The UW-Madison Fusion Forward Path to Commercialization

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INFUSE FY2026 Workshop, Oak Ridge, TN, November 2025

Work Supported by the Wisconsin Alumni Research Foundation

UW-Madison is Developing Tools to Support Fusion Commercialization

Existing capabilities to address challenges of harnessing fusion energy

- Radiation transport & neutronics analysis
- Materials activation
- Parametric modeling for stellarator blankets
- Tritium production & fuel cycle

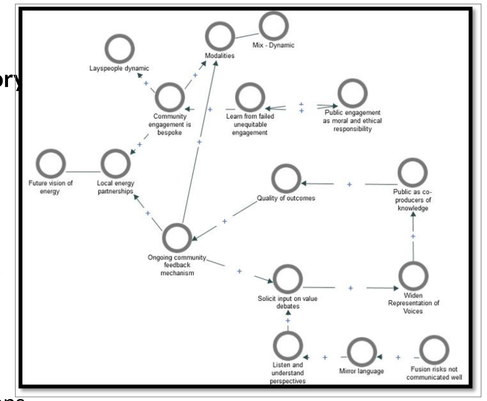
A transdisciplinary approach to address the challenges of rapidly emerging technologies

- Public perception and engagement
- Fusion impacts
  - life cycle assessment
  - regulation and policy
- Safety and risk mitigation

Developing Public Engagement Models to Minimize Risk

Goal: Build trust and transparency with society as new technology is developed while also ensuring a favorable regulatory environment

- Performing surveys of both fusion stakeholders and broader public to determine
  - Experts' mental model of public engagement
  - Public perceptions of fusion and its risks
  - Willingness to engage with or support fusion projects
- Assess how transparency shapes trust, perceived risk, and engagement intent
- Provide evidence-based recommendations for fusion risk communication strategies



Life Sciences Communication
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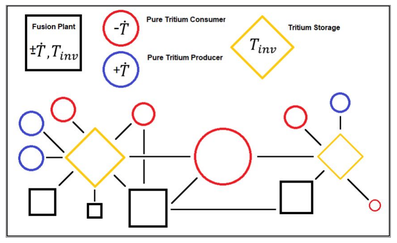
Fusion Fuel Cycle Modeling with Cyclus Underway

- Fuel cycle markets can be complex with many types of facilities
- TRICYCLE models the tritium fuel cycle within a single facility
- CYCLUS models a system of interdependent facilities



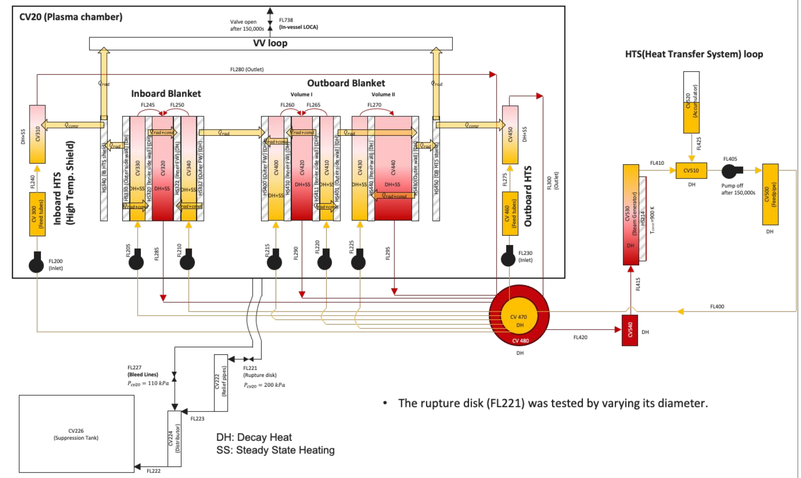
CYCLUS

Fission Tools Adapted for Fusion Risk & Safety Analysis

MELCOR thermal-hydraulics code being adapted for fusion use

- models the progression of accidents
- spectrum of accident phenomena
  - reactor cooling system and containment fluid flow
  - heat transfer
  - aerosol transport
- Used for accident analysis in ITER's Preliminary Safety Analysis Report (RPrS) and ARIES Design Team safety analyses.
- Currently being coupled with TMAP.
  - tritium migration analysis program (TMAP) treats multi-specie surface absorption and diffusion in composite materials with dislocation traps, plus the movement of these species from room to room by air flow within a given facility

❑ **Blanket and High Temperature Sheilding (HTS) loop systems**

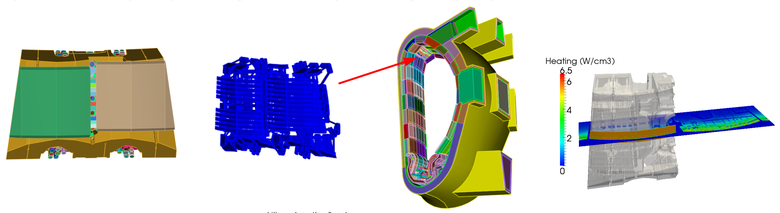


- The rupture disk (FL221) was tested by varying its diameter.

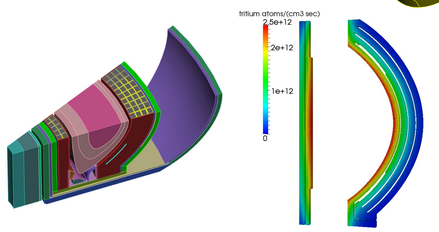
UW is Advancing Tools for Neutronics Analysis and Materials Activation

- Monte Carlo analysis can be performed on 1-D, 2-D, or detailed 3-D models
- Detailed CAD based analysis using DAGMC (DAG-MCNP or DAG-OpenMC)
- Significant experience preparing and repairing highly detailed CAD models

ITER BM08 Heating (detailed CAD model with DAG-MCNP)

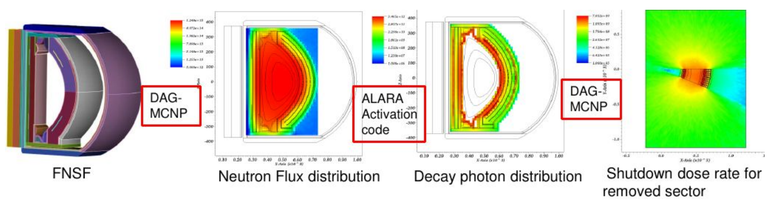


FNSF Tritium production (detailed CAD model with DAG-MCNP)



- Neutron activation analysis can be performed to determine important responses such as shutdown dose rate, decay heat levels, and radioactive waste disposal ratings

FNSF Shutdown Dose Rate with mesh based PyNE R2S method (detailed CAD model with DAG-MCNP)



ParaStell

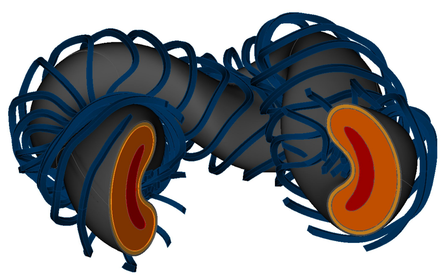
3-D, medium-fidelity, parametric modeling for stellarator blanket

- Model homogenized in-vessel components of uniform or non-uniform thickness
- VMEC geometry, custom first wall data, and user-defined parametric radial build
- Model magnet coils using coil filament point-locus data and a user-defined cross-section

Neutronics support

- DAGMC geometries
- Tetrahedral neutron source meshes
- Neutron wall loading calculations

Open source Python package:
https://github.com/svalinn/parastell

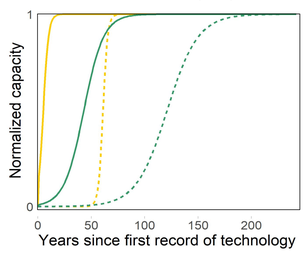


Life Cycle Assessment for Enterprise Deployment Based on Design Choices

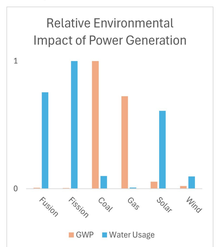
Life Cycle Assessment of environmental impacts & materials supply risks

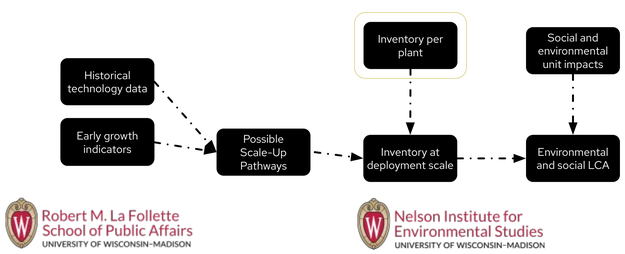
- Inventory hypothetical, grid-scale fusion plant designs focusing on blanket and confinement technology choices
- Model future growth of fusion capacity based on historical technology growth rates and near-term fusion construction targets
- Use environmental impacts database to calculate impacts and trace supply chains of different materials for various plant designs and scale up options

S-curves for Deployment



LCA Comparison of Technologies





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