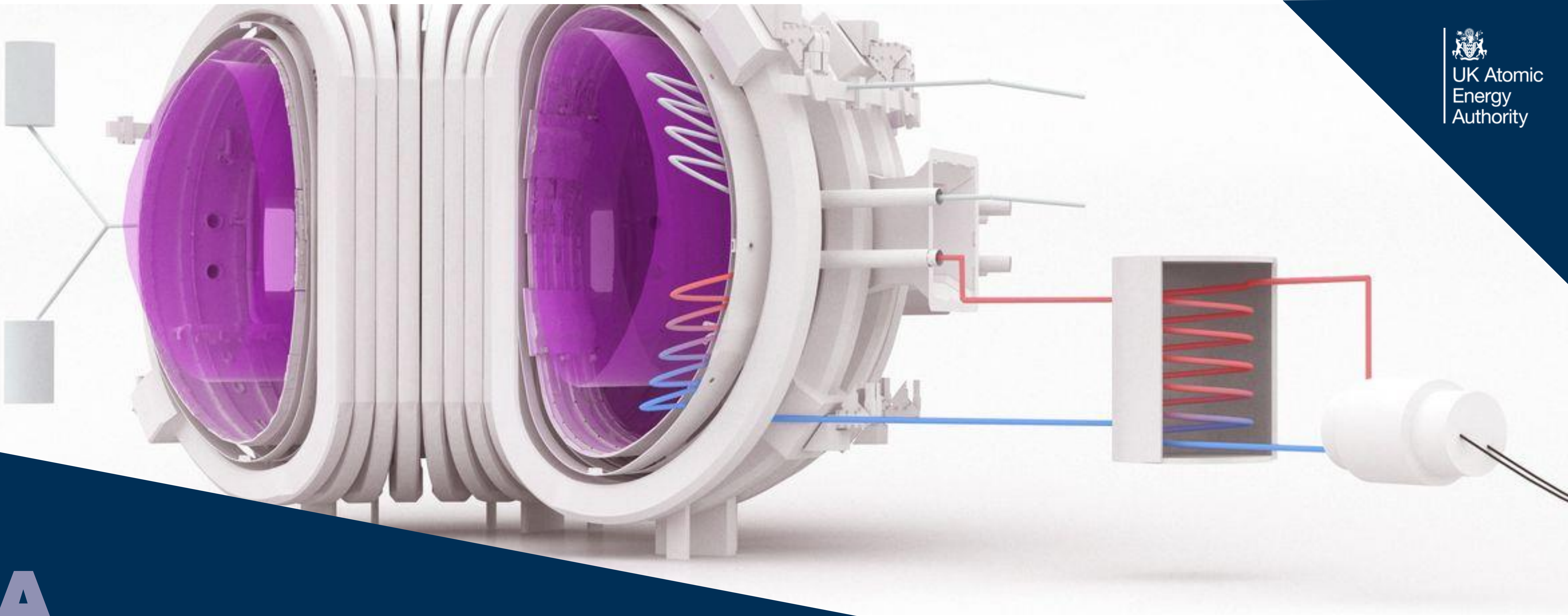

UK Atomic Energy Authority

IAEA

Topic three Summary

Co chairs: R Stigler, K, Hesch, M Gorley,

The story

UK Atomic Energy Authority

1. **The fusion power source** → Plasma physics performance and impact on plant efficiency.

2. **Capture & conversion of the fusion power into electricity** → Thermal power management in view of coolant choice, balance of plant and electricity production.

3. **Powering the reactor** → Electrical power management: challenges in powering the magnets, the heating and the auxiliary systems.

4. **How to design for future operation, integrating all aspects of operation and track efficacy** → Nuclear power plant digital twinning for efficient operation as compared to the present status of Fusion plant flight simulator.

Plasma physics performance and impact on plant efficiency

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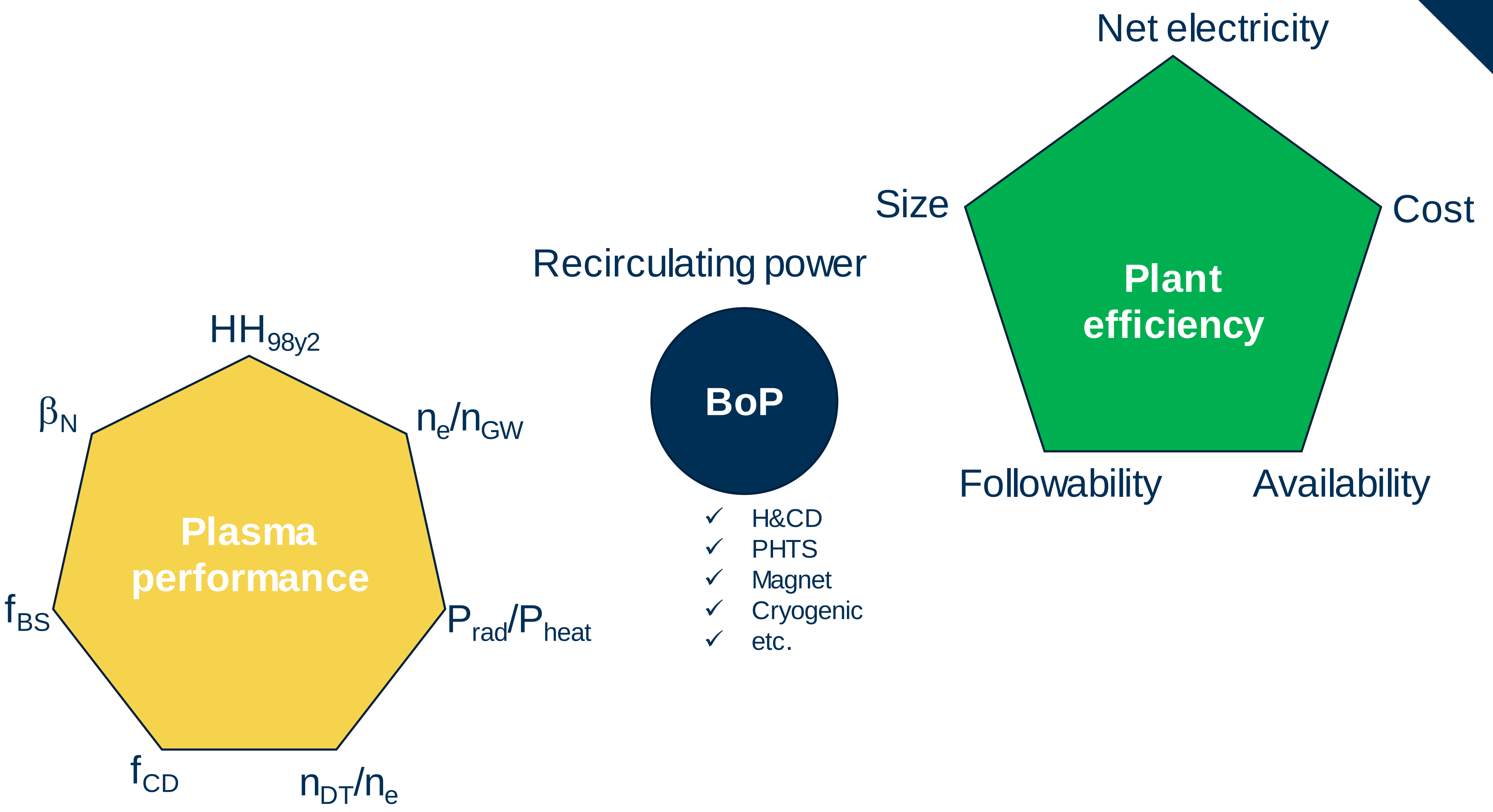
Y Sakamoto-san,

Y Kamada-san.

Lots of performance parameters effect plasma.

Plasma performance highly uncertain.

Translates to uncertainty in BoP and Plant Efficiency.



Thermal power management in view of coolant choice and the balance of plant

W Hering, L Barucca.

Pulsed operation: Large power swings, unlike other power plants

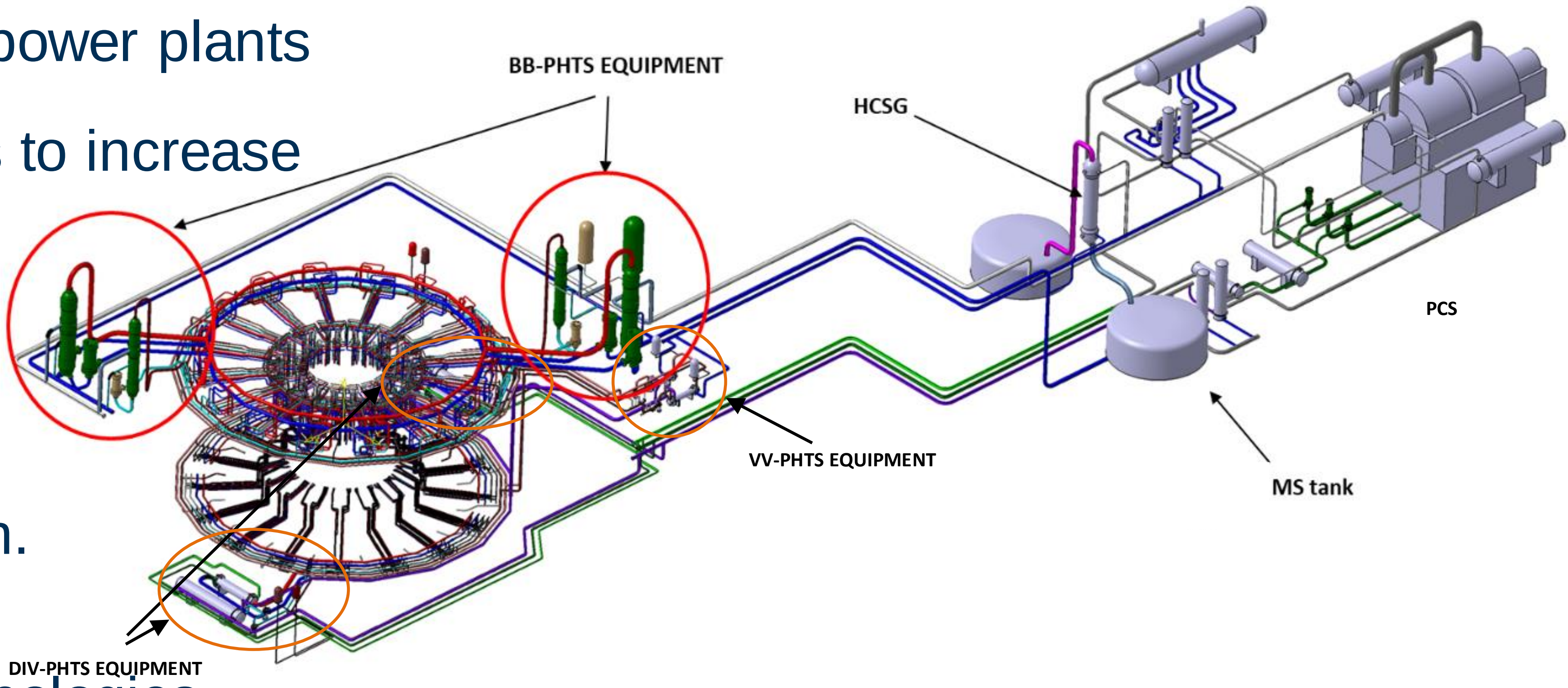
Integration of “cold” sources to increase efficiency

Highly complex coolant networking though tokamak

Architecture substantially effected by coolant selection.

Coolant selection extremely integrated choice, with technologies limited selections.

Example: WCLL BOP DCD with Small Energy Storage for Dwell



Total piping length FW + BZ (In+Ex-VV) [m] **~7000**

*Longer then walk to centre of Vienna from this building

Electrical power management: the path toward energy production

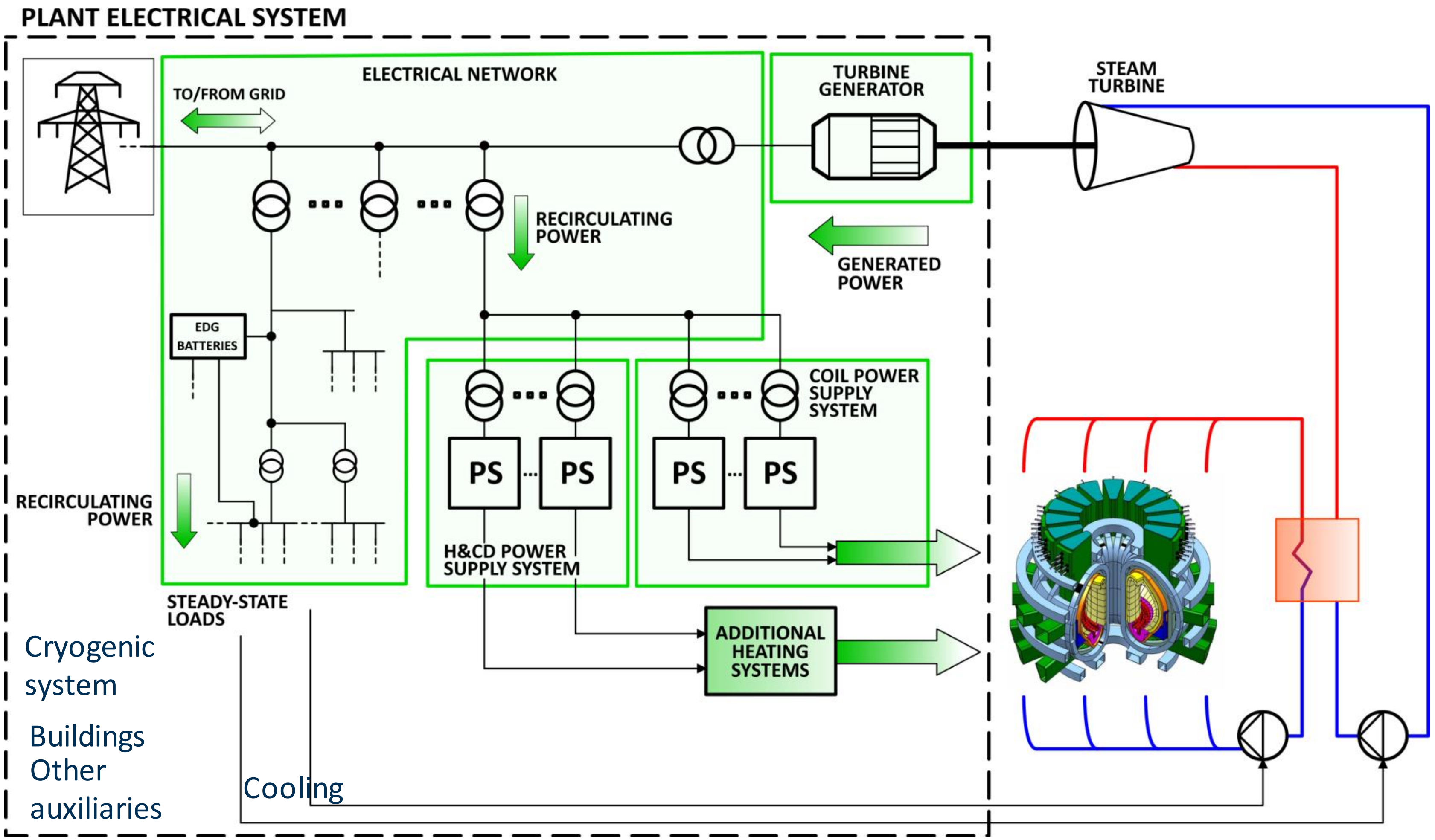
E Gaio.

High complexities – high uncertainties.

Novelty beyond tokamak.

Integrate all auxiliary systems to determine the recirculating power

Instabilities, reactive power demands → Still FOAK system!



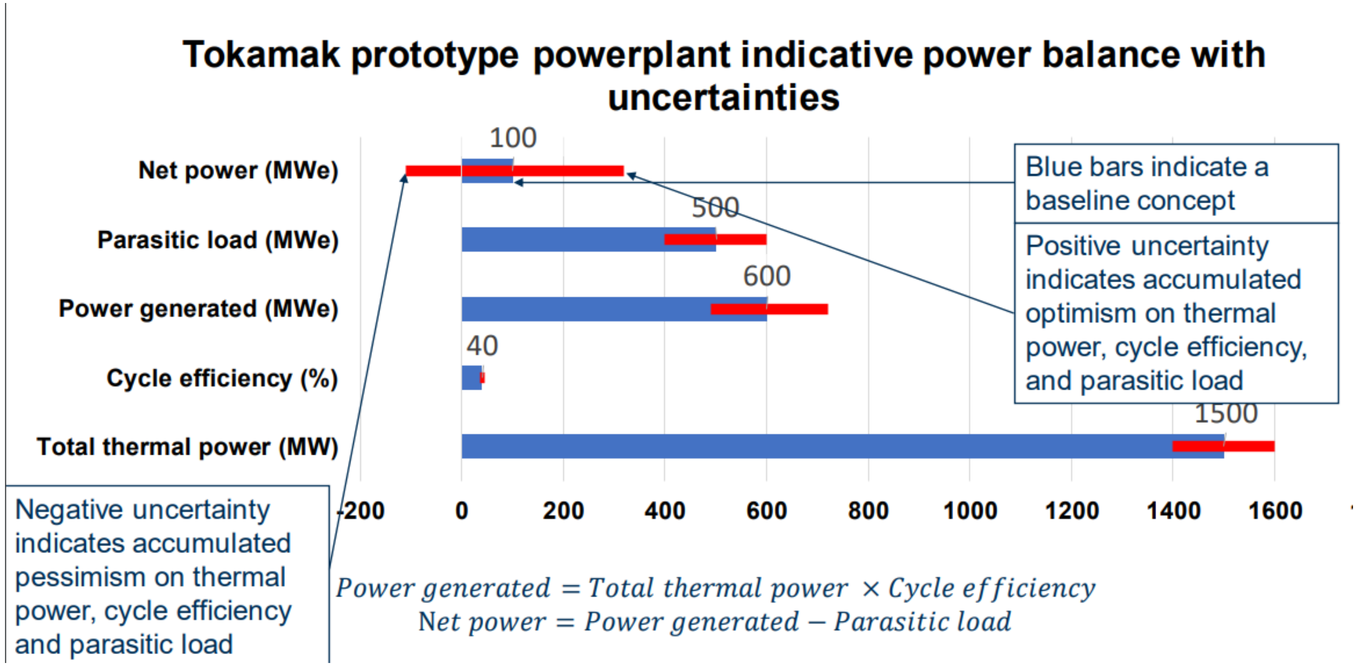
Power balance challenge for fusion

Progress in modeling the D/T component flows in fueling system by SOLPS+ASTRA+FC-FNS codes

UK Atomic Energy Authority

S Wray

Systematic incorporation of all power “sources” and “uses” needed early to dive new power devices; uncertainty “**<u>will</u>**” be high.



$$Power\ generated = Total\ thermal\ power \times Cycle\ efficiency$$
$$Net\ power = Power\ generated - Parasitic\ load$$

S Ananyev

Fuelling of the plasma an example of complex systems that will effect power demands on the fusion power plant.

Nuclear power plant digital twinning for efficient operation

Q Li

Digital Twin for safety assessments.

Digital Twin for training.

Digital Twin for operation.

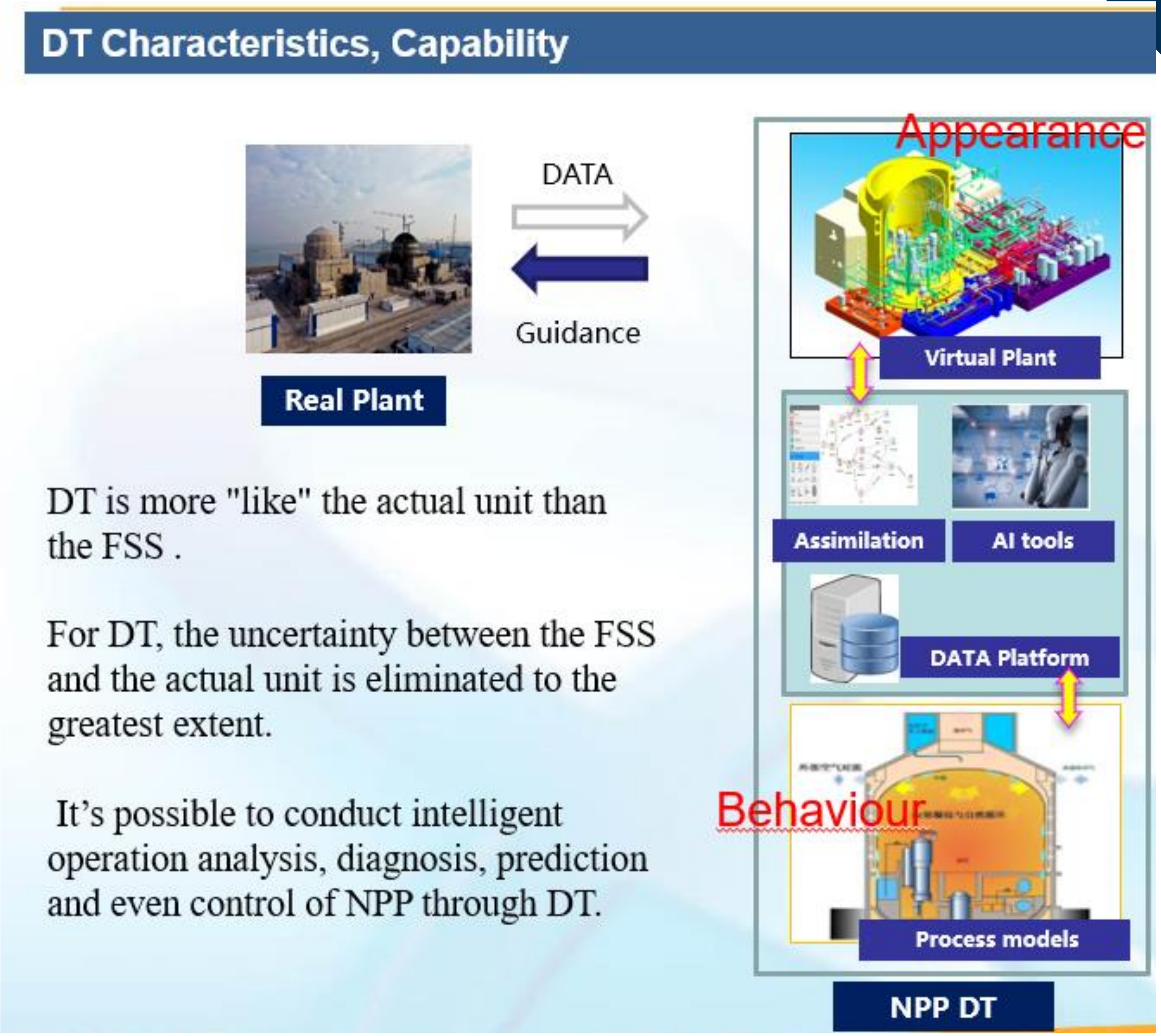
Digital Twin for maintenance.

Digital Twin for design.

Data is the base

Model is the key

Platform is the carrier



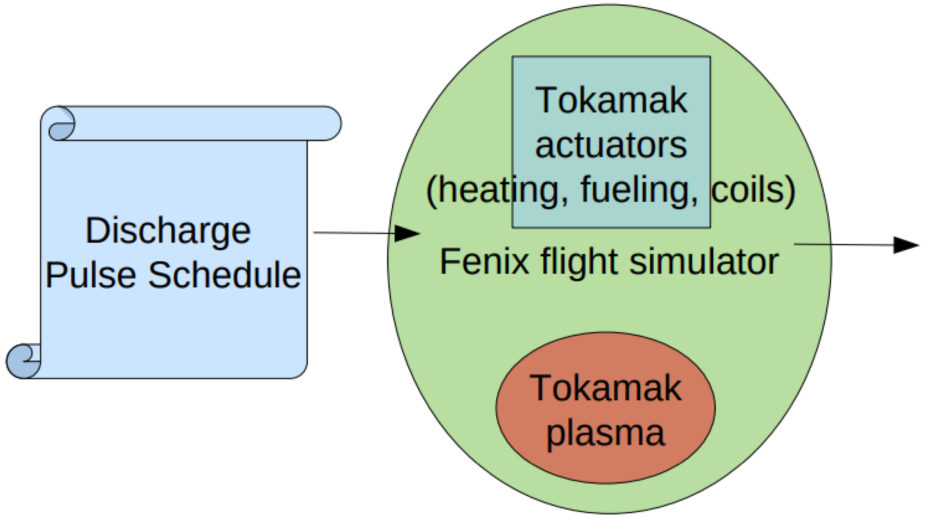
Fusion plant flight simulator: present status

E Fable, JAE MIN Kwon.

Limited worldwide efforts identified on whole plant simulators – Fenix testing this utilising many sub-models.

These systems could prove critical in designing and operating fusion power plants.

Inputs



Outputs

- Actuator requirements:
 * Fuel needed for 1 pulse
 * Electrical power needed to power auxiliary systems like heating, pumps, …
 * Coil currents/forces/ voltages

- Products:
 * Pumped gases not directly recycled
 * Neutron flux to blanket
 * Radiation flux to first wall

- Diagnostics:
 * density, shape, etc...

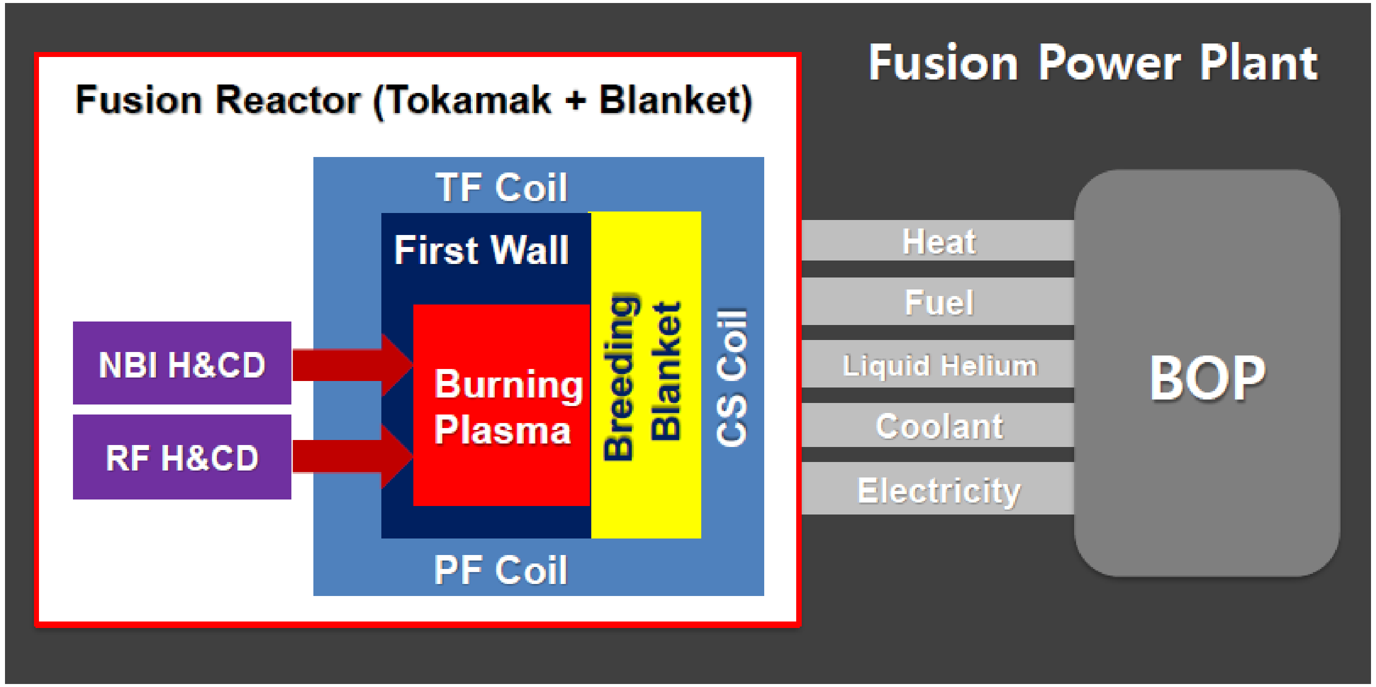
Fusion plant flight simulator: present status

E Fable, **JAE MIN Kwon**

Digital Twin as a platform to integrate fusion plant flight simulator.

Plasma control being perused on Virtual K-Star.

New technologies for more advanced Digital Twin. Engineering reactor digital twins, including industrial engagement e.g. nvidia.



Discussion – key points (1)

- .....
- ...
- ...

Major Takeaway points – Community proposed actions.

- **Integrated scenarios will affect design**.
  - We (the fusion community) need coupling from plasma right through to grid connection. No clarity on when these will be ready, or who will develop!
- **High uncertainty**
  - The performance and efficiency of operation, from: plasma, recirculating power demands, coolant selection, balance of plant performance, electrical systems and extrapolation of ITER system to DEMO reactors all track uncertainty (some epistemic/fundamental). How are we capturing and extrapolating this?
- **Technological development needed**
  - Efficiency of operations is the key driver for many existing power plants and looks to be the same for Fusion power Plants. Do we target advanced technologies to pursue high efficiency of operation for fusion reactors – plasma performance, plasma heating, coolant of systems. OR target proven technologies for DEMOs? Matter of urgency?
- **Pathway to commercial viability.**
  - The move to DEMO reactors encompasses the move to power plant operations, beyond Tokamak experiments. DEMO experiments must provide evidence of “a pathway to efficiency”. Do we have the right systems developed to track this at right levels from outset in designs?

We aimed to leave this topic session with attendees understanding the key drivers in power output from fusion reactors, the dependencies and uncertainties of these systems, and what should be looked at in DEMO programs and to maximize fusion energy output from our reactors.

How did we do – let chairs know!

Many Thanks for your Attention