Commercial Nuclear Fuel Leasing – The Relationships to Nonproliferation and Repository Site Performance

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ABSTRACT

This paper describes the authors' concept of nuclear fuel leasing - - commercially-based and market-driven - - for nuclear power plant (NPP) facilities. Key issues currently affecting further development of this fuel leasing concept are examined, including issues of nonproliferation contribution and spent fuel management. If the nuclear power renaissance is to be realized in conjunction with a serious effort to reduce the impacts of greenhouse gas emissions from increasing electricity demand, nuclear fuel leasing is an important option for the current fuel cycle by its ability to extend the positive benefits of the current nonproliferation regime to countries where the scale of small programs and the complexities of the geology make final disposition so challenging. The authors believe that a principal focus on commercial options for nuclear fuel leasing is essential in order to make these options sustainable and acceptable, especially in countries wanting to build nuclear power plants to meet energy demands in an internationally acceptable way and to meet international concerns for preventing further proliferation of nuclear weapons technology and for reducing climate change effects. The authors are unaware of any public documents that describe market-priced and commercially-driven examples for fuel leasing. This paper discusses the main elements and issues for commercial fuel leasing based on detailed examinations of several conceptual models during the past eight years.

INTRODUCTION

As envisioned by the authors, fuel leasing is a bundled service that combines the provision of fresh nuclear fuel to a nuclear power plant (NPP) through a commercial lease agreement with the subsequent recovery of the hot spent fuel by the leasing company shortly after the spent fuel is removed from the reactor core. The recovered spent fuel must be directed then to a long term storage site available to the leasing company for further cooling. Since about 80% of world's spent fuel is subject to US consent rights and US policy requires there that there is a clear path to final disposal before granting re-transfer to a third party, the leasing company also must practically ensure, through appropriate binding agreements, that a geological repository for its leased fuel will be available after it is adequately cooled and ready for final disposition.

Alternately, the leasing company could transfer the spent fuel for reprocessing and recycling the plutonium and uranium into second generation nuclear fuel, but the leasing company will still retain the responsibility for the disposition of all waste products. The decision to follow a reprocessing track would be influenced by economic and policy considerations.

At the present time, utilities or NPP operators typically contract directly for all phases of fresh fuel services, from uranium oxide resource development through conversion, enrichment and fuel fabrication. The spent fuel remains the responsibility of the utility or plant operator until: (a) the spent fuel is collectively managed by a consortium of all of the utilities in a country, as for example in Sweden, or (b) the spent fuel is managed by the government, as for example in the USA. The fundamental difference between the current methods of procuring nuclear fuel services and nuclear fuel leasing is the leasing company retains complete responsibility for managing the fuel from "cradle to grave" until that responsibility is assumed by the government entity that ultimately controls the final disposition in a geological repository. If the spent fuel is recycled for second generation fuel, the leasing company remains responsible for managing the waste streams from the recycling operation as well as the new fuel supply and the ultimate spent fuel (e.g., MOX spent fuel).

If commercial fuel leasing is to become a viable option in the current fuel cycle paradigm, the fuel leasing process must provide to the utility customer not only security of fresh fuel supply but also security in spent fuel management. These services must be provided at competitive prices that are guaranteed through contract terms. Nuclear utilities that choose fuel leasing services only need to be concerned about supplying cost effective, safely generated electricity while ensuring that the leased fuel is managed in accordance with the terms of the lease contract during the time the fuel is burned in their reactor or resides in their facilities. Nuclear fuel leasing will not in any way remove the responsibilities of a NPP operator for following the safeguard protocols of the International Atomic Energy Agency (IAEA). Indeed, enhanced NPP safeguard protocols would be a contractual condition of the leasing company.

Nuclear Fuel Leasing Concepts Are Evolving

The current world energy situation is being driven by the inevitable doubling of the demand for energy by 2050 and more recently by rapidly growing international acknowledgement that climate change is real, mankind induced, and must be addressed. In summarizing statements by governments and the UN, two key drivers are apparent:

1. 16% of the world's electricity is generated currently by nuclear power; growth of nuclear power reactors must be doubled by 2050 just to maintain this contribution. Not all of these reactors will be developed in existing nuclear power nations, nor is it reasonable or acceptable to expect that only existing nuclear power nations will expand their nuclear capacity.
2. The very concerning situation in North Korea, the clandestine transfer of nuclear technology and weapon designs by A. J. Kahn (Pakistan), and the perceived efforts in Iran to create a nuclear weapons capability have only further increased the proliferation threat level.

In response to these drivers during the past several years the concept of nuclear fuel leasing is becoming more robust. The IAEA has proposed several new multilateral approaches, including fuel leasing and spent fuel take-back, a fuel bank under multilateral control, fuel supply assurances, and conversion of existing proliferation-sensitive facilities to multilateral control.

In 2006, the United States proposed the Global Nuclear Energy Partnership (GNEP). Russia has proposed a network of multination centres to provide nuclear fuel cycle services. The Nuclear Threat Initiative (NTI) has pledged US$50 million towards an IAEA-managed fuel reserve. In June 2006, a group of fuel suppliers (France, Germany, the Netherlands, Russia, the United Kingdom and the United States) proposed a mechanism for the reliable access to nuclear fuel. Separately, Japan has proposed a mechanism for increased transparency in the international nuclear fuel market and Germany has proposed a multination fuel cycle service in a neutral state, which would guarantee supply of nuclear fuel.[1, 2]

And recently, in Australia two reports in December 2006 addressed the potential added value to Australia's substantial uranium exports that could accrue due to new initiatives. The Uranium Mining, Processing, and Nuclear Energy Review (UMPNER) Taskforce considered the implications of nuclear fuel leasing in the context of the contribution to nonproliferation.[2] And at the same time the Australian House of Representatives Standing Committee on Industry and Resources reported on the strategic importance of Australia's uranium resources; a majority of the committee recommended that the Australian government should examine how the nation might add value to its uranium resources while meeting nonproliferation objectives, and to develop a licensing and regulatory framework to provide for the possible establishment of fuel cycle industries and facilities in Australia.[3]

The Business Foundation Is Multifaceted

In the view of the authors, the foundation of a nuclear fuel leasing business must rest on at least 3 common pillars:

- First, a fuel leasing business must provide the ability to extend and enhance the current nonproliferation regime[1].
- Second, fuel leasing must be both commercially-driven and market-driven if it is to be sustainable.
- Third, fuel leasing requires either that all spent fuel management services are capped in costs to the leasing company or that remaining liabilities can be adequately offset by insurance.

Nonproliferation Considerations Are Vital

Early return of leased spent fuel to a secure storage location for cooling, in the authors' opinion, is critical for nonproliferation reasons. Early, rapid removal of hot spent fuel from the reactor cooling ponds (9-16 months after core removal) and transport by sea to a secure, water

[1] The NPT regime is influenced by the commercial nuclear industry process for procuring fresh fuel and exercising utility and government responsibilities for spent fuel management, including final disposition.

cooled storage location underground has been demonstrated without incident since 1985 by SKB (Sweden) in its CLAB facility. The authors believe that this key step is a common nonproliferation prerequisite for any fuel leasing option. Further, the actual storage of the hot spent fuel can be achieved for security reasons either dry or wet, surface or near surface. The duration of storage will depend upon whether reprocessing is considered or whether direct disposal is a requirement of the host nation's repository program.

In any case, the bundled service, fuel supply guarantees, and early removal of hot spent fuel are important considerations in reducing the incentives for some nations to build new, indigenous enrichment and/or reprocessing facilities, even if these facilities will be supervised under the umbrella of the NPT and its future evolution to meet the new threats.

Nuclear Fuel Leasing Contracts Will Vary

A leasing company must have different contracts for every aspect of its bundled service offering and the leasing contract will vary for each commercial nuclear utility company. Each contract will be based upon the characteristics and quantities of fresh fuel to be delivered to the utility and then the services and timing required for spent fuel management, based upon the utility's fuel utilization strategy (e.g., burn-up design considerations). The leasing company must procure adequate quantities of uranium oxide from mining companies; similarly, conversion, enrichment, and fabrication services must be procured, but the enrichment and fabrication services must be uniquely defined for each utility and reactor. It should be noted that many current nuclear utilities will want to limit the leasing company's choice of fabricators due to issues of quality and performance in existing fuel designs (the cost to test new test assemblies must be offset by cost and performance for the long term contract).

The utilities must be convinced that the spent fuel and/or waste products from reprocessing will not be their ultimate obligation under any circumstances. The leasing company must be able to give this assurance to the nuclear utility company. This means in practice that a government guarantee is mandatory; as a minimum, the government must take ultimate responsibility for the long term performance of the closed repository in the host country where leasing companies have made contractual arrangements for management of the spent fuel (see Risks and Liabilities below). In this sense, the leasing company is no different than a nuclear utility that pays money to a spent fuel management entity that is either government-run (ex. United States) or controlled by all the utilities (ex. Sweden). Without this absolute guarantee about responsibility for final disposition of the spent fuel to the nuclear utility company, nuclear fuel leasing cannot occur.

Costing Risks and Liabilities Must Be Considered in Contracts

The lease company has risks associated with the contracts it enters into with utilities because of the future variability in the negotiated costs of the components. The leasing company has at least 2 alternative strategies to address uncertain costs:

1. The lease contract could contain a price that is based upon assumptions of highest costs per service in current dollars with some contingency; this approach will be appropriate to cover the largest uncertainties.

2. Alternately, the lease company could seek cost caps and guarantees from the host country providing the sites for long-term storage and the geologic repository; this approach and resulting cost predictability would reduce risk to the leasing company.

Uranium is currently the largest element of fresh fuel costs and thus represents a challenge for the leasing company in minimizing its risks in the formulation of its contracts. However, this risk is identical to the risks accepted by the fuel buying departments of the utilities in the current system of fresh fuel purchasing. As the world demand increases, though, the price increases in uranium will be mitigated by the discovery of new uranium ore bodies and the extension of the life of mines with higher costs.

Currently the next highest contract risk will be associated with enrichment costs which are the second dominant cost element of fresh fuel; this occurs because there are likely to be perceived shortfalls in enrichment capacity over the next 40 years, even in those countries where enrichment is accepted by the international community to be secure and transparent. The leasing company must off-set these cost risks in the details of the contracts with the utilities and its management fee.

In the case of the spent fuel management portion of the lease, the leasing company will have higher uncertainties there than in the front end (fresh fuel supply), and therefore the associated risks associated with spent fuel management (the back end) will be higher. However, the opportunity to provide a value-based price for the back-end service (rather than purely on a cost basis) provides the leasing company with a new service for some utilities, namely a bundled package of both the front end and back-end components. While transport of spent fuel has been practiced successfully by sea and land, leasing companies should preferentially seek host countries where the storage and disposal sites are close to ports in order to mitigate the risks associated with transportation corridors and potential cost overruns. Away-from-reactor storage of spent fuel is also a well known business and therefore will not present unusual uncertainties and associated risks.

Spent Fuel Management Considerations Have Significant Impact

The leasing company must have assured cost caps for the variety of services that are bundled into the lease package; however, the most important cost caps will occur in the back end services that will be provided. The greatest commercial risk is associated with the licensing and construction of the disposal facility.

The major uncertainty will be related to the costs of final disposition in a deep geological repository, including costs for conditioning the waste and the engineered barriers surrounding the waste packages, whether from spent fuel or reprocessed HLW. Uncertainties include time delays and net present value considerations. The repository costs are directly related to the location and the geology of the site; previously the importance of High Isolation Repository Sites (HIRS) was identified in the proceedings of WM98. [4] More generically, the performance assessment requirements must be able to largely satisfy the overall system requirements without taking credit for the geological system (ex. Sweden). On a more generic case therefore, the performance of a host country repository site will dictate the overall costs

that will be incurred. As the costs for a repository site rise based upon geology, the added value of the lease package bundle will be reduced, and this becomes a key business decision. For the lease company to offer a value-based bundled service that is competitive with the way that fuel cycle services are currently procured, an HIRS is optimal. And while any other site can be accommodated in the costing model for the leasing package, the value component in the competitive pricing to the utility will be reduced.

In the case where the waste management program in a host country has been funded over many years by contributions from its nuclear utilities, objections would be expected if a new customer (leasing company) did not pay its pro-rata share of the sunk costs as well as the future disposition costs, which are likely to have significant uncertainties. Therefore, it is difficult to imagine disposition of leased fuel from overseas in Yucca Mountain, which is already space constrained. It is more likely that nuclear fuel leasing will occur in countries where there are no current sunk costs for a repository - - the lease company would be treated as any other nuclear utility managing its spent fuel.

It is important to note that, in the authors' opinion, for political acceptance reasons in a host country it is unlikely that a nuclear fuel leasing contract would accommodate any client's additional legacy spent fuel; however, if there are several competing lease companies with different host country repository companies and the host country is willing to consider accepting the additional risk of similar but cooler waste, then there might be an opportunity to consider legacy spent fuel within the contractual arrangements for the leased fuel bundled services. This consideration would not be appropriate if it is detrimental to the overall business of leasing new fuel services.

In those cases where private or public partnership entities are required by the repository host country government to participate in one or more of the spent fuel management components, there are options to follow what is internationally known as public private partnerships or Build Operate Own and Transfer (BOOT) long term infrastructure projects. In such cases, the authors have determined that debt financing in lieu of equity financing may be required.

In some host countries, equity ownership by the leasing company in one or more of the spent fuel management components may be required by the government. In such cases, the financial benefits would accrue to the leasing company, but the inherent liabilities would have to be adequately offset by insurance and/or additional equity partners that want to undertake the consequential liabilities. This outcome might be achieved by a variety of corporate structures or contractual arrangements that would isolate the essential liabilities of the leasing company.

The authors believe that most nuclear utility companies will accept the concept of a reasonable management fee for the leasing company. This acceptance is based on acknowledgement of the small amount of liability of the leasing company. This can be offset to a large degree by appropriate insurance included in the management fee.

CONCLUSION

In the authors' opinion, commercial nuclear fuel leasing is a prime justification for global acceptance of new NPPs in countries seeking nuclear energy to meet their growing domestic demand while respecting nonproliferation and global warming concerns. Fuel leasing as a concept contributes to the argument that new, indigenous fuel cycle facilities are not required as a condition for expanding nuclear power. In providing a new bundled service, fuel leasing companies must operate under full transparency and IAEA safeguards that are likely to be further tailored to this new fuel cycle option. Ultimate responsibility must reside with the host country government or entity for final disposition of the spent fuel and wastes in a deep geological repository that meets the operational and long term requirements of the host nation and internationally accepted performance standards.

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