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Fusion Pathways and Technology Needs:

Contribution to discussion

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Power Plant Physics and Technology

EUROfusion

POWER PLANT PHYSICS & TECHNOLOGY DEPARTMENT

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External Constraints: Framing the Program When?

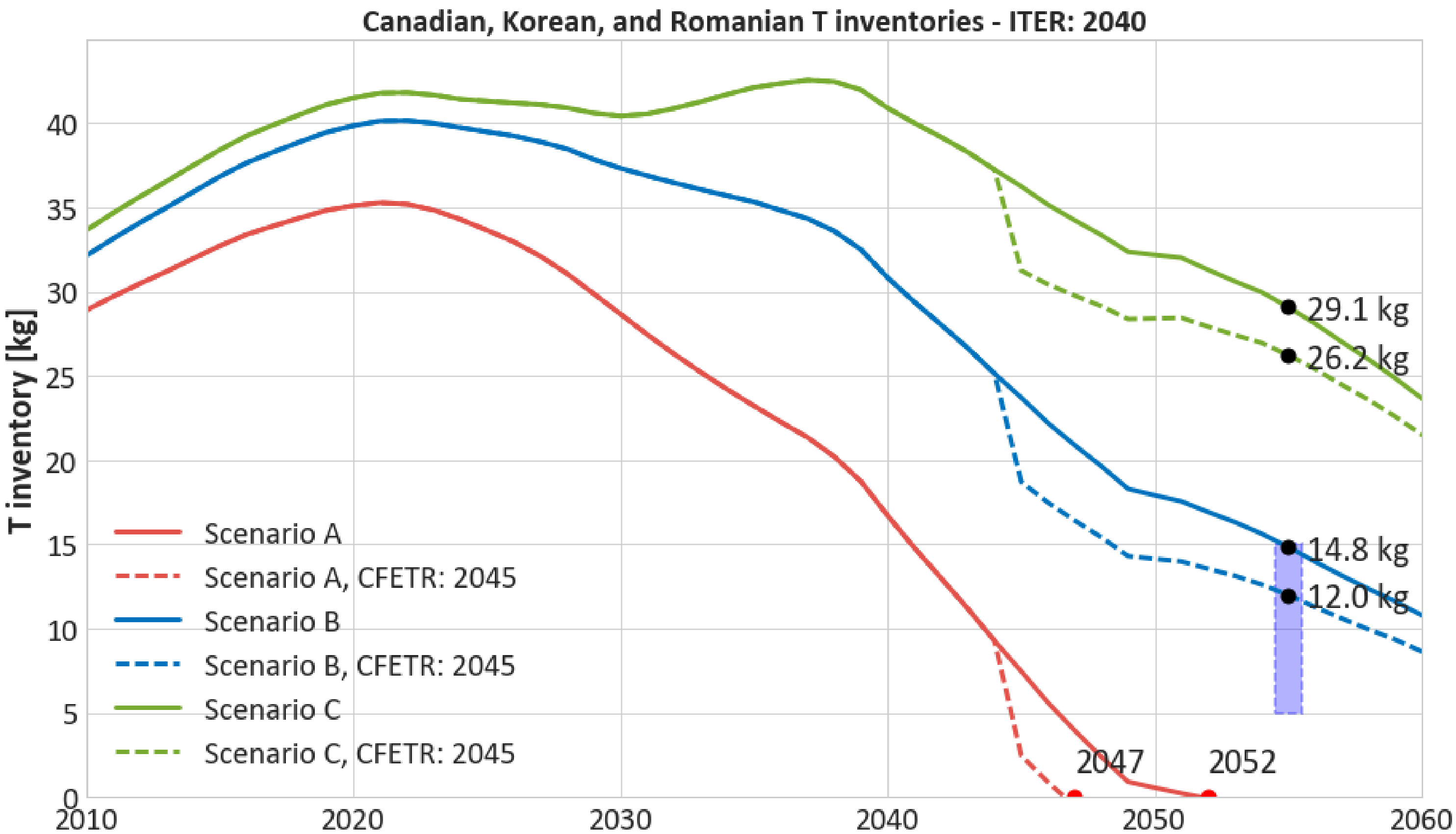
Fusion Design and Engineering expertise is scarce and keeps getting scarcer

- Over the next few decades, not many nuclear reactors being built:
  - Few (60) new fission plants being constructed today, majority in China, India, Russia. Unfavorable future prospects in many countries. Loss of experience and consolidation of vendors.
  - Only a handful of nuclear fusion reactors will exist and operate in the next 20 years: ITER and probably the Chinese Fusion Engineering Test Reactor (CFETR).
- An entire generation of engineers will have brought ITER to fruition, and if the DEMO EDA starts too long after ITER is delivered this highly skilled and experienced workforce will be lost to other industries. **Brain Drain and loss of lessons learned!**
- A large gap from the end of construction and assembly of ITER to the Engineering Phase of DEMO would lead to the **loss of industrial interest and expertise that is critical to DEMO**.

Over time, fusion becomes increasingly sensitive to factors outside our control:

- **Politics:** to justify the continued use of public funds to develop nuclear fusion, there must be an **emphasis on a solution that allows fast deployment of fusion energy**.

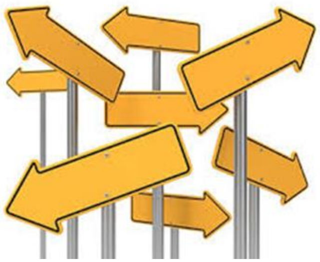
External Constraints: Framing the Program **When?**



Kovari et al, 2017, accepted in NF

- `**Tritium:** A central issue for fusion development. (1) The production of T is largely outside the control of the fusion community. (2) Many uncertainties regarding the future commercial and defence consumption of T. (3) **There *may* only be enough T for one DEMO that enter in operation < 2060.**

Key Messages



- ✓ **A credible roadmap**, i.e., a plan that matches short-term and long-term goals. ITER is an essential element of this roadmap. **Otherwise one gets lost…..**
- ✓ **A lot of discussions about making fusion smaller, cheaper, and faster, but there is no magic bullet to solve the integrated design problem.** Every time you squeeze somewhere, you make problems worse elsewhere…EU-DEMO is current viewed to be the lowest risk option to meet all targets within given timescales (this does not mean it is low risk!)
- ✓ **Stay away from applied science fiction.** Need to be careful with readiness of physics and technology assumptions. This makes a huge difference in the machine design and parameters.
- ✓ **Do not postpone integration** assuming that it restricts innovation and inhibits an attractive plant designs. If you do, you risk developing design solutions that cannot be integrated in practice.
- ✓ **New ideas are welcome but there is a tendency to reinvent the wheel.** A lot of good work has been done in the past.

Key Messages (cont'd)

- ✓ **Fusion is a nuclear technology and as such will be assessed with full nuclear scrutiny by a regulator.**
- ✓ **Safety, reliability, maintainability are the key drivers: allow for design margins as well as redundancy within systems to ensure more fault tolerant design.**
- ✓ **Emphasis should be on maintaining proven design features (e.g., use mature technology) to minimize risks.**
- ✓ **Plant design should drive R&D and not the other way round.**
- ✓ **Traceable design process with rigorous SE approach.**
- ✓ **Main challenges**: a) Integration of design drivers across different systems; b) High degree of complexity/ system Interdependencies; c) Design dealing with uncertainties (physics and technology).
- ✓ **Try to involve early industry….to avoid surprises later.**