Tritium Self-Sufficiency

Attaining tritium self-sufficiency is necessary for self-sustaining fusion plants operating on the D-T fuel cycle. Tritium is bred in a lithium-containing blanket surrounding the plasma. The tritium fuel cycle involves many subsystems whose physical and operational characteristics impact the success in achieving tritium self-sufficiency. To insure tritium self-sufficiency, the calculated achievable tritium breeding ratio (TBR) should be larger than the required TBR.

The minimum required TBR should exceed unity by a margin that accounts for tritium losses, radioactive decay, tritium inventory in plant components, and supplying inventory for startup of other plants. The latter two have the largest impact. The required TBR is >1.01 depending on the tritium inventory, required doubling time and other system parameters. The amount of online reserve tritium inventory required is uncertain and need to be assessed. Tritium fractional burn-up impacts tritium inventory. High burn-up fractions are desirable to reduce the required TBR.

Chamber technology concepts utilizing liquid Li or LiPb have the largest potential for achieving tritium self-sufficiency followed by LiSn and Flibe. Among solid breeder candidates, Li_2O has the best chance for achieving tritium self-sufficiency. An effort should be made to reduce the amount of structural material particularly in the FW and front 10 cm of blanket. Uncertainties in calculating the achievable TBR could be as high as ~10% due to uncertainties in nuclear data, calculation method, and modeling. An aggressive effort is required to reduce the uncertainty to <3%.

The achievable overall TBR depends on the confinement scheme due to the impact on breeding blanket coverage and possible limitation on blanket thickness. The IFE system has a clear advantage since no divertor, limiter, heating and current drive systems are employed. Furthermore, IFE systems have nearly full blanket coverage and the blankets can be made as thick as needed without impacting the high cost driver. Absence of magnetic fields in IFE chambers makes it easier to employ flowing liquid breeders. There is no clear advantage for any of the MFE confinement concepts. Better definition of penetration requirements is needed. Even though some MFE confinement concepts suffer from reduced blanket coverage and limited blanket thickness, tritium self-sufficiency can still be achieved with carefully designed blanket concepts.

Two major critical issues were identified. These are

- Tritium supply is currently marginal and diminishes rapidly after 2025.
- Tritium self-sufficiency in DT fusion power plants can not be assured unless specific plasma and technology conditions are met.

The opportunities that exist for resolving these issues are

- Aggressive tritium breeding technology should start without delay.
- Near-term DT burning devices (e.g. ITER-like) should provide for testing breeding technology and have their own breeding capability.
- Definitive demonstration of tritium self-sufficiency can be performed only in a DT fusion facility. These tests do not require long operating time.
- Use existing 14 MeV neutron source facilities and code development to improve the ability to predict tritium breeding.