NATIONAL NUCLEAR LABORATORY

AFCP
Advanced Fuel Cycle Programme

Advanced Nuclear Skills Innovation Campus

Keynote: The objectives of ANSIC

Si Dilks, Head of Nuclear and Renewable Innovation, SICE, BEIS
Zara Hodgson, Head of Technology, Advanced Nuclear Innovation Team, BEIS

Department for Business, Energy & Industrial Strategy

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PM’s 10 Point Plan

Advanced Nuclear Skills & Innovation Campus

Point 10: Green Finance and Innovation

10 Point Plan and Net Zero Strategy announced a broad set of policy measures to drive the UK to net zero, including a BEIS £1bn+ Net Zero Innovation Portfolio

Point 3: Delivering New and Advanced Nuclear Power

Announced the associated £385m Advanced Nuclear Fund, together with aspirations of first SMR’s and an AMR deo by early 2030’s.

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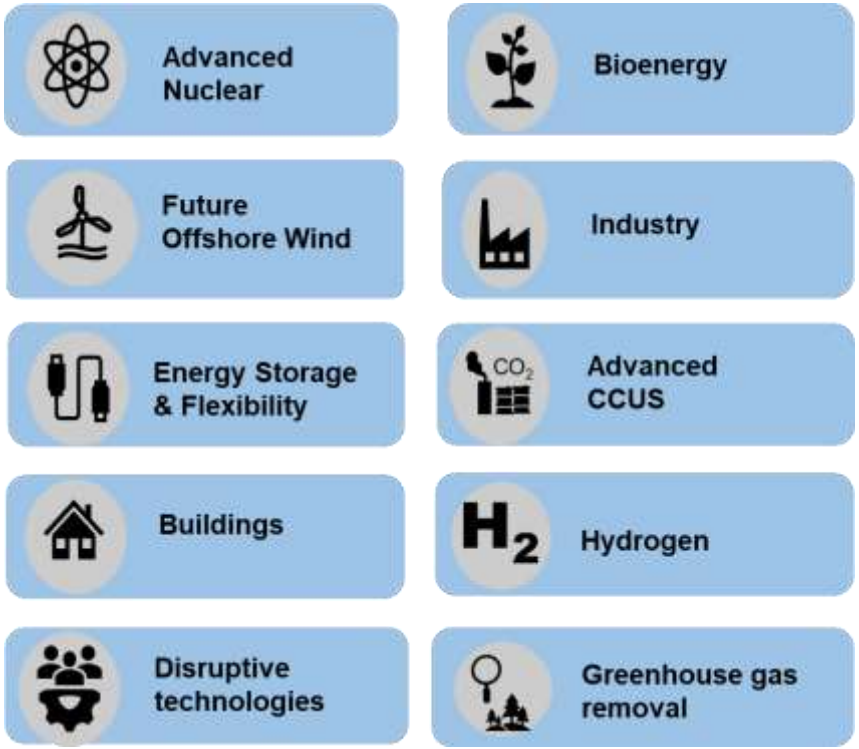
BEIS Net Zero Innovation Portfolio

- £1bn+ of funding.
- Aims to accelerate the commercialisation of innovative low-carbon technologies, systems and business models in power, buildings and industry and decrease the costs of decarbonisation.
- Builds on previous £505m Energy Innovation Programme., which included £180m Nuclear Innovation Programme
- Potential to unlock 300,000 jobs by 2030 in exports and domestic industry; enables savings across low carbon sectors; will have a strong regional impact.
- https://www.gov.uk/government/collections/net-zero-innovation-portfolio



The Advanced Nuclear Fund

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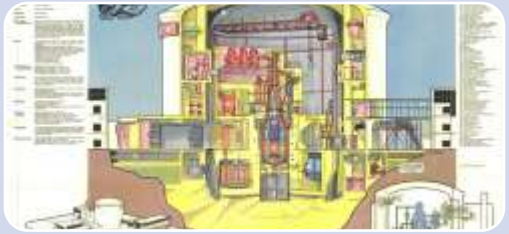
SMRs

Funding for the Low Cost Nuclear Challenge - Phase 2.



AMR

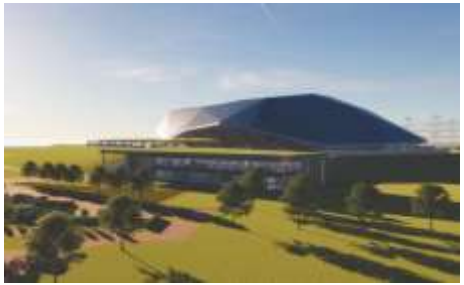
Funding work to put UK on a trajectory to a HTGR demonstration by early 2030

Under-pinning R&D.

Funding for cross cutting and underpinning R&D.

Enabling the Advanced Nuclear Sector

Present
3rd Gen
Reactors



2030s
Small Modular
Reactors

2030s-40s?
Advanced Modular
Reactors

How could HMG….

- **Accelerate capability in the supply chain?**
- **Unlock barriers to innovation?**
- **Promote collaboration in advanced nuclear technology?**

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PILOT PROGRAMME

- £2 million BEIS funding
- August 21 – March 22

- Springfields nuclear licensed site
- R&D at NNL Preston Lab

Nuclear Derived Hydrogen to Gas Networks Project

Phil Rogers, Technical Specialist – Core Materials Performance

NNL

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Department for Business, Energy & Industrial Strategy

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Introduction

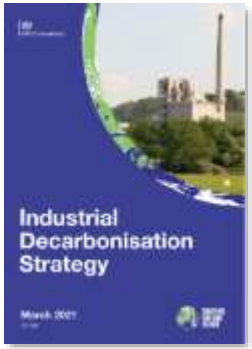
- First of a kind project
- Aim
  - **To assess the technical feasibility of distributing nuclear derived hydrogen through a converted gas network**
  - **Bring together the gas network and nuclear communities to address a key decarbonisation challenge**
  - **Better understand the synergies between the sectors and establish next steps**
- NNL partnered with DNV
- Value: £150,000. Leverage ~£225,000.

Policy led transition – opportunities for decarbonisation

https://www.gov.uk/government/publications/the-ten-point-plan-for-a-green-industrial-revolution

https://www.gov.uk/government/publications/energy-white-paper-powering-our-net-zero-future

https://www.gov.uk/government/news/net-zero-review-publishes-initial-analysis-of-green-transition



Industrial decarbonisation strategy - GOV.UK (www.gov.uk)

Transport decarbonisation plan - GOV.UK (www.gov.uk)

UK government launches plan for a world-leading hydrogen economy - GOV.UK (www.gov.uk)

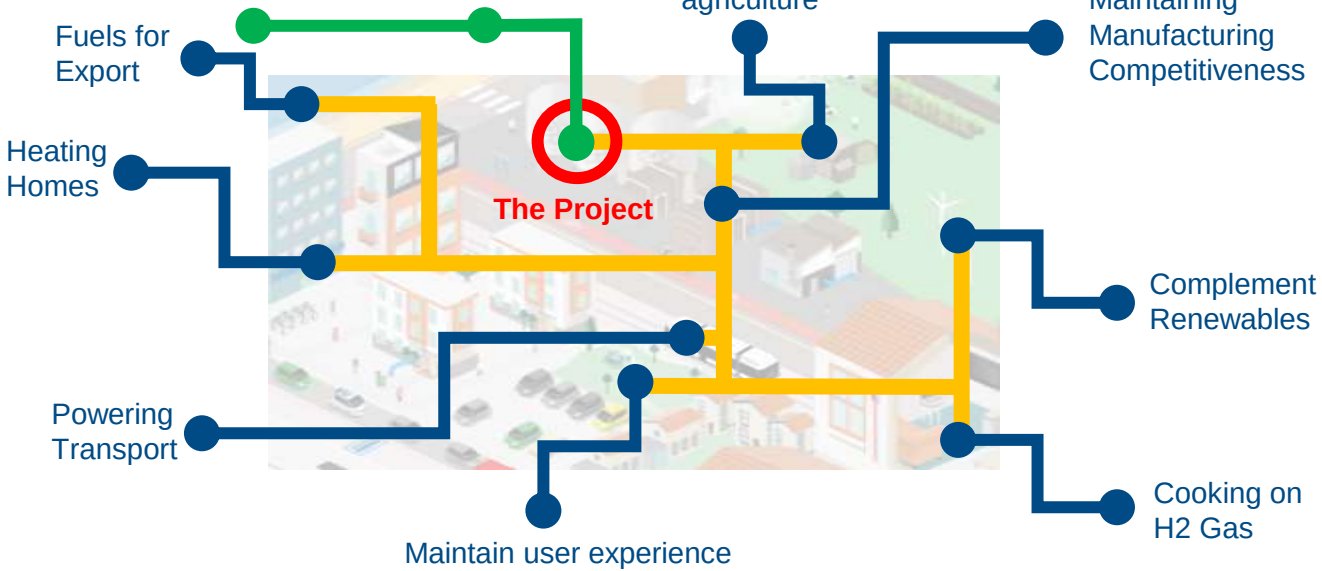
Heat and buildings strategy GOV.UK (www.gov.uk)

Mandating the use of sustainable aviation fuels in the UK - GOV.UK (www.gov.uk)

The challenge

- The energy distributed through the gas network is 3 times that of the electricity grid
- Decarbonisation of gas users is complex
- Hydrogen has been proposed to replace natural gas in the network
- This would have a large demand on hydrogen and certainty of production is required
- Hydrogen predictions equivalent to16 – 48 large reactors
- Government is due to decide before 2026 on gas network conversion to hydrogen

The project focus

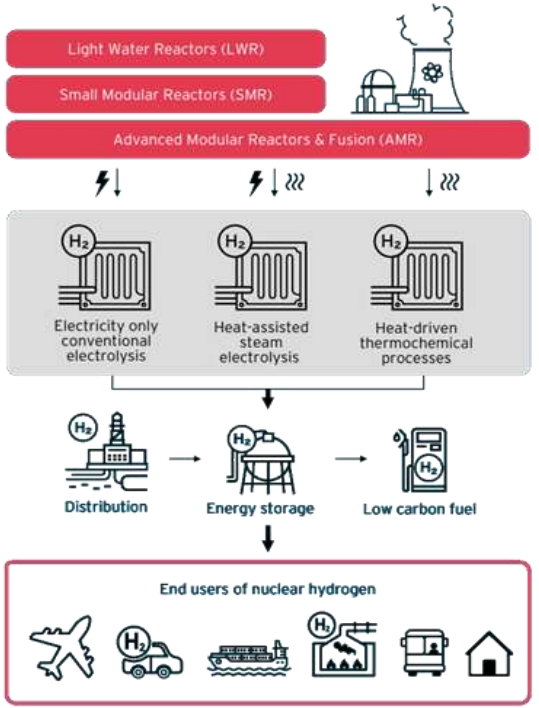


Nuclear derived hydrogen

- Nuclear produced electricity plus conventional electrolysis
- Nuclear produced electricity and heat with steam electrolysis (improved efficiency)
- Nuclear produced heat (higher temperature) with thermo-chemical methods
- Scaleable and consistent hydrogen production
- 4 x Rolls-Royce SMR

  = H_2 for UK Chemical Industry
- 85 x High Temperature Gas Reactor (600 MW)

  = H_2 for all UK domestic heating



Gas Network Transition

Sarah Kimpton, Vice President, DNV

Advanced Nuclear Skills Innovation Campus

Department for Business, Energy & Industrial Strategy

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Introduction to DNV

Our purpose

To safeguard life, property, and the environment

An independent assurance and risk management company

157	~12,000	100,000	100+	5% R&D
years	employees	customers	countries	of annual revenue

Ship and offshore classification and advisory

Energy advisory, certification, verification, inspection and monitoring

Management system certification, supply chain and product assurance

Software, platforms and digital solutions

DNV key publications to guide strategic decisions

Industry Outlook

the industry outlook for the year ahead

2021

Technology Outlook

the technology landscape of the next decade

2030

Energy Transition Outlook

independent forecast of energy demand and supply

2050

DNV hydrogen specific publications

Heading for hydrogen

The oil and gas industry's outlook for hydrogen, from ambition to reality

Hydrogen as an energy carrier

Forecasts decarbonization driving significantly greater use of hydrogen for energy by 2050

Hydrogen Decarbonizing the heat

The benefits and challenges of hydrogen in decarbonizing

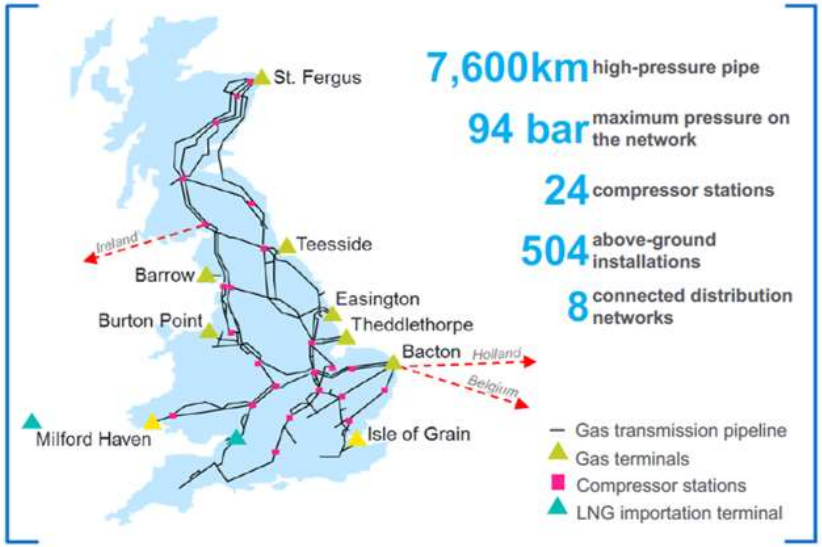
Hydrogen in the electricity value chain

More variability in the generation and demand of electricity

https://www.dnv.com/power-renewables/energy-industry-insights/about-the-research.html

Challenges for gas network transition

The National Transmission System (NTS):



Pressure Tier	Pressure
High Pressure (HP)	7 – 70 bar
Intermediate Pressure (IP)	2 – 7 bar
Medium Pressure (MP)	2 bar – 75 mbar
Low Pressure (LP)	< 75 mbar

1 SGN — SGN supplies all Scotland and South East and South England.

2 Northern Gas Networks — Northern Gas Networks supplies Northern and North East England.

3 Cadent — Cadent supplies East Anglia, East Midlands, West Midlands, North London and North West.

4 Wales & West Utilities — Wales & West Utilities supplies Wales South, Wales North and England in the South West.

Challenges for gas network transition

Every year, the gas networks deliver 900 TWh of energy

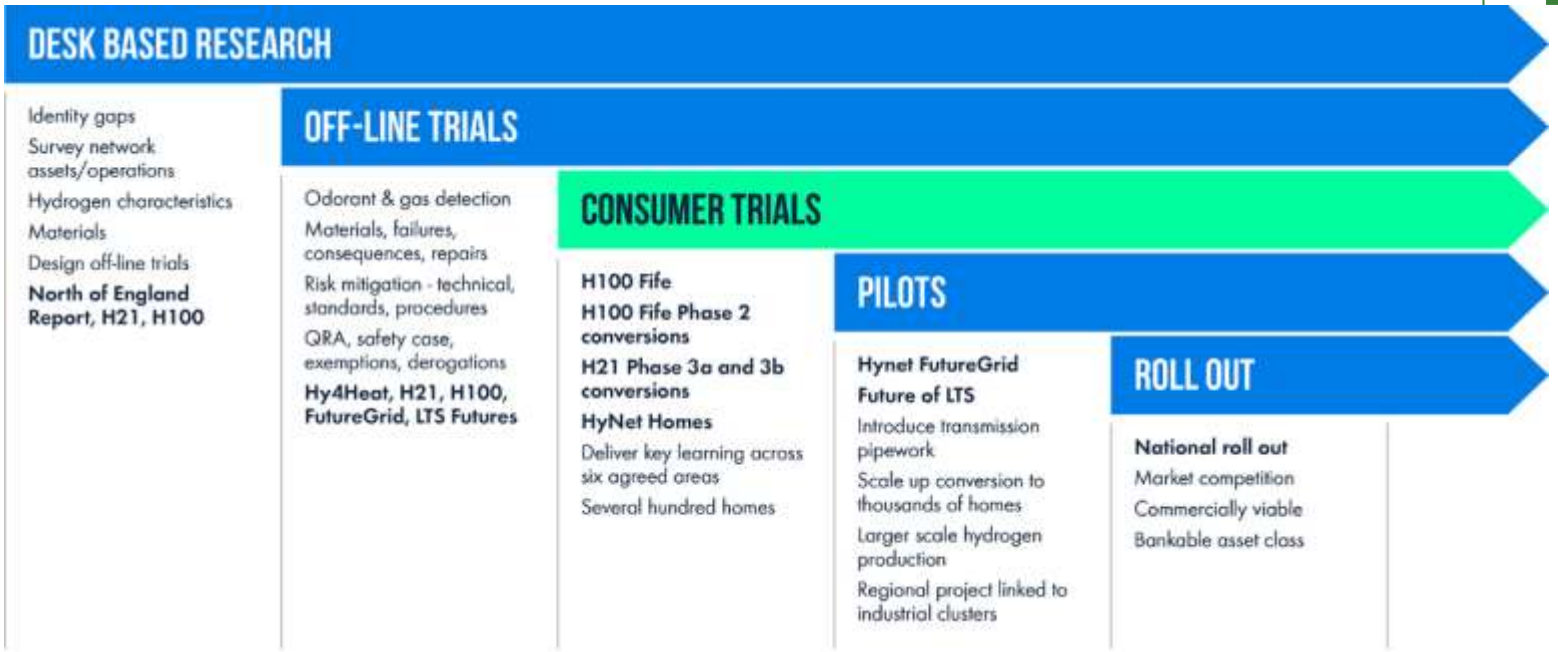
- 85% of total domestic heat
- 40% of total services energy use
- 46% of total industry energy use
- 41% of electricity generation

DNV Role and Perspective

- The gas network is designed for natural gas
- There are a range of materials
  - **Pipelines**
  - **Equipment / components**
  - **End-user appliances**
- Hydrogen can cause adverse effects
  - **Embrittlement**
  - **Cracking**
  - **Fatigue**
- Metallic mains replacement to polyethylene
- Hydrogen ready appliances / industrial burners

H21 phases 1 & 2, FutureGrid, Hy4Heat, LTS Futures

Opportunities and synergies



Low-carbon nuclear hydrogen can progress in parallel with renewable technologies

Project Detail and Outcomes

Department for
Business, Energy
& Industrial Strategy

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Approach and scope

- Collaborative technical projects
- Stakeholder and technical workshops
- Addresses key questions on how and whether nuclear can contribute
- Important to support:
  - **Policymaking and enabling steps**
  - **Investor opportunity**
  - **Regional development and decarbonisation**
  - **System level modelling**
  - **Whole system thinking**

Developing a common understanding

H2 Production Process Modelling

Siting Considerations

Safety and Regulatory

Scenario Assessment

Economic Assessment

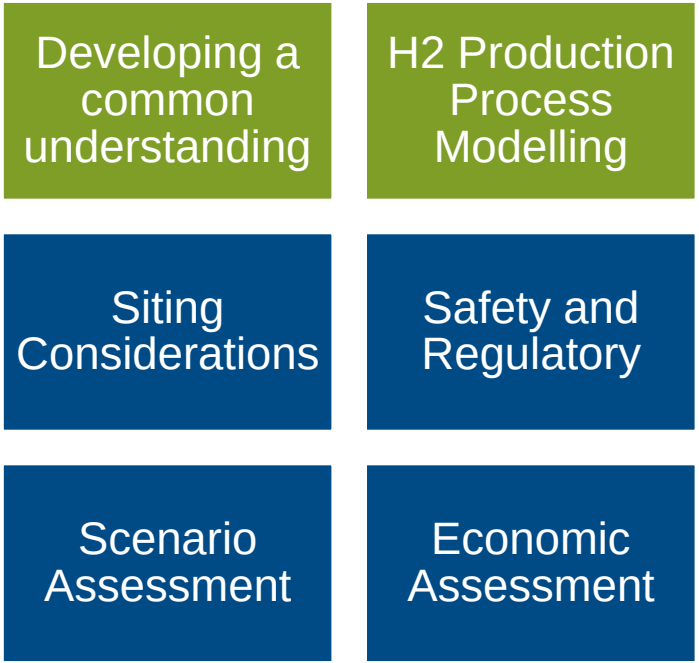
Engagement

- Workshops at 3 different locations including Spadeadam and Preston
- At least 34 organisations have been engaged
- Seminars delivered to a wide range of stakeholders including National Grid, Ofgem, ONR and EA
- Presented at 6 conferences
- In dialogue with 3 organisations about future projects
- NNL joined two UK hydrogen associations
  - **On-going production of a paper ‘Nuclear Enabled Hydrogen Policy Paper’**

Outcomes

- Nuclear and gas sector communities are actively working together
  - **Future projects to incorporate nuclear to regional decarbonisation plans could better define the demand on nuclear and in what locations**

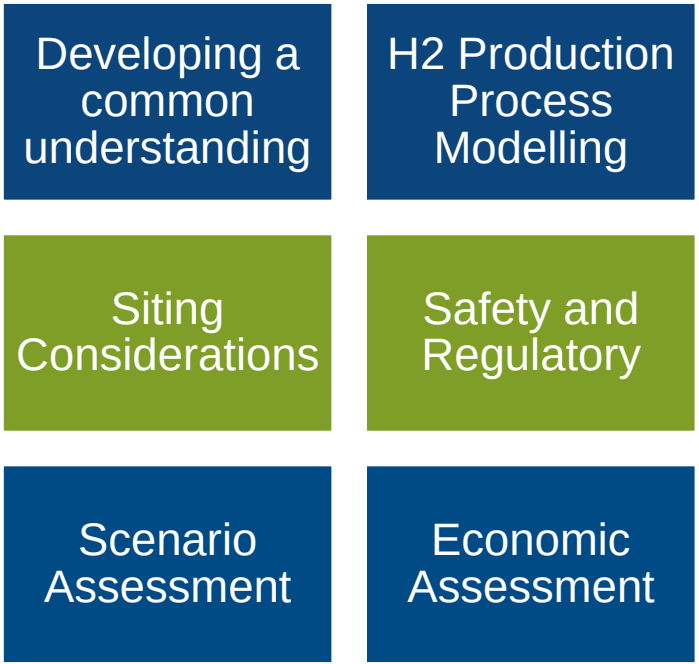
- It is technically feasible to distribute hydrogen generated by different nuclear technologies in the gas network
  - **We can include nuclear as an option for gas network decarbonisation with confidence**
  - **UK has the capability to model from reactor to hydrogen**



Outcomes

- Current siting policies provide limited scope to assess nuclear deployments in a range of locations to suit the gas network. However there are potential locations on the gas network where this would be suitable.
  - **Opportunity for flexible siting based on suitable geography, local demand and infrastructure**

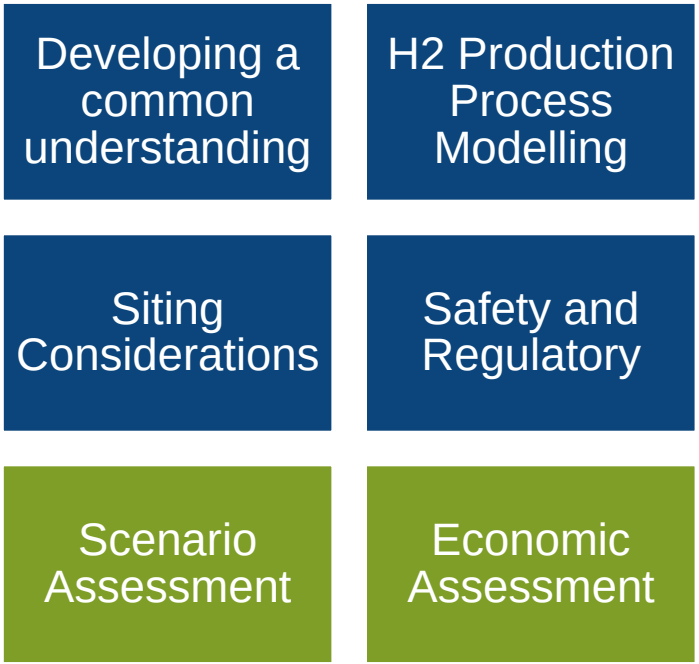
- There are no regulatory or safety blockers
  - **We can progress to assessment of particular scenarios as ‘test cases’**
  - **Opportunity for a regulatory forum for further horizon scanning activities**



Outcomes

- Current scenario modelling assessments do not fully account for nuclear derived hydrogen production, which provides a limited view of the role of ANTs
  - **Opportunity to include this to provide industry, government and investor insights**

- Economics of nuclear derived hydrogen could be attractive with the Regulated Asset Base financing model
  - **Opportunity for further assessments on ANTs, which could drive nuclear derived hydrogen cost below other production routes**

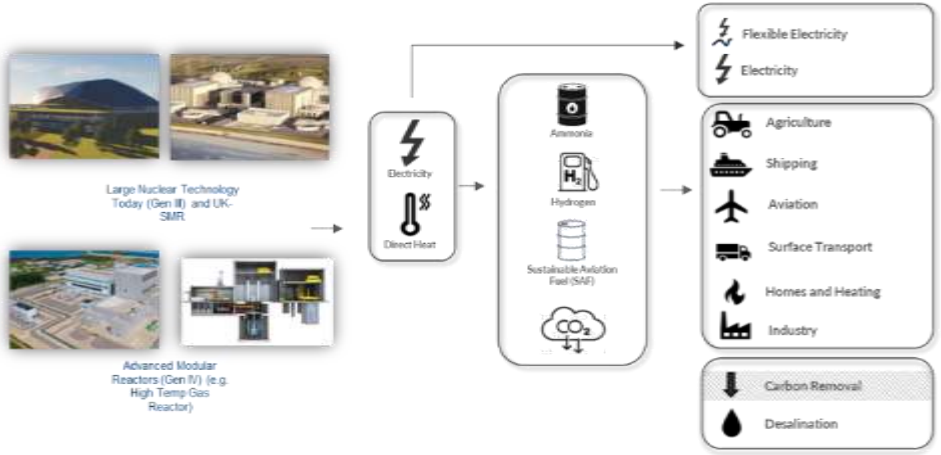


Opportunities

- To more fully assess UK decarbonisation pathways including nuclear – nationally and regionally
- Further development of the modelling suite to support UK decision making
- Techno-economic assessment of derivative products
- Wider collaborative approaches
- Consider the explicit benefits of nuclear in wider energy system
  - **Consistent energy source for economic development**
  - **Reduction in hydrogen storage requirements**

Conclusions

- ANSIC has enabled a new area of decarbonisation research that has great potential
- Lasting legacy with two sectors that have a common goal
- Provides a platform on which to build and a technical evidence base to rely on
- Pushing forward the role of nuclear with end users, establishing the demand and presenting all
- Established clear opportunities for further work to further exploit nuclear – hydrogen is just the start!!



Skills, Training and Education

Liv Thompson, Head of Skills and Development, NNL

Kieron Hersnip, Early Careers Advisor, NNL

Steve Graham, Principal Scientist for Engineering Modelling, NNL

Department for Business, Energy & Industrial Strategy

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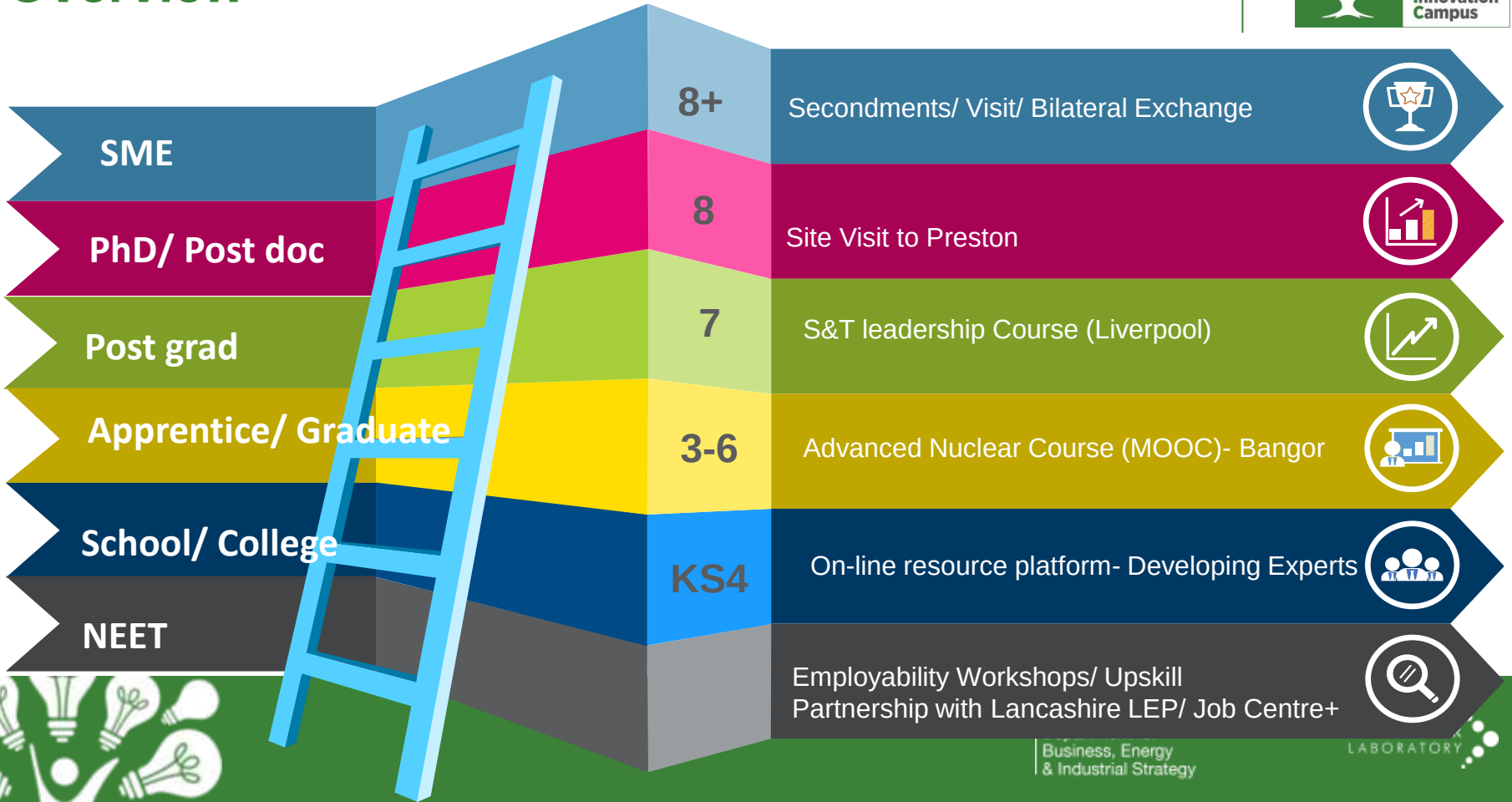
Overview



Advanced Nuclear Skills & Innovation Campus

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LABORATORY

Employability Workshops

Delivered two series of Employability Workshops:

1) Targeted towards participants in the Lancashire area who's current professional status was NEET (Not in Employment, Education or Training) and

2) Targeted to individuals who are considering undertaking an apprenticeship

We campaigned using various methods including via Job Centre Plus customers, social media campaigns as well as a slot on BBC Radio Lancashire advertising the workshops.

Delivered a series of 1 hour workshops delivered via Microsoft Teams held in the afternoons. This format was received very well by participants due to the flexibility and convenience of the sessions.

"I had never seriously considered working in this industry until you provided me with a clear understanding into what is possible and removed the fog of unknowns that surrounds Nuclear energy."

"I was really nervous as I was expecting a seminar, this has been brilliant."

"Many thanks for delivering these fantastic sessions. I know from the feedback I have received from our customers they have found them invaluable."

Education Platform

Key stage 4 Physics:

- Atomic Structure
- Energy

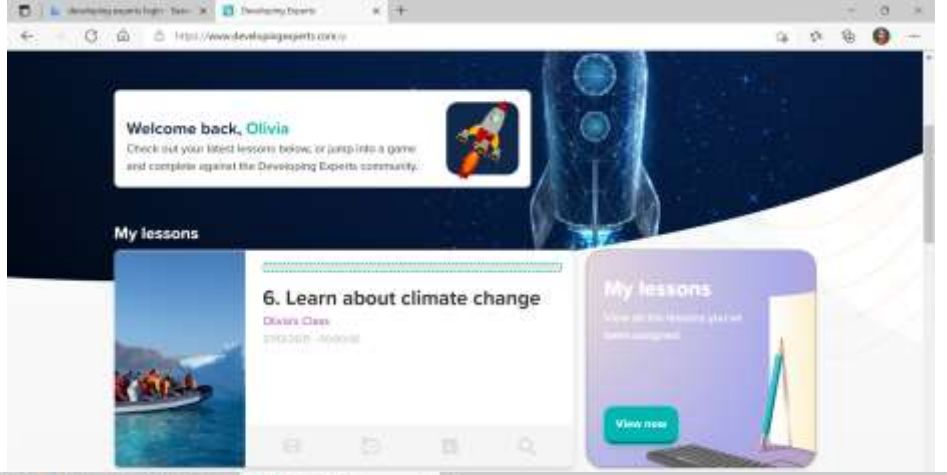
(20 lesson plans, 6 career films,

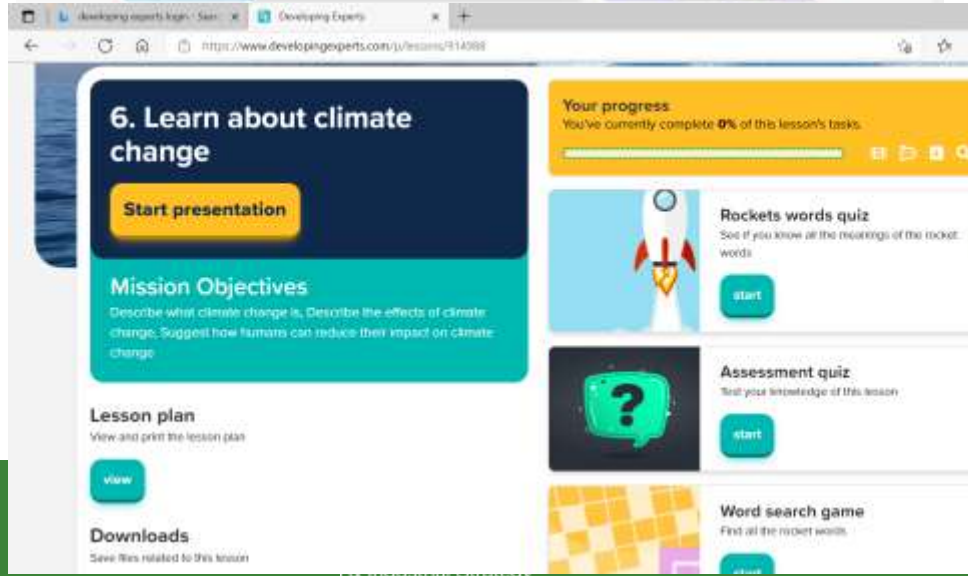
CoP 26: Climate Change:

- Primary
- Secondary
- Workplace

6178 Schools | 190,843 Pupils | 9,463 Tutors | 20,982 Teachers

www.developingexperts.com





Developing Experts

S&T Leadership

Developed and delivered collaboratively between NNL and the University of Liverpool

Post-graduate Certificate in Science and Technology Leadership (level 7)

- Science Leadership and Ethics
- Evidence Based Scientific Writing
- Scientific Impact and Reputation
- Influencing Technical Decision Makers

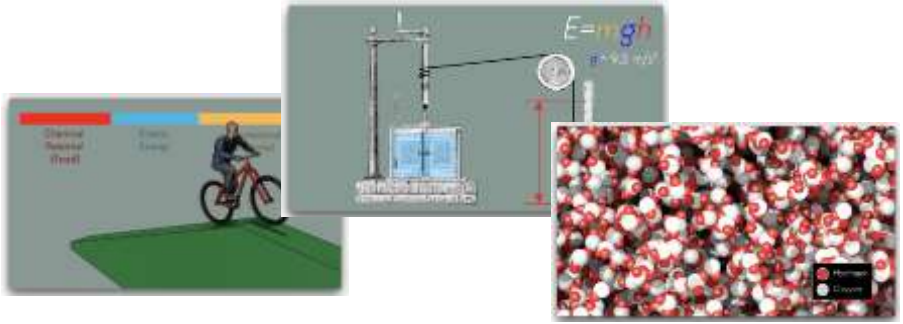
New skills are applied in a ‘real’ science project

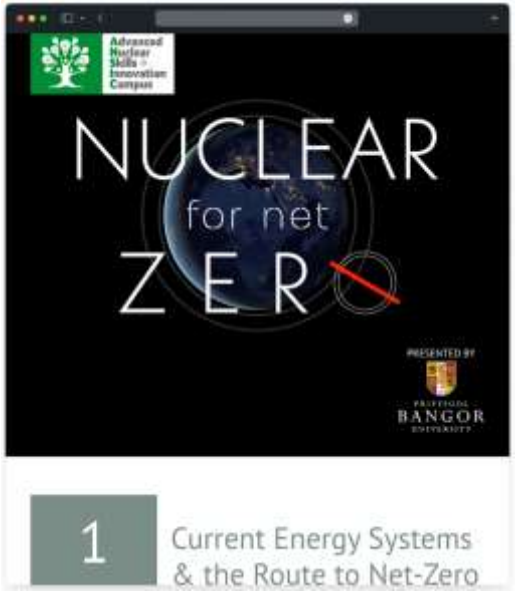
Bangor On-line Course

On-line course “Nuclear for Net Zero” primarily aimed at those with level 3 knowledge (AS/ A level)

3 modules:

1) Current energy systems and routes to net zero
2) The fundamentals of nuclear power and co-generation
3) Enabling net zero through co-generation





Secondments & Site Visits

Due to COVID we were not able to facilitate either the site visit to Preston for Post-doc researchers or the International Secondment task.

Instead a best-practice secondment guide was produced, and a details of the considerations for undertaking a visit to active facilities produced.

Additional scope was added to the education platform- COP 26

Are you a post-doctoral researcher interested in advanced nuclear science and innovation?

About Springfields

About the visit

Thursday 20th January 2022

Onsite Fuels Complex

The National Nuclear Laboratory

Registration closes 10th December 2021

Summary

- Range of activities and materials produced to support the upskilling of people of all academic levels around advanced nuclear
- Covid constraints allowed us to develop additional materials
- Activities undertaken have been created to have longevity
- Activities planned can be repeated/ rescheduled with minimal additional effort
- Feedback on all activities to date has been very positive
- Team have really enjoyed working of the tasks.

Introduction to Open Call Projects

Gary Bolton, ANSIC Technical Lead, NNL

Advanced Nuclear Skills Innovation Campus

Department for Business, Energy & Industrial Strategy

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Open Calls

1) Industry Innovator **2) Academic Research**

- Proposals sought for research projects that explore all potential uses of nuclear technology as part of a low carbon economy
- 74 organisations attended the online briefing events
- 18 Expressions of Interest and 13 full submissions
- Funding awarded to 5 organisations

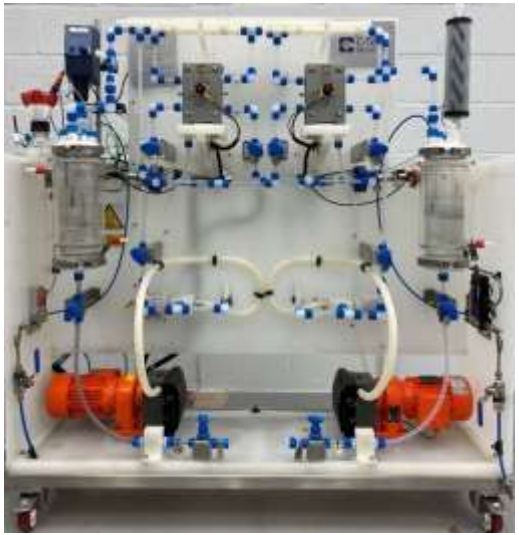
C-Tech Innovation Ltd

C-Tech INNOVATION

Advanced Nuclear Skills Innovation Campus

Electrochemical technology in nuclear material processing

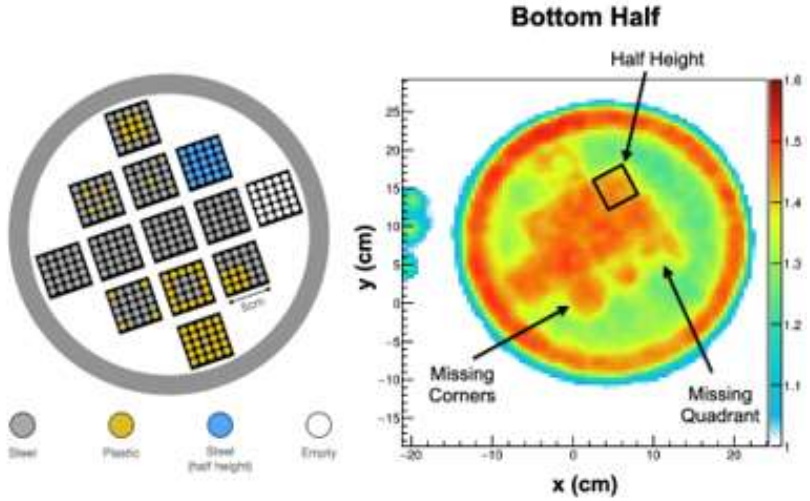
- Significant reduction in waste effluent from recovery and separation processes
- Investigated recovery and separation applications in advanced fuel cycle processes, health and nuclear medicine, space propulsion and radioactive waste minimisation



Lynkeos Technology

De-risking muography for use in advanced nuclear systems and fuels

- Continuous monitoring of SMR spent fuel for safeguarding
- Quality assurance monitoring of HTGR coated particle fuels



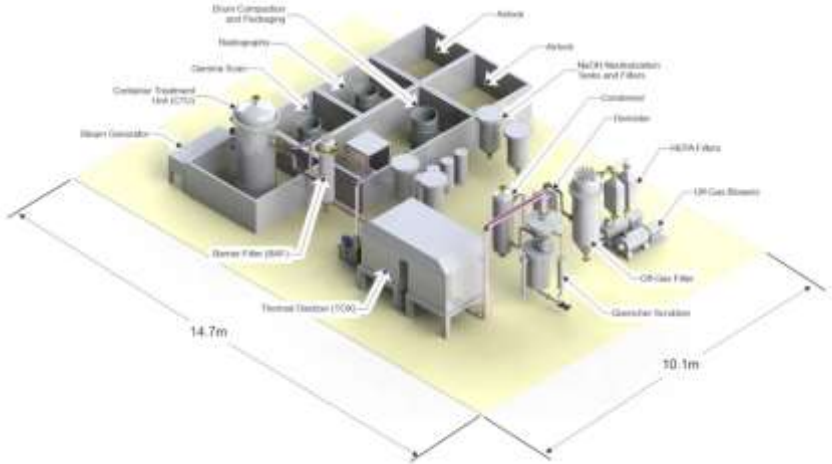
Studsvik

Studsvik | Advanced Nuclear Skills & Innovation Campus

inDRUM waste treatment system for GEN IV Reactor Waste

- Patented inDRUM technology has been designed for treating legacy and problematic waste
- Laboratory-scale experiments with liquid sodium and molten salt to investigate iNDRUM for future Gen IV waste types

ANT – inDRUM Design



Lancaster University

ANZAC@ANSIC: Advanced Technology Fuels in support of Net Zero And DeCarbonisation

- Uranium silicide is a leading candidate for the next generation of nuclear fuels
- Knowledge gaps are being addressed to support the safe deployment of uranium silicide as a fuel

University of Edinburgh

THE UNIVERSITY of EDINBURGH

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Measurement and comparison of the physical properties of surrogate and active molten salt systems

- Working with molten salts of radioactive uranium species is difficult, expensive and time consuming
- Identification of potential surrogate salt species and benchmarking with active molten salt measurement parameters

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Open Call Projects

FIS 360

Advanced Nuclear Skills & Innovation Campus

LINKEOS TECHNOLOGY LTD

C-Tech INNOVATION

Studsvik

Lancaster University

THE UNIVERSITY of EDINBURGH

Introduction to Feasibility Projects

Mark Bankhead, Gary Bolton, Michael Dawson

Department for
Business, Energy
& Industrial Strategy

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Feasibility Projects

- Based around detailed challenge statements
- Aimed at supporting the exploration and development of novel ideas and concepts
- Typical activities within a feasibility project include desk-based studies, development and production of small prototypes, and demonstrations
- Up to £25k funding available

Advancing heat exchangers

Digital technologies

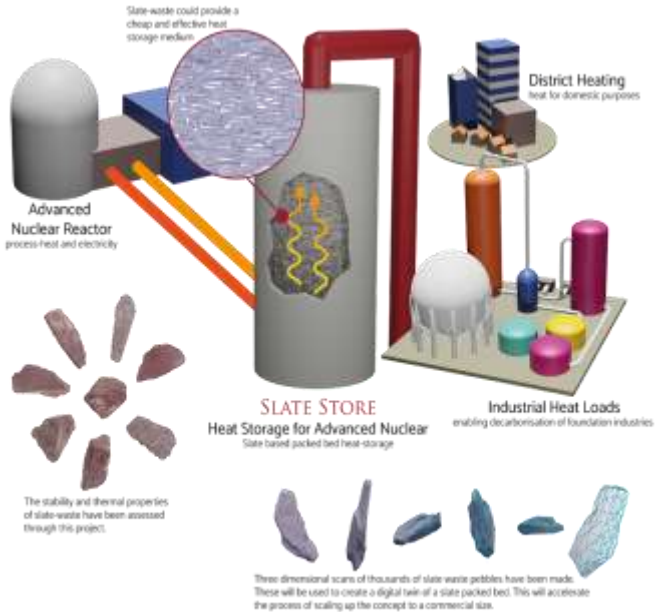
Material irradiation

Advancing heat exchangers

- Advanced Nuclear Technologies have the potential to support decarbonisation
- Technologies capable of utilising high grade heat
- Enables non-electrical energy conversion systems
- Improves efficiency of electrical power generation
- Innovation for extracting and managing the reactor heat required.

Bangor University

- Sustainable heat storage for advanced nuclear systems
- Novel materials such as slate
- Interface between advanced nuclear reactors and industrial consumers of heat.
- Provides flexibility depending of grid demand



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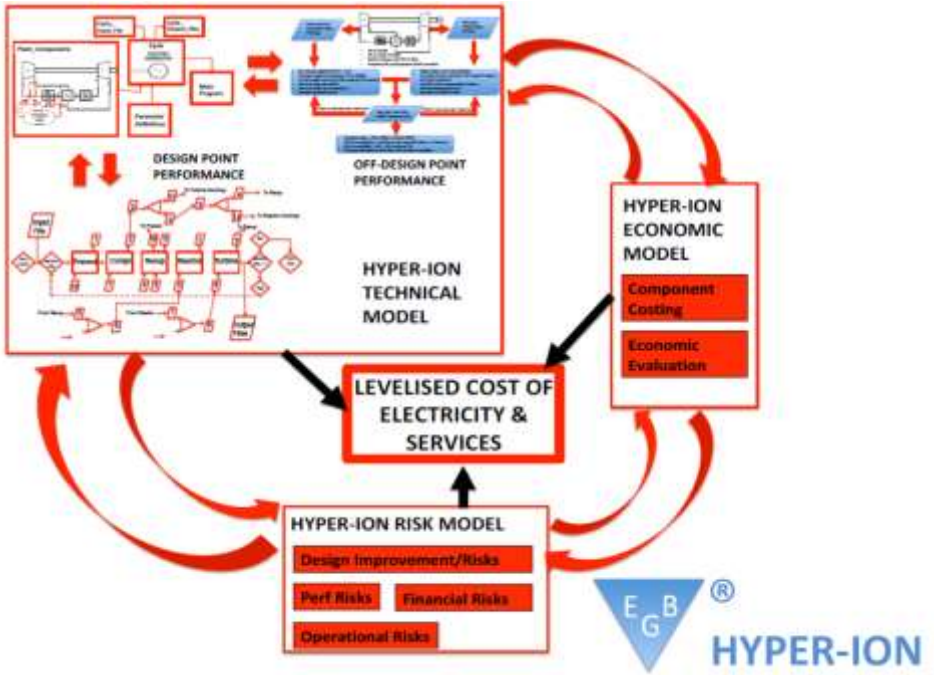
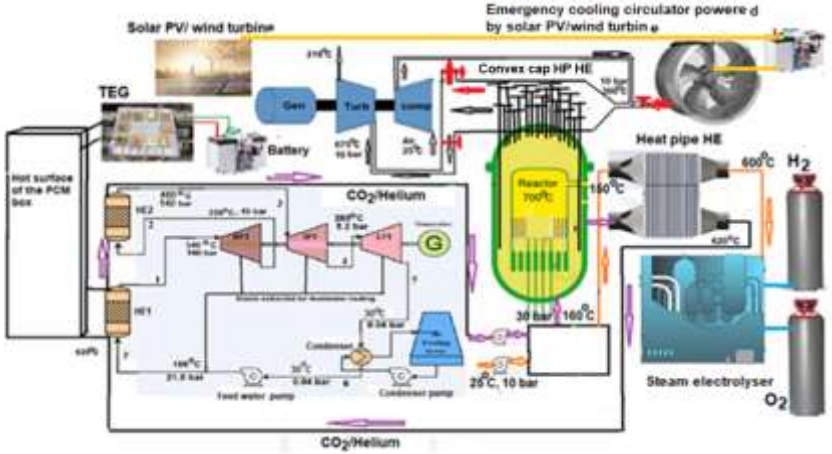
EGB Engineering

- Modelling of Heat, Energy Management and Conversion for Advanced Nuclear Technologies
- Feasibility of new plant designs + cogeneration
- Optimisation of plant performance + economics
- Aid the design + deployment decision-making process



Teesside University

- Heat pipe heat exchanger for high temperature electrolysis & thermoelectric generation to utilise the heat from a nuclear reactor
- Integrated energy system + associated technologies
- Heat pipe technologies to harness high grade heat
- Thermoelectric devices to enhance efficiencies
- Review of high temperature electrolysers



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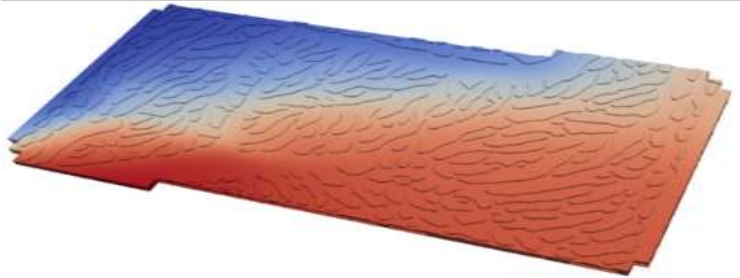
ToffeeAM Ltd

- Design for Additive Manufacturing: Robust Fluid Topology Optimization for High Temperature Heat Exchangers
- Optimised printed circuit heat exchanger design.
- Generative design in an entirely new field
- Step change in performance



Digital Technologies

Demonstration areas:

- Digital twins and Advanced Nuclear Technologies
- Collaboration, Assurance and Information Security
- Cloud and Large-scale Computing
- AI and computer simulation

Challenges:

- Breaking down information silos
- Making advanced industry 4.0 technologies accessible

KANDE International Ltd

Demonstration of Permanently installed Ultrasonic Monitoring Array (PUMA) technology applied to nuclear power plant applications

- Demonstration of ultrasonic sensor array for online monitoring of NPP

- Value of demonstrator in developing digital twins of AMR systems for in-service monitoring of materials integrity

Metrarc Ltd

Trusted Ring ICMetrics Collaboration System

- Security solution for data collaboration based on connected device metrics
- Demonstrated how this technology could be used to enable secure cross sharing of data across organisations complimenting existing security solutions

PixelMill Ltd

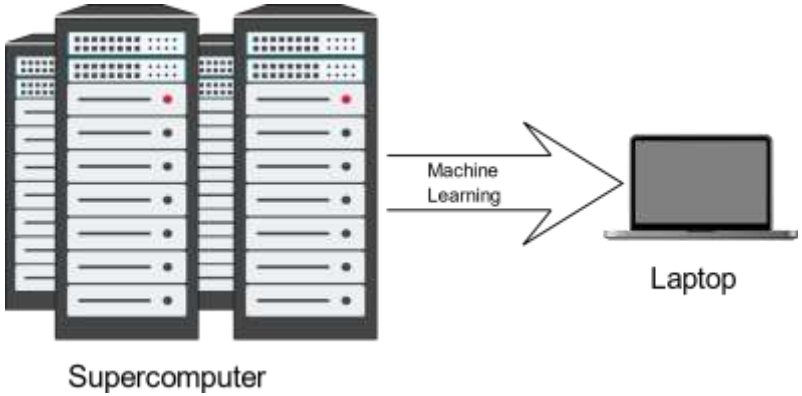
Agile visualisation of advanced nuclear technologies

- In a series of workshops, talked to a range of industry experts to identify the barriers to adopting VR/ AR
  - **Need for demonstrator/ test bed was identified**
- Developed a virtual visitors centre illustrated with NNL test rigs/ demonstrators

University of Liverpool

Application of machine learning technologies for the acceleration of massive high fidelity multi-physics simulations in nuclear engineering

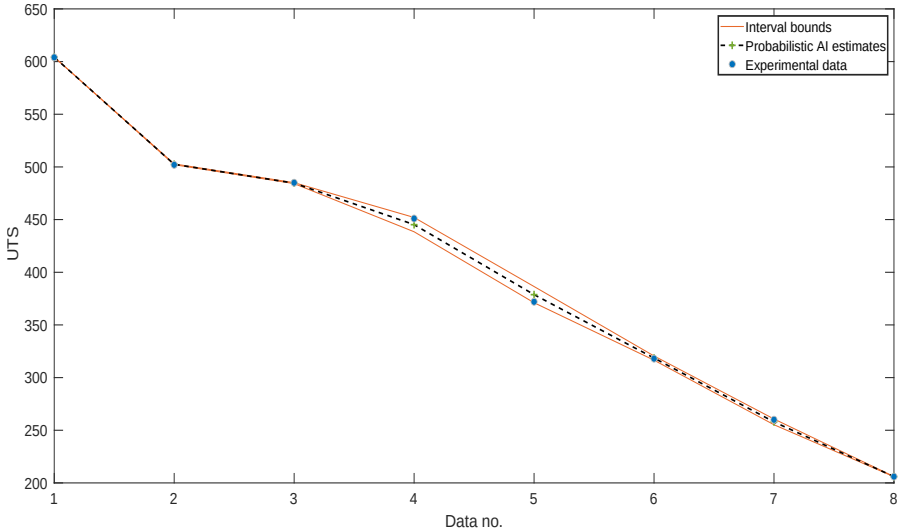
- Developed ML technologies to accelerate ‘computationally expensive’ models of neutron flux in reactor cores
- Demonstrated considerable time savings could be achieved
- Benefits are increased fidelity of simulation to improve safety



University of Strathclyde

Probabilistic AI for Prediction of Material Properties

- Developed AI technologies to digitally enhance sparse materials test data
- Demonstrated high accuracy of models increasing stakeholder confidence in AI technologies
- Reached out to national and international stakeholders to promote the adoption of the technology



Irradiation of material specimens

- Research reactors are currently the main source of medical and industrial isotopes
- Unique opportunity to develop ANT that can harness some of the energy produced to be used for irradiation of material specimens without affecting primary reactor operations

Viridian Consultants

Viridian Consultants

Advanced Nuclear Skills & Innovation Campus

Irradiation of materials in advanced nuclear reactors

- Desk top study has highlighted several ways to irradiate materials in AMRs
- Four innovative approaches identified

Department for Business, Energy & Industrial Strategy

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