Market-Based and System-Wide Fuel Cycle Optimization

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ABSTRACT:

The goal of this project is to create optimizers for the CYCLUS fuel cycle simulator. Two classes of optimizers have been identified and targeted. The first class islocalized and they function on each market individually. These could therefore serve a "clearinghouse" purpose inside the fuel cycle calculation itself, helping to resolve the material offers and requests on an economic or neutronic performance basis. The second class of optimizers works globally over the whole system. These would aid in resolving top level policy questions such as what parameters yield the cheapest levelized cost of electricity, lowest proliferation risk, highest repository capacity, and other fuel cycle response metrics.

Optimization itself is a large and competitive field in applied mathematics. Thus this proposal will leverage existing optimization software frameworks from within, or as a driver of, the CYCLUS fuel cycle simulator. Frameworks to be considered for inclusion are COIN-OR, Dakota, PETSc, Trillinos, SciPy, OpenMDAO, and Coopr. Capitalizing on externally developed tools is in line with performing research on the fuel cycle itself rather than the underlying optimization methodologies.

The results of this project are necessary for the CYCLUS fuel cycle simulator to move beyond static material composition recipes. The capability to handle partially fungible markets that medium-or high-fidelity facility models generate is a feature requirement for any simulator hoping to leverage such models. Furthermore, this proposal would enable material flow based on real world economic cost & analysis, which is itself a highly desirable feature. Moreover, the optimizations proposed also extend to viewing the fuel cycle system as whole. This is critical for being able to address the top-level engineering and policy concerns described above.

This proposal would have major impact on the CYCLUS ecosystem and its stakeholders. Its primary goal is a broad extension to the currently existing (and relatively simple) market clearing mechanism. It is also expected that the project would have significant impacts in the greater nuclear fuel cycle community. An integrated simulator with these optimization capabilities would be a first-of-its-kind technology. Other agent based system dynamics tools exist, and some of them are even used to model the economics of certain commodity markets. However, no tool faces this scale of independent input parameters while simultaneously having to manage partial fungibility. It is this exact situation that makes the pursuit of avalidatable nuclear fuel cycle simulator both challenging and exciting. Demonstrating that such a tool