EPSRC
Engineering and Physical Sciences Research Council

UK-HyRES

UK-HyRES:
Research Challenges in Hydrogen and Alternative Liquid Fuels

Principal Investigator
Prof Tim Mays
University of Bath

Co-Investigator
Prof Rachael Rothman
University of Sheffield

Co-Investigator
Prof Shanwen Tao
University of Warwick

SUMMARY

This presentation outlines the context and project details of the

Co-ordinator for Research Challenges in Hydrogen and Alternative Liquid Fuels

the aim of which is to build a national

Hub for Research Challenges in Hydrogen and Alternative Liquid Fuels

EPSRC CO-ORDINATOR CALL (Phase 1)

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Funding opportunity

Become a hydrogen research coordinator

Opportunity status:	Closed
Funders:	Engineering and Physical Sciences Research Council (EPSRC)
Funding type:	Grant
Total fund:	£700,000
Maximum award:	£350,000
Publication date:	2 September 2021
Opening date:	7 September 2021 09:00 UK time
Closing date:	30 November 2021 16:00 UK time

Last updated: 26 January 2022

Apply for funding to become a hydrogen research coordinator.

Timeline

- **7 September 2021 09:00** Opening date
- **30 November 2021 16:00** Closing date
- **January 2022** Sift panel
- **W/c 31 January and w/c 7 February 2022** Interview panels
- **1 April 2022** Grant fixed date start

Grant award details:
https://gow.epsrc.ukri.org/NGBOViewGrant.aspx?GrantRef=**EP/W035529/1**

six months → **30 September 2022**

TWO LINKED CO-ORDINATOR PROJECTS

Research challenges in hydrogen and alternative liquid fuels

The coordinator for this area should look to create a consortium and research plan which will tackle research challenges that underpin the hydrogen production, storage and distribution parts of the hydrogen value chain. They may also seek to address issues that will impact upon the hydrogen end-use sectors. These may include, but are not limited to, challenges associated with:

- lowering costs of hydrogen technologies
- increasing efficiencies of technological systems
- materials science and engineering
- hydrogen safety.

Systems integration of hydrogen and alternative liquid fuels

Integration can be taken to mean integration within whole energy systems that can include:

- international settings
- whole systems integration across technologies
- technology coupling requirements
- trade-off analysis across technology options
- whole systems.

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- Low TRL research mainly in the EPS space and with identified and significant impacts leading to Net Zero
- Inter-disciplinary and cross-cutting research
- Completely agnostic about technologies
- Stakeholder engagement nationally and internationally
- Equality, diversity and inclusion
- Responsible innovation and ethics
- Building sustainable capacity and talent pipelines

Grant award details:
https://gow.epsrc.ukri.org/NGBOViewGrant.aspx?GrantRef=**EP/W035502/1**

HI-ACT
Hydrogen Integration for Accelerated Energy Transitions

PI: Prof Sara Walker
Newcastle University

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Co-ordinator for Research Challenges in Hydrogen & Alternative Liquid Fuels

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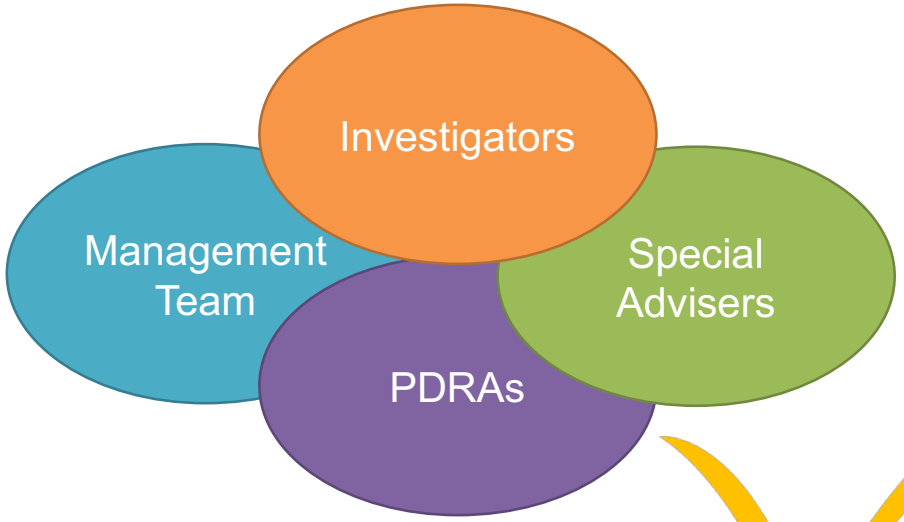
VISION An **inclusive**, **inter-disciplinary** community to **co-create** a plan to tackle the research challenges in hydrogen & alternative liquid fuels for Net Zero. This will lay the foundation of a **UK Centre of Research Excellence in Hydrogen & Alternative Liquid Fuels: UK-HyRES**



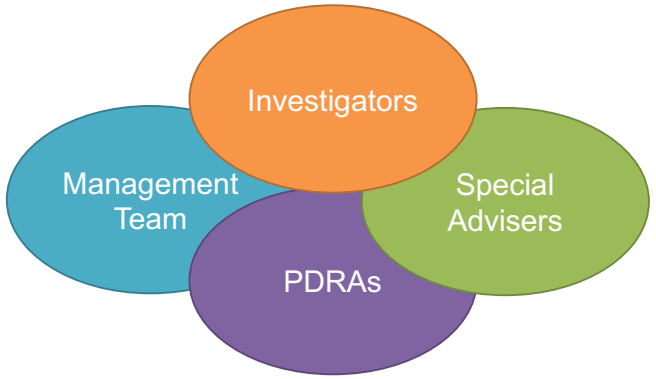
Identification & prioritisation of research challenges

A uniquely connected & informed H&ALF research community

UK-HyRES White Paper

Theory of Change Implemented through accessible, facilitated workshops with direction from special advisers

Why?	What?	How?	How?	What?	Why?
Strategic Drivers	Challenges & Barriers	Opportunities for Research	Outputs	Change (Outcomes)	Impact (Difference & Added Value)



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MANAGEMENT TEAM

Project Manager
Dr Yankı Keleş
University of Bath

Project Support
Amanda Lester
University of Bath

Project Support
Carla Teale
University of Sheffield

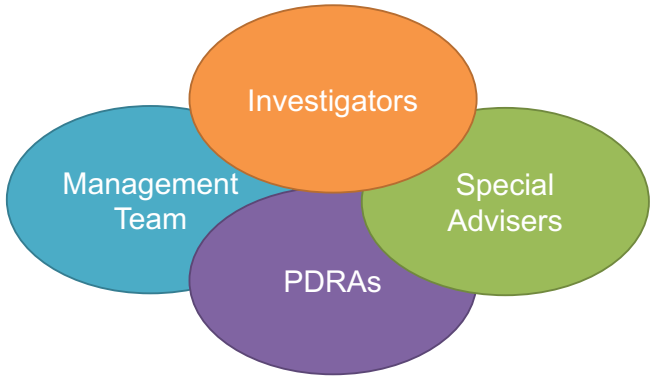
Project Support
Matt Phillips
University of Warwick

Facilitation and Visualisation

THE COLLECTIVE

Scriberia

CWP



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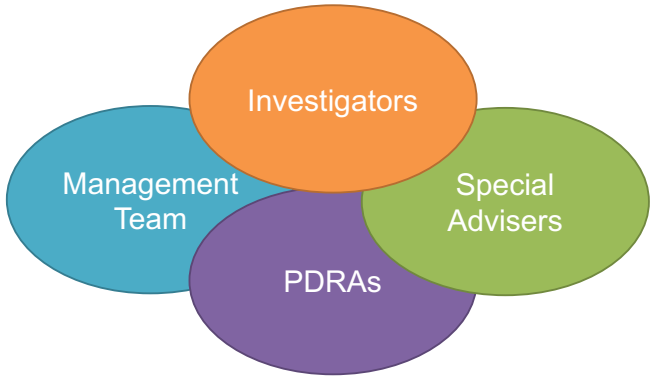
RESEARCHER TEAM

Research Support
Dr Rajan Jagpal
University of Bath

Research Support
Dr Diarmid Roberts
University of Sheffield

Research Support
Dr John Humphreys
University of Warwick



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SPECIAL ADVISOR TEAM

GKN AEROSPACE

HSE Health & Safety Executive

JAGUAR

LAND ROVER

ITM POWER
Energy Storage | Clean Fuel

SCOTTISH Hydrogen & Fuel Cell ASSOCIATION

SIEMENS energy

WALES&WEST UTILITIES

MAIN EVENTS

ONLINE WORKSHOP 1 – Hydrogen Production
09:30 – 12:30 Thursday 16 June 2022

ONLINE WORKSHOP 2 – Hydrogen Storage / Distribution
13:30 –16:30 Thursday 16 June 2022

ONLINE WORKSHOP 3 – Hydrogen End Use
09:30-12:30 Tuesday 5 July 2022

ONLINE WORKSHOP 4 – Alternative Liquid Fuels
09:30 –12:30 Wednesday 20 July 2022

IN PERSON RESEARCH CHALLENGES SHOWCASE
Thursday 15 September 2022
University of Warwick

ONLINE PROJECT LAUNCH
13:30 – 16:30 Monday 6 May 2022

Prof Paul Monks
CSA, BEIS

Please see ….

https://ukhyres.co.uk

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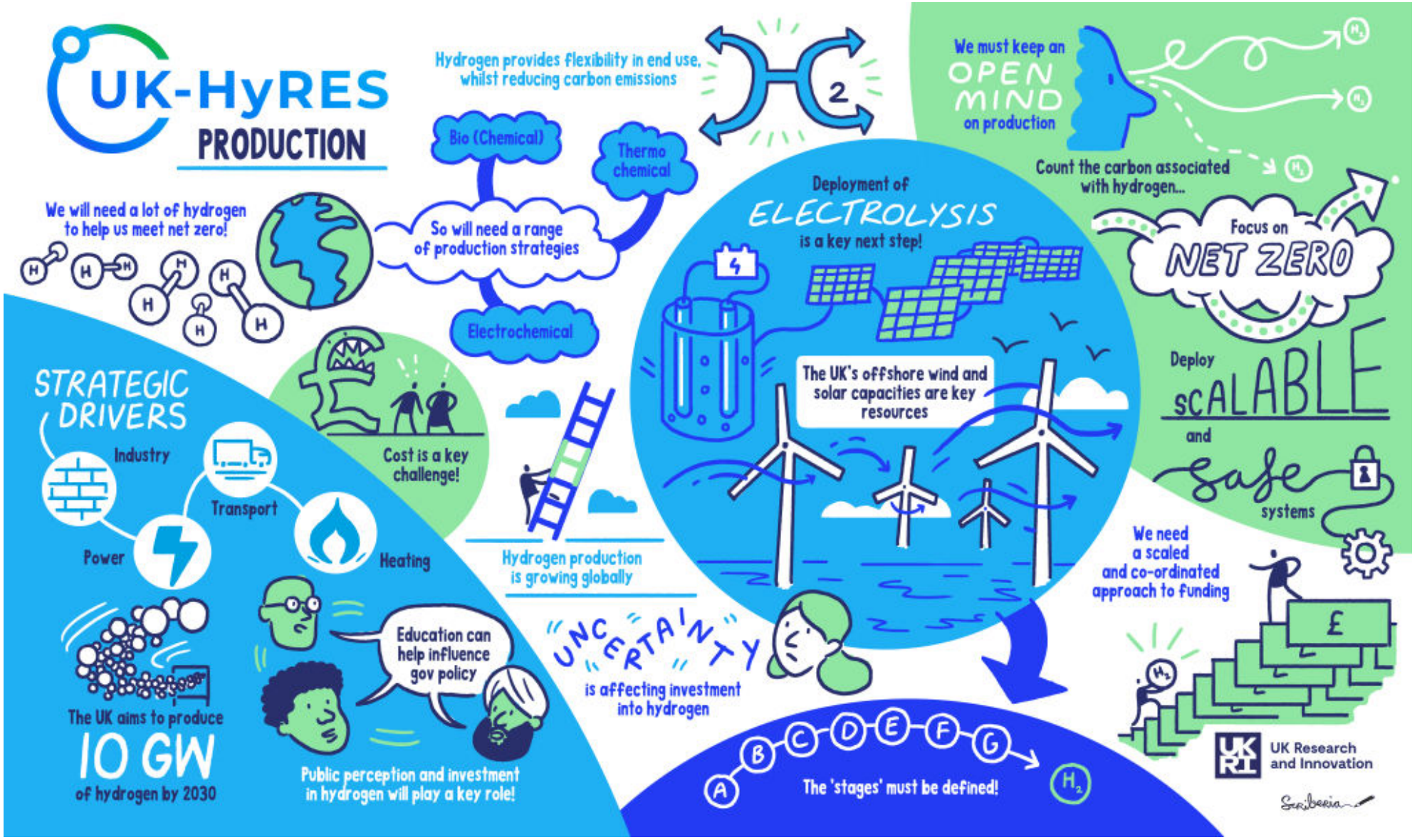
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PRODUCTION
We will need a lot of hydrogen to help us meet net zero!
Hydrogen provides flexibility in end use, whilst reducing carbon emissions
Bio (Chemical)
Thermo chemical
So will need a range of production strategies
Electrochemical
Deployment of ELECTROLYSIS is a key next step!
The UK's offshore wind and solar capacities are key resources
We must keep an OPEN MIND on production
Count the carbon associated with hydrogen...
Focus on NET ZERO
Deploy SCALABLE and safe systems
STRATEGIC DRIVERS
Industry
Transport
Power
Heating
The UK aims to produce 10 GW of hydrogen by 2030
Cost is a key challenge!
Hydrogen production is growing globally
Education can help influence gov policy
Public perception and investment in hydrogen will play a key role!
UNCERTAINTY is affecting investment into hydrogen
We need a scaled and co-ordinated approach to funding
A B C D E F G
The 'stages' must be defined!
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PRODUCTION

Challenges	Potential project areas
1. Alternative catalysts to Iridium	Alternative oxygen evolution reaction catalysts to Iridium.
2. Anionic exchange membranes	Develop step-change anionic exchange membrane.
3. Solid oxide electrolyser development	Oxygen electrode spalling, hydrogen electrode Ni migration, improving durability and reducing manufacture cost of solid oxide electrolyser technology.
4. Seawater electrolysis research	Fundamental research on seawater electrolysis.
5. Bio-based routes	Bio-based routes to hydrogen production.
6. Solar hydrogen production	Using solar energy as the energy source for hydrogen production.

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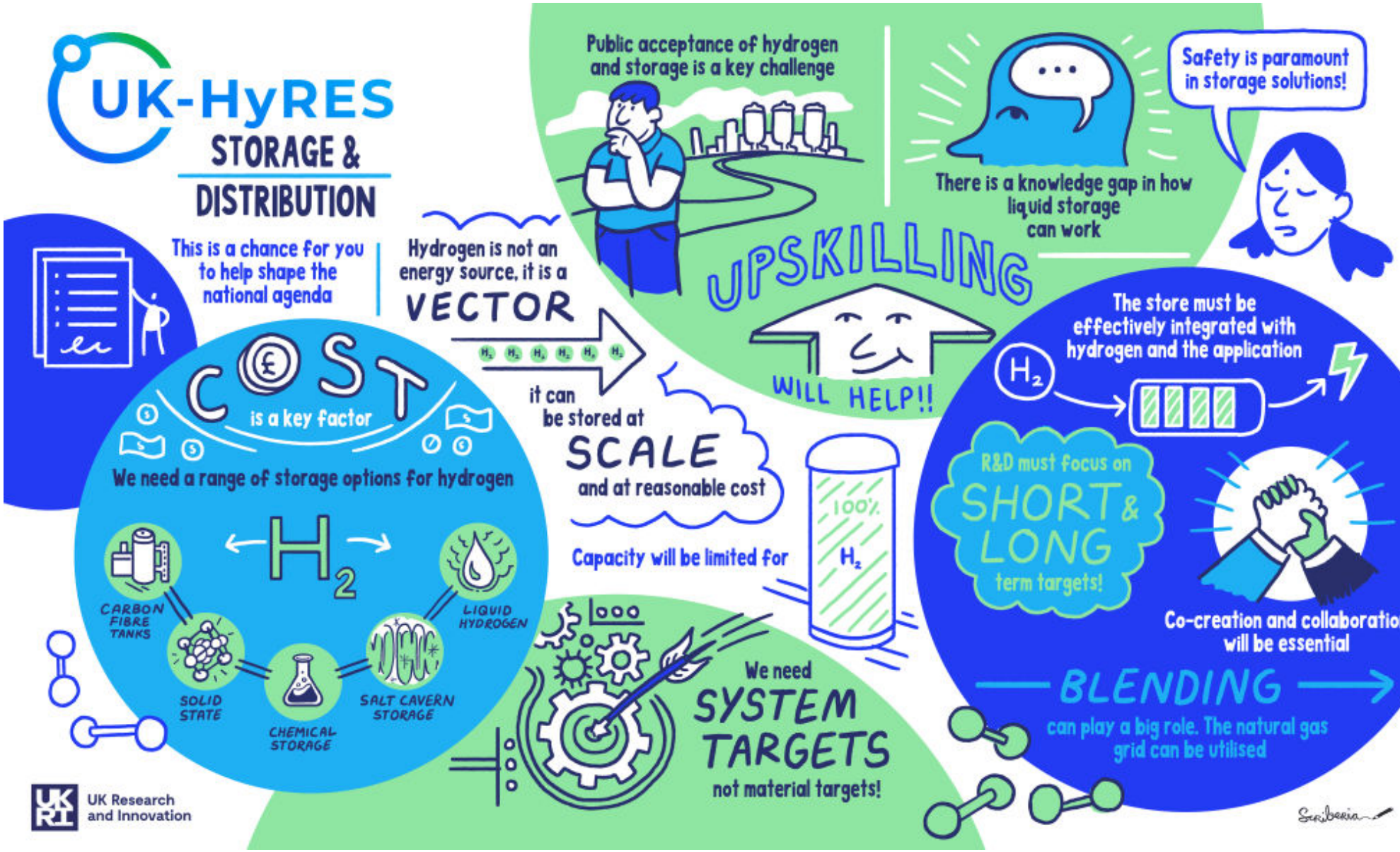
UK-HyRES STORAGE & DISTRIBUTION



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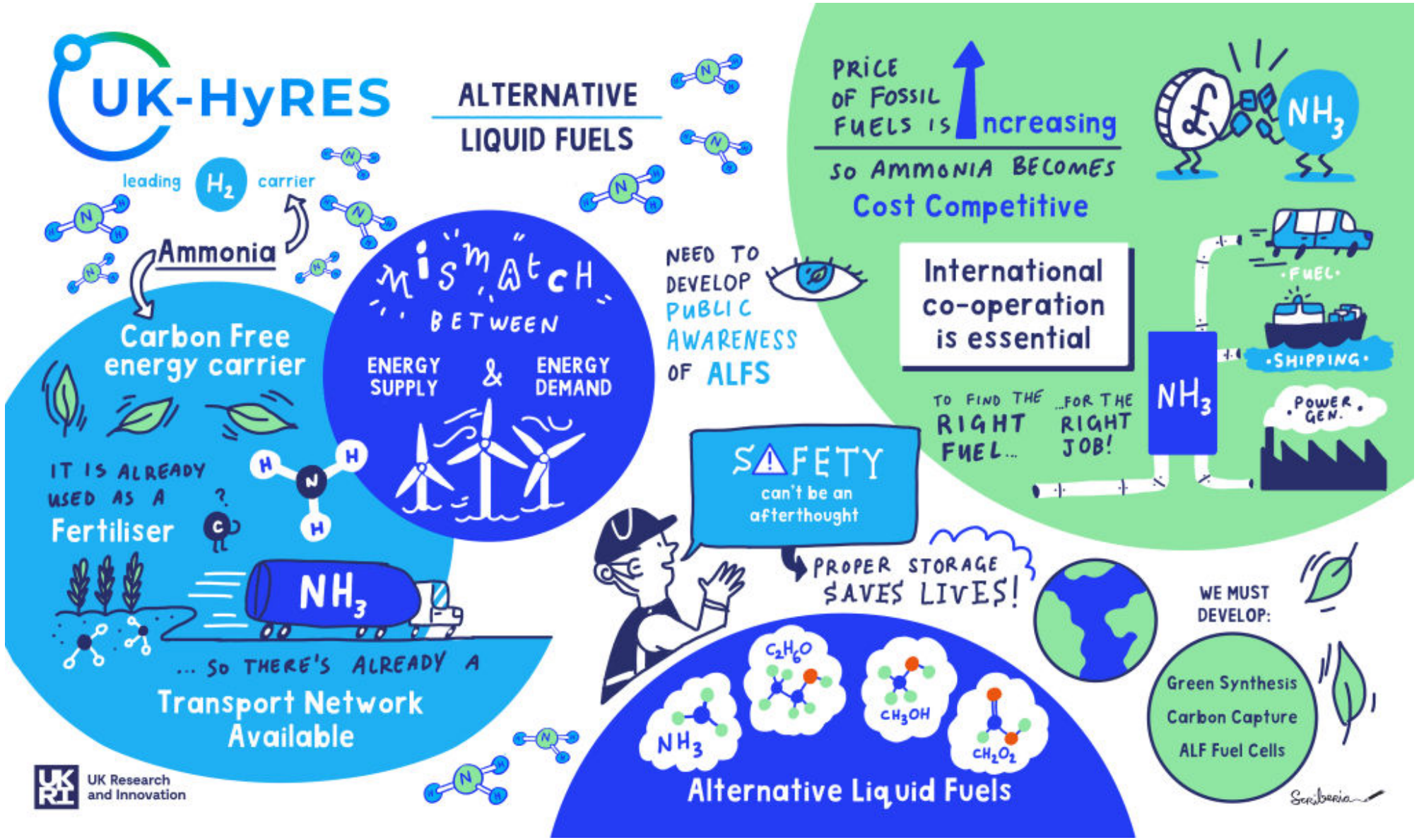
STORAGE & DISTRIBUTION

Challenges	Potential project areas
7. Cryogenic material behavior	Material behavior under cryogenic/ambient cycling. Including material embrittlement models and experiments.
8. Permeation barrier development	Develop novel non-metallic barriers to permeation.
9. Thermal energy recovery	Thermal energy recovery from compression and liquefaction and improvement of compressor technology.
10. Solid state storage	New solid state materials and scale-up of existing solid state storage.
Cross-cutting	
11. H_2 sensor development	Development of novel H_2 sensors, e.g. low-cost, in-line, real time & cryo-compatible.
12. Storage vessel leakage and failure	Modelling leakage and failure mechanics of storage vessels, including O_2/N_2 condensation.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ALTERNATIVE LIQUID FUELS
leading H_2 carrier
Ammonia
Carbon Free energy carrier
IT IS ALREADY USED AS A Fertiliser
NH_3
... SO THERE'S ALREADY A Transport Network Available
mismatch BETWEEN ENERGY SUPPLY & ENERGY DEMAND
NEED TO DEVELOP PUBLIC AWARENESS OF ALFS
PRICE OF FOSSIL FUELS IS increasing
SO AMMONIA BECOMES Cost Competitive
International co-operation is essential
TO FIND THE RIGHT FUEL...
...FOR THE RIGHT JOB!
FUEL
SHIPPING
POWER GEN.
SAFETY can't be an afterthought
PROPER STORAGE SAVES LIVES!
C_2H_6O
CH_3OH
CH_2O_2
Alternative Liquid Fuels
WE MUST DEVELOP:
Green Synthesis
Carbon Capture
ALF Fuel Cells
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AMMONIA AND ALTERNATIVE LIQUID FUELS

Challenges	Potential project areas
13. Catalysts for ammonia cracking	Catalyst development for NH_3 -> H_2 cracking.
14. Electrolysis of ammonia for hydrogen production	Electro-catalysts for electrolysis of ammonia for hydrogen production
15. Ammonia release safety	Ammonia release safety modelling, including cryogenic ammonia release on water.
16. Reducing NOx emissions	Modelling the combustion conditions for reduced NOx emissions.
17. Electrochemical synthesis of green ALFs	Efficient catalysts for electrochemical synthesis of ammonia and other ALFs.
18. Catalysts for green ammonia synthesis	Catalysts for green ammonia synthesis by conventional Haber-Bosch process.

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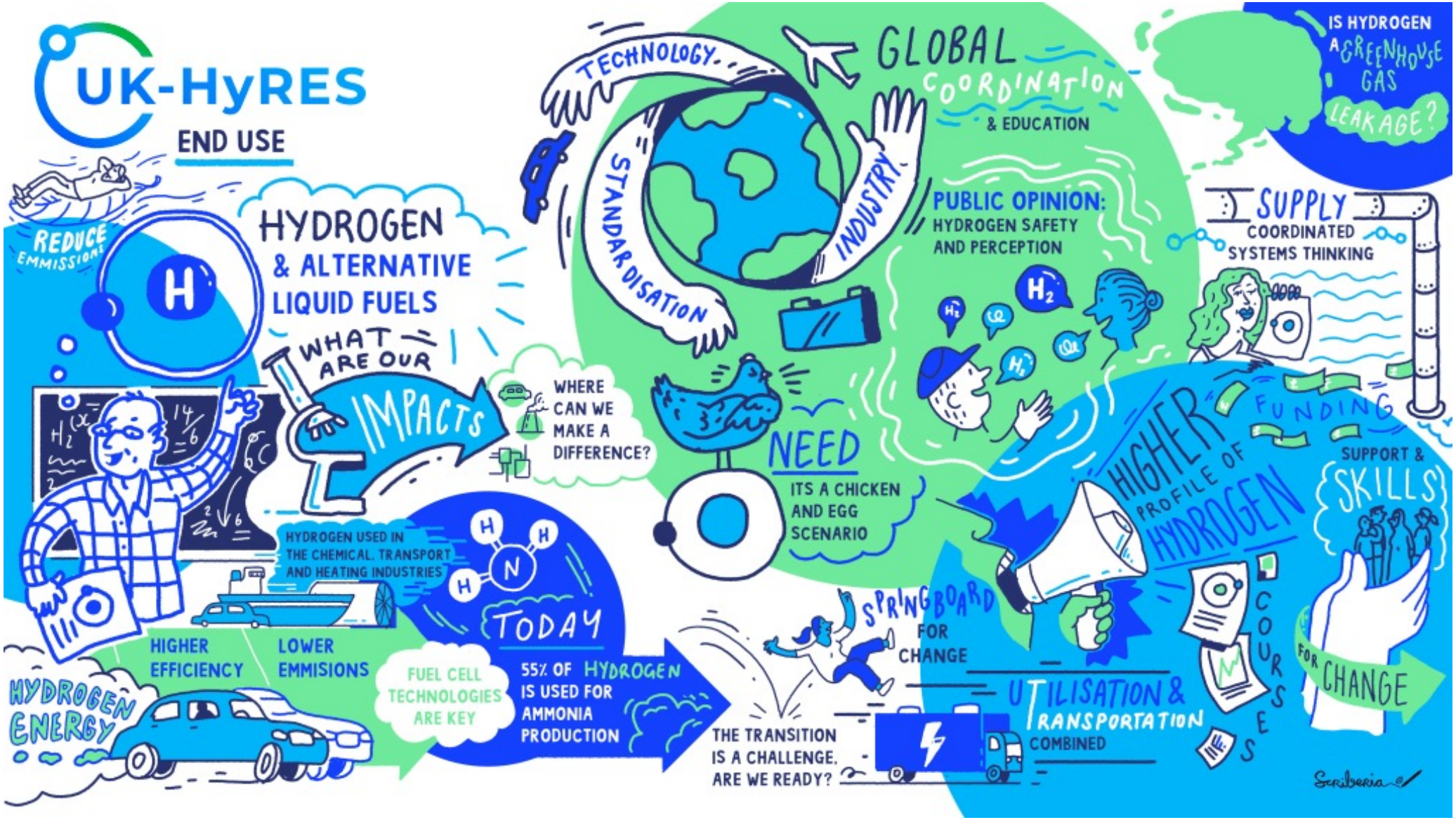
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END USE
REDUCE EMMISSIONS
HYDROGEN & ALTERNATIVE LIQUID FUELS
WHAT ARE OUR IMPACTS
WHERE CAN WE MAKE A DIFFERENCE?
HYDROGEN USED IN THE CHEMICAL, TRANSPORT AND HEATING INDUSTRIES
TODAY
55% OF HYDROGEN IS USED FOR AMMONIA PRODUCTION
HIGHER EFFICIENCY
LOWER EMMISIONS
HYDROGEN ENERGY
FUEL CELL TECHNOLOGIES ARE KEY
TECHNOLOGY
STANDARDISATION
INDUSTRY
GLOBAL COORDINATION & EDUCATION
PUBLIC OPINION: HYDROGEN SAFETY AND PERCEPTION
NEED
ITS A CHICKEN AND EGG SCENARIO
IS HYDROGEN A GREENHOUSE GAS LEAKAGE?
SUPPLY
COORDINATED SYSTEMS THINKING
HIGHER PROFILE OF HYDROGEN
FUNDING
SUPPORT & SKILLS
FOR CHANGE
COURSES
SPRINGBOARD FOR CHANGE
UTILISATION & TRANSPORTATION COMBINED
THE TRANSITION IS A CHALLENGE. ARE WE READY?
Scriberia

END USE

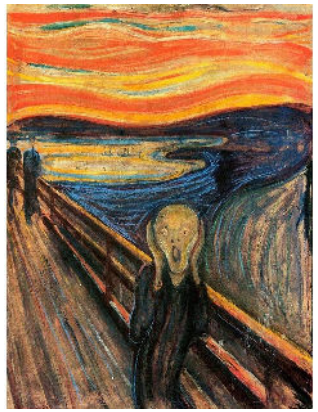
Challenges	Potential project areas
19. Reduction of iron oxide to steel with H_2	Direct reduction of iron oxide to steel with H_2.
20. Redesign of cement kilns	Redesign of cement kilns to reduce CO_2 emissions.
21. Burner improvement to reduce NOx	Improve H_2 and NH_3 burners to reduce NOx emissions.
22. Catalysts for hydrogen and ammonia combustion to reduce NOx	Develop suitable catalysts which can improve combustion of hydrogen and ammonia with reduced NOx emission

Cross-cutting	
23. H_2 as a GHG modelling	Modelling to understand the effects of H_2 as a green house gas.
24. Point-of-use purification	Develop point-of-use purification.

NEXT STEPS

- Continue 1-2-1 interviews with thought leaders in H&ALFs
- Strong engagement with Systems Co-ordinator
- Further analysis / synthesis of all engagement outcomes
- Re-arranged Showcase on 21 October 2022
- Funded Phase 2 Co-ordination from 1 October 2022 to 31 April 2023
  - Activities until Hub start include in person Regional Roadshows
- Hub proposal under review after submission on 2 November 2022

HUB CALL



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Funding opportunity

EPSRC hydrogen programme to establish hydrogen research hubs

Opportunity status:	Open
Funders:	Engineering and Physical Sciences Research Council (EPSRC)
Funding type:	Grant
Total fund:	£25,000,000
Maximum award:	£12,500,000
Publication date:	1 September 2022
Opening date:	1 September 2022
Closing date:	2 November 2022 16:00 UK

Timeline

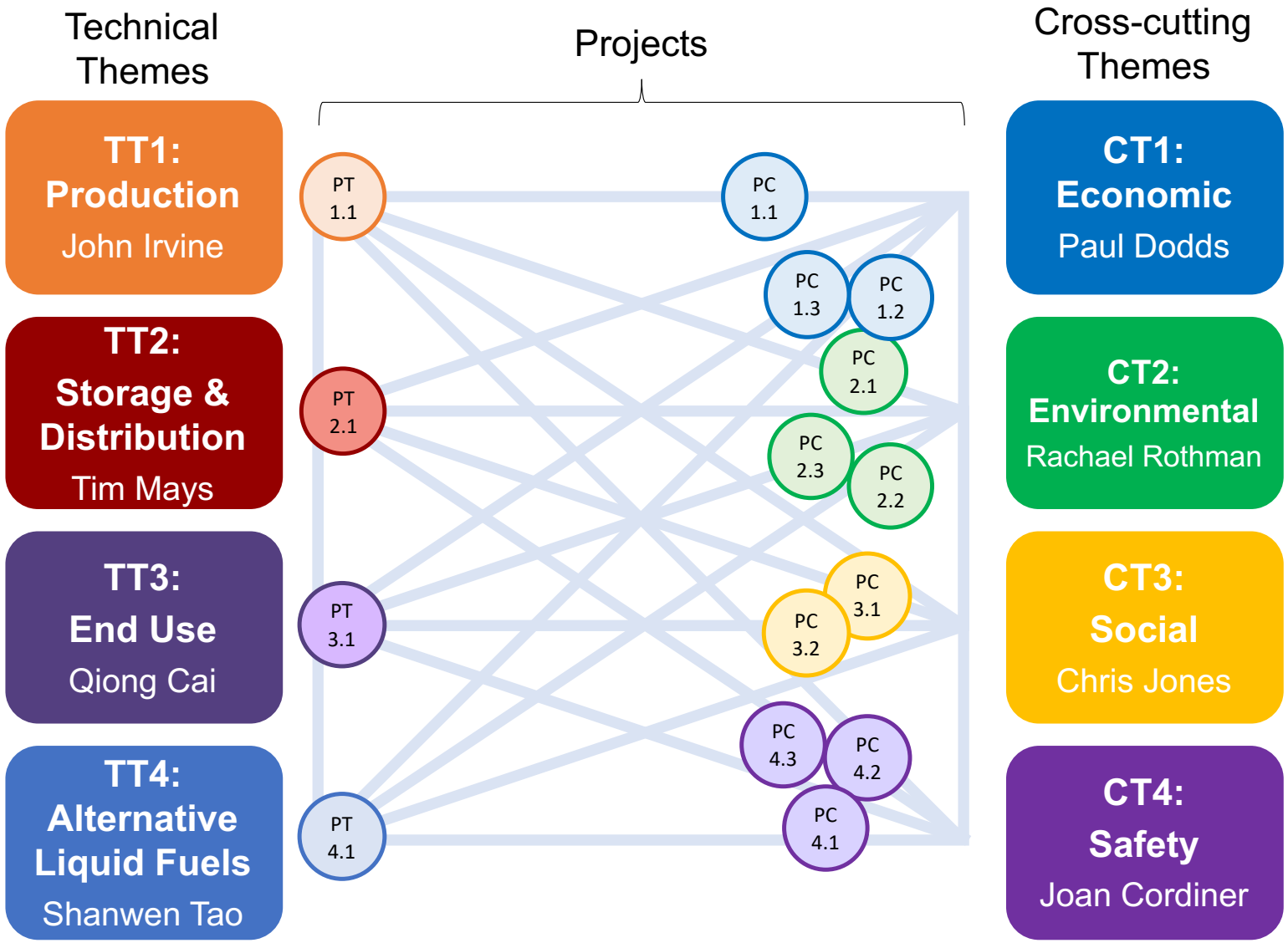
- **1 September 2022 00:00** Opening date
- **2 November 2022 16:00** Closing date
- **1 April 2023** Earliest start date

Guidance on good research

HUB SUMMARY

- Five years from 1 April 2023 (at earliest) with review points
- Initial funding of£12.5M Full Economic Cost / £10.0M EPSRC (@ 80 % FEC)
- At least £3.0 M leveraged funding by Hub start
- At least a further £7.0M leveraged funding during Hub
- Over 80 companies and other organisations already associated with HyRES
- Hub Costs: Operations + Themes + Research Projects
  - ~£425k FEC for each 3 y project (and pro rata) for up to 10-15 projects initially
- Four TECHNICAL Themes: Production, Storage, End Use , ALFs
- Four CROSS-CUTTING Themes: Economic, Environmental, Social, Safety
- Look to 5, 10, 30 years beyond Hub

HUB STRUCTURE



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