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Proliferation aspects of partitioning and transmutation (P&T) fuel cycles

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Abstract. Nuclear fuel is usually irradiated once but sometimes twice (MOX fuel). This procedure leaves a huge amount of spent fuel. Spent fuel is highly radioactive for a long time. Deep geological repositories are considered the best option for final disposal of this high-level radioactive waste. However, no such repository has been put into operation yet.

Several countries consider partitioning and transmutation (P&T) a possible alternative. In P&T nuclear fuel cycles, the spent nuclear fuel is chopped into pieces and separated into different material streams such as plutonium, uranium and minor actinides. This process is called partitioning. From plutonium and minor actinides, new fuel elements are fabricated and used in nuclear reactors. If the overall physical conditions there are favorable, most prominently the presence of a fast neutron spectrum, at least a part of the minor actinides is fissioned and thus transmuted into other, hopefully easier-to-handle, nuclides. Especially when looking at the ingestion-based radiotoxicity index, reduction in minor actinides in nuclear waste is beneficial and might ease the requirements for a final repository.

There are several drawbacks when looking at the concept of P&T: among others, several irradiation cycles are needed because the transmutation efficiency is so low. The technology for the processing of the spent fuel, the fuel fabrication and the irradiation is far from commercially available, and it is not clear whether this level can be met at all.

This presentation focuses on the proliferation risk posed by possible P&T fuel cycles. The nexus between civil and military use of nuclear technology is widely known. If new fuel cycles are implemented, they should be more proliferation-resistant and not less. This would not be true for P&T fuel cycles: they require a closed nuclear fuel cycle with far more advanced reprocessing than today. Fissile material contained in spent nuclear fuel is not sent to final disposal but is separated into its components, which must be made available separately before they can be recombined into new fuel elements. Besides plutonium, this also includes other transuranic elements of small critical mass. The radiation barrier, an essential protection against unauthorized access to fissile material that could be used for nuclear weapons, is no longer present.

The handling of those materials requires special facilities to cope with the immense amount of heat and radiation of the fuel containing high fractions of minor actinides. In those facilities, fissile material fitting for military purposes could be handled as well. Even if thorough safeguards are in place, detailed accountancy of all materials is not possible. The quantities needed to build a nuclear weapon are small compared to the quantities that need to be handled in a commercial-sized P&T fuel cycle. P&T technology is a civil application which clearly strengthens military capabilities. It would be hard to argue why it should only be available to a trustworthy partner (whoever that might be).

The implementation of P&T fuel cycles would thus increase the risk of unauthorized diversion of nuclear material, technology and knowledge.

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