Illuminating Emerging Supply Chain and Waste Management Challenges

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ABSTRACT:

In this work, we propose to add capabilities to Cyclus, an agent-based fuel cycle simulator, to address current and future fuel cycle and supply chain challenges. Potential disruptions to the supply chain may be geopolitical in nature (e.g. sanctions) or localized in nature (e.g., manufacturing plant shutdown, facility closure), therefore our tools need to reflect supply dynamics regionally. Further, our tools need to reflect potential constraints or effects on the back-end of the fuel cycle (e.g. SNF mass or repository capacity). We propose updating Cyclus to include enhanced modeling of supply chain dynamics, regional and temporal variability in material needs, and expanded models appropriate for variations in reactor fueling strategies. These updates will allow Cyclus to better capture the engineering and supply chain aspects of the emerging nuclear fuel cycles driven by a panoply of advanced reactor designs of varying sizes and fuel strategies. We will seek community engagement in designing these features and plan to host a workshop to build community knowledge of these features once they are implemented. All improvements will be made using best practices for open-source software, encouraging collaboration and integration of new members of the Cyclus users community.

This proposal is motivated, in part, by recent events in the US commercial nuclear fuel supply chains, such as the need to develop a non-Russian-based commercial supply of High-Assay Low Enriched Uranium (HALEU), the closure at the the Westinghouse Columbia facility in 2016, and the temporary closure of the CoverDyn conversion facility in 2004. Each of these events highlights the need for modeling capabilities that can accurately account for supply chain disruptions and assist decision makers and key stakeholders. At the same time, there is a growing diversity in reactor fueling strategies being explored by advanced reactor developers that will have impacts on both the front-end supply chain and the back-end waste management concerns. Improved reactor physics capabilities in Cyclus will allow a more nuanced treatment of fuel cycle needs for non-equilibrium fueling strategies. These capabilities will allow for better modeling of emerging fuel cycle transitions and enhance stakeholder knowledge of potential bottlenecks in fuel cycle transactions. Our team brings together collaborators with expertise in fuel cycles modeling, scientific software development, reactor physics, and industry knowledge of fuel purchasing and materials management. The proposed work will be accomplished through four objectives:

Objective I: **Improve Supply chain dynamics modeling**
Objective II: **Add regional and temporal variability capabilities to cyclus to better handle dependencies of modeled technologies**:
Objective III: **Improve reactor physics modeling in Cyclus to support non-equilibrium cores**:
Objective IV: **Provide collaborative stakeholder engagement**