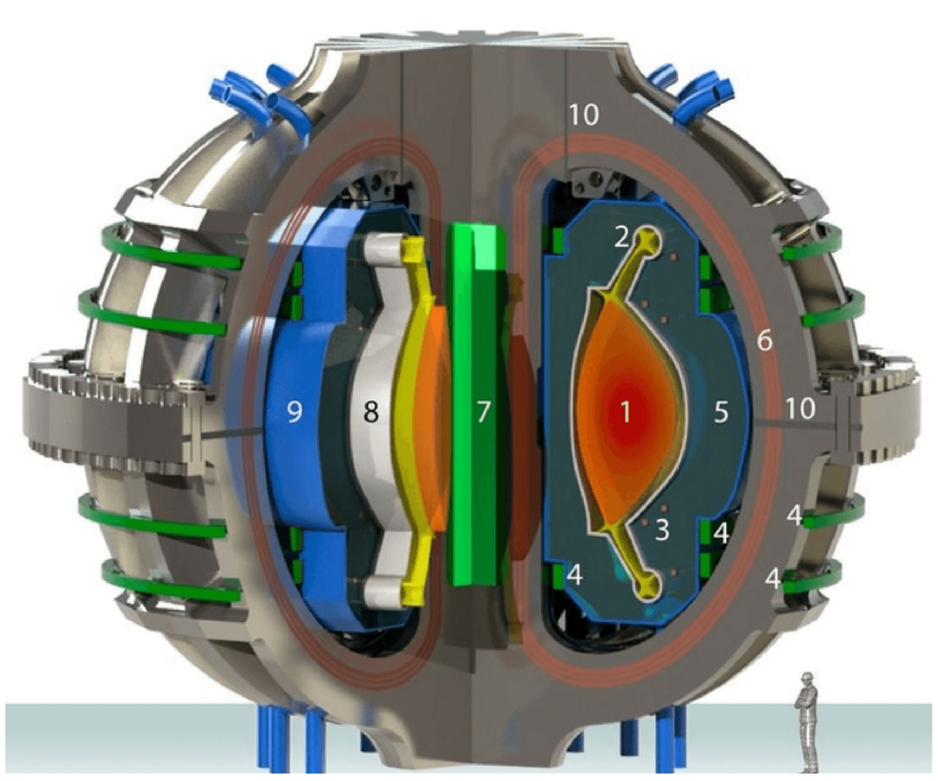
HSLU Hochschule Luzern

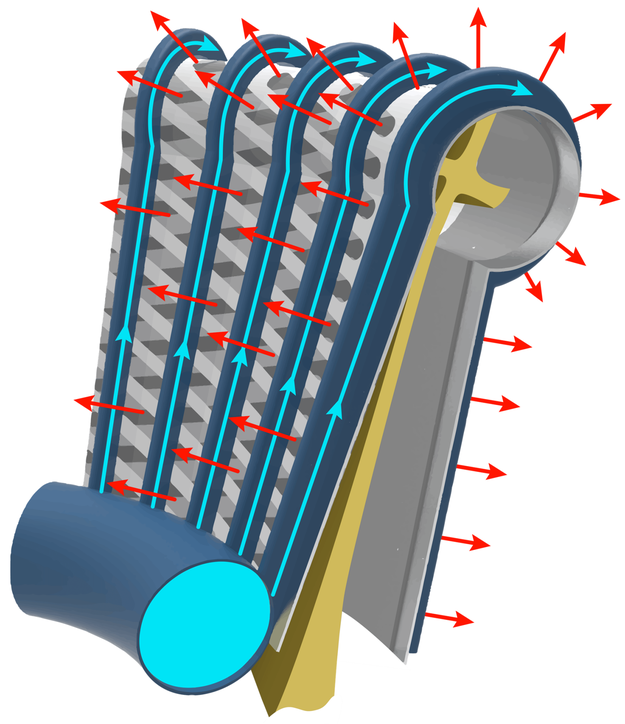
Technik & Architektur
Master of Science in Engineering
Building Technologies

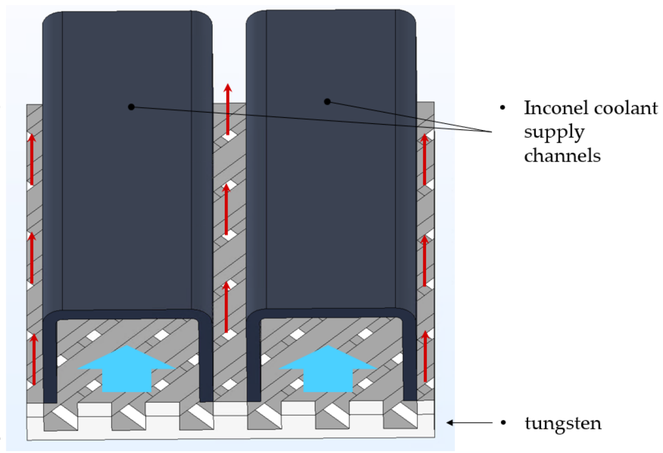
Master-Thesis Energy and Environment

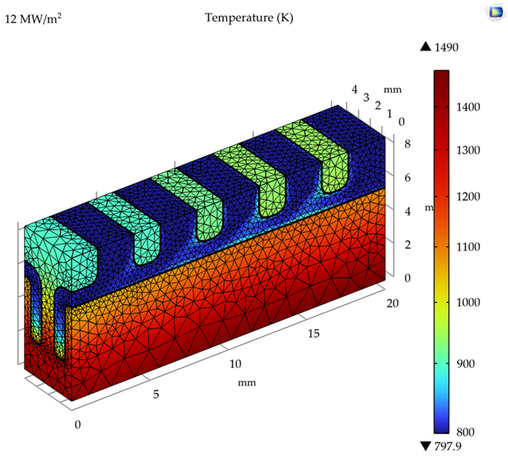
Blanket Cooling of a Fusion Reactor

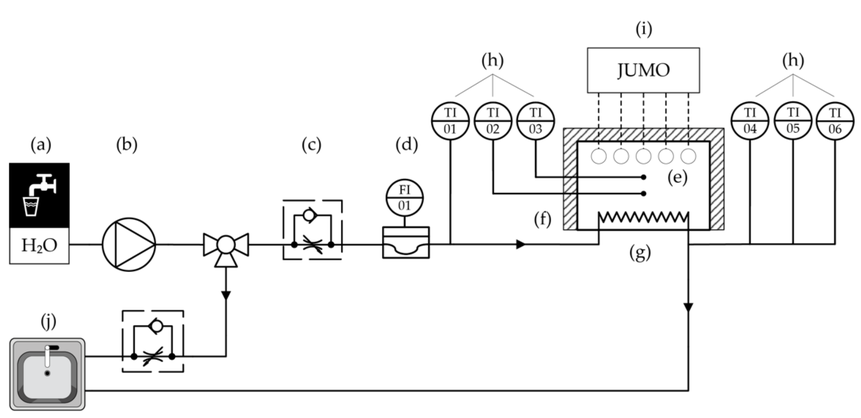


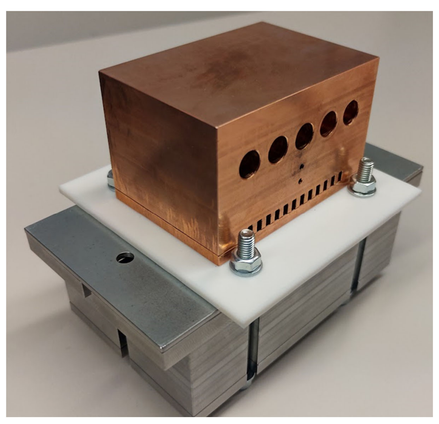
1. plasma
2. newly designed divertor
3. copper trim coils
4. HTS poloidal field coils
5. FLiBe blanket
6. HTS toroidal field coils
7. HTS solonoid
8. vacuum vessel
9. FLiBe tank
10. joints in toroidal field coils

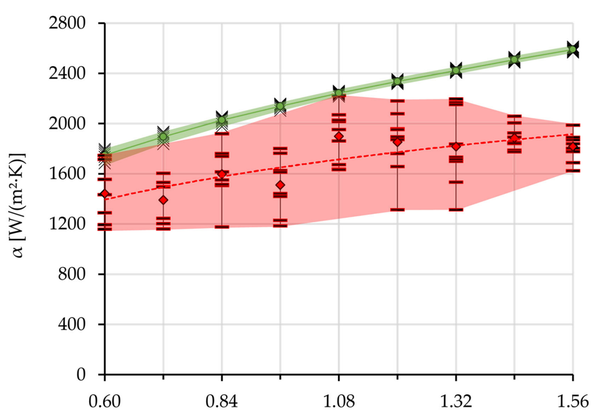












Blanket Cooling
Energy from nuclear fusion of two lighter elements represents the next paradigm in energy generation. It represents the most common type of observable reaction in the universe, the enormous energy released by stars, and the incredible potential it could provide to humanity. These intense reactions create extremely high specific heat fluxes. The Competency Center Thermal Energy Storage (CCTES) is conducting a re-search study based on principle ideas created by Commonwealth Fusion Systems (CFS) to develop a concept for a part of the power exhaust system (PEXS) necessary for the removal of heat from a fusion reactor core. In a former CFS publication, the basic engineering principles for the blanket cooling system within the affordable compact robust (ARC) reactor were described. However, a design proposal for the heat exchange surfaces and heat transfer fluid has not been published yet. The reactor core consists of the fusion fuels reacting in a magnetically confined vacuum vessel re-quiring cooling. Vacuum vessel heat flux density reaches a peak of 12 MW/m2 which needs to be removed via FLiBe (Fluoride-Lithium-Beryllium) molten (liquid) salt to maintain material integrity.

Design Proposal
It was feasible to construct millimeter-scale channels in a flat plate to transfer enough heat to satisfy the boundary conditions. This was discovered using an unvalidated numerical simulation. Further iteration with numerical tools requires validation through comparison with empirical measurements. This phase of the project was the construction of an experimental test rig to collect measurements and compare them with a numerical model. External industry experts in the field were consulted for guidance and/or expertise in using the materials proposed. The results were collected and analyzed to determine the accuracy of the simulated results with experimental measurements. Conclusions and future development recommendations are offered as this an active area of research and development within the fusion reactor design community. The design proposal was inspired by other work done at HSLU as well as external applications requiring high-power heat transfer methods. A cross-fin construction was fabricated using copper and steel as an analogue for the tungsten and Inconel construction. The purpose was to validate the COMSOL model with an experimental set-up designed for measurement and comparison. Recommended changes for further development of the model to include features important to heat transfer are necessary to bring simulated results in better agreement with experimental measurements.

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