HYBRID NUCLEAR CYCLES FOR NUCLEAR FISSION SUSTAINABILITY

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ABSTRACT

Nuclear fission can play and must play an important role in paving the road to Energy Sustainability. Nuclear Fission does not produce CO_2 emissions, and it is already exploited at commercial level with the current NPP (Nuclear Power Plants). Most of them are based on LWR reactors, which have a very good safety record. It must be noted, however, that all LWR (including the advanced or evolutionary ones) have some drawbacks, particularly their *very poor efficiency in exploiting the natural resources of nuclear fuels*. In this paper, an analysis is presented on how to maximize the energy actually generated from the potential contents of fission natural resources. The role of fertile-to-fissile breeding is highlighted, as well as the need of attaining a very high safety performance in the reactors and other installations of the fuel cycle. The proposal presented in this paper is to use advanced and evolutionary LWR as energy-producing reactors, and to use subcritical fast assemblies as breeders. The main result would be to increase by two orders of magnitude the percentage of energy effectively exploited from fission natural resources, while keeping a very high level of safety standards in the full fuel cycle. Breeders would not be intended for energy production, so that safety standards could rely on very low values of the thermal magnitudes, so allowing for very large safety margins for emergency cooling. Similarly, subcriticality would offer a very large margin for not to reach prompt-criticality in any event. The main drawback of this proposal is that a sizeable fraction of the energy generated in the cycle (about 1/3, maybe a little more) would not be useful for the thermodynamic cycle to produce electricity. Besides that, a fraction of the generated electricity, between 5 and 10 %, would have to be recirculated to feed the accelerator activating the neutron source. Even so, the overall result would be very positive, because more than 50 % of the natural resources could be exploited with such a cycle, using very safe reactors. This percentage is much higher than the actual value for the once-through cycle (0.5 %) and the value for multiple Pu recycling in the MOX scheme (1 %). Moreover, thorium could also be exploited through fertile conversion into U-233 in the subcritical breeders. The separation between energy production (to be done in LWR) and nuclear breeding (to be done in subcritical hybrids) presents a scenario with very appealing safety features and a high potential for an efficient utilization of all natural resources of uranium and thorium, that account for 10^{24} J, i.e., 25 Gtoe, which is 35,000 times as large as the annual production of Nuclear Energy nowadays, and about 2,500 times as large as the total annual energy consumption all over the globe.