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Sustainability assessment of different nuclear fuel cycle scenarios

A recent study has assessed the sustainability of different nuclear cycle scenarios in Europe, and suggests trade-offs are required between reducing the amount of uranium fuel needed, costs and proliferation risks.

The study assessed the sustainability of different nuclear fuel cycle scenarios in Europe using material flow analysis. In Europe currently around 30% of the electricity is produced by nuclear power stations the majority of which use enriched uranium as fuel. The study, covering the EU-27, Switzerland and Ukraine, modelled the flow of uranium in the nuclear fuel cycle for the year 2007 and assessed different scenarios based on eight environmental, economic and social criteria. The analysis was based on publicly available data from nuclear energy agencies and industries, national trade offices, and nongovernmental organisations.

The following four different nuclear fuel cycle scenarios representing various approaches to reducing the amount of uranium required were assessed: all recyclable spent uranium fuel is reprocessed to provide MOX fuel; re-enrichment (process to make the uranium suitable as a fuel) of all depleted uranium (the byproduct from the enrichment process), reducing enrichment tails assays (concentration of fuel grade uranium in uranium mixture) and hypothetically replacing all reactors with new generation fast neutron reactors.

These scenarios were then evaluated against eight criteria: environmental (saved uranium, waste production, energy demand, chemical and radiation risks), economic (operational and investment costs) and social (proliferation risks). Proliferation is the spread of nuclear weapons to countries that currently do not have them. Chemical risks are linked to mill tailings (waste material containing radioactive decay products) and the use of chemicals during the front end processing and recycling.

The study notes that in 2007, Europe imported 95 per cent of its 24,000 tons of natural uranium equivalent needed for the nuclear reactors in that year, with the remaining 5 per cent mainly produced in Ukraine. Only 5 per cent of spent fuel was reprocessed and reused. On average, more than half of depleted uranium (the low-level waste) is exported each year beyond the European countries considered, mainly from France to Russia.

The assessment allows identifying the major flows and interaction between different dimensions of the nuclear fuel cycle. The study concludes that, from a material perspective, conventional technologies can achieve at best a 17.9 per cent decrease in uranium demand by reducing the tails assay and using reduced enrichment grade. Fast reactors could theoretically reduce the material demand for uranium by 99.4 per cent. However, there are trade-offs, including significant investments needed in research and development, the cost competitiveness with other technologies and the expected higher risks of proliferation (as reprocessing nuclear wastes causes extra production and manipulation of fissile material, and can make it more readily available by separating it from highly radioactive waste materials).

The approach in this study can be used to identify the trade-offs required when assessing the sustainability of different nuclear fuel cycles in Europe. The study concludes by pointing at the importance of social acceptance of nuclear energy in this context and the need for stakeholders' involvement to determine the most suitable solution.

Source: Tendall, D.M. and Binder, C.R. (2011) Nuclear Energy in Europe: Uranium Flow Modeling and Fuel Cycle Scenario Trade-Offs from a Sustainability Perspective. *Environmental Science & Technology.* dx.doi.org/10.1021/es103270a

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