

Nuclear Fuel Cycle Integrated System Analysis

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The nuclear fuel cycle is a complex system with multiple components and activities that are combined to provide nuclear energy to a variety of end users. The end uses of nuclear energy are diverse and include electricity, process heat, water desalination, district heating, and possibly future hydrogen production for transportation and energy storage uses. Components of the nuclear fuel cycle include front end components such as uranium mining, conversion and enrichment, fuel fabrication, and the reactor component. Back end of the fuel cycle include used fuel coming out the reactor, used fuel temporary and permanent storage, and fuel reprocessing. Combined with those components there are economic and other activities that affect the decisions related deployment of a particular nuclear fuel cycle. Simulation of the nuclear fuel cycle with its different components has been of interest to governmental and international forums/agencies such as the US department of energy (DOE), Generation-4 (GEN-4), and the OECD-NEA. This interest is motivated by projections of nuclear energy demand increase at the national and international levels. Those agencies are assessing the capabilities of nuclear power to support that growing need for nuclear energy and energy security in the US and abroad. Nuclear energy's growth, and thereby its contribution to improving sustainability and energy security, can be enhanced by technology development aimed at key challenge areas of long term waste management, nuclear fuel utilization, energy production flexibility and economics. The area of integrated fuel cycle system analysis and simulation look at those challenges and support policy makers' decisions on technology options that – if implemented – would enable long-term growth of nuclear power while improving sustainability and energy security. An overview of the area of nuclear fuel cycle system analysis and simulation is provided here combined with recent developments in related dynamic analysis simulation tools. Different types of nuclear fuel cycles and fuel cycle deployment strategies are presented, combined with examples of both national and international fuel cycle deployment scenarios.