South Carolina recently ranked third among the 31 U.S. states with nuclear capacity, making it the state with the most nuclear capacity in the southeastern United States. South Carolina's V.C. Summer is among the nuclear plants planning to add a new reactor.

Going Nuclear

The future looks brighter for a once-maligned industry

BY VANESSA SUMO

The partial meltdown of a reactor core at the Pennsylvania Three Mile Island nuclear power plant in 1979 was a watershed event. Although it resulted in no deaths or injuries, it is considered the most serious accident in the domestic nuclear power industry's operating history. No new plants were proposed in the United States after that incident, and the plant construction that was underway saw cost overruns exceed 250 percent, according to a Congressional Budget Office (CBO) study.

Poor performance, safety concerns, and the high cost of constructing a nuclear plant relative to other sources of power continued to plague the industry for several years. But the industry's fortunes seem to be turning. With the demand for electricity in the United States expected to grow 20 percent by the end of the next decade, the country needs more power generation capacity. That could be satisfied by building coal, natural gas, or nuclear plants — power sources that can provide electricity around the clock. Growing concerns over global warming, however, are prompting policymakers, investors, and even environmentalists to take a fresh look at nuclear power.

Unlike plants that generate electricity by burning fossil fuels, nuclear power does not produce carbon dioxide, a primary greenhouse gas which many consider to be at alarming levels already. As a result, expanding nuclear power is often regarded as a vital component in a portfolio of solutions to the problem of global warming.

In choosing the type of plant to build, companies certainly are looking at the possibility that lawmakers may decide to limit carbon dioxide emissions. That would effectively put a price on this greenhouse gas and increase the cost of electricity generated by using fossil fuels.

There are other factors, too, that will help make nuclear power a more attractive bet. New licensing procedures, investment incentives under the Energy Policy Act of 2005, and significant technological improvements in the latest generation of advanced nuclear reactors are giving companies the confidence to invest in new nuclear plants.

The most visible sign of renewed interest is that since 2007 about nine companies have filed for applications with the Nuclear Regulatory Commission to build new nuclear reactors, the first applications in 30 years. Most of these companies operate in the Fifth District, including Dominion, Duke Energy, Progress Energy, South Carolina Electric & Gas, and UniStar Nuclear Energy — a joint company formed by Constellation Energy and the EDF Group, a European energy company.

The industry seems to be in a good position to make a comeback. But while favorable conditions are giving the industry hope, the task ahead is still a daunting one. "I think there is certainly a brighter prospect today," says Eugene Grecheck, vice president for nuclear development at Dominion. "But that needs to be tempered by the fact that we still [have] a lot of work to do."

The Economics of Nuclear Power

More than 100 nuclear reactors currently provide about one-fifth of the total electricity generated in the United

PHOTOGRAPHY: SCE&G

States. Nuclear plants produce electricity using the heat generated by nuclear fission — a process that splits the nucleus of a heavy element, causing a carefully controlled chain reaction that releases a tremendous amount of energy.

Once the plant is built, nuclear power can be a relatively cheap source of electricity. The average cost of producing electricity from nuclear power in 2006 was about 34 percent to 66 percent lower than the electricity generated from fossil fuels, according to the Energy Information Administration. While the cost of operating and maintaining a nuclear power plant is higher than the upkeep required for plants using fossil fuels, nuclear fuel — typically uranium — is cheaper than coal or natural gas.

The existing fleet's performance has also improved significantly over time. "Fortunately we've figured out how to run our plants well," says David Modeen, director of external affairs at the Electric Power Research Institute, a think tank. In the past, protective shutdowns — called "trips" — frequently occurred that forced plants to go temporarily offline. Today, a much more fluid and refined control system has dramatically brought down a nuclear reactor's average number of trips a year. "Most plants don't trip in a year, they just run," says Modeen. As a result, the industry's plants have recently been running at about 90 percent of capacity, up from about 60 percent two decades ago.

Industry executives certainly think that the nuclear plants' safety technology has improved greatly since the Three Mile Island accident. "We've had a long period of demonstrated safe and reliable energy supply from our current nuclear fleet," says Joe Turnage, senior vice president for strategy at UniStar. "As an investor, you would not proceed to put the capital in these projects unless you had a compelling case that your performance and safety track record are assured," he says.

The latest generation of nuclear reactors is expected to continue to improve that record. For instance, some of the new designs include "passive safety" systems that use natural forces such as gravity and natural circulation to prevent an accident in the event of malfunction. No operator intervention is required. A simplified design also makes these reactors easier to operate and less prone to mechanical errors.

But while its performance is encouraging, the price tag for building a nuclear plant and the uncertainty around that estimate might give investors some pause. Each plant can cost several billions of dollars and is more expensive than building one that runs on gas or coal — alternatives that can also generate electricity 24 hours a day. How much more expensive may be hard to pin down. "The history of the industry on cost forecasting is not too good," noted MIT economist Paul Joskow at a 2006 conference on nuclear power. Nuclear plants built in the 1970s through the early 1990s cost much more than was anticipated, mostly because of regulatory delays, safety scares, and poor designs.

For investors to jump into nuclear power, cost estimates must be credible. And after the numbers are crunched, the total cost of constructing and operating a nuclear power plant must be lower than conventional fossil fuel alternatives.

A 2003 MIT study finds that, under most conditions, a new nuclear power plant would be more expensive than a coal or a natural gas plant. But assuming a high natural gas price scenario, nuclear plants may be able to compete with natural gas plants as long as the cost of building a nuclear plant falls by 25 percent, construction time is cut by one year, and the cost of financing it becomes as low as funding a coal or gas plant.

Life gets easier for nuclear, however, if carbon dioxide emissions are priced. Electricity generated from a coal or natural gas plant emits high levels of carbon dioxide that is thought to be harmful to the environment. However, the cost of these side effects is not reflected in the price of electricity. But if emissions were to be priced through a tax or a cap and trade system, the cost of electricity generated by burning fossil fuels could go up significantly.

The MIT study finds that at a price of $100 to $200 per ton of carbon emitted, nuclear becomes more attractive than coal and can even be cheaper than natural gas. A more recent 2008 CBO study likewise finds that at a charge of $45 per metric ton of carbon dioxide (about $165 per ton of carbon), nuclear power would be the least expensive choice for building new base-load plants. However, if this price falls below $5, conventional coal plants would be the lowest cost source of generating capacity. Between these two prices, natural gas would have an advantage over both nuclear and coal.

Emission charges would certainly make nuclear power a more attractive investment than conventional fossil fuel generation. But even in the absence of a price on carbon emissions, the CBO study notes that the investment incentives under the Energy Policy Act of 2005 "would most likely lead to the planning and construction of at least a few nuclear plants in the next decade." Of these incentives, the industry thinks that the loan guarantee program, which covers 80 percent of construction costs, is particularly valuable because it brings down the cost of financing a new plant — a major hurdle in wooing investors to what is perceived to be a relatively risky project. If the first round of nuclear plants to take advantage of this benefit can demonstrate that construction can be completed with only a few snags, then the uncertainty of building the next round of plants — and the financing cost — may fall substantially even without loan guarantees.

An improved licensing process for the new generation of nuclear plants removes another key uncertainty. In the past, nuclear plants were required to get two separate licenses — one to build and another to operate. That meant a fully constructed plant could wait years before it operated commercially. Today's process combines those two licenses and grants approval before a major commitment to construction and a huge amount of expenditure has been made.

Powering Up

	Function	Power Source
Baseload Plants	The backbone of the electric power grid; designed to operate continuously except during breakdowns or scheduled shutdowns.	Coal, nuclear, hydroelectric, or natural gas
Intermediate Plants	To supplement baseload plants, these plants operate during the daytime, and are turned on as needed during the evening.	Coal or natural gas
Peaking Power Plants	To provide additional electricity only during periods of peak demand.	Natural gas or hydroelectric

SOURCE: European Nuclear Society

Another important difference that allows the construction of nuclear plants to proceed more smoothly this time around is that the plant designs are now highly standardized. "Out of the 104 plants currently operating in the United States, almost all of them are custom designed," says Grecheck. Companies today can take a largely completed design and simply make minimal changes to adapt it to a specific site. They can also learn from the construction experience of a similar plant in the country or abroad. UniStar's chosen reactor design, for instance, is being constructed in Finland and France. "Ours is probably serial number 5," says Turnage. "We did not want first-of-a-kind engineering risk. We did not want to be serial number 1."

The economics of nuclear power may also be improved by various state policies. Many of the proposed nuclear plants are located in states that regulate the rates which power companies charge. Rate regulation may provide these companies some guarantee that its customers will pay back the cost of building a "traditional plant." In contrast, a "merchant plant" that relies on the market for setting its rates places the risk squarely on investors rather than its customers. So which type of plant will most likely be built? "There will be a mix," says MIT professor John Deutch and one of the authors of the 2003 MIT report. "But with the size of capital [needed], regulated plants will be easier to finance."

Some states with rate regulations, such as Georgia, Florida, North Carolina, South Carolina, Mississippi, and Kansas, are also allowing utilities to recover the cost of new nuclear plants while construction is in progress. But even in states that have no rate regulations, like California and Maryland, lawmakers are considering limits on carbon dioxide emissions that would give nuclear a definite advantage.

Public Attitudes

Concern over global warming is perhaps the biggest driver in the renewed interest in nuclear power among policymakers. Studies have found that a sizeable reduction in greenhouse gas emissions cannot be achieved without a shift toward less carbon-intensive technologies. Electricity companies are looking at the entire spectrum of possible generation sources to meet the growing demand for electricity, not just nuclear. Renewable energy is another carbon-free alternative. But unlike solar and wind power, which produce electricity only when the sun is shining or the wind is blowing, nuclear power can provide constant base-load electricity much like coal and natural gas plants.

As a result, a number of environmentalists have spoken out in favor of nuclear power to meet the growing demand for electricity. "The only technology ready to fill the gap and stop the carbon dioxide loading of the atmosphere is nuclear power," noted environmentalist and *The Whole Earth Catalog* creator Stewart Brand in a 2005 article.

Public opinion toward nuclear power has inched up over the last two decades, says MIT professor Stephen Ansolabehere, who conducted a survey of people's attitudes toward nuclear power and other power sources. In 2007, the survey found that about 39 percent felt that the United States should reduce the use of nuclear power. That's down from about 47 percent in 2002. Oil is still the most disliked power source but its popularity has dropped even more, which might have helped increase support for nuclear power. That the accident at Three Mile Island happened almost three decades ago seems to have pushed it further from people's minds. "As generations replace each other, you forget about what events shaped people's impressions," says Ansolabehere.

However, it seems that people are warming up to nuclear power *not* because of concerns about climate change. Indeed, the survey finds that the issue of global warming is uncorrelated with people's preferences about nuclear power — or just about any other energy source. "People don't really connect global warming and nuclear power," says Ansolabehere. And when people were asked which energy source they thought contributed most to global warming, a strikingly high percentage answered "nuclear power." So while policymakers, investors, and others who are very much engaged in this issue tend to agree that nuclear is an important part of the solution to stabilizing greenhouse gas emissions, public attitudes seem to lag behind.

The survey also revealed that people were willing to pay only about $5 more a month on their energy bill to help mitigate global warming. Ansolabehere says that this is about a fifth of what is needed to reduce greenhouse gases under the Kyoto Protocol, an international agreement on climate change. This suggests that most would rather stick to cheaper but dirtier electricity than switch to a cleaner but more expensive source like nuclear power.

Ansolabehere's survey also finds that nuclear power is

viewed as somewhat harmful by the public. Safety is still an important concern, but the management and disposal of radioactive nuclear waste is the biggest reservation. When presented with solutions to this issue, support for nuclear power expansion goes up.

While the results of the survey suggest that the public seems to have gotten it wrong in terms of the relationship between nuclear power and greenhouse gas emissions, they seem to be spot-on in identifying the waste problem as one of the most important challenges facing the industry.

A Nuclear Power Renaissance?

Without new investments in nuclear power plants, the country's capacity for generating electricity from this power source will quickly decline after 2030, said Joskow at a 2006 nuclear power conference. But if the industry is to expand in such a way that it can continue to play an important role in future electricity supply and at the same time make a significant contribution to stabilizing greenhouse gases, a number of concerns must be addressed.

What to do with spent fuel from nuclear plants that will remain highly radioactive for thousands of years is perhaps foremost among these concerns. "The perceived lack of progress towards successful waste disposal clearly stands as one of the primary obstacles to nuclear power expansion around the world," noted the 2003 MIT report. Efforts to find solutions have been mostly focused on the planned construction of a permanent disposal facility at Yucca Mountain in Nevada, but that has been much delayed.

Today's cost estimates for building new nuclear plants have also been climbing — at least double what the industry quoted just a few years ago. The cost of copper, steel, concrete, and manufactured components that go into these plants has been rising. Moreover, a significant expansion of nuclear power in the next few decades would only exacerbate the scarcity of materials and skilled labor — electricians, plumbers, pipe fitters and the like, not just engineers — who are necessary to build and run nuclear plants. "With the potential for multiple companies moving forward with plans for new nuclear, the availability of critical materials and qualified workers could pose a challenge," says South Carolina Electric & Gas spokesman Eric Boomhower.

The long hiatus in construction in the industry has not helped. "We've lost much of the infrastructure in the United States that existed 30 years ago to support nuclear plants and we're going to have to rebuild that," says Turnage. Companies will be looking all over the world to find what they need, but supply overseas is tight too. For instance, Turnage says that there is only one company in the world which makes ultralarge forgings that are used in construction of the reactor pressure vessels — that's where the nuclear fuel is contained. He's starting to see a response, however, from companies that are eager to supply their needs. Turnage says that because of the size of their order for turbine generators, Alstom, a big player in the power business, is investing in a plant in Chattanooga, Tenn.

None of the companies that have filed for a license have actually committed to building a plant. While waiting for their license, companies are working hard to get more certainty on what the costs of building these new plants will be. "All the stakeholders in approving such a large investment would like to be confident that we understand what the costs are going to look like," says Grecheck. These companies are also ordering materials that require a long lead time, applying for a loan guarantee, looking at future market conditions, and seeking approval from state agencies before they can begin construction. If all these elements come together as planned and on schedule, the first new nuclear plants in a generation could start operating by the middle of the next decade.

Despite the challenges and a long to-do list, some say that we're already seeing a veritable renaissance for nuclear power. But many in the industry say that they still have a long way to go.

"I kind of cringe when I hear 'renaissance,'" says Modeen of the Electric Power Research Institute. "It's a heartfelt respect for the technology, somewhat humbled by the daunting task before us and we want to do it well. It's not going to be easy." Given the industry's history, Modeen would love to see those first few plants built very well and go from there. He understands that even one accident could upset the hard work that has been put in to overcome the public's long aversion to nuclear power. "Society is not to the point [with nuclear power] like we are with plane crashes. People will still be flying planes tomorrow," says Modeen. For the modern nuclear power industry, an old adage seems appropriate: It's best to proceed slowly but surely. **RF**

Readings

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