Union of Concerned Scientists

ISSUE BRIEFING

Nuclear Power:
A Resurgence We Can't Afford

August 2009

Nuclear power could play a role in reducing global warming emissions because reactors emit almost no carbon while they operate and can have low life-cycle emissions. Partly for that reason, advocates are calling for a nationwide investment in at least 100 new nuclear reactors, backed by greatly expanded federal loan guarantees. However, the industry must resolve major economic, safety, security, and waste disposal challenges before new nuclear reactors could make a significant contribution to reducing carbon emissions.

A forced nuclear resurgence could make efforts to cut the nation's global warming emissions much more costly, given the rising projected costs of new nuclear reactors.

The economics of nuclear power alone could be the most difficult hurdle to surmount. A new UCS analysis, *Climate 2030: A National Blueprint for a Clean Energy Economy*, finds that the United States does not need to significantly expand its reliance on nuclear power to make dramatic cuts in power plant carbon emissions through 2030—and indeed that new nuclear reactors would largely be uneconomical.

That analysis shows that by significantly expanding the use of energy efficiency and low-cost and declining-cost renewable energy sources, consumers and businesses could reduce carbon emissions from power plants as much as 84 percent by 2030 while saving $1.6 trillion on their energy bills. And, under the Blueprint scenario (see below), because of their high cost, the nation would not build more than four new nuclear reactors already spurred by existing loan guarantees from the Department of Energy (DOE) and other incentives.

A forced nuclear resurgence, in contrast, could make efforts to cut the nation's global warming emissions much more costly, given the rising projected costs of new nuclear reactors. A nuclear power resurgence that relies on new federal loan guarantees would also risk repeating costly bailouts of the industry financed by taxpayers and ratepayers twice before.

The Status of Nuclear Power Today

The United States now obtains about 20 percent of its electricity from 104 nuclear reactors. Thanks to better operating performance, the "capacity factor" of U.S. reactors—the amount of power reactors actually produce, compared with their rated capacity—rose from 56 percent in 1980 to nearly 92 percent in 2008. However, U.S. utilities have ordered no new nuclear plants since 1978, and canceled all plants ordered after 1973. Other countries have continued to build nuclear plants, but at a much slower rate than during the peak years of the 1970s and 1980s.

The Nuclear Regulatory Commission (NRC) is in the process of extending the licenses for most, if not all, U.S. reactors now operating, from their original 40 years to 60 years. The industry is currently expected to retire almost all these reactors between 2030 and 2050. The industry has begun discussing the potential for further license extensions, although no one has determined the technical and economic feasibility and the safety implications of such extensions.

Fourteen companies have submitted applications to the NRC to build and operate 26 new plants at 17 sites.

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However, some companies have already withdrawn several applications after announcing plant cancellations or design changes.

The applications reference five different plant designs, of which the NRC has certified only two. And one of those, the AP1000, has undergone significant design changes since it was certified. The NRC is not expected to approve any applications before late 2011. Thus, even optimistic estimates suggest that no new plants will come online before 2016—and probably later.

A Record of Cost Overruns

The cost of nuclear power is driven largely by the cost of building the reactors. The fuel and operating costs of existing nuclear reactors are usually lower than those of other conventional technologies for producing electricity, due to the fact that their large capital costs have been largely written down over the years due to market forces and regulatory actions. However, high construction costs—coupled with long construction periods and associated financing costs—have been and continue to be the economic Achilles' heel of the nuclear industry.

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During the 1970s and 1980s, utilities' cost overruns in building nuclear power plants averaged more than 200 percent, as construction costs skyrocketed even as growth in demand for electricity slowed (see Table 1). The result was what a 1985 Forbes cover story called "the largest managerial disaster in business history, a disaster on a monumental scale." Utilities abandoned some 100 plants during construction—more than half of the planned nuclear fleet. Taxpayers and ratepayers reimbursed utilities for most of the more than $40 billion cost of these abandoned plants.

Meanwhile, the nuclear plants that utilities did complete usually led to significant rate increases in electricity bills. Ratepayers bore well over $200 billion (in today's dollars) in cost overruns for completed nuclear plants. In the 1990s, legislators and regulators also allowed utilities to recover most "stranded costs"—the difference between utilities' remaining investments in nuclear plants and the market value of those plants—as states issued billions of dollars in bonds backed by ratepayer charges to pay for utilities' above-market investments.

The total cost to ratepayers, taxpayers, and shareholders stemming from cost overruns, canceled plants, and stranded costs exceeded $300 billion in today's dollars (Schlissel, Mullet, and Alvarez 2009).

TABLE 1: **Cost Overruns for U.S. Nuclear Plants**

The cost of a typical U.S. nuclear plant completed in this time frame—given an average overrun of 207 percent—was more than three times its original estimate. That figure does not include some of the most expensive plants, built after 1986.

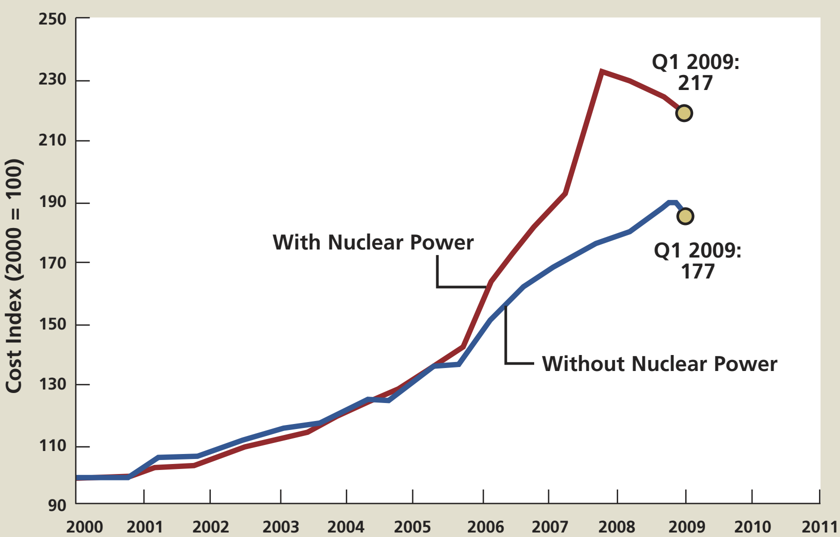
CONSTRUCTION STARTS		AVERAGE OVERNIGHT COSTS[a]		
YEAR INITIATED	NUMBER OF PLANTS[b]	UTILITIES' PROJECTIONS (THOUSANDS OF DOLLARS PER MW)	ACTUAL (THOUSANDS OF DOLLARS PER MW)	OVERRUN (PERCENT)
1966-1967	11	612	1,279	109
1968-1969	26	741	2,180	194
1970-1971	12	829	2,889	248
1972-1973	7	1,220	3,882	218
1974-1975	14	1,263	4,817	281
1976-1977	5	1,630	4,377	169
OVERALL AVERAGE	**13**	**938**	**2,959**	**207**

Source: Congressional Budget Office, based on data from EIA 1986.
Notes: This analysis includes plants for which construction began after 1965 and was completed by 1986. Data are expressed in 1982 dollars, adjusted to 2006 dollars.
a. Overnight construction costs do not include escalating costs during construction or financing charges.
b. This study defines a nuclear power plant as having one reactor. If a utility built two reactors at the same site, those reactors would be considered two power plants.

A Nuclear Resurgence at What Cost?

Reliably projecting the construction costs of new U.S. nuclear plants is impossible, because the nation has no recent experience to draw on. Experience with reactors now under construction in Europe, however—along with trends in the cost of commodities used to build the plants, and in overall construction costs during most of the past decade—show the same vulnerability to cost escalation that plagued the last generation. Four years after its 2005 groundbreaking, for example, the Olkiluoto plant in Finland

FIGURE 1: **Nuclear Power Plant Construction Costs Have Risen Faster than Other Technologies**



Source: CERA 2009.

is reportedly three years behind schedule, with cost overruns topping 50 percent. The project has encountered numerous quality problems, and the principals are in arbitration over responsibility for the cost overruns (Kanter 2009).

An analysis by Cambridge Energy Research Associates shows that construction costs have risen for all technologies used to generate electricity over the past decade—but most dramatically for nuclear plants (see Figure 1). (Recent drops in the price of raw materials because of the severe recession have reduced the costs of all types of power plants, but those costs promise to rebound with the U.S. and global economy.)

As recently as 2002, the industry and the DOE were projecting costs of \$2 billion–\$3 billion per new nuclear plant. However, developers applying for DOE loan guarantees in October 2008 for 21 proposed nuclear plants estimated that their costs—including financing costs and expected increases in construction costs—would total \$188 billion. That translates into an average of \$9 billion per plant.

The industry estimate also represents an average cost of more than \$6,700 per kilowatt. By mid-2009, however, Wall Street and other independent analysts had raised projections of "overnight" construction costs for nuclear plants to as high as \$10,000 per kilowatt. And those overnight costs do not include financing costs or cost escalation during construction, which can raise the total price of a nuclear power plant by as much as 50 percent.

The total cost to ratepayers, taxpayers, and shareholders stemming from cost overruns, canceled plants, and stranded costs exceeded \$300 billion in today's dollars.

A recent analysis by economist Mark Cooper of the Institute for Energy and the Environment at Vermont Law School showed that this cost escalation is consistent with the pattern that occurred in the 1970s and 1980s with the previous generation of nuclear plants (see Figure 2) (Cooper 2009).

Charging Ratepayers for Plants under Construction

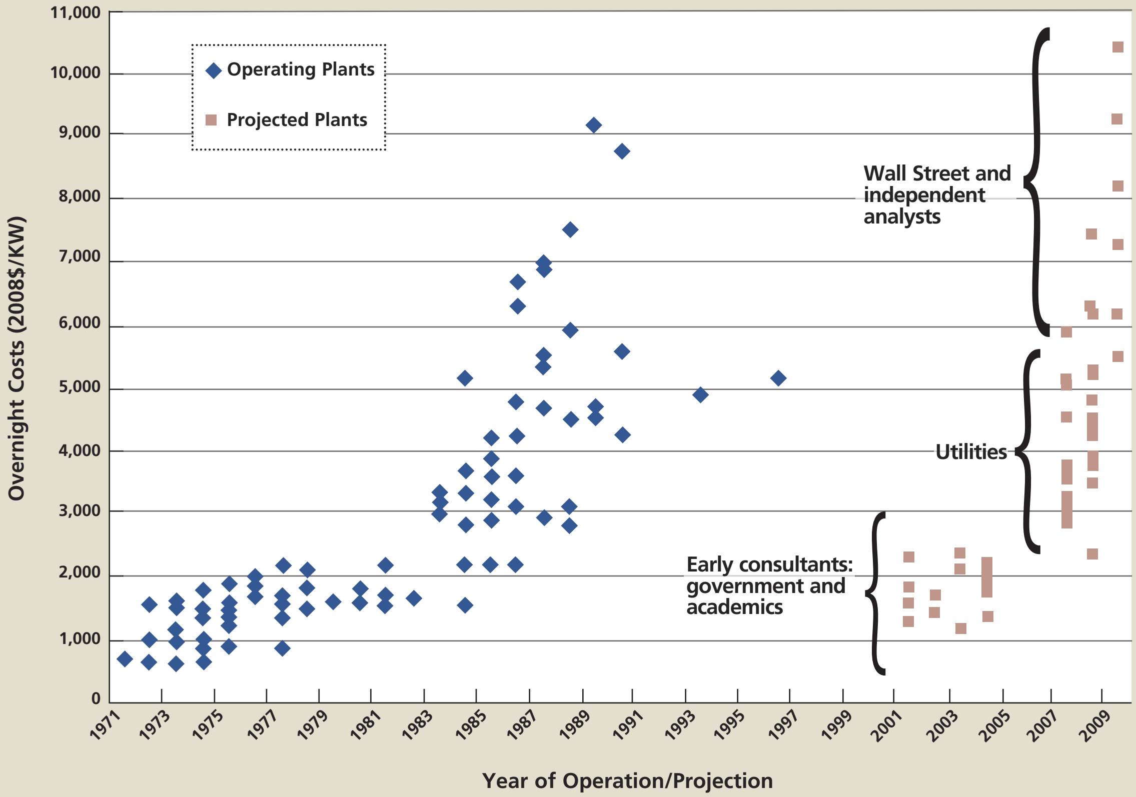
Given such high costs, a new nuclear plant can lead to significant increases in the price of electricity, even before the plant goes online. For example, Progress Energy—a utility that is building two new reactors in Florida at an expected cost of at least \$17 billion—has received regulatory approval to charge ratepayers for construction work in progress (CWIP). These charges have already raised customers' average utility bills by 10 percent—with additional increases scheduled each year—although the plants will not generate a single kilowatt of electricity for at least a decade.

CWIP is receiving greater attention today as utilities seek to shift the costs and risks of building new reactors to ratepayers. Several states now allow electric companies to include CWIP in their rate base (see Table 2), while others are considering it. By phasing in charges during construction, a power producer can reduce the rate hike that typically occurs when a new nuclear power plant begins to operate. However, regulators largely abandoned this practice in the 1980s when consumers ended up paying for nuclear reactors later canceled because of cost overruns.

Nuclear vs. Low-Carbon Competitors

Climate 2030: A National Blueprint for a Clean Energy Economy, the recent UCS report, provides strong evidence that new nuclear plants are not cost-competitive with other electricity

FIGURE 2: **Projected "Overnight" Costs for First-Generation and New Nuclear Power Plants**



Source: Cooper 2009.
Overnight costs for building new power plants do not include financing costs or cost escalation during construction. Overnight costs rose dramatically for first-generation nuclear plants, and financial analysts' estimates of those costs for the next generation are rising just as quickly today.

sources, including energy efficiency and renewable energy. That report provides a peer-reviewed analysis of the costs and benefits of reducing U.S. global warming emissions by 26 percent below 2005 levels by 2020, and 56 percent by 2030. Such cuts would put the United States on a path to reduce those emissions by at least 80 percent by 2050—a drop many scientists deem necessary to avoid the most dangerous effects of climate change.

To perform this analysis, the UCS authors used a modified version of the Department of Energy's Energy Information Administration National Energy Modeling System (NEMS). The model chose the combination of new power sources needed to maintain a reliable supply of electricity at the lowest cost through 2030 while also meeting the emissions targets. The model factored in the costs of building new transmission lines, integrating renewable energy technologies into the grid, and providing reserve power supplies.

The model found that—especially given the recent escalation in cost estimates—new nuclear plants are likely to be among the more expensive options for producing low-carbon electricity. And the model did not consider that the costs of nuclear power are likely to continue to escalate during construction, given the industry's history. Nor did it consider the potential for a number of emerging renewable technologies to become available and cost competitive.[1]

The model analyzed two policy scenarios for achieving the targeted cuts in carbon emissions (see Figure 3). The first scenario—called the Blueprint case—relied on a cap-and-trade system for putting a price on carbon emissions, plus policy incentives and standards to encourage robust reliance on energy efficiency and development of renewable sources of electricity. That scenario reflected earlier analyses showing that such policies can cut energy bills for consumers and businesses, thus lowering the overall cost of reducing carbon emissions (for example, see UCS 2007, Prindle et al. 2007, and EIA 2001). Energy efficiency measures, in particular, cost only about three cents per kilowatt-hour saved—much less than the cost of producing a kilowatt-hour of electricity from any new low-carbon technology.

The second scenario—called the No Complementary Policies case—stripped out the policies promoting efficiency and renewable energy. That left a relatively simple cap-and-trade system, and allowed technologies to "compete" to provide cuts in those emissions at the lowest cost. Both scenarios assumed that government would recycle revenues from auctioning allowances to emit carbon back into the economy, but that government would not target those revenues to specific uses, such as energy efficiency and low-carbon technologies.

The model confirmed that the first scenario was the least expensive for consumers and businesses. Their net savings—beyond the costs of investing in efficiency and renewable energy—would total $1.6 trillion by 2030, compared with business as usual. And that scenario would enable the nation to reduce global warming emissions from power plants by 84 percent by 2030.

According to the model, new nuclear plants would not play a significant role in either scenario. In the Blueprint case, the nation would not build any new nuclear plants beyond four 1,100-megawatt reactors already in the pipeline, spurred by existing nuclear subsidies and loan guarantees. That is because energy efficiency and renewable sources would meet nearly all the nation's needs for electricity, and for cutting emissions from that sector.

In the No Complementary Policies case, the lack of policies promoting energy efficiency would push electricity demand much higher and require more electricity supply. However, even in that scenario, the model found that the nation would build only 12 new nuclear plants by 2030—for a total of 13,600 megawatts—because renewable sources of electricity, and power produced from natural gas, would still be more cost-effective than nuclear power. Under that scenario, net energy savings for consumers and businesses would total $600 billion through 2030—a trillion dollars less than if policies spurred even greater investment in energy efficiency and renewable energy.

Thus the Climate 2030 analysis shows that, despite optimistic assumptions about the costs of nuclear plants, they are not the most economical approach to meeting ambitious goals for cutting carbon through 2030. What's more, the nation does not need new nuclear plants to meet those goals, especially if public policies spur the use of more cost-effective energy efficiency and renewable energy. The cost-effectiveness of using nuclear power to provide electricity to homes and businesses after 2030 is hard to predict and no projections were made on technology advances past that point.

Incentives Are Available Now for New Reactors, but the Industry Wants More

Because of the dismal cost-effectiveness record of nuclear power plants, Wall Street has been unwilling to invest in new reactors for three decades. However, Congress has already put several economic incentives in place to spur the next generation of nuclear power plants.

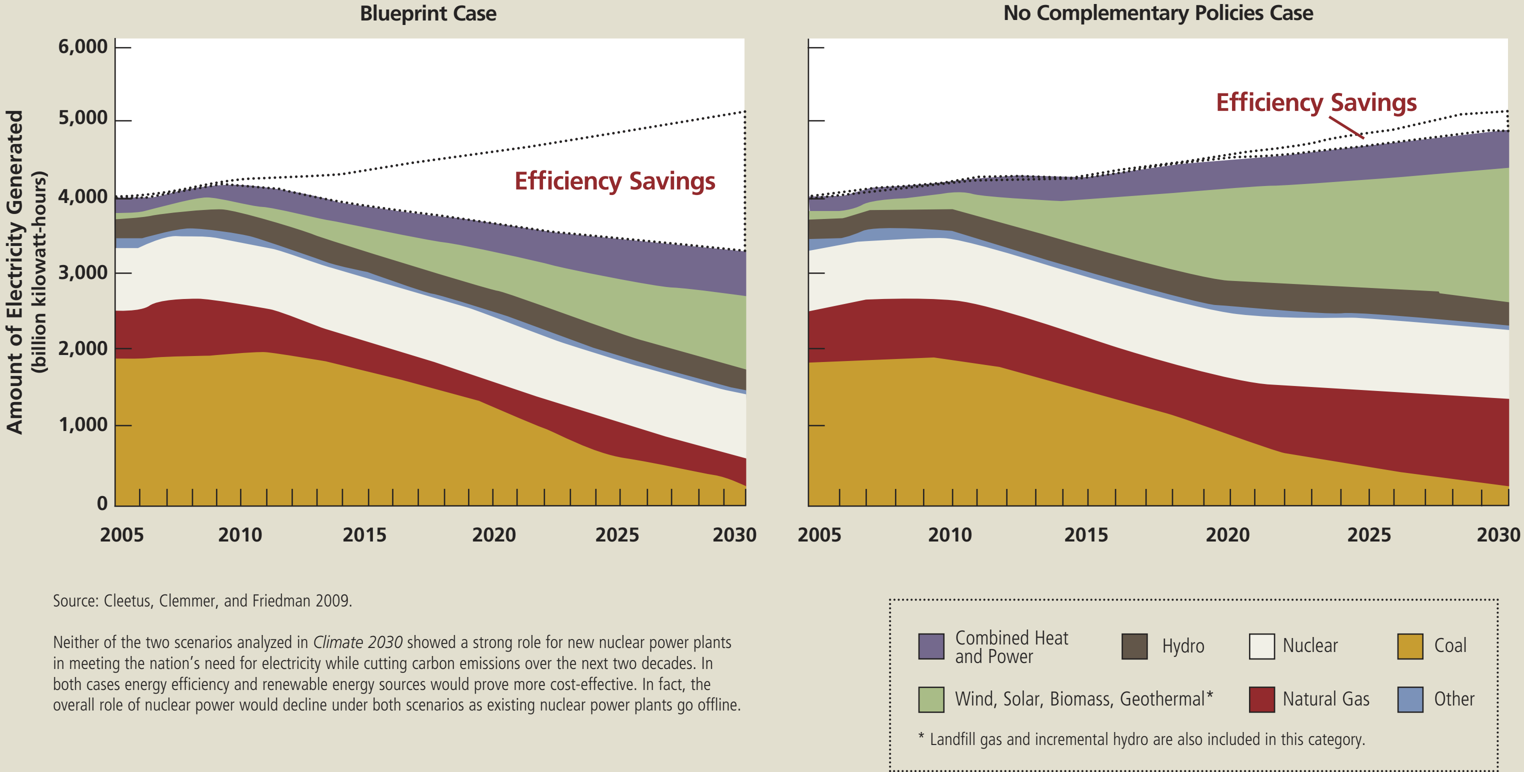
TABLE 2: **State Policies Supporting New Nuclear Power Plant Construction**

STATE	LEGISLATION AND REGULATIONS IN PLACE	LEGISLATION PROPOSED AND/OR REGULATIONS PENDING
Florida	x	x
Georgia	x	
Idaho	x	
Illinois		x
Indiana		x
Iowa	x	
Kansas	x	
Kentucky		x
Louisiana	x	
Maryland	x	
Michigan	x	
Minnesota		x
Mississippi	x	
North Carolina	x	
Ohio	x	
Oklahoma		x
South Carolina	x	x
Texas	x	
Utah	x	
Virginia	x	
West Virginia		x
Wisconsin	x	x

Source: NEI 2009.

Notes: Sixteen states have policies in place that support the development of new nuclear reactors, including recovery of pre-construction costs and construction work in progress as well as defining nuclear power as an eligible resource under a state renewable electricity standard (a policy that requires utilities to obtain a percentage of their electricity from renewable resources). Indiana and Oklahoma are considering new cost recovery policies. Legislation pending in Florida, Indiana, South Carolina, and West Virginia would define nuclear power as an eligible renewable resource. Illinois, Kentucky, Minnesota, and Wisconsin are considering legislation that would repeal existing state moratoria on new nuclear plant construction.

FIGURE 3: **The Future of the U.S. Power Supply: Blueprint Case vs. No Complementary Policies Case**



Source: Cleetus, Clemmer, and Friedman 2009.

Neither of the two scenarios analyzed in *Climate 2030* showed a strong role for new nuclear power plants in meeting the nation's need for electricity while cutting carbon emissions over the next two decades. In both cases energy efficiency and renewable energy sources would prove more cost-effective. In fact, the overall role of nuclear power would decline under both scenarios as existing nuclear power plants go offline.

One such incentive is the 2005 extension of the Price-Anderson Act, which largely shields plant operators from the costs of nuclear accidents. Other incentives include a tax credit of 1.8 cents for each kilowatt-hour of electricity produced by new nuclear plants operating by 2020, and $18.5 billion in DOE loan guarantees for new nuclear plants. An economy-wide cap-and-trade system for curbing global warming emissions would provide yet another incentive to build new reactors, as such a system would require the owners of coal and natural gas plants to buy at least some of the allowances they receive to emit carbon dioxide.

Despite these supports, the nuclear industry is calling for even more federal loan guarantees to back a massive nationwide investment in new nuclear reactors. The Government Accountability Office puts the average risk of default on DOE loan guarantees for all types of power plants at about 50 percent (GAO 2008). That means taxpayers' risk from guaranteeing loans for nuclear plants could range from $360 billion (based on 100 reactors at today's projected costs) to $1.6 trillion (based on 300 reactors with costs 50 percent higher than today's estimates) (Schlissel, Mullet, and Alvarez 2009).

Congress Should Not Risk More Taxpayer Dollars

The nuclear industry's history of skyrocketing costs and construction overruns has already resulted in two costly bailouts by taxpayers and captive ratepayers—once in the 1970s and 1980s, when utilities abandoned some 100 plants, and again in the 1990s, when plant owners offloaded their "stranded" costs. Efforts to again shift the risks of building nuclear reactors to taxpayers and ratepayers—through new loan guarantees and charges for projected construction costs—could lead to another round of bailouts that dwarf the first two.

The industry's track record suggests that policy makers should take several critical steps before expanding taxpayer support for new nuclear plants that the industry and Wall Street consider too risky to finance on their own:

- Congress and the DOE should not expand nuclear loan guarantees beyond today's $18.5 billion limit, and should not try to approve all applications for those guarantees. The existing amount can support enough first-mover reactors to reveal the feasibility of new plant designs and the new NRC licensing process.

- Any new agency charged with overseeing loan guarantees for low-carbon energy technologies—such as the Clean Energy Deployment Administration proposed in the House and Senate climate bills—must thoroughly assess the creditworthiness of borrowers, and their organizational capacity to fulfill their loan obligations.
- All federal loan guarantees—and the agencies that issue them—must be subject to congressional budgetary oversight. Congress must also ensure accountability and transparency by creating a mechanism with enough resources and access to information to monitor any loan guarantee program.
- Developers of all technologies competing for federal loan guarantees must be subject to the same metric for determining the most cost-effective way to cut global warming emissions. Developers of technologies that offer the largest cuts per dollar invested in the shortest amount of time should receive priority for federal support, as they represent the most responsible taxpayer investment.
- The nuclear industry must meet the same requirements for reducing taxpayer costs and risks as other industries subject to government rescue, such as the financial and automotive industries. Such requirements include eliminating "golden parachute" payments and employee compensation that rewards excessive risk, as well as creating "clawback" policies for recovering any excessive compensation that is discovered after the fact.

Given the need to reduce carbon emissions 80 percent or more by mid-century, the nuclear power option should not be taken off the table. But rather than pushing the premature deployment of new plants through massive public subsidies and loan guarantees, the industry and government must attempt to resolve critical economic, technical, and safety issues before committing the United States to a large-scale nuclear resurgence that would put U.S. taxpayers and ratepayers at serious financial risk.

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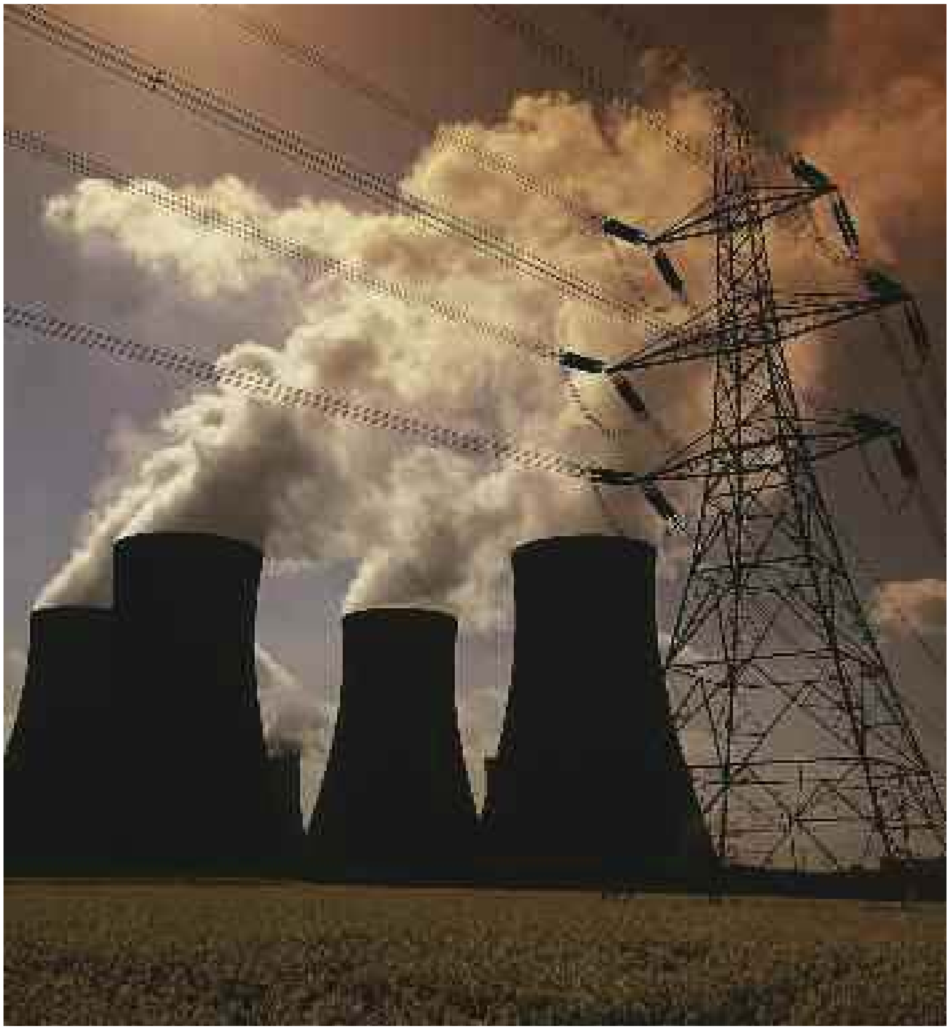

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The most economical way to meet our emissions reduction goals is to increase our use of renewable energy and energy efficiency. UCS analysis shows these low-carbon options are more cost-effective than building new nuclear power plants.

Photo: PPM Energy

Endnotes

1 The cost projections used in the analysis are about 20 percent higher than the most recent estimates from the DOE's Energy Information Administration, but are near the low end of estimates from Wall Street and other analysts included in Cooper 2009.

References

Cleetus, R., S. Clemmer, and D. Friedman. 2009. *Climate 2030: A national blueprint for a clean energy economy*. Cambridge, MA: Union of Concerned Scientists. Online at *www.ucsusa.org/global_warming/solutions/big_picture_solutions/climate-2030-blueprint.html*.

Cooper, M. 2009. *The economics of nuclear reactors: Renaissance or relapse?* South Royalton, VT: Institute for Energy and the Environment, Vermont Law School. Online at *www.vermontlaw.edu/Documents/Cooper%20Report%20on%20Nuclear%20Economics%20FINAL%5b1%5d.pdf*.

Energy Information Administration (EIA). 2001. Analysis of strategies for reducing multiple emissions from electric power plants. SR/OIAF/2001-03. Washington, DC: U.S. Department of Energy. Online at *www.eia. doe.gov/oiaf/servicerpt/epp/pdf/sroiaf(2001)03.pdf*.

Energy Information Administration (EIA). 1986. An analysis of nuclear power plant construction costs. Washington, DC: U.S. Department of Energy.

Cambridge Energy Research Associates (CERA). 2009. Power Capital Costs Index. Cambridge, MA. Online at *www.cera.com/aspx/cda/public1/news/pressReleases/pressReleaseDetails.aspx?CID=10429*.

U.S. Government Accountability Office (GAO). 2008. New loan guarantee program should complete activities necessary for effective and accountable program management. GAO-08-750. Washington, DC.

Gronlund, L., D. Lochbaum, and E. Lyman. 2007. *Nuclear power in a warming world: Assessing the risks, addressing the challenges.* Cambridge, MA: Union of Concerned Scientists. Online at *www.ucsusa.org/assets/documents/nuclear_power/nuclear-power-in-a-warming-world.pdf*.

Kanter, J. 2009. Delays in Finland highlight problems facing nuclear power. *New York Times*, May 28. Online at *www.nytimes.com/2009/05/29/business/energy-environment/29nuke.html*.

Moody's Global Credit Research. 2009. "New nuclear generation: Ratings pressure increasing." June.

Nuclear Energy Institute (NEI). 2009. State legislation and regulations supporting nuclear plant construction. Status report. July.

Prindle, B., M. Eldridge, J.A. Laitner, R.N. Elliott, and S. Nadel. 2007. Assessment of the House renewable electricity standard and expanded clean energy scenarios. Washington, DC: American Council for an Energy-Efficient Economy. Online at *www.aceee.org/pubs/e079.htm*.

Schlissel, D., M. Mullet, and R. Alvarez. 2009. *Nuclear loan guarantees: Another taxpayer bailout ahead?* Cambridge, MA: Union of Concerned Scientists. Online at *www.ucsusa.org/assets/documents/nuclear_power/nuclear-loan-guarantees.pdf*.

Union of Concerned Scientists (UCS). 2009. Clean power, green jobs. Cambridge, MA. Online at *www.ucsusa.org/assets/documents/clean_energy/Clean-Power-Green-Jobs-25-RES.pdf*.

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