2 months*
- *PG&E got 25% of its 1990 new-commercial-construction market in 3 months, raised its 1991 target, and got it all during 1–9 January*
- *New delivery methods are even better — not just marketing negawatts but making markets* in *negawatts, thus maximizing competition*

Is efficient end-use cost-effective?

[US energy efficiency improvements remain] "stubbornly uncompetitive"

— Richard Rhodes & Denis Beller, "The Need for Nuclear Power," Foreign Affairs*, Jan.–Feb. 2000*

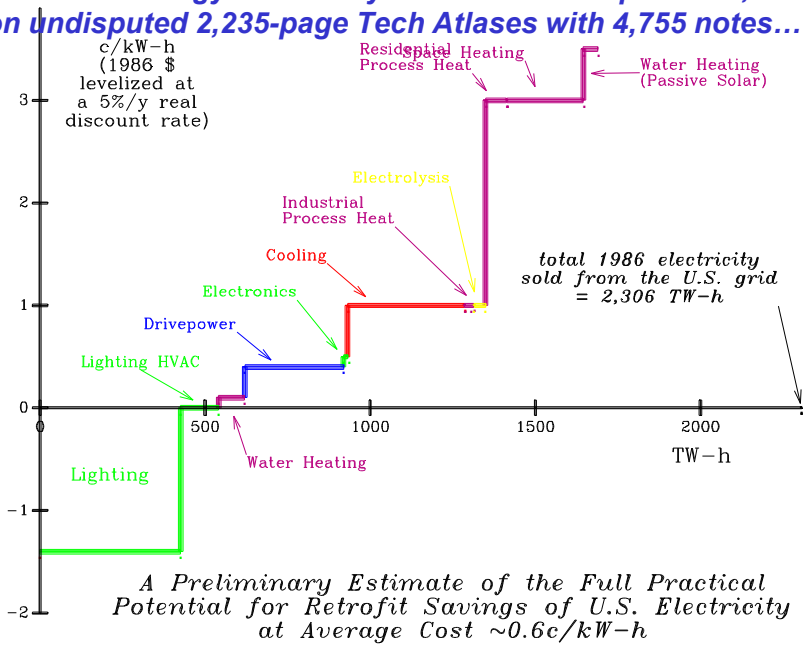
Electric efficiency is very cheap

- *Vast literature documents sophisticated, rigorous measurement and evaluation*
- *Costs and savings accurately predictable*
- *Historic US* **av.** *cost utilities ~2¢/kWh*
  - *SCE's DSM portfolio 1991–94: 2.6→1.2¢/kWh (av. 1.7) despite relatively costly res'l. efforts*
- *Well-designed progs. often far cheaper*
  - **E.g.,** *NYSERDA review of >200 programs by 58 utilities –'88: dozens cost 0.4–1.1¢/kWh*
  - *>20 utilities' comm'l./ind'l. programs cost ≤1¢/kWh, the best <0.5¢/kWh ('88 $); median was ≤1¢ for eight major types of programs*
  - *Transaction costs often tiny (SCE 1984: 0.065¢ res'l, 0.031¢ other — ~1% of tariff)*

Future negawatts can be even cheaper

- *Better technologies, more ubiquitous*
- *Volume production, competitive prices*
- *More streamlined delivery methods*
- *Better marketing, especially in bundles and using valuable side-benefits*
- *Much better insight into how to turn obstacles into business opportunities*
- *Greater customer awareness / eagerness*
- *Continuing innovation expands technical potential faster than it's being exploited*
- *Now add breakthrough design integration*

RMI's >1000-technology 1987 analysis of US retrofit potential, based on undisputed 2,235-page Tech Atlases with 4,755 notes…

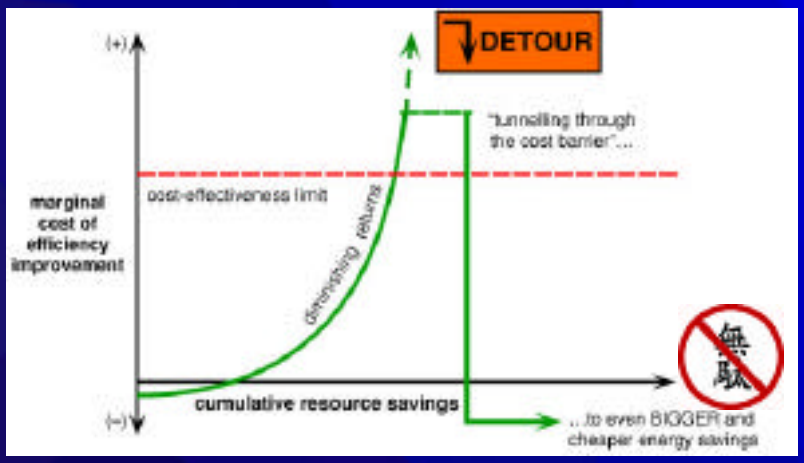


TF 22.X.88

...is now known to be conservative in both quantity and cost

Old design mentality: always diminishing returns...

New design mentality: expanding returns, "tunneling through the cost barrier"



New design mentality: an industrial example

Redesigning a standard (and supposedly optimized) industrial pumping loop cut its power from 95 to 7 hp (–92%), cost less to build, and worked better in every way

Recent building examples

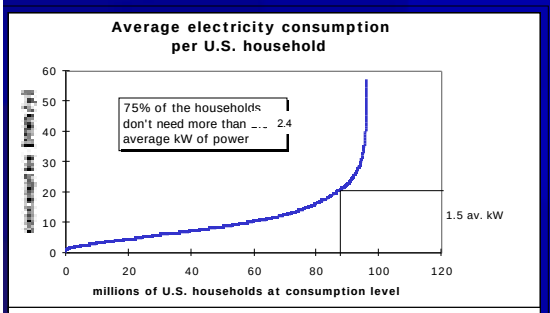
- Grow bananas with no furnace at –47°F (RMI, 1983); comfort without air-conditioning at +115°F (PG&E ACT^2); both cost less to build
- 90% household el. saving (~$5/mo. for 4k ft^2), 99% space- & water-ht. saving, 10-mo. paybk.
- 90% a/c saving in new Bangkok house, 0 cost
- Big office buildings: 75–90% less energy, ~3–5% lower capital cost, 6 months faster, superior comfort and market performance
- 75% energy savings retrofittable in Chicago office tower, costs same as just renovation
- 97% a/c saving retrofit design in CA office

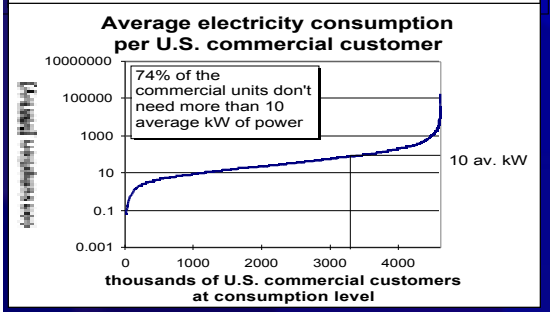
A few industrial examples

- Saving half of industrial drivepower (3/8 of industrial el.) typically retrofittable with 35 measures @ ~100–200%/y aftertax ROI
- Same ROIs recently found for retrofitting chip-fab chiller/fan systems (save 50+%)
- 8th biggest chipmaker (STMicroel.) targets zero net carbon emissions by 2010
- DuPont plans to boost energy productivity at least 6%/y in this decade—European plants no more efficient than U.S. plants
- Dow/Louisiana got >200%/y ROI retrofitting $110M/y of simple energy savings

What about sustainable non-nuclear electricity generation?

What's the right size for the job? Most customers want kW, not GW





Three-fourths of U.S. households have average loads not exceeding 2.4 kW (EIA statistical sample, 7/93)

Three-fourths of U.S. commercial customers have average loads not exceeding 10 kW (EIA statistical sample, 1992, logarithmic vertical axis)

Distributed generation can be quick

- *In 1984–85, CA was being offered private generation, av. 12 MW/unit, mostly renewable, at 9 GW (1/4 of peak load)* per year
- *By fall 1988, small power commitments covered >48% of Maine's and 15% of New Hampshire's total peak loads*
- *By 1998, nonutility producers' output was equivalent to 68% of all electricity sold by utilities in Maine (of which more than 2/3 was renewable), 19% in New Hampshire, and 41% in California*
- *By 1998, 38% of all CA's net el. generation was renewable, 56% in ME, 11% in US*

Land and materials needs are modest

- E.g., *Denmark, now 16% windpowered, on target for 50% in 2030 w/no land-use issue (nor intermittence—long since resolved)*
- *20% of US el. could be made by modern wind turbines occupying 5% of 400×400 mi (4 MT counties, or 0.6% of Lower 48)*
- *U.S. annual el. could come from ordinary PVs occupying 50% of ~100×100 miles*
- *Actual installations would be distributed, sharing land-use, and/or on buildings*
- *Energy paybacks: months to a few years*
- *1 kg Si in thin-film PVs can produce more electricity than 1 kg U in a PWR*

"Distributed benefits" change the game

- **Small Is Profitable: The Hidden Economic Benefits of Making Electrical Resources the Right Size *(RMI, later in 2001)***
- ***Codifies and quantifies ~125 "distributed benefits" that increase economic value of decentralized generation by typically ~10×***
- ***Four kinds: financial economics, electrical engineering, miscellaneous, externalities***
- ***"Fuel Cells Are Profitable" (RMI, 2001) will apply this work specifically to fuel cells***
- ***PVs cost-effective* now *if benefits counted***

And another game-changer that will flower in this decade...

- ***A transportation technology revolution that will change or replace many major industries***
- ***New market entrants, like aeroturbine makers displacing boilermakers***
- ***Could also dominate distributed generation and transform the economics of renewable electricity***

A 5×-more-efficient midsize SUV

An illustrative, uncompromised, manufacturable, and costed concept car (November 2000) developed for a few million dollars in eight months by the private firm Hypercar, Inc. (www.hypercar.com), on time and on budget, with attributes never before combined in a single vehicle

- *5 big adults, up to 69 ft³ of cargo*
- *Hauls 1,013 lb up a 44% grade*
- *1,889-lb curb (47% of Lexus RX300)*
- *Head-on wall crash @ 35 mph doesn't damage passenger cell*
- *Head-on collision with a car twice its mass, each @ 30 mph, meets U.S. occupant protection standards for fixed-barrier crash @ 30 mph*
- *0–60 mph in 8.2 seconds*
- *99 mpg-equivalent (5 times RX300)*
- *330 mi on 7.5 lb of safe 5-kpsi H_2*
- *55 mph on just normal a/c energy*
- *Zero-emission (hot water)*
- *Sporty, all-wheel digital traction*
- *Ultrareliable; flexible, wireless diagnostics/upgrades/tuneups*
- *200k-mile warranty—no dent/rust*
- *Competitive cost expected*
- *Decisive mfg. advantages*

Hypercars will ultimately...

- *save as much oil as OPEC now sells*
- *decouple driving from climate and smog*
- *displace 1/8 of steel market early, ~7/8 later*
- *become immense electricity generators: cars are parked ~96% of the time, and a full US fleet of 150 million light vehicles, @ 20–45 kW each, would be 3–6 TW — 5–10× as much generating capacity as all utilities now own*

WHEN? Within current planning horizons!

- *Hypercars will be widely available in ~5 y, dominant in ~10 (see open-source chronology at www.rmi.org/sitepages/pid414.asp)*
- *The old way of making cars will be toast in 20 y; what about the old electricity industry?*

Similarly in developing countries: China

- *Halved E/GDP elasticity, another halving underway, to help economic development*
- *Cut coal output by 1/3 since 1996, soon by 1/2, to boost development & public health*
- *Fast shift to efficiency, gas, renewables; H_2?*
- *In 3/2000, announced nuclear ordering moratorium of at least 5 years**

**Zeng Peiyan, Director, State Development Planning Commission, 6 March news conference reported in 9 March* Zhongguo Dianli Bao (China Electric Power Daily)

- *South is saving E & CO_2 at least as fast as North in percent & maybe in absolute terms*
- *End-use efficiency instead of el. supply can cut capital needs by ~10^{3-4}× — big leverage*

Why nuclear can't protect the climate

- *Suppose that saving a kWh costs as much as 3¢ while generating a new nuclear kWh costs as little as 6¢*
- *Then each 6¢ spent on a nuclear kWh could have bought* two *efficiency kWh*
- *So buying the costlier nuclear kWh instead resulted in 1 kWh of fossil-fueled generation that could have been avoided*
- *Unless nuclear power is* the cheapest *way of all to meet energy-service needs, buying it will make climate change worse than if the best buys were bought instead*

The nuclear / climate fallacy (2)

- *The order of economic priority is also the order of environmental priority*
- *Whether nuclear power can beat coal power doesn't matter, because energy efficiency and renewables, which are also CO_2-free, cost less than either*
- *Rhodes & Beller note that if fossil fuels had to pay for emissions controls, they'd cost a lot more; but this would competitively benefit not nuclear power so much as its still cheaper, faster, and more attractive alternatives — chiefly efficiency and renewables*

Nonproliferation at a profit

(Lovins, Lovins, & Ross, For. Aff.*, Summer 1980)*

- *Perhaps the first airtight description of what a highly effective, internally consistent nonproliferation regime requires*
  - *Commercial collapse of nuclear power (which is a peculiarly convenient route to bombs because it's innocent-looking, praised, paid for)*
  - *Rise of clearly better / cheaper energy options*
  - *End of Cold War and bipolar hegemony*
- *Few readers were ready for those assumptions 21 years ago*
- *But now that they've all happened, their logic, still sound, merits revisiting*

In a world without nuclear power...

- *All the ingredients needed to make bombs by any of the ~20 known methods would no longer be ordinary items of commerce*
  - *Hence harder to get, more conspicuous to try to get, politically costlier (for both seeker and supplier) to be caught trying to get…*
  - *…Because its civilian "cover" was removed!*
  - *Removed ambiguity smokes out proliferators, focuses attention on fewer transactions*
  - *Doesn't make proliferation impossible, but makes it far harder — in most or all cases of practical interest, probably prohibitively so*
- *Those wanting energy must explain why they're seeking the costliest option*

Essential political conditions include...

- *Go to NPT "bargain"'s purpose — ensuring fair access to affordable energy for development…but not specifically to* nuclear *energy (now that better solutions are available)*
- *Actually provide such energy access*
- *Involve broad-based* energy *experts in the negotiations, not just* nuclear *experts*
- *Educate & set example on why bombs make one less secure and bespeak immaturity*
  - *Try seriously to kick the habit — "Bombaholics Anonymous," deep cuts, ritual / symbolism,…*
  - *Build new security triad — conflict prevention / avoidance, resolution, nonprovocative defense*

"A fit technology for a wise, farseeing, and incorruptible people…"

- *Tragic misallocation, still distorting choices*
  - *Talent, work, hope, investment deserved better*
  - *Shield from accountability — make big mistakes*
  - *Best legacy: don't make the same mistake twice*
- *Market discipline yields the right conclusion*
  - *Trying to reverse verdict has a huge opp. cost*
- *Design an orderly terminal phase*
  - *Neighbors more likely to accept waste if not an open-ended, unlimited, perpetual commitment*
  - *Nuclear religion is main barrier to acceptance*
- *Turn commercial collapse, and rise of better energy alternatives, into the long-awaited missing step toward nonproliferation*

Thank you! And please visit...

- ***www.rmi.org*** *(general information, many publications; Transportation section gives public Hypercar information)*
- ***www.hypercar.com*** *(the new private technology-development company)*
- ***www.naturalcapitalism.org*** *or* ***www.natcap.org*** *for short (the wider context—making business far more profitable by behaving as if nature and people were properly valued): see* **Natural Capitalism** *(Little Brown, NY, & Earthscan, London)*