Hydrogen and other routes to decarbonization of the gas network

FCH2 Conference, Birmingham, 14th March 2018

14th March 2018

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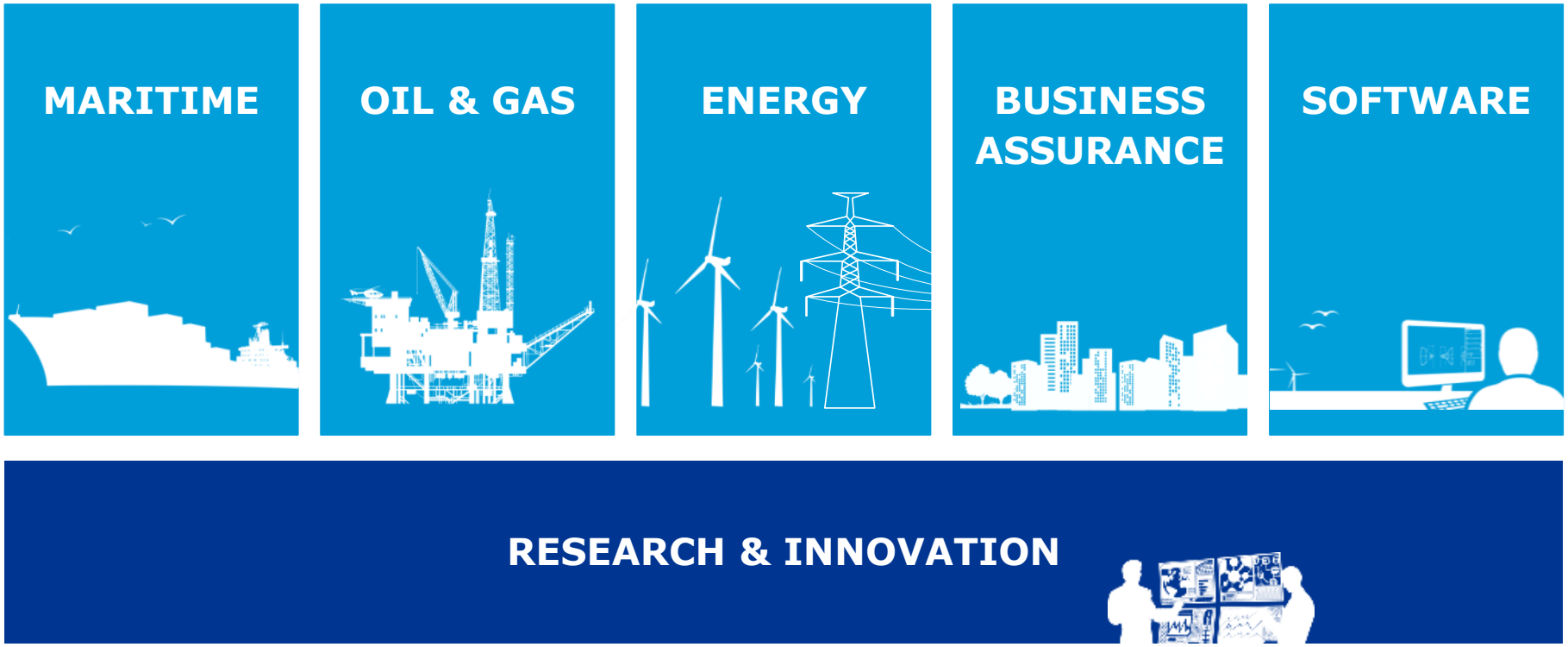
150+
years

100+
countries

100,000+
customers

13,000+
employees

Our vision: global impact for a safe and sustainable future



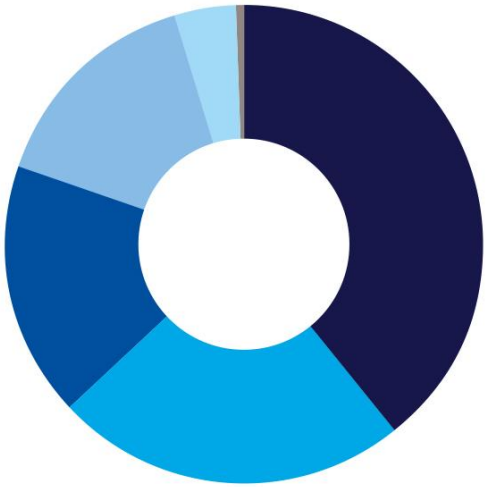
Revenue and people by business area (as of 31.12.2016)

REVENUE (MILLION NOK)

20,834

PER BUSINESS AREA

- MARITIME **8,216**
- OIL & GAS **4,955**
- ENERGY **3,583**
- BUSINESS ASSURANCE **3,146**
- SOFTWARE **859**
- OTHER **76**



NUMBER OF EMPLOYEES

13,550

PER BUSINESS AREA

- MARITIME **4,302**
- OIL & GAS **2,758**
- ENERGY **2,344**
- BUSINESS ASSURANCE **1,960**
- OTHER* **1,520**
- SOFTWARE **666**

Industry consolidation

DNV

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KEMA

NOBLE DENTON

GARRAD HASSAN

ADVANTICA

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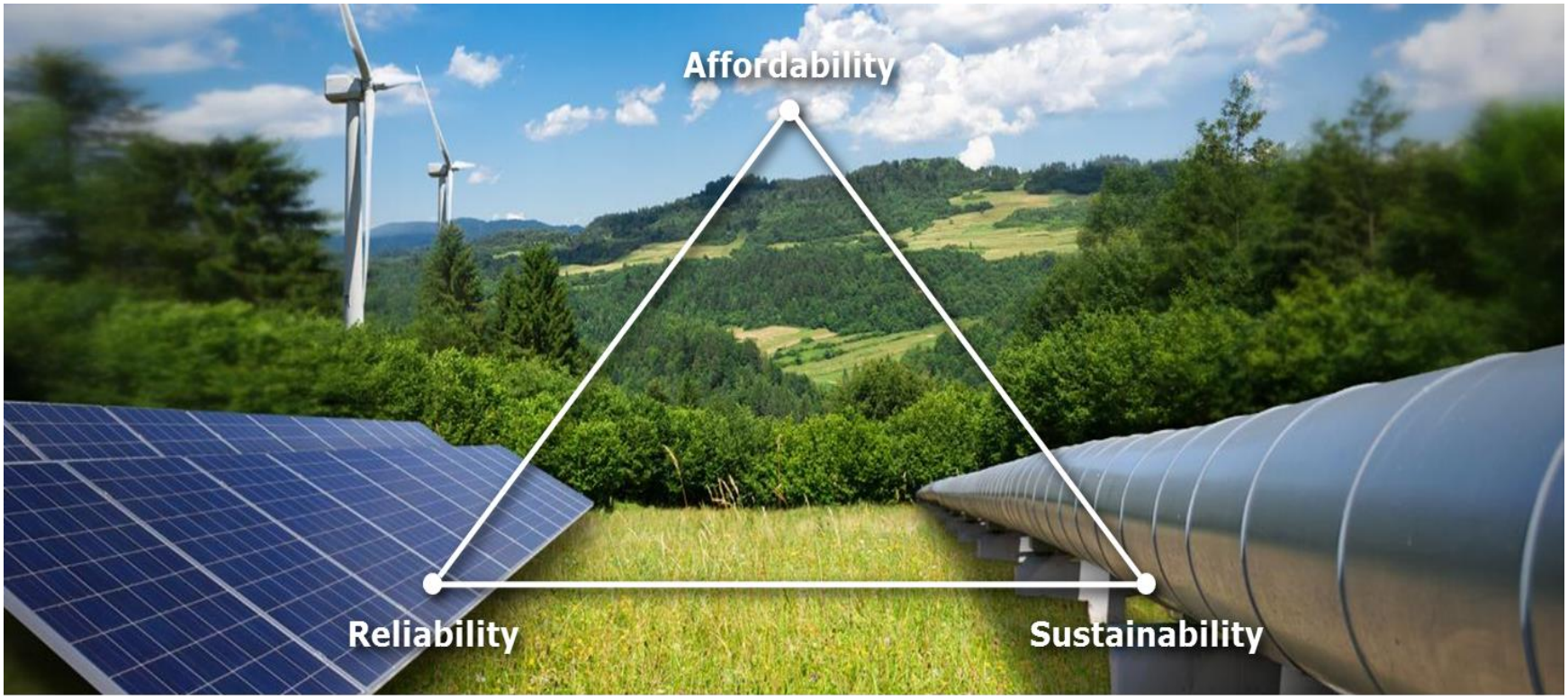
The Future of Gas

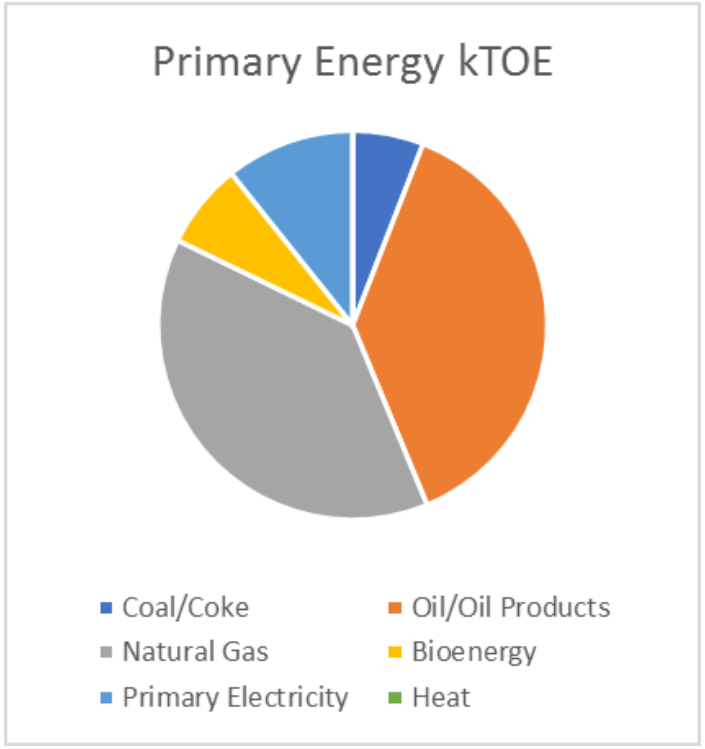
> "Gas provides the fastest and most economic pathway to a world with both lower carbon intensity and cleaner air" (source: COP21 report)

But its role in the long term is still under debate – decarbonisation will be needed to meet 2050 targets of 80% CO_2 reduction

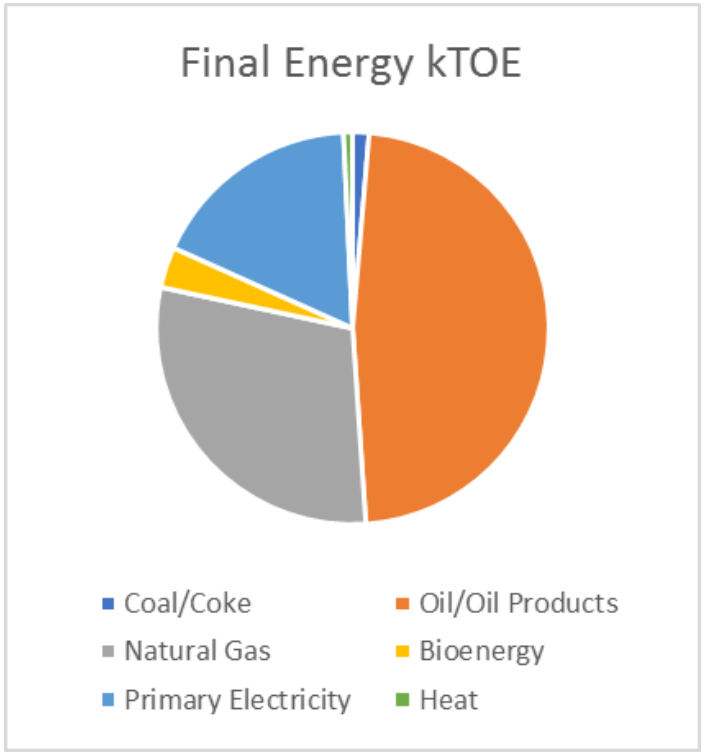


Recent History – 2016 UK Energy Usage

- Natural Gas contributed 38% of primary energy
- Gas provides about 29% of final energy



2016 UK Primary Energy Consumption



2016 UK Final Energy Consumption

UK Gas System

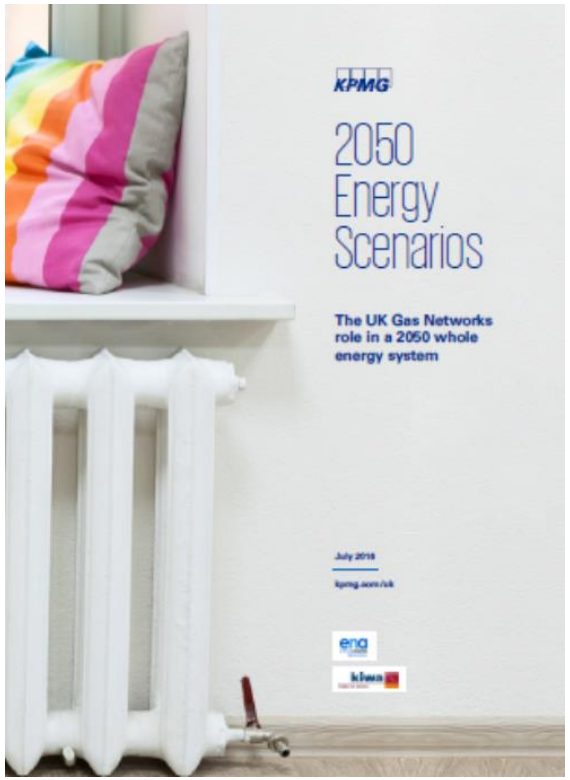
- 884TWh energy delivered in 2015 (electricity grid delivered 334TWh)
- 7,600km transmission pipelines
- 280,000km regional and local systems
- 27 million customers - over 85% of homes are connected to the gas grid
- Nearly all domestic use for heating
- Contributes 14% of UK GHG emissions

How to decarbonise heat ?

Energy Networks Association Gas Futures Groups from KPMG issued in July 2016 – looked at incremental cost of 4 scenarios for the delivery of heat in 2050

Lowest and highest cases were:

- Evolution of Gas (primarily conversion of grid to hydrogen produced via SMR with CCS) – £104-122 Billion
- Electric Future (replacement of the gas grid) - £274-318 Billion

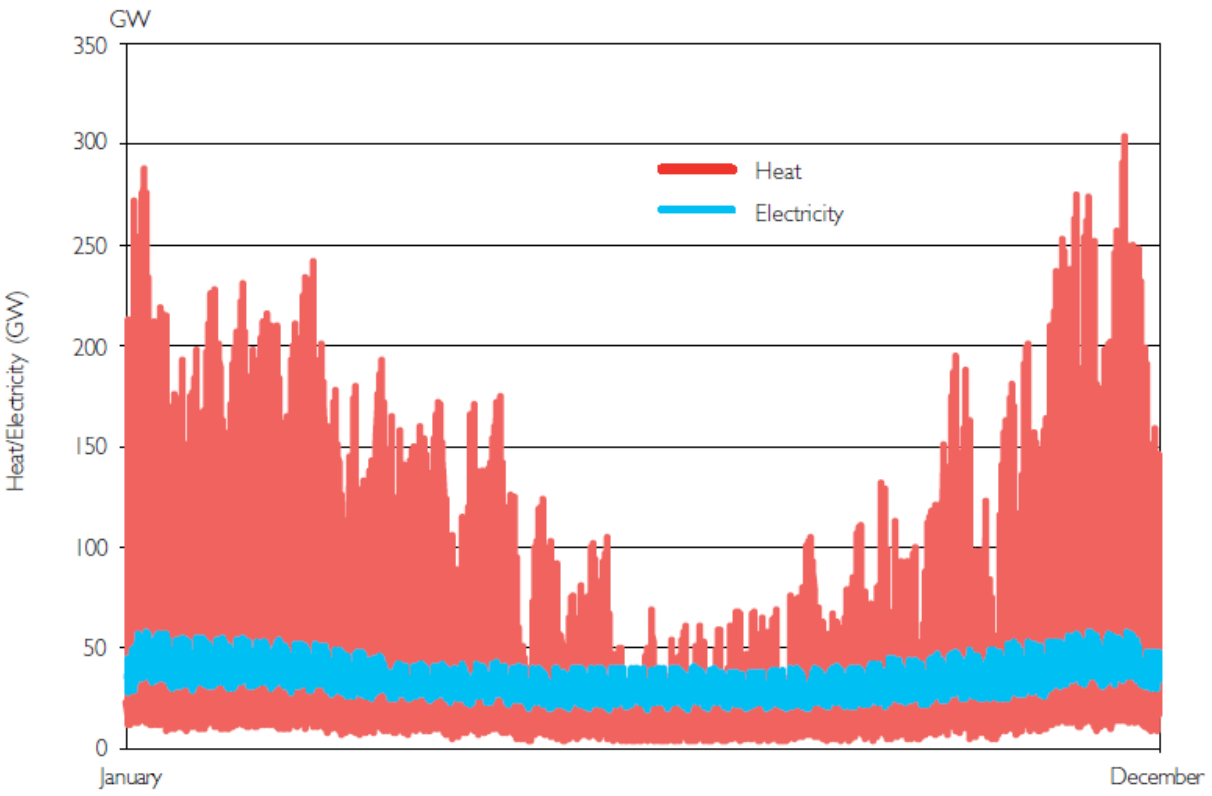


Why does maintaining the gas grid cost less ?

Comparison of heat and electricity demand variability across a year

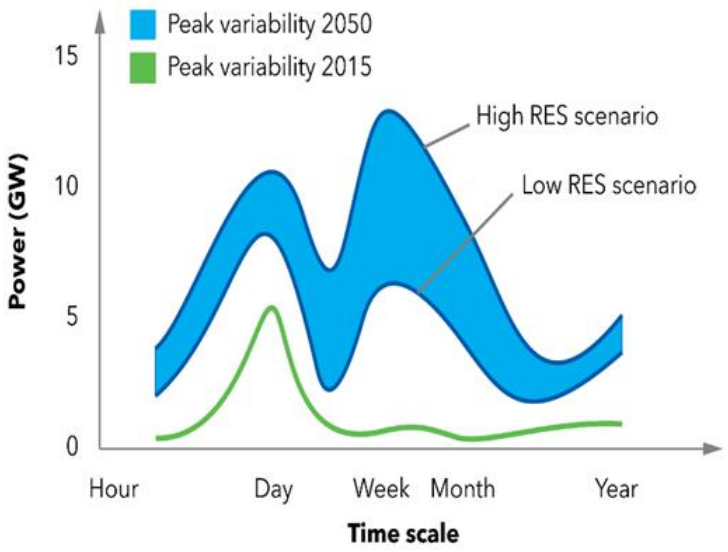
Major increase in electrical grid capacity would be needed to replace gas duties such as space heating and water heating (plus prospect of more EVs)

Avoid the costs and disruption involved in replacing energy infrastructure

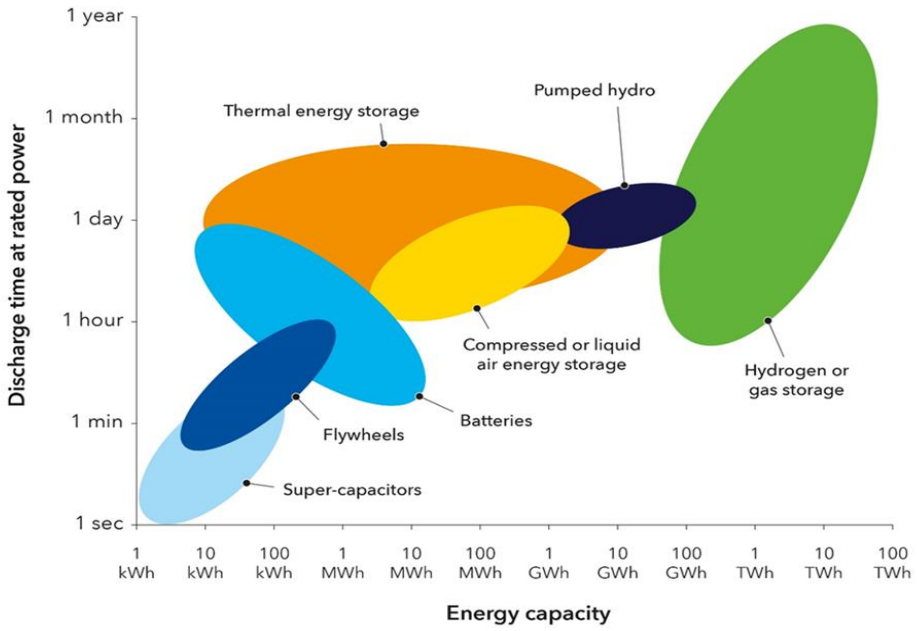


DECC – Future of Heating, March 2013

Why does maintaining the gas grid cost less ?



Variable renewables require storage to support and expand their use



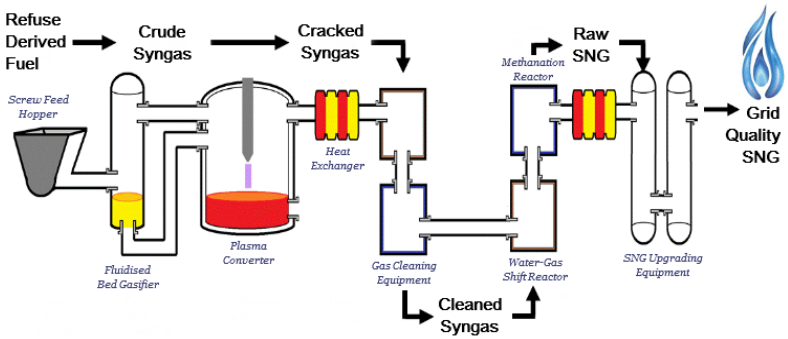
Gas is easier to store to meet seasonal and daily swings in demand and supply

Biomethane ?

- Biomethane produced by clean-up of biogas from anaerobic digestion (AD) of biomass
- Currently 20 sites injecting to UK grid – many more AD sites but most currently use biogas for power generation
- Recent expansion driven by Renewable Heat Incentive (RHI)
- Supplies <1% of UK gas demand
- Limited by availability of feedstocks to at most 5% of demand
- Concerns over potential methane emissions

Bio-SNG ?

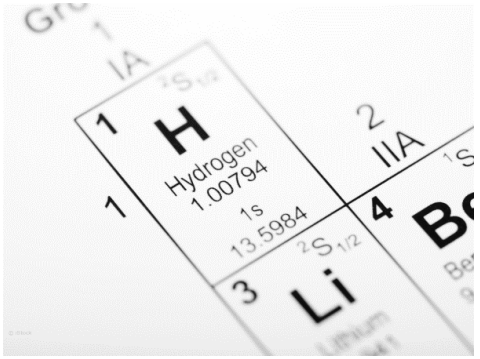
- Substitute Natural Gas – technology proven at scale from fossil fuels
- Bio-SNG produced via gasification of renewable feedstocks – biomass and some wastes
- Currently pilot scale in the UK – (gogreengas at Swindon)
- Demonstration plant under development
- Could supply up to 20% of UK gas needs
  - but that assumes no competition for feedstocks from other sectors (e.g. transport, power generation)



…… or Hydrogen ?

- Blended:
  - 0.1 mol% current GS(M)R limit but most domestic appliances can tolerate more
  - HyDeploy project will demonstrate blending at up to 20% at Keele University
  - But 20 mol% hydrogen is only 7% by calorific value so decarbonisation potential is limited

- 100% hydrogen:
  - Total decarbonisation
  - New transmission and storage facilities needed
  - H21 Leeds City Gate - £2billion to convert Leeds low pressure system to hydrogen
  - Liverpool-Manchester Hydrogen Cluster
  - BEIS Hy4Heat programme



HyDeploy

h21 Leeds City Gate

Cadent – Liverpool-Manchester Hydrogen Cluster

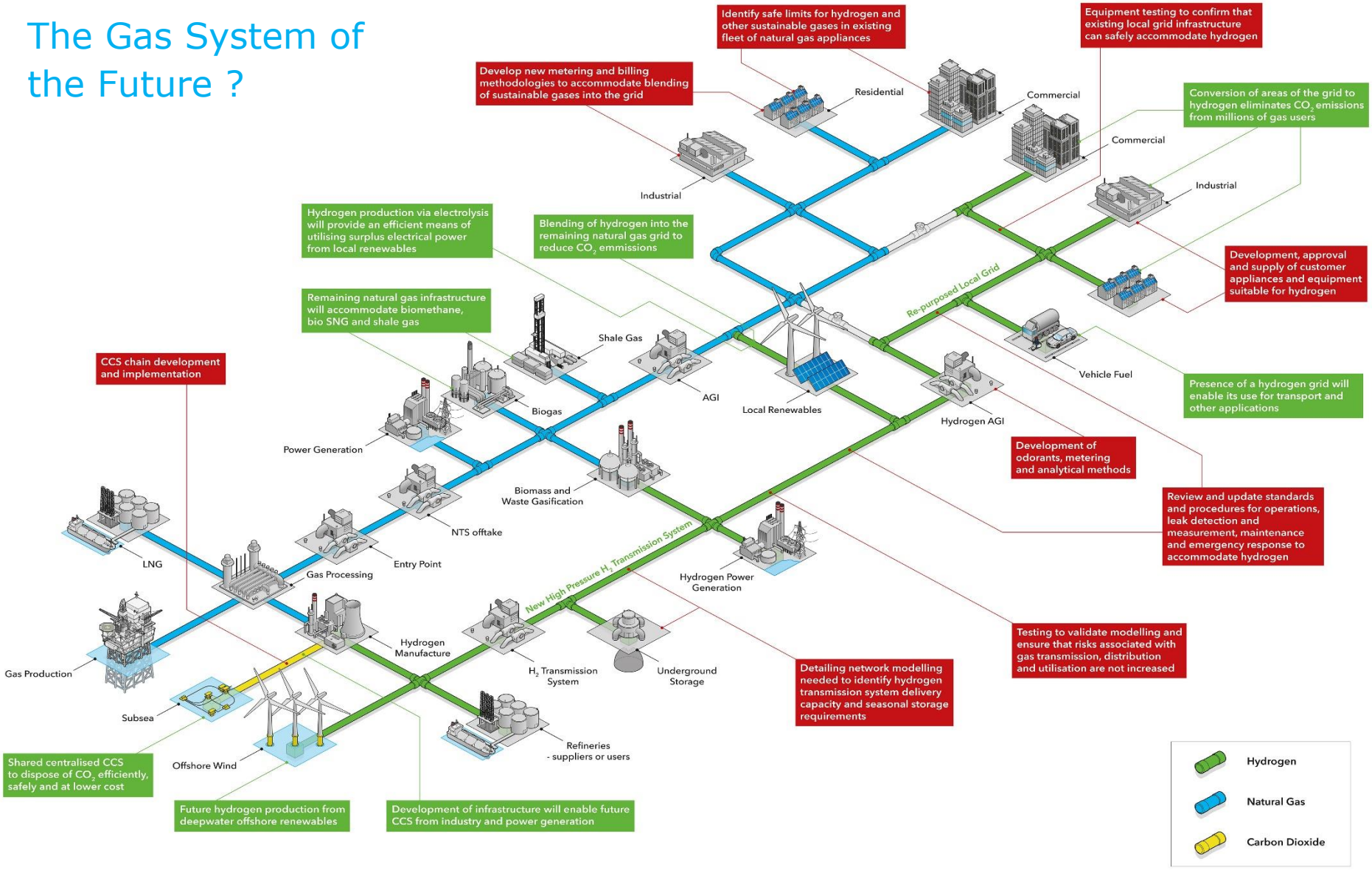
Benefits

- Develops a market and infrastructure into which hydrogen generated from renewables can be exported (and in the longer term replace fossil hydrogen)
- Large scale CCS from central sites easier and more efficient than local decarbonisation of gas
- CCS at scale can form basis for an industrial CCS cluster
- A hydrogen grid can potentially supply hydrogen refuelling stations, lowering the costs of these installations and enhancing the uptake of hydrogen fuelled transport

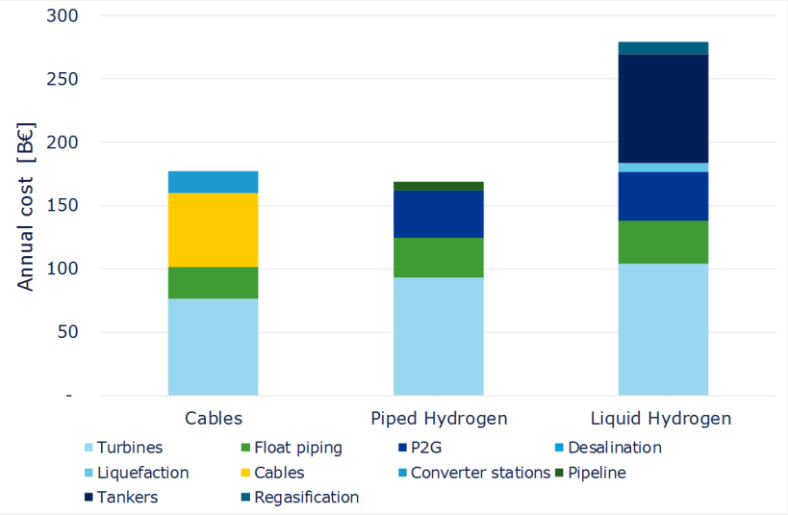
Challenges

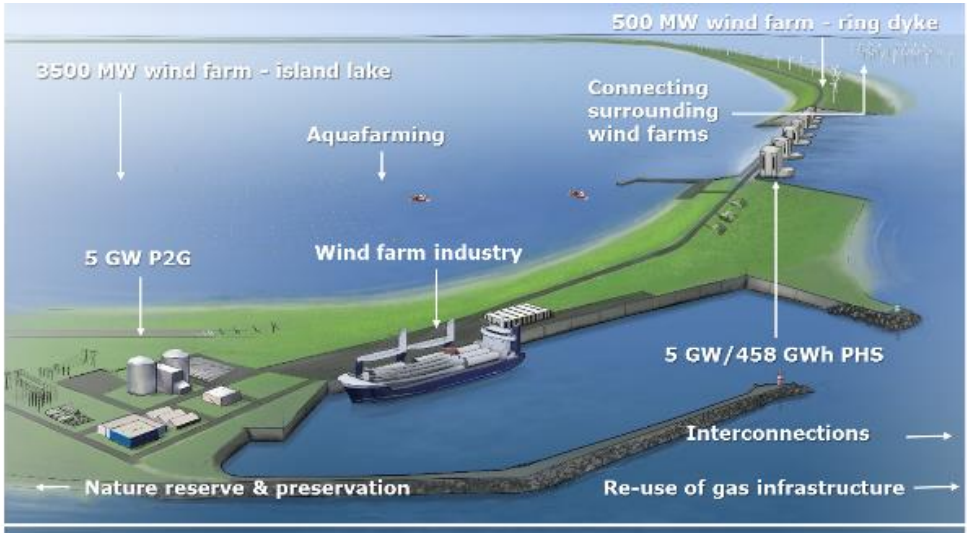
- CCS chain development
- Hydrogen production
- Hydrogen transmission system & storage requirements
- Ensuring risks associated with the gas network do not increase
- Confirming that local gas infrastructure can accommodate hydrogen
- Development of new technologies and procedures for grid operation
- Development and supply of new appliances
- Public acceptance
- How is it all paid for ?

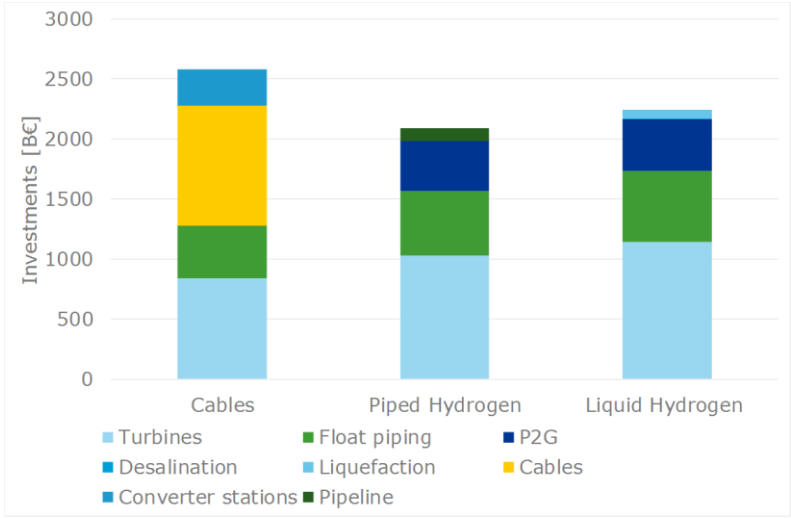
The Gas System of the Future ?



Long term - Workable Offshore Wind







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