



Quality Measurement Issues in a Hydrogen Economy

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Net Zero 2050

- **Natural gas** will remain an important energy source in the transition to renewables
 - Cleanest burning fossil fuel
 - Flexible – support renewable sources
- **Electricity** sector has seen significant reduction in emissions compared to 1990 levels
- **Heating** still relies on natural gas
- **Transport** sector fuel oil alternatives: batteries vs. fuel cells

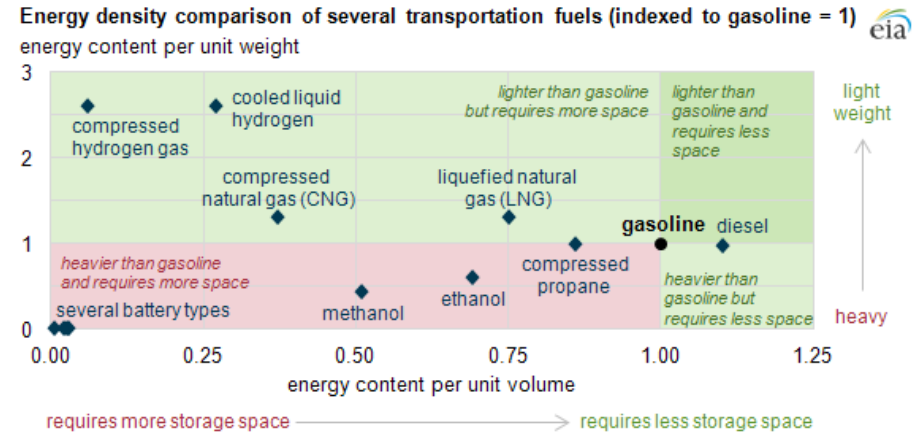


Why Hydrogen?

- Hydrogen is a potential zero carbon energy source
- Produces only water when burned



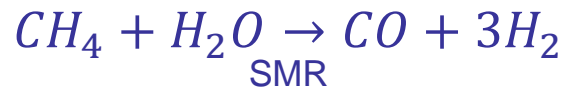
- High mass energy density (but low volume energy density)
- Most abundant element in the universe... but not on Earth
- Requires production from raw materials



Hydrogen Production

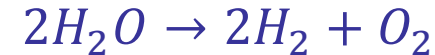
Steam Methane Reforming (SMR)

- Accounts for >95% production
- Uses natural gas as feedstock
- High energy requirements
- CCS required
- “Blue” hydrogen



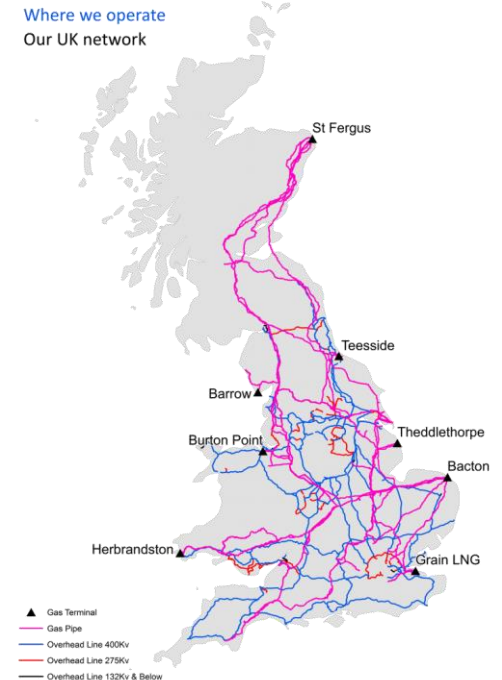
Electrolysis

- H₂ production from water
- “Green” hydrogen *if* electricity generated from renewables
- Otherwise “blue” hydrogen



Hydrogen Utilisation: Gas networks

- The UK gas network supplies around 80% of homes
- Businesses and industry also use the network
- Hydrogen can help decarbonise the gas network



Hydrogen Utilisation: Gas networks

HyDeploy

- Keele University campus gas network
- Up to 20 vol% hydrogen blend
- On site electrolysers
- Next phases – public gas networks in NE and NW England
- Using 20 vol% hydrogen across the UK would be equivalent of taking 2.5 million cars off the road



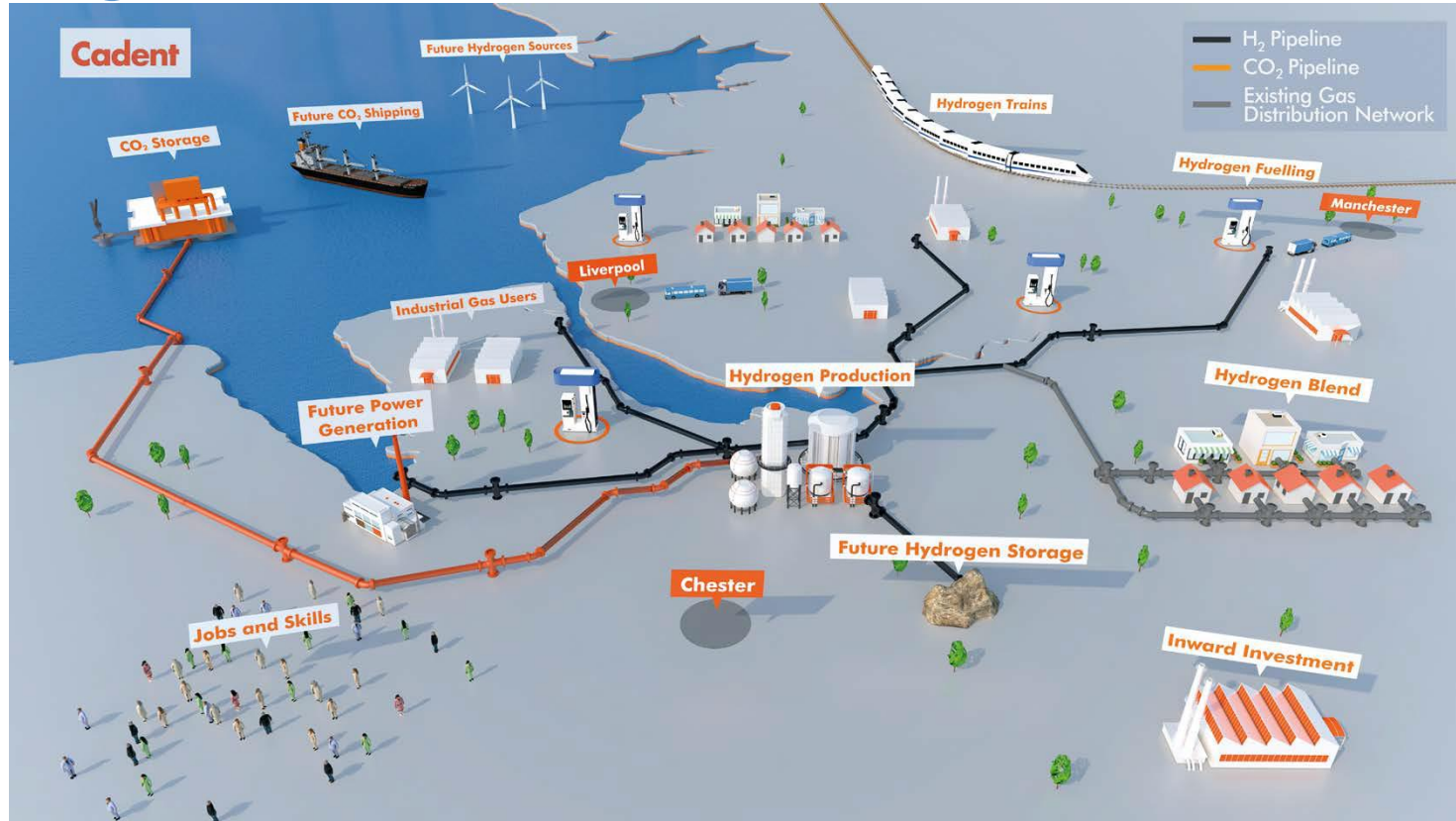
Hydrogen Utilisation: Gas networks

HyNet

- New network in NW England
- Hydrogen production from SMR
- New pipelines for CCS
- Hydrogen used for power generation, transport fuel, residential (blended with natural gas)

**HyNet**

Hydrogen Utilisation: Gas networks



Hydrogen Utilisation: Gas networks

Measurement Challenges

- Composition of the gas is required
 - Physical properties e.g. density, Calorific Value, Wobbe Index
 - Financial
 - H&S
 - Appliance specification
- Measured using Gas Chromatography
 - Separation of components in column (stationary phase)
 - Mobile phase: carrier gas – normally helium
 - Separated components passed over detector e.g. TCD, FID

Hydrogen Utilisation: Gas networks

Measurement Challenges

- Helium is the preferred carrier gas for GC-TCD
 - Inert, only trace component in natural gas
 - High thermal conductivity vs natural gas components
 - Hydrogen has similar TC to helium – detection sensitivity will be low
- Can we modify the existing measurement infrastructure and avoid replacing all process instruments?
- EffecTech have done some preliminary studies on alternative carrier gases

Hydrogen Utilisation: Gas networks

Measurement Challenges

Argon

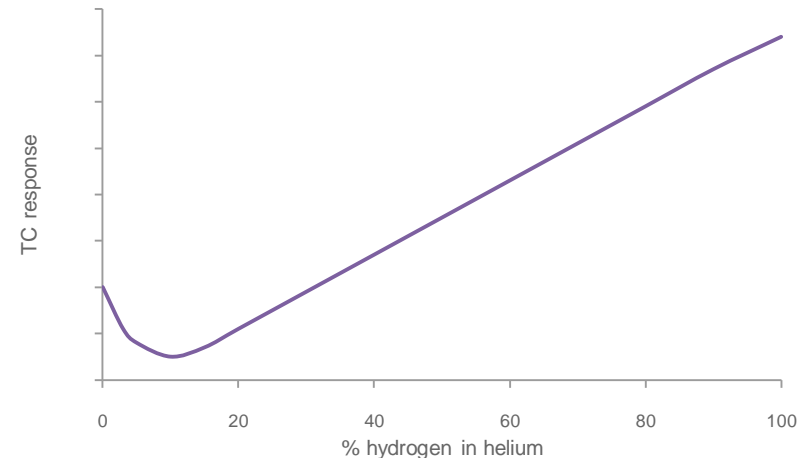
- Inert, low TC. So good for hydrogen but not other natural gas components!
- Use one instrument with He for all components except hydrogen
- Use a separate instrument with Ar for hydrogen measurement. Doubles the number of instruments required

Hydrogen Utilisation: Gas networks

Measurement Challenges

Mixed carrier gas: He/H₂

- Response is not linear with hydrogen content in the helium
- 20% hydrogen was found to be satisfactory
- False hydrogen peak occurred where no hydrogen was present
 - Could be compensated through calibration



Hydrogen Utilisation: Transport Fuel

Fuel Cell Electric Vehicles

- Zero tailpipe emissions
- Quick refuelling
- Very pure hydrogen required



Hydrogen Utilisation: Transport Fuel

ISO 14687-2:2012

Hydrogen fuel — Product specification
— Part 2: Proton exchange membrane
(PEM) fuel cell applications for road
vehicles

Impurity	Amount fraction (ppm)
Helium	300
Nitrogen	100
Argon	100
Water	5
Oxygen	5
Carbon dioxide	2
Total hydrocarbons	2
Formic acid	0.2
Carbon monoxide	0.2
Ammonia	0.1
Total halogenated	0.05
Formaldehyde	0.01
Total sulphur	0.004

Hydrogen Utilisation: Transport Fuel

Hydrogen Purity Measurement Challenges

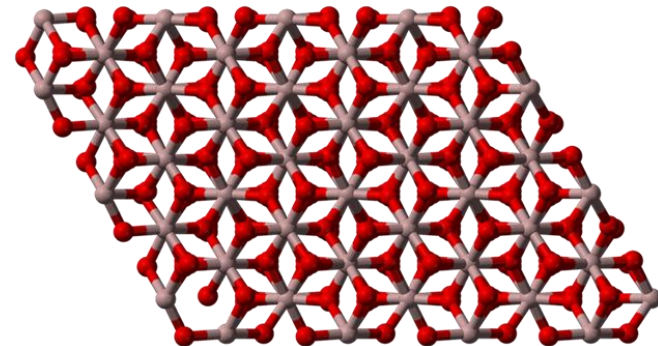
- Analytical laboratories must have the capability to measure low levels
- Multiple methods required to measure all impurities
- Reference materials
 - Need to manufacture verified gas mixtures with low amounts
 - Reference gas cylinders and sample storage – reactive species can adsorb to surface

Hydrogen Utilisation: Transport Fuel

Hydrogen Purity Measurement Challenges

Cylinder Passivation

- Treating the inner surface of a cylinder or sample vessel to reduce the adsorption
- Metal surface contains cavities where reactive components preferentially bind
- Aluminium surface has oxidised layer
- Reactive components may also react
- Passivation “fills in” these cavities
 - Reduces surface area
 - Reduces surface activity / energy



Hydrogen Utilisation: Transport Fuel

Hydrogen Purity Measurement Challenges

Cylinder Treatments

- Electropolishing
- Silicon coatings
- Polymer coatings

- EffecTech's Performax™ treatment uses an inactive polymer which targets the surface structures at the nanometer range
 - Shows promise for several species listed in ISO 14687

Hydrogen Utilisation: Transport Fuel

Hydrogen Purity Measurement Challenges

Further Work

- Optimise treatment process – repeatability, speed / volume, analysis
- Surface analysis – SEM etc.
- Extend to more compounds relevant to hydrogen purity
- Long term mixture stability
- Other sampling components?
 - Valves
 - Tubing

Hydrogen Measurement Issues: Summary

Hydrogen in the Gas Network

- Current process GCs aren't set up to measure hydrogen
- A mixed carrier gas of hydrogen and helium could be used
- Build on preliminary studies into mixed carrier gases

Hydrogen Measurement Issues: Summary

Hydrogen Purity for FCEVs

- High purity hydrogen is required for FCEVs
- Accurate analysis of samples and reference materials for impurities requires treatment of vessel surfaces
- EffecTech is looking to develop and improve the Performax treatment




Thank you for listening



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