[SE1-LT-2] Reprocessing and Disposal of Spent Nuclear Fuel

Lance Kim
University of California, Berkeley

Full Summary

Though not necessarily suggesting an urgent need to move spent nuclear fuel (SNF) into dry cask storage or to reprocess SNF, the role of spent fuel pools (SFPs) in the ongoing accident at the Fukushima Daiichi nuclear power plant has sharpened the focus on the management of SNF. The safety of Japanese reprocessing facilities has also received attention against the backdrop of general nuclear safety issues in the aftermath of the earthquake and tsunami. Though many of these concerns about the safety of reprocessing are likely driven by the proximity of the Rokkasho facility to Fukushima (reprocessing poses similar safety issues to large onsite wet pool storage facilities and closed fuel cycles may have lower life cycle environmental and public health impacts due to reductions in uranium mining and conversion), in the longer run, the decision to reprocess and/or directly dispose of spent nuclear fuel from once-through fuel cycles require states to confront frequently mischaracterized tradeoffs between hard and soft factors related to proliferation risk, repository performance, economics, safety, energy security, resource sustainability.

Several assessments comparing alternative fuel cycles have not produced unambiguous recommendations due to competing risks and benefits that are distributed temporally, including issues of intergenerational equity. Though reprocessing does not obviate the necessity of siting a long-term disposal facility, reprocessing may simplify waste management by improving repository performance (e.g. reductions in decay heat and radiotoxicity, waste form performance), increase sustainability and energy security by improving natural resource utilization, improve safety by reducing front-end risks, and increase stakeholder acceptance. Views on technical performance measures also vary, with some states placing greater importance on the radiotoxicity of spent nuclear fuel in addition to public health risks that account for radionuclide transport and exposure. Comparisons of proliferation risk also produce mixed results. Though the consumption and denaturing of plutonium offers nonproliferation benefits, the potential to divert or steal fissile material and the misuse separation facilities require extensive safeguards and security measures.

The large fixed costs and scaling issues for a geological repository and reprocessing may encourage states, particularly those with smaller nuclear energy programs, to form cooperative arrangements to manage the back end of the fuel cycle. Given the cost scaling issues associated with typical reprocessing technologies and geological repositories, the why, how, when, and where of closing the fuel cycle will likely require a confluence of rationales that will be state-specific and context dependent. In the case of reprocessing, the economic rationale for closing the fuel cycle is more demanding than the case for enrichment, probably requiring a fleet of 20 to 40 large nuclear power plants (NPPs) in comparison to 15 to 20 NPPs to justify enrichment. For example, though French reprocessing experience has tended to avoid many of the downsides of the U.S. and Russian experience that were largely driven by the exigencies of Cold War weapons programs, the French reprocessing facility at La Hague remains underutilized despite processing spent fuel from several countries. Nevertheless, some states with larger nuclear programs and limited uranium resources may be more willing to accept the cost premium of reprocessing in exchange for the energy security benefits of utilizing plutonium in SNF. Advanced reprocessing technologies, such as pyroprocessing, may offer operational benefits in comparison to continuous aqueous processes (e.g. PUREX) due to batch operation, but requires overcoming a number of technological hurdles (e.g. producing fuel with high actinide loading, fast reactor development) and costs are unclear. Similarly, facing costs associated with siting a geological repository that are on the order of a large NPP, states with smaller nuclear energy programs may pursue multinational arrangements to manage SNF that rely upon “big friendly” states or cooperative partnerships between like-minded states such as those in Europe, the Middle East, and Asia.

The waste management experiences in Finland and the United States are studies in contrast. Though initially preferring to reprocess or return foreign-origin spent nuclear fuel to the Soviet Union, the Finnish direct disposal strategy was influenced by the U.S. decision to abandon reprocessing, low uranium prices that reduced the economic incentive to reprocess, and the network effects arising from the Swedish plan to directly dispose of SNF. A systematic, consistent, and participatory approach to repository siting is credited for the relative success of the Finnish nuclear waste management program. First focusing on geological and safety factors, the final siting decision was directed by a local and national response, ultimately choosing to site the repository on the site of an existing nuclear facility. Currently, Finland has spent roughly three billion Euros to manage several thousand tonnes of waste with the option to expand the repository in the future.

The more contentious U.S. experience in waste management also struggles with the fundamental question of whether SNF should be viewed as an asset or a liability. Historically, changes in the regulatory climate, technical failures, and policy reversals stymied the

development of reprocessing in the U.S. Currently, the future of nuclear waste disposal in the U.S. is uncertain as the Obama administration reconsiders the national strategy for nuclear waste management. Efforts to cancel the Yucca Mountain project without credible alternatives has been met by opposition from industry that has brought legal suits, congressional investigations, and a ruling by the Atomic Safety Licensing Board (ASLB) challenging the administration's authority to undermine legislation. Recently released draft findings of the Blue Ribbon Commission subcommittees established to revisit these issues have shed some light on the future of U.S. waste policy, provisionally recommending a "Fedcorp" entity to take responsibility for SNF as well as the continued pursuit of a centralized storage repository and advanced fuel cycle concepts while recognizing the limited rationale for reprocessing in the near term. The de facto U.S. policy of interim and indefinite storage posture of the U.S. will likely require continuing funding, technology development, and siting efforts to constitute a credible waste management strategy. And while often pitched as an "all-or-nothing" proposition, a combination of once-through and closed fuel cycles may be desirable to manage the backlog of SNF, possibly incorporating an interim storage facility of fixed capacity as a strategic reserve of SNF to manage an uncertain future.