HTGR and Co-Generation

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Nuclear Academics Meeting

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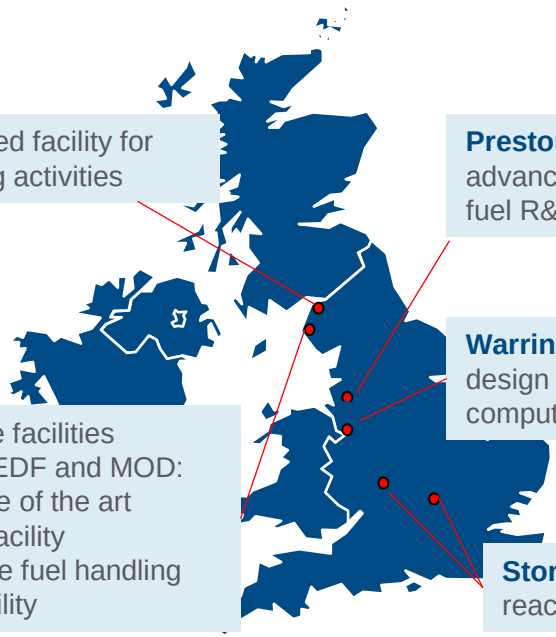
NATIONAL NUCLEAR LABORATORY

NNL: AT A GLANCE

- NNL is the UK's national nuclear laboratory for fission
- Operates on a commercial basis
- NNL is owned by the UK government
- Around 1000 employees including 450 Scientists

£1.5 billion critical nuclear R&D infrastructure



Workington - dedicated facility for non-radioactive test rig activities

Preston - nuclear physics and advanced reactor modelling and fuel R&D labs

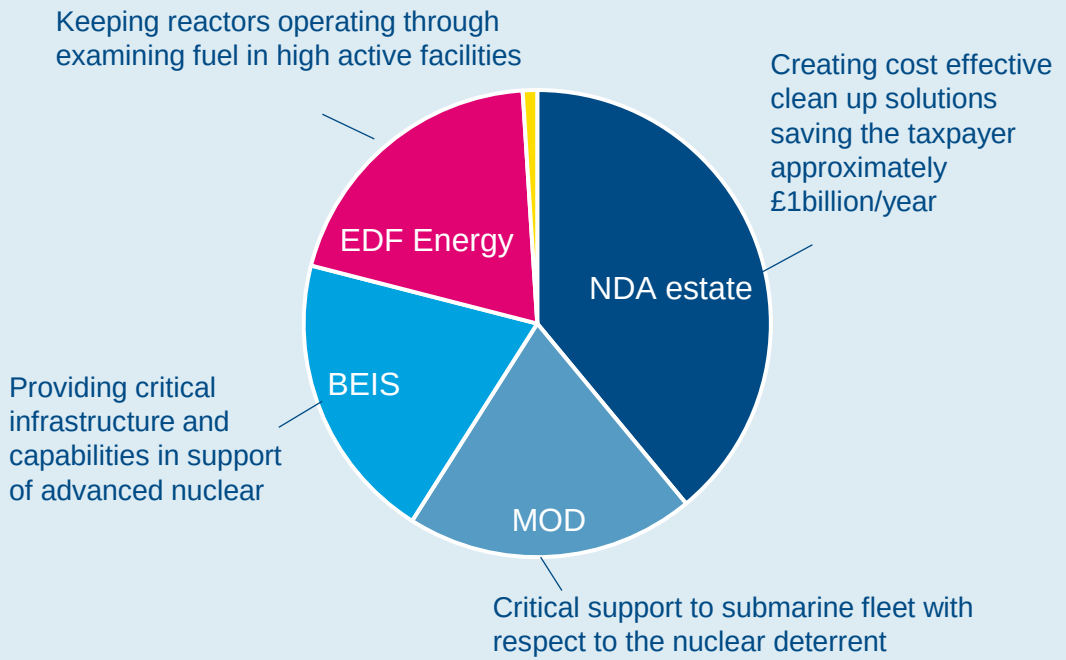
Warrington – engineering design and high performance computing

Sellafield - high active facilities supporting Sellafield, EDF and MOD:

- Central Lab – State of the art nuclear research facility
- Windscale - Unique fuel handling and inspection facility

Stonehouse and Culham – reactor materials expertise

Revenue ~ £100m



Earnings to Reinvest (profit) £10m p/a on average

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UK: A PROUD HISTORY WITH GAS REACTOR TECHNOLOGY

Generation I:
Magnox Fleet: 26 Reactors on 11 sites

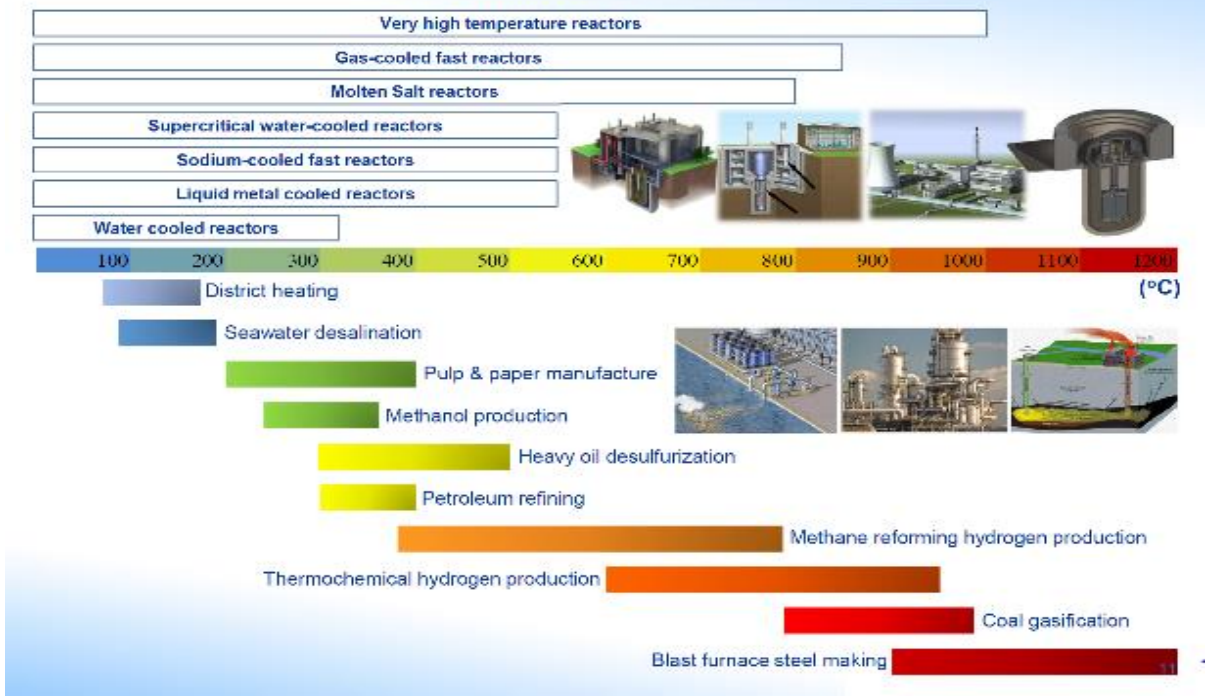
- FOAK - Calder Hall 1956
- A first of a kind Generation I Gas Reactor
- Uranium metal fuel with CO2 cooling
- Capacity 200MWe
- Design to operation in 4 years!

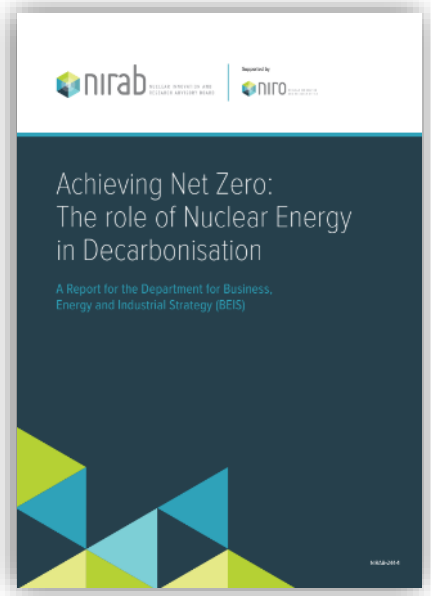
Generation II: COMMERCIAL GAS REACTOR
AGR Fleet: 14 Reactors at 6 sites

- FOAK – Hunterston and Hinkley Point 1976
- A first of a kind Generation II Gas Reactor
- Uranium dioxide fuel with CO2 cooling
- Capacity 610MWe (but operating at 430MWe)
- Same design of turbines and generation equipment as coal plant

NIRAB, NUCLEAR AND NON – POWER APPLICATIONS

Non Electric Applications make up a significant part of the Energy Mix





"Advanced Modular Reactor (AMR) development should focus on systems that can be commercially deployed in time to make a significant contribution to meeting the net zero 2050 target. ***High Temperature Gas Reactor (HTGR) systems score well against these criteria and are also being progressed in international programmes****. NIRAB considers this technology is the most likely to be developed in the timescale required, given the above requirements and Government should enable an advanced reactor demonstrator in the period 2030-2035"*

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HTGR SYSTEM SUMMARY

Helium cooled, graphite core

- <300 MWe
- TRISO (coated particle) fuel

Two core designs

- Primstatic (off-line fuel re-load) core
- Pebble Bed (online) core

High Coolant Outlet temperature

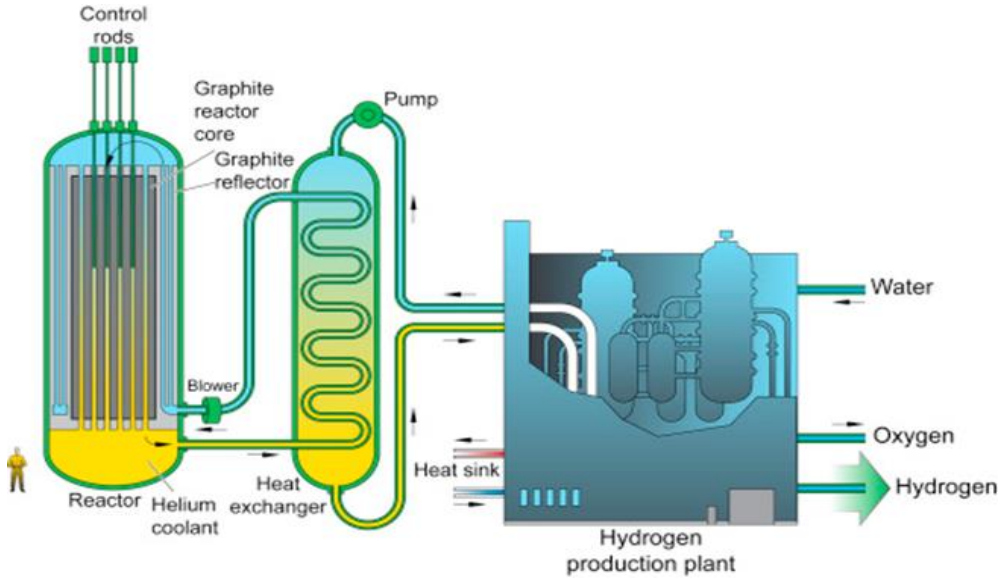
- Typically 950°C, but anything >800°C
- Significant co-generation possibilities

Open Fuel Cycle

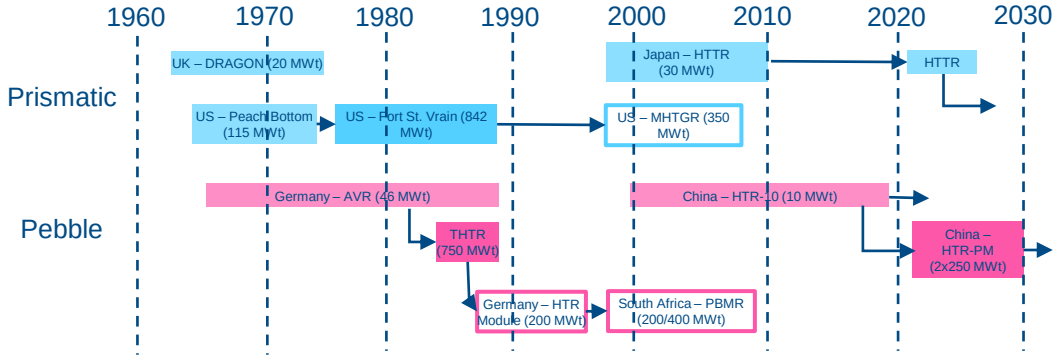
- Direct disposal of spent fuel to repository*

VHTR Technology Experience

- AVR (1966-1988)
- HTTR (1998-?)

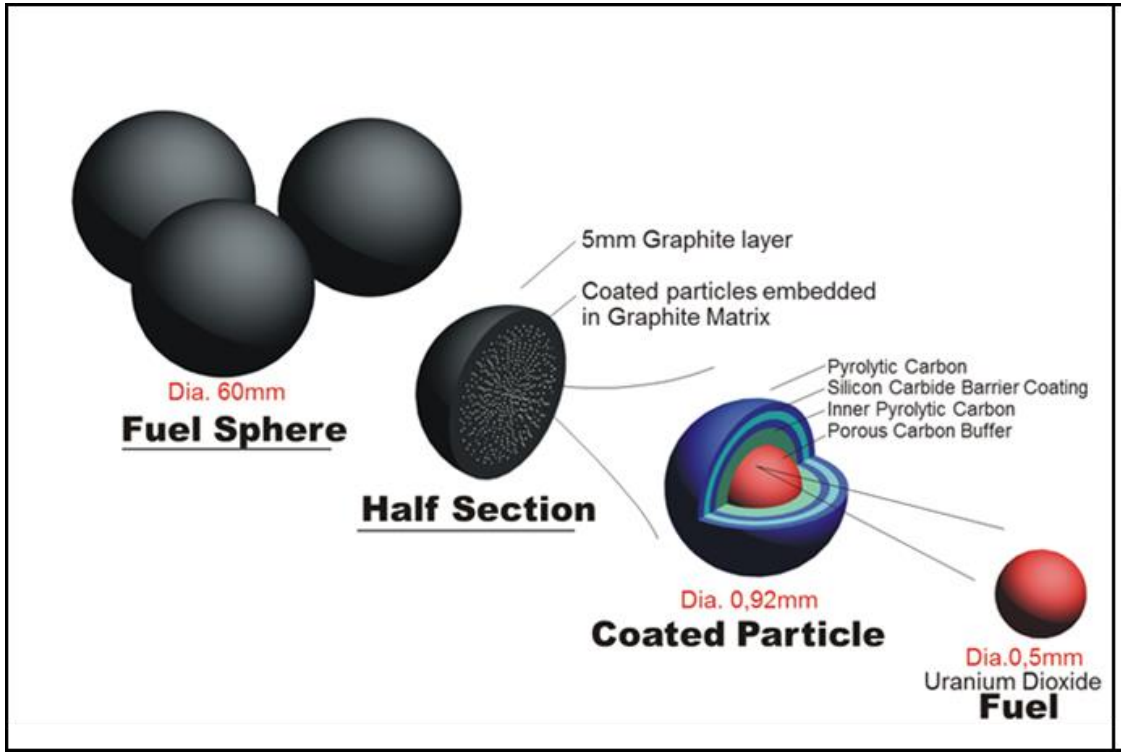


"Generation IV International Forum," May 2018. [Online]. Available: https://www.gen-4.org/.

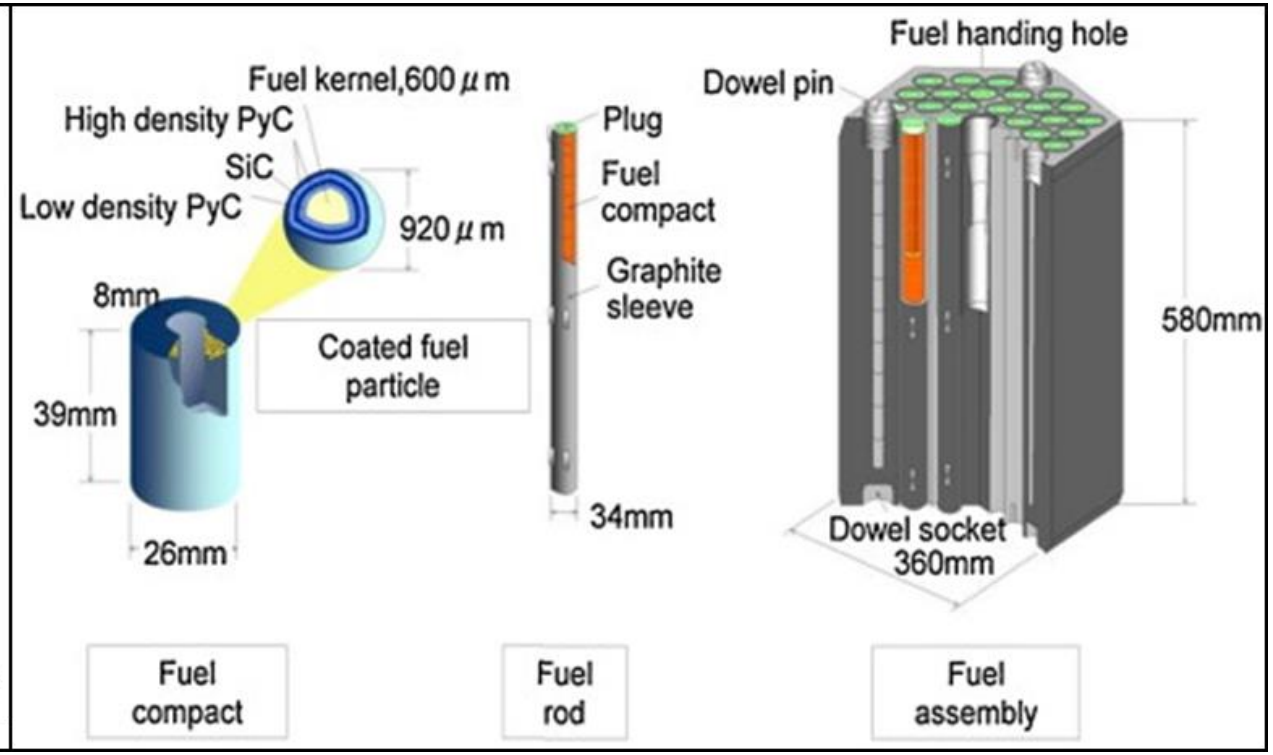


FUELLING THE HTGR – COATED PARTICLE FUELS

The ultimate “Accident Tolerant Fuel”



Pebble type (e.g. PBMR, HTR-10)



Prismatic type (e.g. HTTR, Japan)

WHAT IS ALL THE FUSS ABOUT ?
HYDROGEN

Transport

Heating

Industry

Light Water Reactor

Small Modular Reactor

Advanced Modular Reactors

Electrolysis — Direct Electrolysis

- Same as planned for use with renewables such as wind
- Deployable today using nuclear baseload electricity

Electrolysis — Low & High Temperature Steam Electrolysis

- Thermoelectric process that utilises reactor heat and electricity
- Efficiency of energy conversion increases with steam temperature

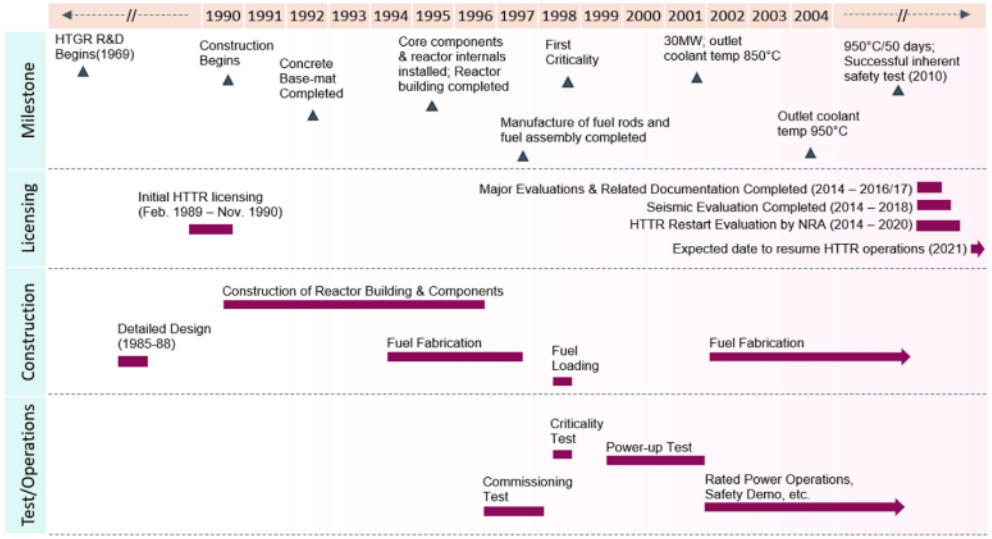
Thermochemical — Sulphur-Iodine

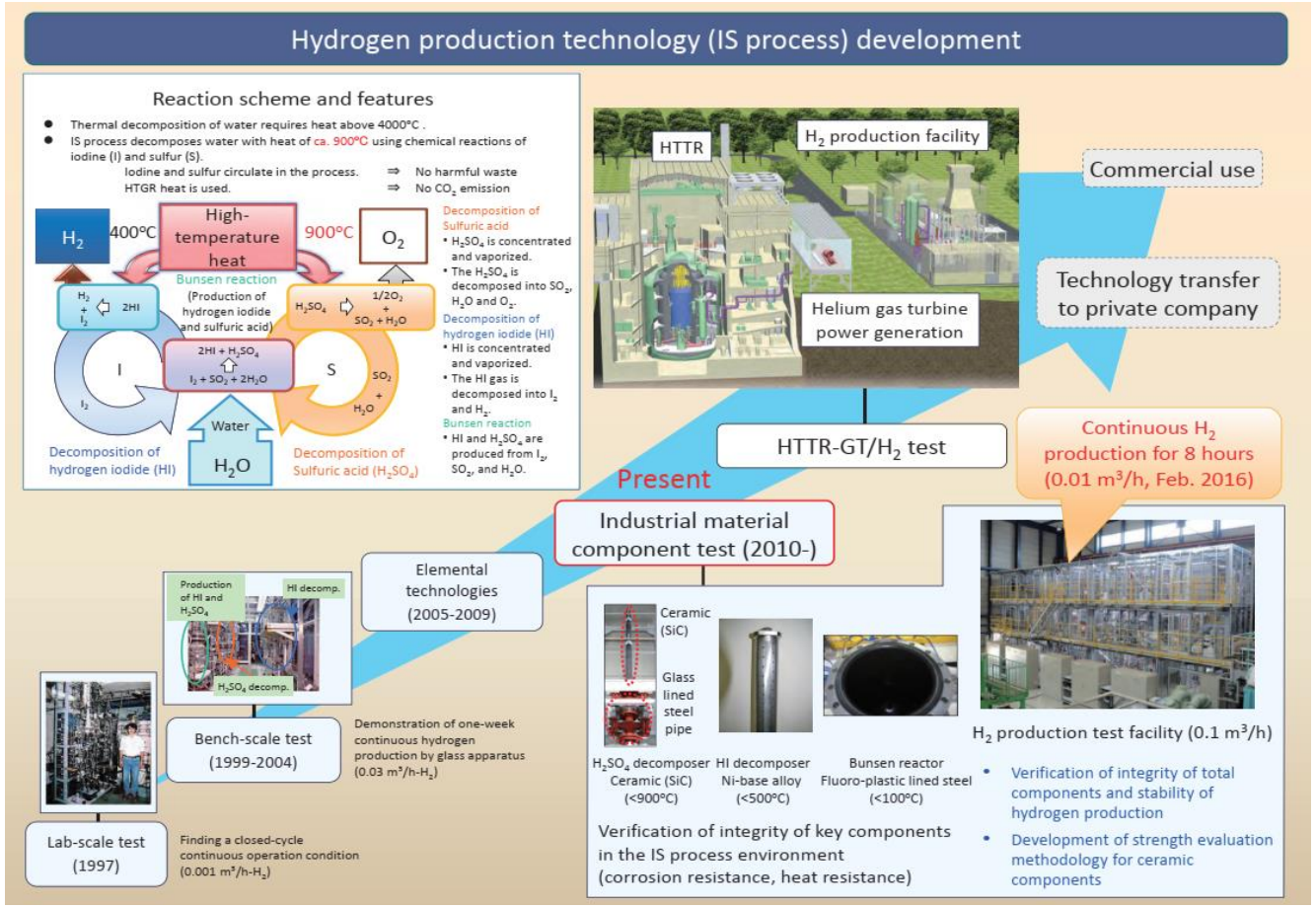
- Thermochemical cycle that utilises high quality, high temperature heat
- Demonstrated at small scales internationally, requires 900°C+ output heat

Thermochemical — Copper-Chlorine

- Electrochemical process that utilises reactor heat and electricity
- Less researched than S-I but demonstrated efficiencies in line with it at lower temperatures

THIS HAS BEEN DONE ALREADY…HTTR





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INTERNATIONAL COLLABORATION

2018 UK re-joined Generation IV International Forum

- Sodium-cooled Fast Reactor (SFR)
- Very High Temperature Gas-cooled Reactor (VHTR)
- Expert and Policy Groups, Working Groups, and Task Forces

Members of GIF VHTR Project

UK GIF Membership for VHTR Project

- Members selected by BEIS.

Department for Business, Energy & Industrial Strategy

Jacobs

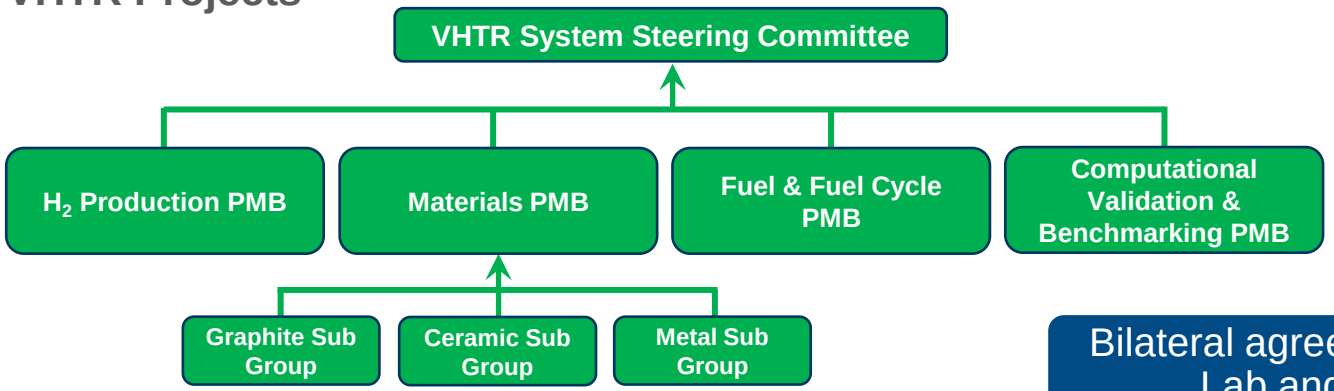
Imperial College London

UNIVERSITY OF OXFORD

NATIONAL NUCLEAR LABORATORY

MANCHESTER 1824 The University of Manchester

VHTR Projects



Bilateral agreements between UK/National Lab and international partners

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