UK REGIONAL COORDINATION WORKSHOP #2 FOR THE HYDROGEN AND FUEL CELL COMMUNITY – WORKSHOP SUMMARY

Location: Birmingham University

Date: 27th November 2008

Hosts: UKHA and Birmingham University

Purpose of the Workshop:

1. To work towards the establishment of a coordinated UK-wide H2 & FC project. It is recognised that the regions working together can make an impact that is big enough to be noticed on the world stage. This makes it possible, for example, to get H2/FC vehicles to use in demonstration projects. By aggregating UK capacity and efforts the UK is better positioned to compete nationally and internationally for funding as well as project partners.
2. To provide early critical information to inform a UK Hydrogen Energy Roadmap. If a coordinated approach to the development of UK H2 & FC initiatives is agreed, it will play a large part in the shaping of a UK H2 Roadmap.

Participants:

Alastair Rennie – Chair, UK Hydrogen Association
Steve Broome – Northeast Fuel Cell Cluster
Tom Read – Scottish Hydrogen & Fuel Cell Association
Rupert Gammon, BMHF
Karen Hall, UK Hydrogen Association
Robert Evans, Cenex
Kevin Kendall, Birmingham Uni.
Jon Maddy, Glamorgan
Andrew Fox, Yorkshire Forward
Pierre Gaudillat, CarbonTrust

Facilitator: Bill Phillips

Future-basing. What if you could pick a date in your or your organisation's future, create your ideal scenario for that time - and then learn how to make it a reality?

AIMS OF THE WORKSHOP

- Identify and appreciate the commonalities and differences of each regional group's aims, aspirations and future plans.

- Identify one or more futures where we will have all achieved our aims. Work through at least one to fully understand our individual roles in achieving the collective target.

Welcome – Alastair Rennie welcomed all participants and thanked the University of Birmingham for providing the workshop facilities.

WORKSHOP RESULTS

Overview of preliminary results of assignments – Karen Hall presented results of commonality analysis:

Participants were asked to provide in advance of the workshop a description of the business case for their regional efforts. These were than listed together and the group discussed the commonalities. The following is a composite list from all the inputs. It should be noted that each group may not include each item on the list among their business case. The composite list was created to identify the largest set of business drivers for the active regions.

WHY WE EXIST

CO_2 mitigation
Articulate industry position
Galvanise across sector boundaries
Engage Government
Drive the UK Hydrogen Economy
Give Voice to Region
Stimulate activities in the region
Networking forum
Information Clearinghouse
Push regional industry
Create jobs
Implementation
Identify & Implement

- Research, development and demonstrations
- Areas for business development
- Training and education requirements

Provide H2FC business opportunities
Business Development

- Process innovation
- Automotive sector
- Innovative technologies

Identify hydrogen benefits
Inform & Influence Government
Make business case for hydrogen
Help industrial users adopt hydrogen

FUTURE-BASING INTRODUCTION AND EXERCISES:

Future-basing™ is a powerful system that allows you to base yourself in the ideal future and then gives you the tools to get there. It was designed to help individuals or groups achieve their dreams and aspirations. It is a specially-structured way of thinking that makes it easier to:

- Pick a date in the future by which time you want success
- Define what you really want to achieve
- Work out how to make it happen

What is the perfect collective endpoint?

STEP 1 – Generating Date & Headlines

Bill Phillips challenged participants to agree a specific date in the future that could be used for the remainder of the workshop. The date should be sufficiently far forward to reflect success of the hydrogen and fuel cell community in the UK. The agreed date chosen was 01 May, 2030. This date allows for realisation of goals pertaining to introductions and uptake of

hydrogen and fuel cell technologies, as well as assessment of success of UK Government targets for low-carbon energy.

Participants were then asked to imagine their most ambitious dreams for this date, and describe the manifestation of success on that date. This technique tricks ones mind into believing you are present on that date and are describing how things ARE, rather than how they could be. This is important to engage your mind into appreciating what must have happened, and when, in order to get to the agreed endpoint. It is now 01 May 2030 and we are filled with success and achievement (beyond our wildest dreams). Participants then wrote descriptors detailing what, specifically, we are successful at.

The description of success agreed by the group is as follows:

A. **ENERGY DIVERSITY**

1. I'm really pleased that we generate hydrogen from so many different sources now.
2. The reliability of nuclear power gives us hydrogen and security and I am proud of helping it happen.
3. My fuel for my vehicle comes from so many different sources these days.
4. I got a real buzz today when I tanked up my motorbike with 'rocket fuel'.
5. It's great to see that we have developed cost effective ways of balancing energy supply and demand on the grid while simultaneously providing zero carbon transport (using hydrogen and battery-powered vehicles).
6. Hydrogen is a traded commodity in the UK with multiple producers and consumers. I can buy the hydrogen in lots of different forms, i.e., to fuel my hand-held computer, my car, my house, my tools, etc.
7. We have no fear of power cuts – Risk is all but gone.

B. **BUILDINGS**

1. We have got 50% of housing stock zero-carbon – great!
2. Zero-carbon buildings are seen as so much cheaper.
3. The buildings I work in export green energy to their neighbours.
4. I'm really proud that we stuck to our targets and achieved zero emissions earlier than required by regulations.
5. We are preparing to move house. We are a bit sad to say goodbye to the old house, but are really looking forward to spending our retirement in our new home. It is quiet, warm, and comfortable.
6. I no longer have energy bills! All my energy is free and unlimited.
7. The company I work for was an early mover towards zero-carbon buildings. It's great to work for such a forward-looking business.
8. Great – we've really made a difference by introducing hydrogen as a viable fuel for building heat, power, and cooling.

C. TRANSPORT

1. Isn't it great that most cars bought today now run on hydrogen?
2. Better still, it's green hydrogen.
3. I've just had a great holiday in the Caribbean. It was quite cheap because the carbon-tax was so low as we were on a low-carbon flight.
4. I've officially retired today and am absolutely chuffed. I celebrated by buying my very first second-hand H2FC car. What a dream come true after a career of working towards hydrogen technologies.
5. It's really good that my transport is available to share.
6. I'm really pleased that my company is a leader in hydrogen transport systems.

7. My sports car costs nothing to fuel!
8. Isn't it brilliant that we helped to revitalise the UK automotive industry by embracing hydrogen technology?
9. Wow, my car runs on water! It's for real!
10. At last we have a diversity of hydrogen certified as zero-carbon supplied through
11. Individual production at home and work
12. Public places
13. Large-scale demand feeds
14. We just opened yet another hydrogen fuelling station today. It would almost seem routine if it wasn't such fun! Had a great journey back (in the FCV, of course) and found myself remembering those old noisy engines we used to have – I'm sure they contributed to road-rage. Motorists seem much calmer these days!
15. Driving is CO2-neutral and costs less than £1/100 miles.

D. GREEN ECONOMY

1. I am delighted that now nothing goes to landfill.
2. Isn't it great that hydrogen is really economically viable now – and we made it happen?
3. UK greenhouse gas emissions are half what they were in 1990.
4. I am proud of the progress we have made in decoupling economic growth from increased material and energetic consumption.
5. I have just had a great meeting with the treasury working out a plan to reduce income tax (again) and raise 'external cost' tax on goods.
6. We are proud to have helped our association member market individual hydrogen generation products that have matched individual wants for zero-carbon fuel at home for transport and heat.
7. I am so pleased that we finally got a fully fledged renewable hydrogen certificate scheme working and making a real difference to green hydrogen.
8. The world looks to the UK as the most successful green economy. We are all proud of where we are.
9. I'm feeling great about very positive feedback from our many international customers this month. They are asking us to replicate the UK's outstandingly successful example in deployment of low-carbon technologies.
10. Embedded carbon is at last properly valued and we are out-competing imported fossil fuel-based products.
11. I am feeling much more optimistic about the future of the planet today. I am reading a report that shows the carbon trading scheme has finally hit a point of global net carbon reductions. And thankfully, there are plenty of low-carbon technologies already tried and proven to meet our energy needs.
12. I'm very pleased with the sales figures on our portfolio of hydrogen fuelling stations this year. We made great profits on fuel sales and grid management services.

E. LOW-CARBON GENERATION

1. All power in the UK is produced with zero carbon emissions. We all live in clean, fresh air and enjoy warm summers with plenty of water.
2. Energy supply doesn't cause inter-regional political conflicts.
3. De-carbonised hydrogen is the low-cost fuel of choice for electricity generation because we made it more market-friendly by serving base to peak electricity and provided new business opportunities to see non-base hydrogen into transport, CHP and chemical markets, out-competing the incumbents for over 15% average demand in those areas.

4. We were just musing about how nice it has been over the past 20 years to have peace. No wars over oil are necessary, because everywhere you go, you can create your own low-carbon energy.
5. Wow – 100% renewable generation of electricity for the UK – who'd have thought that would happen 20 years ago! And we helped it happen.
6. I'm really pleased with the feasibility study we just completed for the new generating plant. Once again the renewable option was the 'no-brainer' winning option.

F. **GREEN EDUCATION**

1. We did a really good job in training the UK workforce to embrace hydrogen technology.
2. Our trade association members are regularly asked to input to education content at all levels with what green/low-carbon hydrogen has done and how it works.
3. Our kids today respect the environment! We made it 'cool'.
4. I am so pleased that the concept of 'green' is so universal that it is no longer a process of education.
5. Petrol cars are only encountered as museum displays.
6. You could stop someone in the street in UK, India, China, etc., and they could tell you what hydrogen is, does, and how it impacts their lives.
7. Now that everyone understands embedded carbon issues, we now have marketed truly zero-carbon products.
8. I had great fun judging a schools competition to design the next generation of hydrogen powered planes today. These kids really know their stuff!

G. **SUPPLY**

1. We all have enough power to live in warmth and comfort. Power is available 100% of the time for work and leisure.
2. I am really pleased that we overcame the 'chicken and egg' dilemma. We have a fully-fledged hydrogen refuelling infrastructure now.
3. My company has enabled low-carbon hydrogen to displace 20% of conventional fossil fuel-based hydrogen in industrial processes.
4. The availability of low-cost clean, green energy enables us to still live a good life! Without 'CO_2 guilt'.
5. Former developing countries have managed to harness their renewable resources and become peaceful, affluent exporters of high-value green energy products.
6. An ability to store energy means we can release it when we want it.
7. I am so excited! Today I bought a new H2FC vehicle and we both experienced refuelling. There are two hydrogen stations near us so we've spent the day showing off the car and experiencing centralised hydrogen fuelling. Of course, at our age, we probably won't be driving much so we will probably just do home refuelling most days.

H. **GLOBAL IMPACT**

1. GHG emissions are now falling. Thanks to the hydrogen energy systems that are being replicated globally.
2. CO_2 concentrations are below 400 ppm.
3. I'm so happy that hydrogen really makes a difference to developing economies because of what we did.
4. I am really pleased that our effort involving Chinese partners has meant that emerging (well they have emerged) markets have stopped increasing CO_2 outputs.
5. I now live in Africa where new towns have zero pollution, unlimited energy, and a happy and healthy population.

6. Back in 2008, we dreamed that the UK would be leader in hydrogen-based living. We did it!
7. I am honoured to be invited to present a keynote address at the World Hydrogen Energy Conference this spring on the UK's accomplishments in hydrogen. I may accept even though I am supposed to be retired, because I am so proud of how the UK Government, industry, academia, and RDAs all pulled together to put the UK at the top of the world. There is much that can be shared to help other countries achieve similar success.

The facilitator then asked the group – If you could have this future just as described, would we take it without reservation? The response was a resounding YES, definitely. Based on this agreement, we moved on to the next step.

STEP 2 – List your Achievements

Participants were then asked to pick a few of the descriptors and expand on them with specific, personal achievements. These achievements should be positive, express good feeling, be in the present tense, include people, and be subject to your own influence in some way. It should express what you REALLY want, not what is possible.

STEP 3 – Remembering Back – The Critical Path

Participants were then asked to look at the selected achievements, and describe at least one critical action or event that took place on the way – What was it and when was it?

As the workshop needed to be concluded in one day, participants picked only a few of the descriptors to expand on. There is scope to revisit further descriptors with additional stakeholders in the future. The United Kingdom Hydrogen Association welcomes opportunities to work with interested parties to expand on their areas of interest.

It is important to recognise that stakeholders have varying roles in implementing the actions envisaged by the workshop participants, and individual views on timeframes may vary. No attempt has yet been made to harmonise the individual results generated at the workshop. Rather, the raw data is provided as generated on the day. The UKHA plans to engage additional key stakeholders and expand on the results of this exercise to form the basis of a UK hydrogen roadmap, which will then involve identifying consensus on critical steps and timeframes.

CRITICAL PATHWAYS – ENERGY DIVERSITY

A1

Today: Stakeholders meet in Birmingham.

2011: The European Union, via the JTI adopted a more holistic approach to hydrogen production technologies following lobbying from the UK H2FC research grouping and the UKHA. Who was involved? N.ERG HY (UK), UKHA

2012: We lobbied the UK and EU governments, and the EU recognised full CO2 embedded certificates for own and imported goods and services. Implemented as an EU directive. Who was involved? Trade associations, UK government. NB: This action is also on the critical pathway for outcomes A3, A5, C2, C3, C5, C8, D3, D5, D6, D7, D8, E1, E3, E4, E5, E7, E10, G4, G5, H1, H3, and H4.

2015: Natural gas prices are up another 25% and oil topped $250/bl and is staying there. At the same time, hydrogen from renewable has become cost-competitive. Bio-hydrogen and electrolytic hydrogen are now realistic, cost-competitive technologies. Who was involved? UK H2 research community, spin out car and broader industry.

2022: External cost correction (ECC) currency unit was globally recognised, embedding carbon price, etc. Who was involved? Bryte Energy, UKHA, EU, UN, Trade Associations, CEOs, Government. NB: This action is also on the critical pathway for outcomes A3, A5, B1, B2, B3, B7, C1, C2, C3, C5, C8, D3, D4, D5, D6, D7, E1, E3, E4, E5, E10, F7, G4, G5, H1, H3, H4

2030: I'm really pleased that we generate hydrogen from so many different sources now.

A4

Today: Stakeholders meet in Birmingham.

2010: The first international set of standards for hydrogen vehicles allows normalisation of fuelling equipment worldwide. Who was involved? CEN, ISO, Governments. NB: This action is also on the critical pathway for outcome C11.

2030: I got a real buzz today when I tanked up my motorbike with 'rocket fuel'.

A5

Today: Stakeholders meet in Birmingham.

2009: We started the Pan-UK Hydrogen Project. Who was involved? All of us! NB: This action is also on the critical pathway for outcomes D12 and H3.

2009: Discussion with Government (and opposition) about external cost correction (ECC) – fiscal and trading mechanisms. Who was involved? Alastair, Bryte Energy, BMHF, Tom, UKHA, SHFCA. NB: This action is also on the critical pathway for outcomes D4, D5, D7, F7.

2010: Amidst recession, the UK launches 'Green New Deal' to refurbish power infrastructure around renewable fluctuation specifications. Who was involved? UK utilities, UK Government.

2012: We lobbied the UK and EU governments, and the EU recognised full CO2 embedded certificates for own and imported goods and services. Implemented as an EU directive. Who was involved? Trade associations, UK government. NB: This action is also on the critical pathway for outcomes A1, A3, C2, C3, C5, C8, D3, D5, D6, D7, D8, E1, E3, E4, E5, E7, E10, G4, G5, H1, H3, and H4.

2012: We helped the government launch the External Cost Correction (ECC) tax on products (with reduction in income tax and VAT). Who was involved? Alastair, Bryte Energy, BMHF, UKHA, etc. NB: This action is also on the critical pathway to outcomes D4, D5, D7, F7.

2022: External cost correction (ECC) currency unit was globally recognised, embedding carbon price, etc. Who was involved? Bryte Energy, BMHF, UKHA, EU, UN, Trade Associations, CEOs, Government. NB: This action is also on the critical pathway for outcomes A1, A3, B1, B2, B3, B7, C1, C2, C3, C5, C8, D3, D4, D5, D6, D7, E1, E3, E4, E5, E10, F7, G4, G5, H1, H3, H4

2030: It's great to see that we have developed cost effective ways of balancing energy supply and demand on the grid while simultaneously providing zero carbon transport (using hydrogen and battery-powered vehicles).

A7

Today: Stakeholders meet in Birmingham.

2017: Distributed generation becomes the norm. Homeowners and businesses connected to the grid as exporters, thanks to the adoption of safety standards we helped write. Who was involved? UKHA, BSI, HSE, ISO, Utilities, Renewable energy companies and associations.

2025: The last time a power cut was experienced – anywhere in the UK. Who was involved? UK Government, energy providers, public.

2030: We have no fear of power cuts – Risk is all but gone.

CRITICAL PATHWAYS - BUILDINGS

B1

Today: Stakeholders meet in Birmingham.

2010: Building codes, standards, and regulations incorporated clear guidelines on the use of hydrogen and fuel cells in

- New-build homes
- New-build commercial buildings
- Retro-fit to domestic and commercial premises

The UKHA led the way in doing the background work and education to make this happen. Who was involved? UKHA and BRE. NB: This action is also on the critical pathway for outcomes B3 and B8.

2010: Centrica installed its 1000th CH4 -> CHP domestic unit. Who was involved? Centrica, local authority.

2014: PV is so cheap that my house and office have it (and it makes good commercial sense). Who was involved? Bryte Energy. NB: This action is also on the critical pathway for outcomes B2 and B3.

2022: External cost correction (ECC) currency unit was globally recognised, embedding carbon price, etc. Who was involved? Bryte Energy, BMHF, UKHA, EU, UN, Trade Associations, CEOs, Government. NB: This action is also on the critical pathway for outcomes A1, A3, A5, B2, B3, B7, C1, C2, C3, C5, C8, D3, D4, D5, D6, D7, E1, E3, E4, E5, E10, F7, G4, G5, H1, H3, H4

2030: We have got 50% of housing stock zero-carbon – great!

B3

Today: Stakeholders meet in Birmingham.

2010: Building codes, standards, and regulations incorporated clear guidelines on the use of hydrogen and fuel cells in

- New-build homes
- New-build commercial buildings
- Retro-fit to domestic and commercial premises

The UKHA led the way in doing the background work and education to make this happen. Who was involved? UKHA and BRE. NB: This action is also on the critical pathway for outcomes B1 and B8.

2012: I ‘sold’ energy to my next-door neighbour. My bills are much lower.

2014: PV is so cheap that my house and office have it (and it makes good commercial sense). Who was involved? Bryte Energy. NB: This action is also on the critical pathway for outcomes B1 and B2.

2022: External cost correction (ECC) currency unit was globally recognised, embedding carbon price, etc. Who was involved? Bryte Energy, BMHF, UKHA, EU, UN, Trade Associations, CEOs, Government. NB: This action is also on the critical pathway for outcomes A1, A3, A5, B1, B2, B7, C1, C2, C3, C5, C8, D3, D4, D5, D6, D7, E1, E3, E4, E5, E10, F7, G4, G5, H1, H3, H4

2030: The buildings I work in export green energy to their neighbours.

B7

Today: Stakeholders meet in Birmingham.

2011: My company secured a large consultancy contract for a zero-carbon housing development. This is the first time we have done this. Who was involved: local government, architects, RDA, BBC.

2022: External cost correction (ECC) currency unit was globally recognised, embedding carbon price, etc. Who was involved? Bryte Energy, BMHF, UKHA, EU, UN, Trade Associations, CEOs, Government. NB: This action is also on the critical pathway for outcomes A1, A3, A5, B1, B2, B3, C1, C2, C3, C5, C8, D3, D4, D5, D6, D7, E1, E3, E4, E5, E10, F7, G4, G5, H1, H3, H4

2030: The company I work for was an early mover towards zero-carbon buildings. It’s great to work for such a forward-looking business.

B8

Today: Stakeholders meet in Birmingham.

2010: Building codes, standards, and regulations incorporated clear guidelines on the use of hydrogen and fuel cells in

- New-build homes
- New-build commercial buildings
- Retro-fit to domestic and commercial premises

The UKHA led the way in doing the background work and education to make this happen. Who was involved? UKHA and BRE. NB: This action is also on the critical pathway for outcomes B1 and B3.

2012: UK adopts regulations for low-carbon affordable homes. We completed a series of domestic demonstrations, showing how renewable, hydrogen, and fuel cells can work together, and drafted appropriate legislation to make it possible for most families to afford

low-carbon homes. Who was involved? UKHA, SHFCA, UK industry, regulators. NB: This action is also on the critical pathway for outcome B5.

2015: We incorporated hydrogen procedures (Best-practice guidance) in building BREAM scheme run by the Building Research Establishment (BRE). Who was involved? UKHA members, BRE.

2030: Great – we've really made a difference by introducing hydrogen as a viable fuel for building heat, power, and cooling.

CRITICAL PATHWAYS - TRANSPORT

C1

Today: Stakeholders meet in Birmingham.

2009: We implemented the UK's first fuel cell forklift truck application. Who was involved? Bryte Energy, Cenex, BMHF, logistics companies.

2010: Positive incentives were put in place for hydrogen internal combustion engines (ICEs) as well as hydrogen FCV developments, following a positive demonstration of the emissions and cost benefits from hydrogen ICE vehicles. Who was involved? Cenex, various UK universities and automotive manufacturers.

2010: We start using hydrogen-powered vehicles at an airport. Who was involved? Bryte Energy, Cenex, BMHF, airport, RDAs.

2010: I drive an H2-fuelled car – regularly! Who was involved? Bryte Energy, BMHF.

2016: I filled up my car with hydrogen for the first time ever.

NB: At first glance, these last two may seem inconsistent, however, it is quite likely (perhaps even necessary) that early adopters will be driving hydrogen vehicles regularly long before the general public is able to purchase them.

2018: We finally convinced them! The UK government made a bold step in making zero-carbon vehicles a priority policy. Having ramped up duty on polluting vehicles, they finally decided to prohibit CO2 exhaust emissions from all new vehicles. Who was involved? UKHA, together with a broader coalition of associations. NB: This action is also on the critical pathway for outcomes C2 and C8.

2022: External cost correction (ECC) currency unit was globally recognised, embedding carbon price, etc. Who was involved? Bryte Energy, BMHF, UKHA, EU, UN, Trade Associations, CEOs, Government. NB: This action is also on the critical pathway for outcomes A1, A3, A5, B1, B2, B3, B7, C2, C3, C5, C8, D3, D4, D5, D6, D7, E1, E3, E4, E5, E10, F7, G4, G5, H1, H3, H4

2030: Isn't it great that most cars bought today now run on hydrogen?

C2

Today: Stakeholders meet in Birmingham.

2011: 100th fuelled fork-lift enters service in UK logistics. Who was involved? RDAs, hydrogen associations, industry.

2012: We lobbied the UK and EU governments, and the EU recognised full CO2 embedded certificates for own and imported goods and services. Implemented as an EU directive. Who was involved? Trade associations, UK government. NB: This action is also on the critical pathway for outcomes A1, A3, A5, C3, C5, C8, D3, D5, D6, D7, D8, E1, E3, E4, E5, E7, E10, G4, G5, H1, H3, and H4.

2013: The UK hydrogen highway project was completed today. This was a bold step to create 50 strategically located hydrogen refuelling stations (70% renewable hydrogen) across England, Scotland and Wales. Who was involved? A coalition involving: Yorkshire, Teesside, Scotland, Wales (key players from each region), London, East and West Midlands – supported by the UK Government, regional governments and assemblies. NB: This action is also on the critical pathway for outcomes G2 and C11.

2016: An energy converter sells green hydrogen competitively against natural gas. Who was involved? My company. NB: This action is also on the critical pathway for outcomes A6, D8, D9, D12, E3, E5, G2, G3, G4, G5, H4.

2018: We finally convinced them! The UK government made a bold step in making zero-carbon vehicles a priority policy. Having ramped up duty on polluting vehicles, they finally decided to prohibit CO2 exhaust emissions from all new vehicles. Who was involved? UKHA, together with a broader coalition of associations. NB: This action is also on the critical pathway for outcomes C1 and C8.

2022: External cost correction (ECC) currency unit was globally recognised, embedding carbon price, etc. Who was involved? Bryte Energy, BMHF, UKHA, EU, UN, Trade Associations, CEOs, Government. NB: This action is also on the critical pathway for outcomes A1, A3, A5, B1, B2, B3, B7, C1, C3, C5, C8, D3, D4, D5, D6, D7, E1, E3, E4, E5, E10, F7, G4, G5, H1, H3, H4

2030: Isn’t it great that most cars bought today now run on hydrogen? Better still, it’s green hydrogen.

C3

Today: Stakeholders meet in Birmingham.

2012: We lobbied the UK and EU governments, and the EU recognised full CO2 embedded certificates for own and imported goods and services. Implemented as an EU directive. Who was involved? Trade associations, UK government. NB: This action is also on the critical pathway for outcomes A1, A3, A5, C2, C5, C8, D3, D5, D6, D7, D8, E1, E3, E4, E5, E7, E10, G4, G5, H1, H3, and H4.

2012: First commercial flight on a 50% bioaviation fuel. Our investment in pilot scale biorefining allowed process to happen. Who was involved? RDAs, industry, CAA.

2022: External cost correction (ECC) currency unit was globally recognised, embedding carbon price, etc. Who was involved? Bryte Energy, BMHF, UKHA, EU, UN, Trade Associations, CEOs, Government. NB: This action is also on the critical pathway for outcomes A1, A3, A5, B1, B2, B3, B7, C1, C2, C5, C8, D3, D4, D5, D6, D7, E1, E3, E4, E5, E10, F7, G4, G5, H1, H3, H4

2030: I've just had a great holiday in the Caribbean. It was quite cheap because the carbon-tax was so low as we were on a low-carbon flight.

C11

Today: Stakeholders meet in Birmingham.

2008 – 2015: Hydrogen refuelling stations were opened up across the UK to service commercial fleets to begin with. Who was involved? RMT, universities, industrial gas companies.

2009: First hydrogen station opened in Scotland in Stornoway, Outer Hebrides. Who was involved? W.I. Council, Air Products, SHFCA.

2010: The first international set of standards for hydrogen vehicles allows normalisation of fuelling equipment worldwide. Who was involved? CEN, ISO, Governments. NB: This action is also on the critical pathway for outcome A4.

2013: The UK hydrogen highway project was completed today. This was a bold step to create 50 strategically located hydrogen refuelling stations (70% renewable hydrogen) across England, Scotland and Wales. Who was involved? A coalition involving: Yorkshire, Teesside, Scotland, Wales (key players from each region), London, East and West Midlands – supported by the UK Government, regional governments and assemblies. NB: This action is also on the critical pathway for outcomes C2 and G2.

2020: We opened the 20th hydrogen refuelling station in the East Midlands. Who was involved? Bryte Energy, BMHF, EMDA, Cenex.

2025: Today the first 4th generation nuclear started to commission its thermonuclear cracker to generate hydrogen. Who was involved? UKAEA, EBF, NIA, RDA.

2030: Individual production at home and work

CRITICAL PATHWAYS – GREEN ECONOMY

D1

Today: Stakeholders meet in Birmingham.

2015: Landfill tax allowance scheme tightened to include more stringent penalties. Who was involved? The waste sector, government, local authorities.

2030: I am delighted that now nothing goes to landfill.

D7

Today: Stakeholders meet in Birmingham.

2009: Discussion with Government (and opposition) about external cost correction (ECC) – fiscal and trading mechanisms. Who was involved? Alastair, Bryte Energy, BMHF, Tom, UKHA, SHFCA. NB: This action is also on the critical pathway for outcomes D4, D5, A5, F7.

2009: World leaders at Copenhagen agreed on the need for a Global Carbon Price traded across sectors and countries. Who was involved? World governments, business, NGOs.

2012: We helped the government launch the External Cost Correction (ECC) tax on products (with reduction in income tax and VAT). Who was involved? Alastair, Bryte Energy, BMHF, UKHA, etc. NB: This action is also on the critical pathway to outcomes A5, D4, D5, F7.

2012: Renewable hydrogen 'ROCs' introduced. UK Government and industry – Scotland led. Who was involved? Trade associations.

2012: We lobbied the UK and EU governments, and the EU recognised full CO2 embedded certificates for own and imported goods and services. Implemented as an EU directive. Who was involved? Trade associations, UK government. NB: This action is also on the critical pathway for outcomes A1, A3, A5, C2, C3, C5, C8, D3, D5, D6, D8, E1, E3, E4, E5, E7, E10, G4, G5, H1, H3, and H4.

2018: The UK energy system has so much renewable generation that it now needs hydrogen. We commissioned the first commercial grid balancing hydrogen production unit. Who was involved? Bryte Energy, BMHF, UKHA. NB: This action is also on the critical pathway for outcomes D2, D3, D12, E1, E3, E5, E6, G3, G4, G5, H1, H4, H6, H7.

2022: External cost correction (ECC) currency unit was globally recognised, embedding carbon price, etc. Who was involved? Bryte Energy, BMHF, UKHA, EU, UN, Trade Associations, CEOs, Government. NB: This action is also on the critical pathway for outcomes A1, A3, A5, B1, B2, B3, B7, C1, C2, C3, C5, C8, D3, D4, D5, D6, E1, E3, E4, E5, E10, F7, G4, G5, H1, H3, H4

2030: I am so pleased that we finally got a fully fledged renewable hydrogen certificate scheme working and making a real difference to green hydrogen.

D8

Today: Stakeholders meet in Birmingham.

2012: We lobbied the UK and EU governments, and the EU recognised full CO2 embedded certificates for own and imported goods and services. Implemented as an EU directive. Who was involved? Trade associations, UK government. NB: This action is also on the critical pathway for outcomes A1, A3, A5, C2, C3, C5, C8, D3, D5, D6, D7, E1, E3, E4, E5, E7, E10, G4, G5, H1, H3, and H4.

2016: An energy converter sells green hydrogen competitively against natural gas. Who was involved? My company. NB: This action is also on the critical pathway for outcomes A6, C2, D9, D12, E3, E5, G2, G3, G4, G5, H4.

2018: The UK was the leading EU country in GHG reduction and renewable deployment, being the first to reach its GHG and renewable objectives set by the EU in 2008 for 2020. Who was involved? UK government, EU.

2018: China awarded the UK the biggest contract ever – to transform the Chinese economy to the UK's 'green' system.

2020: Building on the UK's overachievement on EU targets for GHG and renewable, objectives of -80% GHG vs. 1990 are confirmed unconditionally with tentative 100% targets. Who was involved? UK energy sector, UK government.

2030: The world looks to the UK as the most successful green economy. We are all proud of where we are.

CRITICAL PATHWAYS - LOW-CARBON GENERATION

E5

Today: Stakeholders meet in Birmingham.

2012: Utilities realised that fossil-fuelled power generation simply was no longer an option -> made uneconomic by ROCs and carbon permits/taxes. Who was involved? EU, UK government. NB: This action is also on the critical pathway for outcome E1.

2015: First major tidal farm commissioned. First new UK nuclear started to commission. Who was involved? DECC, RDAs, industry.

2016: An energy converter sells green hydrogen competitively against natural gas. Who was involved? My company. NB: This action is also on the critical pathway for outcomes A6, C2, D8, D9, D12, E3, G2, G3, G4, G5, H4.

2018: The UK energy system has so much renewable generation that it now needs hydrogen. We commissioned the first commercial grid balancing hydrogen production unit. Who was involved? Bryte Energy, BMHF, UKHA. NB: This action is also on the critical pathway for outcomes D2, D3, D7, D12, E1, E3, E6, G3, G4, G5, H1, H4, H6, H7.

2020: Having seen what renewable could achieve and the fact that 2050 targets in GHG reductions are possible, the UK Government made a firm commitment to renewable, which allowed 20% of UK electricity to be produced from renewable by the end of 2020. Who was involved? UK government, G8, UN, renewable energy companies and associations.

2030: Wow – 100% renewable generation of electricity for the UK – who'd have thought that would happen 20 years ago! And we helped it happen.

CRITICAL PATHWAYS – GREEN EDUCATION

F1

Today: Stakeholders meet in Birmingham.

2011: Concerted action between the FE colleges, sector skills councils, Universities, and approval bodies agreed the content, delivery methods and standards for various hydrogen and fuel cell competency certification schemes. Who was involved? Sector skills councils, UKHA – Education Group.

2020: Plan implemented for embracing hydrogen in the 'skills for energy' initiatives that was led by a number of universities and linked first to the further education (17 years old) and sector (5 x Apprentice). Who was involved? UKHA, the RDAs, UKERC and the Technology Strategy Board.

2030: We did a really good job in training the UK workforce to embrace hydrogen technology.

F4

Today: Stakeholders meet in Birmingham.

2020: Our success in proving low-carbon technologies convinced the UK Government to adopt these as the default. Young school students now take this for granted, as we once took coal and petrol for granted. Who was involved: UKHA, UK regions, RDAs, education Ministers, UK Government.

2030: I am so pleased that the concept of ‘green’ is so universal that it is no longer a process of education.

F5

Today: Stakeholders meet in Birmingham.

2028: Last petrol car rolls off the production line. Who was involved? Government, car makers.

2030: UK hydrogen highway is completed for all road vehicles.

2030: Petrol cars are only encountered as museum displays.

CRITICAL PATHWAYS - SUPPLY

G2

Today: Stakeholders meet in Birmingham.

2013: The UK hydrogen highway project was completed today. This was a bold step to create 50 strategically located hydrogen refuelling stations (70% renewable hydrogen) across England, Scotland and Wales. Who was involved? A coalition involving: Yorkshire, Teesside, Scotland, Wales (key players from each region), London, East and West Midlands – supported by the UK Government, regional governments and assemblies. NB: This action is also on the critical pathway for outcomes C2 and C11.

2016: An energy converter sells green hydrogen competitively against natural gas. Who was involved? My company. NB: This action is also on the critical pathway for outcomes A6, C2, D8, D9, D12, E3, E5, G3, G4, G5, H4.

2030: I am really pleased that we overcame the ‘chicken and egg’ dilemma. We have a fully-fledged hydrogen refuelling infrastructure now.

G7

Today: Stakeholders meet in Birmingham.

2015: The regional hydrogen group (us) agreed to a plan to establish a roll-out of hydrogen stations and then proposed to Mercedes et al to guarantee demand (via controlled public procurement) for 10+ vehicles per station per year. This created confidence in the process. Who was involved? UK RDAs and industry partners, Cenex, etc.

2030: I am so excited! Today I bought a new H2FC vehicle and we both experienced refuelling. There are two hydrogen stations near us so we’ve spent the day showing off the car and experiencing centralised hydrogen fuelling. Of course, at our age, we probably won’t be driving much so we will probably just do home refuelling most days.

CRITICAL PATHWAYS – GLOBAL IMPACT

H4

Today: Stakeholders meet in Birmingham.

2012: China is pushed by the international community to integrate climate in its policies – forcing it out of its 'grow now, clean up later' stance. Who was involved? UN, US Government, EU, UK Government.

2012: We lobbied the UK and EU governments, and the EU recognised full CO2 embedded certificates for own and imported goods and services. Implemented as an EU directive. Who was involved? Trade associations, UK government. NB: This action is also on the critical pathway for outcomes A1, A3, A5, C1, C3, C5, C8, D3, D5, D6, D7, D8, E1, E3, E4, E5, E7, E10, G4, G5, H1, H3.

2015: China and India introduced carbon credit and trading scheme for 40% of their CO2 emissions. We helped our Chinese partners see how this creates medium and long-term value. Who was involved? The UK Government, business/legal/trading.

2016: An energy converter sells green hydrogen competitively against natural gas. Who was involved? My company. NB: This action is also on the critical pathway for outcomes A6, C2, D8, D9, D12, E3, E5, G2, G3, G4, G5.

2018: The UK energy system has so much renewable generation that it now needs hydrogen. We commissioned the first commercial grid balancing hydrogen production unit. Who was involved? Bryte Energy, BMHF, UKHA. NB: This action is also on the critical pathway for outcomes D2, D3, D7, D12, E1, E3, E5, E6, G3, G4, G5, H1, H6, H7.

2020: The International Partnership for a Hydrogen Economy, involving the EU H2FC Platform, established best practice guidance (as per European Commission questions JRC in Seville) including standards for hydrogen energy systems that encouraged developing replicable solutions (off the shelf) for implementation. Who was involved? UKHA lobbied UK Government to press IPHE (JTI). NB: This action is also on the critical pathway for outcome H1.

2022: External cost correction (ECC) currency unit was globally recognised, embedding carbon price, etc. Who was involved? Bryte Energy, BMHF, UKHA, EU, UN, Trade Associations, CEOs, Government. NB: This action is also on the critical pathway for outcomes A1, A3, A5, B1, B2, B3, B7, C1, C2, C3, C5, C8, D3, D4, D5, D6, D7, E1, E3, E4, E5, E10, F7, G4, G5, H1, H3

2030: I am really pleased that our effort involving Chinese partners has meant that emerging (well they have emerged) markets have stopped increasing CO2 outputs.

H6

Today: Stakeholders meet in Birmingham.

2015: Glasgow airport became the first zero-carbon airport in the world. Who was involved? BAA Scotland, commercial partners.

2015: Royal Mail Group achieved 50% carbon footprint reduction in both transport and buildings. Who was involved? RMG and partners.

2018: The UK energy system has so much renewable generation that it now needs hydrogen. We commissioned the first commercial grid balancing hydrogen production unit. Who was involved? Bryte Energy, BMHF, UKHA. NB: This action is also on the critical pathway for outcomes D2, D3, D7, D12, E1, E3, E5, E6, G3, G4, G5, H1, H4, H6, H7.

2030: Back in 2008, we dreamed that the UK would be leader in hydrogen-based living. We did it!

WRAP-UP AND NEXT STEPS:

The workshop demonstrated that the regional and UK-wide hydrogen and fuel cell stakeholder groups have much in common with respect to objectives and desired outcomes. In addition, we identified the opportunity to work together on UK-wide projects, linking up the activities already planned for the regions. One key example of where this could occur is with Royal Mail. Partners in Scotland are already working to demonstrate RMG fleet vehicles in distribution facilities. There is a real opportunity to overlay planned activities in other regions with locations of RMG distribution facilities UK-wide. By so doing, synergies for fuel infrastructure and hardware purchases may be found, resulting in a favourable situation for planned regional activities, as well as the ability to roll out hydrogen technologies across the UK in managed, captive fleets of the Royal Mail Group. Follow-up on this, as well as other opportunities, is required.

A map of the UK was tabled that showed the existing clusters of hydrogen and fuel cell activities and the potential for linking them via 'hydrogen highways' to create a UK-wide network or integrated project. Features of the proposed project include:

- Hydrogen highways to "join the dots" between existing clusters
- Support activities that
  - strengthen clusters
  - link clusters (along H_2 highways)
  - justifiably create new clusters
  - use arterial routes
- Joint procurement
- Coordinated actions
- Shared brand
  - Greater than the sum of its parts
- Allow continued regional autonomy

The activity also enabled participants to appreciate their role in achieving the future described during the workshop. The desired future is within our reach and we have already begun the process.

Additional stakeholders are encouraged to build upon the work achieved during the workshop. The UKHA will work with stakeholders who were unable to participate in this workshop and integrate any additional headlines and achievements. We also encourage all participants from the Workshop to use the experience to work with their stakeholders to advance common objectives.

The UKHA will then integrate the outcomes into a UK Hydrogen & Fuel Cell Roadmap, describing the following:

- The consensus description of the future;
- Stakeholders that buy into the proposed future;
- What is in the plan that stakeholders already have or are doing;
- Actions that can be taken immediately;
- What could possibly stop these actions from taking place; and
- How the actions could be resourced and a description of the resources required.

Outreach for portraying the success story: The resulting UK Hydrogen & Fuel Cell Roadmap will be made available to all interested stakeholders and the public. This will be used to advance discussions with funding organisations and input into industry planning activities in order to achieve the results described in the Roadmap. Successes will be highlighted in press releases, conference presentations and news articles to achieve continued momentum.

Conclusion:

The workshop was like the magnet that will pull together the independent regional strengths to create something larger and stronger. It enabled all the regional stakeholders to cease thinking of other regions as competitors and start recognising the synergies and opportunities. The whole really can become greater than the sum of its parts. The UKHA looks forward to continuing this journey with all the stakeholders.