The commercialisation of UCG

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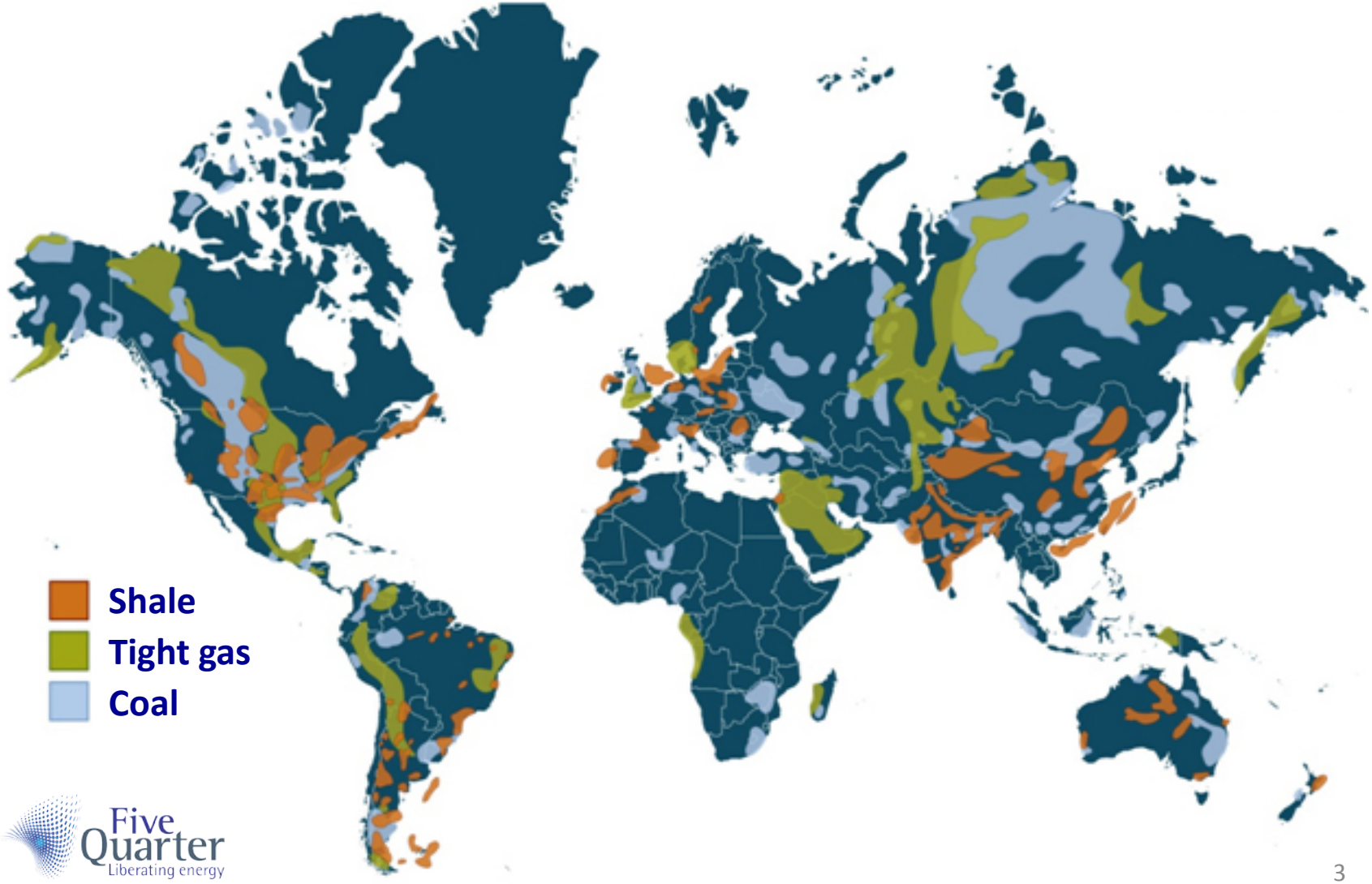
Scale of the UK opportunity

c. 10,000 billion tonnes of sub-sea coal in UK sector of the North Sea

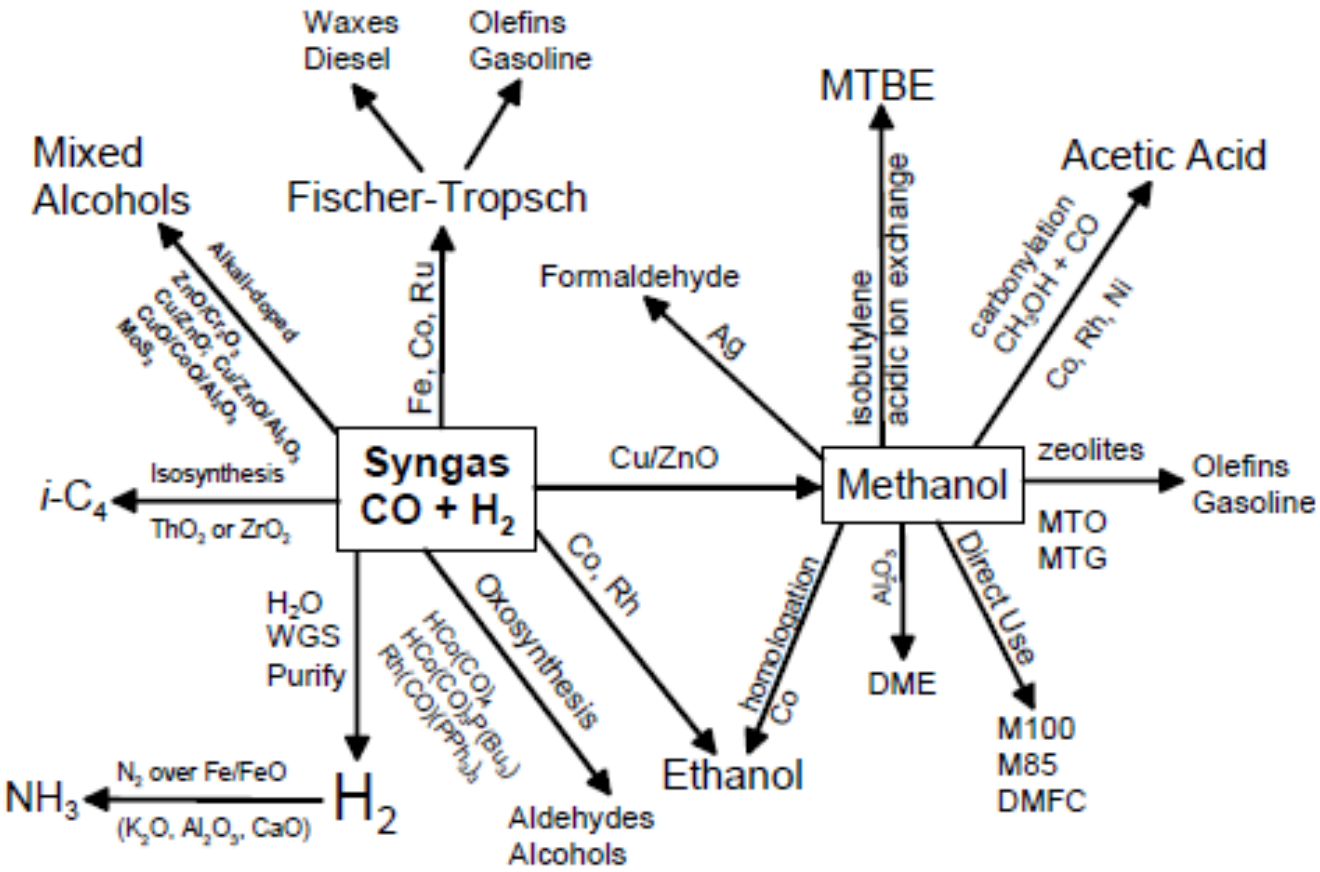
[J L Knight et al., “Coal thickness distributions on the UK continental shelf”, Geological Society, London, Special Publications 1996, v. 109, pp 43-57.]

Scale of the global opportunity



Five Quarter
Liberating energy

Which sector to target?



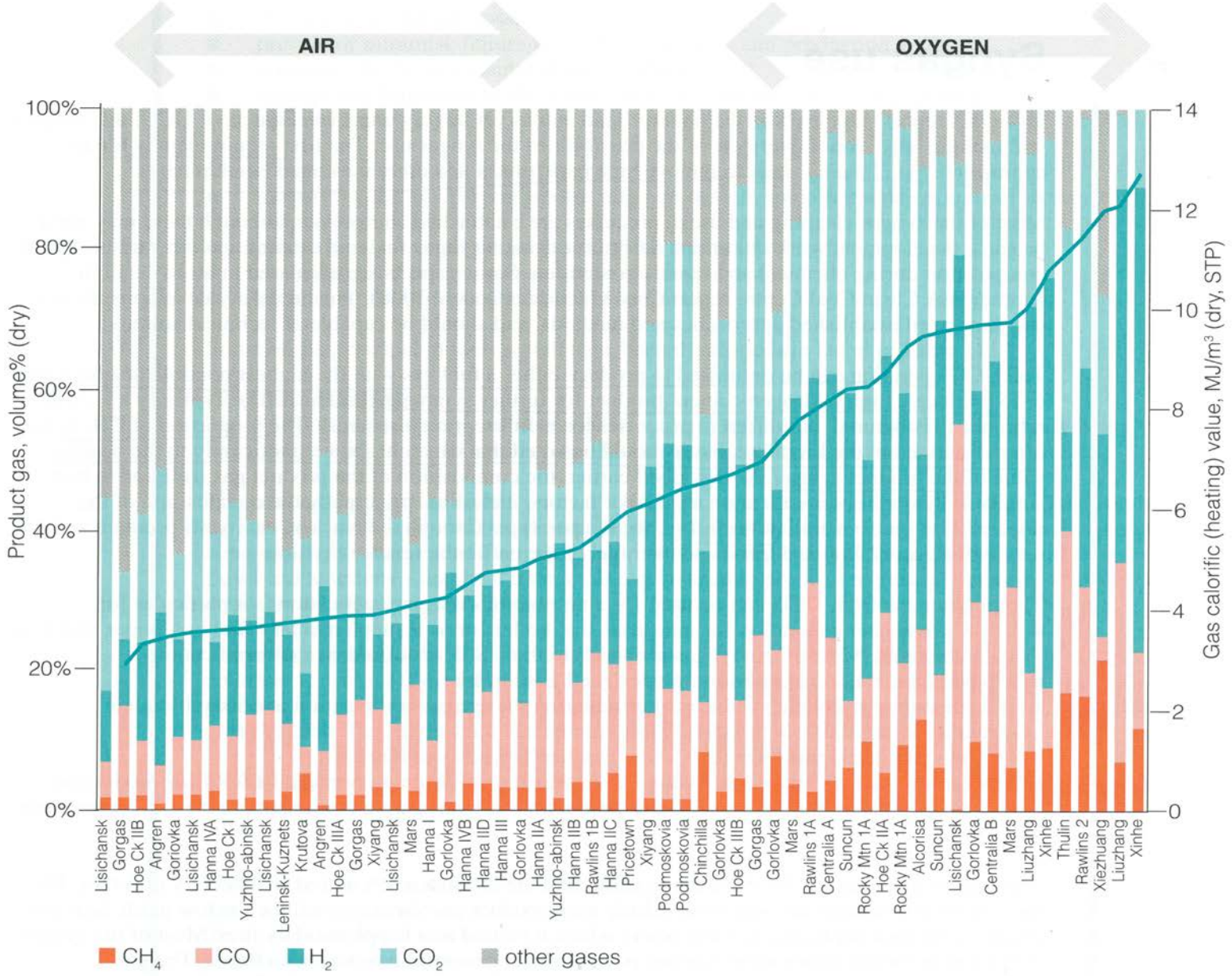
Source: NREL/TP-510-34929

Business niche?

- Owner-operator of a few assets?
- International licensor of technology?
- Roving consultancy?
- Some combination of the above?

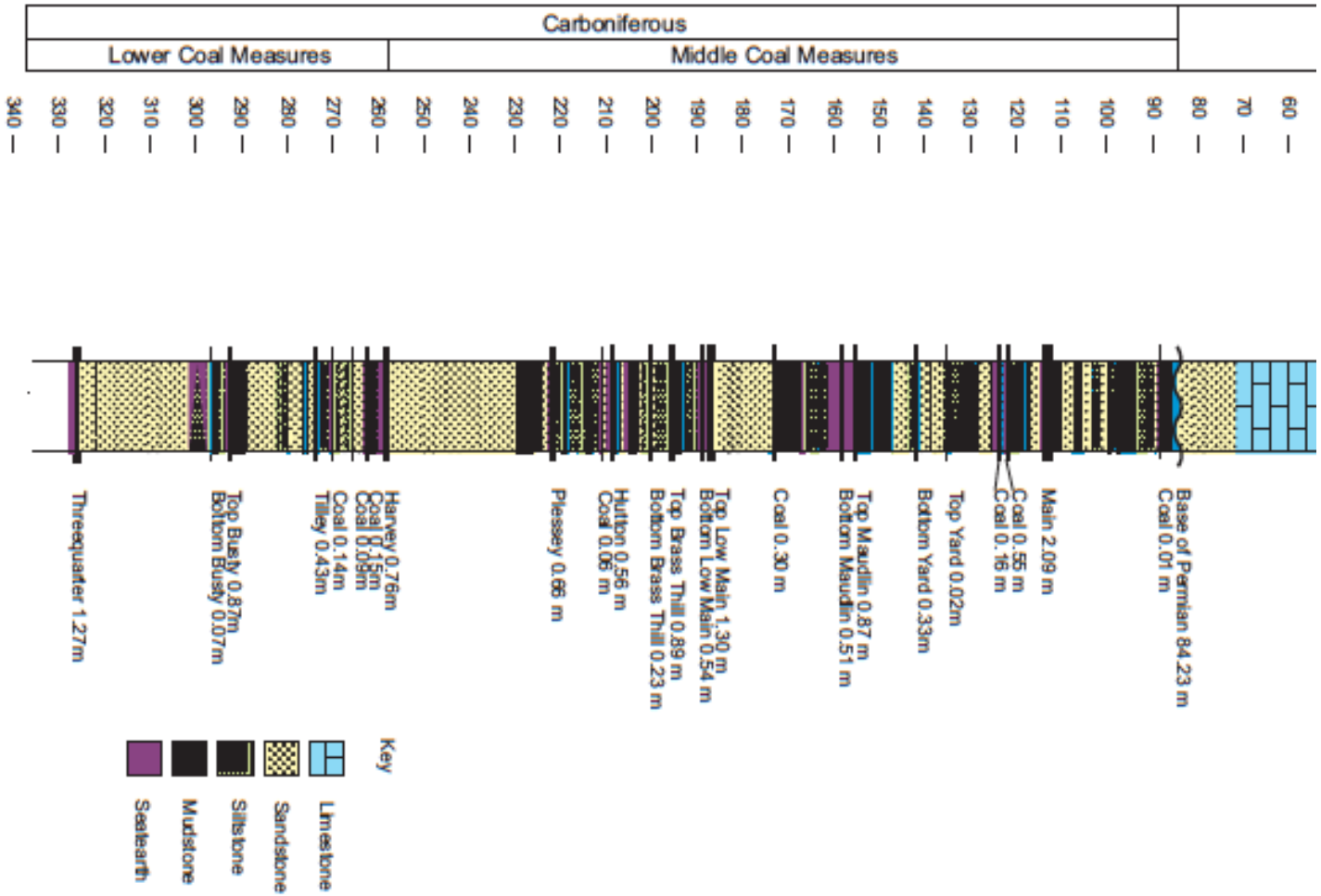
A diversity of business models with different implications.

Right syngas for chosen sector?

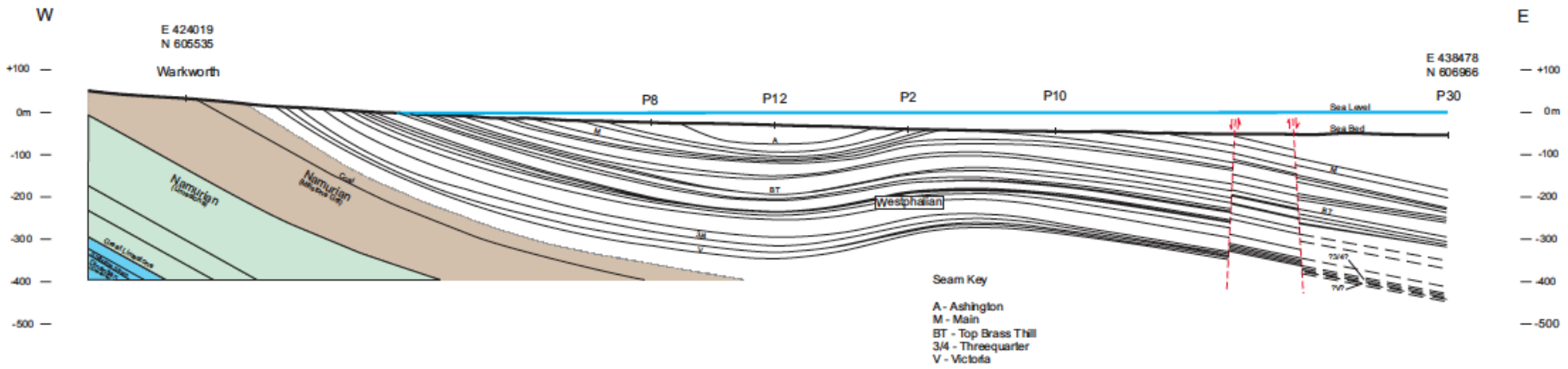


Source: G R Couch, Underground Coal Gasification, IEA Clean Coal Centre

The right coal for the job?



The right coal for the job?



Some coals are easier to deal with than others.

Have you got good separation from sensitive aquifers?

Where is your competitive edge? (and is it protected?)

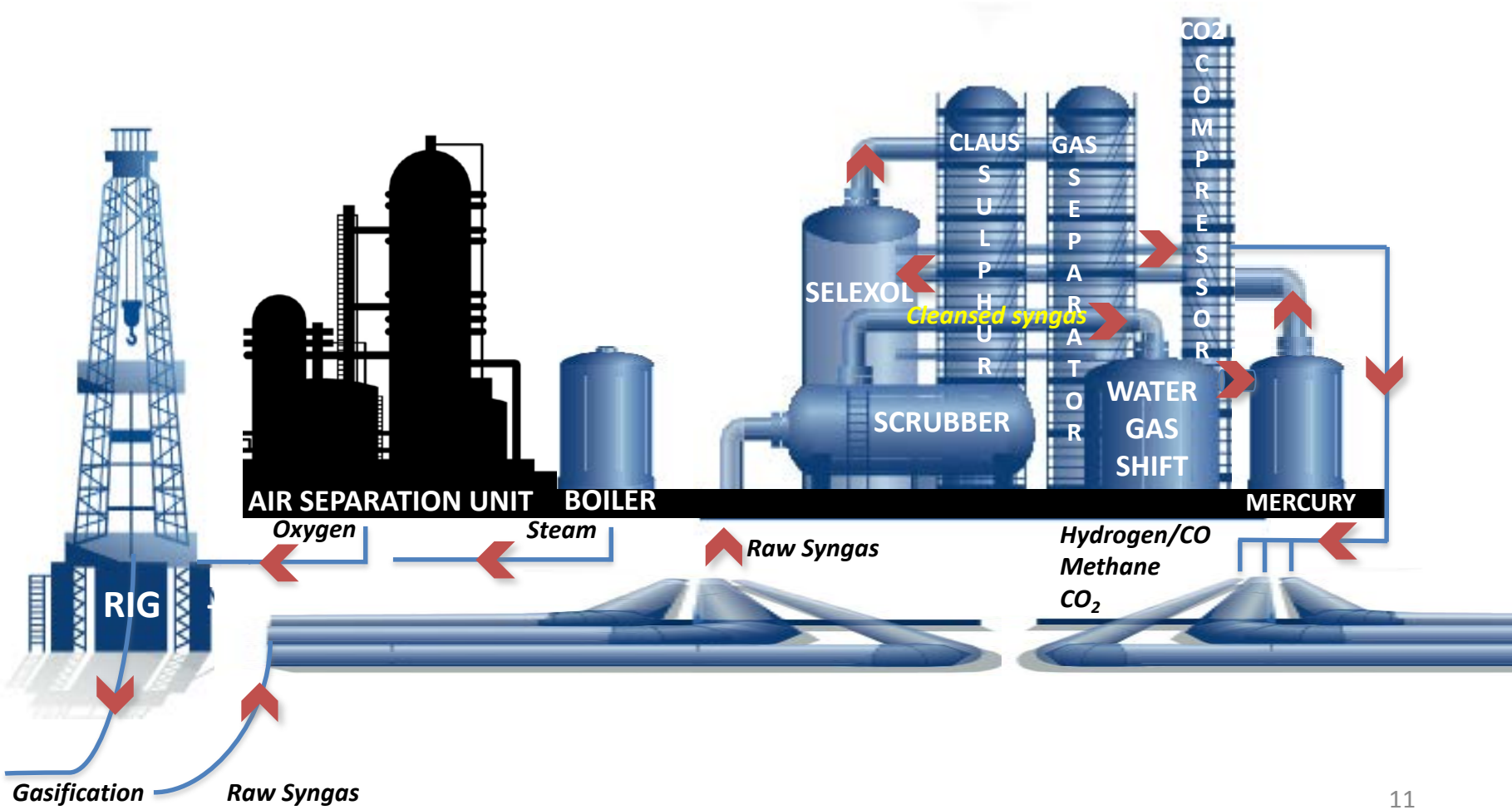
- Why should someone invest several £100m in your company?
- More gas with less drilling?
- Better syngas quality? Lower gas-processing costs?
- A more environmentally robust proposition?
- A more reliable process?
- Confidence in commercial capability?

Why do demonstrator projects?

- To burn a lot of money???
- To show that you have the right coal for the job.
- To demonstrate that your competitive edge is real.
- To gather data needed for designing the commercial-scale plant.
- To win the confidence of investors, customers, regulators & communities.

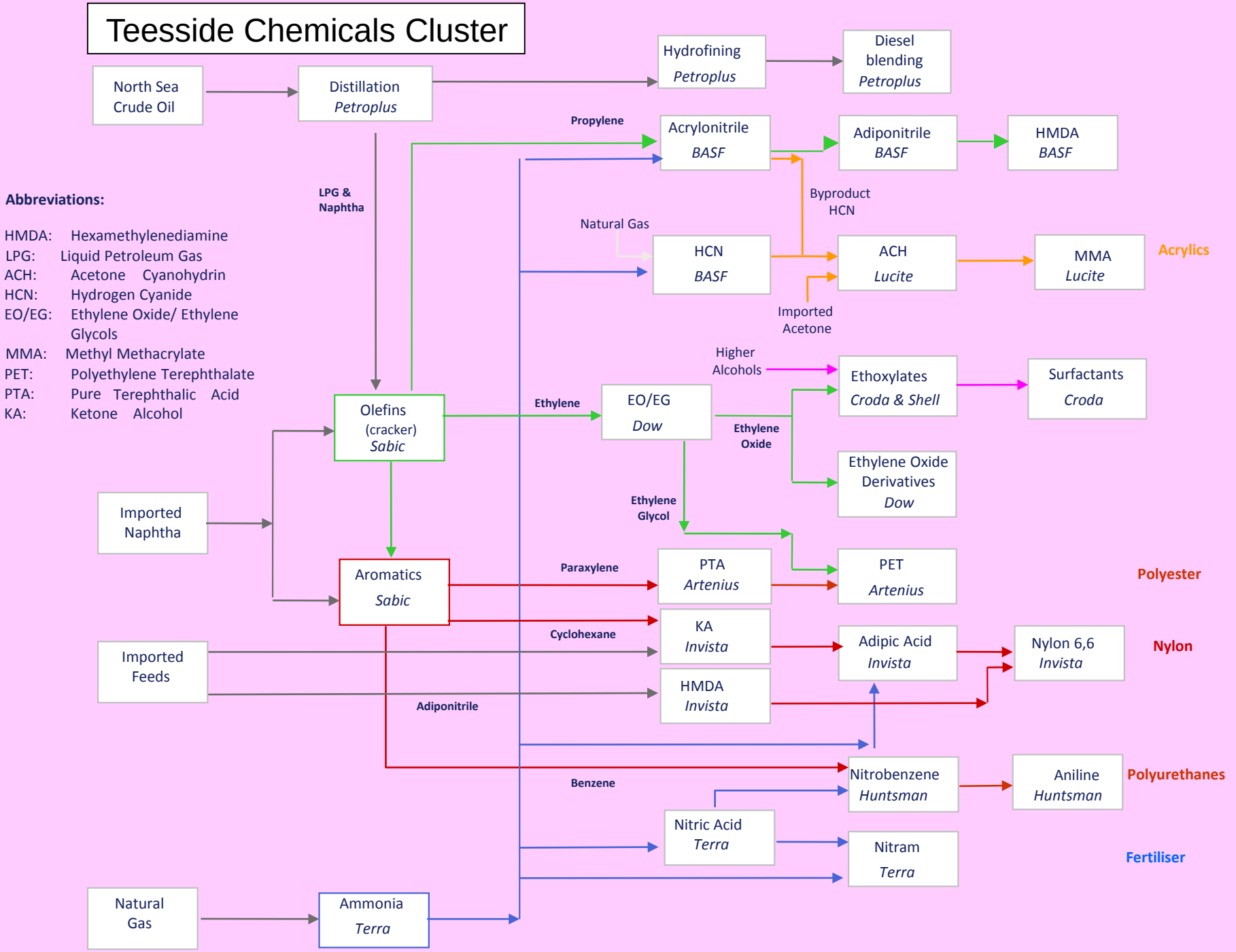
NB: Raising money to build a plant that is not designed to make money is hard work!

Scale of investment & risk



US shale gas is now six times lower cost than Asia, leading to a marked difference in Ethylene cost ($316/ton vs. $1,717/ton)

Teesside Chemicals Cluster

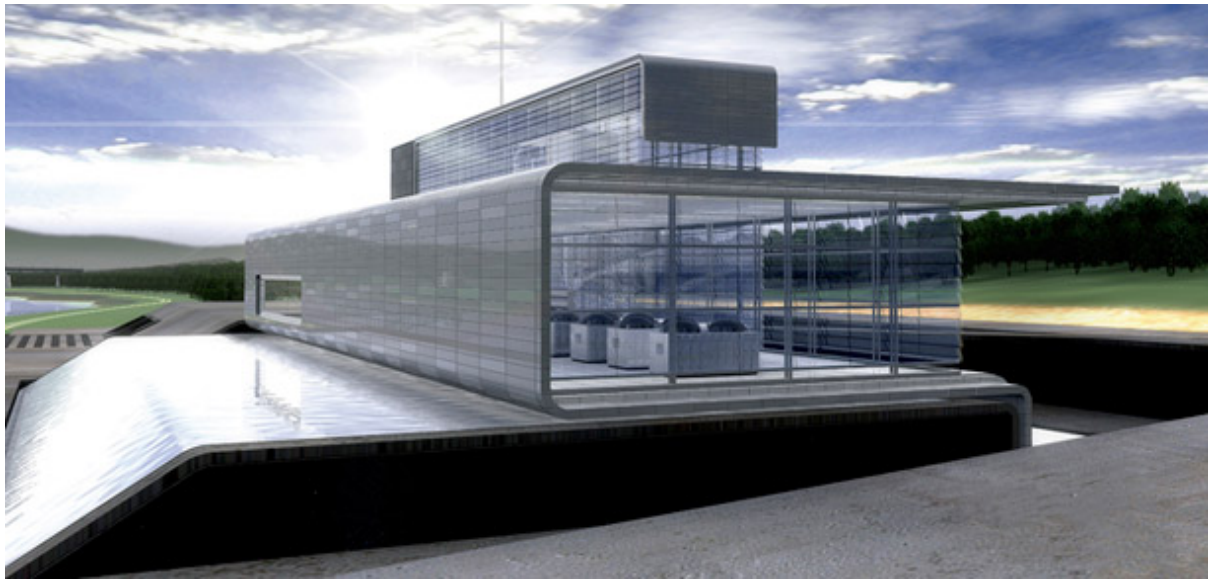


Abbreviations:

HMDA: Hexamethylenediamine
LPG: Liquid Petroleum Gas
ACH: Acetone Cyanohydrin
HCN: Hydrogen Cyanide
EO/EG: Ethylene Oxide/ Ethylene Glycols
MMA: Methyl Methacrylate
PET: Polyethylene Terephthalate
PTA: Pure Terephthalic Acid
KA: Ketone Alcohol

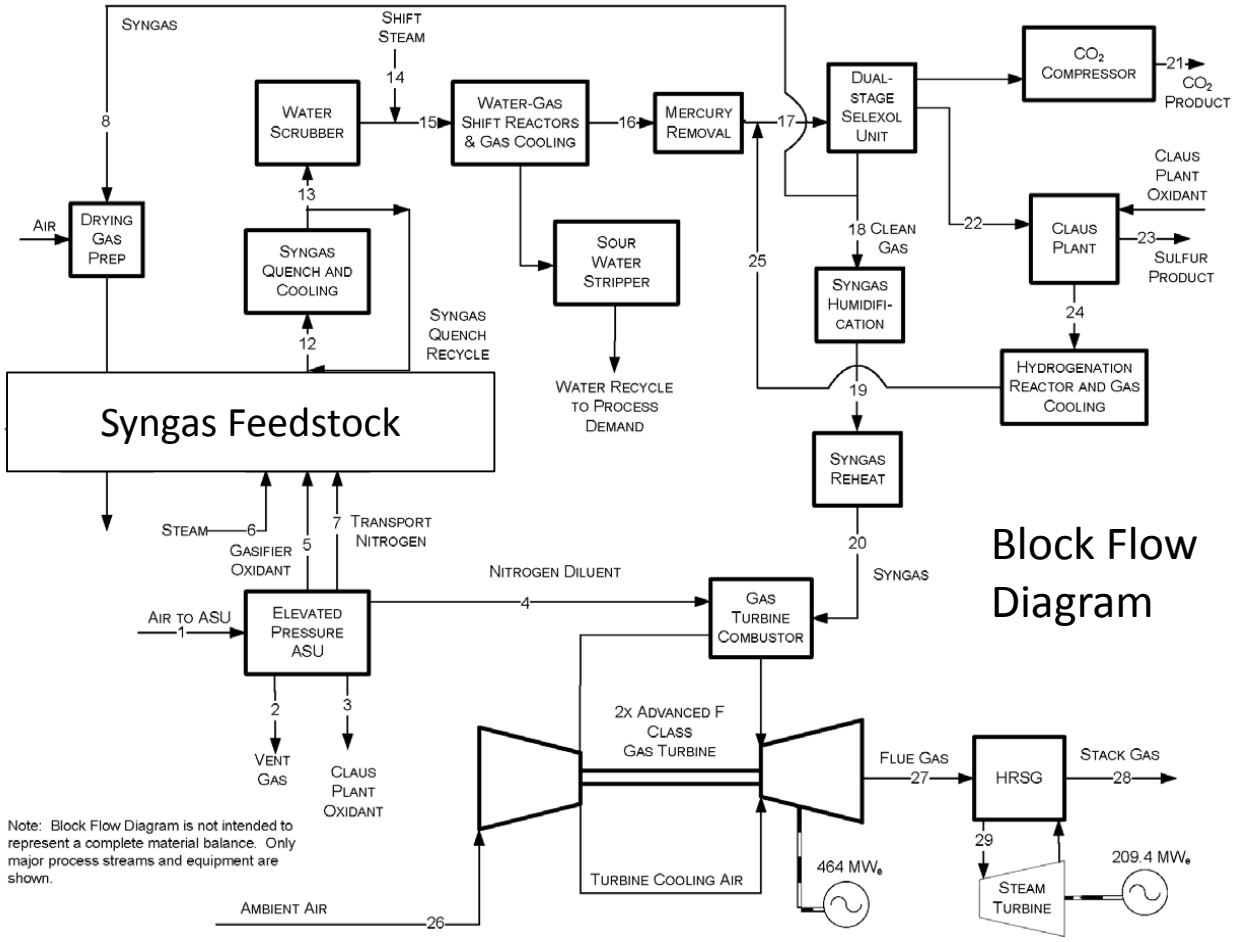
Gas-to-wire

- Mode of running?
- Power Purchase Agreement?



Clean Power Plant. *Artist impression*

Similar concept to IGCC-CCS



Block Flow Diagram

Getting the PR right

Noise & Nuisance

Aquifers

Seismicity

Gas explosions

Wildfire

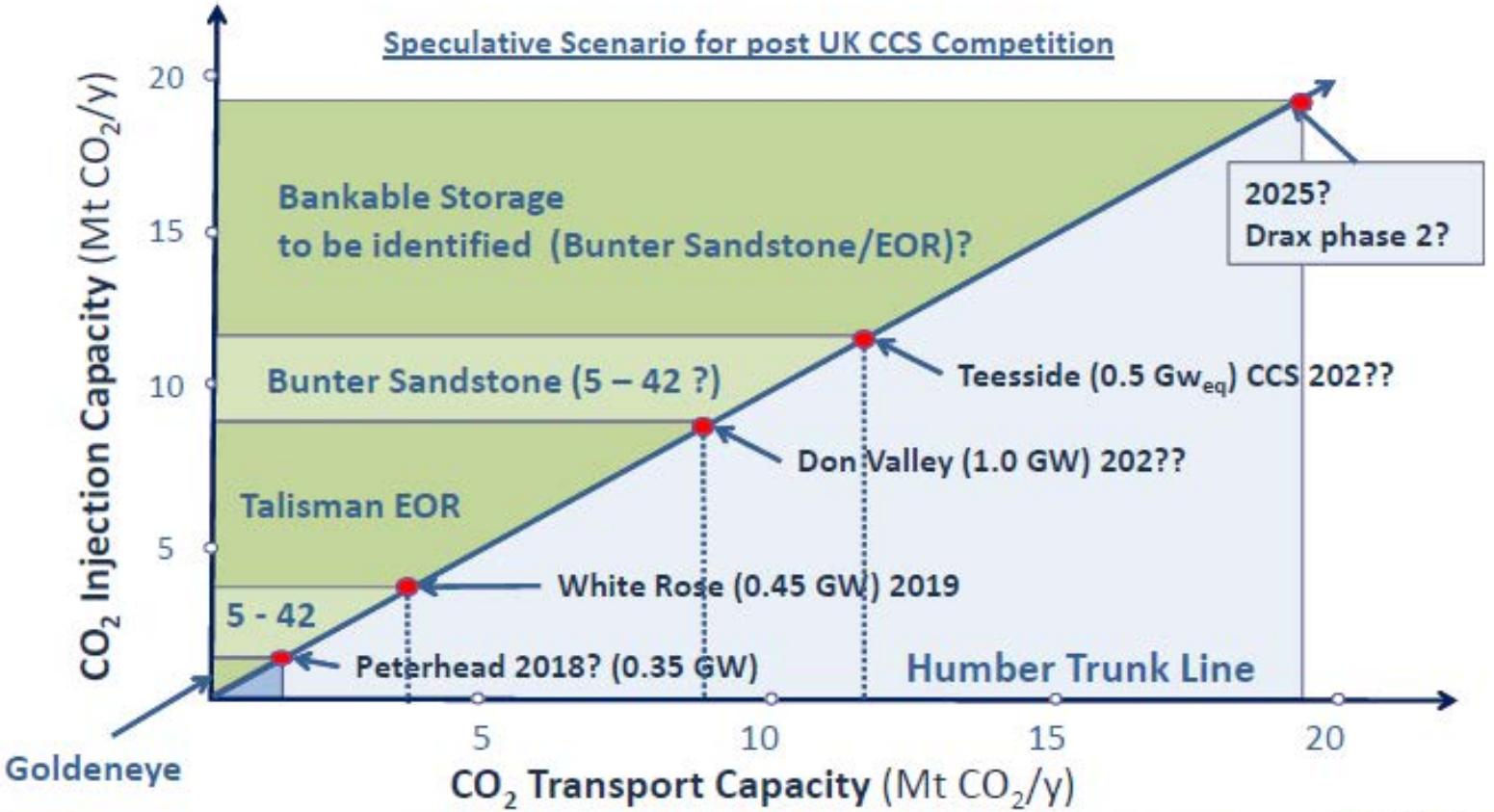
Metal and organic substances

Pollution migration and leaks

Expect more intense questioning at larger scale

CCS Deployment Timeline (to 2025)

20 Mt CO_2 CCS could be realised by 2025 (c.a. 3-4 GW equivalent)



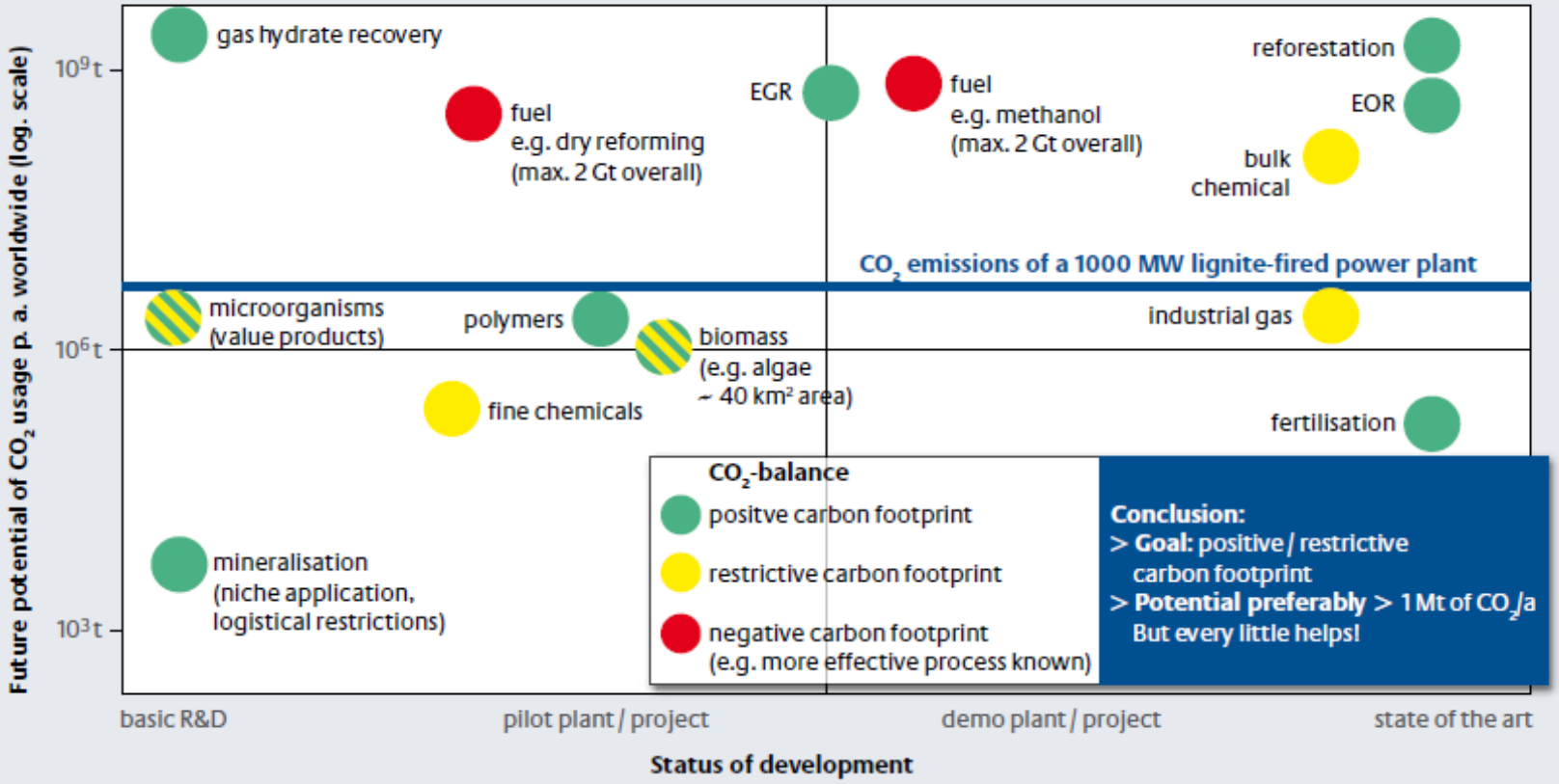
1 GW = +/- 5 Mt CO_2 coal based CCS and +/-2.5 Mt CO_2 gas based

Greenhouse gas issues

- What % of CO_2 is captured from raw syngas?
- Starting when?
- Where to store it? When?
- Who is accountable for CO_2 storage facilities?
- Mandatory or voluntary?
- GHG emissions arising in the gas processing plant itself?
- Carbon footprint of your utility supplies eg electricity for the ASU?
- GHG emissions during construction?
- Fate of CO_2 arising from use of the gases that you sell to others?
- Some may wish to draw the boundary much wider than your facility and compare with alternative routes to various end products from different raw materials

Products from CO_2

Figure 2: Estimation of future CO_2 utilisation potential: technology map



Source: Dr. Johannes Ewers

SHE management topics (part of licence-to-operate)

- Air separation unit
- Auditing
- Borehole design
- Borehole integrity
- Borehole integrity testing
- COMAH case
- Commissioning
- Control of plant modifications
- Control of drilling
- Decommissioning of boreholes and cavities
- Demonstrator unit
- Dispensations
- Effluent and waste treatment
- Emergency preparedness
- Emergency shutdown of DGW® reaction
- Engineering/maintenance procedures
- Engineering standards
- Environmental impact of drilling
- Fire protection
- Gaseous emissions
- Groundwater contamination
- Hazard studies and design reviews
- Inspection and testing of pressure vessels
- Instrumented protection systems
- Isolation of equipment for maintenance
- Job handover processes
- Layers of protection analysis (LOPA)
- Legislation
- Liabilities
- Mitigating operational risks during DGW® operations
- Monitoring
- Multilayer controls
- Natural gas and methane
- Occupational health
- Operating procedures
- Overhauls
- Pipelines
- Pressure relief
- Prior to drilling
- Regulatory authorities
- Reporting
- SHE culture
- Site selection
- Startup and shutdown procedures
- Storing CO_2 in DGW® cavities
- Subsidence
- Syngas
- Tar formation and recovery
- Technical safety case
- Transport logistics
- Well engineering

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