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THE POLITICAL ECONOMY OF NUCLEAR ENERGY IN THE UNITED STATES

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Introduction

"The rest of the world has continued to expand its nuclear power capacity, while we have been standing still."[1]

A tendency among commentators, even experts like the author of the sentence above, is to regard the complicated story of nuclear energy in the United States as exceptionally troubled and frustrating. The root cause of the troubles and frustrations, moreover, is commonly thought to be more political than economic. The promise of nuclear power in this country is said to have been dimmed primarily by an eccentrically risk-averse public and an unusually hostile regulatory climate. Practically nowhere else, it is said, have political and legal institutions been so uncooperative. Supposedly the central governments of most other advanced countries have lent far more support to their nuclear industries. And because those governments are assumed to be more aggressive in combating pollution, including greenhouse gas emissions from burning fossil fuels, surely "the rest of the world" has been doing much more than America to level the playing field for the development of nuclear energy.

The following paper challenges this conventional picture.

With more than a hundred reactors currently in operation, the American nuclear power industry remains the world's largest. Continued reliance on nuclear energy is actually more in question in several European countries than it is here. Because electric utilities in the United States, unlike those in, say, France and Japan, have access to vast reserves of coal and natural gas as well as huge hydro-electric facilities in certain

[(*)]The views expressed in this *Policy Paper* are those of the author only. An earlier draft has been anonymously reviewed by two reviewers.

[1] Bernard L. Cohen, *The Nuclear Energy Option: An Alternative for the 90s* (New York: Plenium Press, 1990), p. 4.

regions, the United States depends on nuclear generators to meet "only" about one-fifth of its demand for electricity. That share (20 percent) is still greater than the worldwide average (17 percent), however, and in half a dozen U.S. states—some of which are large enough to compare to important nations abroad—nuclear energy supplies over half of the electricity consumed.[2] The percentage of electricity generated by nuclear plants in Illinois, for example, exceeds the percentages in the Netherlands, the United Kingdom, Spain, or Germany. At any rate, even at one-fifth, total U.S. electricity production from nuclear reactors approximately equals the *combined* total of the world's two other nuclear giants, France and Japan.[3]

In fact, America's nuclear generating capacity amounts to more than a third of the entire installed nuclear capacity of the industrial nations in the Organization for Economic Cooperation and Development (OECD).[4] A nuclear sector of such magnitude hardly suggests that American governmental institutions and policies, national or local, have always proven particularly unreceptive to nuclear plants. The great majority of American states have accommodated such plants. Arguably, U.S. energy policies and environmental-protection efforts at all levels of government have done at least as much to sustain as to hinder the viability of these facilities along with their fuel suppliers, waste management requirements, and other supporting industries. And if anything like the energy legislation that the Bush administration and the House of Representatives advanced in 2003 were to come to fruition, the amount of assistance would expand significantly.

To be sure, the circumstances for nuclear energy in recent decades are a far cry from the extraordinarily favorable conditions that prevailed before the energy crisis of the 1970s. Major additions to America's already sizeable nuclear presence have not been in the offing for some time. (No new nuclear generating station has been completed here since 1996.) But the holding pattern into which nuclear power finds itself in the United States is hardly unique. A pause in new plant construction has extended to many other countries. In America, it is safe to say, the halt has to do with basic economic considerations, not just political obstacles, and how those economic

[2] More than thirty states have licensed nuclear reactors on line. Mark Holt and Carl E. Behrens, *Nuclear Energy Policy* (Congressional Research Service, April 22, 2003), p. 2.

[3] International Energy Agency, *Nuclear Power in the OECD* (Paris: OECD/IEA, 2001), p. 103.

[4] To take the full measure of a nation's "nuclear industry," of course, factors beside generating capacity ought to be considered. The United States accounts for almost 30 percent of the OECD's uranium-conversion (yellowcake production) capacity, and well over half of the OECD's uranium-enrichment capacity. IEA, *Nuclear Power*, pp. 115-116.

considerations are likely to play out ten or twenty years out is nigh-impossible to predict.[5]

If this assessment is correct, its implications may differ for the immediate and for the longer-range prospects of U.S. nuclear energy. In the teeth of inauspicious market conditions, even the additional government intervention that was envisioned in last year's omnibus energy bill probably would not suffice to entice skeptical investors in the near term. Electric companies at present remain skittish about being encumbered by hugely capital-intensive investments and financial liabilities like those associated with new nuclear installations. Nonetheless, some of these companies are also keeping their options open for the longer run.[6]

The rest of this paper builds on these observations. It begins by reviewing the competitive position of nuclear power in the American energy market. Next, I assay American politics and policies (including market liberalization) that affect that position. Then, viewing some key regulatory dimensions such as climate-change policies, the essay offers international comparisons. Last, I discuss the U.S. industry's outlook, through the remainder of the decade and then beyond.

1. Economic Realities

On average today, the electricity produced by operational nuclear plants in the United States tends to be cost competitive with gas or coal-generated power after the plants have been paid for. Averages can be misleading, of course. Among 28 U.S. facilities surveyed by the International Energy Agency not long ago, operating costs varied by a factor of five.[7] Only about half the plants produced power at below 1.5 cents per kilowatt hour, a distinctly better rate of operation than that of a typical coal-fired plant. Still, most existing plants operate reliably and at a steady cost. And the

[5] I make no special claim to originality in arguing that economics, rather than "politics," largely explain the difficulties of the nuclear industry in recent times. "The extended hiatus in new plant construction is due primarily to economic factors," concluded the authors of a key Energy Department report in 2001. U.S. Department of Energy, Office of Nuclear Energy, Science and Technology, *A Roadmap to Deploy New Nuclear Power Plants in the United States by 2010,* vol. 1 (October 31,2001), p. 1.

[6] Three U.S. electric utilities, Virginia-based Dominion Energy, Louisiana-based Entergy, and Illinois-based Exelon, are participating in a joint government-industry effort to obtain Nuclear Regulatory Commission approval for sites where new nuclear power plants might be built. "Energy Secretary Abraham Announces Private-Public Partnership to Evaluate Sites for New Nuclear Plants in the United States," *U.S. Department of Energy Press Release,* June 24, 2002.

[7] IEA, *Nuclear Power*, p. 127.

efficiency of quite a few has been upgraded, making them attractive to buyers. Between 1998 and 2002, more than a dozen of these plants were sold, some fetching impressive sums. Large energy companies like Entergy, Dominion Energy, and Exelon recently have made such acquisitions, in part as a hedge against increasingly unstable fuel prices for gas-fired generation, and perhaps also in anticipation of possible further environmental restrictions on coal-fired plants.[8] Even foreign investors have been eyeing U.S. nuclear units. The British firm Amergen purchased three between 1998 and 2000.

a. New Plants

The commercial viability of reactors that have not yet been built is a different matter—at least for now. A recent study at the Massachusetts Institute of Technology (MIT) offers probably the best current estimate of the aggregated cost of constructing, licensing, and running a newly commissioned light-water reactor, and how it compares to the coal or gas substitutes.[9] At an average of nearly 7 cents per kilowatt-hour (6.7 cents/kw-hr, to be precise), the "levelized" cost of the nuclear plant decidedly exceeds that of a pulverized coal-fired plant (4.2 cents/kw-hr). Nor does the nuke compete with a combined-cycle natural gas-powered plant (CCGT), even assuming a high price for natural gas. Thus, if gas were priced at $6.72 per thousand cubic feet, the lifetime average for electricity from the CCGT still comes to 5.6 cents/kw-hr, which is less than the nuke.[10]

It is well known that new nuclear plants take exceptionally long to complete and, according to many analysts, cost more than they should to build safely. But, says the MIT report, even reducing completion time to just four or five years, and lowering construction costs by a quarter, would still not put the plants in contention with coal, and would just barely match the price performance of a CCGT using high-cost gas.[11]

[8] Nuclear Energy Institute, "The Outlook for Nuclear Energy in a Competitive Electricity Business," *Fact Sheet* (NEI, 2003), p. 2. Dominion paid a record $1.28 billion to acquire the Millstone plant in Connecticut.

[9] John Deutch and others, *The Future of Nuclear Power: An Interdisciplinary MIT Study* (Cambridge, MA: MIT, 2003), p. 7. The estimates for nuclear-generated electricity assume that new plants would operate at 85 percent capacity over a 40-year economic life-span.

[10] With natural gas prices in a more normal range ($3.77/mcf to $4.42/mcf), the levelized advantage of CCGTs improves to somewhere between 3.8 cents/kw-hr and 4.1 cents/kw-hr—dramatically better than the cost associated with a light-water reactor.

[11] The MIT report's estimate is that accelerating the construction speed, and lowering the construction cost by 25 percent, would enable nuclear plants to produce electricity at 5.3 cents/kw-hr. With rounding error, this rate is essentially comparable to the 5.6 cents/kw-hr average for the *high-cost* gas-fired alternative.

Clearly, these figures do not augur much renewed interest in nuclear construction projects, at least for the foreseeable future.

Let us look more closely at roots of the nuclear sector's predicament to date.

b. Capital Costs: Inflated by Regulation?

Twenty years ago, the cost of building a nuclear power station in the United States averaged almost $3 billion (in 2002 dollars). Years of technological refinements and potential cost-saving measures since then have not succeeded in lowering that price-tag significantly. [12] The persistence of this enormous overhead, which accounts for two-thirds of the cost of nuclear-generated electricity, is what puts it at a marked disadvantage against power from combined-cycle gas turbines or coal-burning plants. Why capital costs are so prohibitive is a question much debated.

We know that cost overruns have to do with delays in the construction process. Before 1979, plants averaged seven years to go on line. By 1990, the average lag from groundbreaking to operation had reached 12 years.[13] The delays, in turn, have been widely attributed to a ratcheting of regulatory requirements for health, safety, and environmental reasons following episodes such as the Three Mile Island (TMI) accident in 1979. One estimate imputed to the post-TMI standards as much as 60 percent of capital costs for plants completed after 1979.[14] The new regulatory regime presumably contributed to a doubling of the amount of concrete, steel, and other materials needed to meet standards, and subjected builders to more fastidious inspections, mid-course corrections, extra labor costs, and other unexpected bills.

There is little doubt that regulatory strictures have slowed construction time and added to expenses. But whether those strictures have been overcautious—or, more precisely, out of line with consumer preferences and market demand—is not so clear. Nor, more basically, is it clear that government regulation stalled nuclear projects more than did other factors. Energy markets underwent a seismic shift after 1974. Earlier,

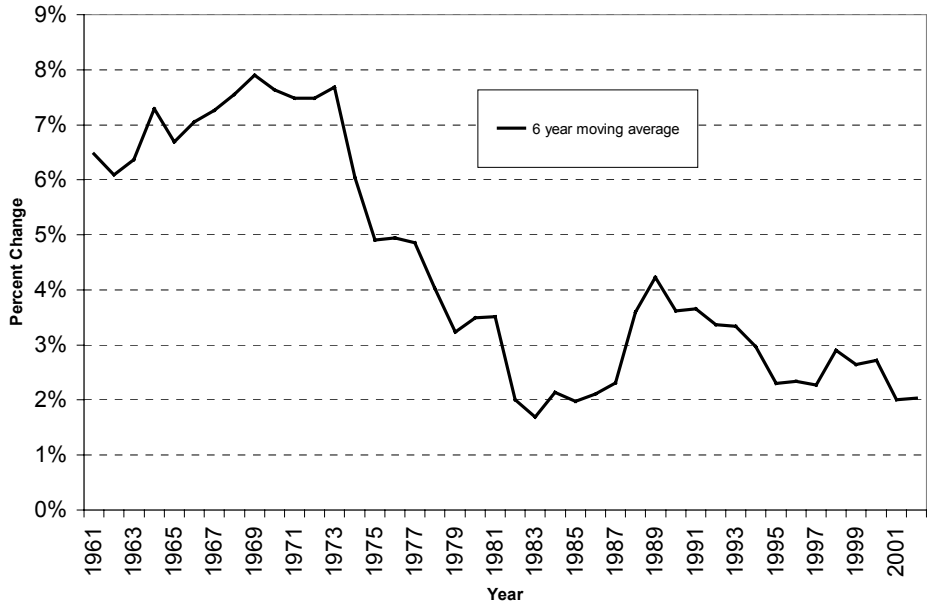
[12] Extrapolating from page 142 of the MIT report, a plausible current average building-cost estimate seems to be about $2.7 billion. Deutch, *Future of Nuclear Power,* p. 142. Plants begun years ago, and that took extraordinarily long to complete, ran up much higher bills, however. See, Roger Dunstan, *Benefits and Risks of Nuclear Power in California* (Sacramento, CA: California Research Bureau, April 2002), p. 36.

[13] David Bodansky, *Nuclear Energy: Principles, Practices, and Prospects* (Woodbury, NY: American Institute of Physics, 1996), pp. 309-310.

[14] Charles W. Forsberg and William J. Reich, *Worldwide Advanced Nuclear Power Reactors with Passive Inherent Safety: What, Why, How, and Who* (Oak Ridge, TN: Oak Ridge National Laboratory, September 1991), p. 136.

electricity consumption had been increasing at nearly 7 percent annually. At that pace, electric utilities could count on a doubling of demand for baseload capacity every ten years. Following the crisis of 1974, the growth rate of consumption year-over-year settled to an average of around 3 percent (Figure 1). Perforce, in this new world of softer demand, most utilities began rethinking commitments to big and costly capacity additions. New orders for nuclear plants in particular started falling off sharply, and dozens of standing orders were cancelled, even *before* the Three Mile Island disaster (see Figure 2).[15]

Figure 1. Percent Change of Electricity Consumption, 1961-2002



Source: Energy Infromation Administration, Annual Energy Review 2001, Monthly Energy Review September 2003

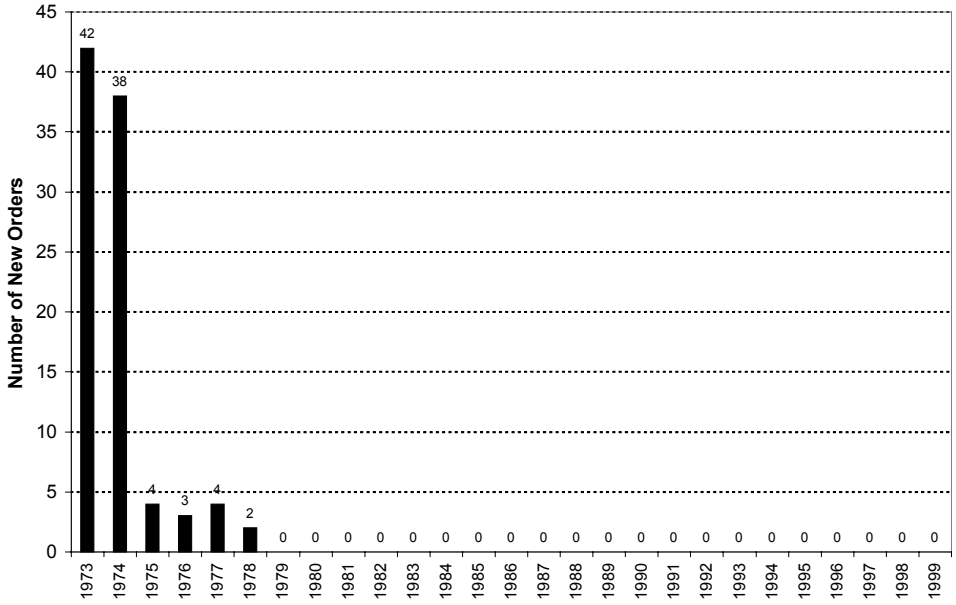
There is no question that Three Mile Island marked a watershed. After it, orders for nuclear facilities ceased. Interestingly, however, the cessation occurred almost everywhere—throughout this country but also in all but three other OECD countries, irrespective of national regulatory systems.[16] Was the collective retreat from nuclear investment attributable to an international wave of public hysteria, and of government red tape? Or, more plausibly, was what happened mostly the culminating consequence of negative market trends that had commenced earlier, and that now were accentuated

[15] Nationwide, there were 42 new plants ordered in 1974 but only 3 by 1977. Thirty-seven orders were cancelled between 1975 and 1978, Dunstan, *Nuclear Power in California,* p. 37-38.

[16] IEA, *Nuclear Power,* p. 99. The three exceptions were France, Japan, and South Korea.

by further loss of investor confidence and by heightened (and not wholly irrational) revealed preferences for supplemental safety measures? No one knew in 1979 that one of the reactor cores at Three Mile Island had actually undergone a partial meltdown. That disturbing fact was not learned until ten years later.[17] Private producers of nuclear power found out at once, though, that cleaning up an accident like TMI would run to billions dollars, and that shuttering a number of other operating plants for safety concerns would be financially prudent.[18]

Figure 2. Nuclear Power Plant Orders, 1973-1999



Source: Energy Information Administration

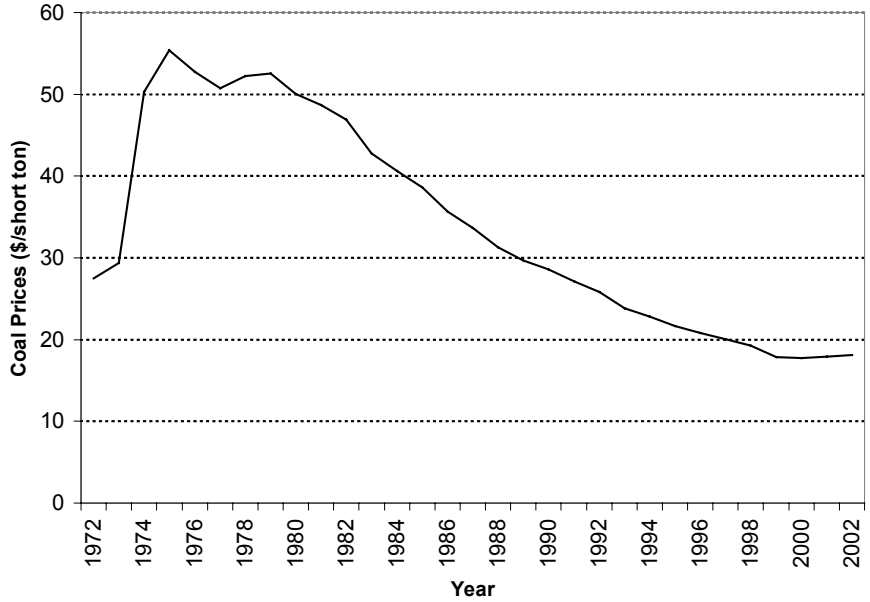
Moreover, if Three Mile Island had been merely an isolated case, the unforgiving reaction of financial markets as well as government regulators might be said to have been disproportionate. But a series of other unfortunate incidents, some preceding 1979, others afterwards, also stirred unease—especially since human error caused several of them, and suggested that existing technical safeguards did not suffice. This, at least, seems to have been a reasonable inference following the fire at the Brown's Ferry reactor in Alabama in 1975, the TMI debacle four years later, the calamity at

[17] Harry Henderson, *Nuclear Power* (Santa Barbara, CA: ABC-CLIO, 2000), p. 14.

[18] The ordinary cost of decommissioning nuclear plants (never mind one severely damaged by an accident) can run high. Pacific Gas and Electric's permanent closure of its two-unit Diablo Canyon plant in California cost well over $1 billion. IEA, *Nuclear Power*, p. 139. In the immediate aftermath of TMI, utilities in California promptly closed three plants. Units in Oregon, Minnesota, Pennsylvania, and a number of other states were soon shut down as well.

Chernobyl in 1986, and such recent accidents as the one at a Japanese uranium processing plant which claimed some workers' lives.[19]

Figure 3. Price of Coal, 1972-2002 (in 2003 dollars)



Source: Energy Information Administration, historical data archive at http://www.eia.doe.gov/neic/historic/htm

c. Competition from Gas and Coal

When measured on a present-value basis, the capital-intensity of a nuclear plant means that two-thirds or more of its costs may be incurred up front, before it opens for business—and that is without factoring in interest payments accrued during the long construction ordeal. By contrast, only a quarter of the costs of the typical gas-powered electric plant are front-loaded.[20] No wonder that the latter have supplied almost all of the total new capacity added in recent years.[21] The invidious comparison is a little

[19] At Brown's Ferry, a technician had used a lighted candle to check for air leaks in one of the plants cable rooms, thereby igniting a fire. By the time it was over, the reactor core had been damaged. At TMI a paper tag had been left on the reactor's control panel, covering a light that would have told operations about a cooling-water valve that had been mistakenly turned off. At Chernobyl, operators had been conducting an experiment with the steam turbine to test the capacity of an emergency cooling pump. Unfortunately, the experiment was not conducted in a fashion that would have allowed the reactor to shut down gradually, as it was supposed to. See Henderson, pp. 12-13, 15, 43.

[20] "A Renaissance that May Not Come," *The Economist*, May 19, 2001, p. 25.

[21] Of the 144 gigawatts added between 1999 and 2000, 138 gigawatts were provided by new gas-fired facilities. Energy Information Administration, *Annual Energy Outlook, 2003*, p. 67. Gas-fired capacity more than tripled from 1999 through 2003. Bryan Sanderson, *Setting the Stage for 2004: Gas Markets Will Soften* (Chicago: Wood Mackenzie and the American Gas Association, August 2003), p. 3.

unfair; many of the gas plants tend to be built to carry peak- or intermediate-loads, not baseloads.[22] In most of the country baseloads are handled predominantly by coal-fired generators. These are not cheap. Their capital costs per kilowatt hour are more than twice those of combined-cycle gas turbines. Yet, coal has been a formidable rival of nuclear power. Even with the latest clean-air gadgetry, coal plants are not as expensive to build as nukes, and once built, are relatively economical to operate because the price of coal has dropped steadily over the past twenty years (Figure 3).

The prominence of coal in the U.S. electricity marketplace is distinctive in comparison with the electric sectors of other OECD countries. Not only is this resource extraordinarily plentiful in the United States; no other nation extracts and delivers the stuff to market with comparable efficiency. Productivity growth in the industry has been dramatic. A half-million miners were needed to produce a little more than 500 million tons of bituminous coal in this country in 1950. By 1990, only about 150,000 miners produced twice that annual output.[23] Not surprisingly, states in proximity to coal mines tend to exploit this inexpensive source of energy more than do states farther away. (Kentucky and West Virginia generate more than 95 percent of their electric power from coal, whereas Maine makes use of it for less than 3 percent.) Nevertheless, thanks to America's ubiquitous and efficient network of commercial railroads, coal, despite its weight and bulk, is also transported far and wide.

Tableau 1. U.S. Electricity Generation Fuel Shares (utility and non-utility generation)

Fuel	1973	2002
Coal	45.6	50.0
Gas	18.3	17.6
Oil	16.9	2.5
Hydro	14.6	6.9
Nuclear	4.5	20.2
Other	0.1	3.0

Source: Energy Information Administration

In time, coal's importance to U.S. electricity producers may decline amid mounting concerns about its pollutants. But its dominance is not about to end swiftly.

[22] There are some big exceptions to this pattern. California generates almost 56 percent of its electricity with gas. Texas generates almost 50 percent with gas.

[23] Duane Lockard, *Coal* (Charlottesville, VA: University of Virginia Press, 2001), p. 48.

Coal's share of U.S. electric generation has, if anything, increased over the past thirty-some years, reaching 50 percent in 2002 (see Table 1). For the most part, the edge over nuclear energy simply reflects market forces: a nation so richly endowed with this particular fossil fuel naturally puts it to extensive use. And those parts of the country that have the easiest access to coal—or natural gas as in Alaska or Texas, and hydropower as in Idaho, Oregon and Washington—inevitably marginalize nuclear power. Straightforward economics, in short, largely determine local choices between nuclear energy and its principal alternatives. Figure 4 displays the tradeoffs graphically.

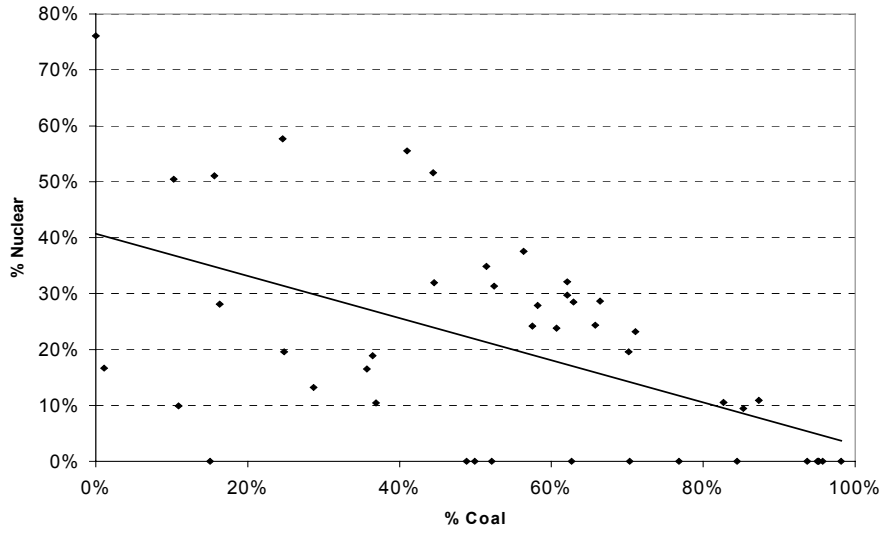
d. Plenty of Power—At Least Through the Decade

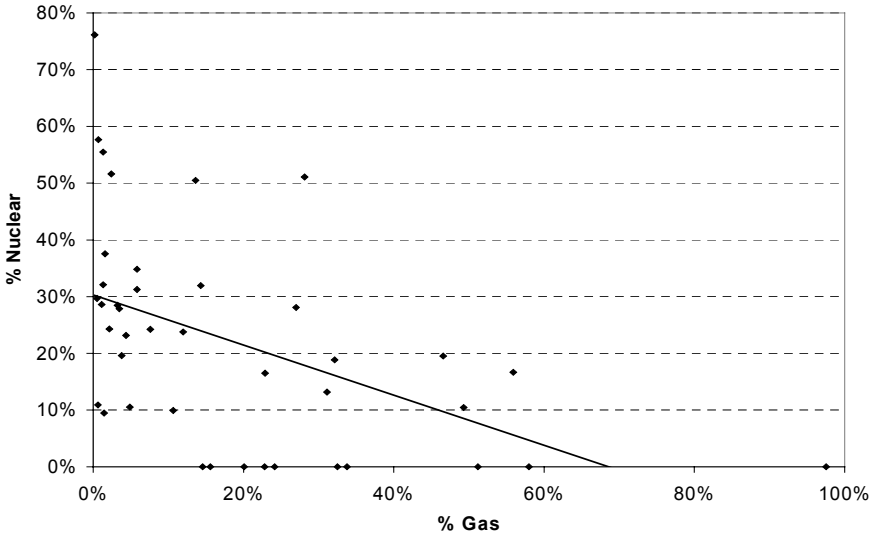
In sum, quite apart from lingering reservations about safety and security, four fundamentals continue to dampen enthusiasm for a nuclear renaissance in the United States today. First, annual growth in demand for power never returned to pre-1974 heights. Second, gas-fired technology is comparatively quick and inexpensive to install. Third, there is, at least for the present, little economic incentive to retire the nation's vast coal-burning infrastructure. And fourth, lest we forget, more than a hundred old atomic reactors are still on line. These realities have contributed to a plush 28.5 percent reserve margin in the U.S. electricity business, and to even larger surpluses in some regions (a huge reserve margin of more than 40 percent in the Southeast, for instance).[24]

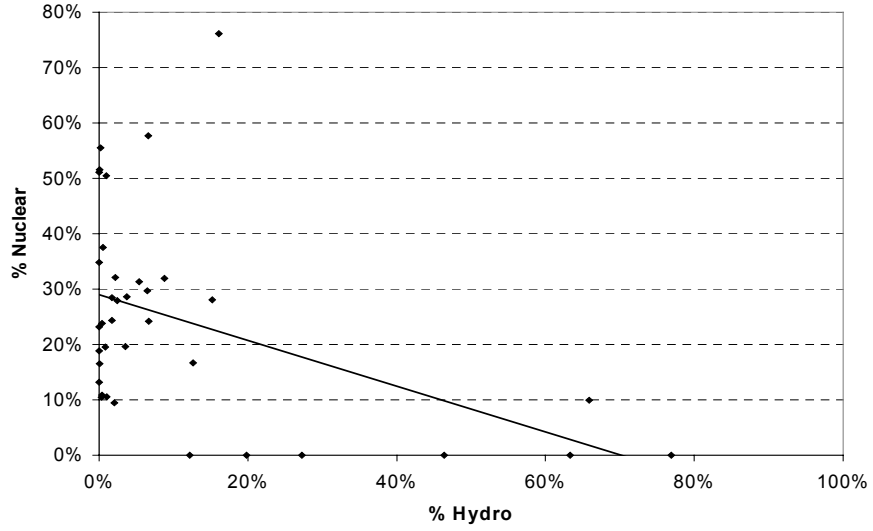
That much slack won't persist in the years ahead, particularly as the national economy regains a robust rate of growth, but contrary to the claims of alarmists, neither is a genuine crunch imminent. In this setting, utilities are unconvinced that basic capacity enlargement, at least on a grand scale, is urgent. Those that are considering significant expansions are gazing into a crystal ball. And for none is this more true than for the firms planning possible nuclear growth. Their ball is the haziest, at least at this juncture. Resuming the nuclear gamble may pay off one day, but precisely *when* is anybody's guess.

[24] A few regional power markets are supply-constrained on account of limited transmission access to the new gas-based capacity that is glutting other parts of the country. New York City, Long Island, San Francisco, and portions of Connecticut have this problem. "U.S. Generating Capacity Soaring this Year—Then it Stops," *Energy Intelligence Group,* July 4, 2003.

Figure 4. State Tradeoffs Between Electricity Generated by Nuclear Power vs. Other Sources (Coal, Gas, Hydro)







Source: Nuclear Energy Institute (2001)

Note: For each chart, only states generating a significant amount of electricity from the combination of the two sources are included (i.e. if nuclear + other > 10% of total electricity generated). Percentages on each chart's axes are the % of electricity generated by competing sources in each state.

2. An American Industrial Policy

The setbacks to nuclear building programs in the United States have not been for want of government support. Indeed, it is hard to think of an energy industry that has received more promotion in the past half-century. In varying degrees and stages, the entire nuclear food-chain, from R&D and fuel supply services to waste disposal and eventual decommissioning, has been backed in one way or another by government policies. The extent of the public effort, even if at times uneven, is worth recapitulating.

a. Assistance

Legislation establishing the Atomic Energy Commission (AEC) in 1946, and then broadening its mission in the ensuing twenty years, put the federal government in the business of commercializing atomic energy. Aid and technical assistance for design and development were provided for experimental reactors. Nuclear fuel was mined, enriched, and then leased at advantageous rates by the government to private operators.[25] A special risk-pooling insurance program (the Price Anderson Act), with caps on liability, was introduced in 1957.

When the infant industry experienced growing pains—unanticipated difficulties such as environmental controversies, waste management problems, or regulatory hardships—Congress was sometimes slow to lend a hand, but at the end of the day, the helping hand was there. By the 1970s, for example, the environmental impacts of stepped up uranium production had become an issue. A program, 90-percent federally funded, was legislated in 1978 to stabilize sites with mill tailings. By then, the question of what to do with a buildup of radioactive waste could no longer be ignored. So in 1980 states were ordered to expand storage space for low-level waste, and two years later, another act of Congress initiated a search for a permanent underground repository for high-level waste.[26] True, it took two decades to get a go-ahead for the selected location, at Yucca Mountain in Nevada, but when that decision was made (in July 2002)

[25] The United States Enrichment Corporation, the dominant supplier of enriched uranium, was not privatized until 1998. Through the late 1980s, government-managed production contributed to an oversupply, hence low prices. More recently, the availability of surplus military stockpiles has extended the glut.

[26] The laws, respectively, were the Low Level Waste Policy Act of 1980 and the Nuclear Waste Policy Act of 1982.

the United States became the only country in the world to approve a repository of such scale. Under an agreement reached in 1999, while commercial reactor owners wait for the site to be readied, the U.S. Department of Energy will assume responsibility for removing their spent fuel to an interim above-ground storage area.[27]

Proponents of nuclear power had long complained about cumbersome regulatory hurdles, most notably the need to obtain from the AEC's successor (the Nuclear Regulatory Commission, or NRC) separate approvals for constructing and then operating a new reactor. The Energy Policy Act of 1992 ended this two-step licensing procedure. Now, a utility, if granted a building permit, knows that an operating license is assured. Following the 1992 law, moreover, the NRC has pre-certified three technologies for application anywhere in the country. A builder opting for any one of them is all but guaranteed that safety features, for example, will not be open to legal challenges during licensing proceedings.[28] That no new plants have been ordered despite these significant adjustments only furthers the impression that finances, more than regulations, continue to pose the chief barrier. As for rules governing extant plants, it is hard to argue that the NRC has been inflexible. Sixteen reactors have received 20-year license extensions, thereby granting them up to 60 years of operation.[29] Many more will be extended soon.

It is true that, in America as elsewhere, there is less political consensus today than there once was on policies bolstering nuclear power. At one time, the public-private partnership enjoyed seamless bipartisan support.[30] In 1980, Jimmy Carter, a Democratic president, recommended pouring $3 billion (in today's dollars) into civilian nuclear research. Nowadays, such largesse is only proposed by a Republican administration. Years ago, even the Sierra Club favored projects like the Diablo Canyon plant in California.[31] Today, almost every environmental advocacy group is in opposition. Rifts over what amounts to a nuclear industrial policy, however, do not appear to have been fatal. Under the energy legislation that Congress nearly passed in 2003—and that might

[27] See Richard L. Garwin and Geroge Charpak, *Megawatts and Megatons: A Turning Point in the Nuclear Age* (New York: Knopf, 2001), p. 378.

[28] U.S. Department of Energy, Office of Nuclear Energy, Science and Technology, *A Roadmap to Deploy New Nuclear Power Plants in the United States by 2010: Volume II* (October 31, 2001), p. 3-4.

[29] License renewal applications for 14 other reactors are presently under review by the NRC. Nuclear Energy Institute, *Nuclear Energy Developments, 2003* (June 2003).

[30] For a comprehensive history of evolution of nuclear politics in the United States, see Robert J. Duffy, *Nuclear Politics in America: A History and Theory of Government Regulation* (Lawrence, KS: University of Kansas, 1997).

[31] Henderson, *Nuclear Power,* pp. 7-10.

eventually resurface—the U.S. nuclear industry stood to gain a tax credit (1.8-cents-per-kilowatt) for electricity generated by newly constructed plants, $2.7 billion in additional nuclear R&D subsidies over five years, $1.1 billion to build and run an experimental hydrogen-producing facility, a twenty-year extension of the Price-Anderson Act, plus tens of millions of dollars for various pilot programs (to ease plant decommissioning, uranium mining, and more).[32]

b. Litigiousness and Federalism: American Exceptionalism?

"There is hardly a political question in the United States which does not sooner or later turn into a judicial one," wrote Alexis de Tocqueville.[33] Surely, the nuclear question has been no exception. Every facet of it, from siting decisions and licensing to insurance and waste policies, has wound up in court at one point or other. That said, a glance at the record suggests that the frequent legal challenges have been less successful and disruptive than industry analysts sometimes suppose.

More often than not, unfavorable verdicts for the nuclear industry have been overturned, if not at the appellate level than at the U.S. Supreme Court. The Supreme Court has upheld the Price-Anderson Act's limited liability provisions, and rejected attempts by groups to invoke environmental laws to delay licensing procedures.[34] After the Three Mile Island accident, plaintiffs sought to prevent the undamaged component of TMI's two-unit plant from reopening. The high court ruled against them.[35] Citizens groups have sought to close plants in a number of places, following supposedly perilous events such as local earthquakes. Their complaints occasionally impress the lower courts but then usually have not stood up on appeal.[36]

Given America's federated political system, it is not surprising that a good deal of the litigation besetting decisions about nuclear power is brought by state and local governments demanding relief from various burdens. Prominent among these has been

[32] Margaret Kriz, "In 1,1000 Pages, Something for Everyone," *National Journal,* November 22, 2003. See also, Aileen Roder, "Analysis of Authorized Spending in Energy Bill Report (H.R. 6)," *Taxpayers for Common Sense,* November 16, 2003.

[33] Alexis de Tocqueville, *Democracy in America*, J. P. Mayer and Max Lerner, eds. (New York: Harper and Row, 1966), p. 248.

[34] *Carolina Environmental Study Group v. AEC*, 431 F.Supp.230, W.D.N.C, 1997, and *Duke Power Co. v. Carolina Environmental Study Group,* 438 U.S. 59 (1978).

[35] *Metropolitan Edison v. People vs. Nuclear Energy,* 460 U.S. 766 (1983).

[36] As an example, when a citizens group sued the NRC to prevent a plant from reopening in Percy, Ohio, after an earthquake had occurred 10 miles away, the appeals courts for the sixth circuit sided with the NRC. *Ohio Citizens for Responsible Energy v. NRC*, 803 F.2d 258 (6th Cir. 1986).

the quandary over waste disposal. In a 1992 case the Supreme Court upheld New York State's objection to a 1985 federal law that effectively "commandeered" the states to take ownership of low-level waste.[37] Three years later 40 states filed suit against the federal government for failing to meet Congress's deadline for establishing a national temporary storage facility for high-level waste.[38] Earlier, at least seven states (California, Connecticut, Kansas, Kentucky, Maine, Oregon, and Wisconsin) had enacted statutes that essentially conditioned further construction of nuclear stations on proper disposal of high-level waste, and the Supreme Court had recognized the states' right to set such a condition.[39]

The effect of locally-inspired laws and lawsuits like these, however, was not to derail nuclear waste-management plans; quite the contrary, the state initiatives applied pressure on federal authorities to make progress. As a result, Yucca Mountain is no longer hopelessly in limbo. The state of Nevada naturally pleaded "not in my back yard," but so far the courts have not concurred—much to the relief of the rest of the states.[40]

Federalism undoubtedly permits local governments to obstruct projects to an extent that might be unthinkable in more centralized regimes, like France. Probably the most notorious example in the United States was what happened to the Shoreham power plant on Long Island.[41] NRC regulations in the aftermath of TMI called for the preparation of emergency evacuation plans by localities in the vicinity of nuclear reactors before they could be commissioned. County governments on Long Island concluded that evacuating communities surrounding Shoreham was infeasible, and so the newly-built $6-billion plant never opened.

But the Shoreham fiasco was unique and extreme. More typically, the "not-in-my-back-yard" syndrome can cut both ways—occasionally impeding nuclear projects, but at other times also enhancing their prospects. Recently, for example, a number of Northeastern states sued the U.S. Environmental Protection Agency (EPA) over its temporary relaxation of so-called "New Source Review" regulations for coal-burning

[37] *New York v. United States*, 488 U.S. 1041 (1992).

[38] *Northern States Power Co. v. U. S, Department of Energy et al.,* 97 U.S.1064 (1997).

[39] *Pacific Gas & Electric v. Energy Resources Commission,* 461U.S. 190 (1983).

[40] At this writing, however, a panel of the U.S. Court of Appeals for the D.C. Circuit seemed to express some concerns about the adequacy of the Yucca Mountain plan's environmental safeguards. The outcome is still pending. Jonathan Groner, "Judges Skeptical About Yucca Mountain," *Legal Times,* January 19, 2004.

[41] See Duffy, *Nuclear Politics,* p. 206.

utilities.[42] The protesting states are downwind of pollution emitted from the coal-intensive plants largely located in the Midwest. If, in the end, state legal actions like these were to stiffen EPA standards for coal plants, thereby raising the price of their electrical output, coal's competitors would stand to gain.[43] This inducement would be but one more manifestation of a wider phenomenon unfolding in the states: many have developed increasingly vigorous carbon abatement programs over the past decade.[44] The state-level activism suggests that American federalism, reputed to erect only roadblocks to nuclear energy, also may be providing (however unwittingly) some preconditions for a modest revival.

c. "Energy Independence"

Ongoing efforts, especially by the federal government, to secure a market for nuclear power in the United States draw some of their inspiration from the recurring quest for "energy independence." For all its political allure, the pursuit of this end—and especially the notion that nuclear generators can contribute to it—is bizarre for the United States. Unlike most other developed countries, America still produces all but about a quarter of the "energy" it needs. Yes, imports of *oil* have increased (mostly because U.S. crude oil is relatively costly to produce, and producers elsewhere hold a comparative advantage in international trade for this particular commodity), but petroleum prices are set in a world market—and the extent of a nation's vulnerability to oil-price perturbations is not a function of how much it produces at home or buys from abroad. In any event, oil is not a major fuel for producing electricity here (see Table 1). Adding to the nuclear inventory now—or, for that matter, to the shares of coal, gas, hydro, and non-hydro "renewables"—would displace an inconsequential quantity of imported oil (Table 1).

Nevertheless, nostalgia for energy autarky persists. "Let us set as our national goal" to develop "the potential to meet our own energy needs without depending on any foreign sources" proclaimed President Richard M. Nixon more than a quarter-

[42] David Kocieniewski, "States Fight Relaxation of Power-Plant Pollution Standards," *New York Times,* August 29, 2003, p. A17.

[43] In January 2004, the EPA decided to continue to enforce the extant rule for the New Source Review provisions of the Clean Air Act until the courts resolve legal challenges to a relaxation of that rule. Among other public pressures, the state lawsuits may have contributed to this about-face. Eric Planin, "In Reversal, EPA to Push Cleanup of Power Plants," *Washington Post,* January 22, 2004, p. A23.

[44] See, on this phenomenon, Barry G. Rabe, *Statehouse and Greenhouse: The Emerging Politics of American Climate Change Policy* (Brookings, 2004).

century ago.[45] While President George W. Bush's reprise of energy planning has been a lot less utopian, its supposition, too, seems to be that Americans will be better off if they reduce "reliance on foreign energy." During the 2000 election campaign, the Bush camp rhapsodized about bygone days when "one of America's greatest strengths was its energy self-sufficiency." Democratic presidential candidates four years later ritually intoned similar themes. However illogically, the U.S. nuclear sector—along with all the other supposed substitutes for "foreign energy"—has been a beneficiary of this mindset.[46]

d. Countervailing Forces

To say that policy and politics in the United States have been, on balance, more solicitous of nuclear power than is commonly supposed is hardly to imply that *all* facets of the U.S. policy agenda have. At least three features would seem indisputably vexing for the nuclear industry.

One is the level of political support for the industry's chief competitor—coal-based power. Eventually, there will come a time in this country when, as in the United Kingdom, coal will lose leverage, and might no longer remain the nation's dominant generating fuel. But that time is decades away. In the 2000 presidential election, coal-producing states like West Virginia proved to be among the pivotal ones. Coal-producers also contributed handsomely to the Bush campaign.[47] These political incentives, alongside policy convictions, may have played a part in the administration's hesitation about pursuing certain environmental restraints on coal production and usage. (The most exacting standards for retrofitting coal-fired power plants, for instance, were called into question.)[48] Parts of the vast energy measure Congress contemplated in 2003 reflected the coal producers' continuing clout. If that legislation had been adopted, it would have thrown multiple billions of dollars in grants and tax incentives at the development of "clean-coal" technologies.[49] If such technologies advance, they

[45] This and the following material is drawn from Pietro S. Nivola, "Energy Independence or Interdependence: Integrating the North American Energy Market," *Brookings Review*, vol. 20, no. 2 (Spring 2002), pp. 24-27.

[46] Inasmuch as the nuclear industry imports uranium, it, too, relies on foreign suppliers.

[47] Barbara Freese, *Coal* (Boulder, CO: Perseus Publishing, 2003), pp. 193-4.

[48] On the coal lobby's role and the importance of West Virginia as a key swing-state in the 2000 election, see Tom Hamburger, "A Coal-Fired Crusade Helped Bring Bush a Crucial Victory," *Wall Street Journal,* June 13, 2001.

[49] Kriz, "1,100 Pages."

could extend the competitive life of coal-fired electrical generation far beyond its already long prospective span.

Additionally, a growing interest in renewable sources is gradually becoming a force to be reckoned with. The 1992 Energy Policy Act ordained a 1.5-cents per kilowatt-hour subsidy for "qualified renewable energy facilities"—for example, those that generate electricity from wind power or from some forms of biomass energy. Moreover, many states have mandated so-called renewable energy portfolios. These effectively allocate market shares to renewables, at the expense of coal and gas plants, but also (in principle) nuclear ones.

Another complication for U.S. nuclear power has been the government's approach to nuclear proliferation. U.S. development of breeder reactors and of reprocessing facilities for spent fissile material was halted during the Carter administration, on the theory that reprocessed fuel might make its way from the United States into the hands of rogue states or other criminal elements around the world. I will revisit the nonproliferation problem toward the end of this paper. For now, suffice it to say that by discouraging "closed cycle" technologies and fuel recylcing, America has piled up almost 50,000 tons of spent fuel in need of disposal. The waste-disposal issue, in turn, became one more thorn in the side of nuclear investors, at least until the question of the Nevada repository was more or less settled.

3. The Implications of "Deregulation"

The U.S. electrical industry is in the course of being restructured. Many analysts have surmised that this process does not bode well for new investment in nuclear energy. Their arguments take several directions.

a. Supposed Malfunctions

One has to do with the fact that federal laws in 1978 and 1992 and then rule-makings by the Federal Energy Regulatory Commission (FERC)—the government agency that regulates wholesale power markets—enabled new sellers to contest markets dominated by established utilities.[50] Courtesy of FERC-ordered open access to utility-

[50] The key legislative and regulatory decisions were the Public Utilities Regulatory Policies Act of 1978, the Energy Policy Act of 1992, and the FERC's Order No. 888.

owned transmission lines, the electricity generated by industrial cogenerators and other independent power producers multiplied almost eight-fold over the past thirty years, now accounting for more than 26 percent of all generating capacity.[51] The growth of non-utility generators has confronted traditional power stations (not least, nuclear ones) with yet another dimension of head-to-head competition. States such as Mississippi are awash with tens of thousands of megawatts of excess capacity, thanks in large part to an influx of independent generators that can hook into existing power grids at little cost.

Local power gluts created by the multiplicity of suppliers presumably make it harder for utilities to justify major plant expansion going forward. Compounding their problem is the prospect that open access is said to draw free-riders into the utility grids: Who wants to invest in an additional power line if independent generators can use it without paying their fair share? Underinvestment in the transmission system means that parts of it become congested and unreliable—so much so that, according to the former energy secretary Bill Richardson, the country risks having a "Third World electric grid."[52] An infrastructure beset by bottlenecks and reliability problems further discourages investment in large capital-intensive power plants, for which uninterrupted operation and a dependable ability to transmit electricity in bulk over long distances is essential.

Another criticism often leveled at the liberalized market of recent years concerns the rate-making practices of state public utility commissions (the entities that determine the prices electric companies can charge their customers). At one time, rates had been structured to recover for utilities more or less the full costs of investments; the investors practically received, in essence, a guaranteed rate-of-return. After some twenty states began abandoning this convention, and companies were forced to accept rates that bore more resemblance to the prices of a competitive market, utilities in some regions found themselves saddled with high-cost projects that had been launched under the old regime but could no longer be defrayed under the new. Nuclear plants represented about one-third of these so-called "stranded" costs, which were estimated to exceed $70 billion.[53] Until the utilities that have labored under this millstone figure out how to shed it, none

[51] Energy Information Administration, *Inventory of Nonutility Electric Power Plants in the United States 2000,* January 2003, p. 1.

[52] Michael Barbaro, "Consumers Must Demand a (Pricey) New Power Grid," *Washington Post*, August 24, 2003, p. F6.

[53] This has been the low-end estimate. The high-end estimate is a staggering $169 billion. Energy Information Administration, *Electricity Prices in a Competitive Environment: Marginal Cost Pricing of Generation Services and Financial Status of Electric Utilities: A Preliminary Analysis through 2015* (August 1997), p. ix.

of them will be disposed to compound their financial exposure with additional big-plant commitments.

b. Deregulation in Perspective

There is no denying that, so far, liberalization of electricity supplies in countries such as the United Kingdom and the United States has not been associated with renewed private investment in nuclear projects which, by nature, entail heavy capital costs, long development times, and financial risk. Some thoughtful writers even conjecture that increasingly competitive markets *inherently* introduce a bias away from such capital-intensive ventures and toward "micropower"—that is, electricity generated from renewables, small-scale gas turbines, and heat-recycling facilities situated close to end-users, as distinct from bulk power stations operating far afield.[54] Imaginably, the micropower theorists may prove to be right. Yet, their predictions seem premature, especially since the transformation of U.S. electrical market is very much a work in progress, and aspects of it do not point unambiguously toward a complete and permanent demise of nuclear power.

For one thing, some uncertainties of the new regulatory environment have been exaggerated. The stranded-cost problem, for instance, is on its way to being solved, typically by the use of state-approved "transition surcharges" on utility bills.[55] For another, what has come to be called deregulation is a misnomer. Wholesale markets have been opened up, but retail sales of electricity remain constrained by state rate-makers who, arguably in many places, still underprice electricity, thereby inducing more demand than might otherwise exist. The price regulators in California, one of the pioneers of "deregulation," bore considerable responsibility for the shortages that afflicted that state three years ago. Utilities there were squeezed because the state prevented them from passing rising wholesale prices through to customers in the form of higher retail rates. Of course, no one will be willing to put up with rolling blackouts indefinitely, so eventually, excess demand creates pressure for capacity additions. The

[54] See, for instance, Vijay Vaitheeswaran, *Power to the People* (New York: Farrar, Straus and Giroux, 2003), chaps. 10-11; Seth Dunn, *Micropower: The Next Electrical Era* (Washington, DC: Worldwatch Institute, 2000); Malcolm C. Grimston and Peter Beck, *Civil Nuclear Energy: Fuel of the Future of Relic of the Past* (London: Royal Institute of International Affairs, 2000), pp. 61-62.

[55] Nuclear Energy Institute, "The Outlook for Nuclear Energy in a Competitive Electricity Business," *Fact Sheet* (2003), p. 6.

California crisis promptly translated into greater public support for the possible construction of more nuclear power plants in that state.[56]

How much open-access to power grids is actually responsible for alleged disinvestment in the electrical transmission system is another question that warrants scrutiny. Critics point to lagging rates of growth in transmission lines as compared to generating capacity, and stress that return on investment in transmission lines at the end of the 1990s was half of what it had been twenty years earlier.[57] The massive power failure in much of the Midwest and Northeast during the summer of 2003 was widely attributed to strain on the transmission network.

In point of fact, however, none of these circumstances prove that the network is inadequate. The 2003 blackout was more than anything else the result of human errors committed by operators at a single Ohio utility.[58] That transmission capacity expansion has not kept up with the building of new generators means little if the system was not utilized efficiently in years past, and only now is beginning to be more optimally exploited. And the presence of additional generating facilities that serve proximate local markets or end-users directly does not necessarily congest existing high-voltage lines.[59] A new industrial cogenerator that, say, primarily supplies in-house electricity for a factory may actually be relieving pressure on a grid.

Moreover, the transmission of electricity over trunk lines and its distribution into homes and buildings continues to be closely regulated. If power companies have insufficient incentive to invest in their grids, that may well be because regulators, not market openness, are setting rates of return too low.[60] In time, the necessary adjustments probably will be made in this regard—and also in another: As utilities move to sell plants and buy more power in wholesale markets, the power grids in more states will be monitored by so-called independent system operators that control the flow of electricity and make sure it gets where it is supposed to go when it is traded.[61] Grids

[56] A Field poll in 2001, for example, found that state residents now favored building more nuclear plants by a margin of 59 percent. Vibeke Laroi, "Most Californians Now Favor Nuclear Power – Poll," *Reuters News Service,* Mary 24, 2001.

[57] North American Electric Reliability Council, *Reliability Assessment 2002-2011*, October 2002; Edison Electric Institute, *Energy Infrastructure: Electricity Transmission Lines,* February 2002.

[58] This was the finding of an exhaustive Department of Energy investigation. Richard Pérez-Pena and Mathew L. Wald, "Basic Failures by Ohio Utility Set Off Blackout, Report Finds," *New York Times,* December 1, 2003, p. A1.

[59] Western Governors' Association, *Conceptual Plans for Electricity Transmission in the West,* August, 2001.

[60] See Neela Banerjee and David Firestone, "New Kind of Electricity Market Strains Old Wires Beyond Limits," *New York Times,* August 24, 2003, p. A1.

[61] See in general, Alex Berenson, "Forget Deregulation. It's the Wires, Stupid," *New York Times,* August 24, 2003, p. WK 3.

will likely interface more smoothly in the future, carrying larger loads more reliably across regions, as the rules and standards for system operators converge.

Inasmuch as transmission expansions lag demand in some regions, who bears the blame? In 1999 a group of utilities proposed adding a 220-mile power line between Minnesota and Wisconsin. The state of Wisconsin took about two years to approve the project. But as of August 2002, the federal government was no better; approvals were still pending from the National Park Service and the Army Corps of Engineers, which began their reviews after Wisconsin's.[62] The delay in starting construction in this instance may be disturbing, perhaps even symptomatic of wider bureaucratic shortcomings. That the problem has had anything to do with "deregulation," however, is far from obvious.

Figure 5. Exelon Corporation, Share Prices (in $US), 1994-2003

Source: Nasdaq

Which leads to a final rumination on the subject: Conceivably, today's restructured electricity markets may be paving the way *for* companies to undertake some nuclear reinvestment, rather than the other way around. Certainly the new, more competitive regime has compelled significant improvement in the technical performance of plants—so much so that, even though eight reactors have closed down since 1990, increased productivity among the rest helped boost U.S. nuclear electrical

[62] Robert J. Samuelson, "Deregulation Mirage," *Washington Post*., August 20, 2003, p. A21.

output by more than a third from 1990 to 2002.[63] The ongoing shakeout in the industry has spurred a series of mergers, joint ventures, and other sorts of management coalitions that seem likely to reduce some 50 separate nuclear utilities to about a dozen. These will be much better positioned to make major financial commitments when the time comes. In the fall of 2000, for example, the merger of two of the nation's largest utilities, PECO Energy and Unicom, consolidated the operation of 17 reactors under a single corporate entity, Exelon Corporation. The securities of that firm now are valued at more than twice their valuation in 1998 (see Figure 5).

4. Some International Comparisons

Proponents of nuclear energy in the United States sometimes labor under the false impression that the political environment in this country has been radically forbidding. Other industrial nations are thought to have subjected their nuclear industries to far less political turbulence. The trouble with this view is that, though fairly valid with respect to a few other countries (France and Japan, for instance), it simply does not stand up in comparisons with the rest of the OECD.[64]

Following Three Mile Island, the building of nuclear plants and fuel production facilities ground to a full stop, often in advanced stages of construction, in many countries. The development of nuclear energy is stalled in Germany, Belgium, Holland, Sweden, and Italy.[65] In some of these places—Germany, for instance—the change of heart has come in spite of extant safety regulations that have sometimes required *more* redundancy, inspections, and so forth than has been the case in the United States. Contrary to a prevalent misconception, America is not the only place where the application and licensing procedures for plants have come under fierce legal attacks. Germany has witnessed some similar cases. Sweden began considering a phase-out of nuclear energy in the early 1980s despite the fact that the country relies on nuclear stations for 47 percent of its electricity. In 1996, much was made of the fact that half-a-

[63] Licensed commercial reactors generated electricity at a record-high average of almost 90 percent of their total capacity in 2002. Mark Holt and Carl E. Behrens, *Nuclear Energy Policy* (Congressional Research Service, April 22, 2003), p. 2.

[64] For example, Cohen, albeit writing in 1990, overgeneralized when he asserted that U.S. regulatory impediments had "no comparable" counterparts in Western Europe. Cohen, *Nuclear Energy Option*, p. 171.

[65] IEA, *Nuclear Power in the OECD*, pp. 19, 84, 137, 155, 208-209, 225-228.

dozen U.S. nukes were closed while no new ones were being added. But that same year, Canada acted similarly.

a. Government Support

A casual observer of the nuclear scene might think that the U.S. government has been stingier in its support than have been the governments of most other OECD members. Not so. Only Japan has spent more money than the United States on nuclear R&D, for instance.[66] Granted, several other important industrial countries—including France, Japan, Germany, Italy, and Britain—have maintained (at least until recently) fuel reprocessing facilities for spent fuel, whereas reprocessing ceased in the United States in the 1970s.[67] On the other hand, few other nations have moved ahead with plans for the alternative to reprocessing—namely, long-term burial of high-level radioactive waste. Nevada's Yucca Mountain depository took years to approve and will take many more before it is ready to receive shipments, but plans for waste disposal in places like Germany have proven to be even knottier. There, studies of possible disposal sites began in the 1960s. The geological salt caverns at Gorleben were selected a decade later. Intense opposition has blocked all progress since then.[68]

The governmental withdrawal from the nuclear enterprise in various European countries has been driven by their governing elites—many of whom sound more disenchanted with nuclear energy than public opinion appears to be. One study in the United Kingdom found members of parliament to be almost twice as unfavorably disposed as the public towards the nuclear industry.[69] The same study found similar disparities in public and official attitudes elsewhere in Europe. "Opinion polls in Sweden," the authors note, "show a considerable majority in favour of existing nuclear power stations continuing to operate, a view shared by most of Swedish industry, yet the governing coalition forced closure of one nuclear plant in 1999, and another closure is, in principle, due to follow." If policymakers in parts of Europe seemingly have outdone their local publics, geography may be a contributing factor: the governments of

[66] IEA, *Nuclear Power in the OECD,* p. 230.

[67] It may be noted, however, that the future of the reprocessing plants in some of these countries is in doubt. In 2001, for instance, the Green Party in Germany succeeded in obtaining a government commitment to end reprocessing by mid-2005. "A Renaissance that May Not Come, *The Economist,* May 19, 2001, p. 24.

[68] IEA, *Nuclear Power in the OECD*, p. 186.

[69] Malcolm C. Grimston and Peter Beck, *Civil Nuclear Energy: Fuel of the Future or Relic of the Past?* (London: Royal Institute of International Affairs, 2000), p. 93.

small countries such as Sweden have to deal not only with their indigenous anti-nuclear movements but with those of several neighboring nations. Sweden's Barsebäck plant, for instance, has aroused concern in nearby Denmark. Ireland and Norway have complained about the operation of Britain's Sellafield plant.[70]

b. Climate Change

A plausible way to slow emissions of carbon dioxide into the atmosphere is to generate a larger share of electricity through nuclear power stations. Thanks to the stations currently on line, carbon emissions by the OECD countries are about one-third lower than they otherwise would be. Given that straightforward proposition, one might suppose that by now the climate-change issue would have boosted nuclear projects more than it has. It would seem logical, in other words, that nations formally committed to cutting emissions of heat-trapping gases would be the most pro-nuclear. Conversely, America, with its apparent high tolerance for fossil-fuel effluents, renders its nuclear industry uncompetitive.

In practice, matters are not so simple. Many of the countries that officially accepted Kyoto's mandatory greenhouse-gas reductions have nonetheless declined to install more nuclear capacity. At the United Nation's Framework Convention on Climate Change in November 2002, the ministerial representatives of Austria, Denmark, Germany, Greece, Ireland, Italy, and Sweden appeared disinclined to displace existing fossil-fuel fired generation with more nuclear power as a means of meeting emissions targets.[71]

True, these and other industrial countries abroad have long restrained the consumption of (*certain*) fossil fuels in ways that the United States has never tried. For example, the contrast in tax rates on oil products, particularly gasoline (Figure 6), between the United States and the rest of the OECD is striking.[72] However, while this difference can help explain the comparatively high American level of carbon dioxide emissions per capita (Figure 7), it has little bearing on the question at hand—the relative promise of nuclear power. Heavily taxing motor fuel, or any of oil's other refined products, is not the kind of carbon-curbing policy that might enhance the competitive

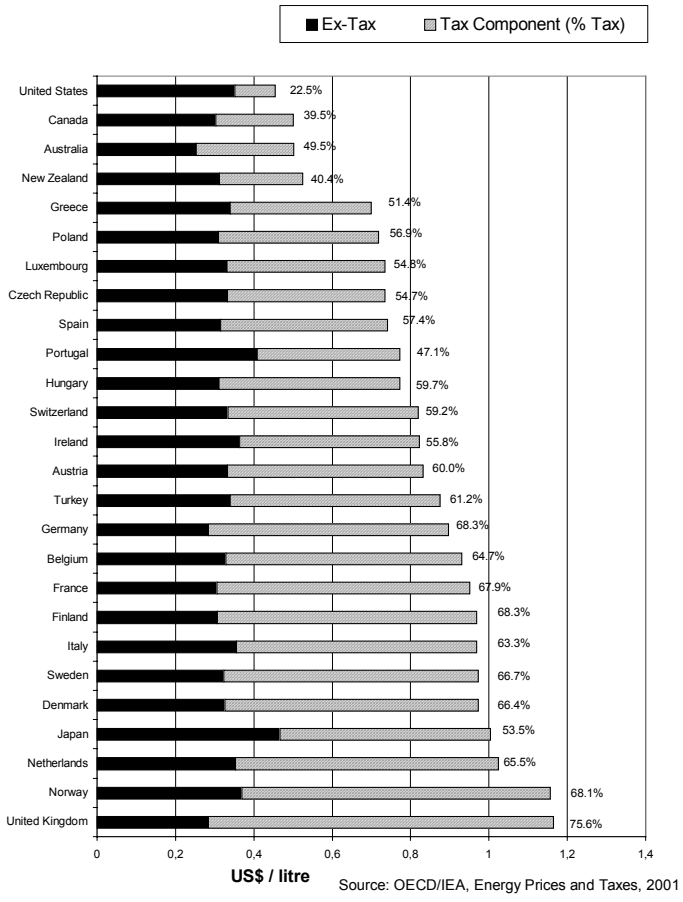
[70] IEA, *Nuclear Power,* p. 216.

[71] IEA, *Nuclear Power,* p. 54.

[72] For a comprehensive treatment of the reasons for high levels of motor-fuel taxation in most European countries and Japan, and the low rates in the United States, see Pietro S. Nivola and Robert W. Crandall, *The Extra Mile: Rethinking Energy Policy for Automotive Transportation* (Washington, DC: Brookings, 1995).

position of nuclear power producers. The reason is plain: petroleum is no longer used to propel many electric generators in the industrial world. Only taxes that cover the main competitors to nuclear-generated electricity—coal and, to a lesser extent, natural gas—might put the nukes back in contention. To do so decisively, moreover, a broad-based carbon tax of this sort would have to be steep—approaching perhaps $100 per ton of carbon emitted.[73] No OECD member has yet come close to imposing a penalty of that magnitude.[74]

Figure 6. Gasoline Prices and Taxes in OECD Countries, 4th Quarter 2000



Source: OECD/IEA, Energy Prices and Taxes, 2001

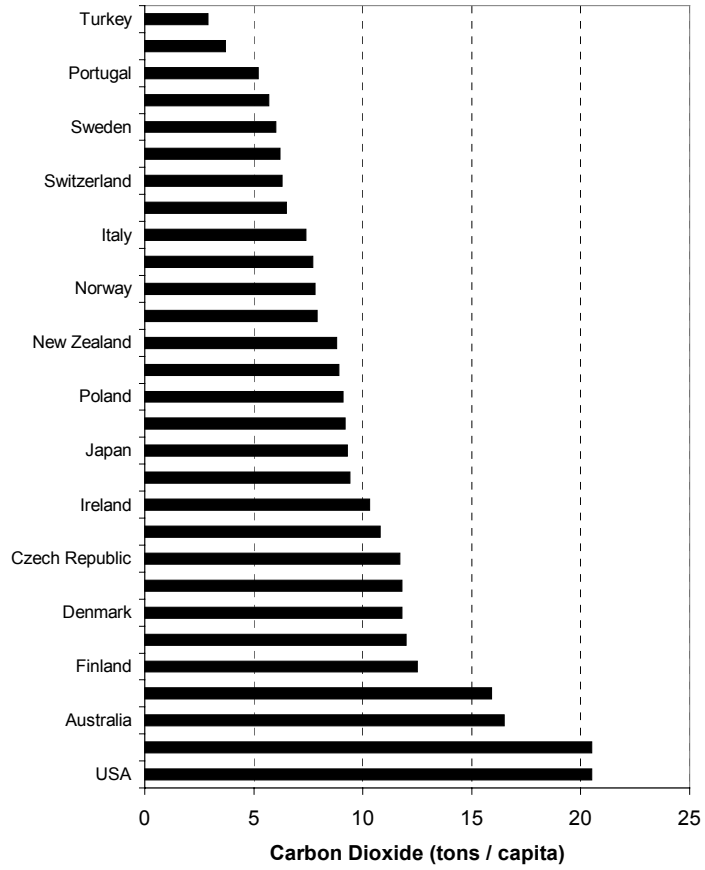
In sum, the fact that foreign countries heavily tax particular fossil fuels—chiefly petrol—helps many of those countries emit less carbon dioxide per person than the

[73] Deutch, *Future of Nuclear Power,* p. 7. Other estimates of the necessary carbon tax run higher. *The Economist,* May 19, 2001, p. 26.

[74] Even Norway's unusual levy falls short. Annegrete Bruvoll and Bodil Merethe Larsen, "Greenhouse Gas Emissions in Norway: Do Carbon Taxes Work?" *Discussion Paper No.337* (Oslo: Statistics Norway, Research Department, December 2002), p. 10.

United States. But that distinction, however interesting, is of little relevance to the question of whether nuclear power in America is being disadvantaged by this country's rejection of the Kyoto protocol.

Figure 7. Per Capita Carbon Dioxide Emissions, 1999



Source: OECD Environmental Performance Reviews, 2001

What can have greater implications for the future of nuclear power here and elsewhere is the assortment of other environmental policies that, in effect, penalize coal-burning electric plants. The European Union, unlike the United States, is on track to create a large-scale tradable permits market for carbon emissions. (The U.S. Congress has barely begun to debate anything along these lines.) Having just issued its directive last year, the EU's program is still in its infancy. Formal emissions trading will commence next year, when more will be known about the system's outcomes. But if, for 2005, allowances per ton of carbon emission are trading at only € 7 to 8, they will represent, at best, a very distant substitute for the kind of hefty carbon tax that would be

needed to put American builders of nuclear plants back in business.[75] Nevertheless, the experiment in Europe is a significant start—and has stirred some interest in Washington, at least in the Senate.

In the autumn of 2003, the U.S. Senate defeated a carbon emissions-trading proposal cosponsored by senators John McCain (Republican of Arizona) and Joseph Lieberman (Democrat of Connecticut). The McCain-Lieberman bill would require firms to purchase allowances at an estimated value of around $14 per ton of carbon emitted, which could add to the cost of coal approximately $32 per short ton, and about 77 cents per thousand cubic feet to the cost of natural gas.[76] The odds of Congress enacting a measure such as this in the foreseeable future are probably poor, though, the upper chamber may revisit McCain-Lieberman later this year.[77]

Whatever the case, it is important to keep in mind that even without something comparable to the European Union's projected trading system presently in prospect on this side of Atlantic, existing components of the U.S. environmental agenda have been of considerable consequence for electric utilities. Obviously, for example, actions required by the Clean Air Act (CAA) are not trivial. Between 1987 and 1994, utilities shelled out upwards of $6 billion (in 1993 dollars), mostly to reduce coal effluents such as sulfur dioxide.[78] Compliance costs have nearly doubled again, as the second phase of the 1990 CAA amendments gets implemented. The CAA, which makes coal-combusting power plants install sulfur-cleansing scrubbers, for instance, translates into the functional equivalent of a tax on the use and production of coal. Although most producers have readily absorbed that "tax," a number of high-sulfur coal mines were forced to close.[79]

5. Conclusions

Government policies, including environmental regulations, have not been the overriding source of the nuclear industry's tribulations in the United States over the past

[75] That, according to the current carbon market indicator, is the most recent bidding price for allowances in the 2005 market. Estimates are in *Carbon Market Europe,* April 8, 2004.

[76] These estimates are in William A. Pizer and Raymond J. Kopp, *Summary and Analysis of McCain-Lieberman "Climate Stewardship Act of 2003"* (Washington, D.C.: Resources for the Future, January 28, 2003), p. 4.

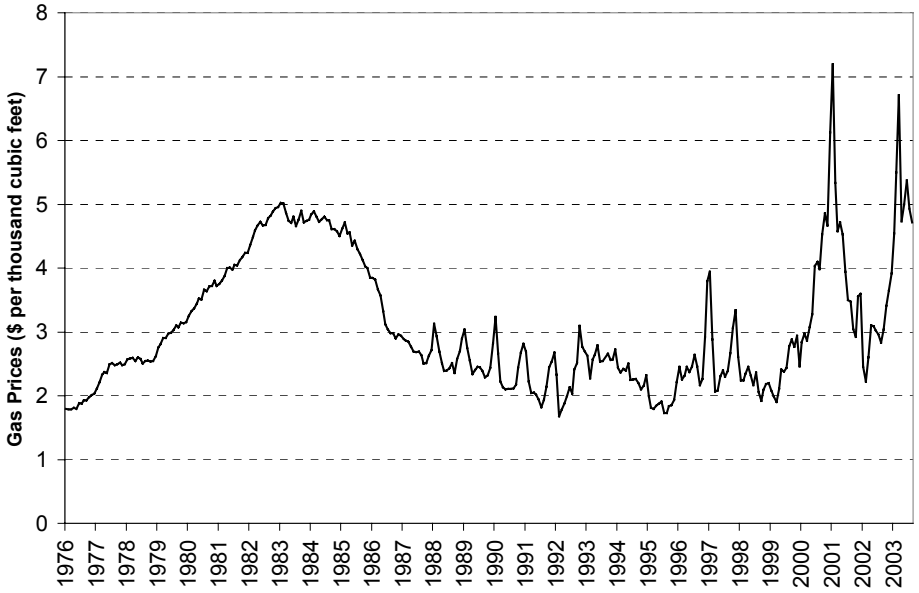
[77] "Measuring the Climate for Change," *National Journal's Congress Daily,* April 22, 2004.

[78] Nuclear Energy Institute, "The Outlook for Nuclear Energy in a Competitive Electricity Business," *Fact Sheet,* 2003, p. 9.

[79] Lockard, *Coal*, p. 152.

thirty years. Rather, the industry's difficulties derived, first and foremost, from upheavals in energy markets following the shocks of the 1970s. Much depends, therefore, on whether the economic fundamentals of tomorrow will remain like today's, or whether the economics of nuclear plants may turn more conducive to a resumption of investment.

Figure 8. Natural Gas Prices from 1976-2003 – Monthly Data (in 2003 dollars)



Source: US Energy Information Administration

Companies contemplating possible construction projects continue to face daunting conditions. Traditional light-water reactors, never mind the variety of more advanced technologies, remain too expensive to build. To render them even faintly competitive, environmental restrictions on coal would have to be ratcheted far beyond current levels, natural gas prices would have to top, say, $7 per thousand cubic feet *and stay there*, and construction would have to take no more than three or four years, not ten or twelve. None of these circumstances looms close at hand. Even among Kyoto signatories, not to mention the United States, few societies show signs of cracking down hard on carbon dioxide from all sources. Gas prices have been increasingly volatile (Figure 8). The price fluctuations are giving power companies discomfort—but not the degree of discomfort that would occur if the prices fastened consistently on the $7-mcf range. Only the Japanese, the French, and the South Koreans seem to practice the art of completing a nuclear plant in under five years.

a. Safety and Security

Exacerbating these travails is society's continuing sensitivity to safety issues. Scientists, of course, view this problem as grossly overblown. No Western reactors, including the old ones that were built more expeditiously, are designed like Chernobyl's. The one American accident that looked as if it came closest to a Chernobyl incident—the partial meltdown at Three Mile Island—caused little discernable harm to human health and no environmental damage. Physicists are reasonably confident that, given TMI's massive containment structure, not even a complete core meltdown within the structure's confines would likely have matched the cumulative health-impairing effects of coal-fired power plants, which claim lives each year by polluting the air.[80] No matter; the health threat of routine coal combustion (or, similarly, other non-nuclear hazards like leaks or explosions in gas pipelines or in transporting oil or liquified natural gas) ordinarily does not receive the intense scrutiny the public accords every corner of the nuclear energy industry.[81]

It would be a mistake to assume that this imbalance is more pronounced in the United States than in other Western societies. Indeed, judging from the contemporary course of the civilian nuclear programs in many other countries, nuclear phobia often seems at least as acute there as here. In the past three years, however, another kind of peril—the possibility of nuclear terrorism—has heightened anxiety in America. Foes of nuclear energy warn that plants could be sabotaged, that hijacked jet liners could be used to smash through reactor containment structures, that fissile fuel could be diverted to make a nuclear device, or that waste material could be stolen to wrap around a conventional explosive (a so-called dirty bomb).

Again, some of these risks are probably being exaggerated. Other types of terrorist attacks (for example, blowing up a chemical plant in an urban area) would be easier to attempt, and would almost certainly cause far greater loss of life than, say, a dirty bomb.[82] The nightmare of weapons-grade fuel making its way to the likes of al Qaeda, whose followers might someday figure out how to fabricate and detonate an

[80] Cohen, *Nuclear Energy Option,* pp. 76, 134. Even an average coal-fired plant using scrubbers and precipitators to filter out 95 percent of particulate emissions still spews more radioactive material into the atmosphere than does a nuclear plant. Henderson, *Nuclear Power,* pp. 27-28.

[81] In 1984, a toxic gas leak from a Union Carbide plant in Bhopal, India, killed thousands of people. Even Chernobyl, two years later, was nowhere near as lethal.

[82] For a good review of the myths and realities of nuclear terrorism, see Gwyneth Cravens, "Terrorism and Nuclear Energy: Understanding the Risks," *Brookings Review,* vol. 20, no. 3 (Spring 2002).

atomic bomb, is a worst-case scenario. But it is also a relatively implausible one—if it presupposes pilfering the fuel *from a U.S. facility*. Stealing the necessary enriched uranium or plutonium from civilian nuclear installations in this country would be an amazing feat, compared to smuggling the ingredients from the loosely guarded stockpiles elsewhere in the world.[83] In short, to perceive nuclear power *within* the United States as playing into the hands of terrorists makes little sense, given the far greater danger of proliferation from other places. So long as the perception persists, though, it further muddles the outlook for U.S. nuclear energy.

b. The Upside

With all the impediments it confronts, nuclear generating capacity in the United States is not poised to expand any time soon. But that is not to conclude that this major source of electricity is on its way to becoming a relic of the past. A number of factors will keep nuclear generators in the U.S. energy mix.

Environmental rules are among the wildcards. Americans will continue to resist direct taxation of the fossil fuels associated with global warming. But other clean-air regulations can have some of the same effect—by imposing additional burdens on coal users, for instance, and thereby blunting a bit of their competitive advantage. Granted, those regulations are still far from unaffordable for the coal industry. Nevertheless, they have become more, not less, exacting over time, and if they continue to do so, the notion of maintaining a sizeable nuclear component (which emits practically no sulfur dioxide, no nitrogen oxide, no particulates, no trace metals, as well as no carbon) could regain traction.[84]

The odds will improve if several other preconditions sink in. The most basic, naturally, is strong growth of demand for electric power. The U.S. Department of Energy forecasts an increase of more than 30 percent in consumption through 2020.[85] Given that a number of worn out nuclear plants will have been decommissioned by

[83] Since the end of the Cold War there has been no global shortage of plutonium that could, theoretically, make its way into the hands of terrorists. Diverting some of it from parts of the former Soviet Union, and weaponizing it by employing rogue scientists from places like Pakistan, looms as a much greater risk than the remote chance of someone absconding with enriched uranium from a U.S. plant. Likewise, it was odd for the Carter administration to impose a unilateral ban on fuel reprocessing in the United States while various other countries continued to pursue far more reckless actions (including, as an example, French assistance to Iraq in developing a "research" reactor in 1980).

[84] As noted above, in January 2004 the EPA returned to enforcing the CAA's New Source Review provisions, thereby again leaving utilities less flexibility with regard to the installation of anti-pollution equipment.

[85] Energy Information Administration, *Annual Energy Outlook 2004 with Projections to 2025* , January, 2004.

then, the nation could face an appreciable deficit in overall capacity. Filling it with coal-fired plants could prove problematic, at least barring accelerated breakthroughs in "clean coal" technology or carbon sequestration systems.[86] Various renewable-energy technologies undoubtedly will progress over the next fifteen years, but almost certainly not to the point of meeting our anticipated baseload requirements.[87]

That leaves natural gas-powered turbines. Predicting the quantities and prices of gas has been a fool's game from year to year—to say nothing of ten or fifteen years out. It is conceivable that America may be able to acquire the supplies it will need by a combination of expanded drilling on public lands, pipeline projects that can bring in more sales from Canada and Mexico, and massive growth of liquified natural gas (LNG) shipments from locations such as Trinidad, Nigeria and Norway. But all of that may be a tall order. Currently, the lower 48 American states hold 3 percent of the world's natural gas reserves but the United States accounts for 25 percent of the world's gas consumption.[88] Only 1 percent of the nation's supply comes in the form of LNG from outside North America.

The addition of a few more nuclear plants, therefore, is a possibility that cannot be entirely ruled out over the long haul—particularly if improved technologies do more to cut costs while also helping to allay security concerns. Those improvements could occur. The U.S. government continues to throw significant sums of money into nuclear R&D. The Bush administration's fiscal year 2004 budget requested almost $390 million for that purpose, not including a futuristic "nuclear hydrogen initiative" that would use nuclear power to produce fuel for hydrogen-powered motor vehicles.[89] Further, some U.S. electrical utilities are emerging as giant corporations, no longer dwarfed by the likes of EDF (Electricité de France). These big businesses, which are the upshot of deregulation's shake-up of the electricity industry, may have the

[86] Presently, power plants using coal treated by so-called fluidized bed technology still emit about 10 times more smog-causing nitrogen oxide than do comparably sized plants fueled by natural gas.

[87] For a good synopsis of the realities of renewables, see Joel Darmstadter, "Whistling in the Wind? Toward a Realistic Pursuit of Renewable Energy," *Brookings Review,* vol. 20, no. 2 (Spring 2002).

[88] Matheew L. Wald and Jennifer Lee, "When the Laws of Supply and Demand Don't Apply," *New York Times,* August 10, 2003, p.12wk. Canadian production of natural gas, on which the U.S. is increasingly dependent, does not appear to be rising steadily enough to meet U.S. requirements.

[89] The FY'04 budget request came in considerably higher than what was appropriated for FY'03. Holt and Behrens, *Nuclear Energy Policy,* p. 1.

wherewithal to overcome more of the financial uncertainties of underwriting nuclear facilities.[90]

So, who knows? What looks too risky for the time being might become a bit less speculative in due course.

[90] Indeed, one such company, Exelon, is already doing so—building a reactor in South Africa that uses so-called pebble-bed technology.