Operating Flexibility of CO_2 Injection Wells

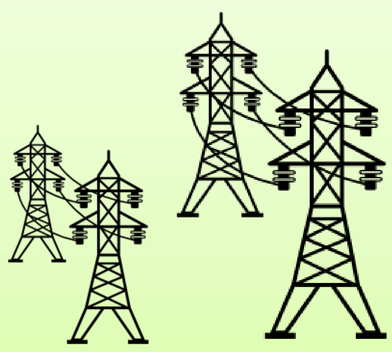
T. Spitz[a]*, H. Chalmers[b], F. Ascui[c], M. Lucquiaud[a].

[a] *Institute for Materials and Processes, School of Engineering, University of Edinburgh, Mayfield Road, Edinburgh, EH9 3JL, UK*

[b] *Institute for Energy Systems, School of Engineering, University of Edinburgh, Mayfield Road, Edinburgh, EH9 3JL, UK.*

[c] *Business School, University of Edinburgh, 29 Buccleuch Place, Edinburgh, EH8 9JS, UK.*

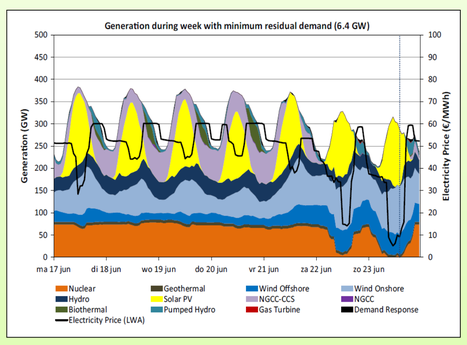
Overview



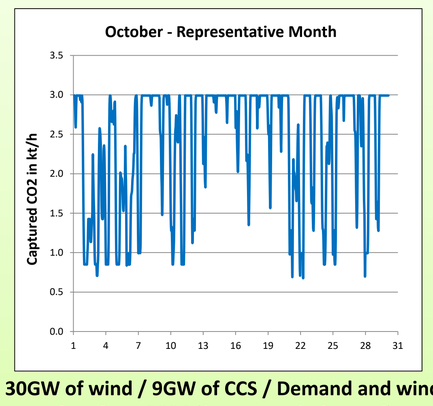
Electricity system dictates operating regimes of CCS plants

CCS system is required to handle large and regular fluctuations in CO_2 feed flows

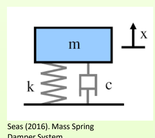
Profiles



Brouwer et al. (2016). Least-cost options for integrating intermittent renewables in low-carbon power systems.

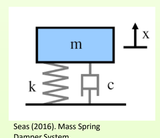


30GW of wind / 9GW of CCS / Demand and wind data from 2004 ('average windy year')



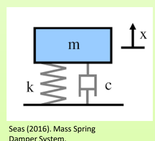
Seas (2016). Mass Spring Damper System.

?



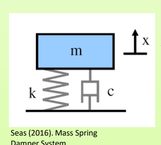
Seas (2016). Mass Spring Damper System.

Flows are smoothed out



Seas (2016). Mass Spring Damper System.

?



Seas (2016). Mass Spring Damper System.

What are the risk and issues associated with variable flows for transportation, injection and storage networks?

How much variability can injection and storage system handle over the short and long term?

Electricity system dictates operating regimes of CCS plants

CCS system is required to handle large and regular fluctuations in CO_2 feed flows

Risks & Issues for Injection Wells

Hydrate formation

- Forms under high pressure and low temperatures
- Solid and ice-like appearance
- Consists of CO_2 trapped in a water lattice
- **Can plug flow and interrupt operation**
- **Difficult and time consuming to remove once they have formed**

Cracking of cement & wellbore materials

- Thermal load and temperature variations have large effect on casing, cement and formation stresses
- Steel, cement and rock will repeatedly expand and contract in volume and relative to each other due to different thermal expansion coefficients
- **Repeated cycling can create and enlarge fractures, fissures and radial cracking in cement sheath**

Hydrogen induced embrittlement

- Generally only a risk when there is H_2 or H_2S present in the flow
- Due to volatility of the gases their concentrations in the gas phase when flashing are increased
- Atomic **hydrogen can penetrate the well material which makes the material brittle**
- It **can also make the material more susceptible to fatigue failure**

Oscillations & Vibrations

- Vibrations can be classified into steady-state and dynamic transient vibrations
- Dynamic transient vibrations are usually more severe
- **Increased requirement for ramping amplifies risk associated with transient vibrations and oscillations**
- This is particularly the case when flashing happens across the well-head choke valve

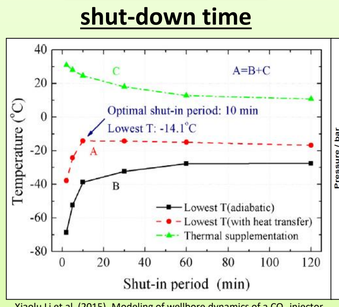
Reduced lifetime

- **The above effects can lead to reduced lifetimes of injection wells**
- No data yet available regarding lifetime reductions
- **Reduced lifetime leads to additional costs**
- Higher maintenance / work-over costs
- Need for drilling more wells
- These costs need to be compared against the cost of mitigating lifetime hampering processes and effects
- CO_2 flow balancing options
- Enable wells to cope better with CO_2 flow variability

Exaggerated by JT-effect at low loads when flashing is taking place across the wellhead choke valve

Operational & Design options → *Enabling CO_2 injection wells to cope better with fluctuating flow rates*

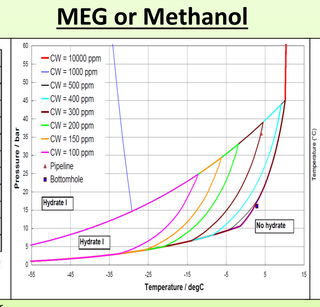
Optimal start-up & shut-down time



Xiaolu Li et al. (2015). Modeling of wellbore dynamics of a CO_2 injector during transient wellshut-in and start-up operations

Mitigating low temperatures

Additional Injection of MEG or Methanol



Eon, Kingsnorth CCS demonstration project (2010).

Avoiding hydrate formation

Additional Injection of Nitrogen

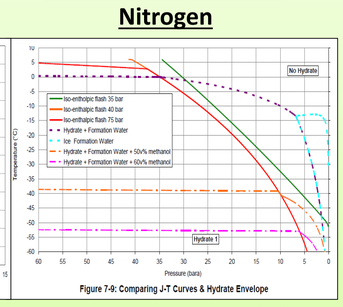
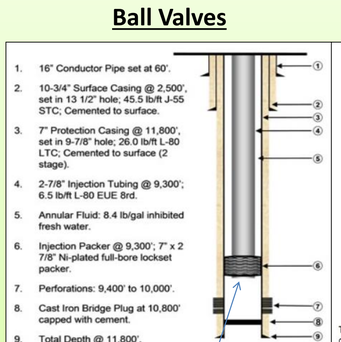


Figure 7-9: Comparing J-T Curves & Hydrate Envelope

Eon, Kingsnorth CCS demonstration project (2010).

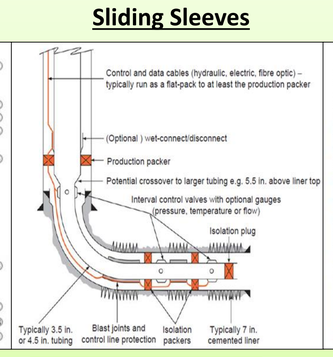
Increasing backpressure to reduce JT-effect

Ball Valves



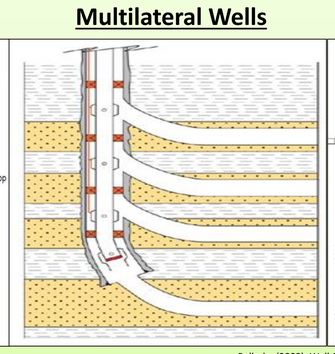
Haliburton (2016). LV-ICV Lubricator Valve.

Sliding Sleeves

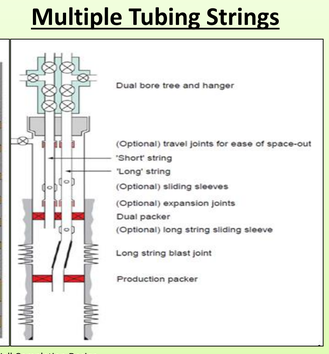


Bellarby (2009). Well Completion Design.

Multilateral Wells



Multiple Tubing Strings



Bellarby (2009). Well Completion Design.

Increasing backpressure in the injection well to reduce JT-effect

Alternative Options → *Mitigating fluctuations of CO_2 flows to the injection wells*

Energy Storage

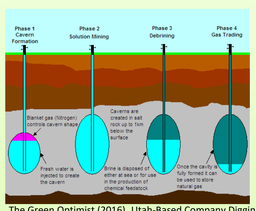
GreenWorldPartners (2016). Energy Storage.

Power Plant level

- Pre-combustion: H_2 storage
- PCC: Solvent storage
- Oxy-fuel: LOx storage

→ Balances CO2 feed flows to T&S system in order to mitigate flow fluctuations in injection wells

T&S Network level



The Green Optimist (2016). Utah-Based Company Digging Underground Air Batteries.

Interim Storage:

- In Buffer Tanks
- Underground

ZCL Composites Inc. (2016). Fibreglass Storage Tanks.

$ $

What is the cheapest option?

$ $

***Corresponding author: T.Spitz@ed.ac.uk +44 (0)131 6507444**

View this poster with the Poster in my Pocket app

Install the free iPhone/Android app via: www.posterinmypocket.com