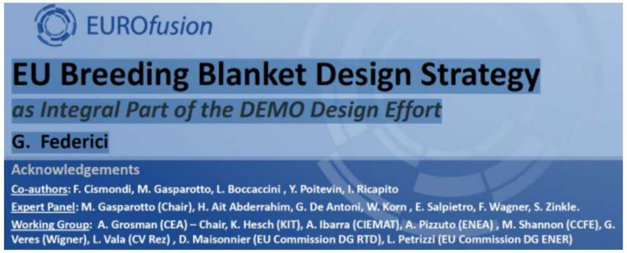
SAND2019-2942PE

Integration of Fuel Cycle Components Thrust

Richard E. Nygren, Sandia National Labs



Examples of possible program elements

- (c) Develop blanket integration metrics
- (c) Evaluate blanket concepts re: integration, i.e., confirm fidelity (concept operates with other systems, e.g., tritium loop, BoP, div.).
- (a) Develop concepts for shaped FW protection; develop requirements to integrate these with blankets.
- (b) Identify preferred/excluded combinations of technology and confinement systems,
  e.g., ST + LiqSurf – Current Drive
- (c) Develop US working group and expertise; collaborate with international partners.

FW protection PFCs likely will displace volume for breeding

all blankets work for all confinement types — **NOT**

(a) *also part of another proposed Thrust*
(b) *differs from working assumptions elsewhere, e.g.., Meade et al. Roadmap activity*
(c) *activities with international partners*

Sandia National Laboratories

Exceptional service in the national interest

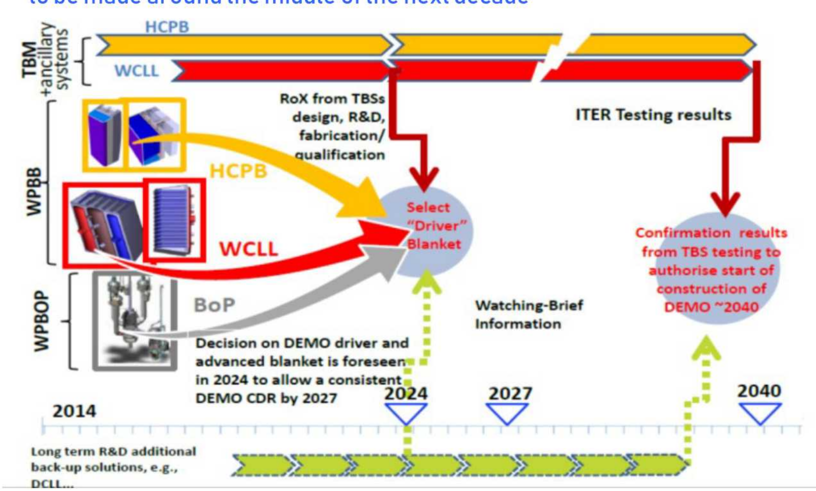
EU Breeding Blanket Design Strategy

as Integral Part of the DEMO Design Effort

ederici — EUROfusion

Key Recommendations

- The decision on the driver blanket cannot be made today, because of the existing performance uncertainties and feasibility concerns
- However, a down-selection is possible and R&D is in place for a decision to be made around the middle of the next decade



HCPB design and R&D

KIT

- Li_4SiO_4 tritium breeder material, Be neutron multiplier
- He coolant (inlet 300°C, outlet 500°C, 8 MPa).
- Sandwich-like structure of parallel cooling plates (CPs)
- He purge gas (0.2 MPa) with 0.1% wt. H_2 (doping agent)

Areas of research:

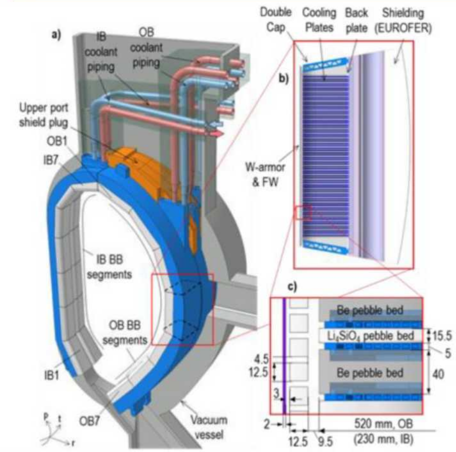
- Purge gas chemistry: use H_2O as doping agent (to form tritiated water species, instead of HT).
- Improving the nuclear performance simplifying the design to minimize the amount of steel
- Simpler blanket internals reduce the Δp from former designs (Pumping power of ~130 MW).

Key issues still need to be solved:

- Strict restriction on the upper circulating power for He coolant.
- Large tritium inventory in Be at end of life.

Alternative design concepts explored:

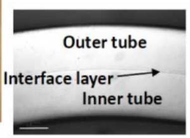
- Enhanced design hexagonal arrangement of fuel-breeder pins: simpler blanket internals, x10 less cooling channels with significant reduction of plant circulating power, improved reliability.
- $Be_{12}Ti$ as n-multiplier to minimise T inventory.



F. A. Hernández et al., O2C.1

Other Technology Achievements: DEMO Blanket Manufacturing

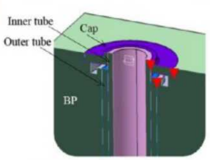
Fabrication of DWT (Double Wall Tube)

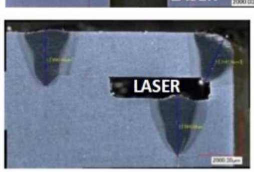


L. Forest et al., (O1B.5)

DWT to Back Plate welding

cea den

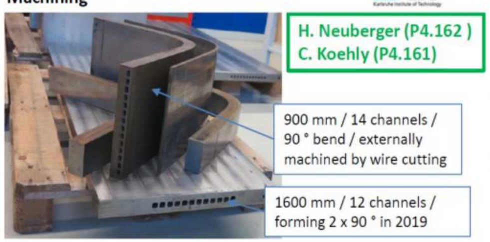




Electrical Discharge Machining / Forming / Machining

KIT

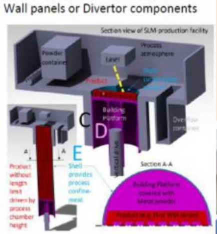
H. Neuberger (P4.162)
C. Koehly (P4.161)



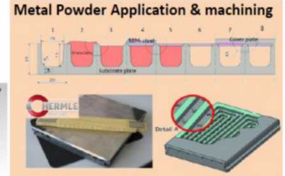
Innovative routines based on Additive Manufacturing

Selective Laser Melting

Concept for continuous production by SLM e.g. for fabrication of First Wall panels or Divertor components



Metal Powder Application & machining



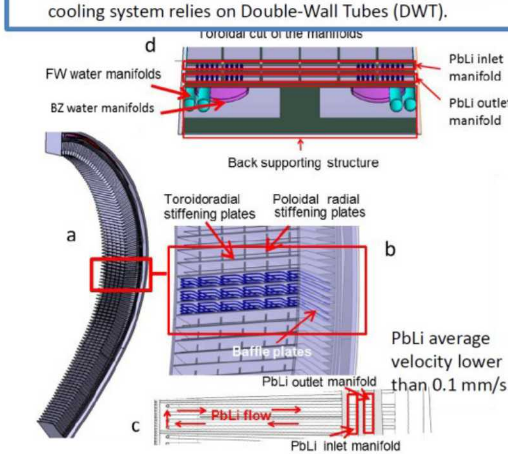
WCLL design and R&D

ENEA

- PbLi as breeder, n-multiplier and T carrier.
- Water coolant at PWR conditions: 295 – 328 °C @ 15.5 MPa.
- Two independent loops: FW and BZ. FW loop can remove the maximum average plasma heat flux (1.17 MW/m²); BZ cooling system relies on Double-Wall Tubes (DWT).

Areas of research:

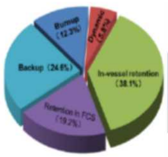
- Analyse design alternatives to optimize the internals, the PbLi distribution, draining capability and minimize the MHD issues.
- R&D on accidental scenarios with water/steam ingress into the PbLi.
- R&D on permeation barriers: production and characterization of Al_2O_3 coating developed by Pulsed Laser Deposition (PLD) and Atomic Layer Deposition (ALD).
- R&D to qualify the Permeator Against Vacuum (PAV).
- Development of computational tools and experiments for PbLi flow under MHD flows.
- EUROfusion/ US collaboration – upgrade of MAPLE facility at UCLA. equipped with a rotating magnet. Study the mixed-convection phenomena of volumetrically heated PbLi flowing in variable magnetic fields. First experiments are running.
- Develop suitable T transport models and computational tools.



A. Del Nevo et al., O2C.2

Achieving acceptable tritium inventory is extremely challenging.

PbLi fuel cycle Humrickhouse & Merrill FED2017



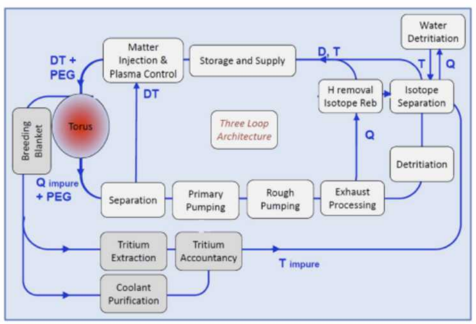
The makeup of startup tritium for CFETR.

Burnup (g)	Dynamic (g)	In-vessel retention (g)	Retention in FCS (g)	Backup (g)	Total (g)
226	107	661	353	452	1799

Totally, CFETR may need around 2 kg of tritium for startup.

Present Progress and Activities of CFETR
Y Xan, J. Li, SOFT2018

Smart DEMO Fuel Cycle Architecture



A Smart Architecture for the DEMO Fuel Cycle
C. Day SOFT2018

1 critical R&D - blanket/fuel-cycle

- *Tritium inventory will severely limit choices for materials and components. Systems integration renders many concepts infeasible.* **feasibility**
- *Evaluations needed to focus the R&D path.* **strategy**

2 cross-cutting & common elements

- *Science of tritium in materials*
- *Heat & mass transfer, systems integration*

3 US focus (elements/strategy) **strategy**

- *Develop metrics for design/systems integration*
- *Evaluate US and foreign designs; share information*
- *Leverage this engagement to develop depth for fusion applications. and for access by other US researchers to experiments and testing at foreign facilities.*

Why US: Unique US capabilities and legacy

- Capabilities at STAR and SRNL are unique.
- US has well-established history in design studies and development of issues for FNS. Some of this is old and ITER has added much depth, but world recognition is still there.
- Some prior work at UCLA and through PHENIX task.

Thank You

and Best Wishes for the New Year

Questions/Discussion