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Development of DEMO-FNS Tokamak for Fusion and Hybrid Technologies

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Limited resources of fissile nuclides, disposal of spent nuclear fuel and controlled nuclear fusion are the major system challenges on the path from contemporary to future large-scale Nuclear Energy (NE). Creation of fusion-fission hybrid systems in near-term outlook will definitely ensure success in solving these problems. This will provide involvement of practically unlimited resources of fertile isotopes (U238 and Th232) into the nuclear fuel cycle and realize that with substantially reduced radiotoxicity. In combination with ITER data on burning plasma physics, development of hybrid systems will make decisive input in progress of enabling technologies and materials needed for realization of the fast track strategy to Fusion Power Plant by 2050. Subjective tests show that the optimal power fraction of hybrids in the NE structure is less than 10 %. The fusion power varies from 50 MW to a few GW in energy valuable hybrid systems.
Development of a fusion neutron source DEMO-FNS for demonstrating energy valuable hybrid technologies based on a conventional tokamak (CT) with the power of deuterium and tritium fusion up to 50 MW started in Kurchatov Institute in 2013. The design is aimed at steady state operation of the device providing the neutron flux (~0.2 MW/m2) and the fluence (~2 MW-y) with the blanket area (~100 m2) sufficient to test materials and components in fusion spectra for DEMO program support and to develop hybrid technologies for transmutations, fissile nuclides production and energy generation.
The concept of DEMO-FNS has been formulated assuming amplification factor Q ~1, duty factor ~0.3, electric power consumption < 200 MW, tritium consumption < 700 g/y, divertor loading < 10 MW/m2, plasma current 5 MA, magnetic field 5 T, major radius 2.5 m, aspect ratio 2.5 and auxiliary heating power up to 36 MW, construction cost ~1 $B. From safety point of view the device was considered as a radiation source with opportunity to become a subcritical nuclear facility with generated heat power less than 500 MW. Commercially available materials are considered in the design owing to reduced neutron loadings and fluencies compared with DEMO.

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