A review of problems and methods of optimising sensor grids for CO_2 pipeline transport networks

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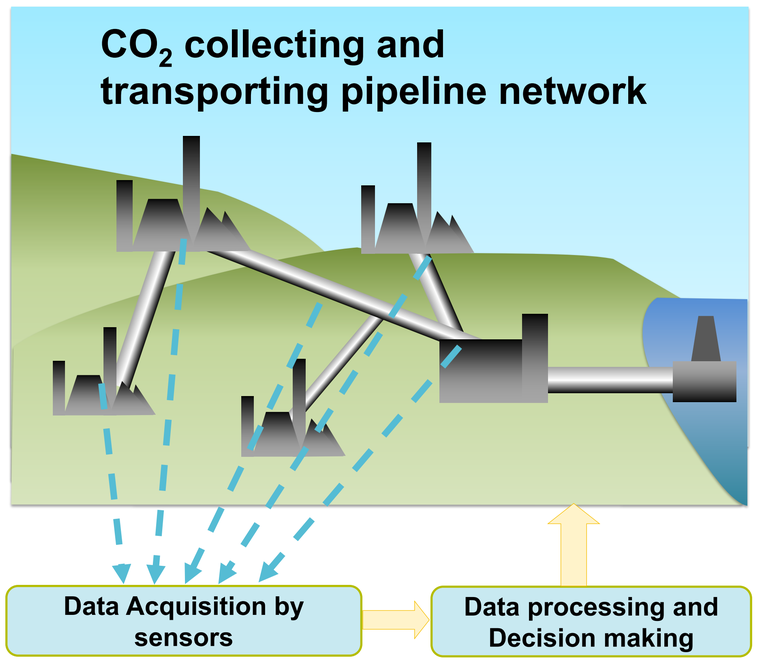
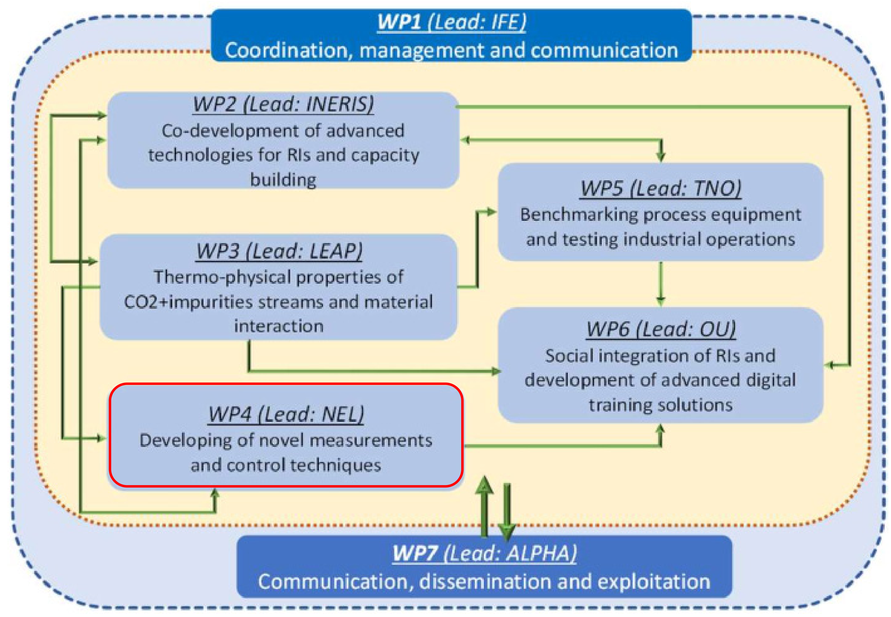
1 Background

- In Carbon Capture and Storage (CCS), pipelines provide the most economical and safe way to transport CO_2, [2].
- Monitoring and Control (M&C) of CO_2 transporting pipelines are essential for various purposes, e.g., flow assurance and anomaly detection, [3].
- Optimal sensor placement is one of the main parts of optimising the monitoring system.

M&C feedback loop



ENCASE project [1]



2 Aims of the literature review

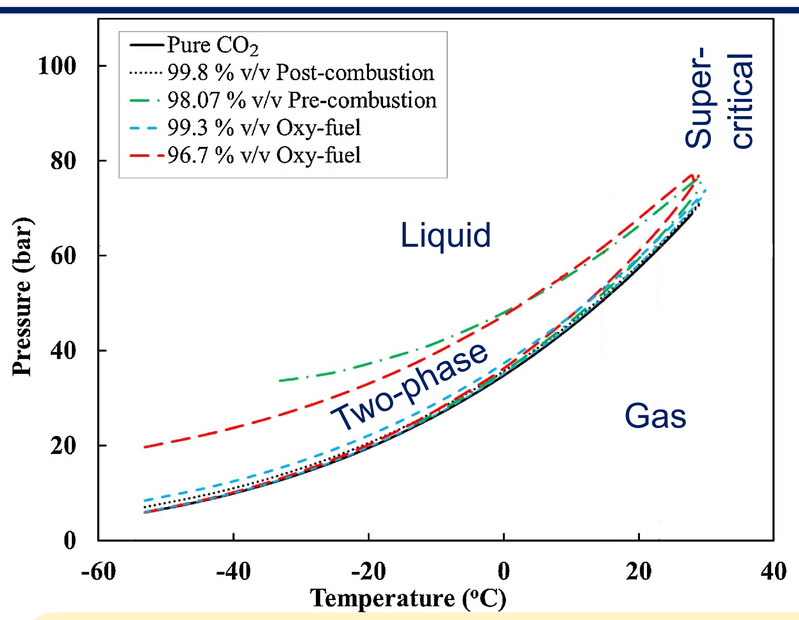
1. Identify objectives for monitoring of non-CO_2 (water, oil, natural gas) pipeline systems that are necessary for monitoring CO_2 pipelines.
2. Classify optimisation problems and the relevant algorithms of optimal sensor placement for the objectives in 1.

3 The literature review findings (1): Monitoring system objectives

Transported fluid	Leak Detection	Components	Flow control	Fluid Phase
Water	✓	✓ (Contaminants)	✓	Not relevant
Oil	✓	Not relevant	✓	Not relevant
Natural gas	✓	Not relevant	✓	Not relevant
CO_2	✓	✓ (Impurities)	✓	✓

4 The literature review findings (2): Sensor placement optimisation problem and algorithms [4][5][7][8]

Monitoring system objectives	Optimising variables	Algorithms/ Methods
Leak detection	Sensor locations, detection probability, detection time, the number of sensors	Genetic Algorithm, Greedy Algorithm, Multi-Integer Linear Programming (MILP)
Components detection	Detection time, detection probability, the number of sensors	Genetic Algorithm, K-means clustering, Multi-Objective Evolutionary Algorithm (MOEA)
Flow control (flow rate/pressure)	Sensor locations, pipe coverage, measurement accuracy, the number of sensors	Genetic Algorithm, Monte-Carlo approach



p-T saturation lines for CO_2 mixtures [6]

5 Special concerns for CO_2 pipelines

- The phase of CO_2 stream is sensitive to impurities (see the plot on left), a wide range of two-phase area with low impurity level, adding the difficulty to the flow assurance.
- The operation conditions for CO_2 transport (especially in the supercritical phase) are different from other pipeline systems, e.g., the temperatures are to be monitored for the flow assurance.
- Fluid phase needs to be directly measured or computed to avoid two-phase flow.

6 Conclusions

- The literature review findings can be used to inform optimising monitoring of CO_2 pipelines.
- Special adaptations (e.g., monitor fluid phase and temperature) are needed for the flow assurance due to CO_2 physical behaviours.

7 References

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