Fuel Cycle Analysis Framework Base Cases for the IAEA/INPRO GAINS Collaborative Project

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Abstract

Thirteen countries participated in the Collaborative Project GAINS "Global Architecture of Innovative Nuclear Energy Systems Based on Thermal and Fast Reactors Including a Closed Fuel Cycle", which was the primary activity within the IAEA/INPRO Program Area B: "Global Vision on Sustainable Nuclear Energy" for the last three years. The overall objective of GAINS was to develop a standard framework for assessing future nuclear energy systems taking into account sustainable development, and to validate results through sample analyses. This paper details the eight scenarios that constitute the GAINS framework base cases for analysis of the transition to future innovative nuclear energy systems. The framework base cases provide a reference for users of the framework to start from in developing and assessing their own alternate systems. Each base case is described along with performance results against the GAINS sustainability evaluation metrics. The eight cases include four using a moderate growth projection and four using a high growth projection for global nuclear electricity generation through 2100. The cases are divided into two sets, addressing homogeneous and heterogeneous scenarios developed by GAINS to model global fuel cycle strategies. First, the business as usual (BAU) cases model a homogeneous world scenario with only LWRs and HWRs and no reprocessing. Next, the BAU-FR cases extend the BAU cases to include the introduction of fast reactors starting in the first half of the century and slowly replacing LWRs in the second half of the century. The rate of introduction of FRs is specified to 2050, after which they are commissioned based only on availability of plutonium for their start-up. The heterogeneous world scenario considers three separate nuclear groups based on their fuel cycle strategies, with separate non-synergistic and synergistic cases. Two of the groups, G1 and G2, are modeled to represent the existing global nuclear infrastructure, split between countries pursuing a closed fuel cycle with recycling and fast reactors (G1) and countries continuing to use a once-through fuel cycle without reprocessing (G2). The third group (G3) represents new nuclear growth and is modeled in the non-synergistic scenario as a standalone group that develops its own fuel cycle facilities. In the synergistic scenario, G3 works together with G1 and G2, obtaining fuel cycle services to support reactor deployment and operations. The framework base case analyses results show the impact of these different fuel cycle strategies while providing references for future users of the GAINS framework. A large number of scenario alterations are possible and can be used to assess different strategies, different technologies, and different assumptions about possible futures of nuclear power. Results can be compared to the framework base cases to assess where these alternate cases perform differently versus the sustainability indicators.