Johnson Matthey
Inspiring science, enhancing life

Low Carbon Hydrogen

Sam French

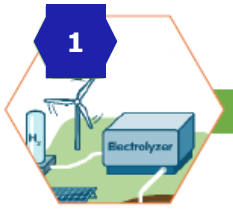
December 2019

Why H_2?

H_2 Generation	Transport	H_2 Use

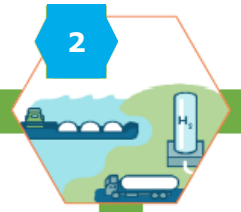
Enable **large-scale renewables integration**

1



Distribute / transport energy across sectors and regions

2



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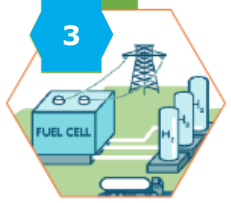
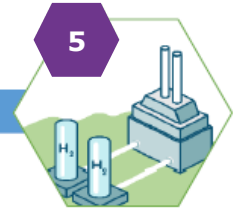


Act as a **buffer** to increase system resilience

4

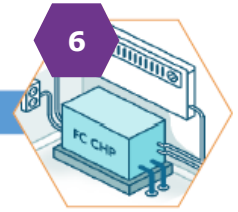
Decarbonise **transportation**

5



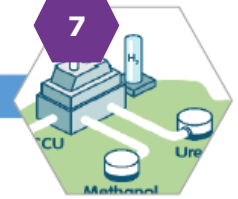
Decarbonise **industry energy use and power generation**

6



Decarbonise **building heating and power**

7



Serve as **clean feedstock for industry**

Hydrogen Council

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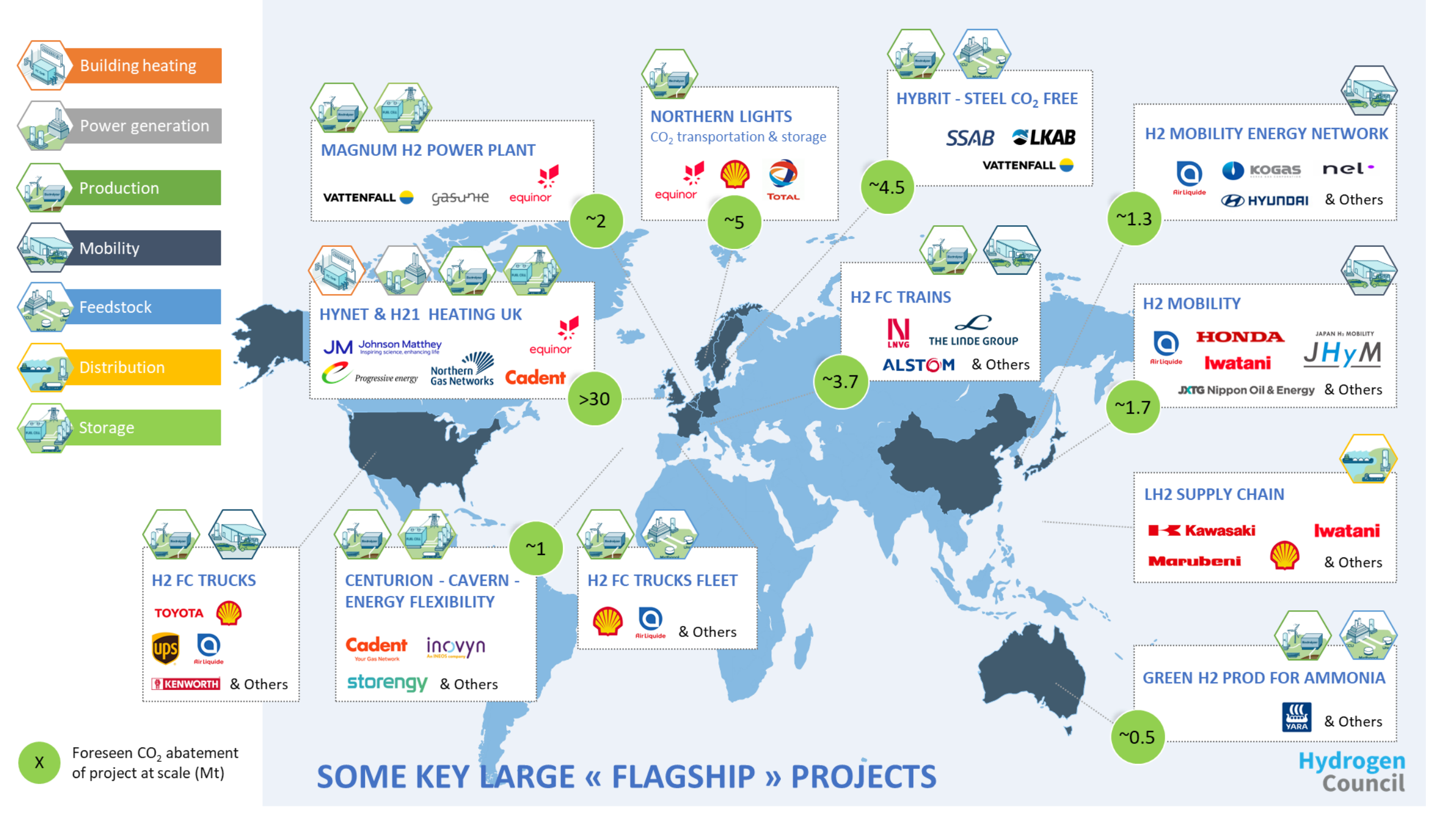
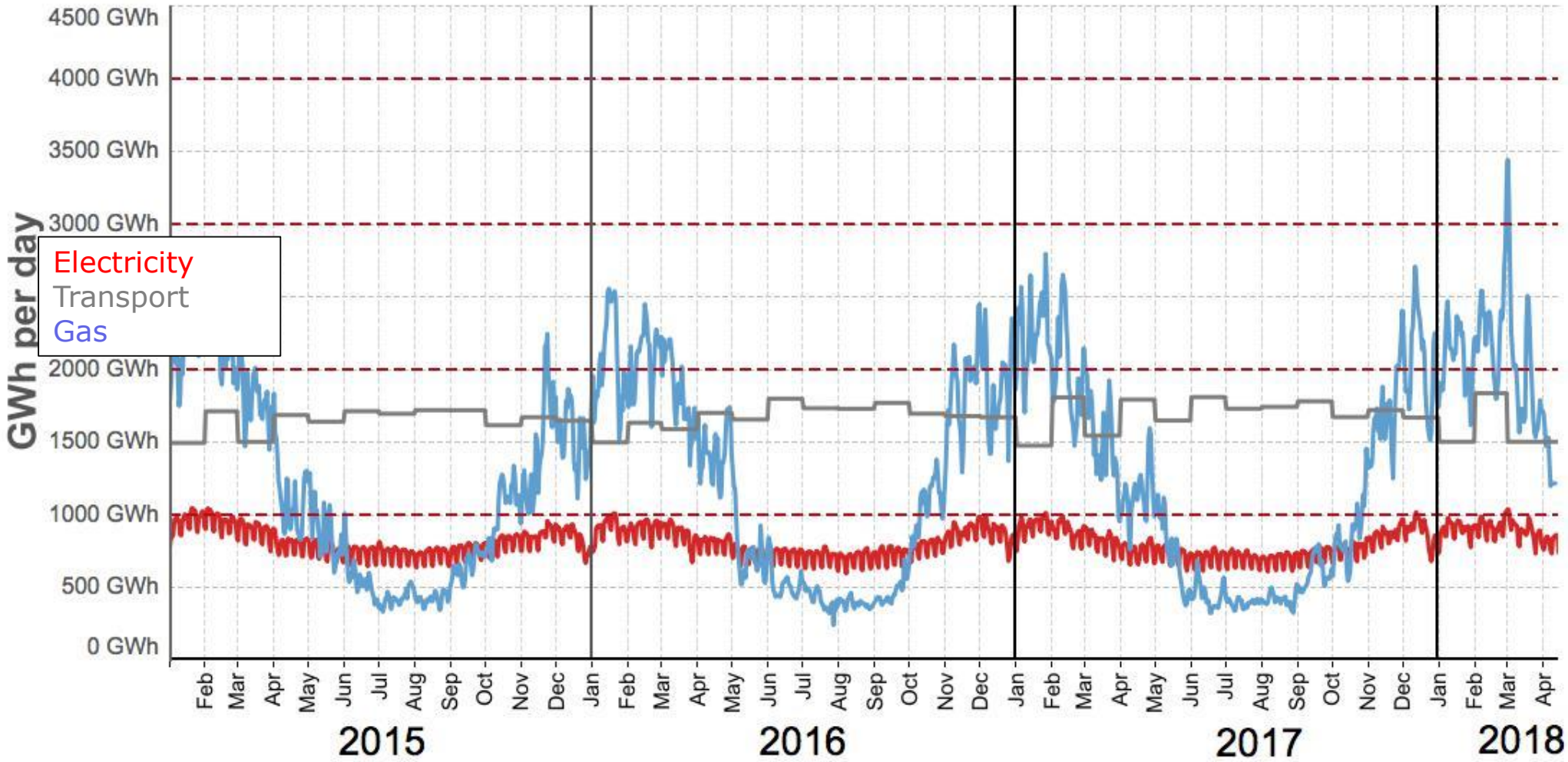

Building heating
Power generation
Production
Mobility
Feedstock
Distribution
Storage
MAGNUM H2 POWER PLANT
VATTENFALL
gasunie
equinor
~2
NORTHERN LIGHTS
CO_2 transportation & storage
equinor
TOTAL
~5
HYBRIT - STEEL CO_2 FREE
SSAB
LKAB
VATTENFALL
~4.5
H2 MOBILITY ENERGY NETWORK
Air Liquide
KOGAS
nel
HYUNDAI
& Others
~1.3
HYNET & H21 HEATING UK
JM Johnson Matthey
Inspiring science, enhancing life
equinor
Progressive energy
Northern Gas Networks
Cadent
>30
H2 FC TRAINS
LNVG
THE LINDE GROUP
ALSTOM
& Others
~3.7
H2 MOBILITY
Air Liquide
HONDA
Iwatani
JAPAN H2 MOBILITY
JHyM
JXTG Nippon Oil & Energy
& Others
~1.7
LH2 SUPPLY CHAIN
Kawasaki
Iwatani
Marubeni
& Others
H2 FC TRUCKS
TOYOTA
ups
Air Liquide
KENWORTH
& Others
CENTURION - CAVERN - ENERGY FLEXIBILITY
Cadent
Your Gas Network
inovyn
An INEOS company
storengy
& Others
~1
H2 FC TRUCKS FLEET
Air Liquide
& Others
GREEN H2 PROD FOR AMMONIA
YARA
& Others
~0.5
X
Foreseen CO_2 abatement of project at scale (Mt)
SOME KEY LARGE « FLAGSHIP » PROJECTS
Hydrogen Council



Data are from National Grid, Elexon and BEIS. Charts are licensed under an Attribution-NoDerivatives 4.0 International license

Charts can be downloaded from http://bit.ly/energycharts

by Dr Grant Wilson grant.wilson@sheffield.ac.uk

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In the UK, moving beyond an 80% target changes hydrogen from being an option to an *integral part of the strategy*

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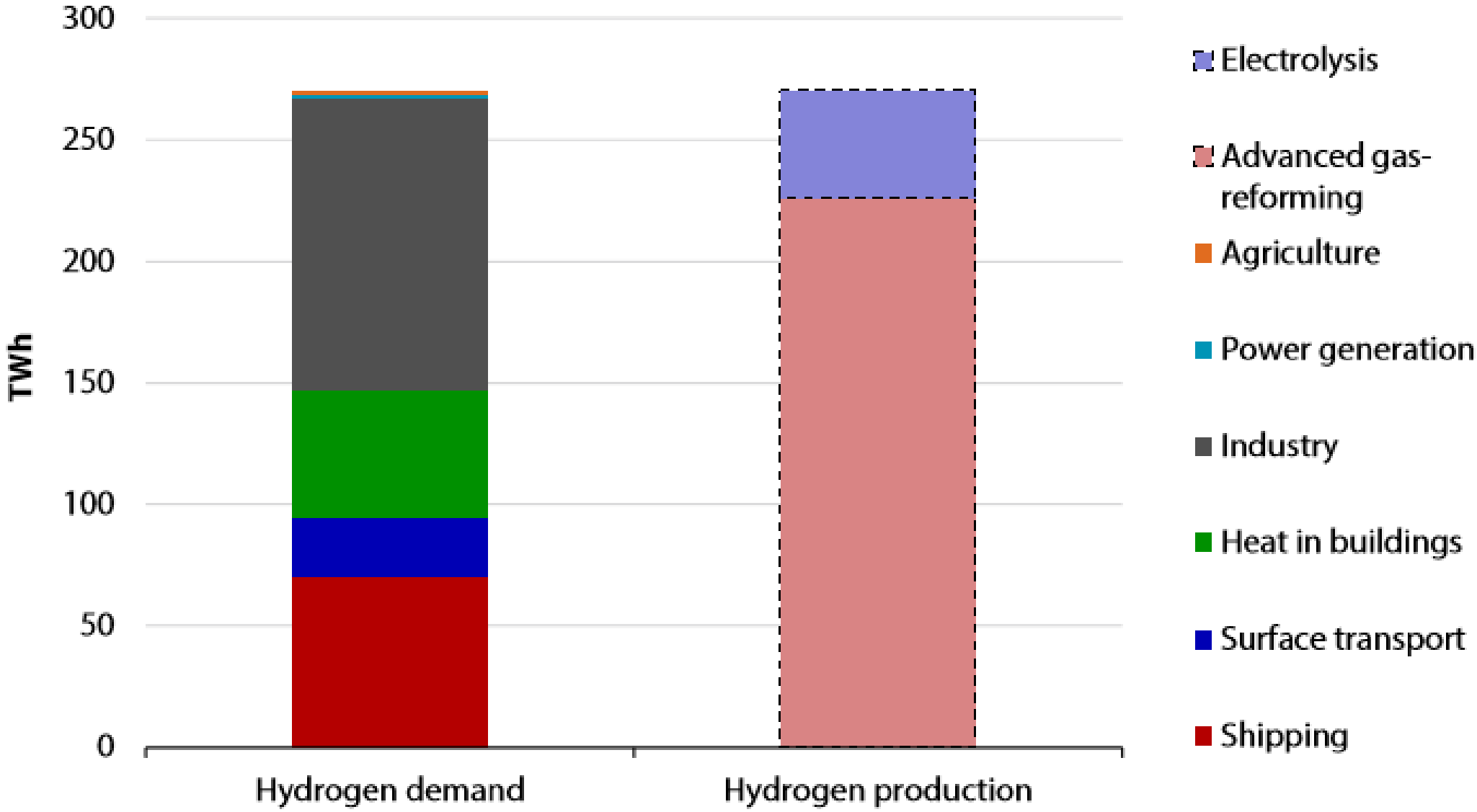
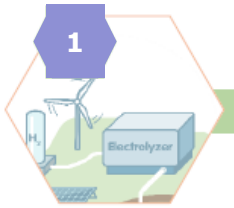


Source: Committee on Climate Change, Net Zero – Technical Report, May 2019

H_2 Generation

Enable large-scale renewables integration



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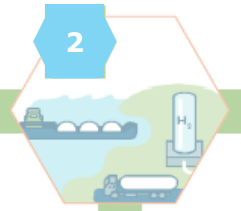
a **Large-scale Hydrogen production + carbon capture**

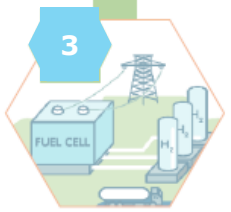
b **Large-scale electrolysis**

Transport

JM → **H_2 Transportation in the form of LH_2, NH_3, LOHC**

Distribute / transport energy across sectors and regions



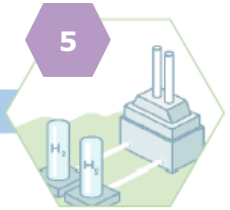


Act as a buffer to increase system resilience

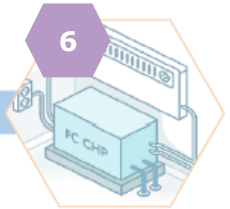
H_2 Use

Decarbonise transportation

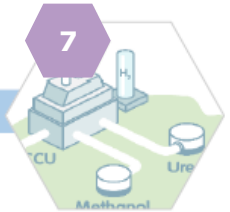
JM → **Fuel cell technologies**



Decarbonise industry energy use and power generation



Decarbonise building heating and power



Serve as clean feedstock for industry

Hydrogen Council

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H_2

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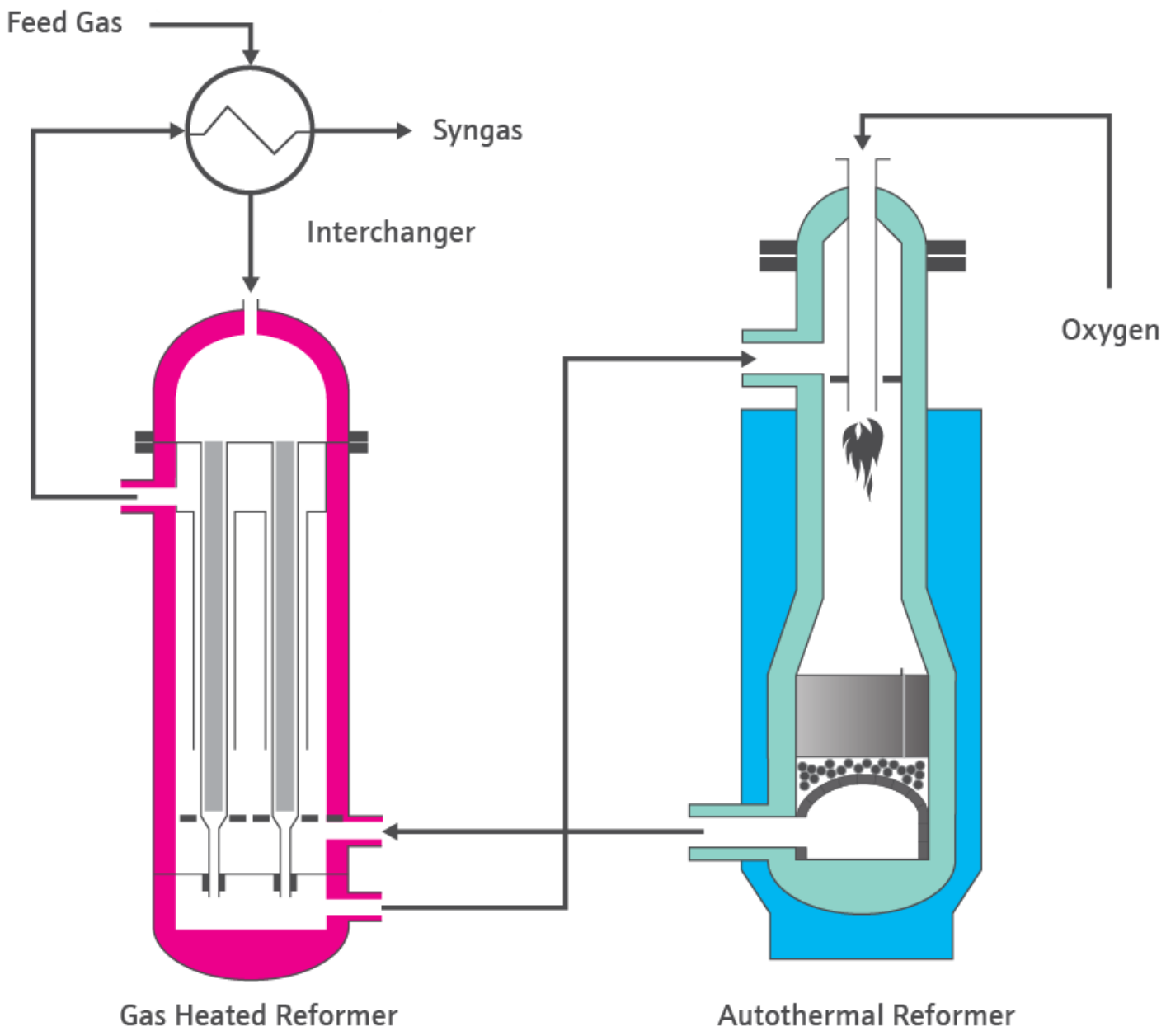
H2

GHR/ATR


Feed Gas
Syngas
Interchanger
Oxygen
Gas Heated Reformer
Autothermal Reformer

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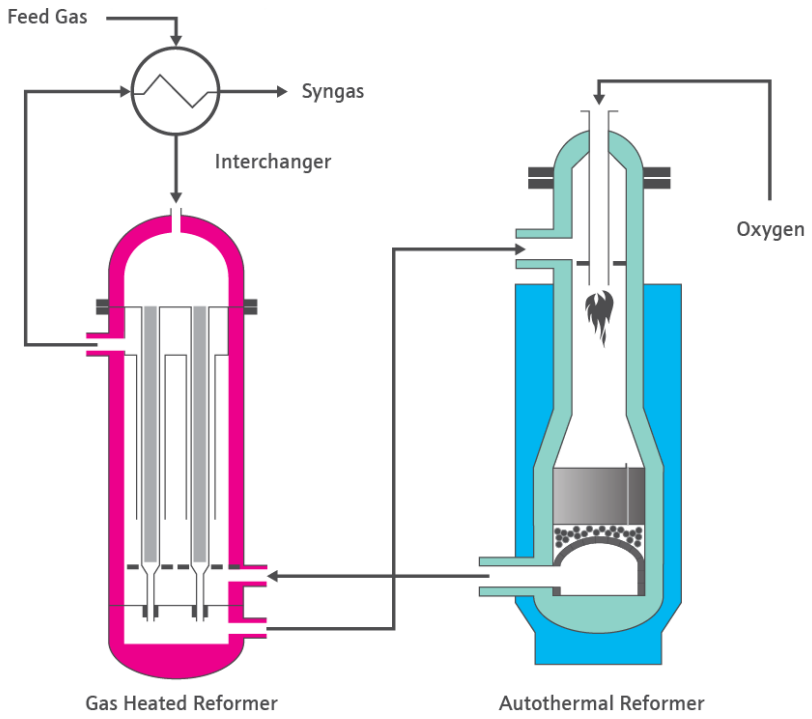
JM has a market leading technology for the production of Low Carbon Hydrogen

- Highest efficiency – lowest CapEx
- Lowest levelised cost of H_2
- Lowest nat gas usage per unit H_2 – lowest OpEx
- Lowest amount of CO_2 produced per unit H_2
- Advantageous to couple with renewable electricity generation as no steam is generated



Methane is converted into hydrogen by reacting it with steam, and >95% of CO_2 from the process is captured and subsequently used or stored

JM provides a technology licence for this market leading process as well as the catalysts required

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Cadent
H_2 Pipeline
CO_2 Pipeline
Future Hydrogen Sources
Future CO_2 Shipping
CO_2 Storage
Hydrogen Trains
Hydrogen Fuelling
Manchester
Liverpool
Industrial Gas Users
Hydrogen Production
Hydrogen Blend
Future Power Generation
Future Hydrogen Storage
Chester
Jobs and Skills
Inward Investment

Pale Blue Dot.

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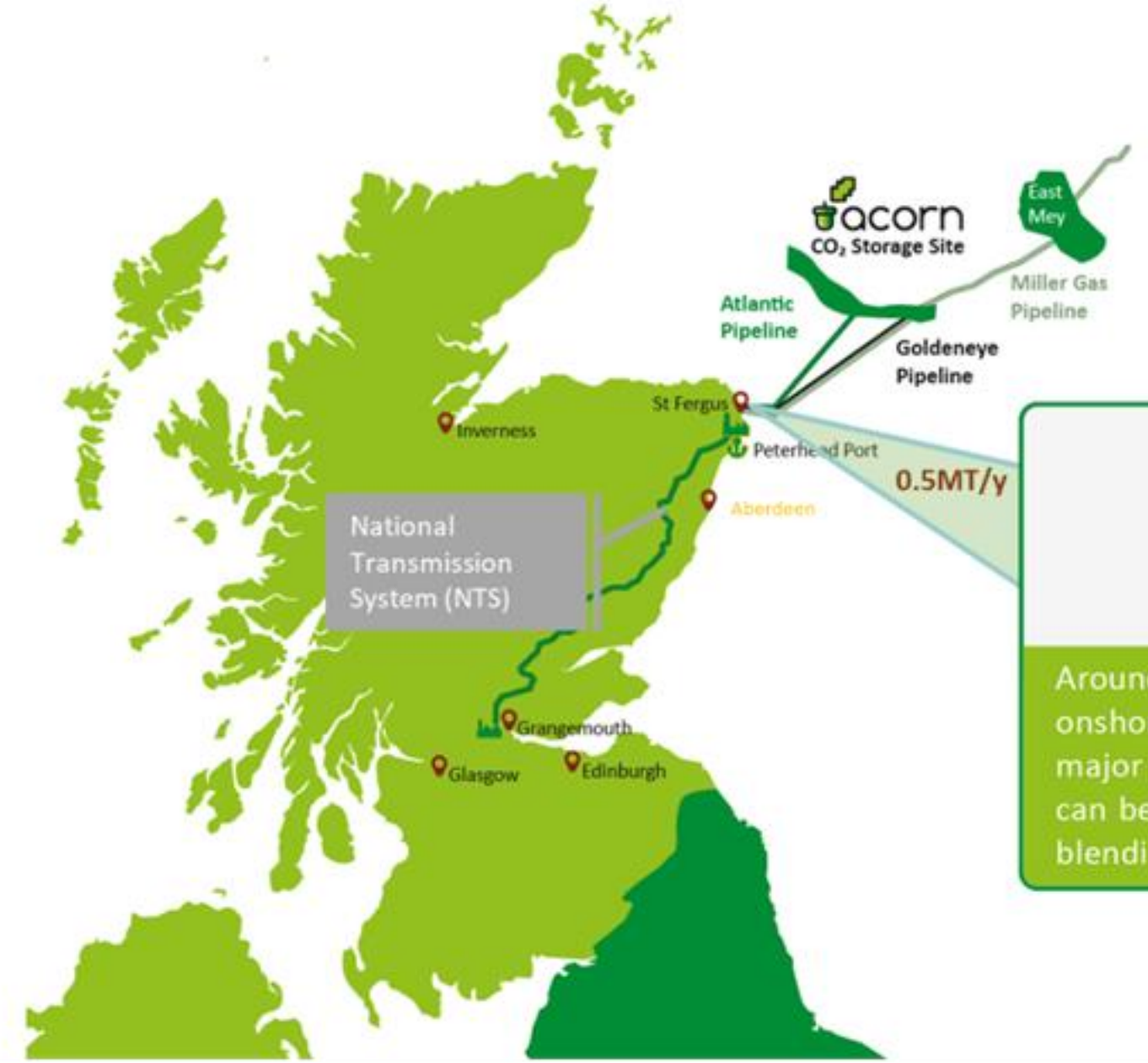
TOTAL



H_2 Production Hub

Around 35% of all UK natural gas comes onshore at St Fergus - an ideal site for a major H_2 production hub. H_2 at St Fergus can be fed directly into the gas grid from blending and decarbonising gas.

A low cost, low risk, clean growth catalyst.
acorn

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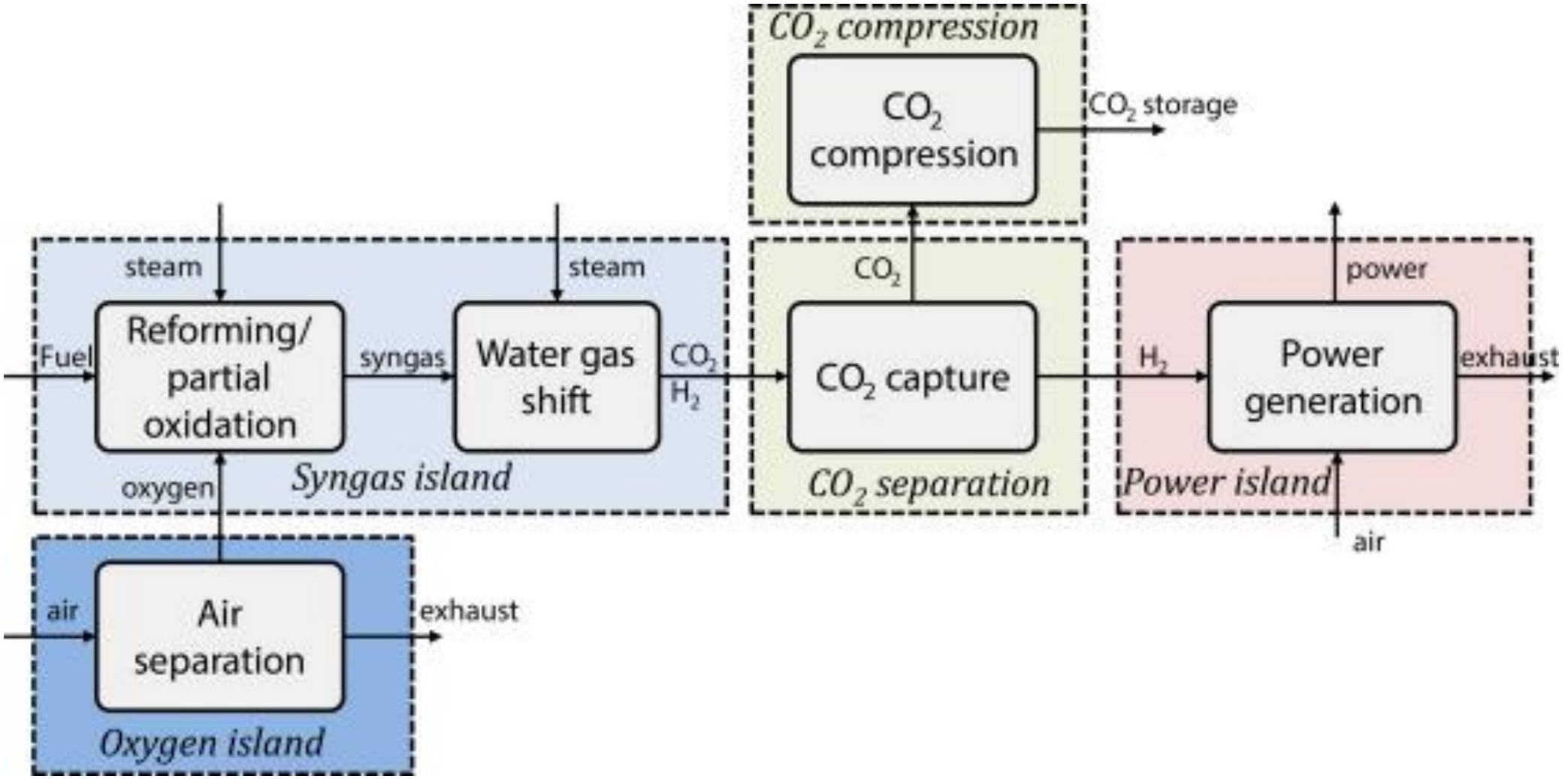
CO_2 compression
CO_2 compression
CO_2 storage
steam
steam
Fuel
Reforming/ partial oxidation
syngas
Water gas shift
CO_2
H_2
Syngas island
oxygen
CO_2
CO_2 capture
CO_2 separation
power
H_2
Power generation
exhaust
Power island
air
air
Air separation
exhaust
Oxygen island

CO2 Capture for CCS

Challenges of carbon capture using amine include:

- Low pressure gas increases difficulty of transferring CO_2 from the gas into amine
- Oxygen content of the gas can cause amine degradation and acid formation
- CO_2 degradation of primary (and secondary) amines
- High energy consumption
- Very large facilities
- Finding suitable location for the removed CO_2

The partial pressure is the driving force to transfer CO_2 into the liquid phase. Under low pressure, this transfer is hard to achieve without increasing the reboiler's heat duty, which will result in higher cost

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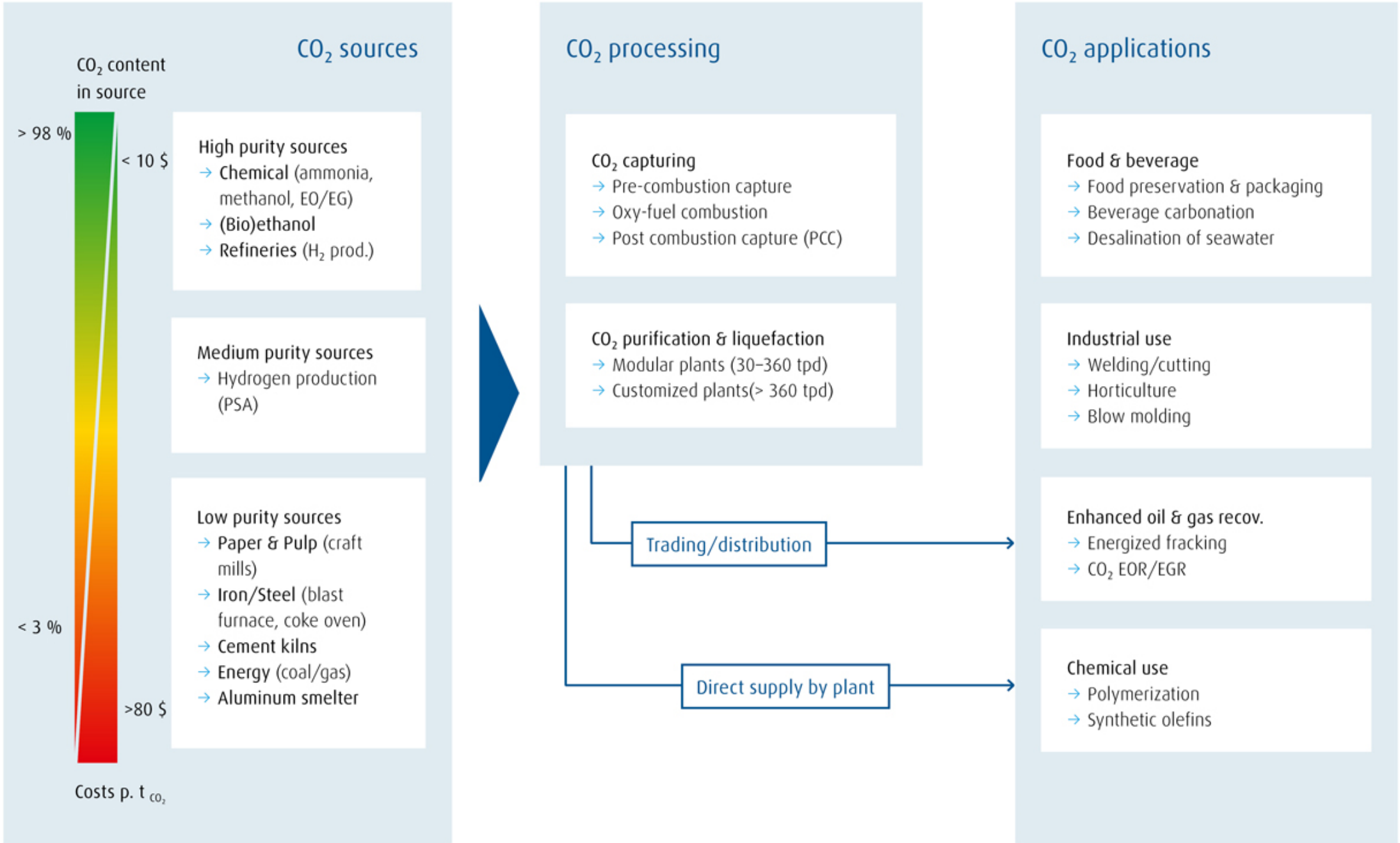

https://www.linde-engineering.com/en/images/20180717_120826_9003_tcm19-483761.jpg

CO2 Capture

Key attributes

- Safety
- Reliability
- OpEx cost
  - Energy
  - Consumables
- CapEx cost
- Capture rate/CO2 slip

Technology Choice

- Process conditions – T, P etc
- Acid gas content of feed gas
- Specification of product

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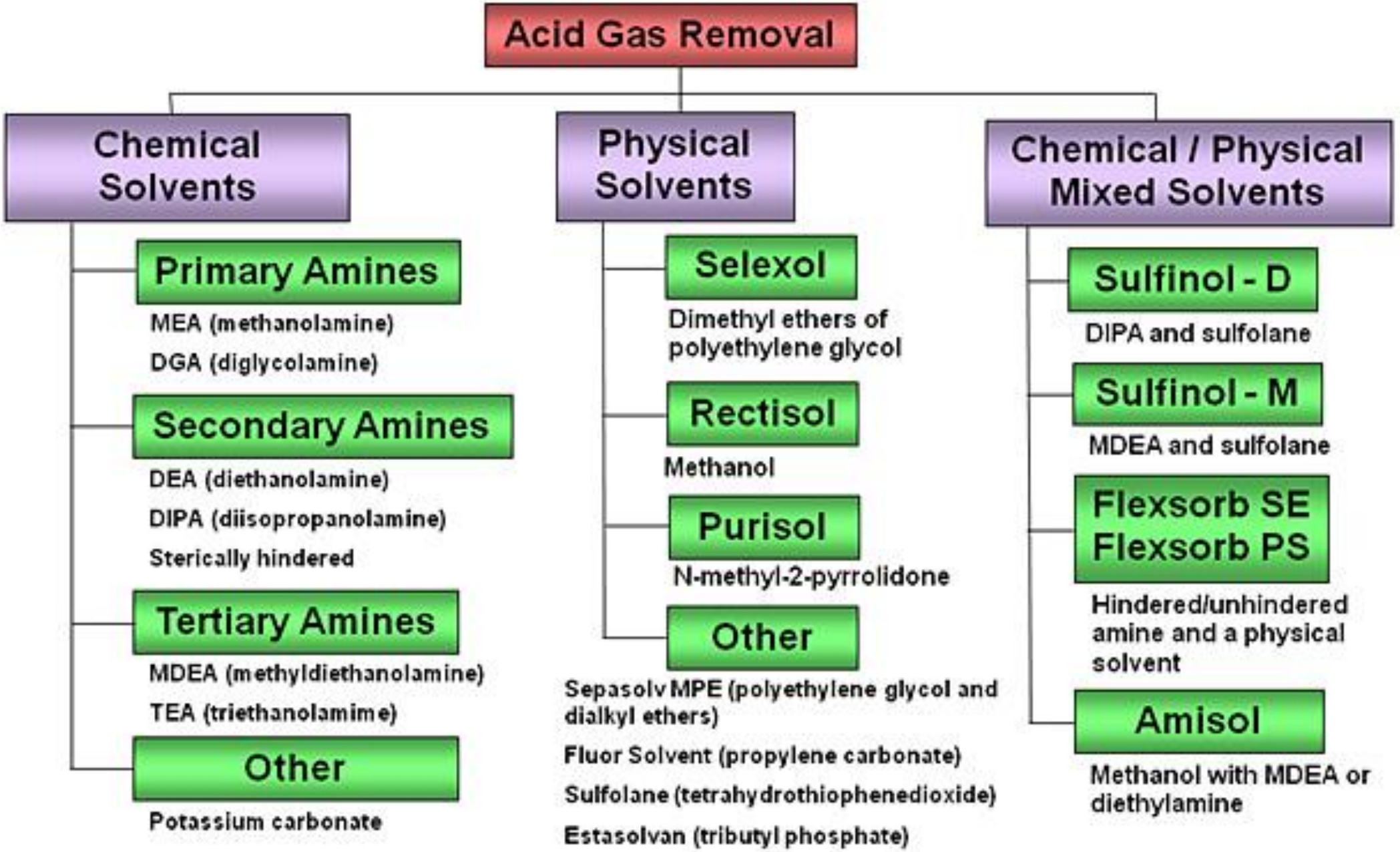
Acid Gas Removal
Chemical Solvents
Primary Amines
MEA (methanolamine)
DGA (diglycolamine)
Secondary Amines
DEA (diethanolamine)
DIPA (diisopropanolamine)
Sterically hindered
Tertiary Amines
MDEA (methyldiethanolamine)
TEA (triethanolamime)
Other
Potassium carbonate
Physical Solvents
Selexol
Dimethyl ethers of polyethylene glycol
Rectisol
Methanol
Purisol
N-methyl-2-pyrrolidone
Other
Sepasolv MPE (polyethylene glycol and dialkyl ethers)
Fluor Solvent (propylene carbonate)
Sulfolane (tetrahydrothiophenedioxide)
Estasolvan (tributyl phosphate)
Chemical / Physical Mixed Solvents
Sulfinol - D
DIPA and sulfolane
Sulfinol - M
MDEA and sulfolane
Flexsorb SE
Flexsorb PS
Hindered/unhindered amine and a physical solvent
Amisol
Methanol with MDEA or diethylamine

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In the UK, moving beyond an 80% target changes hydrogen from being an option to an *integral part of the strategy*

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