Idealized Transition Scenarios to Nuclear-Based Energy Supply in a Hub-Spoke Architecture

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Abstract

Aggressive, 100-year nuclear market penetration scenarios are studied using idealized modeling of a Hub-Spoke architecture wherein fuel cycle and waste management operations are coalesced into a few dozen fuel cycle centers worldwide. These centers support deployment of growing and evolving mixes of thermal reactors and small fast reactors of long refueling interval at user sites.

Hamilton's principle is employed to optimize the mix and timing of reactor deployments in a growing nuclear park – constrained by reactor park dynamic response (as a function of mix) and finite ore reserves. Various degrees of market penetration are considered – ranging from maintain market share to cap greenhouse gas emissions to finally take over all world primary energy supply.

Strategies are identified such that even the most aggressive growth would not be precluded by the laws of physics and ore resource base – a prerequisite to considering the more complex social, institutional and financial hurdles to aggressive growth. Were aggressive nuclear growth to become a societal goal, the insights gained from the idealized modeling can help guide higher-fidelity nuclear futures scenario studies.