Flexible CCS Network Development

FleCCSnet

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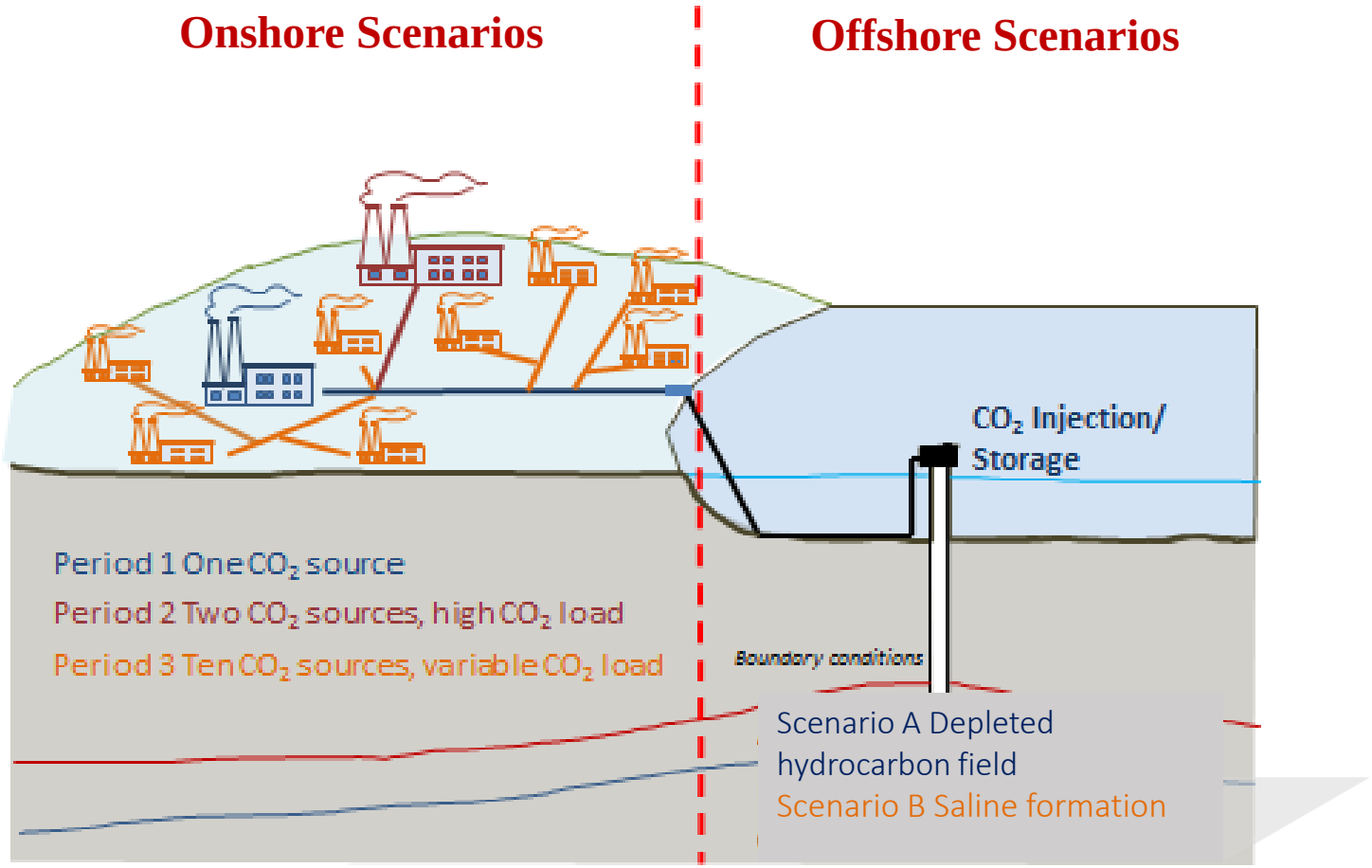
Scope of the FleCCSnet Project

- The Flexible CCS Network Development (FleCCSnet) project 1.5 year project funded by UKCCSRC.
- Considered the impact of flexibility across the whole CCS chain
- Studied the interfaces between each element of the system; e.g. at the entry to the pipeline system from the capture plant and at the exit from the pipeline to the storage site.
- Factors identified are intended to allow CCS network designers to determine the degree of flexibility in the system.
- Allowing effective reactions to short, medium and long term variations in the flow of CO_2 from capture plants and the constraints imposed on the system by CO_2 injection and storage.

FleCCSnet Scenarios



Research Highlights

Operational flexibility in power plants with post combustion capture

- E. Sanchez Fernandez, M. Sanchez del Rio, H. Chalmers, P. Khakharia, E.L.V. Goetheer, J. Gibbins, M. Lucquiard, 2016. Operational Flexibility Options in Power Plants with Integrated Post-Combustion Capture, International Journal of Greenhouse Gas Control,48, Part 2, 275–289.
- M. Lucquiaud, E. Sanchez Fernandez, H. Chalmers, N. Mac Dowell, J. Gibbins Enhanced, 2014. Operating Flexibility and Optimised Off-design Operation of Coal Plants with Post-combustion Capture, Energy Procedia Volume 63, 2014, Pages 7494–7507.

Impact of storage uncertainty

- E. Sanchez Fernandez, M. Naylor, M. Lucquiaud, B. Wetenhall, H. Aghajani, J.M. Race and H. Chalmers, 2016. Impact of Store Uncertainties on the Development of Flexible CCS Offshore Infrastructure, International Journal of Greenhouse Gas Control, 52, 139-154.

Line packing time

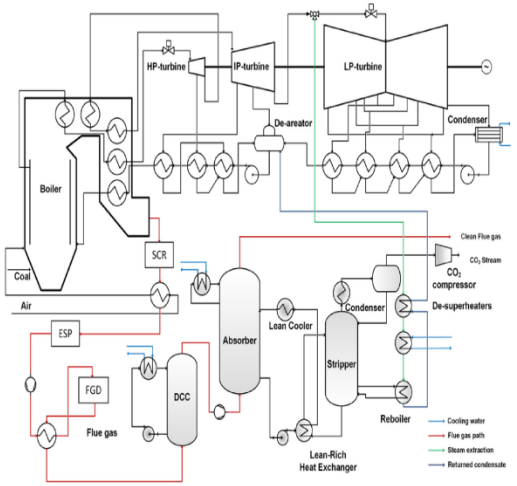
- H. Aghajani, J. M. Race, B. Wetenhall, E. Sanchez Fernandez, M. Lucquiaud and H. Chalmers, 2017. On the Potential for Interim Storage in Dense Phase CO_2 Pipelines. International Journal of Greenhouse Gas Control (accepted).

CCS network development in terms of the quantity of flow into the network

- B Wetenhall, JM Race, H Aghajani, E Sanchez-Fernandez, M Naylor, M Lucquiaud, H Chalmers, 2017. Considerations in the Development of Flexible CCS Networks, Energy Procedia, 114, 6800-6812.

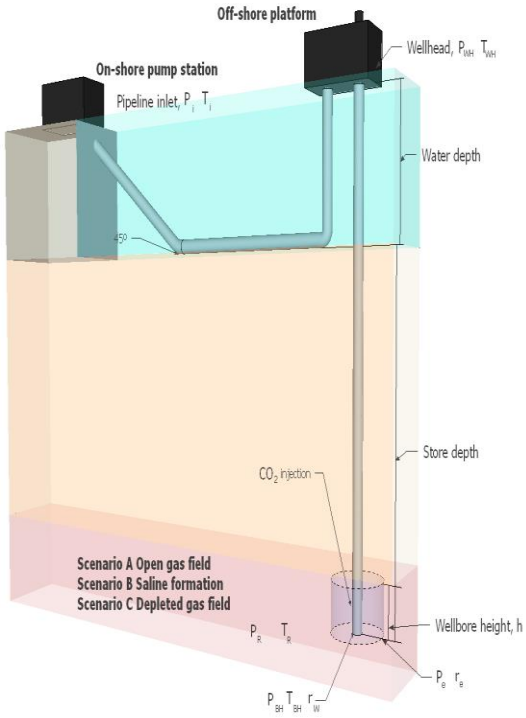
Operational flexibility in power plants with post combustion capture

- Used a rigorous, fully-integrated model along with accurate assumptions about the capabilities of power plants to operate at part load and to regenerate additional solvent.
- Characterises the operating envelope, performance and the corresponding compressed CO_2 flow of coal power plants for a range of loads.
- Rigorously validated guidelines were published.
- Part-load operating strategies



Impact of storage uncertainty

- Link between offshore storage and transportation infrastructure.
- FleCCSnet looked at how uncertainty in CCS store properties lead to variations in CO_2 flow that can impact transportation infrastructure.
- The proximity of wellhead conditions to the CO_2 equilibrium line and a maximum limit on velocities constrain the operational envelope.
- Can limit the ability of the storage site infrastructure to handle variations in CO_2 flow coming into the store.
- These factors can impact on the design of the pipeline infrastructure



The Short-term Storage Potential of Dense Phase CO_2 in Pipelines

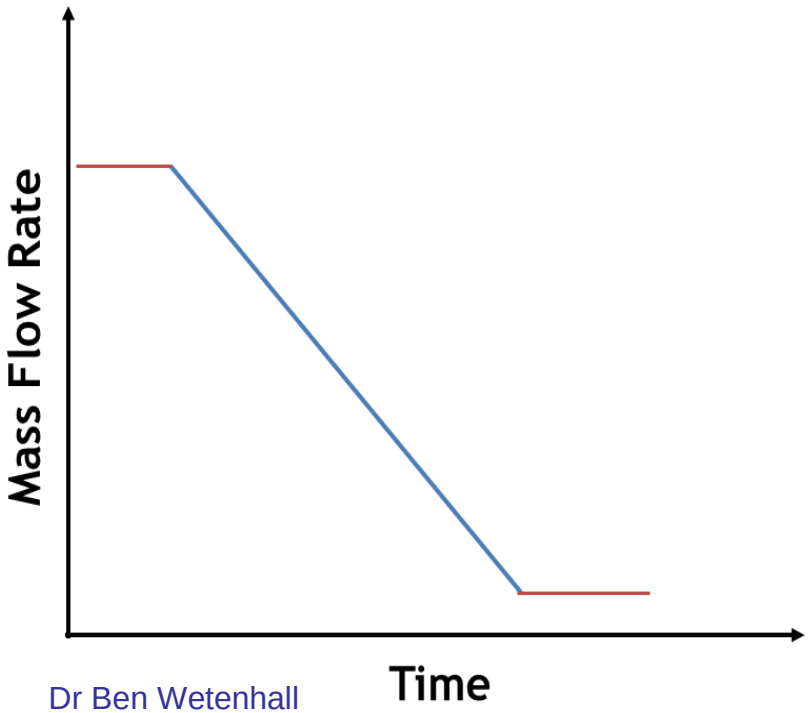
- The project studied the available line packing time of CO_2 pipelines in terms of pipeline geometry, mass flow rate and line pressure and will publish relationships between these variables.
- These relationships allow an estimation of the line packing capability of a CCS pipeline network in terms of pipeline design and operation.
- Indicates that a pipeline, with dimensions typical of those considered for CCS schemes, can provide short term storage of CO_2 for around 10 hours.
- The level of flexibility for the pipeline to act as short-term storage could be key in the design of a CCS network system.

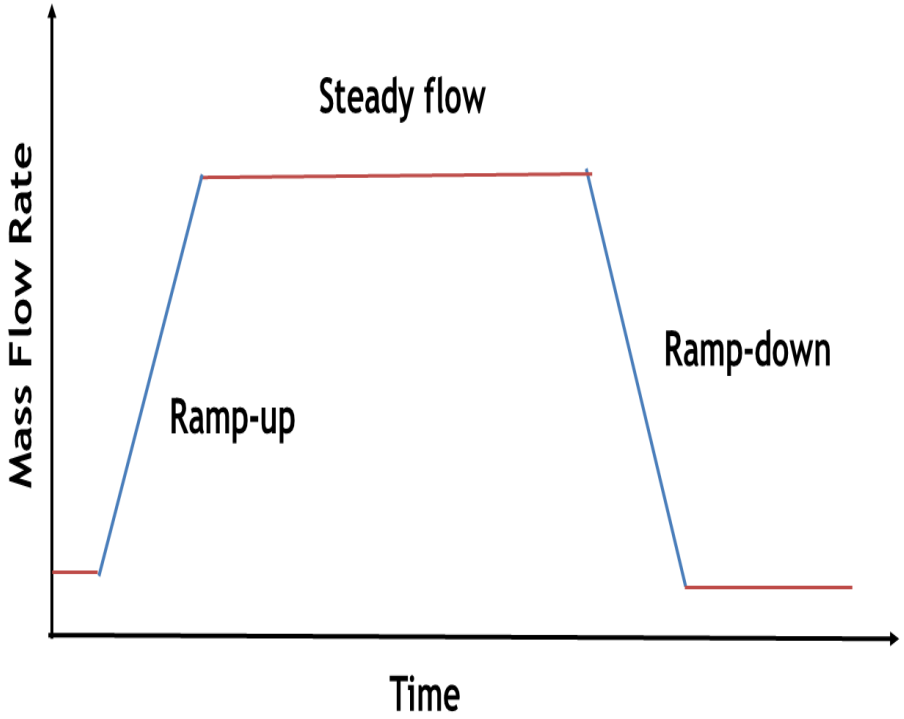
Dr Ben Wetenhall

CCS network development in terms of the quantity of flow into the network

Link between capture and transportation infrastructure.

To investigate the effect of varying flow rate from the capture plant on pipeline networks on the timescales of Periods 1 and 2, two kinds of flow patterns were modelled using OLGA on simple pipeline networks.





The effect of varying flow patterns on transportation networks

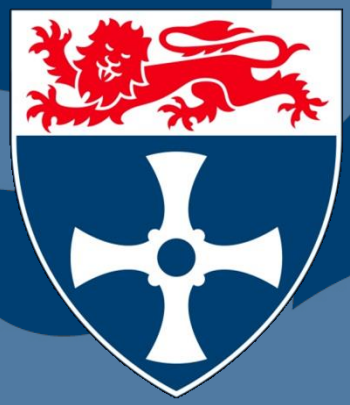
- Results indicate that a pipeline will follow the flow of the capture plant with a slight delay and single phase operation can be maintained as long as adequate pressure management options exist in the system.
- With more active sources connected into a CCS network, network management in terms of maintaining flow into the storage site is made easier.
- As would be expected, the flow is dominated by the emitter with the highest flow rate and flow can be easily maintained as long as both emitters are not shut off at the same time.
- With more complex networks that could develop in Period 3, the number of sources connected to a single pipeline can grow organically as long as the pipeline is designed to accommodate the peak volume.

FleCCSnet Project Conclusions

- Post combustion capture plant flexibility is often understated.
- Variations in key geological store properties and the required level of injection flow flexibility must be considered so that the transportation system can deliver the required CO_2 flow at the required conditions.
- The capability of the pipeline system to act as short-term storage in the network is very important and should be considered in the design of system (including reuse of infrastructure).
- If designed to accommodate peak flow, the transportation system can cope with fluctuating levels of CO_2 given adequate pressure management exists.
- Fluctuations in flow can still impact on storage side operation; this needs to be considered in more detail in future work.
- Further work should also focus on different power plant and/or CO_2 capture options including capture from large industrial sources.

Acknowledgements

- This work was funded by the UKCCSRC through its Call 1 for project proposals.
- UKCCSRC is supported by the EPSRC as part of the RCUK Energy Programme.
- Financial support for Dr. Mathieu Lucquiaud through the Royal Academy of Engineering Research Fellowship.
- Schlumberger for the donation of the OLGA software program.
- All the workshop attendees for their contributions to the project.



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