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NATIONAL NUCLEAR POWER REACTOR AND FUEL CYCLE RESEARCH AND TECHNOLOGY DEVELOPMENT*

by

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1. UTILITY INDUSTRY RESTRUCTURING

The commercial nuclear power industry in the U.S. has experienced a year of remarkable successes, as the industry emerges from the deregulation and restructuring which was mandated by the Energy Policy Act of 1992. The industry performance indicators, created and tracked by the Institute for Nuclear Power Operations (INPO), were in almost every case already equal to or better (in 1999) than the aggressive industry goals that had been established for year 2000. Two examples: Unit Capability Factor averaged 88.7% compared to the 2000 goal of 87.0 and unplanned Capability Loss Factor was only 2.0% against the 2000 goal of 3.0%. In addition, the median refueling outage interval was 5½ weeks and several outages were under 30 days duration.

In May, the U.S. NRC issued 20 year renewal licenses for Duke Power's Oconee Station (three B&W PWRs of 846 MW_e each); in March, 20 year license renewals were approved for Baltimore Gas & Electric's two unit Calvert Cliffs Plant (825 MW_e Combustion Engineering PWRs). These license renewals were accomplished in slightly less than two years. Currently, Arkansas Nuclear of Entergy Operations Unit 1 and Southern Nuclear Operating Company's Edwin I Hatch Units 1 and 2 are under licensing renewal review, another 22 units have notified the U.S. NRC of intent to file renewal requests, and ultimately more than three quarters of the U.S.'s 103 nuclear plant owners are expected to seek license renewal applications.

While distribution grids remain largely in the hands of local utilities, horizontal integration of the industry is occurring at two levels; multi-utility operating contracts to virtuoso operations specialist companies and multi plant ownership by large energy supply conglomerates. For example, Nuclear Management Co. (NMC) recently (May 15) received U.S. NRC approval to operate seven midwestern power plants owned by four midwest utilities. (The two BWRs and five PWRs generate a total 3700 MW_e of capacity.)

For those utilities desiring to divest their nuclear supply assets, the number of bidders for plant purchases is increasing and the purchase price is increasing. The Indian Point 3 and James A. Fitzpatrick plants sold to Entergy Operation for \$536/kw_e in March (after a bidding war with Dominion Resources Inc. and at a value nearly four times higher than the previous high for a nuclear plant sale). Niagara Mohawk Power Corporation is anticipating as many as seven bidders in their upcoming auction of Nine Mile Point Units 1 and 2.

While current capacity additions in the U.S. are being made exclusively via gas turbine plants, horizontally-integrated owner companies seek to balance their resource mix and are valuing both nuclear and coal-fired plants to hedge the volatility of natural gas prices. For example, Pinnacle West Energy is not only acquiring the Southern California Edison share of the three-unit Palo Verde Nuclear Plant, but their share of the Four Corners coal-fired plant as well. The combined deal comprises \$550 million for about 1300 MW_e of

capacity. Pinnacle will end up with a 23, 32, and 45 percent mix of gas, nuclear, and coal, respectively.

The rapidly growing appreciation in the U.S. financial sector of the earnings potential of already well amortized, well-operated existing nuclear plants, the recognition of the large number of plants capable of twenty year license extension, and the demonstrated efficacy of the U.S. NRC in processing license renewal applications is a very positive outcome of the restructuring events of the past several years. The Nuclear Energy Institute (NEI), the industry's Washington organization, is aggressively publicizing the state of the industry's financial health, its safety record, and especially its clean air ecological benefits.

2. INSTITUTIONAL

On a not yet successful but positive trend, the U.S. Senate failed by only one vote to overturn the presidential veto of the bipartisan Nuclear Waste Policy Amendments Act of 2000 (S-1287) -- which would have enabled the transfer of used fuel from onsite storage to a centralized above-ground monitored retrievable storage facility placed in the vicinity of the proposed Yucca Mt. Geological Repository.

Separately, a site recommendation and license submittal for the geologic repository at Yucca Mountain is expected during U.S. FY2001.

In February, the U.S. Department of Agriculture approved the use of radiation to eliminate bacteria in red meat. Irradiation of poultry, fruits and vegetables had already been approved.

3. VENDORS

In the domain of vendor offerings, the Westinghouse AP-600 received licensing approval from the U.S. NRC. This action completed the licensing approval of the generation of Advanced LWRs of U.S. design (ABWR, System 80+, and AP-600) which had been developed under joint government/industry funding during the 1980s and early 1990s. The Westinghouse nuclear business was purchased by British Nuclear Fuels.

4. RESEARCH AND DEVELOPMENT

Governmental funding of nuclear power research and development is, of course, responsive to the public constituency's view of the future role of nuclear power. The quite recent successes enumerated above in the nuclear electric supply industry can only help to improve support for further R&D – which bottomed out at zero in U.S. FY98 (see Fig. 1). Subsequent to the zero funding in FY98, and in response the recommendations of the President's Council of Advisors on Science and Technology (PCAST), a $19 million U.S. program of peer reviewed competitive grants in the area of advanced nuclear technology was initiated in U.S. FY99. $3 million of new starts ($22 million total) were funded in U.S. FY00 and for U.S. FY01, the administration's request is for $35 million total. This Nuclear Energy Research Initiative (NERI) program currently funds 55 three-year grants each in the range of $350 thousand/year at national laboratories, universities, and industry; the aim of the program is to "mine" for innovative ideas relevant to advanced nuclear power technology (including waste management, safety, economics, and nonproliferation aspects as well as the underlying

enabling basic science). The intent is that the best of these ideas can, in the future, be brought to bear on focused advanced design concepts which the U.S. DOE is calling Generation IV.

The two-year campaign to demonstrate the use of "dry" electrometallurgical technology for treatment of 100 assemblies of EBR-II used metallic nuclear fuel was completed successfully in the judgement of the National Research Council's Committee to evaluate its efficacy:

> "On April 18, the National Research Council's Committee on Electrometallurgical Techniques for DOE Spent Fuel Treatment issued the final report from their review of the Electrometallurgical Treatment Research and Demonstration Project. The committee concluded that all of the criteria developed for judging the success of the demonstration project have been met. Further, the committee
> found no technical barriers to the use of electrometallurgical treatment (EMT) technology to process the remainder of the EBR-II fuel." (DOE Weekly: Electrometallurgical Treatment Technology Program).

The Environmental Impact Statement for completing the electrometallurgical treatment of the remaining EBR-II used fuel and blanket assemblies was finalized, and the formal decision by the U.S. Secretary of Energy on whether to proceed with electrometallurgical treatment of all EBR-II used fuel is pending.

Following a $4 million program in U.S. FY99 to create a roadmap for the creation and deployment of an Accelerator Transmutation of Waste (ATW) complex for consuming the transuranics contained in the U.S. inventory of used nuclear fuel, a six-year science based investigation was launched in U.S. FY00 with $9 million of funding. This year's work has focused on producing point designs for Pb-Bi, Na, and gas cooled options and for initiating basic R&D on partitioning, fuel fabrication, accelerator reliability, Pb-Bi/structural chemical compatibility, and waste forms. If continued as recommended in the Roadmap, the six-year science based program will cost ~$300 million total and will provide the government with the technical and institutional knowledge base to decide whether or not to launch a prototype development effort.

5. SUMMARY

The apparent financial health of the nuclear power production industry as it emerges from restructuring, coupled with the demonstrated relicensing potential of a majority of the existing U.S. fleet of plants bodes well for nuclear's role in the next twenty-year energy mix of the U.S.

Advanced Light Water Reactors of U.S. design [ABWR (GE); System 80+ (ABB/CE), and AP-600 (Westinghouse)] which were developed over the past decade have all received licenses from the U.S. NRC and are proffered for purchase.

A tiny R&D program of public funding (NEPO, at $5 million/year -- with matching funds from industry) aims to provide technologies in I&C, aging, etc. to further refine operations in existing plants.

A small but growing publicly funded R&D program (NERI) aimed at producing innovations relevant to advanced nuclear energy systems was instituted in 1999, and it currently supports 55 competitive grants -- with researchers in academia, industry, and national laboratories.

Public opinion polls show that a majority of the U.S. adult population believe nuclear power has a place in the future energy supply mix.

As the world enters a century where the competing issues of energy demand growth, ecology, and sustainability will become a dominant theme in social development, the deregulation and restructuring of the U.S. utility industry which is currently in progress can be expected to unlease market forces which will diversify the energy products offered, incentivize the discovery of mutually beneficial symbioses with other industries for beneficial consumption of wastes, and generally to exploit the ecological advantages (and the already-internalized waste management costs) of nuclear power in a competitive portfolio of energy supplies. In summary, the U.S. prevailing conditions in the year 2000 *should* position nuclear energy to blossom to its full potential as a significant contributor to global energy sustainability in the 21st century.

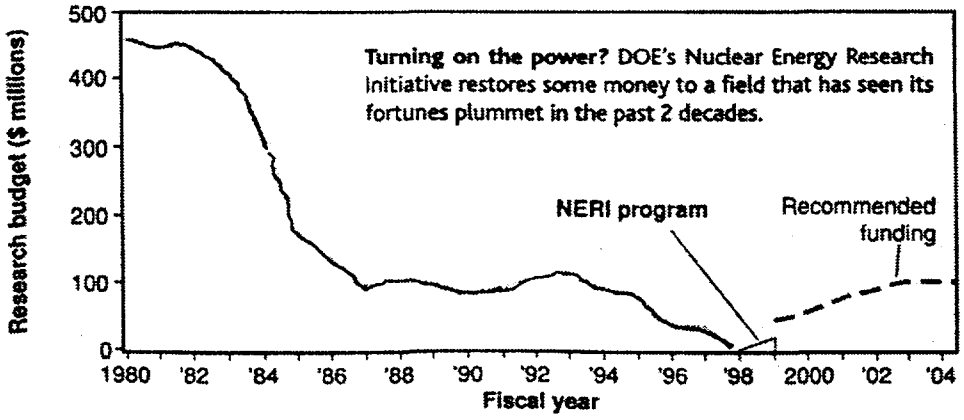

FIG. 1. Recent History: U.S. R&D Program for Advanced Nuclear Energy