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Safe and Efficient Operation of Multi-Emitter CCUS Projects Using an Advanced Flow Management Tool

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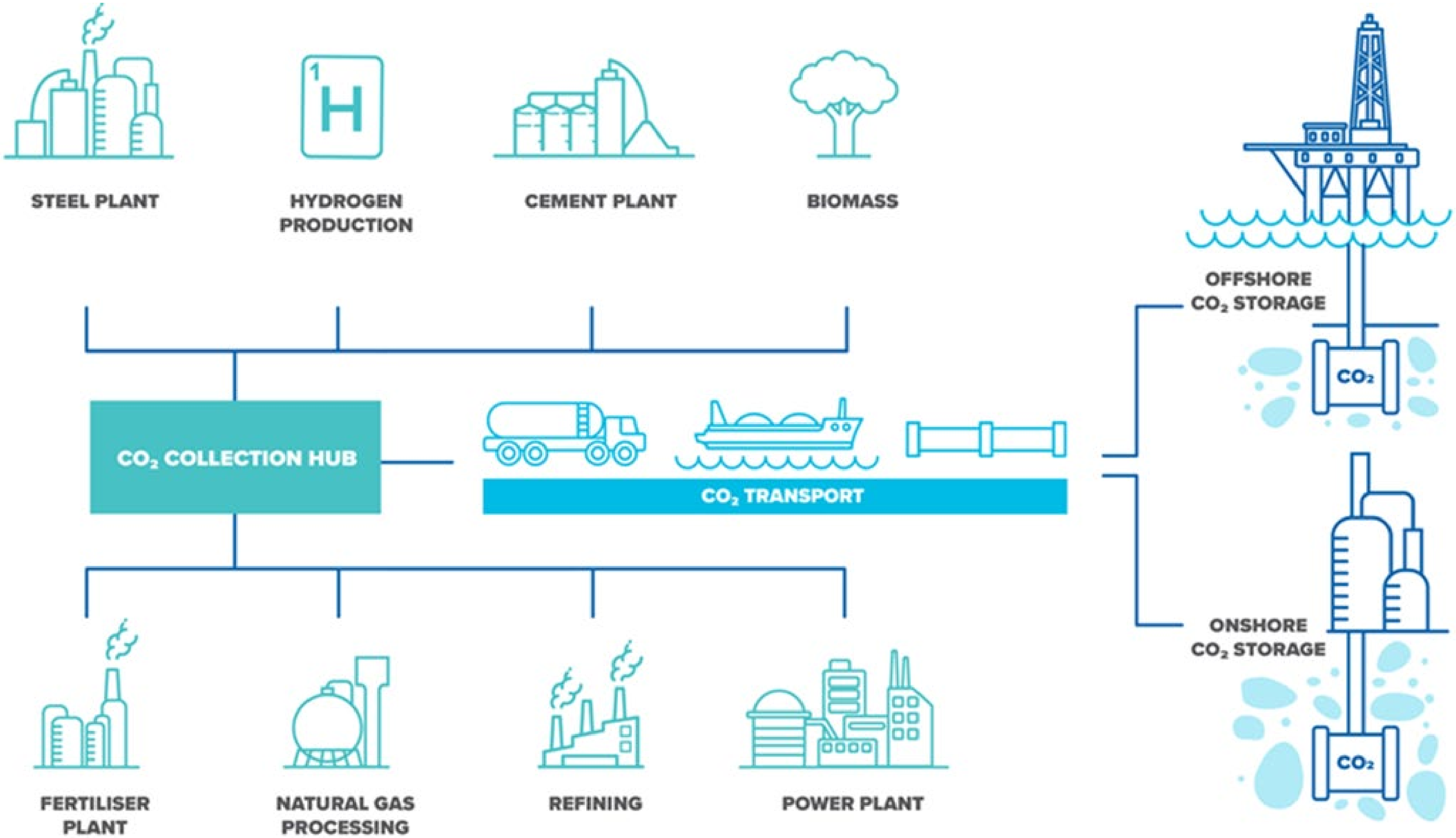
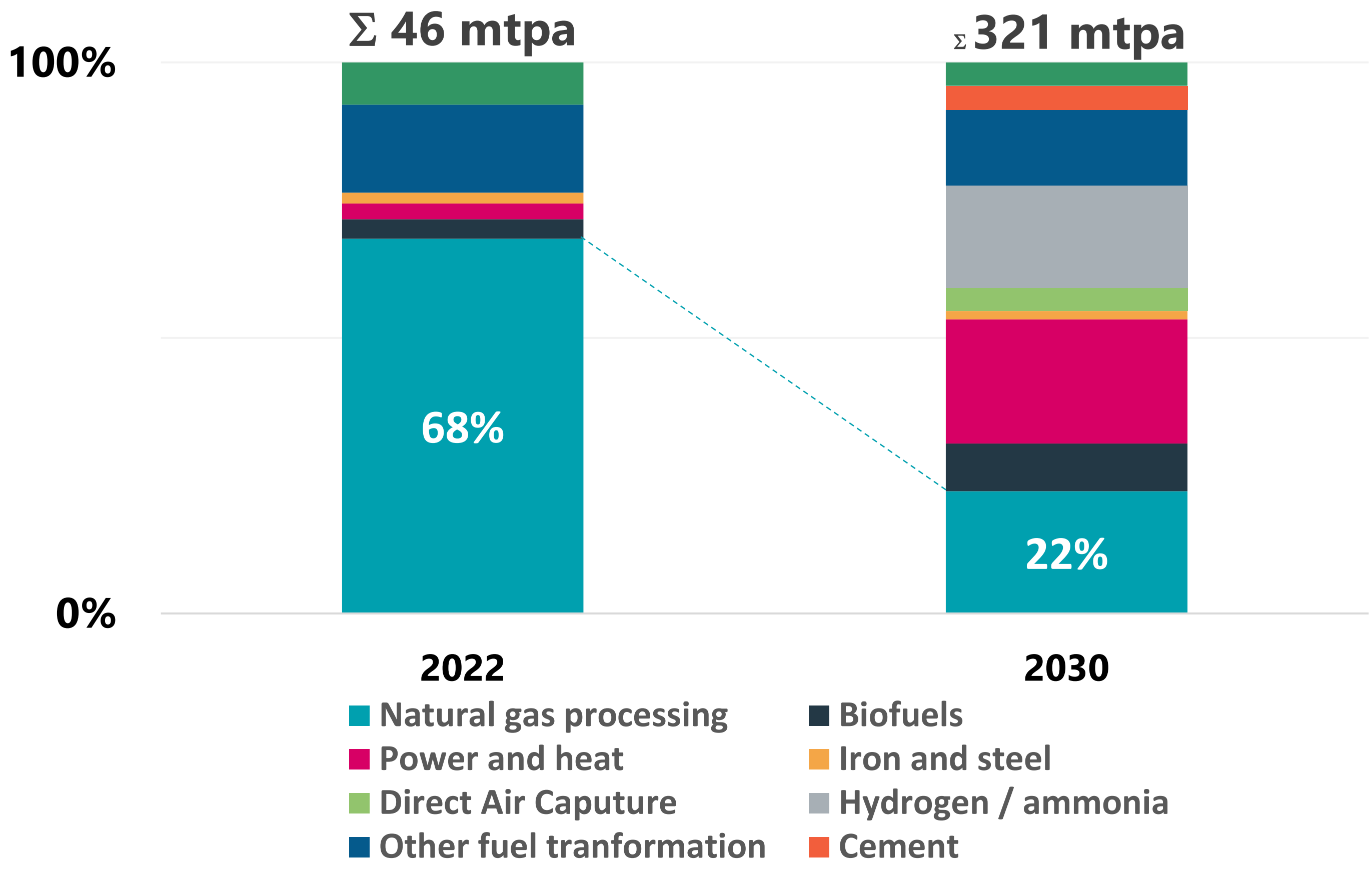
The CCUS Hub



Source: Global CCS Institute

CCS - growth and source diversification



Operational and planned capture capacity, IEA. Licence CC BY 4.0

2022 - momentum

140+ new projects announced
>30% increase in capture capacity

>80% increase in planned storage…

15 x FIDs (vs. 8 in 2021)
Climate pledges, rising carbon price

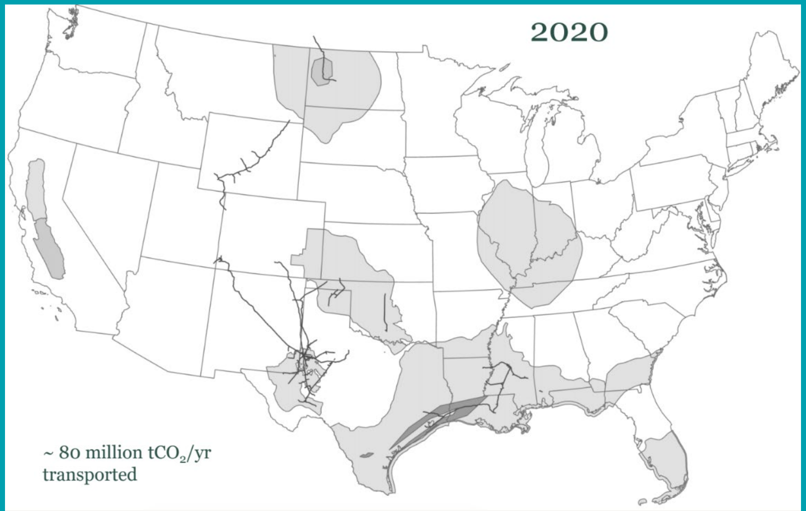
2030 - diversification

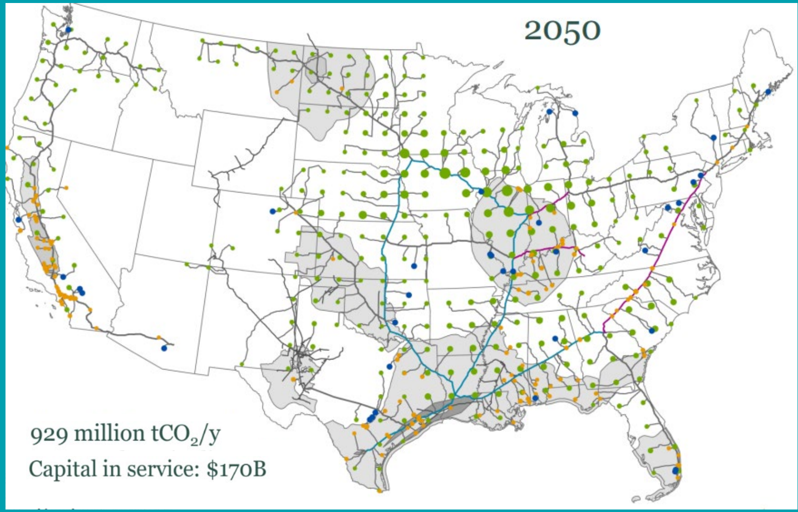
Multi-user CO2 transport and storage infrastructure business model….

Enabling for small-scale emitters to decarbonise their operations

Closing the transport gap

- Transport is often considered a ‘low-tech’ component of the value-chain…. however:
  - There are approximately **8,500 km** of CO2 pipelines operating today (primarily USA)
  - An additional **14,500 km** of CO2 pipelines are under development globally[1]
  - Net-zero carbon emissions by 2050 requires up to **106,000 km** of CO2 pipelines - USA alone[2]
- The challenge is both scale and technical – a vast expansion of pipelines managing varying CO2 sources and composition from multiple emitters connecting into central trunklines





Hub business model is evident – CO2 capture plants connect to trunk lines [21,000 km trunklines + 85,000 km spurlines[2]]

[1] Source: https://www.iea.org/energy-system/carbon-capture-utilisation-and-storage/co2-transport-and-storage

[2] Source: NETL Review of CO2 Pipelines in the United States, Princeton net-zero Americas, Great Plains Institute

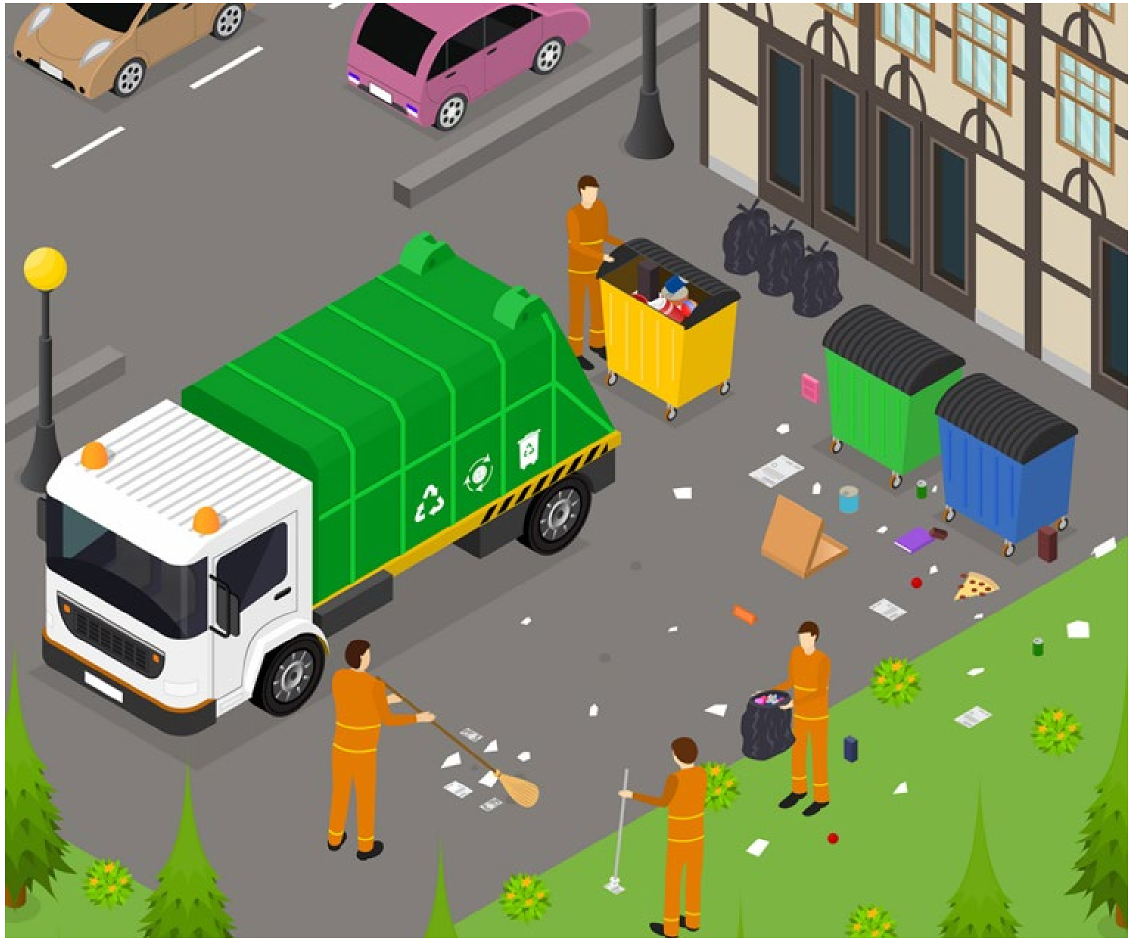
The Business Model

- Storage of CCUS is effectively the "waste management" business;

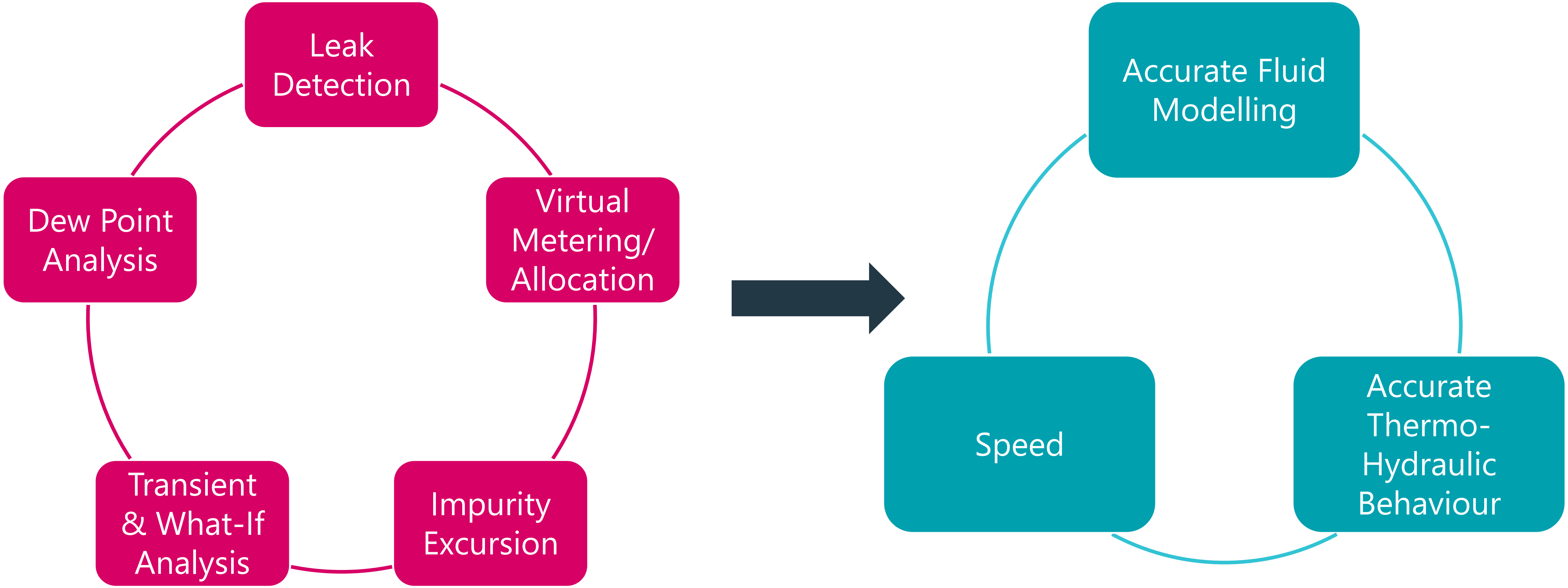
- We (the transportation hub) control the required quality (i.e. CO_2 specification);

- Excursions can occur, we need a robust design to withstand this:
  - Corrosion: acid gases such NOx, SOx, H_2S;
  - Corrosion, hydrates and phase split: Water, Amine, TEG/MEG;
  - Transient events

- Robust design can only go so far…



Uses & Requirements for a Flow Management Tool



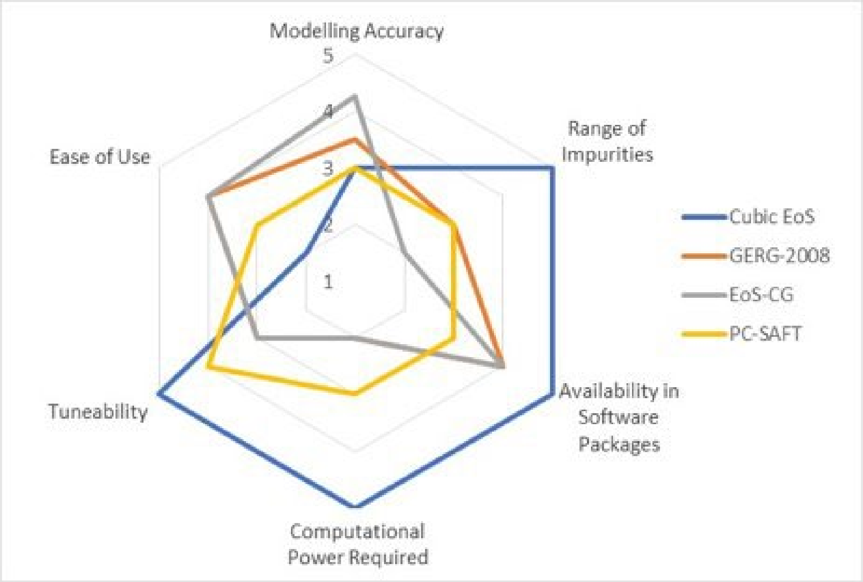
Fluid Modelling Accuracy

The Challenge:

- Equation of State (EoS) performance varies considerably depending on the requirement;
  - The thermophysical property of interest;
  - The phase;
  - Ability to model certain impurities;
  - Impact of impurities on bulk behavior (MEG/TEG, water, etc);
  - Required speed!

The solution:

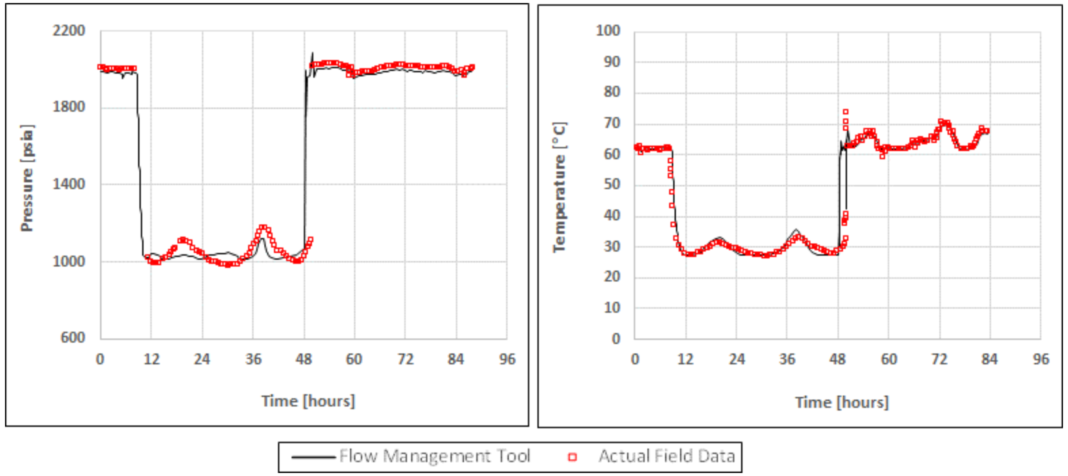
- Flexibility in the fluid modelling: use of cubic EoS for phase equilibria and GERG-2008 for density and enthalpy predictions

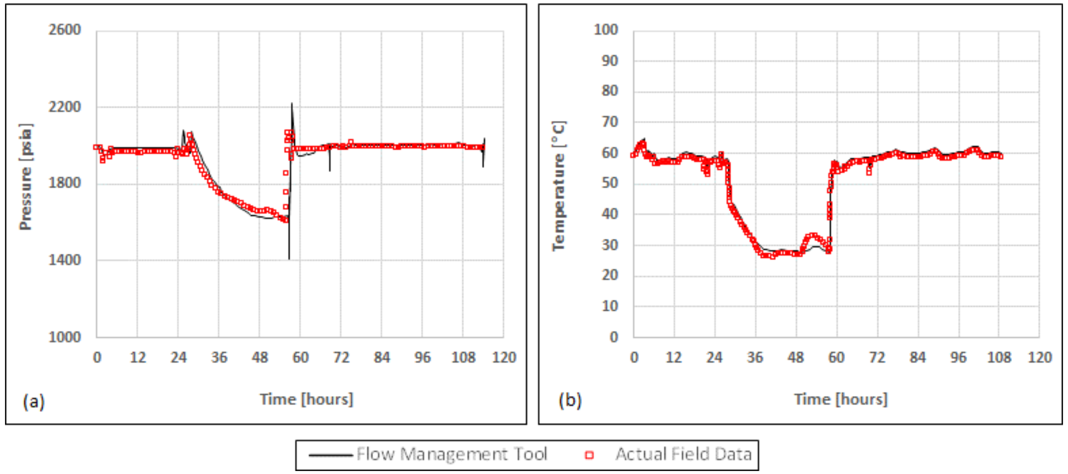


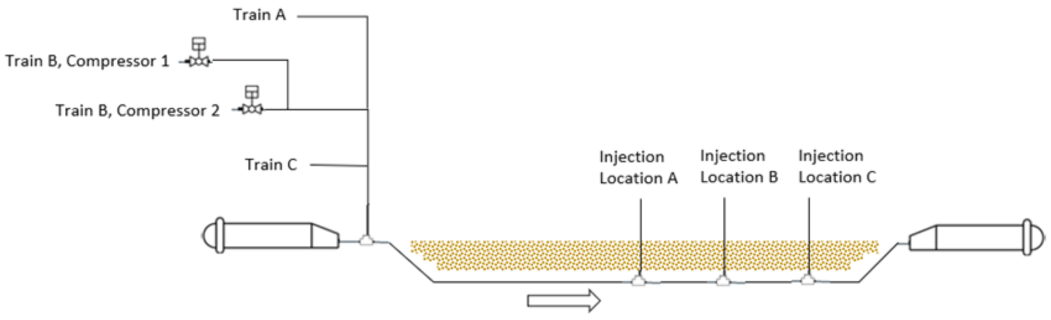
Note: There is no single EoS which is fit for all CCS modelling purposes

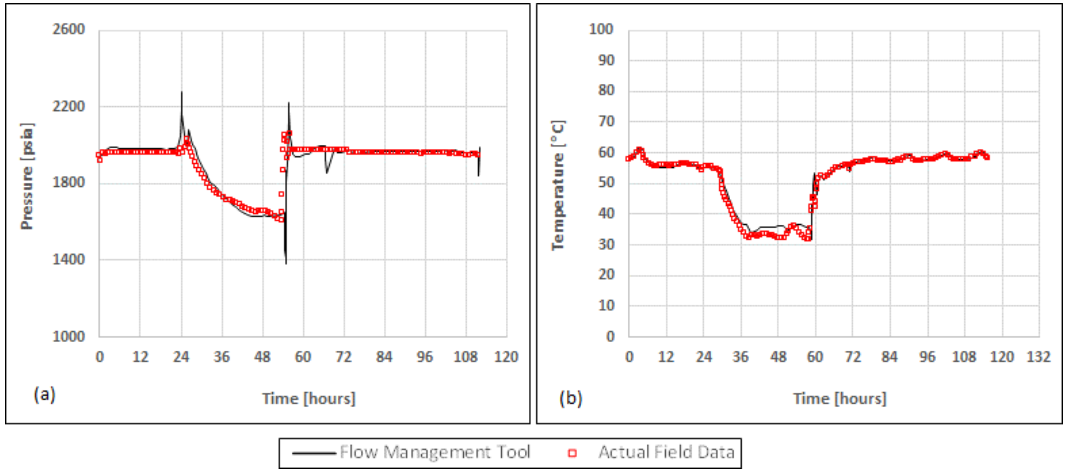
Thermohydraulic Modelling Accuracy

The FMT deployed on a CO_2 injection system, tuned to field operating data

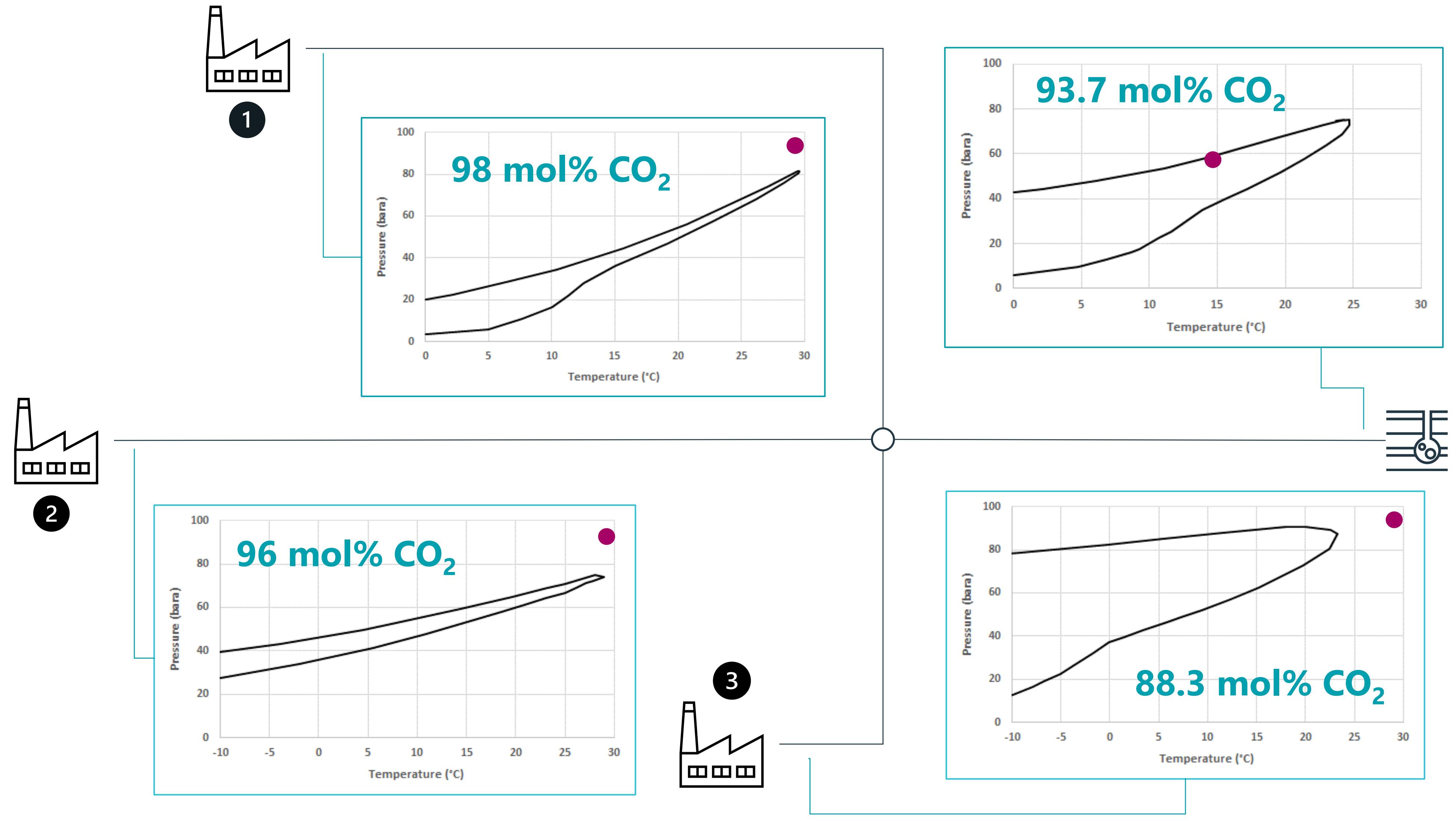








Use Case - Fluid Specification Excursion



Use Case -Dew Point Control & Transient Modelling

Challenge: Reliable thermodynamic properties of CO_2 rich mixtures.

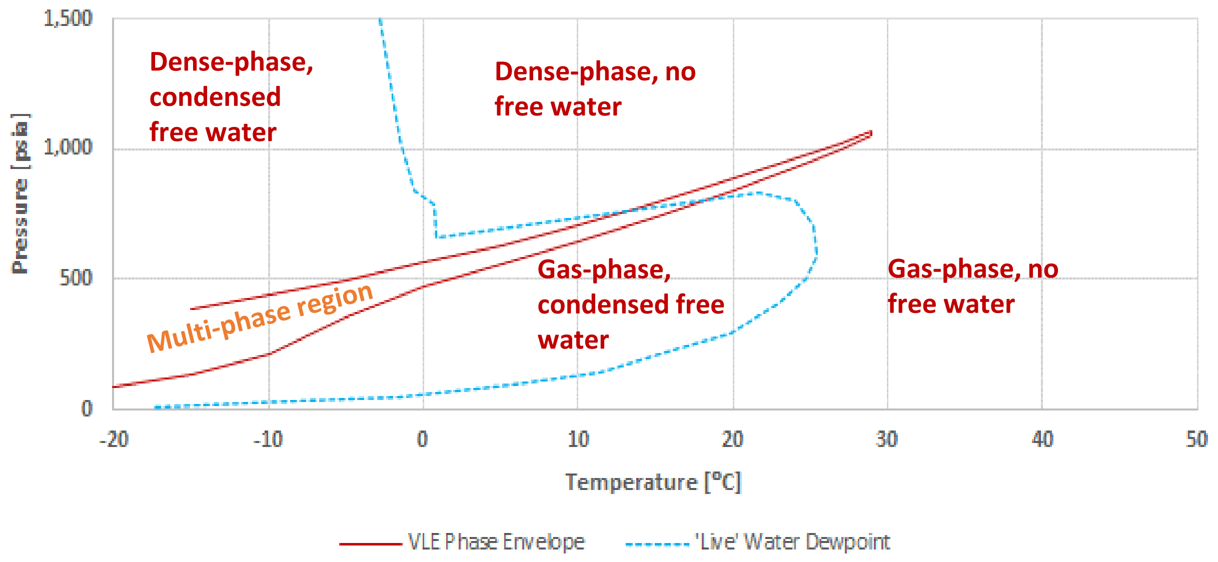
✓ Specialised EoS for water-CO_2 interaction, with GERG2008 for enthalpy

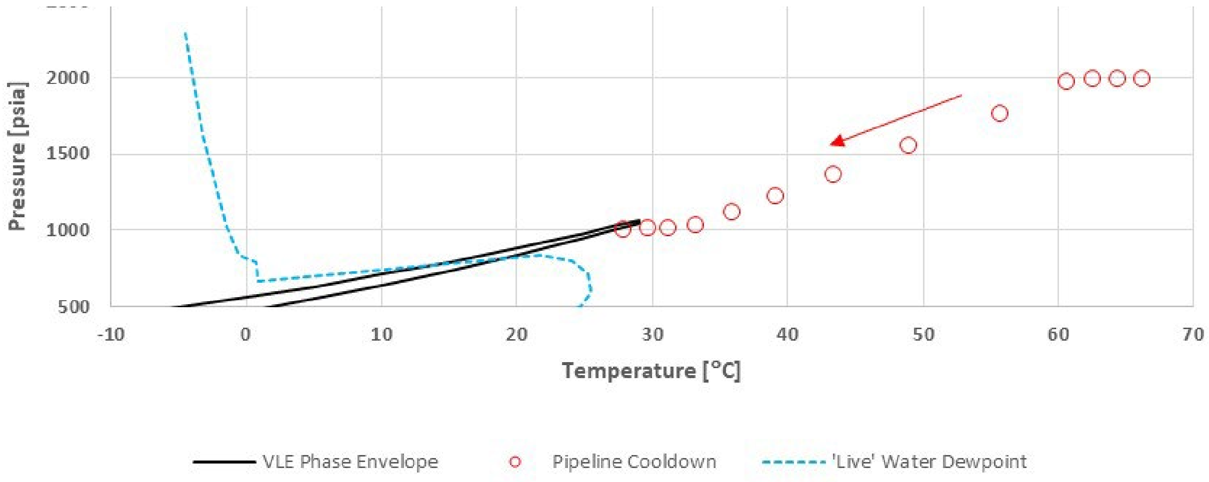
Challenge: A transient two-phase flow model which will account for several components and include a robust, accurate and efficient numerical method.

✓ Virial form of GERG2008 EoS for phase density curve fitting

Challenge: A thermal approach that accounts for CO_2-rich fluid enthalpy and enables tuning for buried vs exposed pipeline with varying seasonal conditions.

✓ Tuned for buried / exposed pipe as well as wet / dry soil conditions

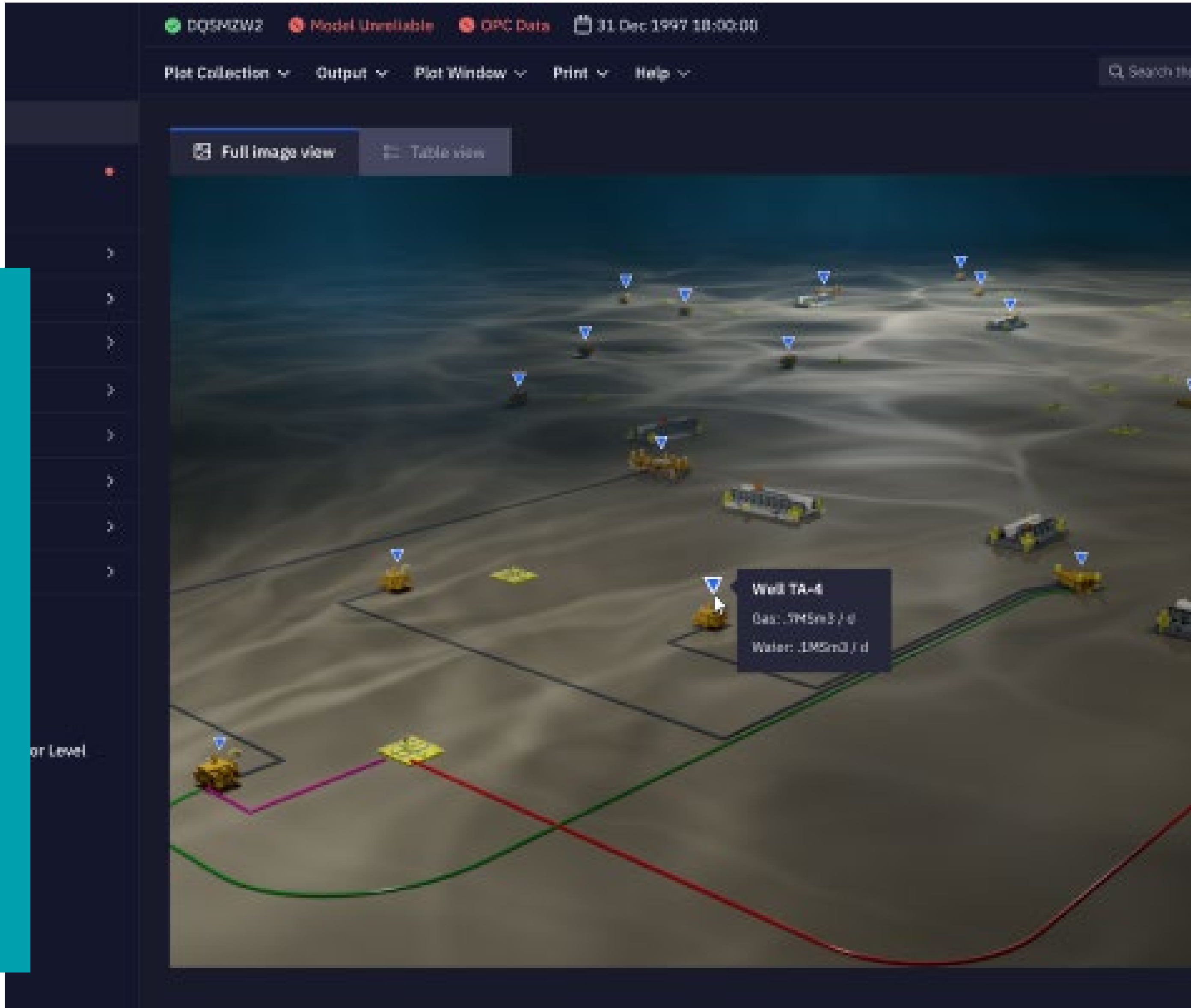




Conclusion

Many complex challenges to safe operation of CCUS hubs. The use of an advanced flow management tool can provide a benefit in the following ways:

- The speed to perform look-ahead forecasting for dew point and excursion mitigations/remediations.
- The fluid modelling accuracy to capture complex behaviour of CO_2-rich systems whilst maintaining speed;
- Thermohydraulic model tuned to operational data, with the flexibility to be further tuned to environmental conditions and reservoir properties



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