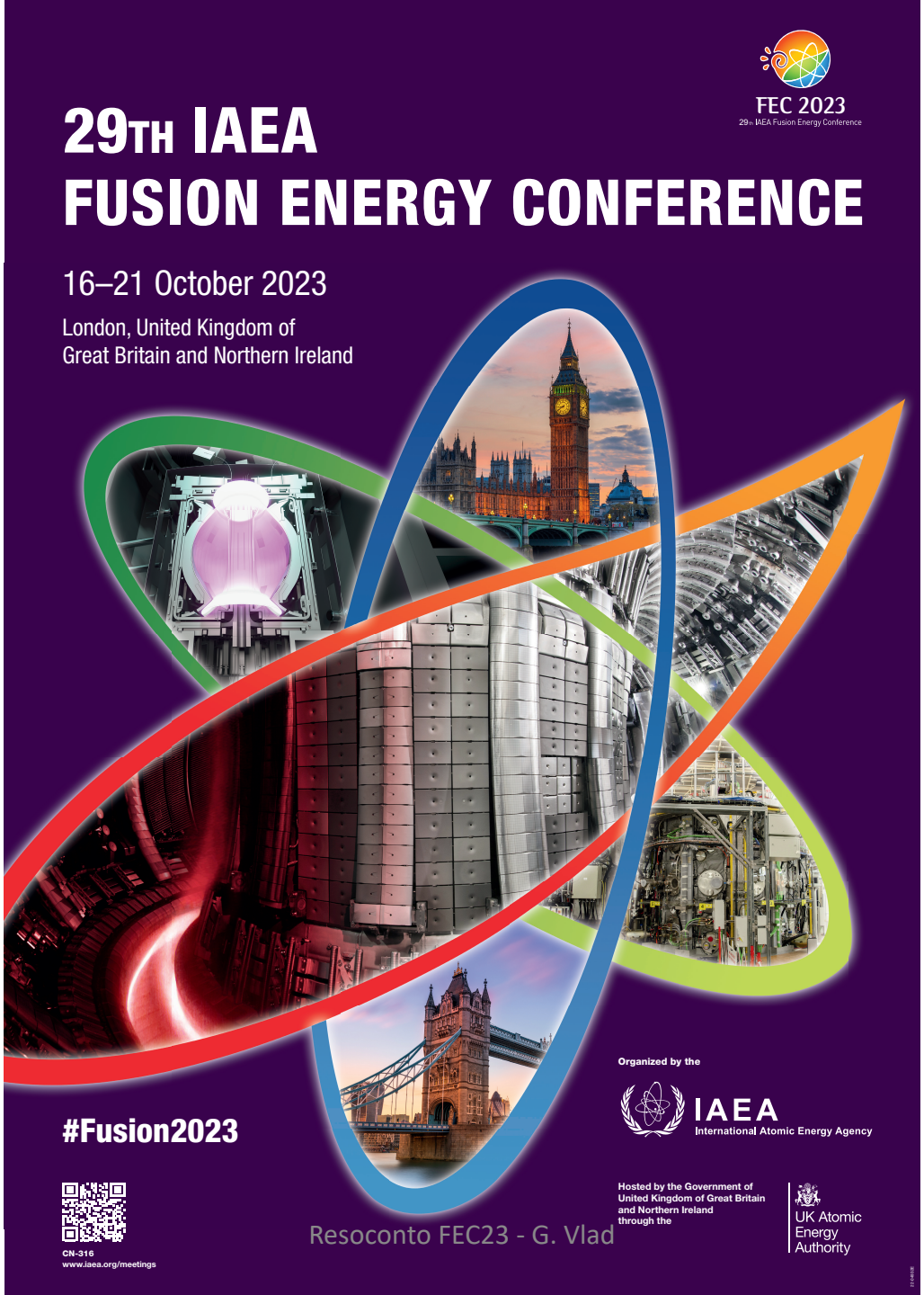
FEC 2023
29th IAEA Fusion Energy Conference
29TH IAEA
FUSION ENERGY CONFERENCE
16–21 October 2023
London, United Kingdom of
Great Britain and Northern Ireland
#Fusion2023
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Authority

Monday 16 October 2023

O/1 Opening & High Level Session (08:30-11:00)

08:30	O/1-1	**R. Grossi** Opening Statement by IAEA Director General	IAEA
08:40	O/1-2	**A. Bowie** Opening Statement by UK Parliamentary Under Secretary of State (Minister for Nuclear and Networks)	UK
08:50	O/1-3	**Rafael Mariano Grossi** **I. Chapman** **Andrew Bowie** **Pietro Barabaschi** **Jean Paul Allain** **Satoshi Konishi** High-level Panel on "World Fusion Outlook"	IAEA UK UK ITER DOE Japan
09:50	O/1-4	**I. Chapman** UK Fusion Program	UK
10:10	O/1-5	**Nuclear Fusion Journal Representative** Nuclear Fusion Journal Awards (2021-2023)	IAEA
10:45		**IAEA FEC Secretariat and Technical Programme Committee Chair** Administrative and Technical Remarks	IAEA

OV/1 Overview 1: Burning Plasmas and Long

Chairperson: Arianna Gleason-Holbrook (USA) **(11:00-12:45)**
Co-Chairperson: Melissa Denecke (IAEA)

11:00	OV/1-1	**C. Maggi** Overview of T and D-T results in jet with ITER-like wall	UK
11:21	OV/1-2	**A. Pak** Target gain >1 from inertial confinement fusion implosions at the National Ignition Facility	USA
11:42	OV/1-3	**P. Barabaschi** Progress on ITER manufacturing, construction, commissioning and plans	ITER
12:03	OV/1-4	**X. Gong** Overview of recent experimental results on EAST tokamak	P.R. China
12:24-12:45		**Discussion, Q & A**	

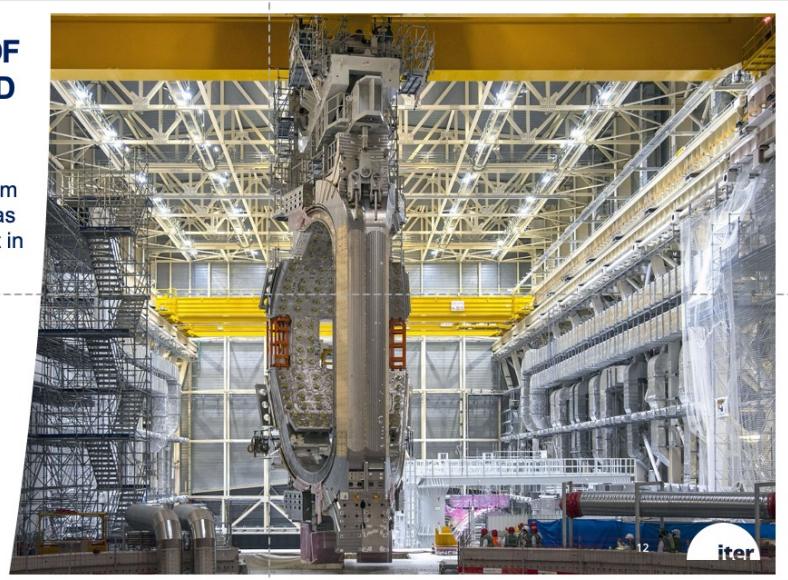
P. Barabaschi (DG-ITER)

- Power supply system completed
- Toroidal Field Coils: all 19 (18+1) manifacturing completed, 17 already on site, 2 on the way
- Poloidal Field Coils: to be finished 2023
- Central Solenoid: 2nd module installed, 3rd module arrived from San Diego, module #3 damaged during testing, now being repaired, will be used as a spare
- Cooling System operational
- Cryogenic Plant completed, pre-commissioning phase
- ...

P. Barabaschi (DG-ITER)

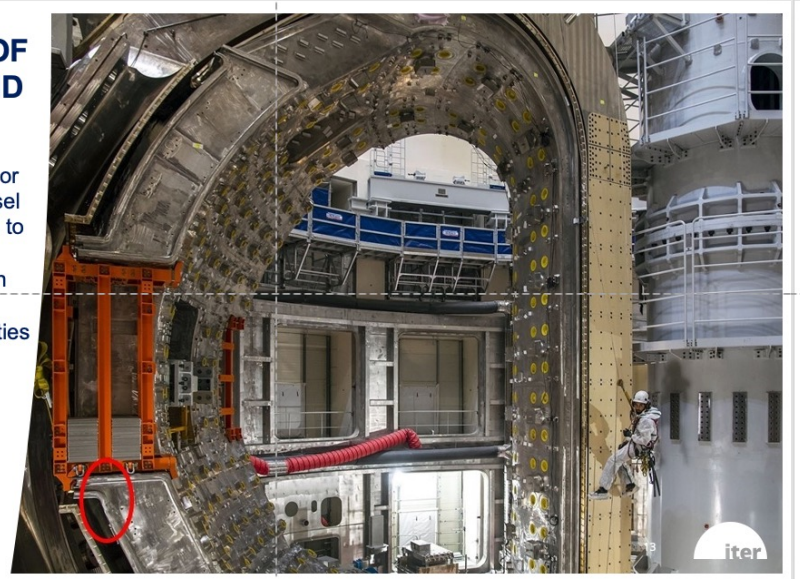
CHALLENGES OF FIRST-OF-A-KIND COMPONENTS

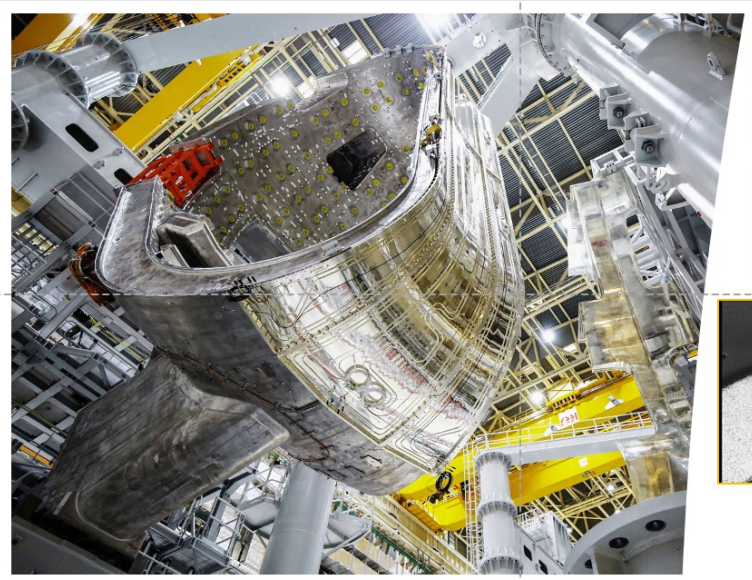
The first complete Vacuum Vessel Sector Module was lifted into the tokamak pit in May 2022 ...



CHALLENGES OF FIRST-OF-A-KIND COMPONENTS

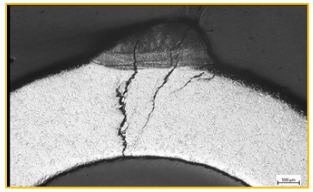
… but the sector-to-sector welding of Vacuum Vessel sectors was reassessed to be too challenging to perform *in situ,* based on the previously identified geometric non-conformities in the field joints.





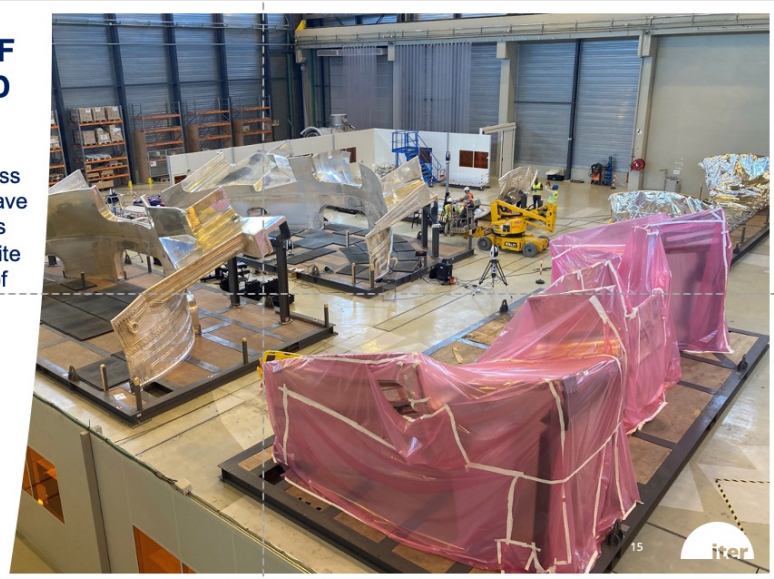
CHALLENGES OF FIRST-OF-A-KIND COMPONENTS

Leakage was also identified in thermal shield cooling piping due to chloride stress corrosion.



CHALLENGES OF FIRST-OF-A-KIND COMPONENTS

Repair contracts to address these non-conformities have been awarded, and teams have been deployed on site executing the first steps of the repair campaign.



P. Barabaschi (DG-ITER)

PREPARING AN UPDATED BASELINE by Mid-2024

The current ITER cost and schedule "baseline" was set in 2016. A review of the baseline is underway, and a new baseline proposal will be presented to the ITER Council in 2024.

Overall objective: to achieve Q=10 as soon as possible, with a plan that includes contingencies.

Key challenges and considerations include:

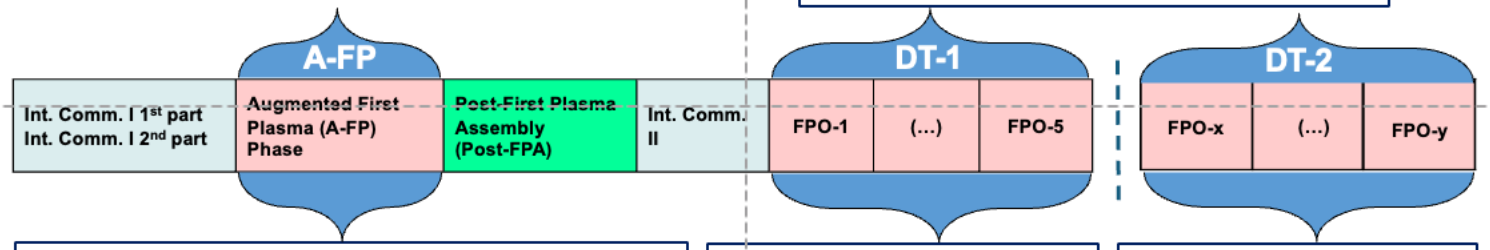
- Known delays created by the Covid-19 pandemic and First-of-a-Kind technical challenges.
- Repairs to the Vacuum Vessel sectors and Thermal Shield cooling pipes, as described.
- Ensuring alignment with ASN, the French nuclear safety regulator, in part by implementing a stepwise approach to safety demonstration.
- Reconsideration of Vacuum Vessel welding sequence, to control deformations.
- 4 Kelvin testing of some Toroidal and Poloidal Field coils.
- Realistic timing for assembly and commissioning.
- First Wall Material Beryllium → Tungsten.
- Adjustments to scope of First Plasma campaign, followed by two DT operational phases.

NEW BASELINE MACHINE CONFIGURATION

P. Barabaschi (DG-ITER)

- 40 MW EC heating power (4 Upper + 1 Equatorial Launchers)
- 10 MW of ICWC & ICH
- Boronization system (Glow Discharge Cleaning + *dropper*)
- Full in-vessel coil system (ELM control and VS)
- 4 Pellet injectors (fueling + ELM control)
- W divertor (water cool.) + inertially cooled W wall in key areas

- **All A-FP systems, plus FW, TBM, …**
- 67 MW EC heating power (4 Upper + 2 Equatorial Launchers)
- 33 MW Neutral Beam (NB) heating power
- 10 → 20 MW IC heating (depending on A-FP tests)
- 50 MW NB upgrade for DT-2



- Fully commission tokamak system (including divertor)
- Demonstrate H-mode (DD) plasmas **5.0-7.5 mega-amperes (MA) / 2.65 Tesla (T).**
- Commission Plasma Control, Protection and Mitigation Systems (including DMS) to **15 MA / 5.3 T.**

- **Q = 10, 300-500 second pulses.**
- 1% of total fluence
- Confirm safety demonstration for DT-2

- Confirm reliable operation
- **Q=5, to 3000 seconds**
- Full TBM qualification
- 100% of total fluence

THE QUESTION OF FIRST WALL MATERIAL: Beryllium or Tungsten?

The question of First Wall (FW) Material remains key: today we have no proven material for FW that is compatible with a power production fusion device.

Explaining the ITER team decision to change the FW material from Beryllium (Be) to Tungsten (W):

1. Is ITER's *raison d'etre* to reach Q = 10 and a conduct a set of experiments? Or to serve as precursor to DEMO?
   - Answer: **both**
2. Concerns regarding excessive erosion of Be (first wall lifetime, dust production and tritium retention)
3. Concerns regarding structural integrity after disruption damage, due to FW design
4. Concerns on maintainability in the commissioning phase, due to Be toxicity

All fusion devices designed for a burning plasma plan to use W as armour material; therefore, the remaining concerns of W, related to plasma compatibility and suitable risk mitigation (e.g., boronization) must be further developed.

P. Barabaschi (DG-ITER)

CONCLUSIONS

- ITER construction and commissioning has made significant progress since last IAEA FEC.
  - Serious issues have been identified, related to the Vacuum Vessel sectors, Thermal Shield piping, integrated assembly and licensing strategy.
- To address these issues while also providing a robust approach to licensing, safety demonstration and scientific exploitation, an updated Baseline will be presented to the ITER Council in 2024.
  - Augmented First Plasma (nuclear operation in DD);
  - DT-1 (Q = 10 with low fluence);
  - DT-2 (full achievement of all project goals).
- Cold tests of TF coils and PF1 will be carried out before in-pit installation.
- Change of First Wall material from Beryllium to Tungsten will lead to other changes:
  - Modified mix of Heating & Current Drive power, optimized for DT-1
  - Boronization system
- **Support from ITER Members is essential as we refine New Baseline Research Plan and to address outstanding R&D issues!**

TECH/4 Next steps and Heating & Current drive

Chairperson: Jérôme Bucalossi (France) **(10:40-12:20)**
Co-Chairperson: Matteo Barbarino (IAEA)

10:40	TECH/4-1	**G. Federici** Status and prospects for DEMO related developments in EUROPE	Germany
10:57	TECH/4-2	**J. Kang** Assessing the technological and physics maturity required for the design space of the K-DEMO	Korea
11:14	TECH/4-3	**Y. Sakamoto** Progress of basic conceptual design of JA DEMO	Japan
11:31	TECH/4-4	**U. Fantz** Contributions of the extended ELISE and BATMAN Upgrade test facilities to the roadmap towards ITER NBI	Germany
11:48	TECH/4-5	**H. Tobari** Progress on long-pulse and ITER-relevant-intensity negative ion beam accelerations for ITER neutral beam injector	Japan
12:05-12:25		**Discussion, Q & A**	

PWF Pathways to fusion

Chairperson: Richard Buttery (USA) **(14:00-16:35)**
Co-Chairperson: Matteo Barbarino (IAEA)

14:00	PWF-1	**R. Buttery** Introduction	USA
14:05	PWF-2	**D. Brunner** Commonwealth Fusion Systems' High-Field Path to Fusion Energy ***Continued...***	USA
14:17	PWF-3	**B. Grierson** Design and Technology Maturation of General Atomics Steady-State Advanced Tokamak Fusion Pilot Plant	USA
14:29	PWF-4	**A. Becoulet** Pathways to fusion energy – the ITER contributions and views	ITER
14:41	PWF-5	**A. Donné** The European path towards fusion electricity	Germany
14:53	PWF-6	**S. Ishida** Pathways to fusion energy at the QST	Japan
15:05	PWF-7	**T. Pedersen** The High Field Stellarator Direct Path to Fusion Energy	USA
15:17	PWF-8	**S. Diem** Reimagining The Design Of Fusion Energy Systems In Support Of A Just Energy Transition	USA
15:29	PWF-8	**K. Masuda** EX-Fusion: Advancing high power high repetition laser as a platform for laser fusion power	Japan
15:41-16:00		**Discussion, Q & A**	
16:00-16:35		**Discussion with invited panel**	

Why the revision?

Interest in fusion has grown enormously thanks to

- Fusion research successes at JET, NIF, W7-X, Medium-Sized SC Tokamaks, ITER assembly
- Realization that baseload electricity power plants are essential for energy transition & security
- Booming of private fusion efforts

Present Roadmap contains all the linked elements of a reactor-oriented program but is based on a sequential JET-ITER-DEMO approach

- Delays have impacted ITER, but also JT-60SA, IFMIF-DONES and DTT
- Unique and valuable lessons learned from every stage of the ITER project can and must be integrated into the Roadmap

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Main elements of the Roadmap revision

1. Definition of the DEMO step
2. Gaps to be addressed
3. Measures to accelerate the DEMO and FPP programs
   - Parallelization of ITER and DEMO activities
   - Public-Private Partnerships

These points are in addition to the specific activities for the ITER project, which remain central

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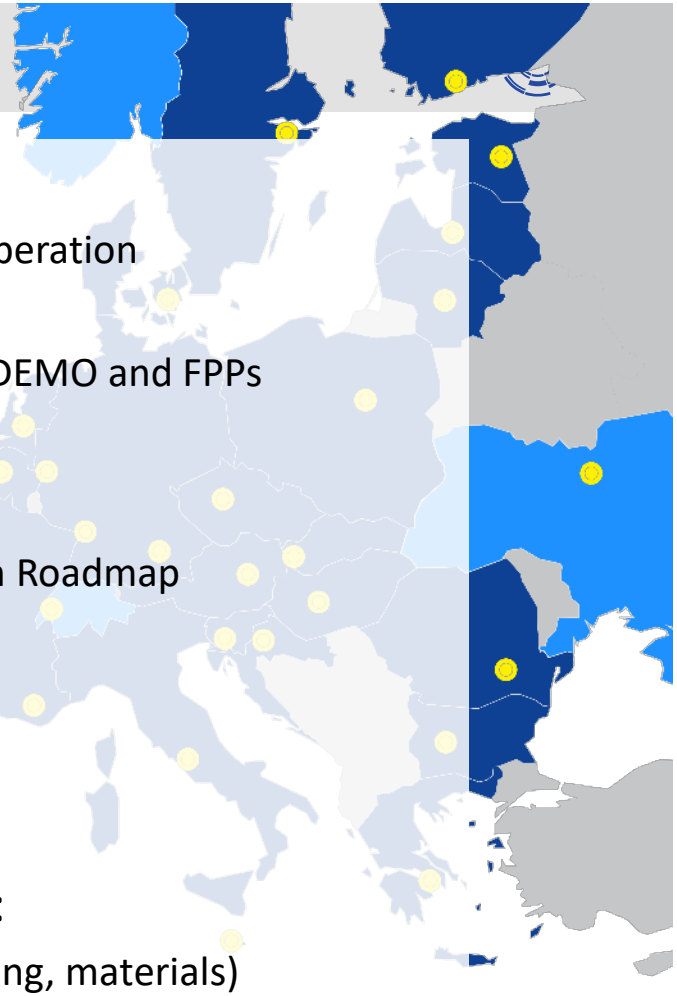
Summary



EUROfusion plays an increasingly important role

- Assist ITER developments and have a crucial role in ITER operation
- Feed increasing demand for education & training
- Allow R&D and exploration of new technologies for ITER, DEMO and FPPs
- Ensure cohesion in the European fusion programme

Strong support for ITER and the present re-baselining

- ITER continues to be an essential element of the European Roadmap

Fusion R&D programme in support of DEMO will be:

- Focused on addressing the remaining technology gaps
- Carried out in parallel to the ITER programme
- Making maximum use of lessons learned from ITER

Public-private-partnerships need to be established to:

- Address and accelerate the long-lead R&D issues (T breeding, materials)
- Take ownership of the DEMO and FPP design

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