IMPACT OF ELECTRICITY DEREGULATION ON THE U.S. NUCLEAR INDUSTRY

Neil J. Numark, President
Robert P. Grant, Senior Associate
Numark Associates, Inc.
Washington, D.C.

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Introduction

Thank you very much for the opportunity to address the Global Foundation's annual conference today. For this session concerning the experience to date with electricity deregulation, I am going to focus, as the title of our paper implies, on the specific experience of the U.S. nuclear power industry under deregulation, which I suspect will be a quite different set of comments from those of Mr. Vasconcelos earlier in this session. We will examine mainly how deregulation has affected the existing fleet of nuclear plants in the U.S., but also briefly the implications of deregulation for building more nuclear plants.

Note first of all that 25 U.S. states have adopted measures to reduce or eliminate the regulation of retail electricity prices, and that the vast majority of the nation's 103 operating nuclear reactors are located in these states. This move to open market competition among power generators has been painful for consumers as well as utilities in some parts of the country, and the pain is probably not over yet. Like the airline, railroad, trucking, natural gas and telecommunications industries before it, the electric power industry is likely to experience shocks in the transition to open markets. But the deregulation of these other industries did eventually bring lower prices, expanded markets and a smaller number of bigger, more competitive, more efficient producers and suppliers. Of course electricity is a somewhat unique animal, since it cannot be stored like other commodities. But we expect to see benefits in the U.S. as you have seen here in the U.K.

We are still in the early days of electricity deregulation in the United States, and some worry the future will be darker if deregulation does not offer sufficient incentives for new power plant construction. The benefits of competition, however, in other formerly-regulated industries are too apparent for state policymakers to forfeit the game in the power industry now. Despite the recent difficulties in California's partial deregulation of the power industry, it appears that the

deregulation of U.S. electricity markets is here to stay. Major industrial customers continue to press for cheaper power, and as a result, individual states will continue to deregulate so as to attract and retain these industries.

The pace of deregulation has recently slowed in response to the California crisis. Of the 24 states and the District of Columbia that have already mandated deregulation (see Figure 1), six states have now taken steps to slow down its implementation, and California has suspended retail competition. For the remaining 26 states that have not yet instituted retail competition, it is difficult to assess what influence the California situation is having on what they have yet to do. You can see from this figure that deregulation is perhaps a somewhat more complicated process in the United States than it has been in the U.K. at least, as it involves decisionmaking not only at the Federal government level but also by fifty individual state governments.

On the road to complete deregulation, the largest transition pain, of course, is reliability. Regulatory uncertainty has had a chilling effect on investment in new generating as well as transmission capacity since the early 1990s. The transmission system has become increasingly antiquated and reserve margins have declined severely in some areas, as the economy has rapidly grown and conservation measures have been de-emphasized, with little regulatory oversight to ensure reliability. Average reserve margins nationally dropped to about 14% in 2000, from 20-some-odd percent back in the days of regulation. We can only hope that as regulatory certainty increases, competition will give companies the confidence to make the necessary investments.

Existing Nuclear Operations

It could be said that nuclear power was not supposed to be competitive under deregulation. Predictions from the early- to mid-90s were that many nuclear plants in the United States would have to shut down long before their licenses had expired due to their high costs.

But very few plants have in fact shut down early. Many of the plants that were in jeopardy have now been sold to larger companies better able to improve them. And most U.S. plants will renew their licenses to extend operation for another 20 years.

Let’s take a quick look at the performance data, courtesy of the Nuclear Energy Institute. As Figure 2 illustrates, nuclear production costs have been consistently low in relation to fossil fuel production costs and are today less than 2 cents per kWh. Of course, more kWh produced is a big part of this story, and Figure 3 shows the growth in the nuclear industry's total electricity output through the 1990s. This in turn is largely due to the trend shown in Figure 4 of substantially improved plant capacity factors.

What explains these unexpected good results? One part of the answer is certainly the lessons learned from years of operating experience, and I will come to that in a moment. But

deregulation itself appears to be an important part of the story. Contrary to early expectations, deregulation has not stifled nuclear power in the United States but rather appears to be stimulating its competitiveness. Regulated utilities of the past were guaranteed a fixed rate of return on their investments, in exchange for providing reliable supply at stable, regulated prices. Operators did not have to worry as much about expenditures as today, when they have more incentive to be cost-competitive.

Furthermore, deregulation has caused a very beneficial restructuring of the industry. With the forced "unbundling" of generation companies from transmission and distribution companies, nuclear plant operators have consolidated a great deal. The result is presented in Figure 5, which shows the emergence of a much smaller number of nuclear plant operators in the United States than ever before. And this number is sure to continue going down, through plant sales and other mechanisms.

As a result of this transition from horizontal to vertical integration of the electric power industry, on the whole the operators of U.S. nuclear plants are companies that want to be in the nuclear generating business much more so than a few short years ago. Thus, it is increasingly only the stronger companies that remain in the game, but almost all of the plants remain (and there is talk of re-starting certain plants that have shut down). Furthermore, there are now improved economies of scale, which has benefits in outage management and in procurement buying power. In short, consolidation has already provided major benefits in reducing the cost of operating nuclear power plants.

Certainly another important factor underlying nuclear energy's much-improved standing is that state regulators have permitted utilities to recover stranded costs -- mainly unpaid debts -- more so than originally expected, through higher regulated rates during longer transitions to open markets.

So there have been important regulatory and structural changes benefiting nuclear power in the United States. But, largely in response to the onset of competition, U.S. nuclear plants have simply become more productive, cheaper to operate and maintain, and at the same time – by Nuclear Regulatory Commission measures -- safer than they were even five years ago, at the threshold of the retail competition era.

Engineering Measures to Improve Plant Output

While consolidation has reduced the costs of operating affected U.S. nuclear plants, improved performance has increased their output. The principal measures leading to this improved performance are summarized here.

One key factor in the increased output of U.S. nuclear plants has been the ability to increase the

rated thermal power levels at many plants. Figure 6 summarizes past and pending uprates approved by the Nuclear Regulatory Commission. Forty-seven units – almost half of the U.S. fleet – have been or will be approved for uprates of 5-10% of their originally-licensed limits, and four units have already been approved for uprates exceeding 10% of original limits. Further power uprates are likely throughout the industry, driven by competition.

A second key factor has been the shortening of outages for refueling and maintenance. As Figure 7 illustrates, average outage durations have fallen dramatically, from over 100 days in 1990 to only 40 days last year. Those 60 additional days on line account for more than a 15% improvement in plant output. Predictions are that average refueling shutdowns will decrease to just 20 or 30 days in the coming years.

Third, besides shortening outages, nuclear plant operators have also managed to perform them less frequently. Extended burnup fuels are allowing 18- and even 24-month fuel cycles.

Finally, the NRC's commitment to implementing "risk-informed regulation" appears to be allowing enhanced competitiveness of U.S. plants. Risk-informed regulation considers information about the probability and consequences of a potential safety problem, and – according to NRC – "focus[es] licensee and regulatory attention on design and operational issues commensurate with their importance to health and safety."[1] This is surely a good way to devote more attention to the higher-priority safety concerns and expend less resources on items of lower safety significance.

So NRC has changed the way it regulates, without easing regulation, permitting plant managers to get the "most bang for the safety buck." This is helpful in a deregulated environment. With all these steps to improve the performance and competitiveness of U.S. nuclear plants in response to deregulation, the NRC says that: "the safety and reliability of the nuclear industry has improved markedly since the late 1980s and early 1990s."[2] NRC performance indicators shown in Figure 8 illustrate safety improvements according to several different measures. I will not go through these but you can readily see the overall slope of most of the curves.

The above-mentioned measures to improve plant performance have required the approval of the NRC. The agency's flexibility in certain areas reflects its willingness to "reduce unnecessary conservatism" when improved data and analyses demonstrate that prior requirements were indeed unnecessarily conservative.

It is interesting to look at the comments of one of the NRC's most influential watchdogs, the Union of Concerned Scientists:

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[1] U.S. Nuclear Regulatory Commission, *White Paper on Risk-Informed, Performance-Based Regulation*, http://www.nrc.gov/nrc/commission/vote/1998-144vtr.html (February 24, 1999).

[2] U.S. Nuclear Regulatory Commission, *Primer on Reactor Oversight Process*, http://www.nrc.gov/opa/primer.htm.

> There's been a greater focus on plant output, but that doesn't necessarily mean exactly the opposite of safety. You can do both. For example, power uprate takes up some of the margin that's built into the plant, but if that's done prudently and wisely and with forethought then that's acceptable. We don't have an issue with that.[3]

License Renewal

Finally, it's important to mention briefly the improved prospects for license renewal. Most plant operators are now concluding that it is far cheaper to extend the operation of these amortized units than to replace them with new gas-fired or other generating facilities. As illustrated in Figure 9, NRC has already approved 20-year license extensions for six units; is currently reviewing applications for about a dozen more; and has released firm dates over the next three years when it anticipates receiving applications for about another 25 units. The industry's restructuring, and the emergence of larger, stronger nuclear operating companies, appears to be a very large part of the explanation for the high rate of license renewal applications. The prior owners of some plants would almost certainly have decided to get out of the nuclear business by not renewing these plants' licenses, had they not had the opportunity to sell the plants.

New Reactors

The question concerning new nuclear plant orders in the United States has evolved in the past year or two from "whether" to "when" and "what kind." The short answers to these questions appear to be "soon" and "different kinds." Furthermore, the question of "who" has become clearer, with companies such as Entergy and Exelon likely to be among the earliest players.

Entergy and Exelon, the nation's two largest nuclear operators, appeared to be taking different approaches with respect to reactor types, but their approaches could now be converging. Exelon chairman Corbin McNeill has been particularly vocal in his view that large scale plants will not have a place in the competitive U.S. market.[4] Exelon has now joined the international consortium developing the 120 MW-scale Pebble Bed Modular Reactor (PBMR), a gas-cooled design of the South African utility Eskom, which they expect will provide much greater inherent safety than existing plants. Exelon states that:

> To compete in deregulated power markets, … new plants must be able to get permits and be brought on-line quickly, in thirty-six to forty-eight months at the most, and be

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[3] Numark Associates Interview with David Lochbaum, Union of Concerned Scientists, on Nuclear Energy and Safety Policy, January 2000, http://www.numarkassoc.com/policy/lochbaum.htm.

[4] Corbin McNeill, Jr., Chairman, President & CEO, PECO Energy (now Exelon), testimony before the U.S. House of Representatives, Subcommittee on Energy and Power, Hearing on National Energy Policy: The Future of Nuclear and Coal Power in the United States, June 8, 2000.

> able to compete with gas-fired combined cycle power plants on a total cost basis in the 3 to 3.5 cents per kilowatt-hour range. They must be small enough so that as their capacity is added to the market, an oversupply situation is not created in the region that drives prices down below the producers' marginal costs. We believe that the PBMR is the only reactor currently under development that may be able to meet the needs of this deregulated marketplace in the next five years. We intend to find out if it can.

Exelon says if their review of an ongoing feasibility study is favorable, they intend to submit a license application for early site permitting to the Nuclear Regulatory Commission in 2002, followed by an application for a combined construction and operating license in 2003 after the detailed design is completed in South Africa. Exelon hopes the licensing process could be completed in twenty-six months.[5] However, for a first-of-a-kind facility like this, a lengthy NRC review would not be surprising.

Entergy, like several other companies, has focused in the recent past on standardized advanced light water reactors (ALWRs) offering safety and economic improvements over existing plants, such as the Westinghouse AP-1000, a potential successor to the AP-600 advanced LWR which the NRC has already certified. More recently, however, the company has shown considerable interest in General Atomics' gas-cooled reactor, the GT-MHR, while keeping its options open to consider others. The reactor would be constructed in 285-MW modules with four modules to a plant. Using modules would create the economies of scale necessary to be cost-effective and would minimize the negative impacts of outages. The GT-MHR is designed to be housed entirely underground, which would lessen security fears and perhaps increase public and regulatory support for its construction.

Entergy appears to agree with Exelon regarding the appropriateness of large-scale plants in competitive electricity markets. An Entergy official recently stated that "There are few places you can drop in a 1,000-MW plant and not disrupt the market."[6]

Entergy has also recognized the ability of the GT-MHR to produce hydrogen, which presumably would make it possible to produce electricity during daytime periods of peak demand and produce hydrogen fuel at night.

Entergy indicated recently that its board is committed to at least one application for an early site permit under NRC's new streamlined licensing procedure. The company plans to identify its two

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[5] Edward F. Sproat III, Vice President of International Programs, Exelon Corporation, Testimony before the U.S. House of Representatives, Subcommittee on Energy and Air Quality, Hearing on National Energy Policy: Nuclear Energy, March 27, 2001.

[6] E. Hiruo, "Industry Moving Toward Revival, But Still Needs Federal Help," *Nucleonics Week*, November 8, 2001, p. 1.

favored sites by the middle of 2002. Following board approval, it would submit an early site permit application to NRC for one or two sites in the second quarter of 2003.[7]

If Entergy does indeed move toward a preference for the GT-MHR, we would have a very curious situation: the two largest nuclear generating companies in the United States -- and the two most likely to build new nuclear power plants -- would then be favoring gas-cooled reactor technologies over advanced versions of the light-water technologies in use at all of the nation's now-operating nuclear plants. It is certainly too early to play down the prospects for such advanced light water reactors, however. Other U.S. power companies still say they favor larger units that take advantage of economies of scale, such as the Westinghouse AP-1000.

There are of course additional vendor offerings under development, and this discussion is by no means intended to be comprehensive but rather to identify what appear to be the primary near-term prospects. Note that the U.S. Department of Energy's program to develop "Generation IV" nuclear power technologies intended for 20 years or more from now. These designs are intended to be innovative technologies that would be safer, cheaper, less waste-producing and more proliferation-resistant than existing "Generation II" light water reactors and "Generation III" advanced light water reactors. But details concerning the Generation IV program are beyond the scope of this presentation. The reactors being discussed for the most near-term potential deployment, e.g. the AP-1000, the PBMR and the GT-MHR, discussed above, could perhaps best be described as "Generation III ½."

With regard to capital costs, most U.S. utilities speak of the $1000/kW level as the point that vendors must reach before they will be ready to order a new unit. However, in private discussions we have heard numbers as high as $1,400/kW, and the Electric Power Research Institute (EPRI) has suggested that nuclear plants could probably compete at about $1,250/kW.

One final word about deregulation vis-à-vis new reactors: the restructuring of the industry is probably speeding up the interest, by creating larger and stronger nuclear operating companies. The main issue now is waiting for capital costs to come down.

Summary/Conclusions

This review has of course omitted a number of critical questions concerning the future prospects for nuclear energy in the United States, such as the nuclear waste situation, the impact of potential strategies to combat global warming and public and political opinion towards nuclear energy. We will be hearing about these topics from other speakers today and tomorrow. But to summarize this presentation, suffice it to say that while nuclear power continues to have a reputation as an expensive energy source, the industry has in fact clearly demonstrated the

[7] *Idem.*

competitiveness of existing nuclear power plants in deregulated markets. And while industry critics still say it is too expensive to build new units, the companies who would make these investments appear to believe otherwise.

Thus, to repeat, deregulation has clearly not stifled nuclear power in the United States as many had anticipated, but rather appears to be stimulating its competitiveness. The managers of existing nuclear plants will continue to seek cost reductions to remain competitive with coal- and gas-fired units. In general, as long as domestic electricity prices continue to be set at the margin by coal- and gas-fired generation, and significant nuclear safety incidents remain a thing of the past, the economics look good for continuing to run nuclear units as maximally and as long as NRC will allow. Due to risk-informed NRC regulation, the NRC is allowing more opportunities for licensees to press these limits. This means, in turn, that there should be a continuing healthy demand for operating initiatives and capital improvements that can be shown to improve performance without a safety penalty.

Of course there has been renewed concern over security at nuclear power plants since the terrorist attacks of September 11, and plants have been on heightened alert. U.S. nuclear operators maintain, however, that even with heightened security measures, nuclear remains the lowest-cost generating technology in the United States and is still well competitive with alternatives. Concerns regarding terrorism also do not appear to be having a detrimental effect on the consideration of building new nuclear power plants. It is interesting to note, however, that there appears to be increased appreciation for the underground siting that is possible for certain advanced reactor technologies.

The key to the competitiveness of new plants will be significant reductions in capital costs as well as construction times compared to current designs. Deregulation appears to be accelerating efforts to lower both. If these efforts succeed; if existing plants continue to operate safely; and if there is tangible progress on the waste management front, then the time may soon be ripe for new orders.

On a final note, deregulation also appears to be shortening the investment horizons of electric generating companies, which could enhance the attractiveness of smaller, modular reactors to some operators, even as others continue to believe in larger ALWRs. In the end, each generating company will have to weigh the lower financial risk of incremental investment in designs that are small and modular but still unproven, against the economies of scale and lower licensing risk of designs that have evolved from well proven technologies but that require larger investment commitments and bigger additions to generating capacity. But again, regardless of which designs ultimately triumph, the focus of the debate about future nuclear power plants in the United States has shifted from the question of “whether” to the questions of “when” and “what kind.”