

**Discussion on blanket and divertor heat capture,
heat transport from blanket to power conversion system,
power conversion system options**

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Power plant concept, proposed as first „Strawman“ for the assessment of power management

Characteristic features of the power plant:

- A) Dual Coolant Lead Lithium blanket concept
- B) Helium cooled divertor target plates
- C) Tritium extraction from lead-lithium by a permeator
- D) Closed cycle helium turbine power conversion system (“BRAYTON cycle”)

Important issues for the heat capture from:

A) DCLL blanket

- Fraction of the total thermal power to be removed with helium
- Achievable helium exit temperatures
- Achievable lead-lithium exit temperatures
- Required pumping power for helium
- Maximum allowable steel/lead-lithium interface temp.

B) Helium cooled divertor target plates

- Allowable maximum heat flux
- Plate, T-tube or finger modules?
- Minimum/maximum allowable temperature of target structure
- Limits on helium temperatures
- Required pumping power

Heat Transport from blanket/divertor to power conversion system

- The total thermal power of blankets and divertors is transported to a common HX of the power conversion system.
- 3 to 6 parallel primary lead-lithium loops between blankets and the HX of the power conversion system. All pipes are concentric tubes with the "hot" LM in the inner tube and the "cold" LM in the annulus. There is thermal insulation arranged in the inner tube in order to have this tube cooled by the "cold" inlet flow to a temperature allowable for ferritic steel.
- Similar concentric tubes are used for the primary helium loop between blankets and HX.
- High temperature tubes are needed for the heat transport from divertor plates to the HX of the power conversion system (anticipated inlet/outlet temperature 600/700 C)

Crucial issues of tritium extraction system

Basic requirement:

Maintain T partial pressure in lead-lithium < 1 Pa in order to:

- Keep the T-inventory in permeator and HX tubes below safety limits
- Minimize tritium permeation losses into helium and the environment outside the coolant pipes of the loops

Key issues of the permeator:

- Mass transfer (tritium) from the flowing LM into the permeation tubes
- Impact of impurities on tritium permeation
- Elimination of potential for air ingress into permeator vacuum chamber

Options for power conversion system

Two candidate concepts:

A) Rankine cycle (Steam turbines)

B) Brayton cycle (Closed cycle helium turbine)

Brayton cycle power conversion system has the advantage that it avoids any potential for steam/water ingress into the liquid metal breeder.

However, it requires the development of large components (turbines, compressors, heat exchangers)

➔ piggy-backing from the development of high temperature fission reactors

Suitable power conversion system and achievable efficiency depend on available coolant temperatures:

Helium cooled blankets with exit temperatures of

450-500 C Rankine cycle efficiency 38-42 %

500-600 C Rankine cycle efficiency 40-46 %

650-700 C Brayton cycle efficiency 40-45 %

Dual Coolant blankets with LM exit temperatures of

650-700 C Brayton cycle efficiency 42-46 %

700-800 C Brayton cycle efficiency 44-50 %

Self cooled LM blankets with exit temperatures of

900-1100 C Brayton cycle efficiency 50-58 %