International Atomic Energy Agency

Contribution ID: **11** Type: **Oral**

Reliability Optimised Blanket Using Simulation & Test: A Novel Approach to Breeder Blanket Design

Tuesday 2 September 2025 17:10 (30 minutes)

Many public and privately funded fusion reactors are due to begin operation around the middle of the 21st century, the vast majority of which will rely on a deuterium and tritium fuel cycle, with a lithium-containing breeder blanket responsible for providing a sustainable tritium supply. The tritium consumption of large (DEMO-scale) devices will be in the order of 100kg per full power year, several times the current global civil tritium inventory of approximately 35kg. Whilst tritium breeding in fission reactors has supplied experimental devices (the Joint European Torus tritium inventory was limited to 90g), supporting a global fusion industry in this way is not a viable solution.

Breeder blanket technologies are immature and are yet to be tested in operational tokamak environments, where tritium breeding and extraction requirements must be met whilst maintaining structural integrity under thermal and electromagnetic loads, plasma disruption events and high neutron fluences. Therefore, it is crucial that blanket design is approached using a methodology with a proven record for success, that minimises risk and ensures thorough exploration of the associated design space.

The aim of this work is to develop blanket concept designs by utilising industry-standard systems engineering processes and methodologies. These include requirements capture, requirements validation and verification, Model-Based Systems Engineering (MBSE), Failure Modes & Effects Analysis (FMEA) and concept generation and selection methodologies.

A requirements verification plan lays out a detailed description of the verification activities that need to be executed in order to verify breeder blankets designs –including simple 1D analysis, complex transient 3D high fidelity simulations and a range of experiments and tests, forming the basis of a qualification plan.

Additionally, an analysis workflow has been developed which links an integrated set of analysis models, which provide low-fidelity concept design verification through a pre-conceptual multiphysics systems simulation, covering neutronics, thermal hydraulics, structural analysis and fuel cycle assessments.

Finally, the project has developed a methodology to provide uncertainty quantification for the key performance parameters such as tritium breeding ratio. The output is a range of down-selected blanket concepts corresponding to minimal risk and highest likelihood of meeting the sub-system (i.e. Breeder Blanket) requirements. This has allowed for the exploration of novel areas of design space, alongside the rationale which has led to the decisions.

Speaker's title

Mr

Speaker's email address

david.pickersgill@ukaea.uk

Country/Int. organization

United Kingdom of Great Britain and Northern Ireland

Affiliation/Organization

United Kingdom Atomic Energy Authority

Author: PICKERSGILL, David (United Kingdom Atomic Energy Authority)

Co-authors: Mr SAIGIRIDHARI, Anurag (United Kingdom Atomic Energy Authority); Mr BAILEY, James (United Kingdom Atomic Energy Authority); Mrs BAXTER, Michelle (United Kingdom Atomic Energy Authority); Mr ROSINI, Sebastian (United Kingdom Atomic Energy Authority); BARRETT, Thomas (Culham Centre for Fusion Energy (CCFE)); Mr DEIGHAN, Tom (United Kingdom Atomic Energy Authority)

Presenter: PICKERSGILL, David (United Kingdom Atomic Energy Authority)

Session Classification: Topic I

Track Classification: Track I: Breeding blanket design and performance