Innovation Challenge 8: Renewable and Clean Hydrogen

Deep dive workshop

17-18 October 2018, Berlin, Germany
About

Mission Innovation is a global initiative of 23 countries and the European Union to dramatically accelerate global clean energy innovation.

As part of the initiative, participating countries have committed to seek to double their governments’ clean energy research and development investments over five years, while encouraging greater levels of private sector investment in transformative clean energy technologies.

These additional resources will dramatically accelerate the availability of the advanced technologies that will define a future global energy mix that is clean, affordable, and reliable.

The Renewable and Clean Hydrogen Challenge is one of eight Innovation Challenges established under Mission Innovation. Co-led by Australia, the EU and Germany, it aims to accelerate the development of a global hydrogen market by identifying and overcoming key technology barriers to the production, distribution, storage, and use of hydrogen at gigawatt scale.

Innovation Challenge Members:

Australia
Europe Union
Japan
United States

Austria
France
Norway

Canada
Germany
South Korea

Chile
India
Saudi Arabia

China
Italy
United Kingdom

Observers:

Denmark
Mexico
Netherlands
South Korea
Workshop objectives

*The deep-dive workshop is the first milestone for the Challenge. We have three objectives for our two days together.*

1. **Identify key barriers in the hydrogen value chain**

2. **Set clear, quantifiable targets for each key barrier**

3. **Identify targeted collaboration opportunities and research gaps (including public–private initiatives)**

*These will be used to create a Challenge workplan, to be finalised by the end of 2018.*
# Program Day One

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<td>Lunch, networking and voting on research focus areas</td>
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<td>Speed dating – matching member interests to activities and workstreams</td>
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<td>Summary, thank you and farewell</td>
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Working session: production

Objective: identify 2-3 central production problems, and set clear targets / measures to overcome the identified barriers to producing hydrogen at GW scale

Group one: integration

Discussion starters

• How can production facilities at GW scale be integrated?

• What are existing barriers for the integration of large scale hydrogen production into existing energy / industry systems?

Group 2: technology

Discussion starters

• What are the main technological barriers for large scale hydrogen production?

• How can industrialization be facilitated?

Group 3: operations

Discussion starters

• What are the main barriers for global hydrogen market (prize, regulatory framework)?

• How can the market ramp-up be facilitated?

Cross-cutting issues

Report back to plenary:

What are the problems?

How can they be overcome?

What should targets be?

What implications are there for logistics and end use?
Working session: logistics

Objective: identify 2-3 central problems, and set clear targets / measures to overcome the identified barriers to moving and trading hydrogen at GW scale

Topic 1: Carriers and bulk transport

• What are the opportunities to reduce the cost of distributing hydrogen at scale?

• Would any carrier be more economically efficient at a system level if adopted uniformly? Are there particular technical challenges associated with that carrier to focus on?

• What technological or logistical challenges are common across all methods of bulk transport, regardless of type?

Topic 2: Storage and local distribution

• What are the main technological barriers to storing and distributing hydrogen via existing gas or oil systems—either as a blend, a carrier or 100% hydrogen?

• What are the limits of current infrastructure?

• What characteristic or properties do new storage and distribution materials require to support 100% hydrogen?

Cross-cutting issues

Report back to plenary:

What are the problems? 

How can they be overcome? 

What should targets be? 

What implications are there for production and end use?
Working session: large scale consumption

Objective: identify 2-3 central problems, and set clear targets / measures to overcome the identified barriers to using hydrogen at GW scale

Group one: Hydrogen in energy intensive industries

Discussion starters

Group 2: Hydrogen admixture into natural gas

Discussion starters

Group 3: Hydrogen to Power/Heat (H2 turbines, industrial scale FCs etc.)

Discussion starters

• What are the main barriers for global hydrogen market (prize, regulatory framework)?

• How can the market ramp-up be facilitated?

Cross-cutting issues

Report back to plenary:

What are the problems?  

How can they be overcome?  

What should targets be?  

What implications are there for production and logistics?
Working session: cross-cutting issues

Objective: identify 2-3 central problems that affect aspects of the whole supply chain, can be solved through technical R&D, and set clear targets / measures to overcome the identified barriers.

Presentation summary of crosscutting issues

• From the production session
• From the logistics session
• From the end-use session
• Are there additional issues?

Analysis framework

For technical issues:

• How significant is the problem?
• Will solving it make a transformational change, or an incremental one?
• When is a solution required by? And why? (Priority)
• What are the potential technical solutions? (Actions)
• What is the role for government, industry, and researchers? (Ownership)
• What targets can we set?

For non-technical issues:

• How significant is the problem?
• Will solving it make a transformational change, or an incremental one?
• When is a solution required by? (Priority)
• Whose job it is to solve this problem?
• What advice would we give them?
Pre-reading

All attendees were invited to propose interesting pre-reading for workshop attendees. These can be found at the following links.

- **National Hydrogen Roadmap – pathways to an economically sustainable hydrogen industry in Australia** (AU)
- **Opportunities for Australia from hydrogen exports** (AU)
- **Basic Hydrogen Strategy** (JP)
- **Study on early business cases for H2 in energy storage and more broadly power to H2 applications** (EU)
- **Sectoral integration - long-term perspective in the EU Energy System** (EU)
- **Hydrogen Meets Digital** (Hydrogen Council)
- **Analysis of different heat decarbonisation pathways for the UK Committee on Climate Change 2018 Progress Report to Parliament** (UK)
- **National Physical Laboratory – Identifying measurement challenges in the hydrogen industry** (UK)
- **Hydrogen from renewable power: Technology outlook for the energy transition** (IRENA)
Survey results

All countries were invited to complete a survey on the current state of the hydrogen market and research and development. These are the results.

Note: because only a subset of participating countries completed the survey, and not every country answered every question, the results should be treated as indicative rather than definitive.

If projections are right, we will need a lot of hydrogen

Sample size: 8 countries answered this question

- The power sector will grow the most, from around 890,000 t H2 in 2030 to over 10 million t H2 in 2050
- Transport, heat and other uses all grow between 4-fold and 6-fold between 2030 and 2050
Projected prices in 2030 vary widely between countries and regions

Sample size: 7 countries answered this question

- Japan and the UK had the lowest price expectations
- The European price was closest to the global average
- Not all countries have target prices set in policy
### Production barriers

- Low temperature electrolysis - cost
- Low temperature electrolysis - efficiency
- High temperature thermochemistry - cost
- High temperature thermochemistry - performance
- High temperature thermochemistry - durability
- High temperature electrolysis - performance
- High temperature electrolysis - durability
- Performance (not specified)
- Production (not specified)
- Renewable energy availability at scale
- Large scale electrolysis

### Production R&D gaps

- Reduce/eliminate PGM catalysts in electrolysis
- Reduce cost of system components in electrolysis
- Develop advanced manufacturing for electrolysis
- High temperature electrolysis - scale
- High temperature electrolysis - increasing operating pressure
- High temperature electrolysis - alternative electrode materials
- Electrolysis - increase robustness of components
- Develop catalysts for SMR where carbon fibre can be harvested easily
- Develop SMR reactors that tolerate frequent start/stop
- Novel industry-specific production of hydrogen
- Cost of production in general
- Synthetic fuels

**Potential production priorities?**

- **Electrolysis (7 countries)**
- **Thermochemistry (3 countries)**
- **SMR (2 countries)**

Sample size: 8 countries answered the barriers question. 9 countries answered the R&D gaps question.
Logistics barriers

- Capital cost of liquification
- Efficiency of liquification
- Capital cost of hydrogen pipelines
- Chemical carriers
- Supply chain
- Purification
- Storage - price
- Storage - scale
- Transport - scale

Logistics R&D gaps

- Safety of hydrogen in natural gas network
- Bulk shipping
- Storage - improve costs of materials
- Storage - reduce qualification time
- Storage - general cost reductions
- Improve efficiency of compressors
- Increase robustness of compressors
- Reduce costs of compressors
- Develop carriers for large scale transportation

Potential production priorities?

- Pipelines (5 countries)
- Storage (5 countries)
- Shipping (4 countries)

Sample size: 8 countries answered the barriers question. 9 countries answered the R&D gaps question
End use barriers

- Cost of fuelling stations
- Reliability of fuelling stations
- Fuelling stations (not specified)
- End use tech (not specified)
- Lifetime of fuel cells

End use R&D gaps

- Reliability of fuelling stations
- Safe operation of hydrogen facilities
- Using hydrogen in natural gas appliances
- PEM fuel cells - develop cheaper catalysts
- PEM Fuel Cells - develop high temperature systems
- PEM Fuel Cells - advanced manufacturing
- Novel industrial use of hydrogen
- Fuel cells - increase efficiency
- Fuel cells - increase robustness
- Fuels cells - reduce costs

Potential end use priorities?
No clear priorities identified

Cross cutting barriers

- General cost issues
- Environmental issues
- Safety

Cross-cutting R&D gaps

- Materials compatibility with hydrogen

Potential cross-cutting priorities?
No clear priorities identified

Sample size: 8 countries answered the barriers question. 9 countries answered the R&D gaps question
Safety issues

Production
• None raised

End use
• Fuel station - design
• Fuel station - operations
• Fuel station - materials
• Parking of hydrogen vehicles

Cross-cutting
• Materials and/or reliability
• Public perceptions of safety

Logistics
• Transport - confined spaces
• Network - introduction to gas network
• Storage
• Hydrogen appliances
• Regulatory standards
• Hydrogen in mining

Sample size: 8 countries answered the safety questions
Workshop information

Workshop venue

Canada House, Leipziger Pl. 17, 10117 Berlin, Germany. Tel: +49 30 203120
(Nearest U-Bahn: Potsdamer Platz, U2)

Dinner venue

Augustiner am Gendarmenmarkt, Charlottenstraße 56, 10117 Berlin (Zirbelstüber room)
http://www.augustiner-braeu-berlin.de/
(Nearest U-Bahn: Stadtmitte, U2)

Map
The Governments of Australia and Germany, and the European Commission extend our thanks to the Government of Canada, and the Hon Stéphane Dion, Ambassador to Germany and Special Envoy to the European Union and Europe, for providing the workshop venue.

We also thank the following organisations for donating their time and expertise to making the workshop a success:

- Hydrogen Council
- International Energy Agency
- International Renewable Energy Agency
- International Partnership for Hydrogen and Fuel Cells in the Economy
- Fuel Cells and Hydrogen Joint Undertaking
- Fraunhofer ISE
- NOW
- CSIRO
- SINTEF
- And all other participants, volunteer facilitators and presenters