

Global supply of tritium for fusion R&D

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The tritium start-up inventory required by a tritium self-sufficient DEMO-class fusion reactor is subject to a wide margin of uncertainty, with estimates in the literature varying from less than 1 kg to almost 20 kg for a ~2 GW fusion reactor. If ITER is successful, it is conceivable that multiple DEMO-class devices may be developed in parallel; the European DEMO machine, the Chinese Fusion Engineering Test Reactor and others could require several kilograms of tritium each in the 2050s.

Tritium production from heavy water (D2O) CANDU reactors in Canada presently meets the entire fusion R&D demand of tritium. Ontario Power Generation (OPG) plans to supply ITER with all of the tritium required for its exploitation. Yet OPG may only be able to supply up to 8 kg for a DEMO reactor in the mid-2050s, following the delay to the ITER D-T operations (now scheduled in 2036), owing to the progressive phasing out of Canadian CANDU reactors in the 2030s and the natural decay of stocks. There is a risk that commercially available tritium stockpiles in the 2050s are insufficient to meet the fusion demand.

Herein, we present several data-based scenarios of tritium production from heavy water reactors (HWRs) and fusion tritium consumption with varying degrees of optimism. At present, only Canada and the Republic of Korea actively extract tritium from their HWRs in tritium extraction facilities (TEFs), and Romania plans to build one. Based on the assumption that only these countries contribute to the global supply of commercially available tritium, results range from 0 kg to 30.5 kg of T available in 2055, depending on the scenario considered.

Alternative methods for tritium production are discussed; D-D fusion start-up with a breeding blanket, modifications to CANDU reactors and other HWRs, and production of tritium in commercial light water reactors using tritium-producing burnable absorber rods.

Tritium production in HWRs remains the best source of tritium for fusion R&D. If Canada, the Republic of Korea, and Romania supply the fusion community with their HWR tritium, there is a reasonable chance that 10 kg of T would be available for fusion R&D in 2055.

We call attention to the dependency of the fusion community on events outside its control, most critically the refurbishment of existing HWRs and TEFs, and the construction of new ones in several countries.

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