

Scenario Study for Closing Nuclear Power Generation

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Abstract

When we think of the end of the nuclear power generation in the future of a certain country, there will be considerable amount of nuclear material that will be no longer burnable in the commercial nuclear power reactors. Some countries may stop nuclear power generation after they operate only the light water reactor (LWR) with the use of the uranium fuel. They will have depleted uranium, plutonium (Pu) and small amount of minor actinides (MA) in the spent fuel. Others may stop after introducing a fleet of the fast breeder reactor (FBR), and they will have larger amount of Pu and MA in the FBR spent fuel than those in the LWR one. When they stop the nuclear power generation, they have to choose among directly-disposing of the spent fuels, transporting them to the other country and burning them in the dedicated transmutation systems. The first choice might be superior in economics aspect, but difficult to find and construct the repository owing to large size and possibility to recover Pu for nuclear weapon. The second one is reasonable if neighbouring countries need them, but is not available for the last country that stops the nuclear power generation. The third one is costly but effective to minimize the burden of repository.

In the transmutation strategy, Pu has to be transmuted prior to MA because of its amount and usability as the nuclear weapon. For the country without the FBR technology, Pu must be transmuted in the LWR dedicated for the transmutation in forms of the MOX fuel or the ROX fuel. The ROX fuel that stands for “rock-like oxide” fuel contains mainly Pu with less amount of ^{238}U to reduce Pu production and to transmute about 90% of fissile Pu. The spent ROX fuel is so stable to confine radio-nuclides and it is difficult to recover Pu after disposal. Both transmutation methods in the LWR can reduce the emission of radio-nuclides to the environment and the opportunity to use Pu in the repository as the weapon. However, the potential radio-toxicity is not reduced due to remaining Pu and MA. If the transmutation systems such as fast reactor or accelerator-driven system are introduced in the nuclear fuel cycle, very small amount of Pu and MA are contained in the high-level waste, and, the potential radio-toxicity is reduced by one to two orders of magnitude.

In the present study, above mentioned transmutation methods were investigated quantitatively in terms of necessary number of transmutation systems and period after closing the nuclear power with the use of the analysis code for nuclear material flow. Moreover, the comparison of repository size and its potential radio-toxicity were made along the transmutation scenarios.