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Statement of

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Before the

U.S. Senate Committee on Energy and Natural Resources

November 14, 2007

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Mr. Chairman and members of the Committee: My name is Pattabi Seshadri, and I am a Partner and Managing Director with the Boston Consulting Group and Leader of BCG's Americas Utility Practice. I appreciate this opportunity to testify before you today on the findings from our study on nuclear fuel recycling economics which was completed in July 2006.

The Boston Consulting Group is a Global Management Consulting firm with over 6,000 employees across 60+ countries. BCG advises corporations in every major market and industry sector, as well as prominent public sector organizations. A majority of our clients in the Americas, Asia Pacific and Europe rank among the largest corporations in those markets. In addition, BCG also consults to and advises non-profit and governmental organizations. The firm conducts strategic and economic analyses and supports implementation of major improvement programs at clients across a number of sectors including, energy, industrial goods, technology and communications, financial services, health care, and consumer products. BCG's energy practice comprises a significant proportion of our global activities.

What I plan to present today is a summary of the findings from The Boston Consulting Group's study of the economics of recycling and once-through fuel cycles. First I would like to begin by discussing the unique characteristics of our approach that differentiates this study from other such economic assessments. Then I will discuss the summary findings of our study including the key sensitivities in the results. I will then highlight the risk management benefits – beyond economics – that we believe a portfolio solution comprising a repository-recycling combination can deliver. Finally, I will conclude with a few directional observations around recent market changes that have further affected the balance between recycling and repository economics.

Our approach

There have been many studies to date that have focused on the economics of recycling relative to repository solutions. However, we believe there are five major themes that differentiate our overall approach to evaluating recycling economics which we would like to highlight prior to discussing the study findings.

First and foremost, this study brings an industrial perspective to recycling, starting with specific cost economics based on actual capital and operating experience at existing AREVA facilities. In this regard, our study benefited from an "open-book" approach, in which AREVA provided us proprietary operating and accounting data from its operations at La Hague and Melox. In addition, we were provided unfettered access to a variety of AREVA's internal technical and economic experts in each relevant area of operation. We should note that this project was not meant to be an accounting audit of the data provided by AREVA to test its veracity. However, the level of access provided by AREVA helped us in gaining confidence in the underlying assumptions of the study and in maintaining a high level of analytical rigor.

Second, we took an independent third party view in analyzing the estimates provided by AREVA, using our expertise in industrial cost analysis to validate assumptions. In many cases, we developed specific methodologies to triangulate on sensitive data elements or explain cost differences with previously reported data. For example, AREVA provided a bottom-up build up of recycling facility costs taking into account specific facilities that will be required, high value process improvements that can be implemented, and the unique characteristics of the U.S. market in terms of licensing, security, engineering and construction standards and requirements. In this case, we conducted a top down validation of the cost of the recycling plant which represents a significant portion of the overall cost. We estimated this just as we would typically assess the cost of an industrial project which involves introducing a state-of-the-art technology in a new market – taking into account local conditions, feasible range of cost improvements from operating experience, and the like.

Third, in addition to accessing AREVA information we also gathered input and feedback on key assumptions from a variety of sources external to the company. We conducted informal interviews with experts in academia, in the Department of Energy's National Laboratories, and in the energy industry. Specifically, we undertook a substantial effort to involve key senior managers at four of the top 10 U.S. nuclear utilities as they are important stakeholders with regard to spent fuel management issues. Our effort included three separate steps – at the beginning of the project we solicited input on the key issues from their perspective; we then conducted an interim dialog on findings to understand and address potential areas of concern; towards the end, we presented our final findings in a workshop setting.

Fourth, our study is unique in that it explicitly recognizes the differences in the US market relative to other international markets where recycling has been implemented. The US market has the largest base of legacy spent civilian nuclear fuel to be addressed – approximately 55,000 metric tons accumulating across utility nuclear plant sites across the nation. In the case of some of this legacy fuel, it would not be advisable to directly recycle all of it, as the recycling by-products would have adverse radioactive characteristics. However, some of this accumulated base can be recycled in dilution with more recently discharged spent fuel – providing a steady source of spent fuel for a large scale recycling facility. In addition, the US nuclear market also has a large installed base of nuclear plants annually generating approximately 1,900 to 2,100 metric tons of spent nuclear fuel on a consistent basis. Taken together, these two sources provide the basis for a 'world scale' recycling plant that can operate at very high levels of utilization on a continuous basis – unlike any other facility in operation today. This can indeed help achieve more advantaged economics – just as 'world scale' Liquefied Natural Gas (LNG), petrochemical, refining, cement and other industrial facilities achieve cost advantages relative to their smaller, less well-positioned competitors.

And finally, our study considers important elements beyond economics, such as the impact of recycling on flows of used fuel, the improved ability to optimize repository space in a recycling-repository 'portfolio' solution, and the potential risk management benefits of such an approach. It is our view that these are important financial and other benefits of recycling that are not fully reflected in 'straight-up' economic comparisons.

We would like to note that throughout this engagement, BCG had complete control over the emerging results, key messages, and analytical comparisons. Under BCG's agreement with AREVA, the company may only publish this report in the public domain without any further alterations. Any changes or alterations by AREVA would need to be specifically agreed to by BCG.

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Findings on recycling economics

We developed economic comparisons of recycling and once-through repository strategies using two analytical approaches. The first is a theoretical comparison of the estimated long-term cost of recycling used fuel and the estimated cost of a repository to handle the same used fuel in a once-through strategy. This comparison is referred to as the "Greenfield" approach. In the Greenfield approach, no consideration was given to existing legacy fuel stored at the utility sites. The key economic metric is the unit cost, expressed in dollars per kilogram ($/kg). The Greenfield approach answers the question, "How much would it cost to recycle used fuel in the U.S. over the long-term?" In this respect, the Greenfield approach lends itself well to comparisons with previous studies that have used a somewhat similar approach.

The second approach involves comparison of recycling as a solution that would complement development of the Yucca Mountain repository, termed the "Portfolio" strategy, and a pure once-through strategy that will require additional repository capacity in the future. This second approach is referred to as the "Implementation" approach. The Implementation approach addresses economic questions such as, "How much would it cost to implement a recycling plant in conjunction with the repository?" and "What is the cost differential between a portfolio strategy and a once-through strategy in which only repositories are developed?" In this approach, we also looked at a broader set of assessment criteria. In addition to the economics, the Implementation approach addresses issues related to flows of used fuel, financing requirements and risk management.

In the Greenfield approach, we estimated the overall discounted cost of recycling used fuel to be in the order of $520/kg. The cost of a once-through strategy using a repository was estimated at about $500/kg. Considering uncertainties that surround many of the variables used in the assessment, such as uranium price, repository costs, recycling facility capital requirements, and the like, we determined the economics of the two approaches to be comparable.

In the Implementation approach, the cost of a portfolio strategy, based on a new integrated recycling plant opening in 2020 and handling 2,500 tons/year, combined with development of a repository (such as Yucca Mountain) for high-level waste from recycling and untreated legacy fuel, has a total net present cost of $48-53B. The net present cost of an exclusive once-through strategy with Yucca

Mountain and an additional repository is estimated at $47-50B. This represents a $1-2B difference in baseline estimates of net present costs of the two alternatives.

As part of our economic assessment, we estimated the sensitivity of the conclusions to various factors, including, the capital and operating costs of the repository and recycling facility, the price of uranium, discount rates used to estimate net present costs of future cash outlays, and the like. The impact of each of these variables, with all other variables remaining constant, is of the order of 0-14% of the estimated baseline net present costs of each fuel management strategy. This translates to the potential for approximately $0-7B in variation in net present costs of a portfolio solution that combines a recycling facility with a repository and a pure once-through solution that includes multiple repositories over time.

The largest uncertainty underlying this economic comparison is the total installed capital and operating costs – both for the recycling facility and for the repository. Given the intrinsic uncertainties of the cost projections for both of these facilities, we determined the $1-2B difference in baseline estimates of net present costs of the two alternatives to be comparable.

Furthermore, even at the upper end of the potential net present cost difference of 14% between a recycling-repository solution and a repository-only solution, we believe there are significant risk management benefits to the portfolio solution that make it worthy of further consideration. I will discuss these risk management benefits subsequently in this testimony.

It is important to note that the total undiscounted life cycle cost for the recycling strategy is estimated to be about $113B, compared to about $124-130B for the once-through strategy in which a larger portion of the cost is deferred. Therefore, discount rates (or financing costs) used to calculate the net present costs would differentially affect the economics of the two solutions. We assumed a similar discount rate for both the solutions in order to enable a pure economic comparison of the alternatives. As part of this study, we did not explore alternate business models such as public-private partnerships to implementing a recycling solution. While such alternatives are likely to incur higher financing costs, they would also provide financial benefits in the form of transfer of some risks to non-governmental entities. We believe that such a cost versus risk trade-off across business model alternatives should be valued separately from the basic cost economics of the two fuel management solutions.

A key differentiating element in our assessment of recycling costs, when compared to previous studies is that the Integrated Recycling facility unit costs are significantly lower than previously published data. We estimated a unit cost for the integrated plant of $630/kg, based on a plant with the following main characteristics:

- 2,500 tons per year of net capacity, based on effective throughput at 300 days per year (about 80 percent of nameplate capacity)
- Total capital investment (CapEx) of about $16B, which is mainly composed of overnight cost of construction at market price, contingencies, development, licensing and start-up costs; storage costs for High Level Waste from Recycling (HLW-R) and used MOX fuel assemblies are also included and decommissioning costs are considered after the closure of the plant; and
- Operating costs (OpEx) of about $900M per year, which include operating expenses for both treatment and fuel fabrication, running investments, estimated taxes or taxes equivalent, and other charges.

As discussed before, AREVA provided to BCG a bottom-up estimate of the capital and operating costs of a new Greenfield plant in the U.S. market. We undertook a process of reconciling these bottom-up estimates with the actual costs of recycling at existing AREVA Plants.

Overall, the total capital investment required for the integrated plant is within 10 percent of the total capital investment that has been made over the years for the AREVA European plants at La Hague and Melox. We took in to consideration some key modifications that will be required between the existing plants and the U.S. plant, including:

- A few workshops not in use anymore or not in the scope of a U.S. plant.
- No duplication of similar workshops — the La Hague and Melox facilities were built “piecemeal” over time resulting in some inefficiency (La Hague for example is made of two largely independent units).
- U.S. plant larger in size to accommodate a higher volume of used fuel.
- Limited optimization for some key process steps, based on AREVA operational experience at La Hague
- Additional costs and contingencies, such as costs driven by specific licensing and design requirements in the U.S., development costs, etc.

It is important to note that there are inter-linked impacts that are difficult to clearly separate and quantify in this reconciliation process. As an example, when a sub-process within a plant is scaled up by 50-100% of its current size, there can be significant associated benefits around how the new process is implemented and optimized. In that instance, the cost of increasing the size of the process and the offsetting value of scale benefits and process improvements cannot be fully and clearly separated out – only the net total benefits can be clearly identified.

Based on these assessments, we concluded that the capital investments and the operational expenses of the U.S. plant can be comparable to those of existing European plants. A key difference, however, is that a much higher used fuel throughput is expected in the U.S. plant, because of its larger size and the higher expected utilization. Utilization is expected to be at about 80 percent of the nameplate capacity, significantly higher than the current value at La Hague. Higher utilization in the U.S. is guaranteed by larger volume of newly discharged fuel and existing inventory. Thus, our recycling unit cost estimates, especially for treatment, are significantly lower than the historic unit cost incurred at La Hague and Melox.

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Additional risk management benefits of recycling

As mentioned before, our study looked at the risk management and other peripheral benefits of a portfolio solution that combines recycling and repository approaches. While several of these features cannot directly be 'priced' in as part of the economic comparison, the benefits can be compelling and need to be considered in the overall evaluation. Our study concluded that in addition to comparable economics, recycling as part of a portfolio strategy presents at least four important benefits.

First and foremost, developing a 'world scale' recycling facility has the potential to eliminate the need for additional repository capacity beyond the initial 83,800 ton capacity at Yucca Mountain, until the 2070 timeframe. In a repository-only approach, we estimated that an extension of Yucca Mountain capacity to its estimated technical capability of 120,000 tons would be required to dispose of fuel discharged after 2020 and an entirely new repository would be required for used fuel discharged after 2040.

Second, a recycling-repository portfolio solution can contribute to early reduction of used fuel inventories at reactor sites — in particular, removing newer, hotter fuel for recycling within three years of discharge and eliminating the need for additional investments in interim storage capacity at power plant sites.

Third, the portfolio solution relies on existing technology with known improvements and modifications to enhance its effectiveness. This would be very similar to new nuclear power plant development where electric utilities migrate to subsequent generations of technologies over time rather than starting by scaling up one-of-a-kind technologies. Thus, a portfolio approach has the potential to significantly reduce implementation risks. It can also provide an operational transition to future technology developments such as Advanced Fuel Cycles and fast reactors.

Finally, a very important benefit of recycling is that it offers a tool for the nuclear power sector to protect against potential increase in uranium prices. The recycling approach produces MOX and recycled UOX fuel to nuclear power plants. We estimate that a recycling facility processing 2,500 tons/year of spent fuel would produce MOX and recycled UOX fuel equivalent to approximately 20-25% of the US nuclear power plant annual fuel requirements. The production cost of this fuel is, for the most part, independent of uranium prices and enrichment costs. In addition, the facility would be located within the US, thus providing supply security for a portion of US nuclear fuel needs.

We believe that access to such a supply source of recycled fuel can be quite valuable. Spot Uranium prices over the last two years have averaged approximately $75/lb compared to the 2000-2005 average of approximately $14/lb. This included a peak price of approximately $135/lb in 2007. The planned build out of new nuclear plants over the next 10-15 years has the potential to put further upward pressure on Uranium prices. The natural gas sector provides a useful analogy to consider the impact of such commodity price uncertainties. Between 1990 and 2005 the US power sector added approximately 250,000 MW of new gas-fired generation. During that same timeframe, natural gas prices moved up from an average of $1.60/MMBtu to $8.70/MMBtu, a more than five-fold increase in nominal terms. A steady and meaningful source of recycled nuclear fuel can provide a potential hedge against such price increases.

Conclusion

In conclusion, our in-depth evaluation of nuclear fuel recycling indicates that the economics are comparable to a once-through or repository-only solution. In addition, a portfolio solution that implements a recycling facility complementary with a repository development can provide important risk management benefits for the United States.

A few recent trends also appear to be improving the relative economics and comparability of recycling to a repository solution. Specifically, increasing Uranium prices, the potential for increased future nuclear fuel demand from a nascent nuclear renaissance in the US power sector, and increasing cost estimates for a large scale repository indicate that a recycling solution can provide significant benefits in managing the spent fuel disposal problem.

Mr. Chairman and members of the Committee, I appreciate having this opportunity to join you today. I would be pleased to answer any questions you may have at this time.

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Pattabi joined the Boston Consulting Group in 1997. He presently leads BCG's Americas Utilities practice, and has worked with clients on a broad range of issues including strategy development, growth, M&A, risk management, reorganization, cost reduction and operational improvements.

Prior to joining BCG, Pattabi was a Transportation Planning and Economics Consultant at Louis Berger International. Pattabi received a B S in Civil Engineering with Distinction from the Indian Institute of Technology, Madras, an M S in Civil Engineering with Honors from the University of Texas at Austin, and an MBA with High Honors from University of Chicago.