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Hydrocarbon Production vs. Carbon Dioxide Injection Infrastructure Considerations

Murray Anderson

Outline

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1. Background.
2. Comparing the Behaviour of Carbon Dioxide with Natural Gas.
3. Implications of Carbon Dioxide Behaviour for System Modelling and Operation.
4. Transport and Storage System Operation.
5. Conclusions and Discussion Points.

UK Industrial Decarbonisation – Published Strategy

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UK Government Published "Industrial Decarbonisation Strategy" in March 2021

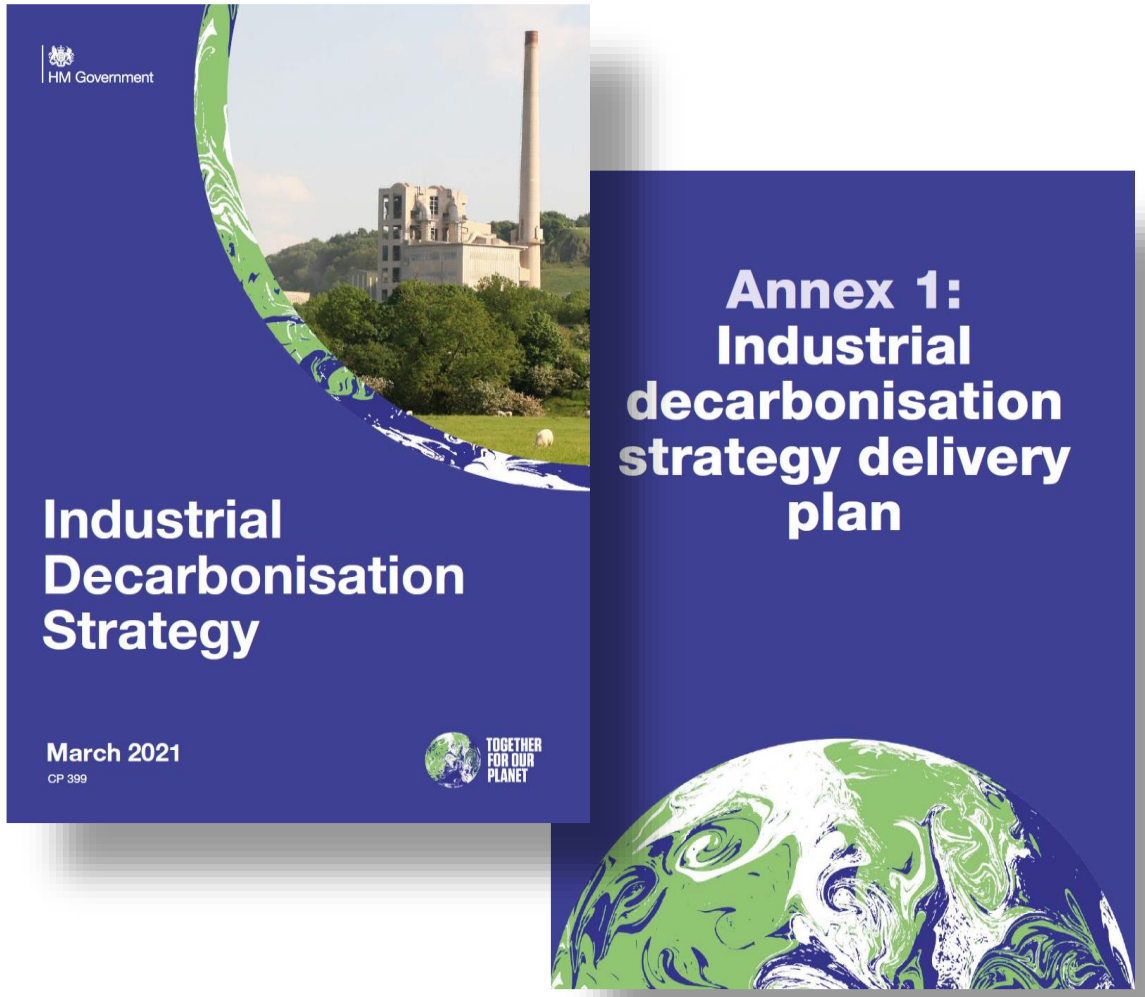
The Delivery Plan identifies

- Carbon Capture, Usage and Storage
- Low Carbon Hydrogen

as key elements of industrial decarbonization.

Carbon Capture is essential for energy-intensive, hard to abate industries:

- steel
- petrochemicals
- aluminum
- cement
- fertilizers



https://www.gov.uk/government/publications/industrial-decarbonisation-strategy

UK Industrial Cluster Sequencing and Implementation

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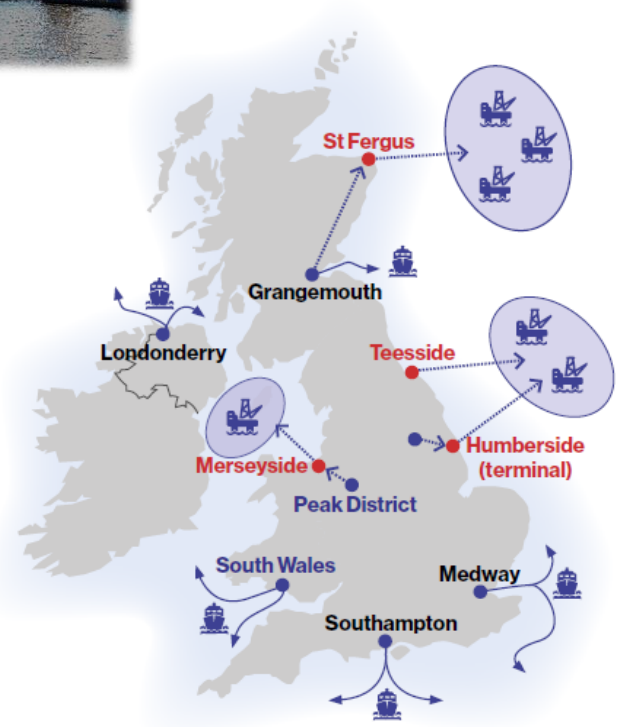
19 October 2021:

Minister of State for Energy, Clean Growth and Climate Change confirmed the UK commitment to funding CCUS at pace and at an industrial scale in a Parliamentary Statement

The statement identifies Hynet (Merseyside) and East Coast Cluster (Teeside/Humberside) to be taken forward into Track-1 negotiations. Scottish Cluster (St. Fergus) is identified as a reserve cluster.



Press reporting on CCUS included comments about "easy to implement by putting existing infrastructure into reverse".

But how true is that?

Natural Gas Production – Transmission Infrastructure

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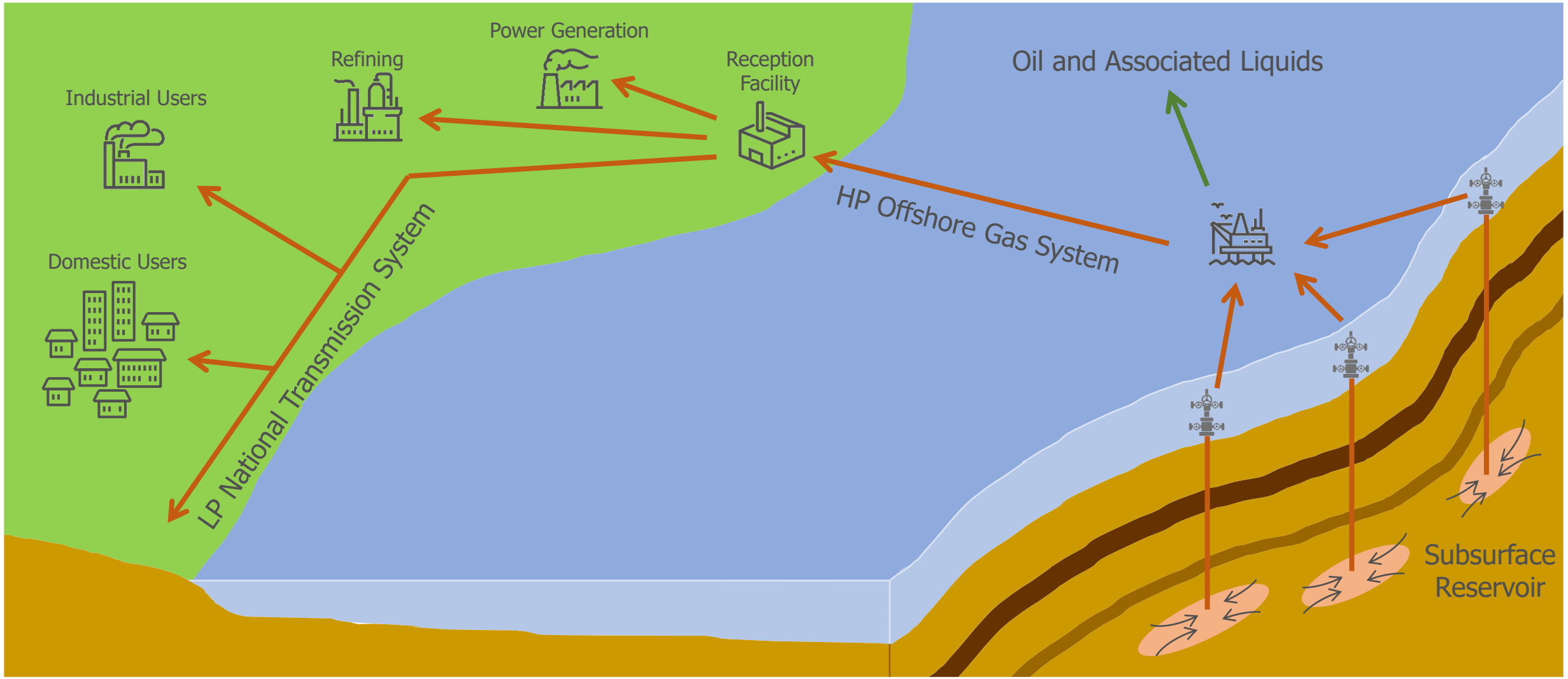

CCUS Cluster - Transport and Storage Network

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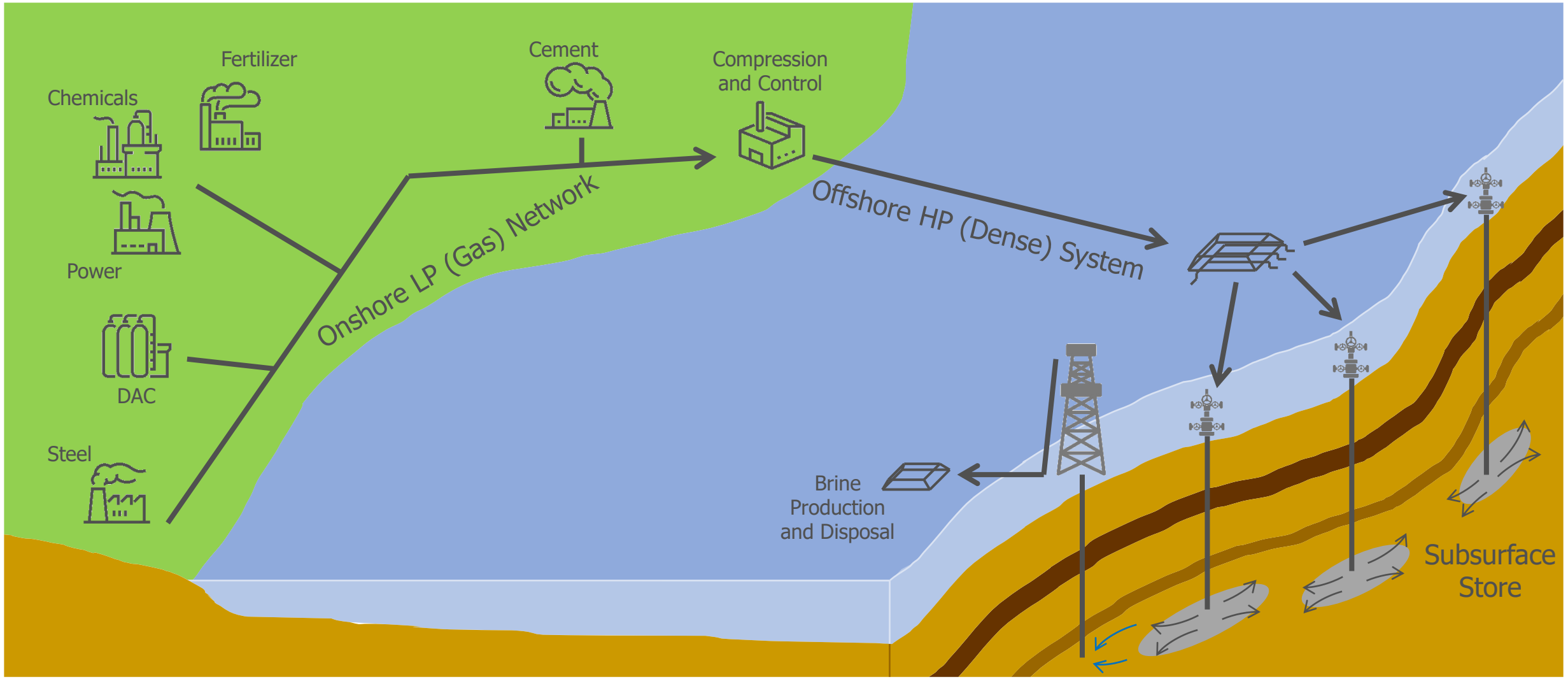

Carbon Dioxide versus Natural Gas

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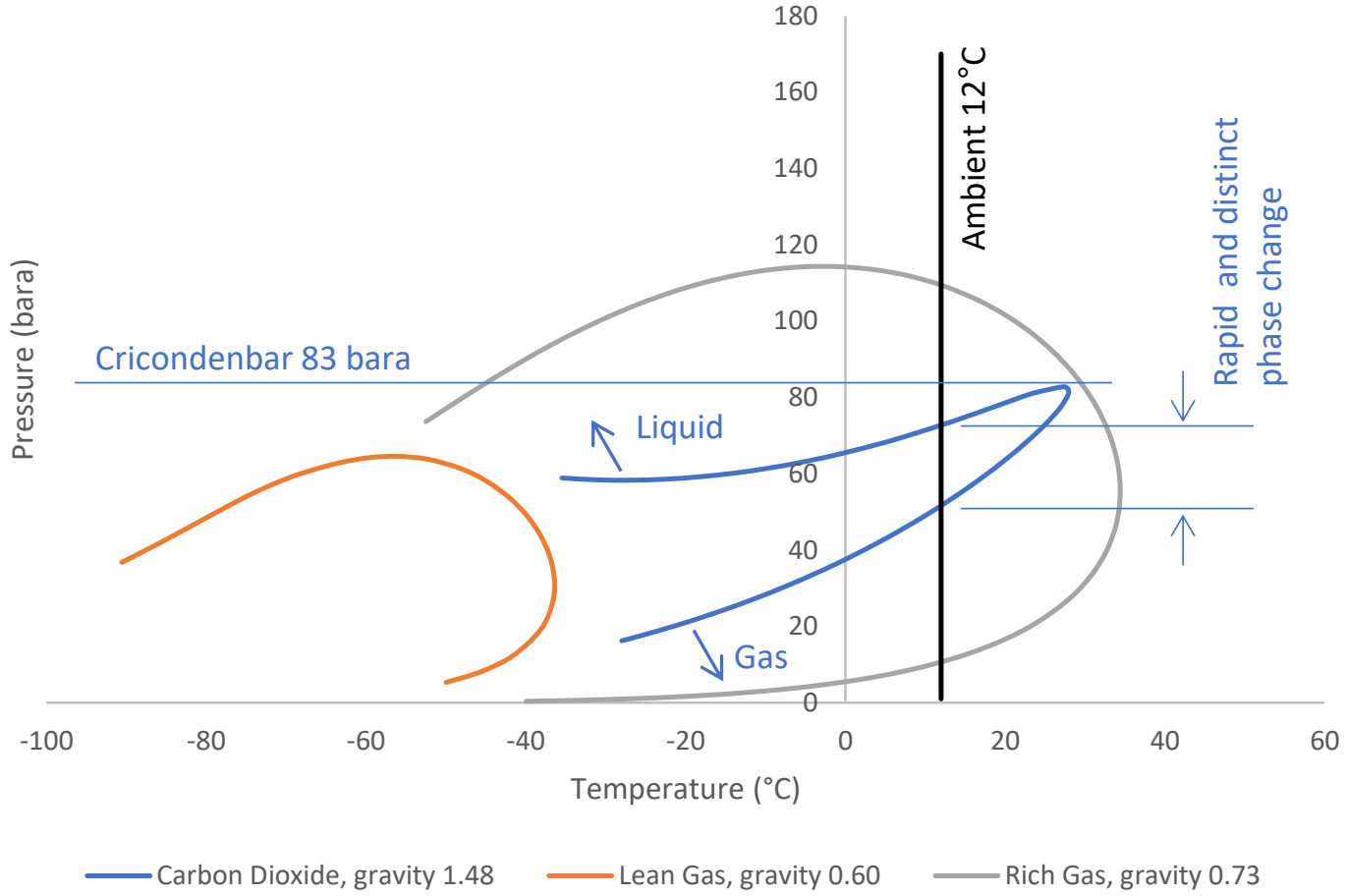
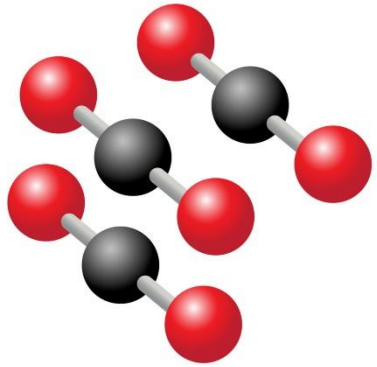
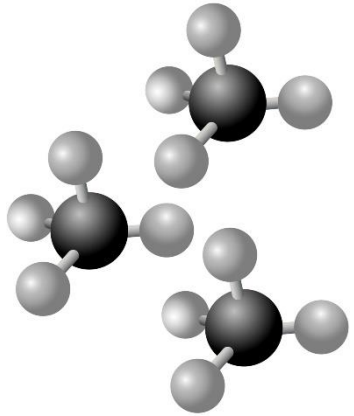




Carbon Dioxide
44.01 g/mol



Methane
16.04 g/mol

Carbon Dioxide Stream:

Carbon Dioxide	95.0 mol%
Nitrogen	3.9 mol%
Hydrogen	1.0 mol%
Carbon Monoxide	0.1 mol%
Water	50 ppm
Oxygen	10 ppm
Hydrogen Sulphide	5 ppm

Natural Gas Stream:

Methane	91.3 mol%
Ethane	3.4 mol%
Propane	0.8 mol%
Butane	0.3 mol%
Pentane	0.1 mol%
Nitrogen	3.4 mol%
Carbon Dioxide	0.6 mol%
Oxygen	500 ppm
Hydrogen Sulphide	100 ppm

Pipeline Phase Change Risk

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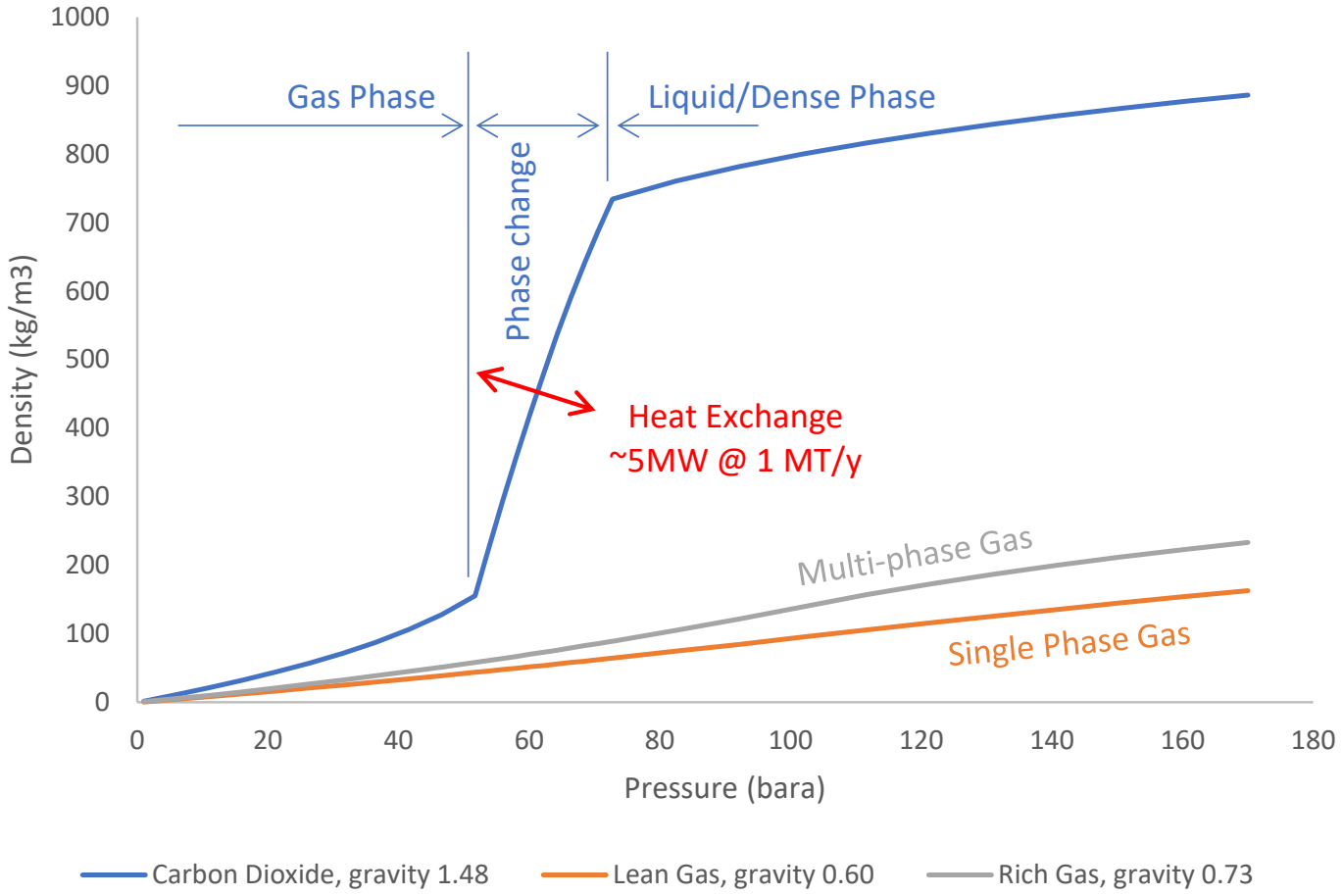
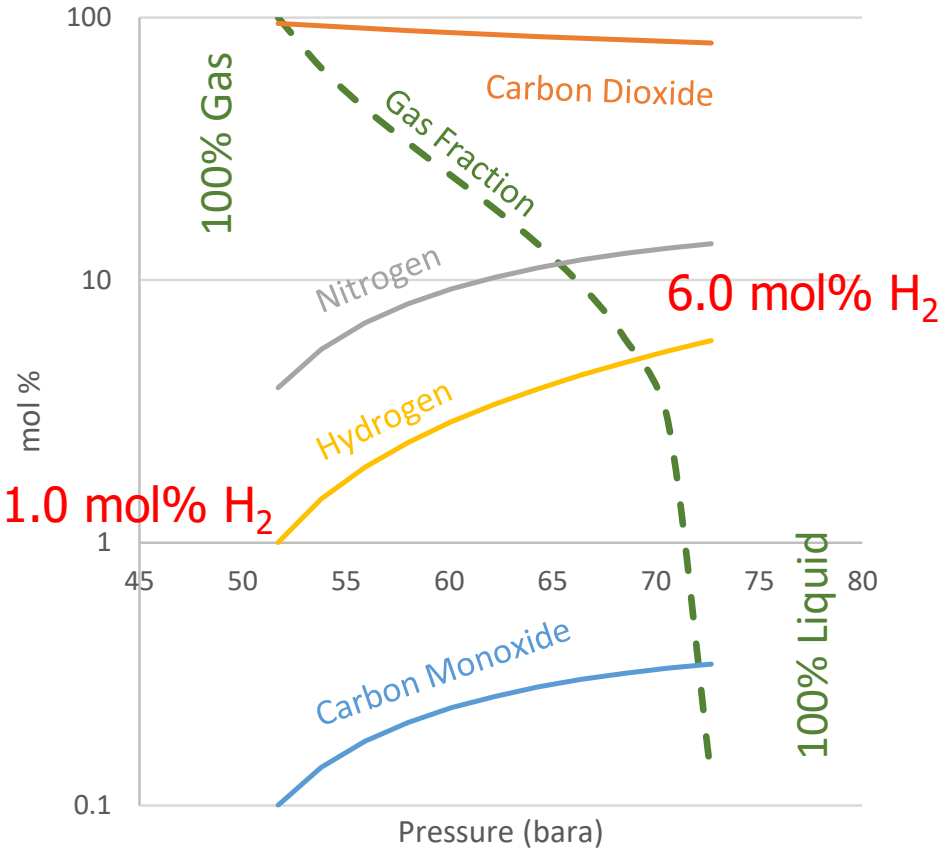
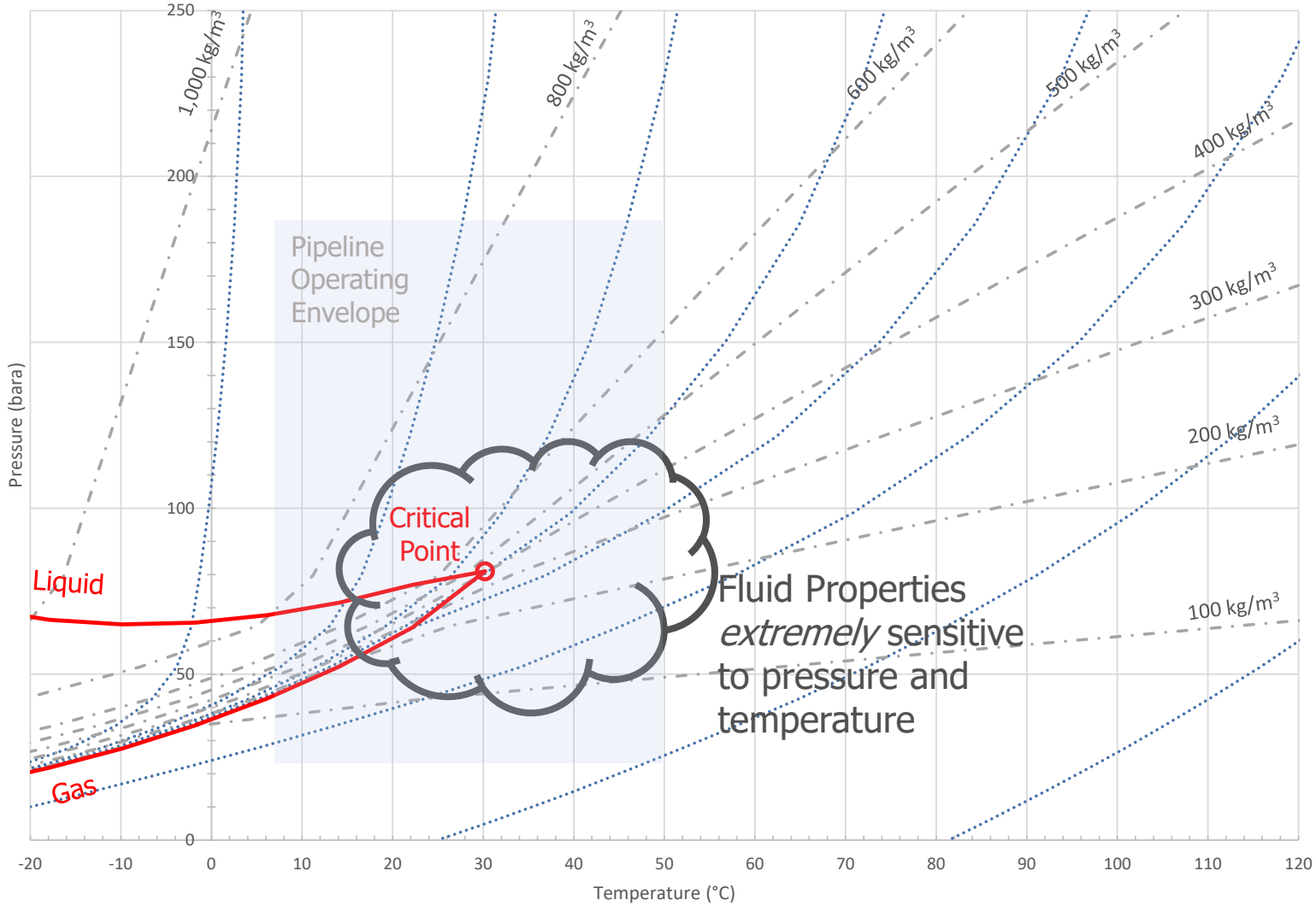


Overall Mixture Density at 12°C



Gas Phase Composition at 12°C

Fluid Property Estimates



Three issues:

1. Small changes in composition (non-condensibles) can change the chart
2. Small errors in pressure and temperature estimate lead to big errors in density or enthalpy estimate.
3. The chart probably isn't accurate anyway (state equation modelling and measured validation)

The overall sensitivity of any modelled result has to be checked: does a small change in one parameter lead to a significant change in operation?

Operability – Intermittent Supply

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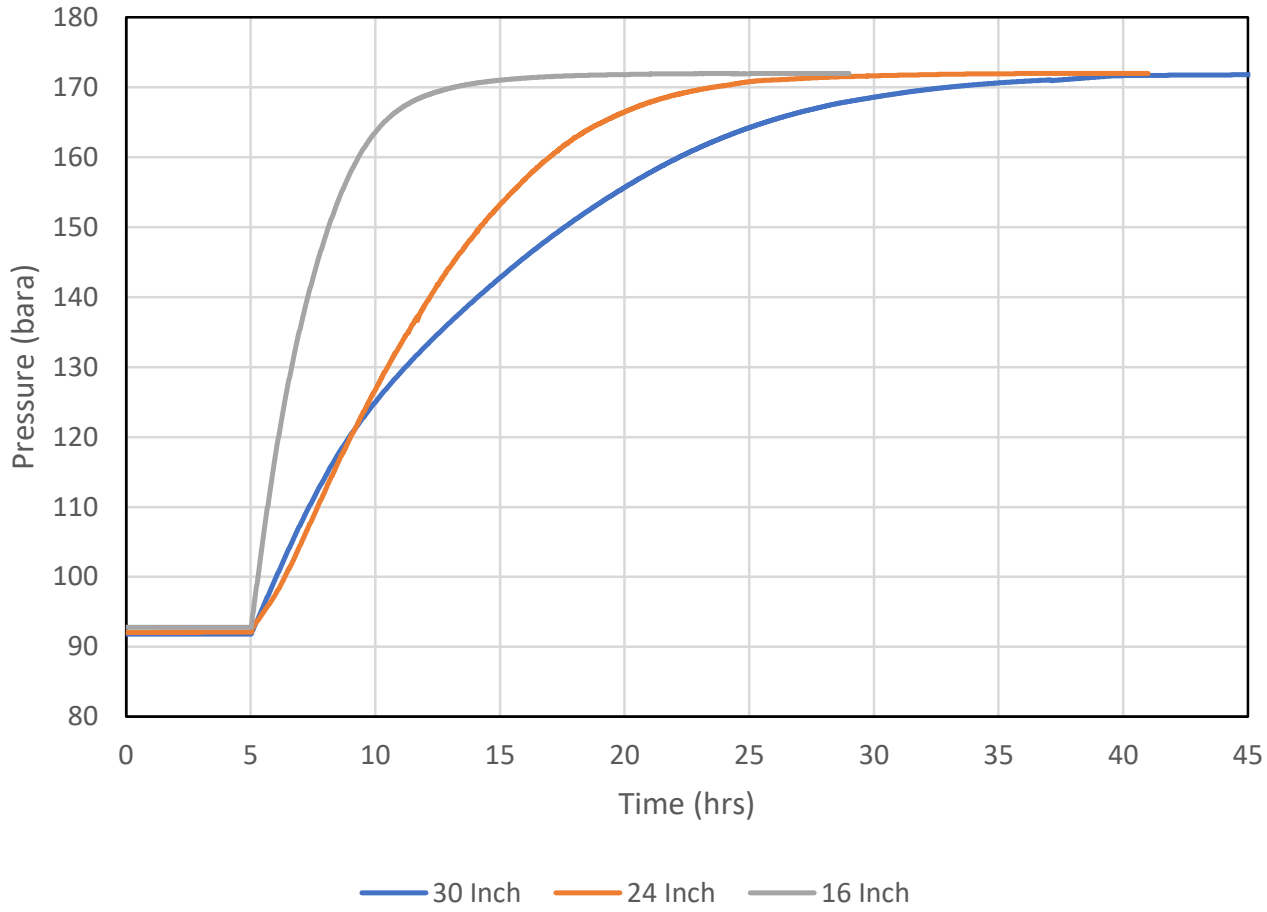
Injection wells need to maintain stable flow (between 0.25 and 1.0 MT/y per well)

Emitters do not necessarily deliver continuous emissions

For initial development and early operation, line pack or storage must address imbalance

Estimates suggest line pack times could be about a day (offshore), but operating procedures and supply agreements need to account for this.



What Might it Mean in Practice?

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Carbon Dioxide Service

Emitters don't emit continuously

Unification of Gas Specification

Wells/subsurface don't like frequent shut-downs

Unstable phase changes in wells

Production and disposal of displaced brine

Constricted range of operating pressures (single phase)

Detection of off-specification fluids (water, hydrogen bubble)

Predictability of corrosion (dense phase CO_2) and condition monitoring

Natural Gas Service

Steady Consumption (power, chemicals, NTS)

Fully mature market and predictable demand

Continuous Production

Predictable fluid behaviour in wells and pipelines

Less constrained operating pressure (cricondenbar)

Materials tested for natural gas service

Conclusions and Discussion Points

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1. **Carbon dioxide is a very challenging fluid to transport over long distances.**

   Offshore pipeline systems will operate close to the critical point.

   Is our understanding and modelling of the fluid behaviour at the critical point good enough?

2. **Understanding the fluid composition will be critical to stable, safe operations**

3. **Single phase operation requires:**

   1. Pressures below about 35 bara to stay wholly in gas phase
   2. Pressures above about 80 bara to stay wholly in dense phase

   Transport over long distances onshore may be challenging (safety issues with dense phase, large pipelines required in gas phase, potential requirement for multiple compression stations). Offshore transportation will be very challenging for low pressure stores (possible phase change in well-bore or formation).

4. **Balance between onshore emitter volumes and offshore injection rates**

   Particularly for low flow rates – one or two emitters on the system may give intermittent production, but wells require steady flow with a minimum turn-down.

5. **Is there a need for buffer storage, particularly when operating at low capacity?**

Contact locations

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For more information go to

www.crondall-energy.com

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