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Advanced Breakeven Molten Salt Fast Reactor (BeMFR) for Sustainable Nuclear Energy

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Amid rather optimistic expectations about roles of nuclear energy in battling global warming and climate crisis, there are also strong concerns about the sustainability of nuclear energy in a long-term view. In this talk, an ultimate nuclear reactor is pursued and suggested to address the essential nuclear trilemma, i.e., safety, spent nuclear fuel, and limited U resource. A breakeven molten salt fast reactor (BeMFR) is devised to fully resolve the nuclear trilemma in a competitive and reliable way. The BeMFR is a fast reactor using a chloride salt fuel and its fuel cycle is closed with the proliferation-resistant pyro-processing. The initial core of BeMFR can be loaded with U-TRU fuel. The U-TRU is directly recovered by the pyro-processing of the SNF stock without any TRU separation. In a new-comer nuclear country, an HALEU fuel can also used in the initial core. The reactor is operated such that the excess reactivity should not succeed about 1 dollar via on-line fission-product removal and feeding of metallized SNF. And the BeMFR core slowly transitions to an equilibrium breakeven one through a transition period. Depending on the initial core fuel, the operational transition strategies are different since the reactor characteristics are quite different. The detailed operational strategies are discussed to achieve the equilibrium BeMFR core. The safety and operational characteristics of BeMFR are evaluated for the whole operational period. It is shown that the SNF can be very efficiently reused and BeMFR can enable a long-term sustainable nuclear energy without relying on natural uranium. All the physics simulations are performed using both the Serpent 2 and iMC Monte Carlo codes.

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