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STEP Power Infrastructure – Supply Chain Presentation

Scott McHugh, Thomas Stroud, Ioannis Antoniou and Andi Begolli.

Power Infrastructure – Introductions

Quick introduction to the members of the STEP Power Infrastructure Project team, on todays call:

- Scott McHugh – Project Manager (UKAEA)
- Ioannis Antoniou – Lead Electrical Engineer (UKAEA)
- Thomas Stroud – Process Engineer (UKAEA)
- Andi Begolli – Lead Cryogenics Engineer (UKAEA)

Power Infrastructure – "Busbars, Turbines and Fridges"

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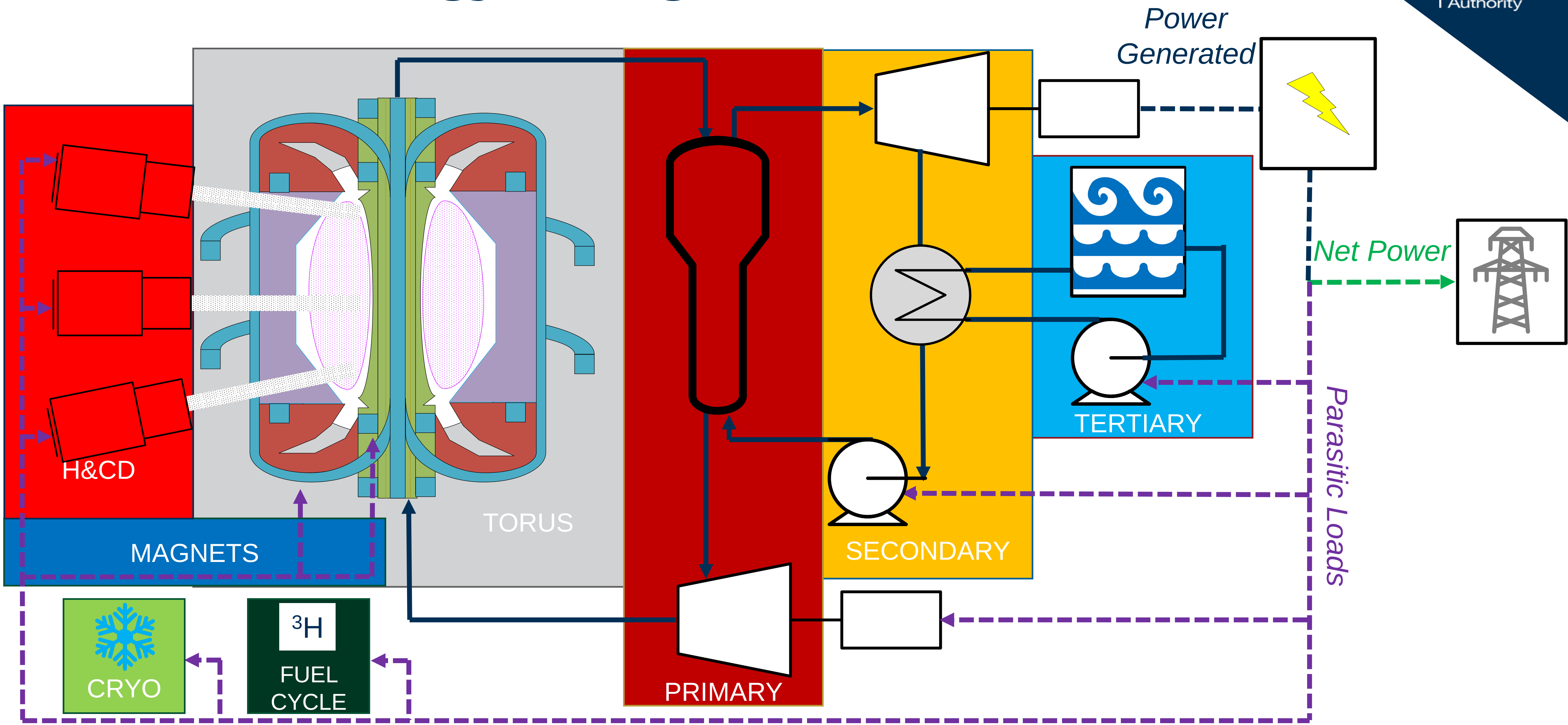
Power Infrastructure capability split into 3:

- **Power Generation (+ Plant Cooling)**
  - Capability discipline: Process Engineering
    - Main Studies: **Concept studies**, **Basic Engineering Packages (BEPs)**, Pre-FEEDs, FEEDs, Detail Design
    - Main Design Deliverables: **H&MB**, P&IDs/**PFDs**, Safety Assessments (**HAZID**/HAZOPs), **Control Philosophies**, **Equipment Sizing/Costing and Datasheets, piping design.**
    - Main Equipment: Pumps, Compressors, Heat Exchangers, Piping, Process C&I, Separation equipment (Filters, absorbent beds etc…)
    - Research/Pilot rigs may be needed within 5 years.

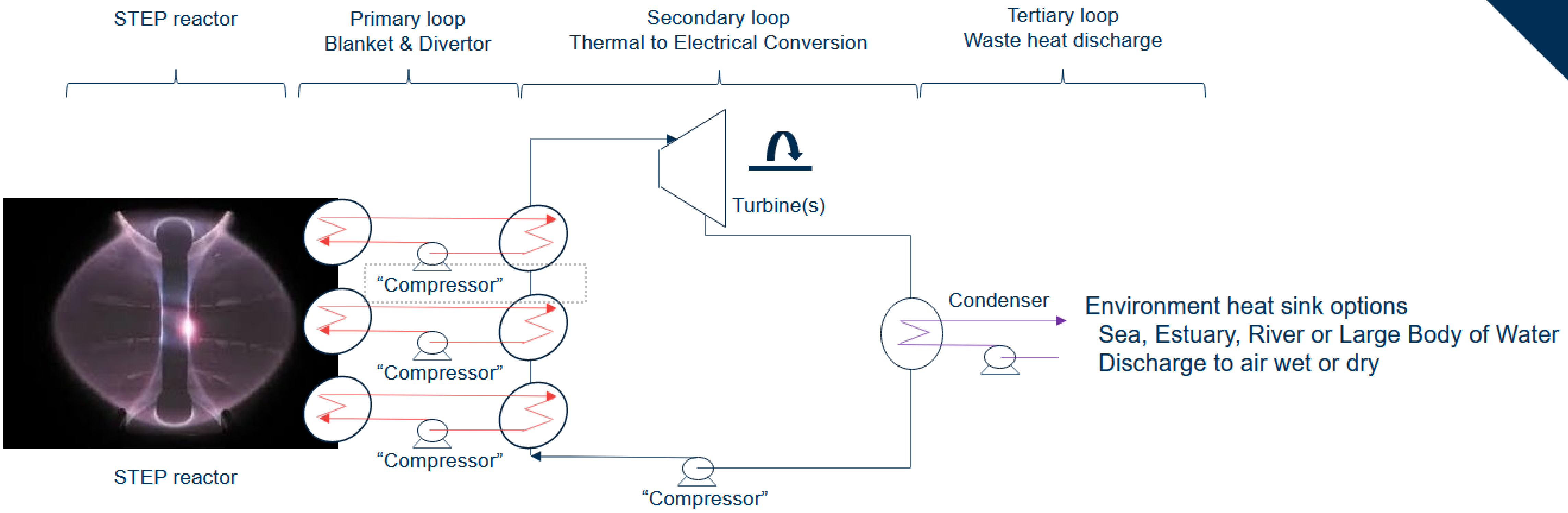
- **Electrical Infrastructure**
  - Capability discipline: Electrical Engineering
    - Main Studies: Concept studies, Basic Engineering Packages (BEPs), Detail Design.
    - Main Design Deliverables: Single Line Diagrams, Electrical Distribution Design (Load Flow Analysis, Grid Constraints), Safety Assessments (HAZID/HAZOPs), Control Philosophies, Equipment Sizing/Costing and Datasheets.
    - Main Equipment: Transformers, Power Supply Converters, Busbars.

- **Cryogenic Plant**
  - Capability Discipline: Cryogenic Engineering.
    - Main Studies: Cryoplant feasibility study (ITT now live), room temperature helium/nitrogen compressors (with focus on efficiency improvement and oil-less design), cryogenic circulators, STEP cryodistribution system

Whole site energy management



Power Generation



Primary loop thermal fluid options	Secondary loop thermal fluid options	Tertiary coolant
Helium, Carbon dioxide, Nitrogen	Brayton Cycle Helium, Carbon dioxide, Nitrogen	Water
Water	Rankine Cycle Water / Steam	
Molten Salts or Liquid Metals	Rankine Cycle Hydrocarbon or Ammonia	

Electrical Infrastructure

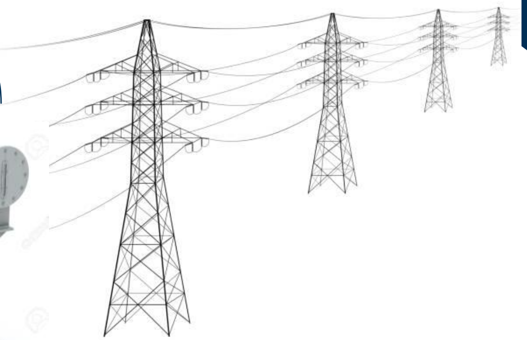
Voltage Regulation, Power Conversion & “Protection”
Surge arrestors, snubbers, inductors..

Grid transformer

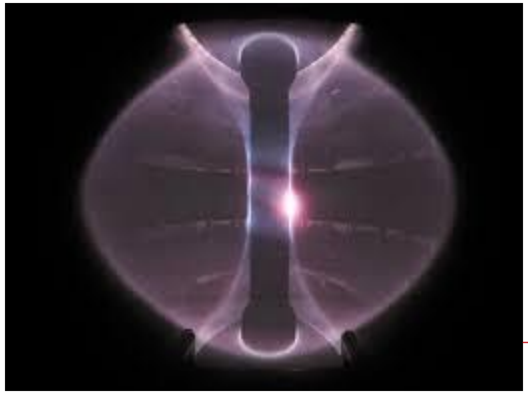
“National grid”

Pulsed power users

- Magnets 0.005 – 5 kV d.c.*
- PINI 75 – 150 kV d.c.*
- Hotel Loads 415 – 11 kV a.c.



132, 275 or 400 kV ac



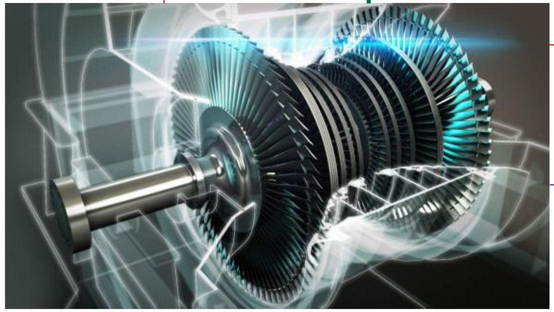
Hot Fluid Transfer

“local grid” 33 kV ac

Non-Pulsed power

- Cryogenic systems
- Cooling Systems
- Tritium handling
- Process and Building HVAC
- Support Equipment including offices

Step down transformer
32 kV to 400 V



STEP Turbines & Generator

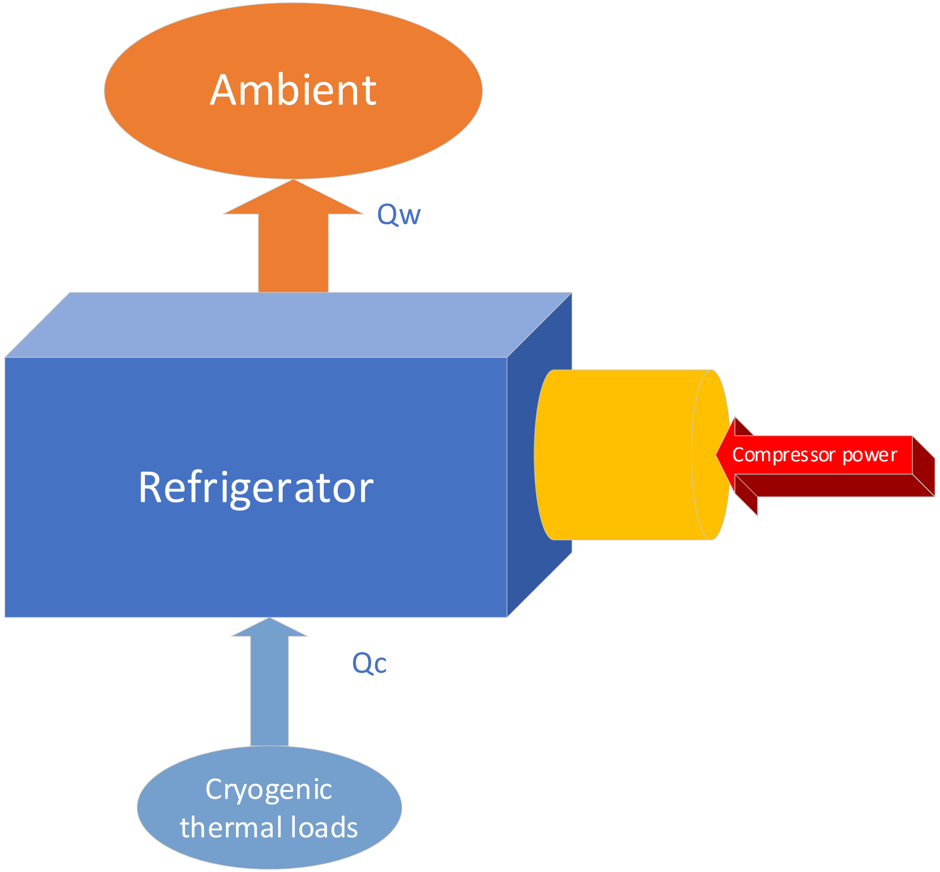
Hot Fluid Transfer

Utilities Shared Services

Auxiliary Boiler
Combined Heat Power Plant

STEP Cryogenic Plant

- Given that STEP will utilise cryogenically cooled magnets and cryopumps, a dedicated Cryoplant will be required
- At present, given the various requirements, STEP the cryoplant will have the following cooling loops
  - A 4.5K loop
  - A 15K loop
  - A 20K loop
  - 80K loop
    - This is likely to be a LN2 plant producing nitrogen at 77K, used to cool helium to 80K)
- As an absolute minimum, STEP will require 3 separate cryoplants i.e. 4.5K, 20K and 80K



Primary Cryoplant technological challenges requiring industry input

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Due to the high cryogenic thermal loads, the design of a suitable Cryoplant represents a significant challenge to the STEP programme. The primary challenges are:

- **Helium compressors**. STEP requires mass flow rates in 10's of kg/s rather than g/s
  - Includes **Oil/helium separator, filtration and coalescer systems**
- **Cold box design**, specifically
  - Size of Plate fin heat exchangers
  - Transportability of such vessels
  - Turbo expanders
- **Cold circulators** to circulate the helium around the various cryogenic systems
- **Cryodistribution** system to supply cryogens around plant efficiently e.g. vacuum insulated transfer lines, valveboxes
- For each of these, an initial feasibility study will be done requiring industry input
  - An overall Cryoplant feasibility ITT is currently live covering:
    - Cold box design
    - Helium compressor