Nuclear Power to Hydrogen and Alternative Liquid Fuels

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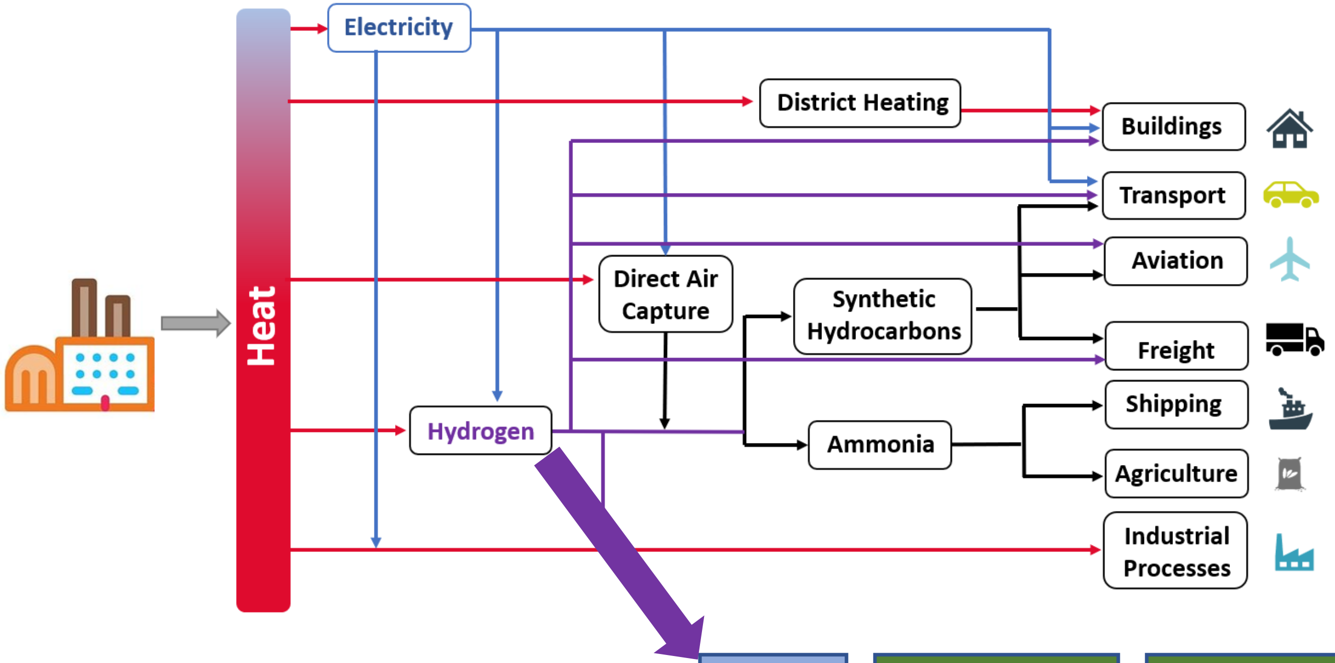
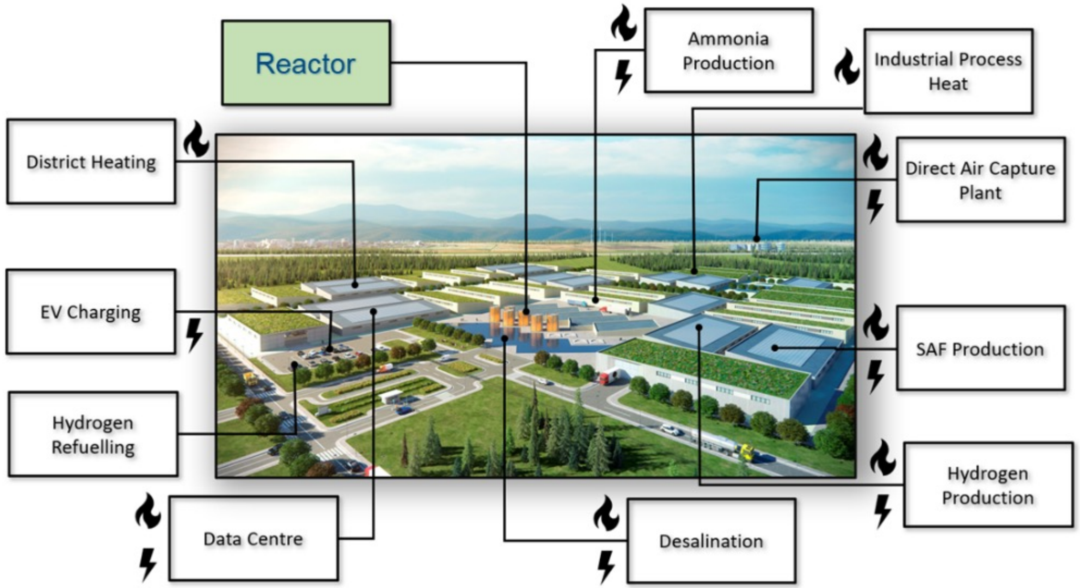
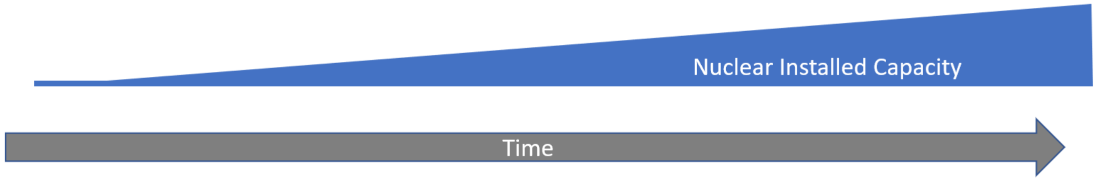
Nuclear Energy Integration



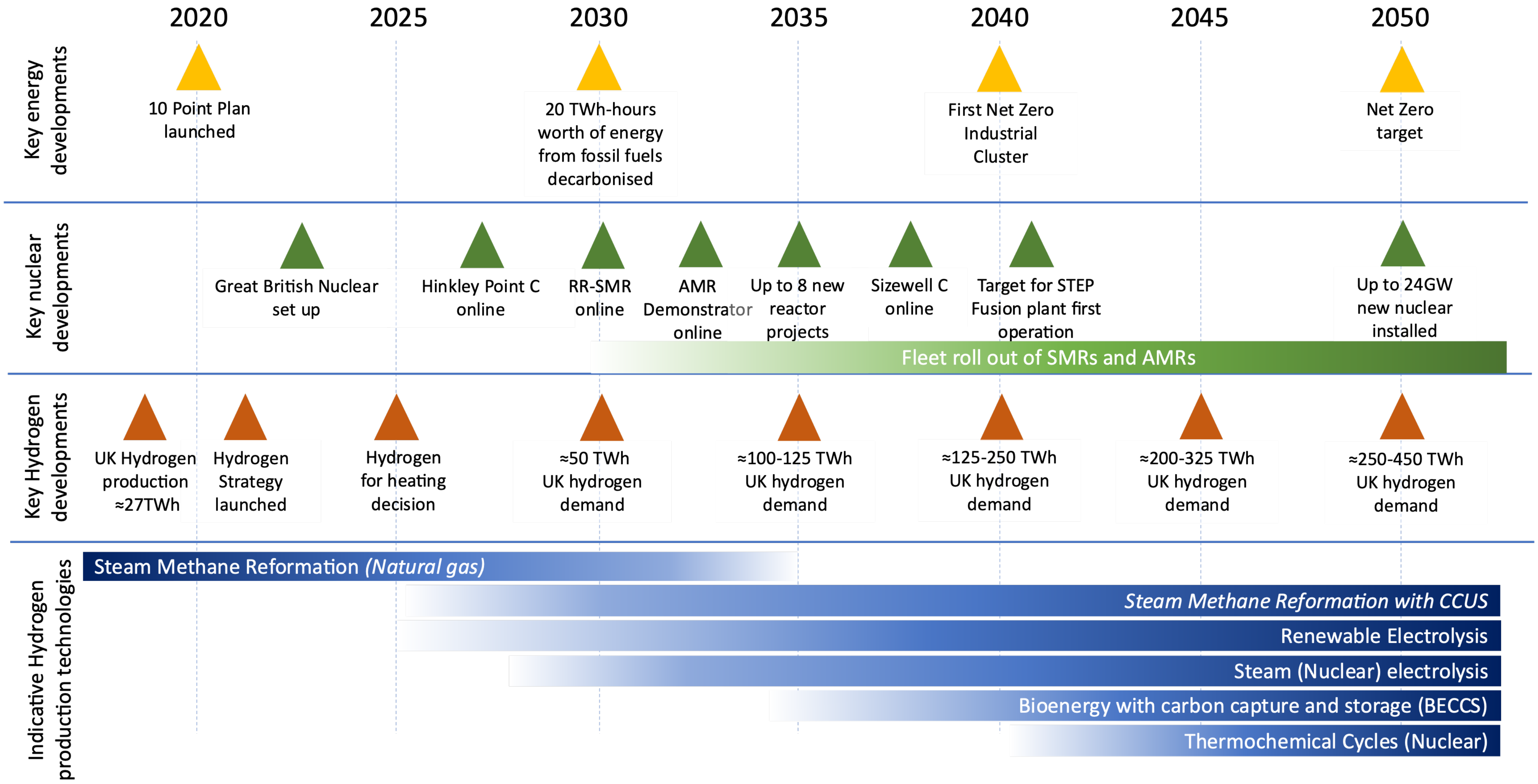


	Present day	2030	2035	2040+
Anticipated Hydrogen Demand	≈27 TWh	≈50 TWh	≈100-125 TWh	≈125-450 TWh
Nuclear Technology Availability	GW Scale	SMR	AMR	Fusion

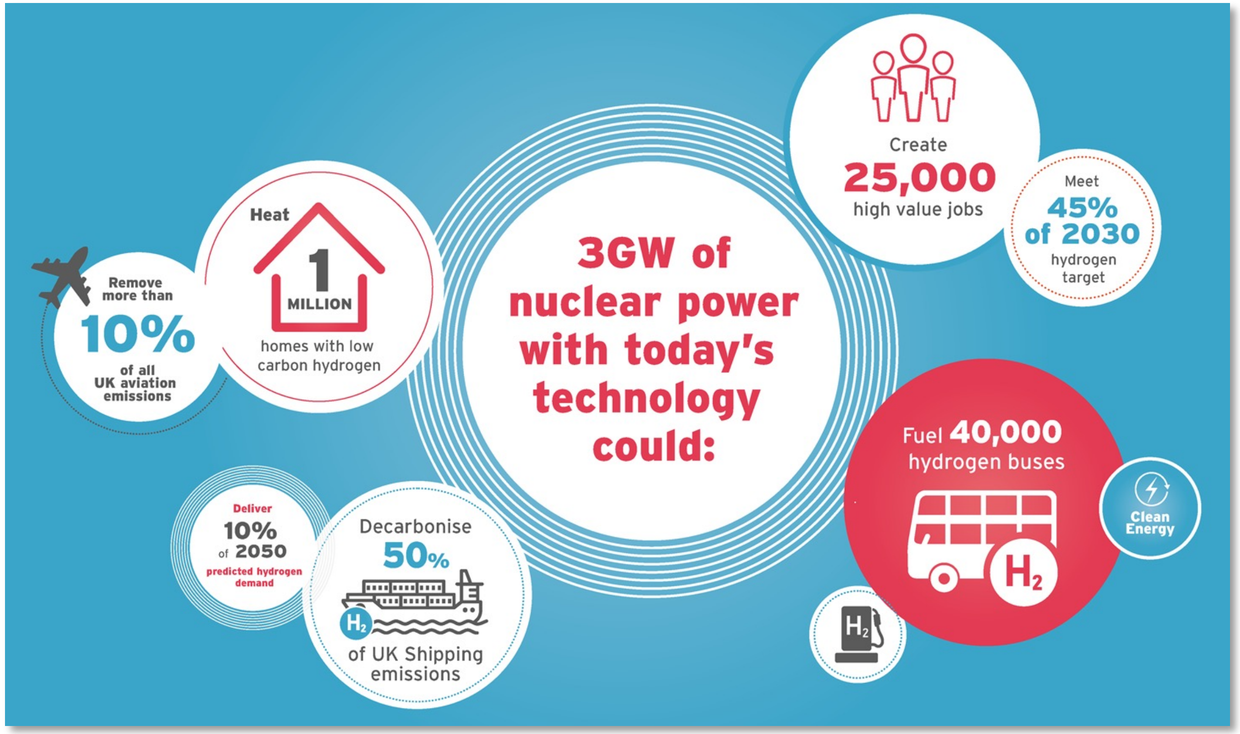


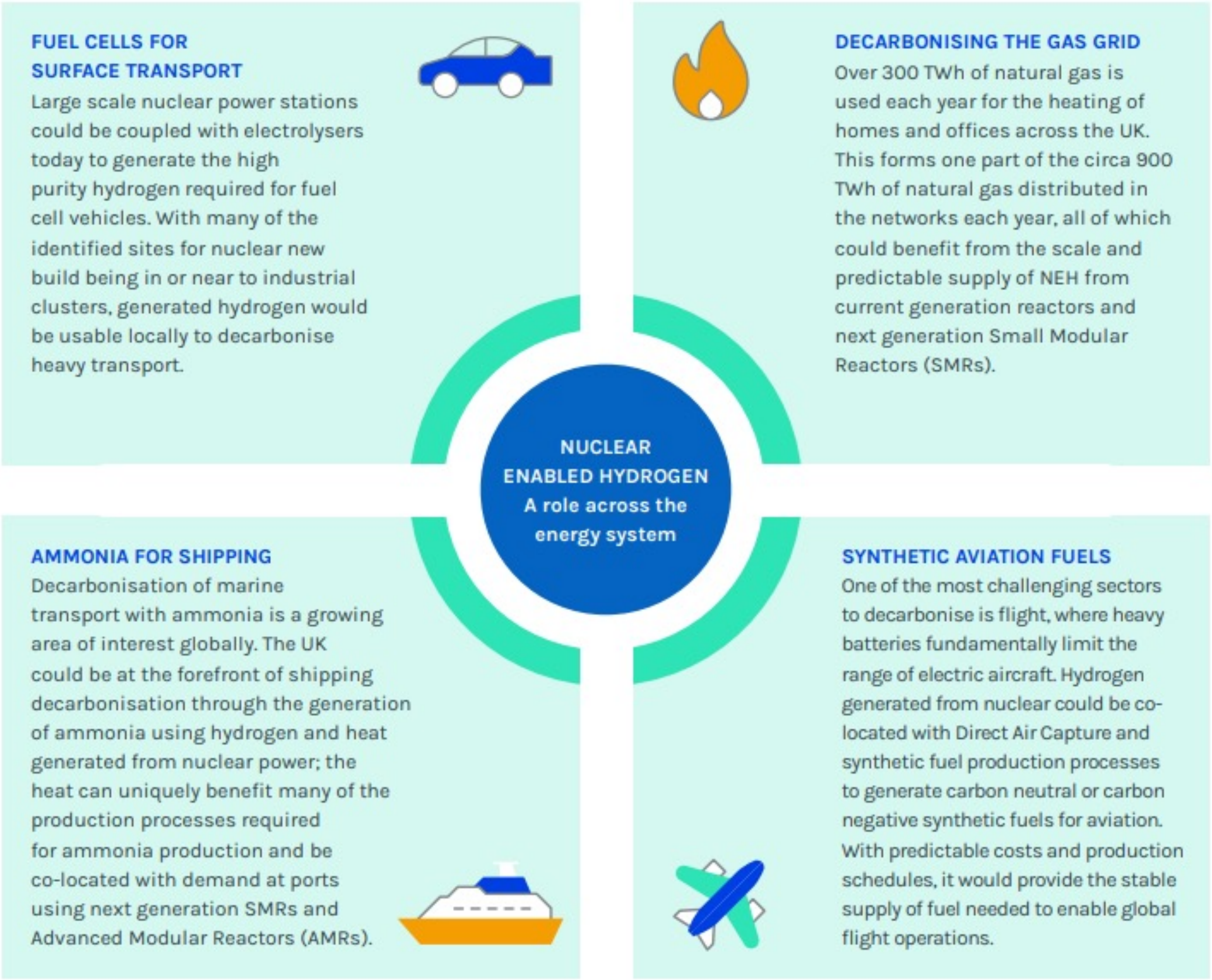
Hydrogen demand data source - UK Hydrogen Strategy

Nuclear Energy Integration



Hydrogen Production





Source: Hydrogen Energy Association

Hydrogen Generation

Low Temperature-Electrolysis

Low Temperature Water Electrolysis (TRL 9)

- Same as planned for use with renewables such as wind & solar
- Perceived USP of nuclear energy is the capacity (high GW) and ability to produce constant output
- Deployable today using nuclear generated electricity

High Temperature-Electrolysis

High Temperature Steam Electrolysis (TRL 7)

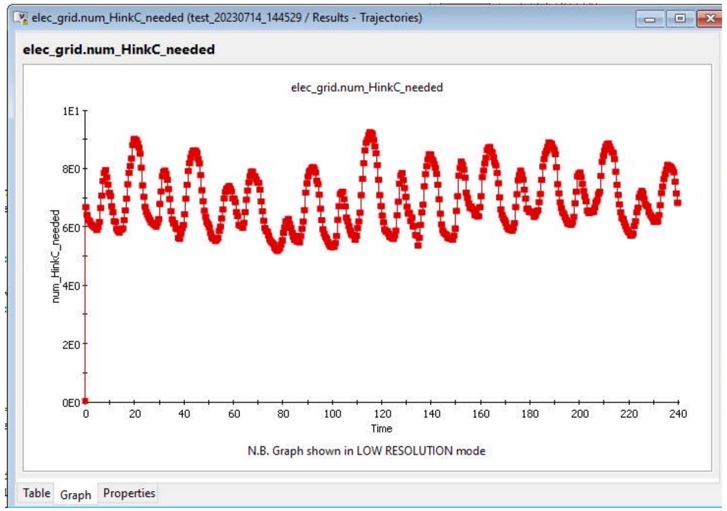
- Thermoelectric process that utilises reactor heat and electricity
- Can utilise waste heat from nuclear electricity production to vaporise feed steam
- Potential advantages when coupled to AMR designs (higher efficiencies)

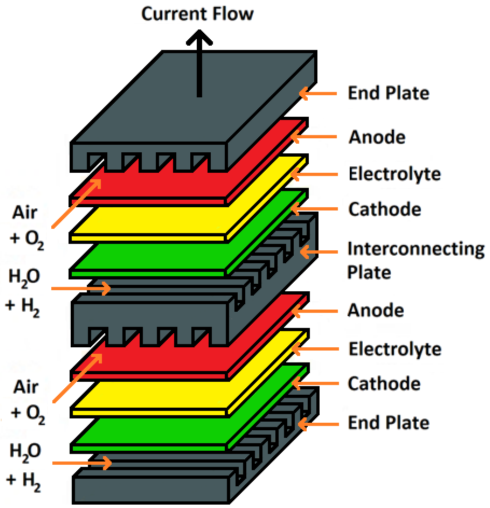
Thermochemical Cycles

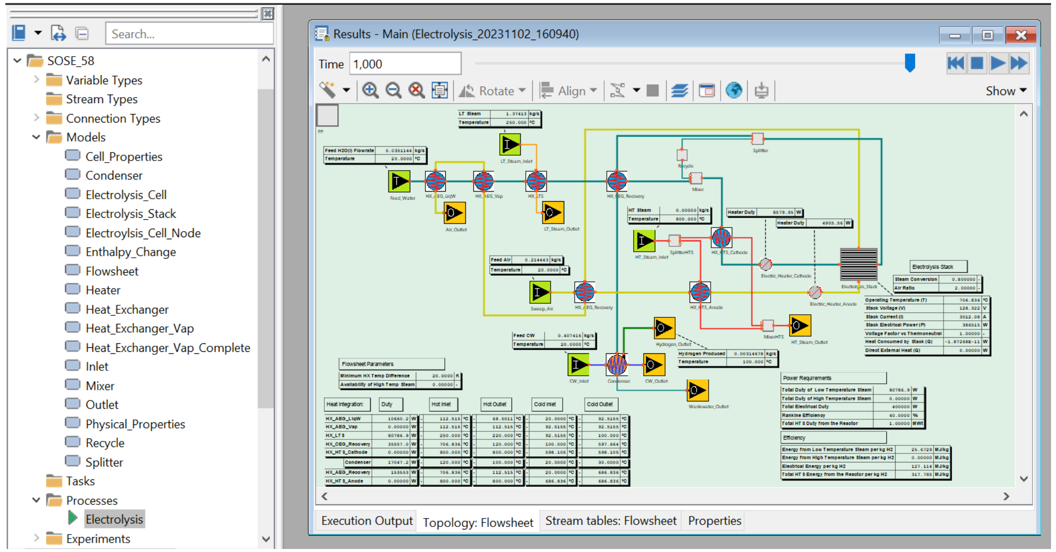
Multi-step and hybrid cycles (TRL <<5)

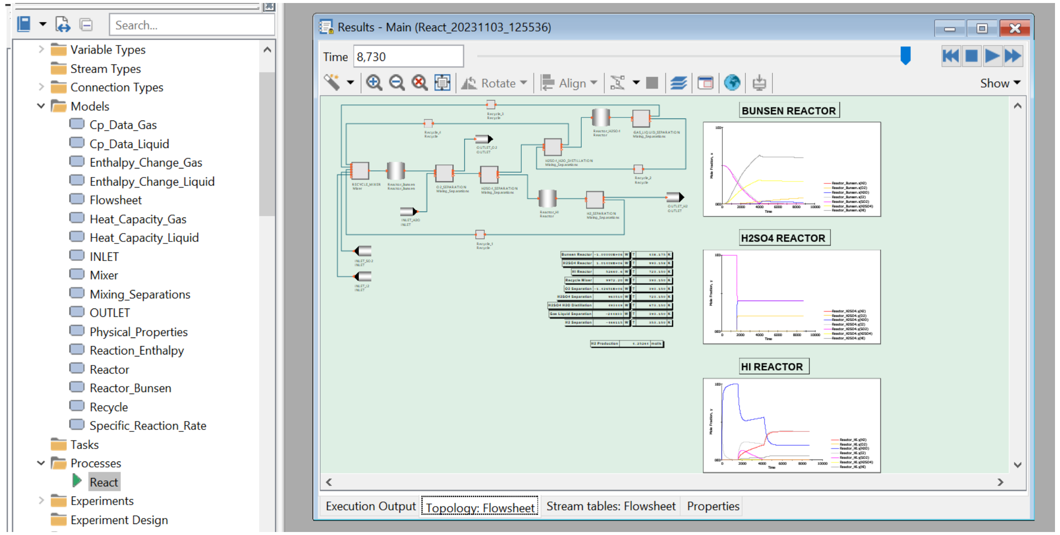
- Theoretically sound approach, but with large technical challenges to overcome
- Limited research in UK, unlikely to make much impact in short/ near term due to technical 'dead ends'
- Difficult to reliably determine the potential with nuclear derived energy due to low-TRL

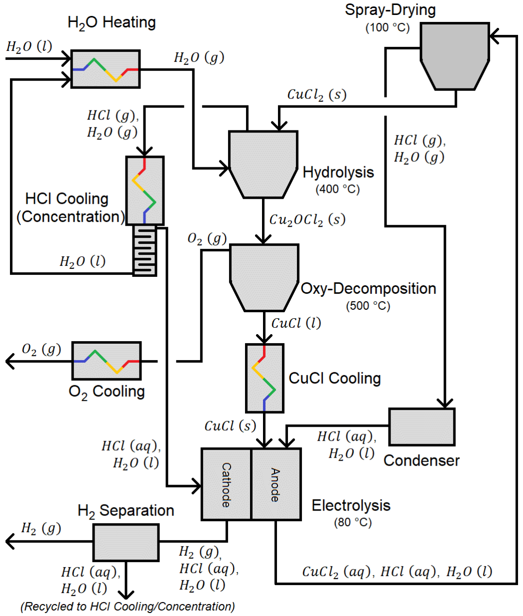
Process modelling of coupled hydrogen generation and nuclear systems

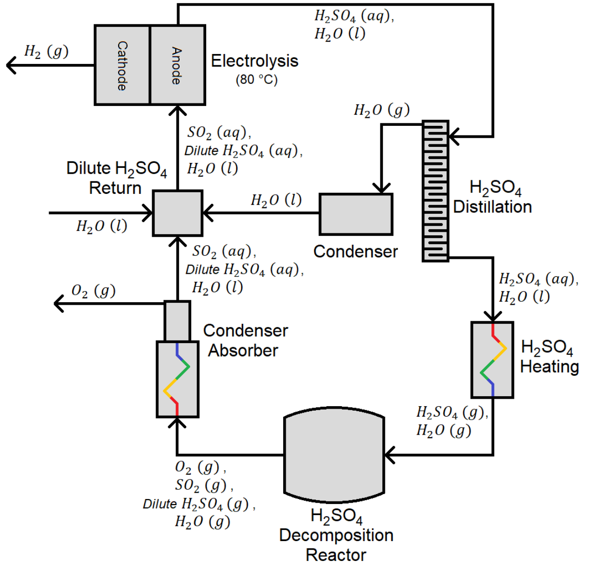




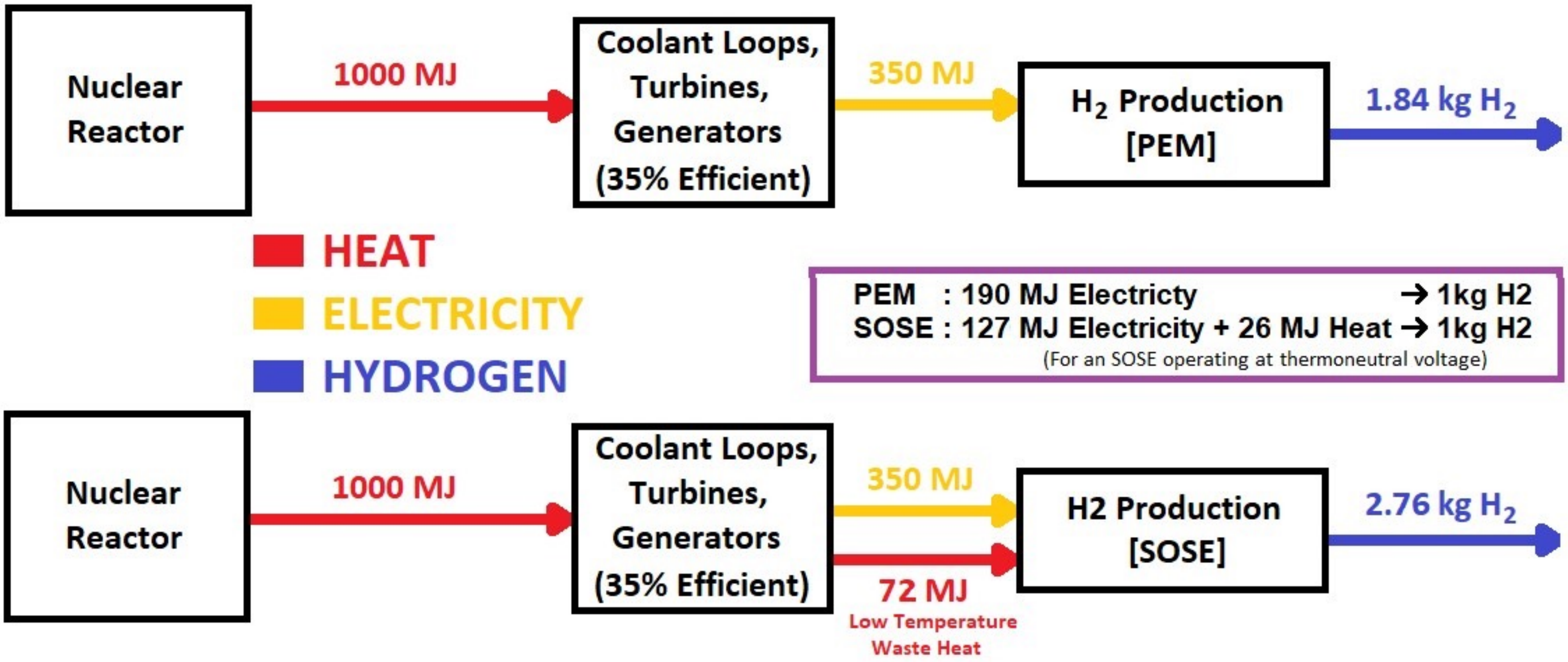








Process modelling of coupled hydrogen generation and nuclear systems



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Advanced Modular Reactor- High Temperature Gas Reactor

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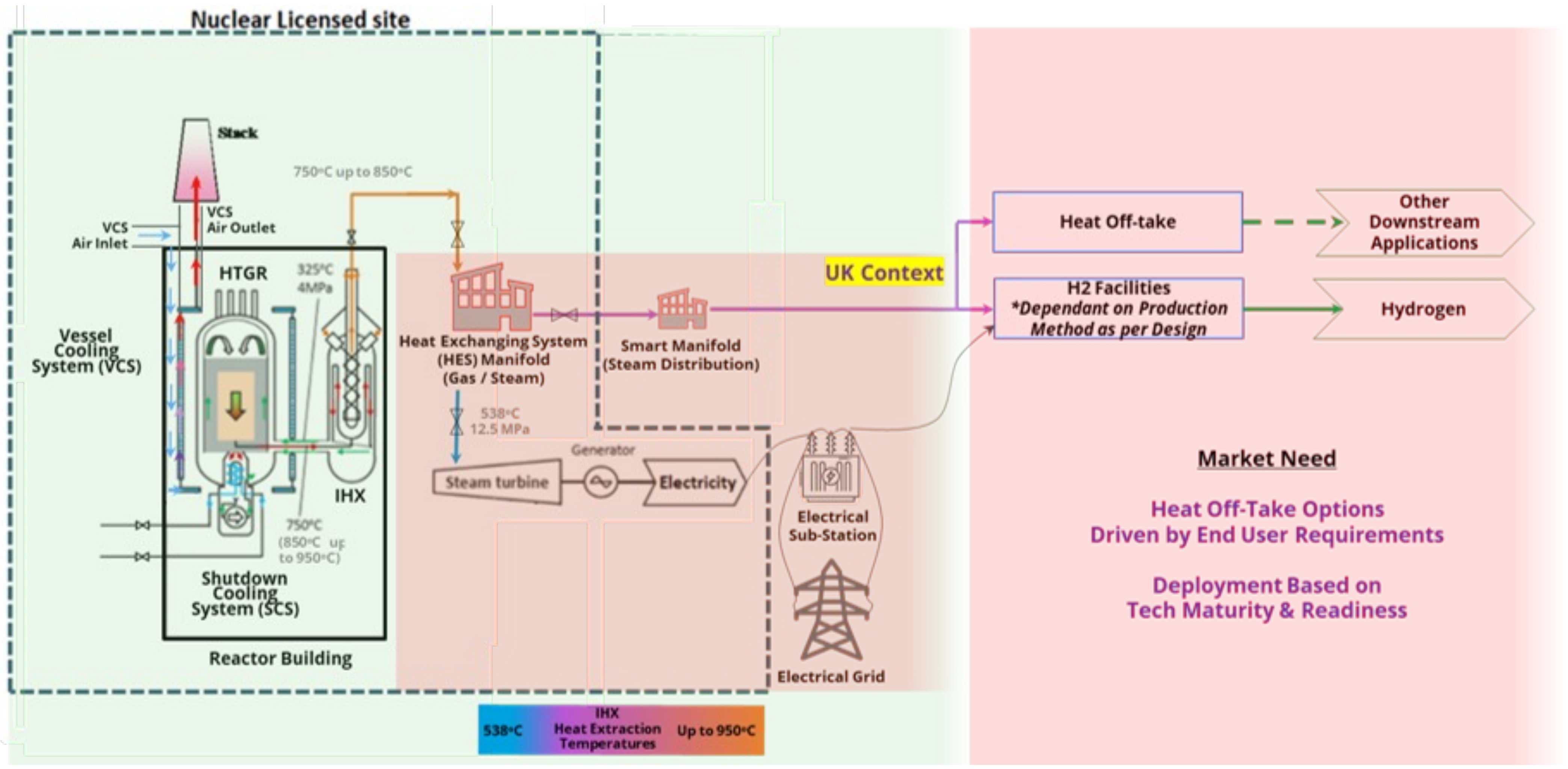
UKJ-HTGR


Nuclear Licensed site
Stack
750°C up to 850°C
VCS Air Inlet
VCS Air Outlet
HTGR
325°C
4MPa
Vessel Cooling System (VCS)
IHX
750°C
(850°C up to 950°C)
Shutdown Cooling System (SCS)
Reactor Building
Heat Exchanging System (HES) Manifold (Gas / Steam)
Smart Manifold (Steam Distribution)
UK Context
538°C
12.5 MPa
Generator
Steam turbine
Electricity
Electrical Sub-Station
Electrical Grid
538°C
IHX Heat Extraction Temperatures
Up to 950°C
Heat Off-take
Other Downstream Applications
H2 Facilities
*Dependant on Production Method as per Design
Hydrogen
Market Need
Heat Off-Take Options
Driven by End User Requirements
Deployment Based on
Tech Maturity & Readiness

AMR Competition

Department for Energy Security & Net Zero

Phase A — 2022

Phase B — 2023

Phase C — 2025

HTGR Demonstrator — Early 2030’s

Phase A Understood the potential size, type, cost, and delivery method for a HTGR demonstration

Phase B Underway to develop the HTGR solution.
Output will be the basis of the detailed design and engineering

Phase C Detailed site-specific design, nuclear site licensing, construction, commissioning and operation of the HTGR demonstration.

Summary

- The UK government has recognised the strong potential for High Temperature Gas-cooled Reactors to decarbonise industry, and has a plan to develop a HTGR demonstrator by the early 2030s

- Heat from HTGRs can be used directly in industrial processes and to generate hydrogen which can be used directly as a fuel to generate heat or for other purposes

- Japan and the UK have unrivalled experience in HTGRs gained from operating the HTTR and commercial fleets of reactors for decades

- The UK can accelerate the deployment of HTGR technology in UK by collaborating with Japan

- The result of our work will benefit the UK, Japan and ultimately the world


Nuclear


HYDROGEN
PRODUCTION & USES
ELECTRICITY


INTEGRATED ENERGY SYSTEM
NATIONAL NUCLEAR LABORATORY
SOURCES OF ENERGY
HYDROGEN PRODUCTION & USES
HEAT FROM NUCLEAR
ELECTRICITY
ENERGY STORAGE
ISOTOPES

Thank you

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