UK-HyRES
UK Hub for Research Challenges in Hydrogen and Alternative Liquid Fuels

HI-ACT
Hydrogen Integration for Accelerated Energy Transitions

Summary of Round Table between Hydrogen Academics and Companies

TOPIC: FUTURE RESEARCH NEEDS FOR THE COMMUNITY

May 2025

Editors: Sara Walker and Tapas Mallick.

UKRI Engineering and Physical Sciences Research Council

Summary of Round Table Between Hydrogen Academics And Companies, on the Topic of Future Research Needs for the Community.

Chaired by Nigel Holmes, Hydrogen Scotland

Arranged by UK HyRES (UK Hub for Research Challenges in Hydrogen and Alternative Liquid Fuels), HI-ACT (Hydrogen Integration for Accelerated Energy Transitions), and the Hydrogen Innovation Initiative (HII).

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What follows is a summary of the key points of a round table. The attendees discussed issues of digitalisation, technologies, and whole systems in three breakout rooms. All attendees then discussed what this means for key research to support hydrogen and alternative liquid fuels (HALF). The overall summary of research needs is presented first, followed by a summary of the three breakout sessions.

This summary has been prepared by the editors. We have attempted to best represent the key points made by all attendees. Any errors are our own.

Summary

1. **Digitalisation and Technology's Role:** Digital tools are crucial for understanding energy usage patterns and designing systems accordingly. These tools can help bridge the gap between technology and whole energy systems, facilitating long-term forecasting and optimisation. More research is needed on:

    - balancing standardisation with cybersecurity risks and formalising sector-specific standards;
    - continuous development of dynamic models that incorporate real-time data and adjust to long-term trends;
    - developing frameworks for responsible and transparent data use, with attention to security and access.

2. **Technology and (not vs.) Systems:** Technology not only supports energy systems but also has the potential to innovate (e.g., value chains, production, storage). The complexity of integrating emerging technologies into energy systems may be assisted by digital technology. Introducing new technologies requires careful policy communication, especially as citizens become major consumers of new tech. More research is needed on:

    - more affordable production options, with an emphasis on low-cost hydrogen sensors, as well as increasing hardware development;
    - durable, stable technologies that can reduce long-term costs and maximize efficiency.

3. **System Thinking:** The interaction between technology and energy systems is a key research area, with a focus on how various systems work together within the broader "system of systems" approach. More research is needed on:

    - new and cheaper production and storage technology, integration to other energy vectors, primarily for green hydrogen, H2 integration with intermittent renewable energy and effect of flexibility and reliability;
    - better understanding of capabilities of modelling tools and their limitations for complex energy systems;
    - understanding different level of H2 technologies, scale, feasibility infrastructure such as storage, system operation asset utilisation and flexibility. Also, understanding stages of deployment, i.e. a pathway to 2030/2050;
    - integrating hydrogen into existing energy infrastructure (e.g., repurposing gas pipelines).

4. **Hydrogen's Role in the Energy Mix:** Hydrogen is one of several tools in the transition to Net Zero, but it needs to be positioned within the broader energy mix, not as a standalone solution. Policymakers are increasingly supportive, but questions remain about its scale and application. More research is needed on:

    - development of models to support transition pathways and not just end-point scenarios i.e. when might gas networks convert to H2;
    - hydrogen's role in decarbonizing industries (e.g., steel, chemicals), which varies and should be considered on a sector-by-sector basis;
    - the role and value of hydrogen in supporting cost effective transition to zero carbon future, and ways to communication this evidence to policy makers.

5. **Energy Security and Resilience:** Hydrogen plays a key role in ensuring energy security, especially in power generation, infrastructure, and storage. Energy resilience is a critical consideration for policymakers. More research is needed on:

    - optimizing systems to ensure resilience in hydrogen production and transport;

   - understanding H2 and HALF supply chain, manufacturing capabilities, and relationships with external stakeholders.

6. **Public Engagement, Messaging and Safety:** Effective communication around hydrogen adoption is essential, with an emphasis on safety. Messaging around specific projects should be tailored to local contexts and should emphasise benefits to local people and environments as well as to the climate. More research is needed on:

   - wider participant and societal engagement work, incorporating safety and public perception.

7. **Collaboration with Key Stakeholders:** Collaboration with local energy operators and stakeholders, such as Cadent, and experts from organizations like NESO, can help move hydrogen projects forward.

   - It is vital for stakeholders to be engaged with the aforementioned research ideas, to ensure that they can contribute to, and benefit from, research outcomes.

A. Digitalisation and Hydrogen Research

Key issues/insights:

- **Decision Makers & Models**: Understanding how decision makers interpret models, especially given that models are simplifications of reality and not fully representative of the real world.
- **Dynamic Models**: Developing more temporally sensitive models that can be adjusted over time, incorporating real-time data and responding to changing conditions.
- **Short-Term vs. Long-Term Missions**:
    - **Short-Term (up to 2030)**: Focus on data validation and data governance (access, use, and security). Also data use for model validation.
    - **Long-Term**: Evolving models to better represent complex, dynamic systems. End-use sectors could also be categorised as shorter/longer term.
- **Hydrogen Use Predictions**: Using models to predict hydrogen integration and usage across different sectors over both short and long periods. This needs development of models to support transition pathways and not just end-point scenarios i.e. when might gas networks convert to H2.
- **Real-Time Data Integration**: Ensuring models incorporate up-to-date data, to respond quickly to changes.
- **Hydrogen Standardization**: Exploring the effects of different standardisation levels on investment and decarbonisation goals, through modelling work.
- **AI & Machine Learning**: AI can enhance predictions and support extrapolations from small to larger scale, particularly for large-scale hydrogen integration scenarios.
- **Sector-Specific Hydrogen Use**: Hydrogen's role in decarbonizing industries (e.g., steel, chemicals) varies and should be considered on a sector-by-sector basis.
- **Data Management & Sharing**: Effective data management and secure sharing practices are crucial, particularly with large datasets and cybersecurity concerns. What learning from other sectors could be transferred?
- **Carbon Budgets**: Carbon budgets are useful for setting timelines and guiding model development and implementation.

Ongoing Research Needs:

- **Standardization & Cybersecurity**: More research on balancing standardisation with cybersecurity risks and formalising sector-specific standards.
- **Model Evolution**: Continuous development of dynamic models that incorporate real-time data and adjust to long-term trends.
- **Data Governance**: Developing frameworks for responsible and transparent data use, with attention to security and access.

B. Hydrogen Technologies

Key issues/insights:

- **Hydrogen Production and Technology:** There's a focus on reducing hydrogen production costs, with promising new technologies such as net-negative hydrogen (e.g., BECCS, direct electrolysis of seawater). Emerging technologies, including ambient pressure hydrogen and biohydrogen, offer potential for scalability at lower costs, though challenges like compressor technology and hardware components remain.
- **Tech Integration and Scaling:**
    - Challenges in integrating electrolysers with intermittent renewable energy sources were discussed, with a consensus that smaller-scale technologies should be explored before scaling to large systems.
    - Innovation in niche areas, such as novel electrolysers that operate at lower pressure to avoid cross-over issues, could provide opportunities to compete with lower-cost international players.
- **Public Engagement and Communication:** Public acceptance and understanding of hydrogen are key. A narrative around hydrogen's longstanding presence in industries (like food processing) can help build consumer trust.
- **Collaboration and Learning from Global Efforts:** Collaboration across sectors and understanding international technologies, particularly in the EU and US, is vital for avoiding unnecessary duplication and enhancing the UK's hydrogen strategy.
- **Industrial Clusters and Infrastructure:** Focus should be placed on industrial clusters, including electrolytic hydrogen use in industries like chlorine production. These areas present significant opportunities for scaling hydrogen technologies and should be aligned with existing supply chains and infrastructure.
- **System Optimization and Resilience:** Optimizing systems to ensure resilience in hydrogen production and transport is crucial.

Ongoing Research Needs:

- Production techniques are diverse, and there's a need for more affordable options, with an emphasis on low-cost oxy and hydrogen sensors, as well as increasing hardware development at universities.
- A focus is needed on durable, stable technologies that can reduce long-term costs and maximize efficiency, especially in high-cost applications like gas turbines.
- The challenge of integrating hydrogen into existing energy infrastructure (e.g., repurposing gas pipelines) was discussed as an important area for future development.

C. Whole Systems and Hydrogen Technology

Key issues/insights:

- **Energy systems interaction**: Greater understanding of hydrogen pathways, readiness for power station and other energy vectors for clean power dispatch, and unified interaction between research centres and stakeholders.
- **Hydrogen and Hydrogen-based Alternative Liquid Fuel (HALF) value proposition**: There is a need for greater understanding of the role of hydrogen for heating, power, transport across individual, local, regional and national scales, through to social acceptance and production technologies.
- **Short-Term vs. Long-Term Missions**:
  - **Hydrogen & HALF technology for Short-Term (up to 2030)**: Identifying priorities of clean power 2030 by NESO, and understanding technological challenges.
  - **Hydrogen & HALF technology for long term**: Diversifying production technology, supercritical water degradation, advanced metering, sensing, atomisation and digitalisation. This needs to be underpinned by cross-cutting themes, ensuring safe operation, public expectations and gaining public confidence.
- **UK's manufacturing and exporting capabilities**: Understanding H2 and HALF supply chain, manufacturing capabilities, and relationships with external stakeholders.
- **Technology priority and value chain**: Identifying different levels of technology penetration, scaleup, priority, cost effectiveness, and integration issue with renewables.
- **Niche technology**: The role of niche technologies for net-negative H2 production, aquatic, biohydrogen and artificial photosynthesis, ammonia, low cost & low pressure compressor, oxy and H2 sensors, metering, and cross-cutting edge technology.
- **Cost and social acceptance:** Low-cost technology development in various H2 and HALF pathways for new and reliable production, storage and utilisation technologies, engaging a diverse range of users. Engagement should begin as early as possible in project development, proceeding on a two-way basis, and take local concerns seriously. Project advocates should be prepared to respond to basic questions about safety and impacts on things like home insurance. In the case of converting domestic gas supplies, strong messaging and backing at a national level may be required, backed up with co-ordinated wraparound support for homeowners, similar to that provided during the 1970s town gas conversion programme.

Ongoing Research Needs:

- **Technology development**: New and cheaper production and storage technology, integration to other energy vectors, primarily for green hydrogen, H2 integration with intermittent renewable energy and effect of flexibility and reliability.
- **Whole system interaction**: Heat, power, transport, and interaction with other key energy vectors, better understanding of capabilities of modelling tools and their limitations for complex energy systems.
- **Public engagement**: Wider participant and societal engagement work incorporating safety and public perception. This might include public perceptions of trade-offs between blue hydrogen use and energy system resilience, the forms of local benefits host communities might desire from hydrogen infrastructure, and issues of choice associated with domestic gas network conversion.
- **Understanding H2 pathways:** Understanding different level of H2 technologies, scale, feasibility infrastructure such as storage, system operation asset utilisation, and flexibility. Also, understanding stages of deployment, i.e. a pathway to 2030/2050.

APPENDIX: Round Table Attendees and Affiliation

Name	Affiliation
Nigel Holmes	Hydrogen Scotland
Rita Wadey	NESO
Nazmiye Ozkan	HyPT, Cranfield University
Mercedes Maroto-Valer	IDRIC, Herriot Watt University
Dani Strickland	Loughborough University
Rob Gross	UKERC
Marcus Walls-Bruck	Hydrogen Innovation Initiative (HII)
Ruqaiyah Patel	UKRI
Joe Howe	North West Hydrogen Alliance
Sara Walker	HI-ACT
Goran Strbac	HI-ACT
Danny Pudjianto	HI-ACT
Natalia Pynirtzi	HI-ACT
Sian Allister	HI-ACT
Gareth Thomas	HI-ACT
Martin Stringer	HI-ACT
Tapas Mallick	HI-ACT
Paul Dodds	HI-ACT and UK-HYRES
Tim Mays	UK-HYRES
Raj Jagpal	UK-HYRES
Louisa Wood	UK-HYRES
Sophie Hill	UK-HYRES
Carla Teale	UK-HYRES
Shanwen Tao	UK-HYRES
Joan Cordiner	UK-HYRES
Rachel Rothman	UK-HYRES
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