NUCLEAR AMRC

ADVANCED MANUFACTURING RESEARCH CENTRE

Advancing UK manufacturing

The University Of Sheffield.

MANCHESTER 1824
The University of Manchester
Dalton Nuclear Institute

CATAPULT
High Value Manufacturing

UKRI Innovate UK

NUCLEAR AMRC
ADVANCED MANUFACTURING RESEARCH CENTRE

Nuclear Landscape

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8 September 2021

Objectives

- Nuclear Landscape and the road to 2050
- AMR/SMR/Fusion - What are Nuclear AMRC doing
- Cogeneration

UK civil nuclear 2021

Current generation

- EDF Energy: 13 reactors at 7 sites*
- Total capacity of 9GWe
- Supply chain requirements c£600M pa
- Most to be retired 2023–30
- Sizewell B due to be retired 2035

Existing 9GWe capacity will have gone by 2035

*Dungeness B (2x AGR) retired June 2021

EDF Energy

Net zero by 2050

Total decarbonisation of electricity generation

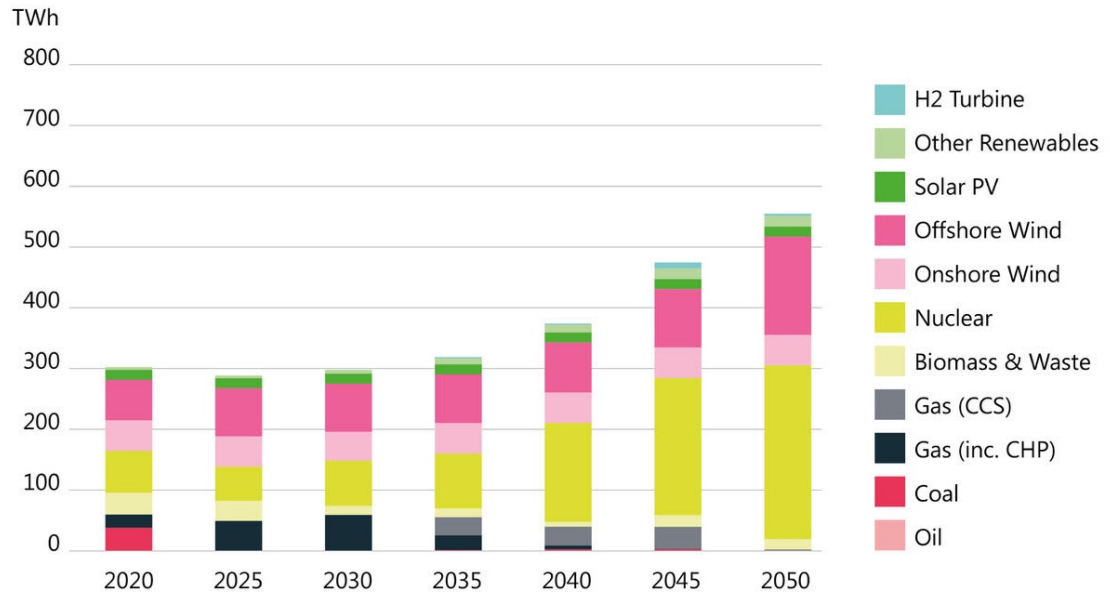
Total demand to double.

Low-carbon generation needs to quadruple.

Mix of renewables & low-carbon baseload.

Nuclear requirement:

- Up to 40GWe by 2050
- 50% of grid capacity



Electricity supply under centralised 'Clockwork' pathway: Energy Systems Catapult, *Innovating to Net Zero* (2020)

New nuclear capacity

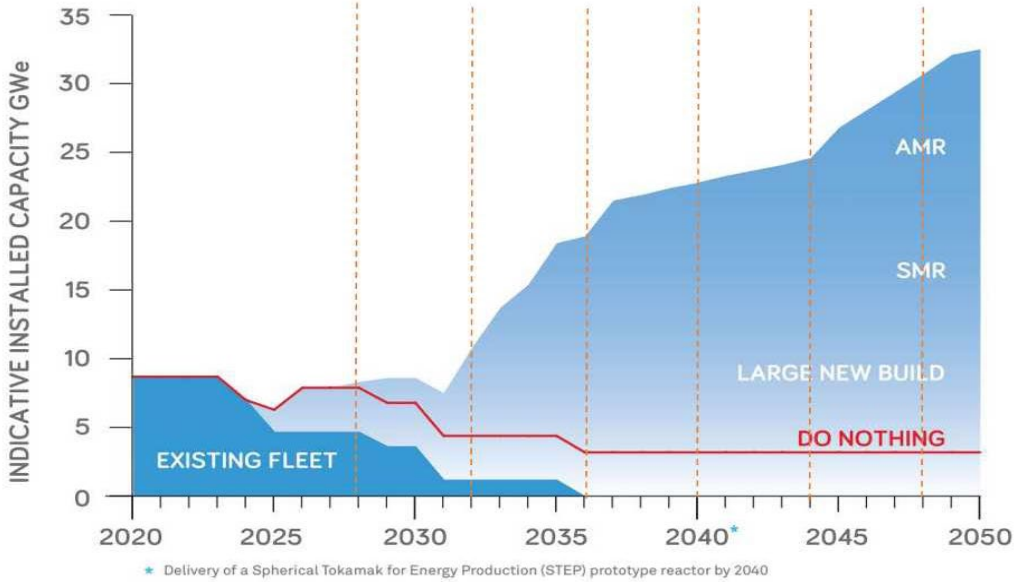
- 40GWe nuclear needed by 2050
- Existing fleet gone by 2035

Gigawatt scale (GW)

- Up to 19GWe new capacity has been proposed at six sites but only Hinkley Point C (3.6GWe) is under construction.
- Sizewell C & Bradwell B awaiting go-ahead.

AMR/SMR

- A number of smaller capacity reactors under development for deployment in early 2030s

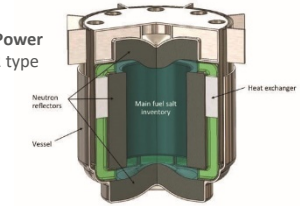


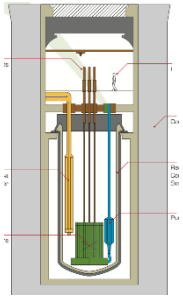
NOTE: dashed vertical lines represent parliamentary stages.

SMR/AMR

- Around 50 Gen III+ and Gen IV designs globally
- Range of outputs from 4MWe to 500MWe*
- Many are more focused on cogeneration - hydrogen / district heating
- Factory construction

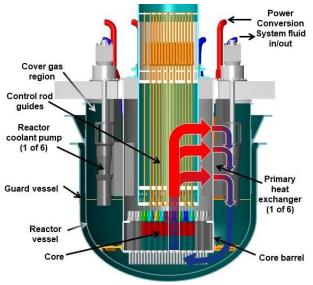
TerraPower
MCFR type



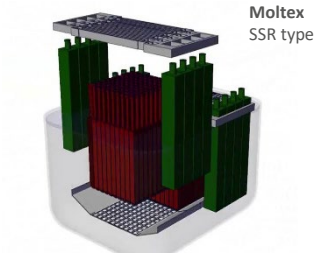


ARC
SFR type
100MWe

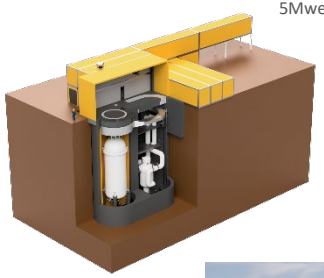
Westinghouse
LFR type



Moltex
SSR type

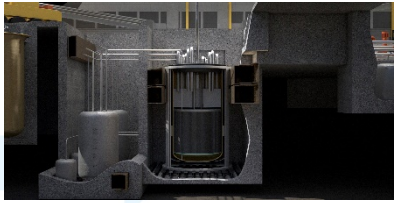


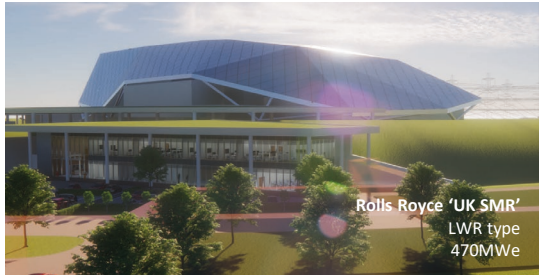
USNC
Micro HTGR type (MMR ™)
5Mwe

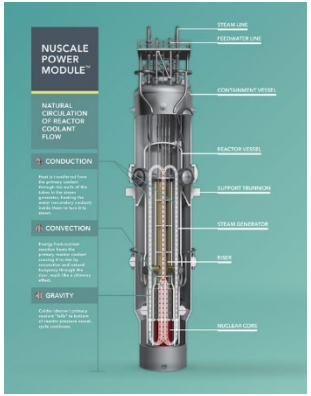


U-battery
Micro HTGR type (MMR)
4MWe

Terrestrial
IMSR type
195MWe







NuScale
LWR type
Up to 12 x 50Mwe power modules

*IAEA defines SMR as output less than 300MWe

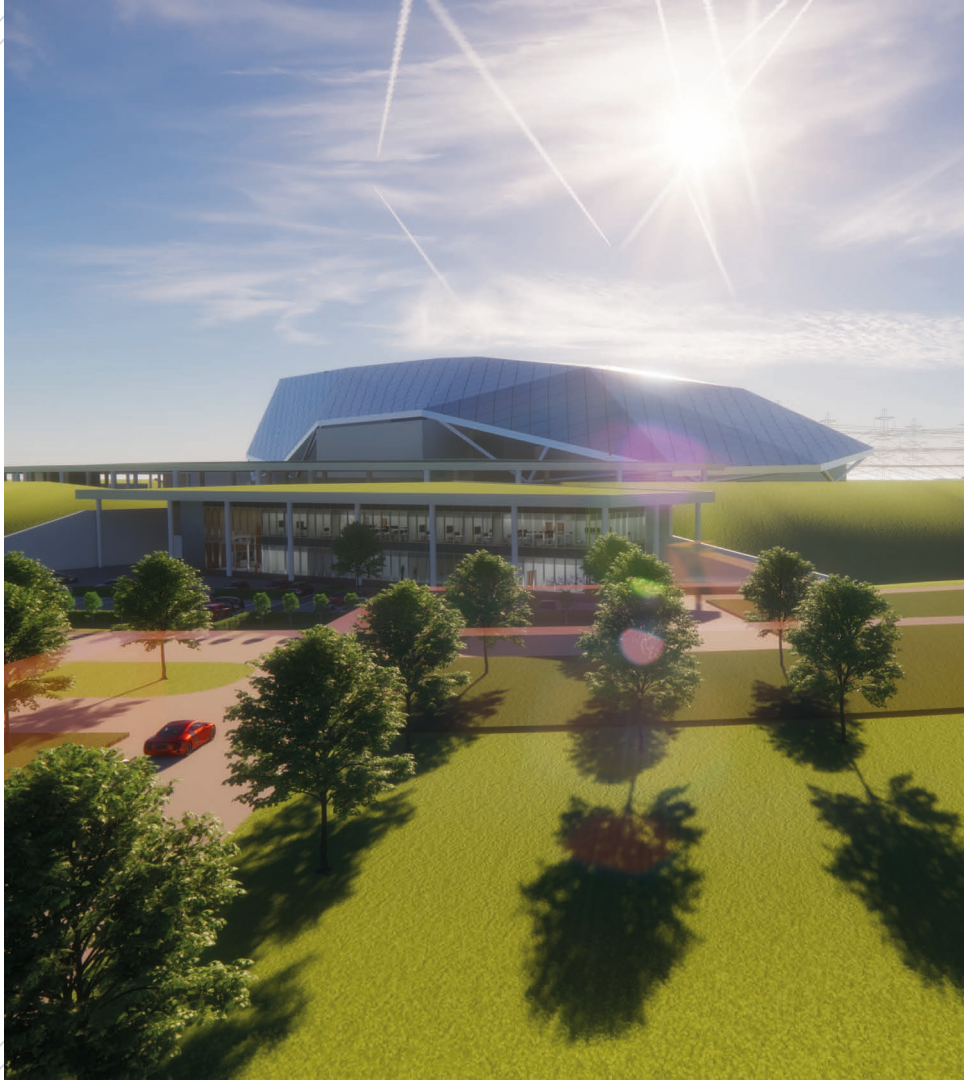
Rolls-Royce SMR

A new type of nuclear power station

- Compact modular design.
- 470MWe Gen III+ PWR.
- Target cost £1.6bn, £40-60/MWh.

Proposed UK programme of up to 16 power stations by 2050

- 40,000 jobs.
- £52 billion economic value.
- £250 billion export potential.



Rolls-Royce

Rolls-Royce SMR

Phase 1: £36M programme. UK companies and R&D institutions, backed by government (£18M + match)

Phase 2: Up to £215 million match funding announced November 2020.

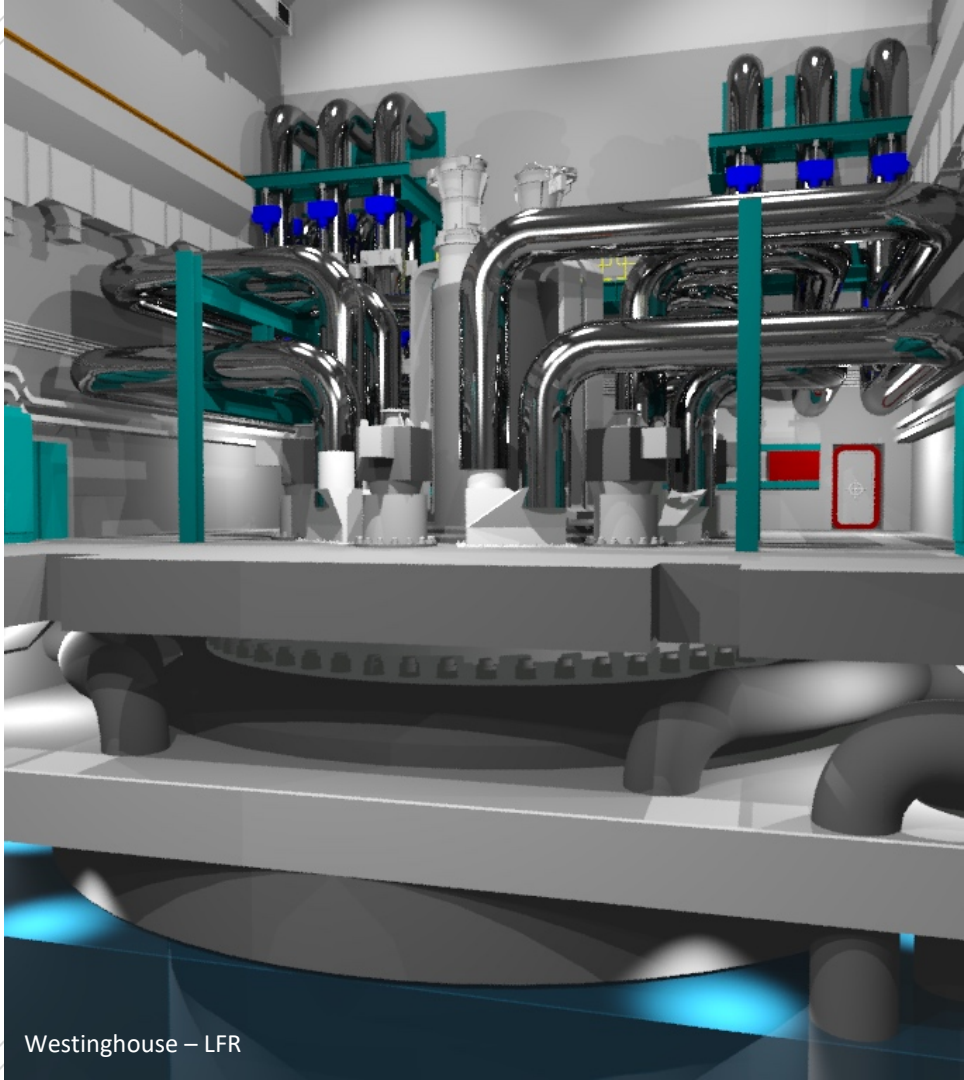
Nuclear AMRC role

Manufacturing Capability Acquisition (MCA) and HPV factory preparation

- Robotic & fixed machining
- Cleanliness
- Large-scale metrology
- Component handling & lifting
- Digital manufacturing
- Large-scale prototype manufacture

Advanced modular reactors

- Range of Gen IV technologies.
- Industrial applications in co-generation, hydrogen production, grid balancing.
- Government £170M funding for R&D programme to support AMR demonstrator by early 2030s.
- HTGR call for evidence (9th Sep closes)
- AMR competition Phase 2 funding of £10M each:
- U-Battery – compact high-temperature gas-cooled fission reactor (HTGR)
- Westinghouse – lead-cooled fast reactor (LFR)
- Tokamak Energy – ST40 spherical tokamak fusion reactor.
- Gen IV Forum – Nuclear AMRC leads for UK on advanced manufacturing & materials.



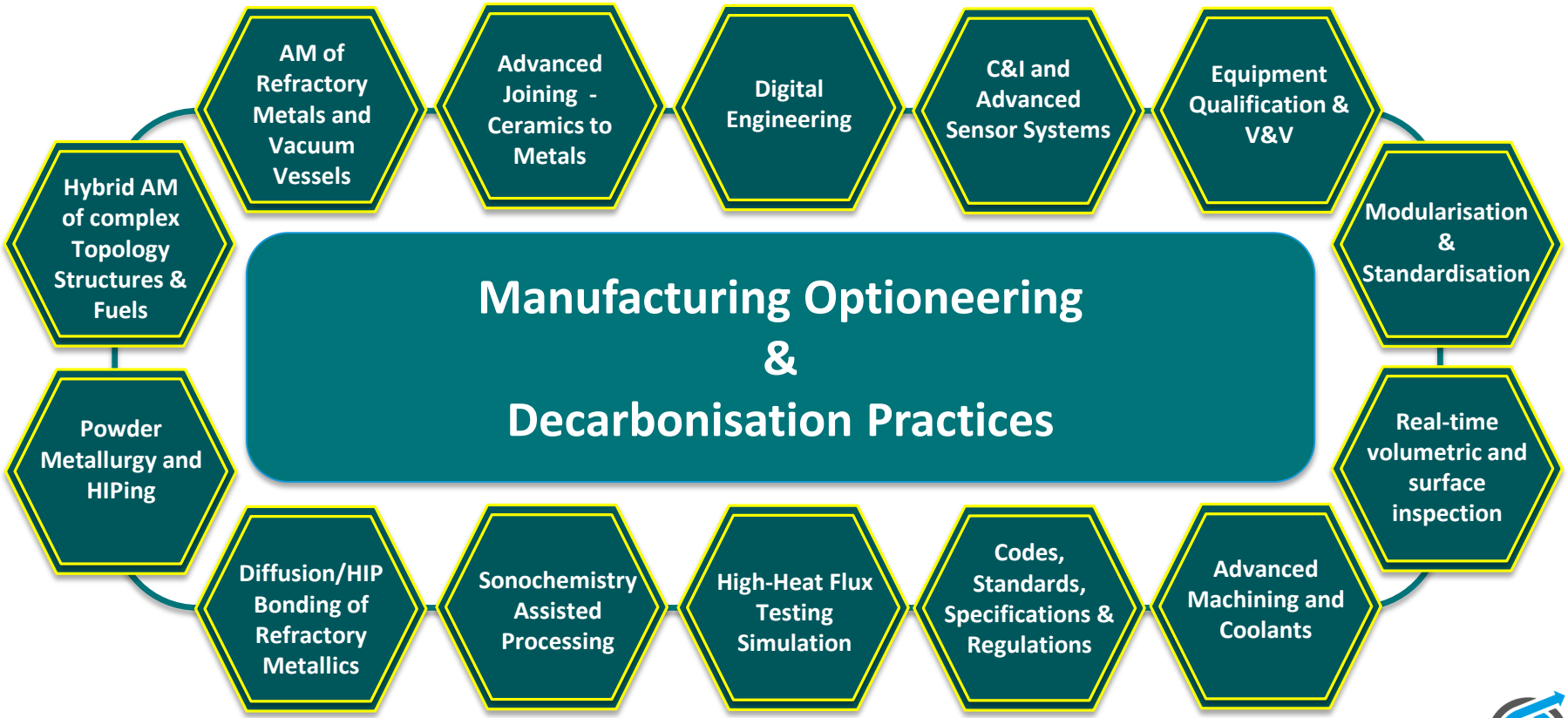
Westinghouse – LFR

Fusion - UKAEA Yorkshire

New material testing facility

- £22 million development on Advanced Manufacturing Park.
- To develop and test technologies for fusion materials and components.
- 40 highly-skilled jobs.
- Working with regional research and industrial partners.
- Funded through Nuclear Sector Deal.

Manufacturing Technologies Applicable to GEN IV & Fusion

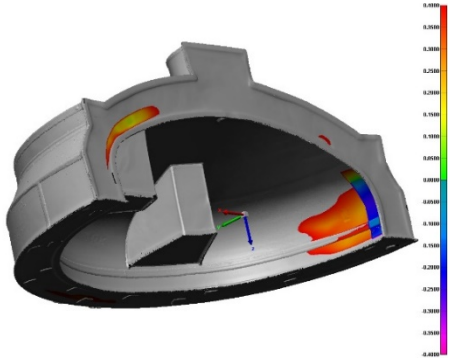


SMR/AMR – Complex Geometry Near Net Shape (NNS) Components

Reduce the burden on the forging capacity for complex geometry pressure vessel components.

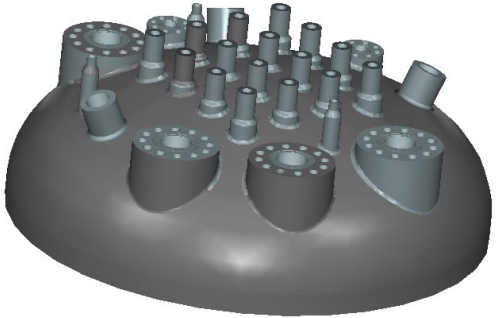
SMR Lower Head

- **66% Scale**
- SA508 Gr3. Cl1.
- Achieved geometry
- 3250Kg



SMR Upper Head

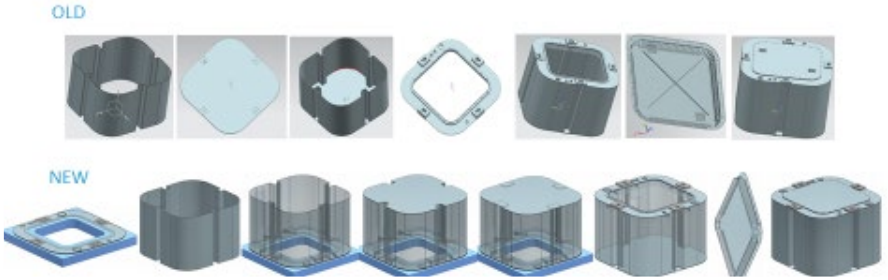
- **40% Scale**
- SA508 Gr3. Cl1.
- 27 penetrations
- 1650Kg



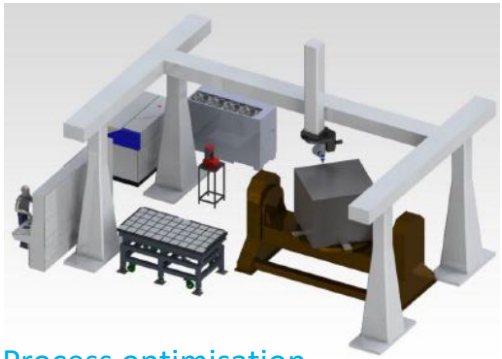
All images courtesy of EPRI

Waste container research

Full manufacture cost lifecycle cost optimisation

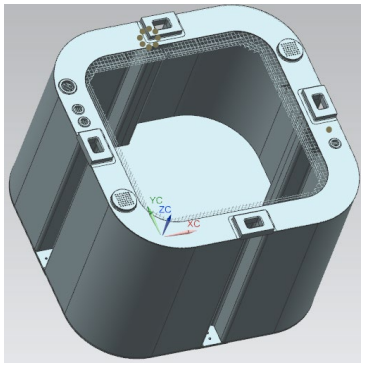


Method and material optimisation



Process optimisation

Factory optimisation



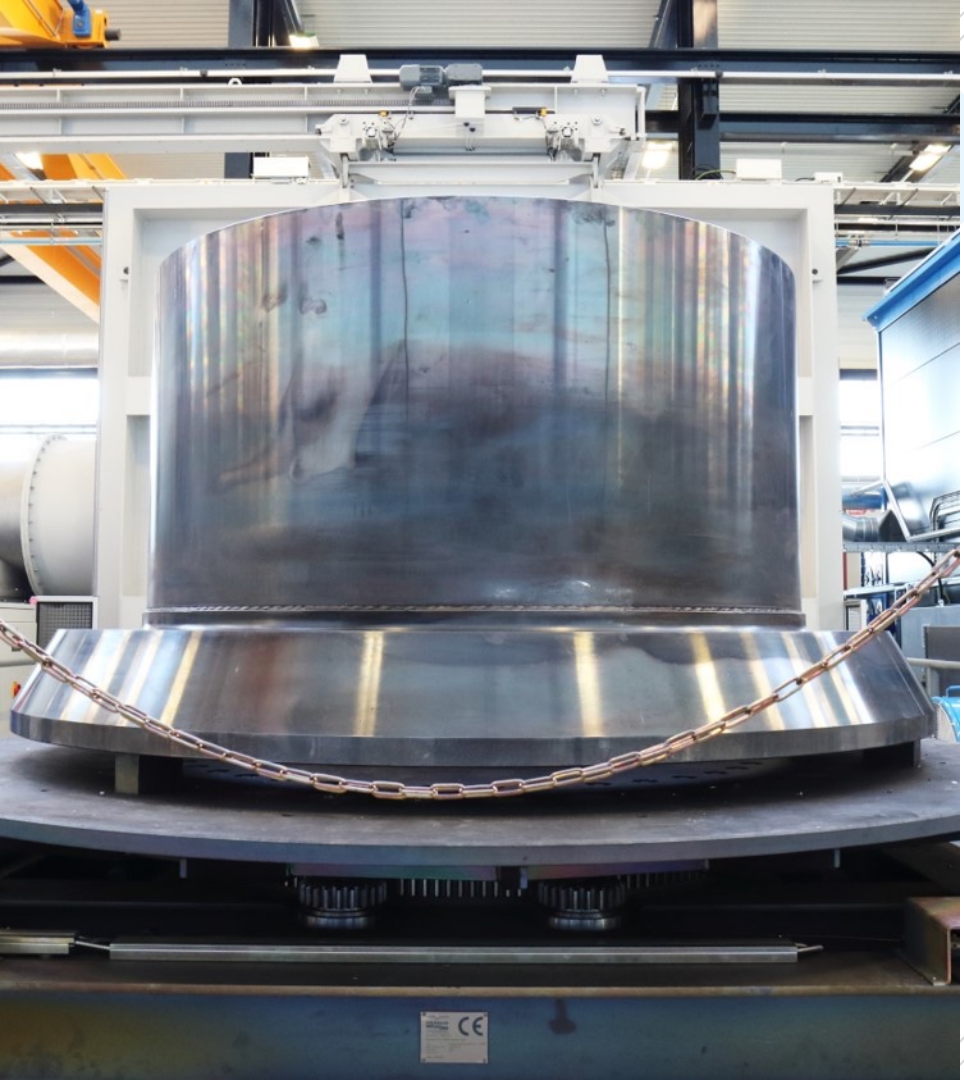
Product design optimisation

Supported by:

Manufacturing Technology Centre

AFRC ADVANCED FORMING RESEARCH CENTRE

AMRC ADVANCED MANUFACTURING RESEARCH CENTRE



Case study

SMR pressure vessel manufacture

Challenge

Reduce the production time for an SMR pressure vessel from x2.5 years to less than 12 months.

Solution

- Four-year international collaboration led by US Electric Power Research Institute.
- 2/3-scale pressure vessel – upper and lower assemblies.
- Processes include electron beam welding, diode laser cladding, powder hipping.

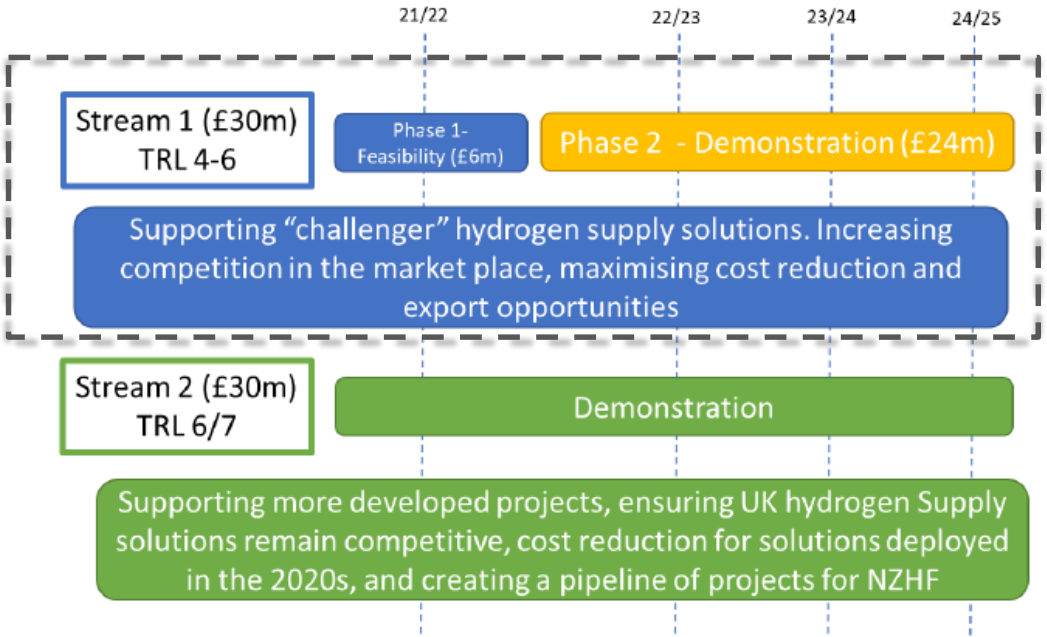
Impact

- Section weld time (1.8m diameter, 80mm wall) reduced from 10 days to two hours.
- Less energy used – 1,800kg CO_2 saved.

Cogeneration – NAMRC activities

Department for Business, Energy & Industrial Strategy

- BEIS Low Carbon Hydrogen supply 2 competition (HYS2)
- HYS2 is the first significant Hydrogen theme competition of the £1 billion Net Zero Innovation Portfolio (NZIP) and builds on the Low Carbon Hydrogen Supply (HS1) competition.
- HS1 featured projects HyNet, Gigastack, Dolphin, Acorn, and HyPER
- Focus on Stream 1



Cogeneration – NAMRC activities

Department for Business, Energy & Industrial Strategy

- Nuclear AMRC and Frazer Nash
- Large CHP-powered H2 test facility designed to mimic the thermal outputs of all SMR/AMRs
- Focus on HTSE and thermochemical water splitting with electrolysis as a comparator
- Allows nuclear H2 to be matured on a parallel track to the AMR/SMR themselves then converge in 2030s – not wait for reactors to be ready first
- Operational by 2025
- Cost approx £6M
- Fits with BEIS AMR programme and HTGR focus
- Announcements early October

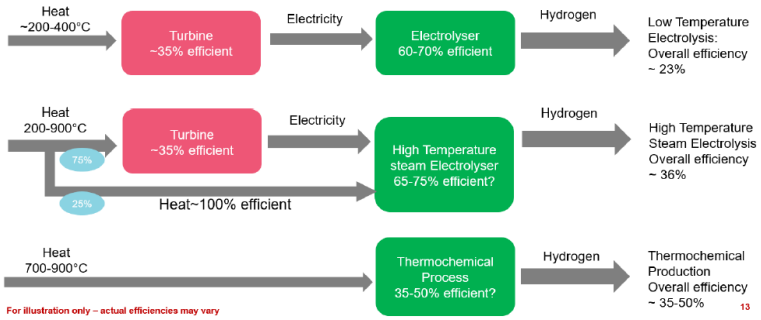


Figure 1: Comparison of different Nuclear Cogeneration Hydrogen Production Technology Efficiencies

Summary

- **Reliable** – Nuclear can provide high-temperature heat 24/7 regardless of location or conditions (compared to electricity from solar or wind).
- **Clean** – Zero carbon emissions. No reliance on CCUS.
- **Proximity** – Small size of AMR/SMRs and passive safety designs should enable industrial and domestic co-location.
- **Toolkit for 2050** – Each reactor type has a different role to play based on outlet temperature and commercial readiness e.g. Gen III+ suited to district heating and H2 via electrolysis -> HTGR suited to H2 production via thermochemical water splitting
- **Demand** – Invigorate the nuclear industry. The prospect of nuclear cogeneration creates additional pull for nuclear energy which helps to attract investors and drive down costs.
- **NAMRC** – Working hard with industry and partners to identify and address the fundamental challenges in nuclear manufacturing to help realise the full potential of nuclear cogeneration.

Nuclear Manufacturing Summit 2021

SAVE THE DATE

Tuesday 16 and Wednesday 17 November

Nuclear AMRC, Rotherham

Opportunities and challenges for the UK supply chain

Questions?

NUCLEAR **AMRC**

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