NNWI
New Nuclear Watch Institute

12 May 2025

Non-Electric Applications of SMRs: Catalyzing Clean Hydrogen Production and Beyond

Panel 1: Unlocking the Potential of Small Modular Reactors for Hydrogen Generation and Non-Electric Applications

Moderator: Tim Yeo, Chairman, NNWI

- **Dr. Hirofumi Ohashi**, Deputy Director, HTGR Project Management Office, Japan Atomic Energy Agency (JAEA)
- **James Bowyer**, Project Director, newcleo
- **Mike Crawforth**, Strategy & Business Development Manager, Rolls-Royce SMR

Clean Hydrogen and Process Heat Production by HTGR Under UK-Japan Collaboration

12 May 2025

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Non-Electric Applications of SMRs: Catalyzing Clean Hydrogen Production and Beyond

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1. Contribution of High Temperature Gas-cooled Reactors (HTGRs) for Net Zero
2. Japanese knowledge and experience in HTGR
3. The UK HTGR Demonstrator Programme in collaboration with Japan
4. Summary

Clean hydrogen is necessary for Net Zero

- Achieving net zero in the UK requires decarbonisation of hard-to-abate sectors (transportation, industrial sectors).
- Decarbonisation in these sectors necessitates a stable supply of high-temperature heat and hydrogen from non-fossil resources.

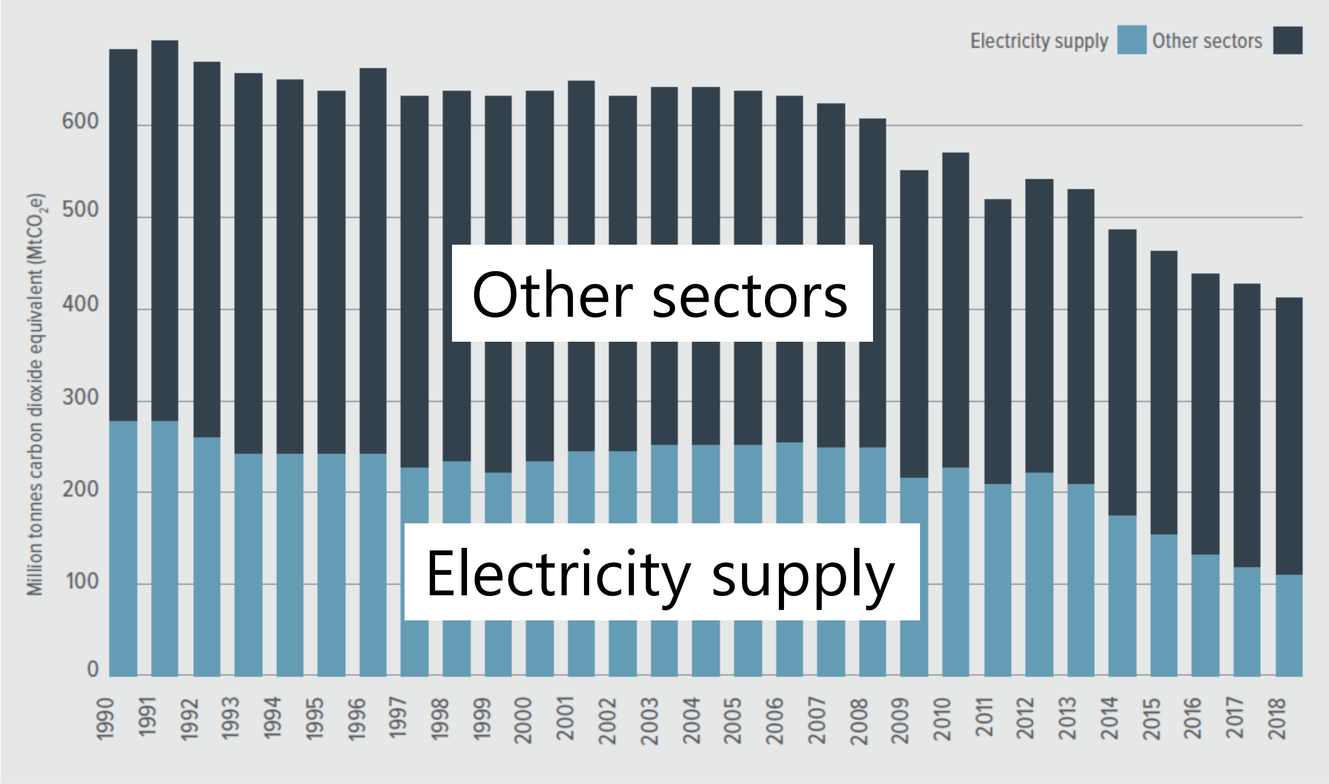


Figure 2 CO_2 emissions from electricity generation compared to other CO_2 emissions, 1990 – 2018 ($MtCO_2$) [18]

CO_2 emission in the UK

https://www.nirab.org.uk/our-work/publications

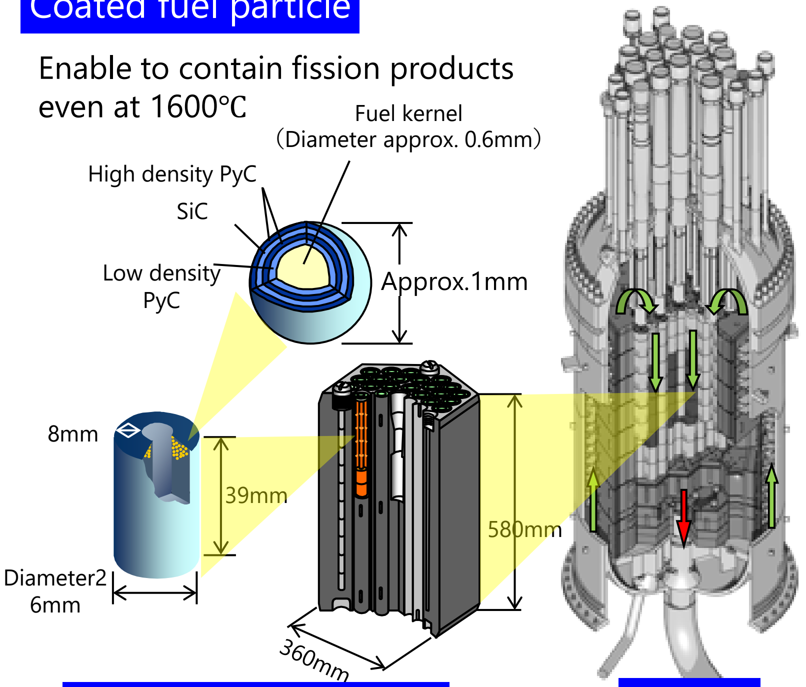
Contribution of HTGRs towards Net Zero

Attractive safety

Feasible to design a reactor with
No core meltdown due to inherent safety features.

Coated fuel particle

Enable to contain fission products even at 1600℃



Graphite components

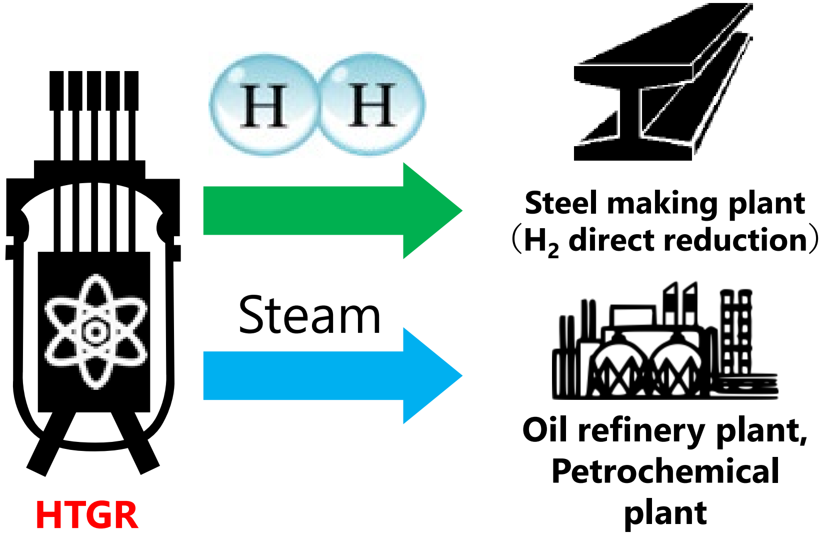
Allowable temperature limit 2500℃

Helium

Stable at high temperature (No temperature limits, chemically inert)

Capability to produce large amount of clean hydrogen and process heat stably

HTGR can supply high-temperature heat above 900°C* and support various applications, including hydrogen production, process heat supply, power generation, desalination, etc.



* Other types of nuclear reactors, including Small Modular Reactors (SMRs) and Advanced Modular Reactors (AMRs), cannot achieve such high temperatures as HTGRs. The Japanese HTGR is the only HTGRs capable of producing high-temperature heat suitable for hydrogen production.

JAEA' HTGR - The only prismatic-type HTGR in operation in the world

HTTR: High Temperature Engineering Test Reactor

Major Specifications

Thermal power	30 MW
Fuel	Coated fuel particle / Prismatic type
Core material	Graphite
Coolant	Helium
Outlet temperature	950°C
Pressure	4 MPa

H2 Production Demonstration

Establishment of fundamental technologies

2024	Loss of forced cooling test at full power
2022	Station blackout test
2021	Restart operation
2020 ～ 2014	Conformity review on the new regulatory requirements
2010	Start of loss of forced cooling test
	950°C/50 days operation
2007	850°C/30 days operation
2004	Reactor outlet coolant temperature 950°C
2002	Safety demonstration test (control rod withdrawal test)
2001	Reactor outlet coolant temperature 850°C (30MWt)
1998	First criticality

First in the world

Construction of reactor

1997 ～ 1991	Construction
1990 ～ 1989	Application and permission of construction
1988 ～ 1985	Detail design

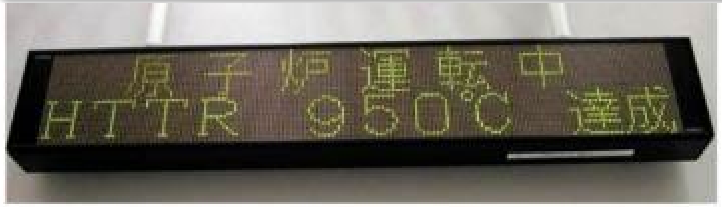
H T T R

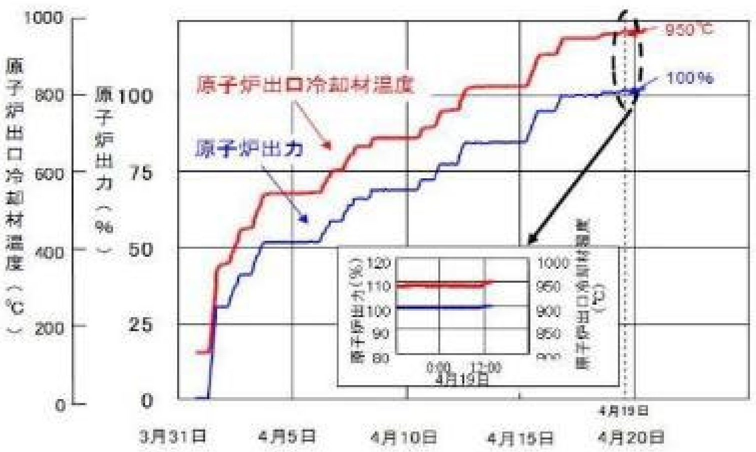
Research and development and design

1984 ～ 1981	Basic design
1980 ～ 1974	System integrity design
1973 ～ 1969	Conceptual design

Multi-purpose experimental Very High Temperature Reactor (VHTR)

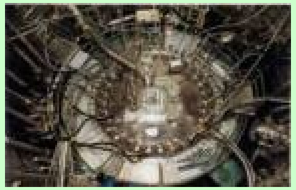
Attainment of reactor outlet temp. 950°C





Research and development

Fuels・Materials



In-pile helium loop (OGL-1)

Reactor physics

Very High Temperature Reactor Critical assembly (VHTRC)

Thermal hydraulics

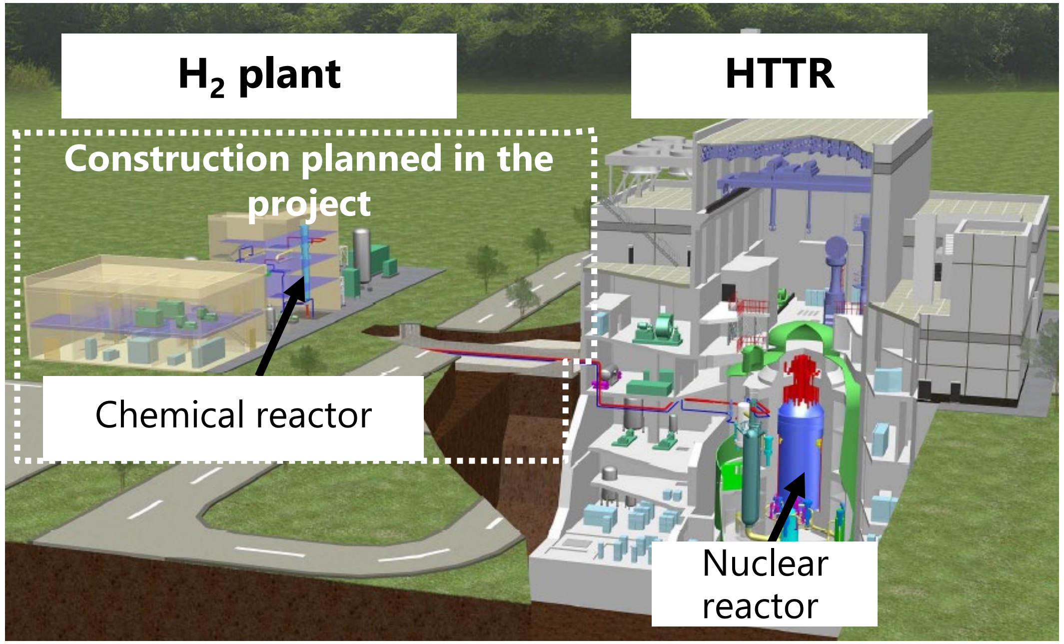
Helium Engineering Demonstration Loop (HENDEL)

H_2 production demonstration using HTTR in JAEA

- The world's first hydrogen production utilising high-temperature heat from a nuclear reactor.

【Tasks】

- ➢ Use the HTTR as a heat source for hydrogen production, which has demonstrated a 950°C heat supply capability.
- ➢ Establish safety design and evaluation technologies for coupling between HTGR and H_2 plant
- ➢ Demonstrate performance of components required for coupling between HTGR and H_2 plant



Just applied on 27th March

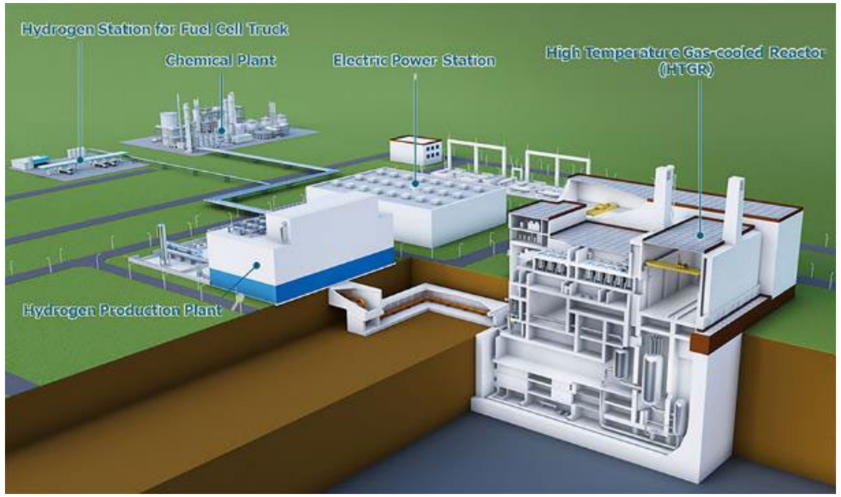
Schedule (JPFY)

2022	2023	2024	2025	2026	2027	2028	2029	2030

- Safety design/ safety analysis (2022–2024) → Licensing (2025–mid 2026)
- HTTR modification design, H_2 plant design (2022–2025) → Modification, Manufacturing/Installment (2026–2028) → H_2 production test (2028–2030)

HTGR demonstrator for H_2 production in Japan

- Target of operation in the 2030's.
- The budget for FY2023 through FY2027 has been approved at 183 billion JPY (about £963 million)
- A reactor power range from 150 MW-250 MW*1.
- Supply a very high temperature above 800°C to H_2 plant*2.
- Combination with a carbon-free H_2 production technology enables large-scale, low cost, carbon-free H_2*3.



https://www.mhi.com/jp/news/230725.html

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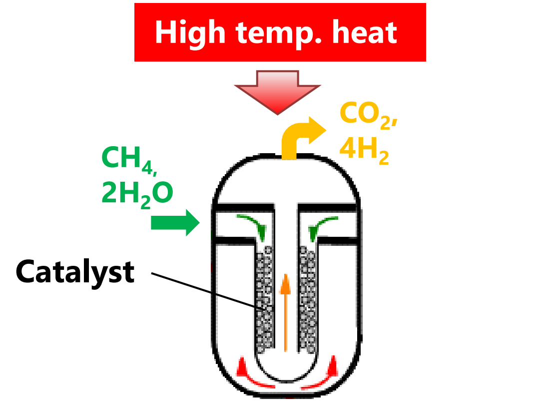
<td>
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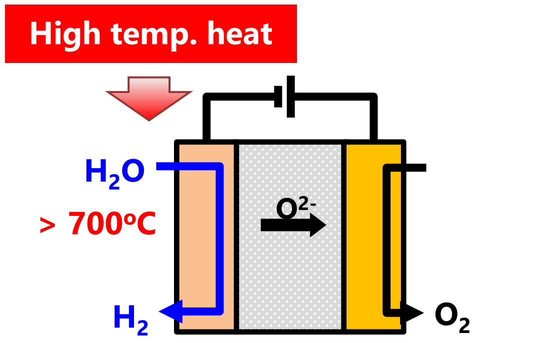
<td>
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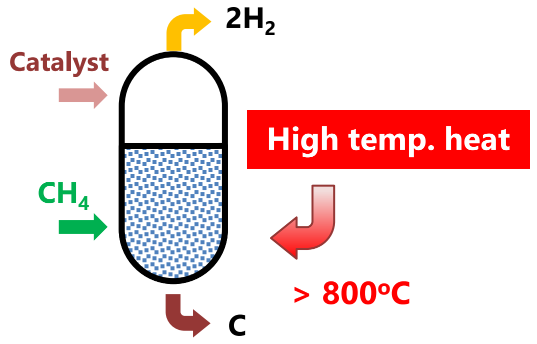
<td>
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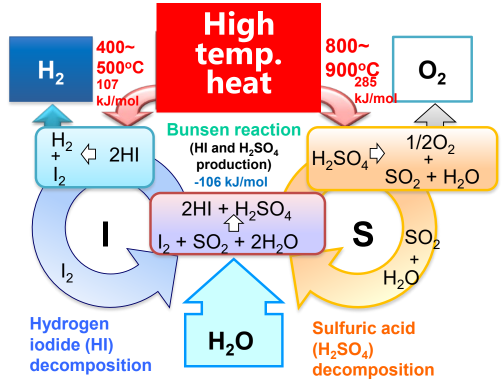
<td>
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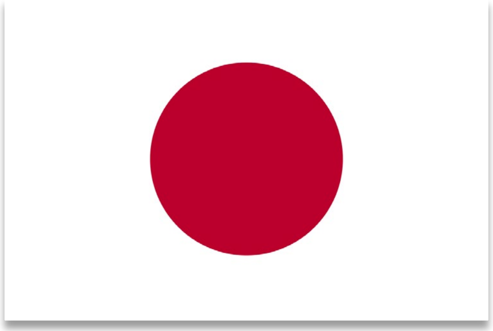
<tr><td>$CH_4 + 2H_2O \rightarrow CO_2 + 4H_2$</td><td>$H_2O \rightarrow H_2 + 1/2O_2$</td><td>$CH_4 \rightarrow 2H_2 + C(s)$</td><td>$H_2O \rightarrow H_2 + 1/2O_2$</td></tr>
</table>

*1 Y. Usui, et al., Development of High Temperature Gas-cooled Reactor by Mitsubishi Heavy Industries, The 19th Lecture Meeting of the Japan Society of Maintenology, C-1-1-4 (2023).
*2 METI, www.enecho.meti.go.jp/appli/submission/2022/0222_01.html, accessed on January 19, 2024.
*3 K. Asano, et al., Development of Large-scale Hydrogen Production Technology utilizing Very High Temperature Part1 (2) Feasibility Study of Hydrogen Production Technology utilizing Very High Temperature, 2022 Fall Meeting of AESJ, September 9, 2022, Ibaraki, Japan

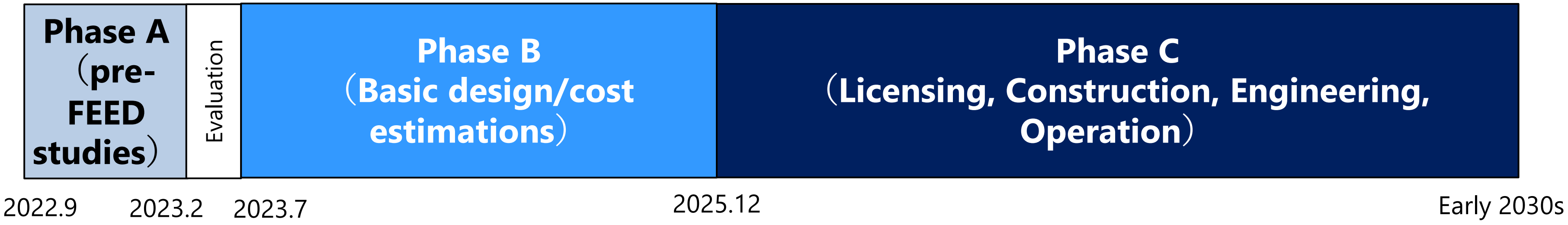
HTGR demonstrator programme in the UK

- The UK government (DESNZ) is currently promoting the development of an HTGR demonstrator and HTGR fuel as part of the AMR RD&D Programme Phase-B and the UK Coated Particle Fuel (CPF) - Step 1 Programme.
- The United Kingdom National Nuclear Laboratory (UKNNL), in collaboration with JAEA, has been selected for both Phase-B and Step 1.
- JAEA is currently providing both design information for the HTGR demonstrator and fuel manufacturing technology to UKNNL.



AMR RD&D Programme

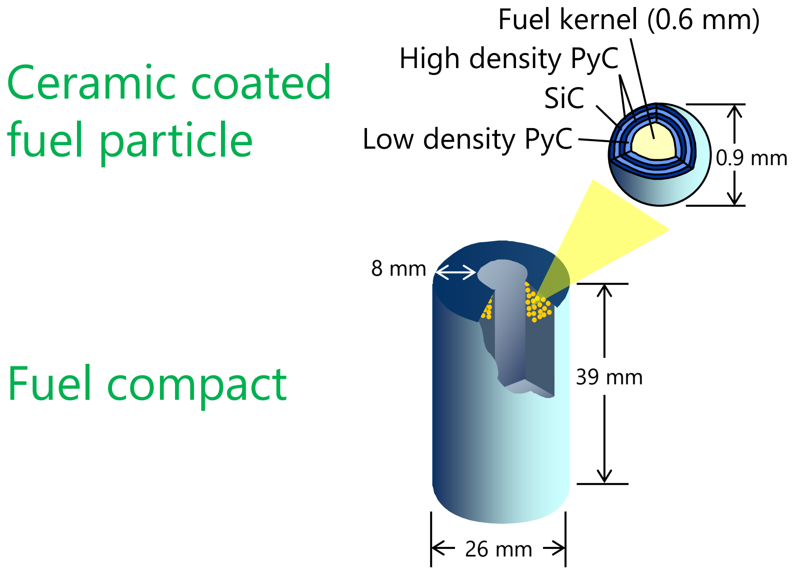
- Phase A：pre-FEED studies (2022.9～2023.2)
- Phase B：Basic design, cost estimations (2023.7～2025.12)
- Phase C：Licensing, Construction, Engineering, Operation



Technology transfer to the UK

- The technology transfer of HTGR fuel manufacturing to the UK is ongoing.

- HTGRs use an advanced type of nuclear fuel known as Coated Particle Fuel (CPF)
- Japan successfully manufactured this fuel for the Japanese HTGR (HTTR) with high quality.
- Two x 2-week training (Jan. and Feb. 2025) at Nuclear Fuel Industries, Ltd. (NFI) in Japan, with 9 participants from UKNNL and Springfield Fuels Ltd. (Westinghouse).

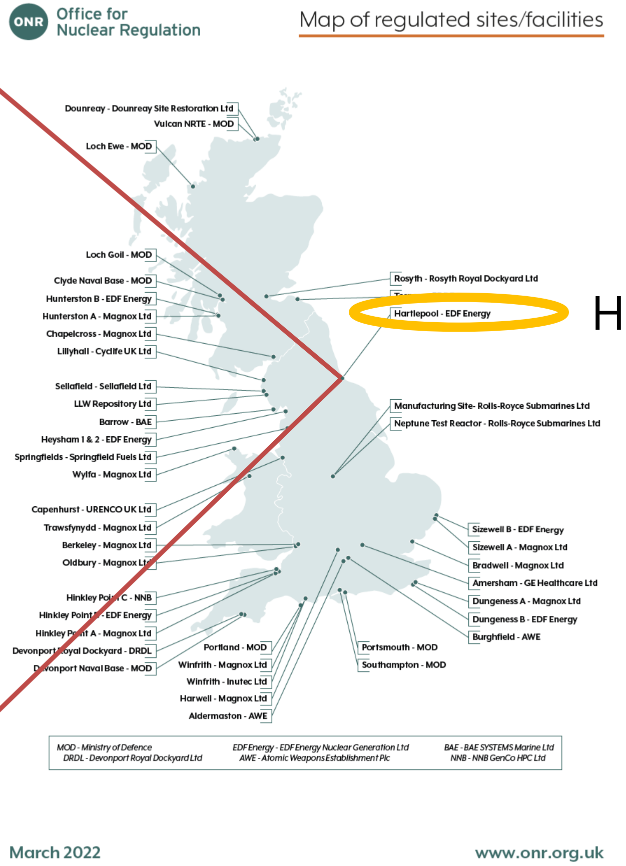


Fuel manufacturing training in Japan

UK HTGR demonstrator potential site

- The UK has extensive experience from existing Advanced Gas-cooled Reactors (AGRs) operated in the UK by EDF. These reactors have been operating since the 1970s and possess technologies in common with HTGRs.
- HTGRs are the optimal choice from the perspective of utilising EDF knowledge and personnel following the shutdown of the AGRs in the next few years.

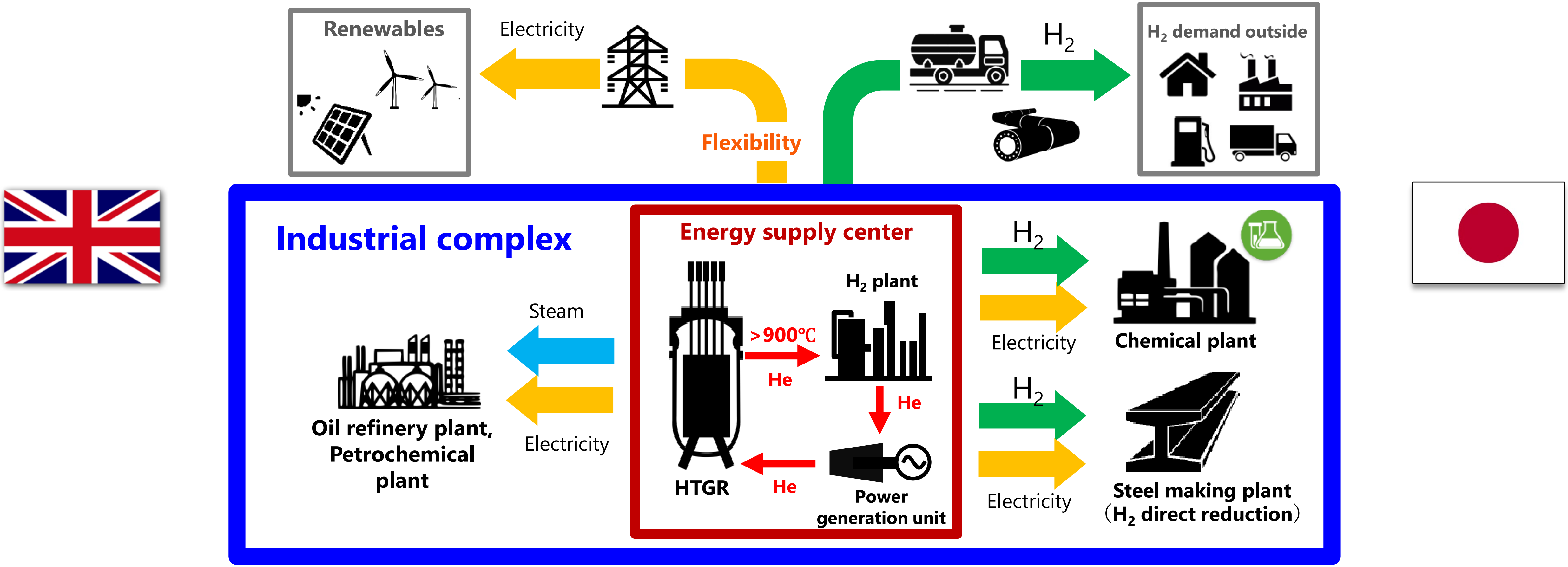
EDF-Energy flyer



Hartlepool EDF Energy

Contribution of HTGR towards Net Zero under UK-Japan Collaboration

- The UK-Japan collaboration, combining Japan's expertise in HTGR technology with the UK’s extensive experience in AGR operation, enables the early deployment of HTGRs in both the UK and Japan, contributing to the decarbonization in both countries.



Adding new social value

Achieving carbon neutrality in Hard-to-Abate industries

Reinforcement of resilience for carbon neutral society

※Figures in the following report is used
METI,
https://www.meti.go.jp/shingikai/energy_environment/suiso_nenryo/pdf/027_01_00.pdf
(accessed on November 14, 2023)

Summary

- HTGRs enable large-scale and stable hydrogen production, which is challenging to achieve with renewable energy alone. HTGRs can contribute to achieving Net Zero in the UK.
- Japan has the only operational HTGR (HTTR) outside of China, along with advanced associated nuclear fuel technologies. The Japanese HTGR is the only Advanced Modular Reactor (AMR) capable of producing high-temperature heat suitable for hydrogen production.
- JAEA is currently preparing to obtain permits for a hydrogen production facility adjacent to the HTTR, where operational data will soon be collected.
- Japan is advancing HTGR commercialization initiatives for large-scale hydrogen production (HTGR demonstrator) with a £963 million government budget allocated for 2023–2027.
- The UK is capitalising on Japan's significant new investment in the HTGR demonstrator development and more than 50 years' experience and investment in the HTTR development through collaboration on the AMR RD&D and the UK Coated Particle Fuel Programmes.
- The UK-Japan collaboration, combining Japan's expertise in HTGR technology with the UK's extensive experience in AGR operation, enables the early deployment of HTGRs in both the UK and Japan, contributing to the decarbonisation in both countries.

newcleo
Futurable Energy

Unlocking the potential of SMRs and AMRs for Hydrogen and Sustainable Aviation Fuel in the UK – the key opportunities and challenges

James Bowyer, UK Project Director, newcleo

12th May 2025

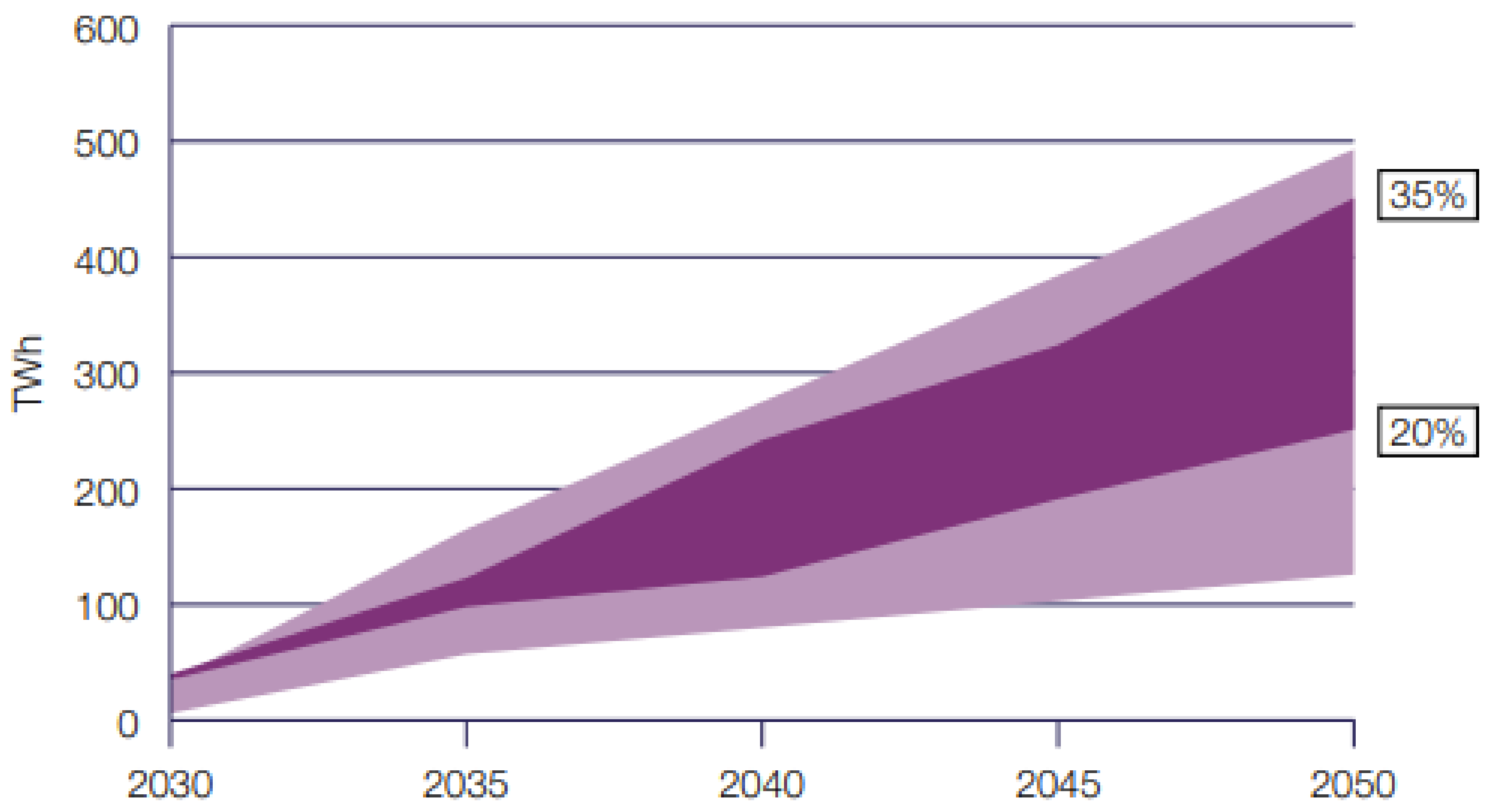
Unlocking the potential of Small Modular Reactors (SMRs) for Hydrogen & Sustainable Aviation Fuels (SAF)

- Demand for power and heat created by the Hydrogen and SAF revolution & the potential role of SMRs / AMRs in the UK's Clean Energy Transition
- Hydrogen Production Methods using nuclear
- Technical Advantages & Deployment Considerations - Why Nuclear for Hydrogen?
- Deployment Pathways in the UK
- Regulatory & Policy Landscape, opportunities and challenges
- Supply Chain & Infrastructure Readiness
- Long Term Vision for nuclear derived H_2 and SAF – what could the future look like?
- Call to Action: Making SMR/AMR Driven Hydrogen a Reality in the UK

The surging demand for power and heat created by the Hydrogen and SAF revolution

- UK Government's Hydrogen Strategy: deliver 10 GW of low-carbon hydrogen capacity by 2030, with at least half coming from electrolytic sources.
- SAF production is being prioritised through the Jet Zero Strategy, which targets 10% SAF blending in UK aviation fuel by 2030 and Net Zero aviation by 2050.
- SMRs and AMRs are uniquely positioned in the UK and Europe to meet these ambitions by providing clean, stable, secure, and dispatchable energy at industrial scale.

Hydrogen demand and proportion of final energy consumption in 2050 for the UK

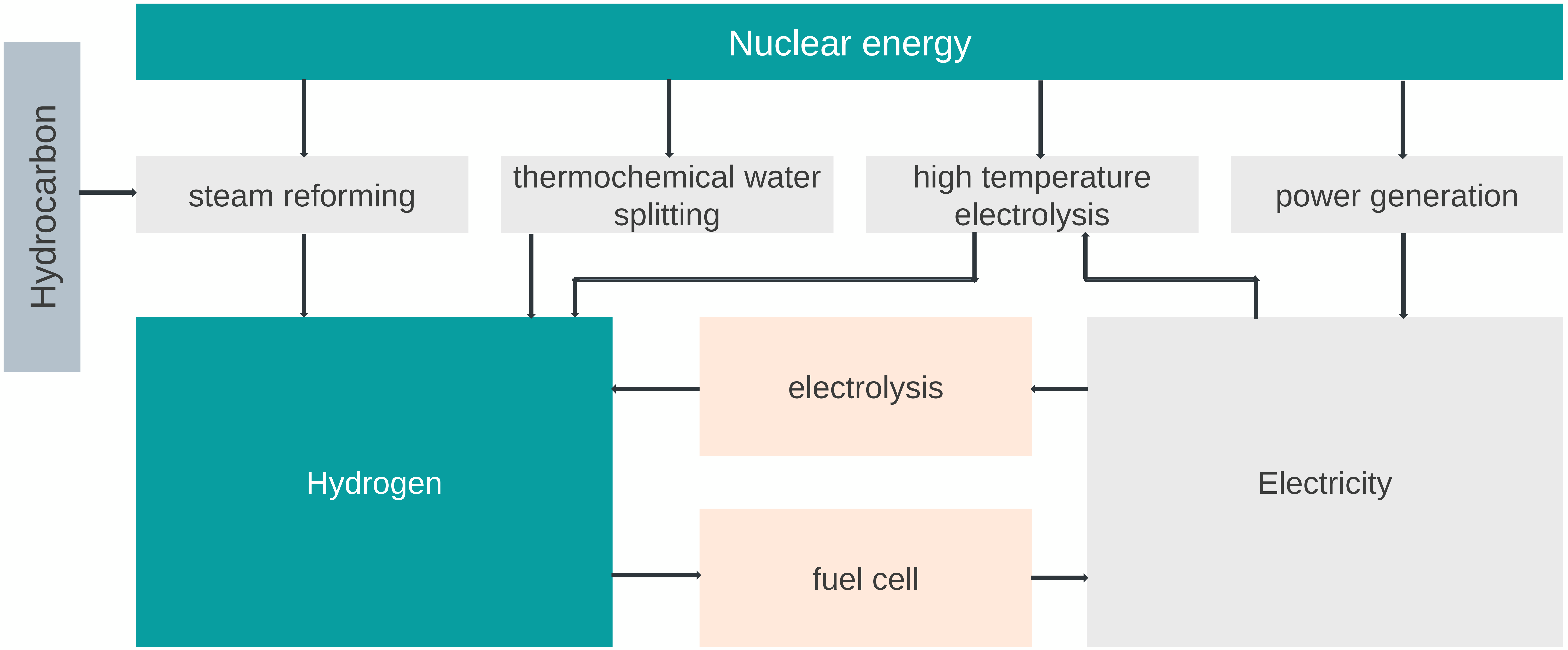


% = hydrogen as proportion of total energy consumption in 2050

Source: Central range – illustrative net zero consistent scenarios in CB6 Impact Assessment. Full range – based on whole range from UK Hydrogen Strategy Analytical Annex. Final energy consumption from ECUK (2019).

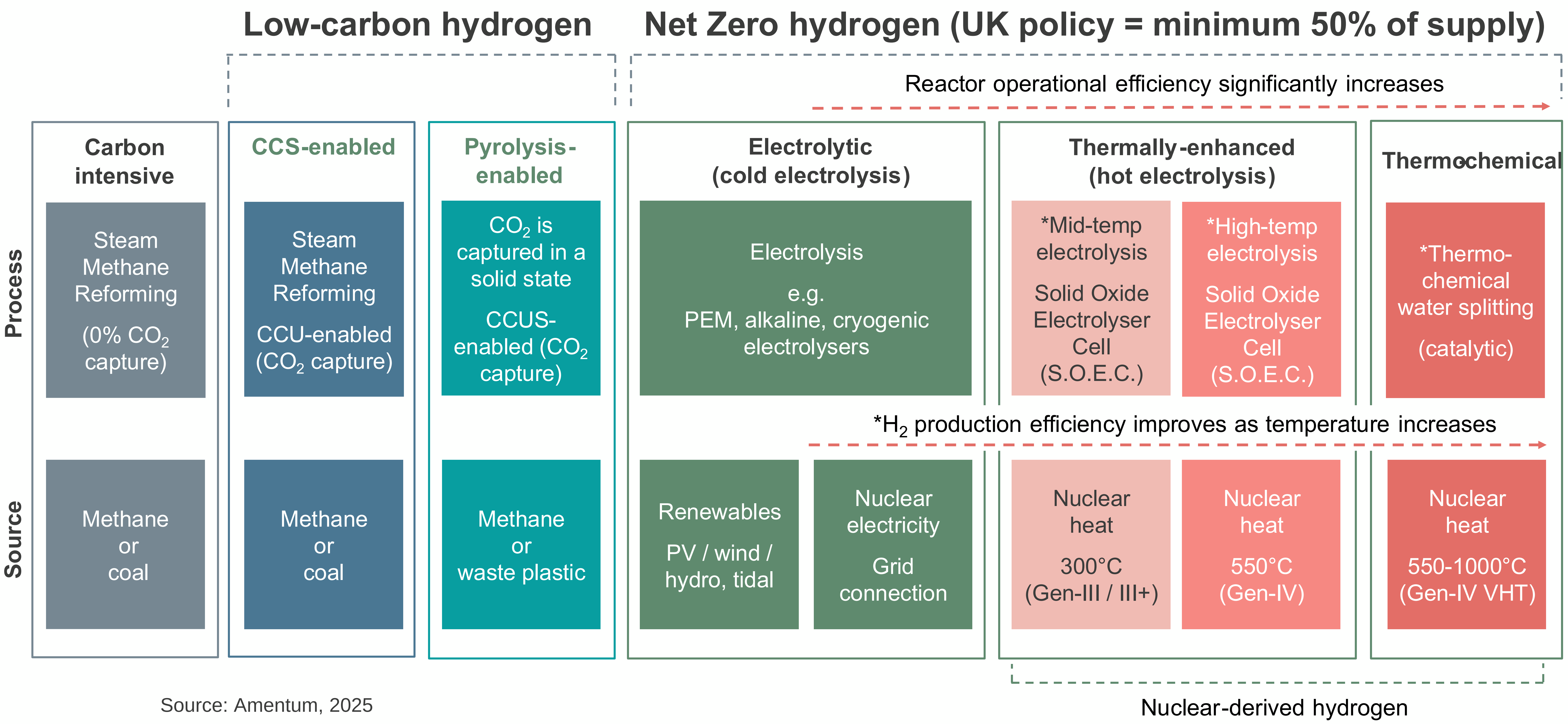
Image, right: UK Hydrogen Strategy
https://assets.publishing.service.gov.uk/media/64c7e8bad8b1a70011b05e38/UK-Hydrogen-Strategy_web.pdf

Nuclear-derived hydrogen production methods



Why nuclear-derived hydrogen?

- Nuclear-derived hydrogen is the most efficient method of hydrogen production, with the added benefit of continuous power output too



Source: Amentum, 2025

And why SMRs and AMRs for hydrogen?

1

Continuous and reliable

- Nuclear power, unlike intermittent renewables, provides 24/7 reliable low-carbon baseload power with continuous, high-capacity power for uninterrupted electrolysis and synthesis processes

2

Small and modular

- Smaller footprint of SMRs/AMRs makes them ideal for integration into industrial clusters - reducing transmission losses, infrastructure costs, financing burden, and risk due to faster deployment

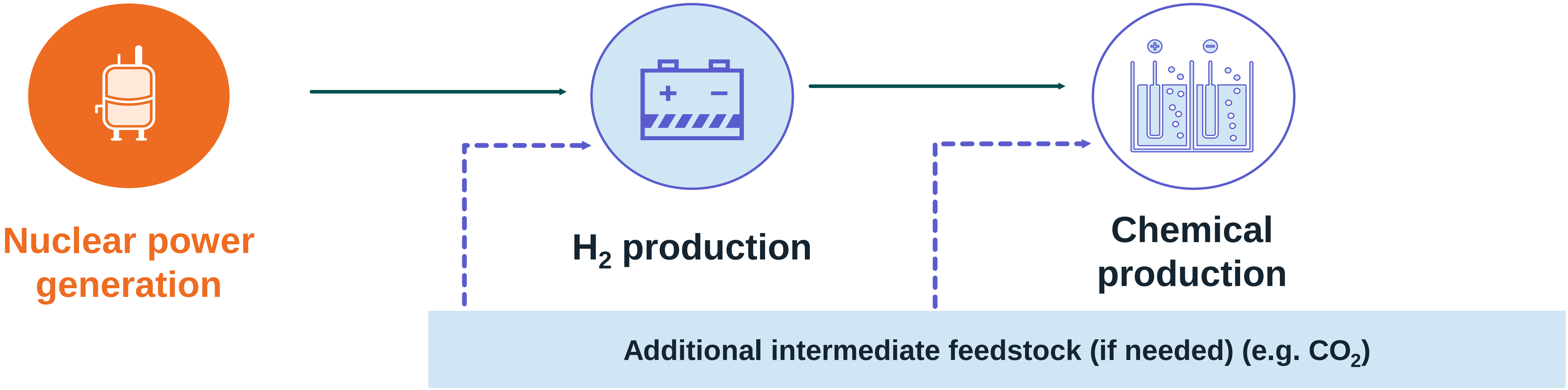
3

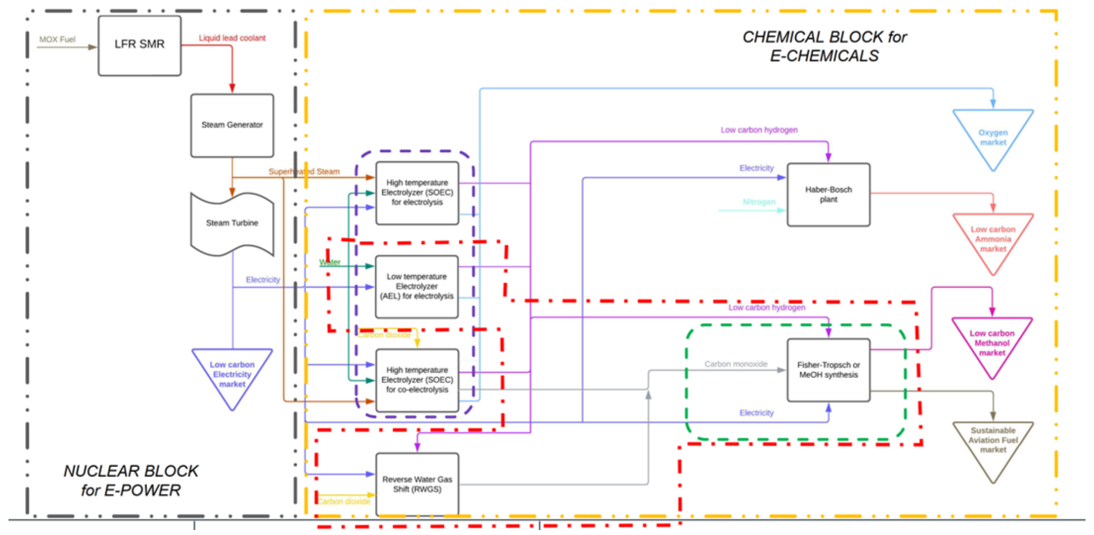
Stability for industry

- SMRs and AMRs provide the operational stability and thermal efficiency that large-scale hydrogen and SAF systems require, complementing renewables while alleviating grid pressures

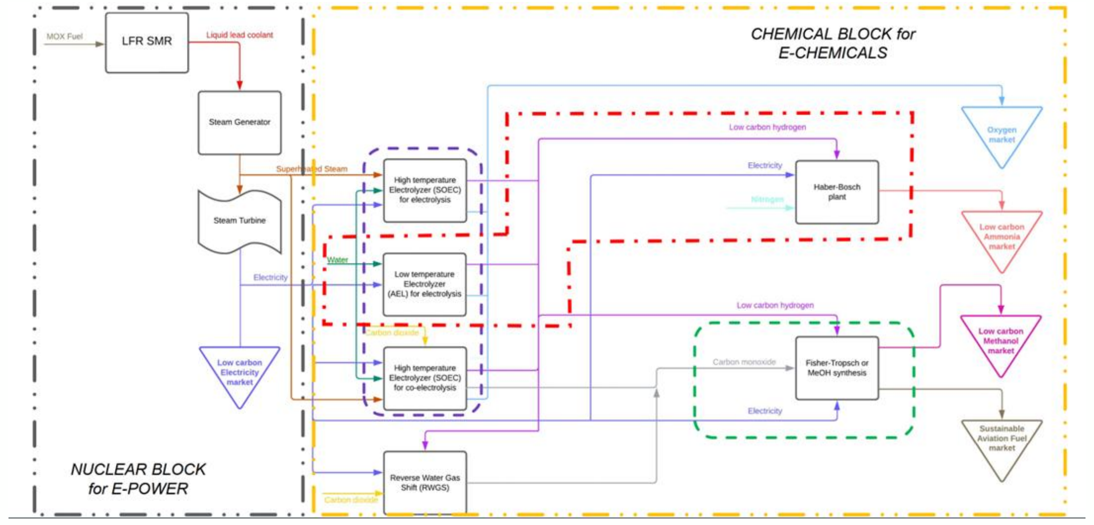
MAIRE NEXTCHEM e-factory for low carbon chemistry

NEXTCHEM and *new*cleo collaboration to make the Energy Transition happen





Routes to eMethanol and eSAF



Routes to green ammonia

*new*cleo technology

Selection of LFR-AS-200 as best AMR solution and process optimisation according with downstream technological blocks

H_2 technology

Selection of best H_2 solution and analysis considering tech maturity and economics

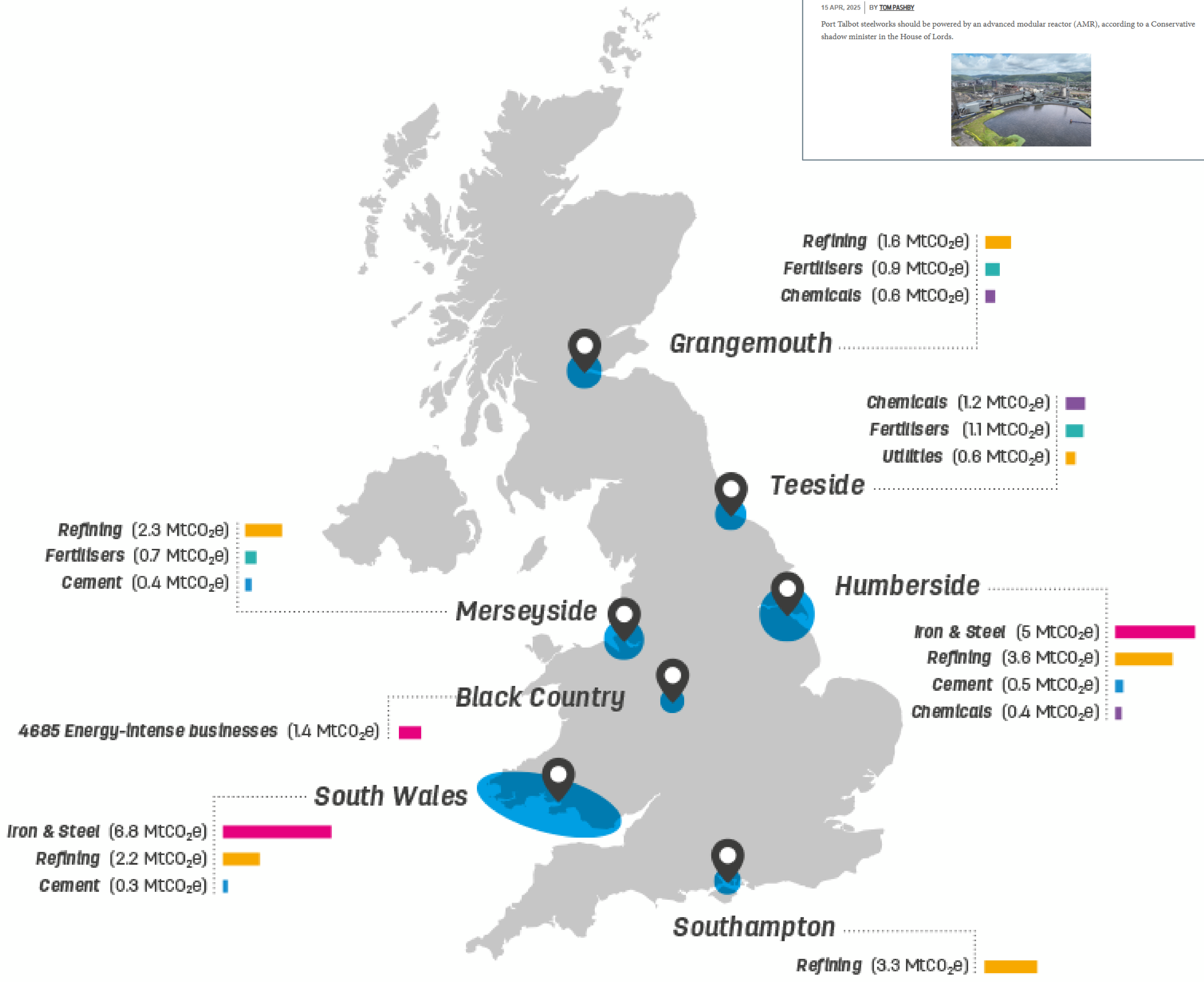
Chemical technology

Selection of different chemical tech solution within NEXTCHEM Holding portfolio or future developments or based on third party licensed technologies

Deployment opportunities in the UK

- Deployment must consider proximity to hydrogen users to minimise transport losses and integration with existing energy infrastructure.
- The UK is well-positioned to host SMR-powered hydrogen and SAF clusters in areas that already possess industrial hydrogen demand, strong infrastructure, and regional innovation ecosystems.
- Existing UK Industrial Clusters have scope to be decarbonised by nuclear energy.
- Early community engagement with robust safety messaging and clear communication of local skills, employment and investment benefits aligned with regional development plans are essential to unlocking local acceptance.

Current UK Industrial Clusters



Source: Zero Carbon Hubs, 2025 https://zerocarbonhubs.co.uk/industrial-clusters.html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SECTORS CLIENTS PROJECTS TOPICS MAGAZINE PODCAST ASK NCE EVENTS WHITE PAPERS

LATEST

Peer advocates for AMR to power Port Talbot steelworks

15 APR, 2025 | BY TOM PASHBY

Port Talbot steelworks should be powered by an advanced modular reactor (AMR), according to a Conservative shadow minister in the House of Lords.

Huge potential market size

- UK Government Policy is for **50%** of its low-carbon hydrogen target to be **electrolytic hydrogen (5GW)**
- This is the equivalent of **55 Modular Reactors** to meet demands of the 3 main UK Industrial Clusters

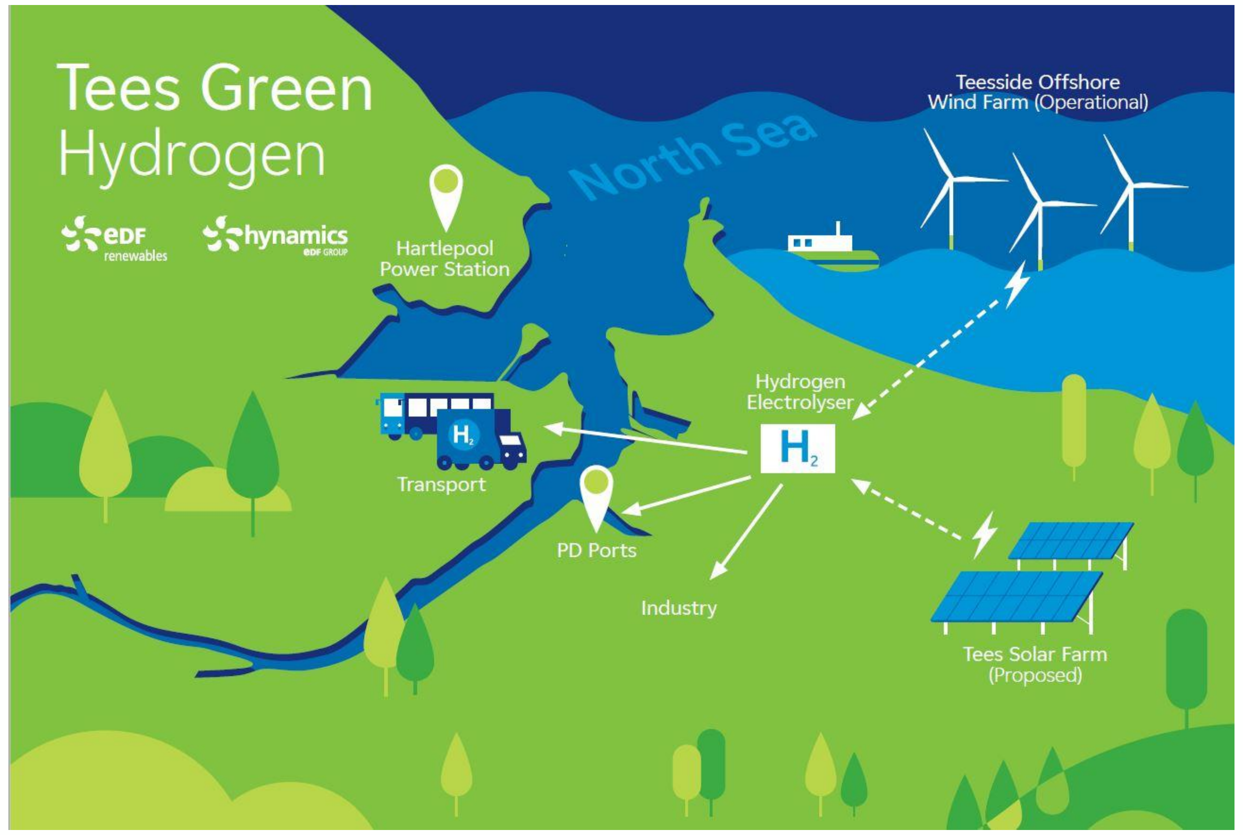
Industry segment / application	New clean energy sources required to decarbonise by 2050	Source references / proofs	AMR >550°C (900MWth)
Northwest Cluster	**9 GW** (for 7.5 GW of H_2 capacity)	Demand modelling by Northwest Hydrogen Alliance (NWHA) and Gemserve	**30**
East Coast Cluster	**12 GW** (for 10GW of H_2 capacity)	East Coast Hydrogen Association - 63 TWh/year	**40**
Net Zero Humber	**12 GW** (for 10GW of H_2 capacity)	Humber Zero demand modelling (ERM & Equinor) - 92 TWh/year potential for 100% hydrogen	**40**

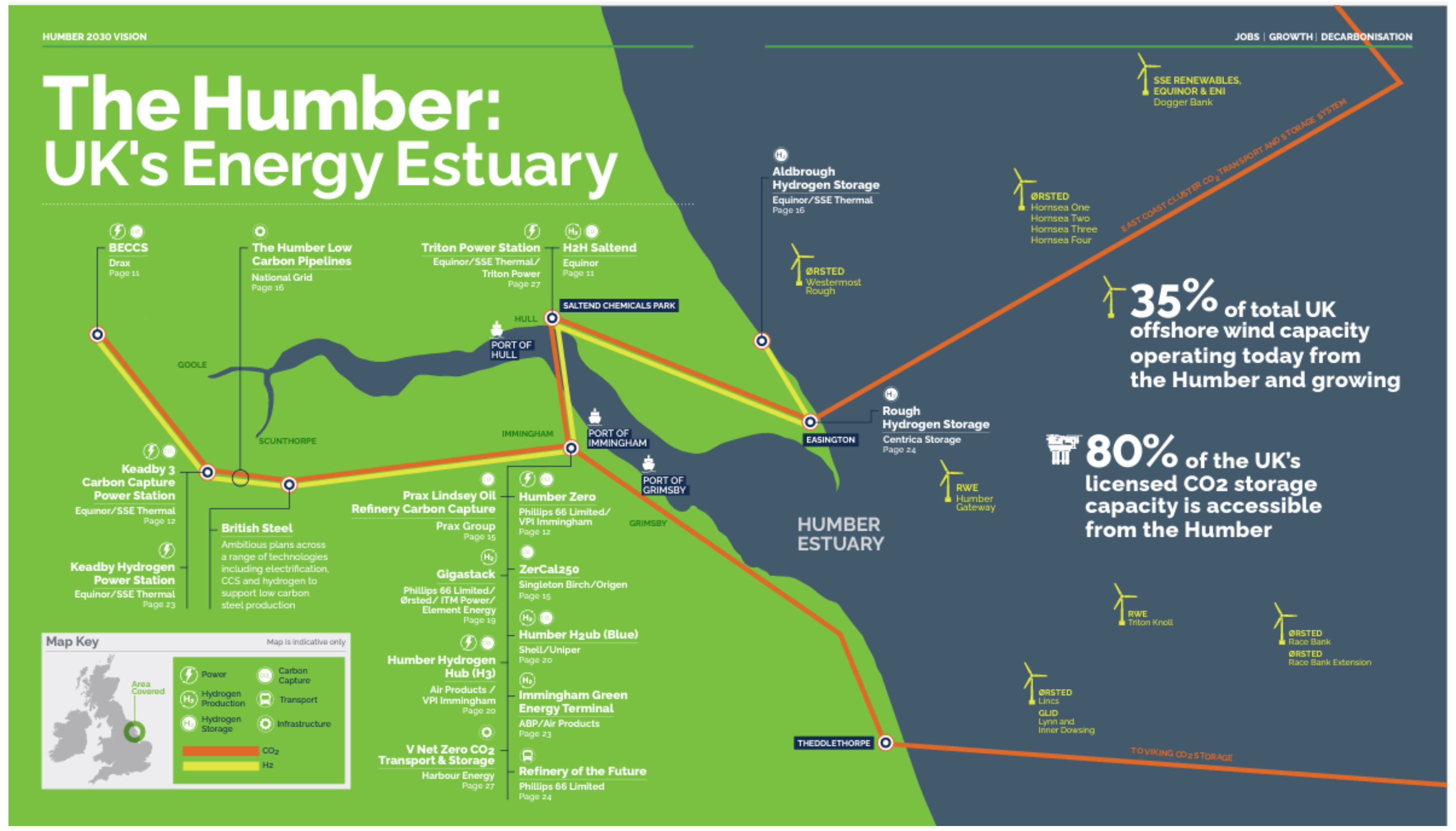
Source: Amentum, 2025

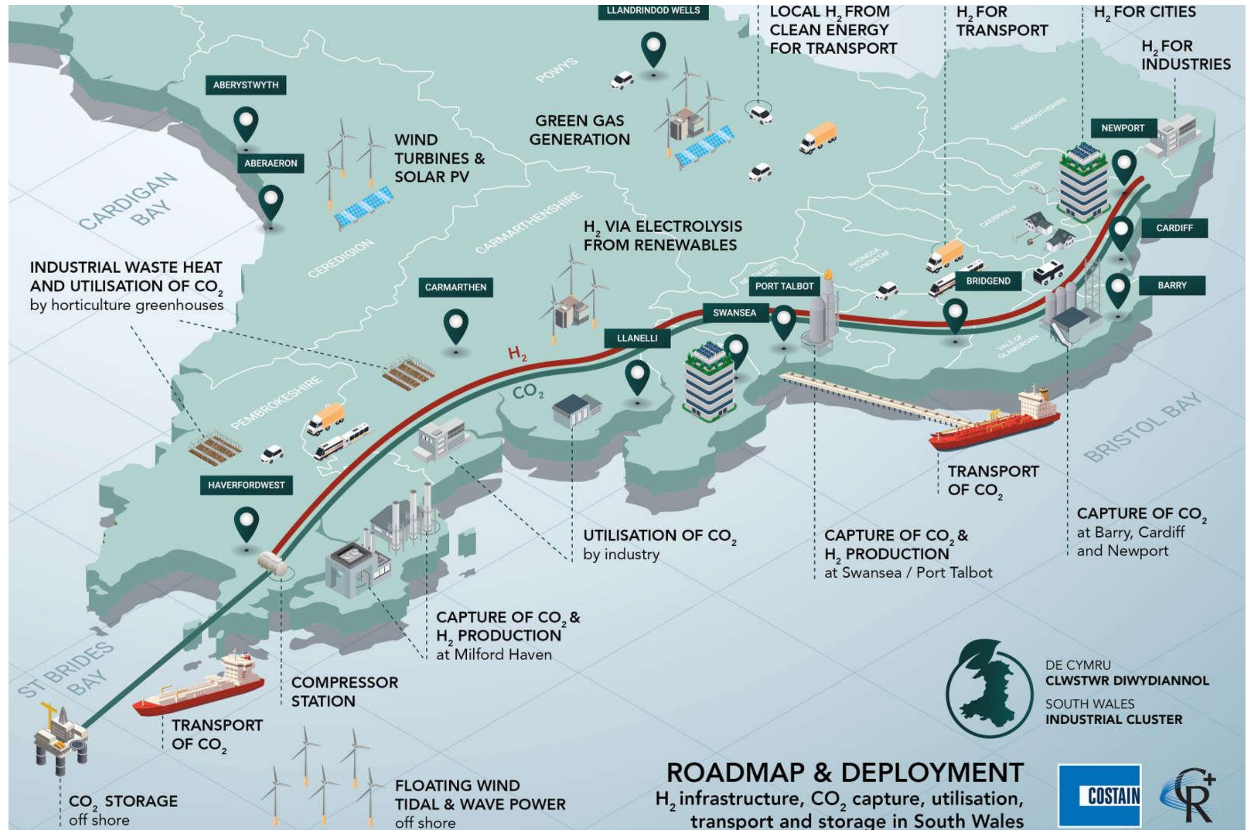
Supply chain & infrastructure readiness

- UK's nuclear supply chain is poised to support SMR, AMR and Hydrogen Plant manufacturing, although a pan-European effort will be required. Skills is going to a big challenge though!
- Joint ventures and public investment in manufacturing capabilities (e.g., gigafactories for electrolysis and modular reactors) will be needed to boost readiness.
- Government-industry collaborations like the Nuclear Sector Deal and Hydrogen Sector Development Action Plan will be crucial for readiness, but we recommend Industry-Government taskforce on nuclear-derived hydrogen to identify supply chain gaps and opportunities.

Examples of supply chain and inter-industry connectedness in the UK

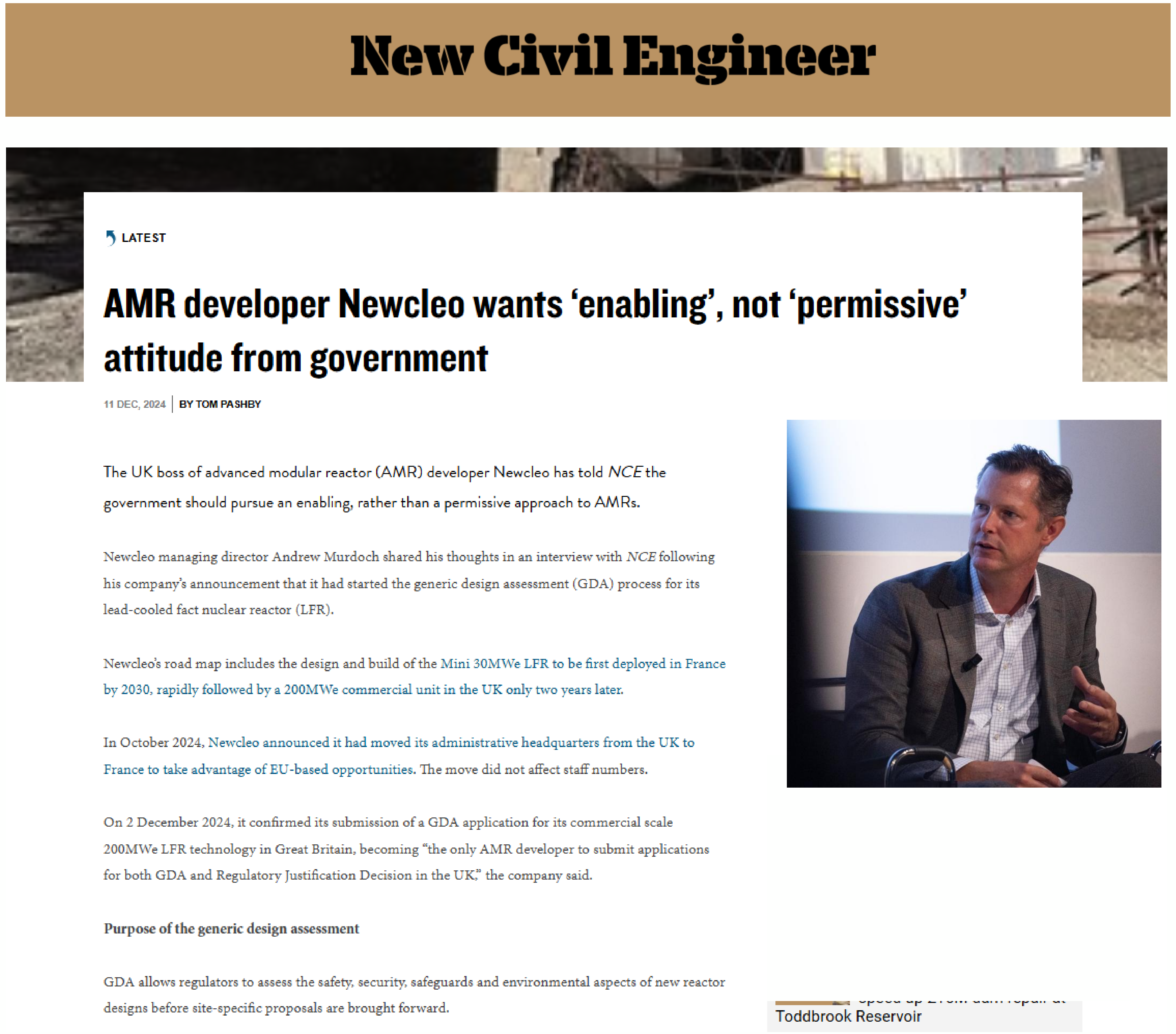






Regulatory landscape - progress and gaps

- While the Generic Design Assessment (GDA) provides a pathway for SMR/AMR approval, greater coordination is needed between nuclear, hydrogen, and environmental regulators to enable a joined up regulatory approach to co-located facilities and integrated permits and consents.
- Support the development of a risk-based regulation for the definition of Exclusion Areas for AMRs, specifically to facilitate support for energy intensive industrial areas.
- *new*cleo welcomes the recent planning reform as part of the Government's Plan for Change, which helps to clear a path for SMRs and AMRs to be located at such industrial sites outside the previously designated locations detailed in EN6.
- Regulatory clarity and policy support will be decisive in driving investor confidence and project bankability.


New Civil Engineer

LATEST

AMR developer Newcleo wants 'enabling', not 'permissive' attitude from government

11 DEC, 2024 | BY TOM PASHBY

The UK boss of advanced modular reactor (AMR) developer Newcleo has told *NCE* the government should pursue an enabling, rather than a permissive approach to AMRs.

Newcleo managing director Andrew Murdoch shared his thoughts in an interview with *NCE* following his company's announcement that it had started the generic design assessment (GDA) process for its lead-cooled fact nuclear reactor (LFR).

Newcleo's road map includes the design and build of the Mini 30MWe LFR to be first deployed in France by 2030, rapidly followed by a 200MWe commercial unit in the UK only two years later.

In October 2024, Newcleo announced it had moved its administrative headquarters from the UK to France to take advantage of EU-based opportunities. The move did not affect staff numbers.

On 2 December 2024, it confirmed its submission of a GDA application for its commercial scale 200MWe LFR technology in Great Britain, becoming "the only AMR developer to submit applications for both GDA and Regulatory Justification Decision in the UK," the company said.

Purpose of the generic design assessment

GDA allows regulators to assess the safety, security, safeguards and environmental aspects of new reactor designs before site-specific proposals are brought forward.

Toddbrook Reservoir

Policy & Investment considerations - How UK Gov can help

- Whilst the UK has taken positive steps to support hydrogen development, several gaps remain. Nuclear-generated hydrogen is not yet formally recognised in the UK's hydrogen certification or low-carbon hydrogen business model, potentially excluding SMR/AMR projects from contracts for difference (CfDs) or funding under the Net Zero Hydrogen Fund and Industrial Energy Transformation Fund (IETF).
- The right market support, incentives and funding mechanisms are needed form Government for industry adoption such as loan guarantees, tax incentives/credits, and grants to encourage private investment.
- UK Infrastructure Bank could also be a key enabler to provide funding to early-stage projects and help provide investor confidence.
- Support the development of low-carbon industrial clusters - Regional clustering linking SMRs to hydrogen and SAF projects in industrial zones could further reduce project risk, promote supply chain efficiency, and drive down unit costs. Requires joined up government facilitating planning approvals, land use, and access to water, grid, and transport.
- Allocate funding for research and development (via UKRI) into advanced nuclear technologies specifically geared towards industrial and co-generation applications.

Long-term vision for nuclear-derived H_2 and SAF

What could the future look like?

By 2040, a mature nuclear-derived H_2 ecosystem could:

- power decarbonised aviation and maritime sectors by producing SAF and ammonia at scale with synthetic feedstocks;
- drive green industrial clusters, fuelled by nuclear steam and hydrogen;
- connect industrial zones to international markets via the creation of export-oriented clean fuel corridors; and
- create grid-independent hydrogen hubs, offering energy sovereignty and resilience.

A vision for secure energy sovereignty, strengthened industrial competitiveness, and emissions reduced in line with the Climate Change Act and 6th Carbon Budget

Call to Action - a strategic imperative

- Nuclear is more than a clean energy option; it's a crucial enabler of the UK's Hydrogen and SAF ambitions.
- Unlocking its potential is no longer a technological question, it is a strategic imperative for the UK's energy sovereignty, climate commitments, and industrial future.
- With bold policy, targeted investment, and integrated planning, SMRs and AMRs can become a cornerstone of the UK's clean energy transition to a resilient decarbonised industrial future.

The tools are available.

The ambition is clear.

It's time to make SMR-powered hydrogen a pillar of the UK's Net Zero transition.

Thank you

Rolls-Royce SMR

Unlocking the Potential of SMRs for Hydrogen Generation

Mike Crawforth – Strategy and Business Development Manager

Traditional nuclear business models are setup for providing grid power and do not enable wider use cases

Baseload Power

Thermal Power

Grid Electrical Power

Private-wire
High Utilisation

Industrial Heating

Residential Heating

Power to X

Hydrogen Production

Sustainable Fuel Production

Ammonia Production

Six key pillars are required to be fulfilled for nuclear projects

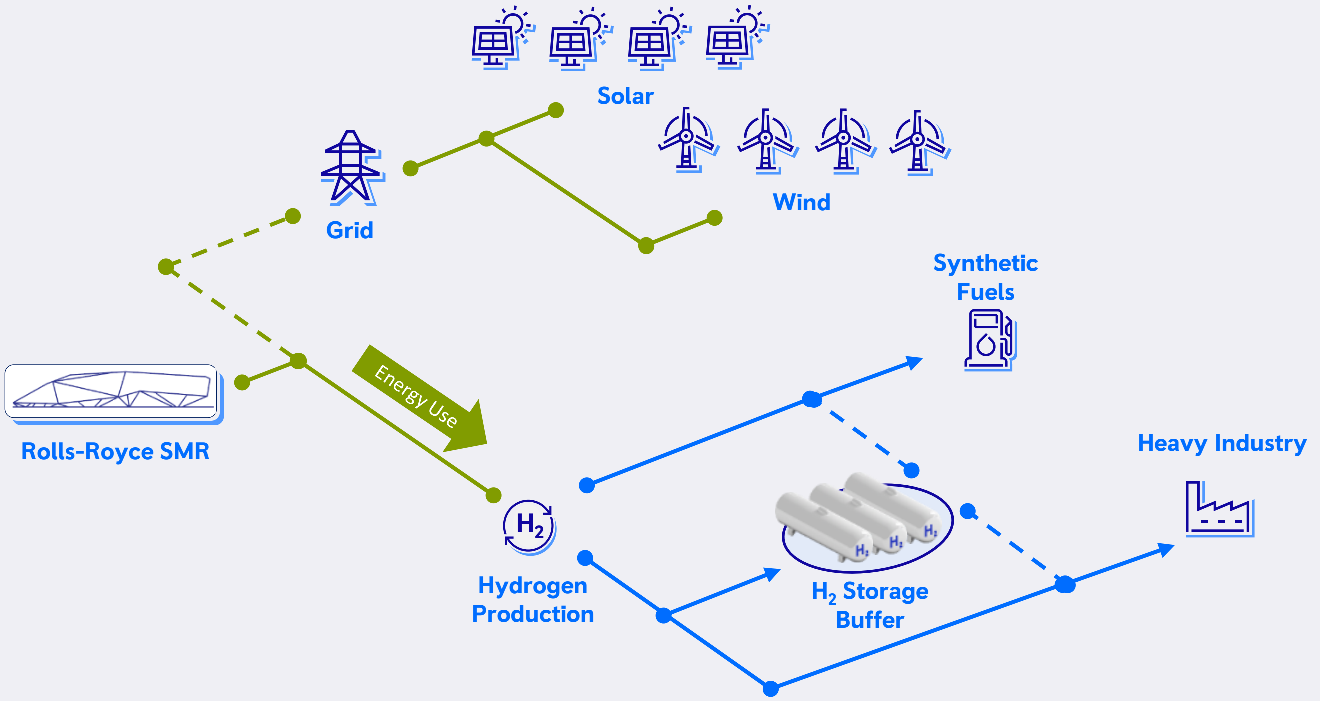
Industrial end users provide the offtake demand to stimulate SMR Projects,
but it must be high-quality offtake agreement to secure suitable financing

Key Capability Pillars

1. Technology
2. Site & Prog Development
3. Operator
4. Offtake
5. Finance Solution Equity & Debt
6. Enabling Government Policies

Nuclear hydrogen can drive system level flexibility

SMRs, hydrogen and renewables can combine to optimise system performance and extend the potential for full system decarbonisation



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