Decarbonising heat: the potential for steam methane reforming as an enabling technology

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Solving complex problems across the group with world class chemistry

Materials characterisation and testing

PGM chemistry and metallurgy

Material design and engineering

Surface chemistry

and its application

Provision of customised solutions

Development of new and next-generation products

Scale-up of complex manufacturing
Opportunities to Apply our Expertise Across a Range of Emission Control and Decarbonisation Related Technologies

Vehicle Emissions Control

Renewable Fuels

Batteries

Hydrogen/Syngas Generation

Fuel Cells

Solar
Decarbonisation of the Energy Sector

Historically siloed energy vectors are all being disrupted.

- Power has been first sector to undergo change.
  - Wind
  - Solar
- Transportation is starting to follow
  - Hybrid and Electric Vehicles
  - Biofuels
- Heat is far behind, yet is the largest source of GHG emissions
Drivers for Decarbonisation
Lessons learned from Power and Transport

Outcome – a move away from the use of fossil fuels for energy generation.

Drivers
- Climate Change
- Air Quality
- Energy Security
- Cost
- Disruptor organisations
- New opportunities

Power (non Heat)
Good Progress
Accelerating Take Up
Disruptive
Wind cost competitive

Initially driven by climate change considerations and subsidy – but other factors have come in to accelerate transition.

Transportation
Ethanol and biodiesel - politically driven. Subsidy based and has been a rocky road. Relatively low capital intensity compared to other options.

Electrification trend more driven by efficiency and air quality considerations. Political influence playing part

Increasingly disruptive, but earlier stages. Still lots to do technically and uncertain landscape.
If We Do Want to Decarbonise Heat What are the Options.

**Heat Pumps**
+ve – small incremental cost  
-ve – cost of electrical infrastructure to deal with winter demand prohibitive. Will be part of solution for off-grid homes.

**Hydrogen**
+ve – current gas grid has large capacity and connected to 85% of homes. Increase in H₂ content could be staged for low concentrations.  
-ve – large infrastructure cost to achieve sufficient GHG savings

**BioSNG**
+ve – same fuel as currently used  
-ve – large capital cost of building sufficient capacity to supply enough gas to make a difference.

**Heating Networks**
+ve – very efficient  
-ve – best implemented for new builds and needs to be part of planning scheme.
Current Activities Focussed on Decarbonising Heat Using Hydrogen

Leeds City Gate
Feasibility study looking at converting Leeds to run on 100% Hydrogen. Whole system analysis. Hydrogen generated by 4 SMRs. CCS offshore.

The Liverpool – Manchester Hydrogen Cluster
Feasibility study for 20% Hydrogen blend with CCS offshore. Hydrogen to come from SMRs.

Magnum - Holland
Feasibility study to consider the conversion of Vattenfall Natural Gas power plant to run on hydrogen. Pre-combustion CCS.

HyDeploy
0.5MW Electrolyser to be deployed at Keele University to carry out live trials of blending Hydrogen into Natural Gas in private grid.
Current Electricity Grid Isn’t Going to Cope with Demands of Heat

Chart 36: Comparison of heat and electricity demand variability across a year (domestic and commercial) – 2010

Source: Courtesy of Imperial College. For illustrative purposes only and based on actual half-hourly electricity demand from National Grid and an estimate of half-hourly heat demand.
JM in Hydrogen

- Technology licensor – large SMRs and novel reforming technologies.
- SMR catalyst manufacturer inc.
  state of the art coated structures
- Manufacturer of membrane electrode assemblies for low temperature fuel cells
- Manufacturer of reforming catalysts for stationary fuel cells
Challenges to Decarbonise Heat

The only driver for decarbonising heat is climate change.

- Earlier attempts to use EOR to bankroll demonstration didn’t workout.
- Progress solely around CO2 reduction is hard to bank to any significant degree
- Need long-term commercial viability to fund
- Worth looking at what is needed to manage risk of large capital projects – who takes the risk and how to mitigate
- Good work around UK grid – Good example of how to progress the derisking process

However boundaries are now blurring, with significant overlap between energy vectors meaning solutions often overlap or rely on and/or can be boosted by progress in other areas.
Steam Methane Reformers

- An SMR is an integral part of many methanol and ammonia plants as well as providing hydrogen to refineries for the removal of sulphur from crude.
- Approximately 30,000MMSCFD of $H_2$ are produced by SMRs annually.
- There are a number of different designs of SMR.
- The steam generated by the process is often of high value and exported as a product and the process is highly optimised.
Steam reformers come in different shapes and size

M5000 - Trinidad
- 864 tubes
- 157 m³ reformer catalyst
- 16.6 m³ pre-reformer catalyst
- 63 m³ purification
- 539 m³ methanol

Hydro-Chem
- 12 tubes
- Bucket full of reformer catalyst
- 14 * 18 m plot
Advanced Steam Reforming – Autothermal Reforming

- Proven at large scale
- High Oxygen utilisation
- Lower methane slip than SMR
- All CO$_2$ at process pressure so reduces size of CO$_2$ removal equipment
Advanced Steam Reforming – Gas Heated Reformer

- Low methane in product gas which lowers CO$_2$ emissions
- Low CO slip exit shift which lowers CO$_2$ emissions
- CO$_2$ captured from process at pressure so CO$_2$ removal system is well proven and cheap

- Proven at scale in Methanol
- Advantageous to couple with Renewable Electricity generation as no steam is generated.
Steam Reforming with CCS has been Demonstrated at Scale

SMR + CCS – Air Products Port Arthur

2 SMRs on Valero Refinery produce 925,000 tonnes CO2/year
90% CO$_2$ capture
Total Project: $431 Million
DOE $284 Million
Operation: PA-1 Mar 2013, PA-2 Dec 2012
FEED complete: Nov 2010
Construction: Dec 2012
1 MTPA of CO$_2$ – exported for EOR
UK is Advantaged Location for CCS
Risk Management

- No shortage of money
- These are capital intensive projects to hit any significant capacity

Since these technologies cross traditional boundaries, consortium building is increasingly important to have risk managed by most appropriate party.
Managing Technology Risk

- Is possible to get new technology implemented at scale if the commercial drivers are there.

- Seek opportunities to derisk individual elements of risk by focussed tests and trials at lower cost.

- It is a big world, there will be niches with unusual attractive characteristics.
Managing Technology Risk

Use of insurance products to close the risk gap, eg New Energy Risk

- More capital is accessible for early stage technologies, and mature technologies.
- Mid-stage technologies (Pilot plant, data, but not yet widely adopted) have a tougher time.
Summary

Hydrogen is attractive as a fuel to decarbonise heat. Other technologies will also have a role to play. However H2 is likely to dominate.

There are many hurdles to implementation.

Making Hydrogen is not one of them.
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