GEOLOGICAL CO_2 BUFFERING FOR RE-USE ENOS PROJECT

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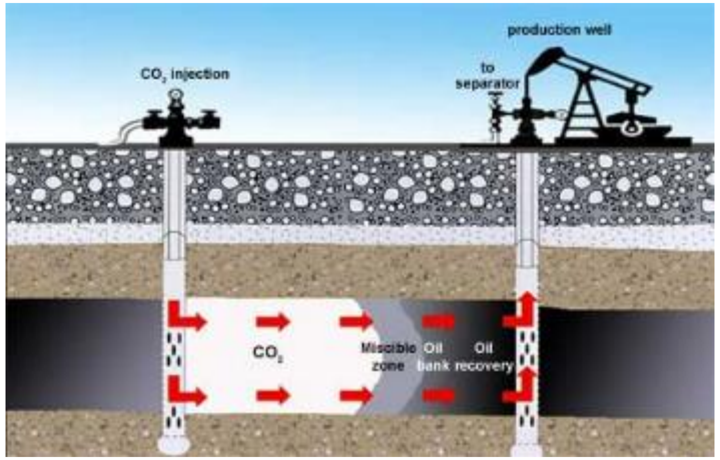
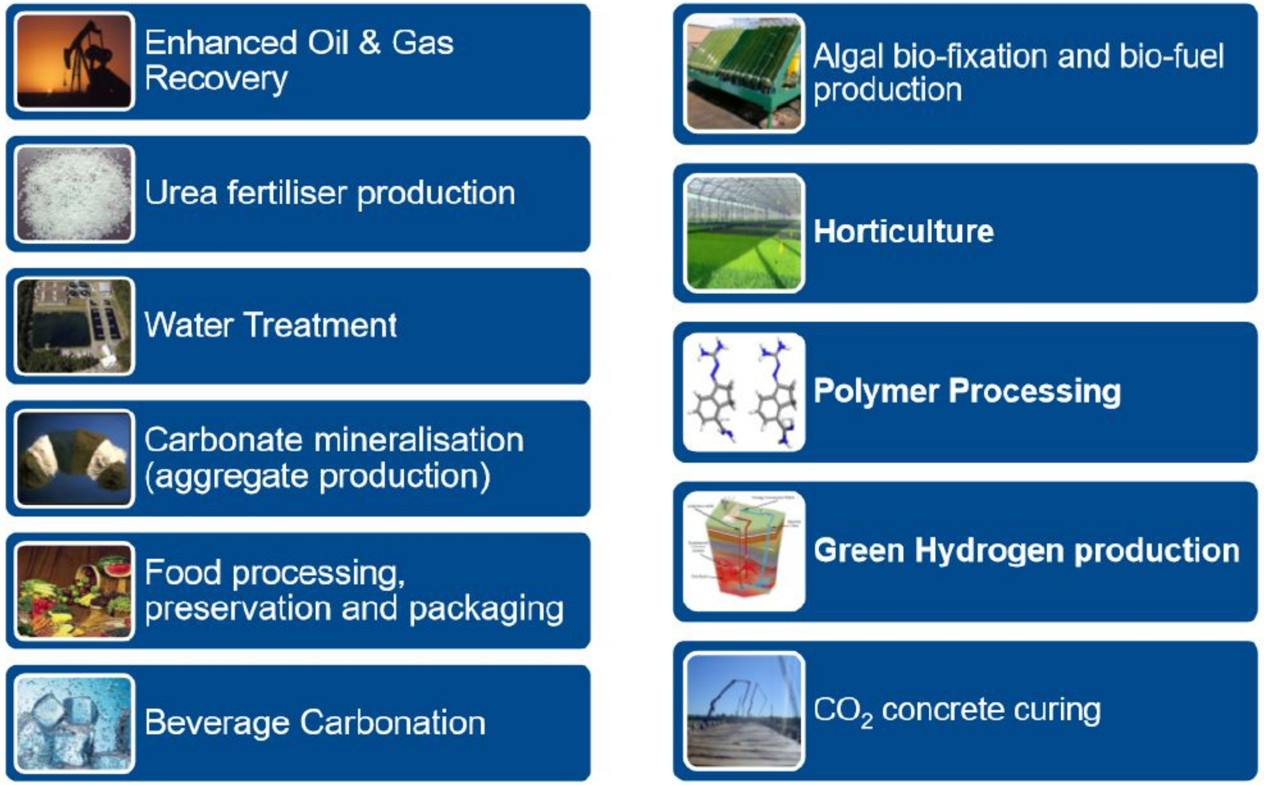
- What is geological buffering and why is it interesting?
- ENOS: Buffering for re-use in Dutch greenhouses
  - ➢ Buffer design
  - ➢ Technical and economic feasibility
- Key messages for geological buffering



What is geological buffering and why is it interesting?

- Geological buffering = **temporary storage** in a **geological formation**
- The CO_2 is injected when there is excess, and back-produced when needed
- CO_2 re-use; existing and emerging industrial uses
  - ✓ Cheaper source of CO_2
  - ✓ Becoming independent of natural gas
  - ✓ Reduce CO_2 emissions



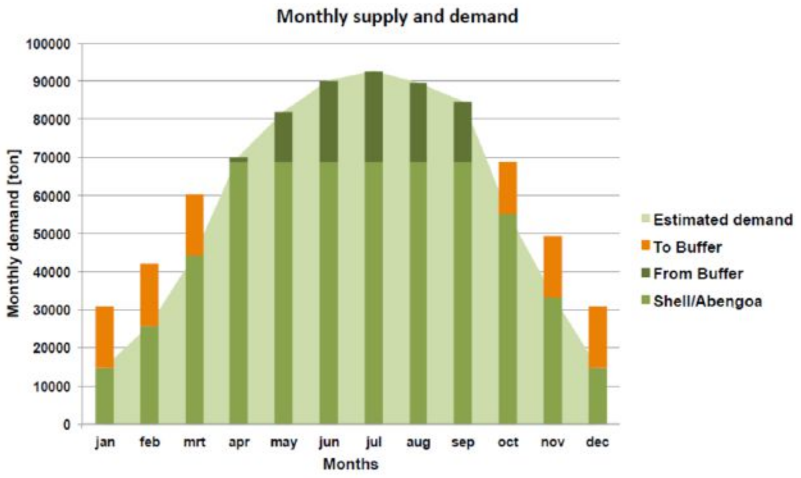
ENOS project: The Dutch case of CO_2 buffering for greenhouses

<u>Greenhouses</u>

- Use of waste CO_2 to enhance crop growth: 500 ktonne/yr
- Increased use of geothermal energy
- Additional heat and CO_2 from CHP installations

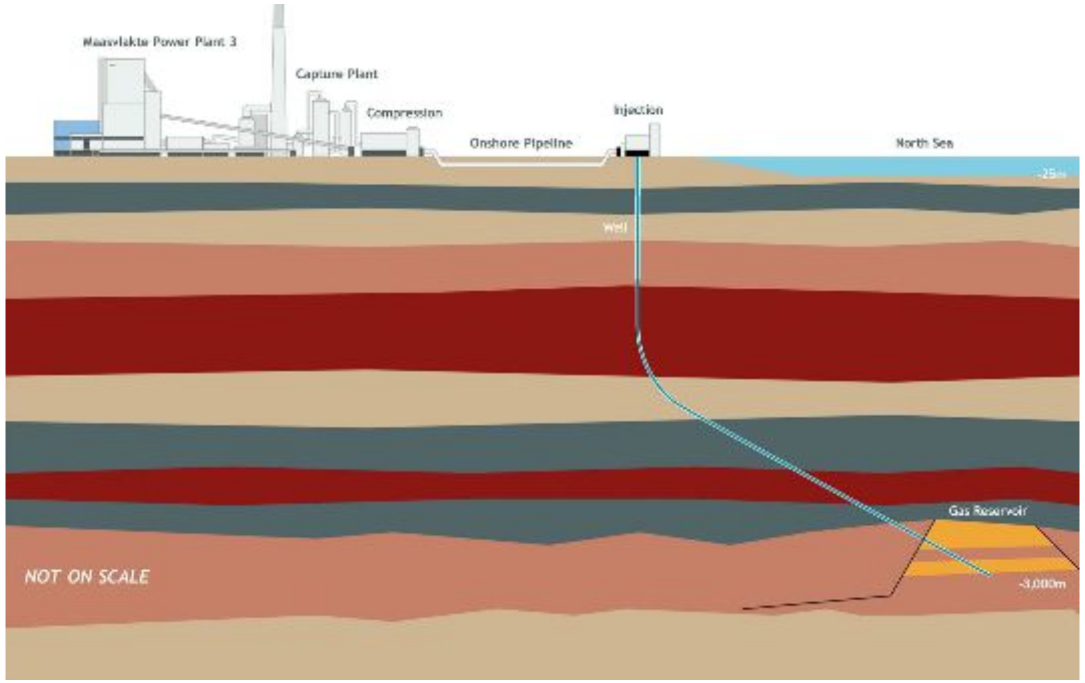
<u>Business case for buffering</u>

- Solve seasonal mismatch supply and demand
- Improve security of supply
- Serve more greenhouse areas

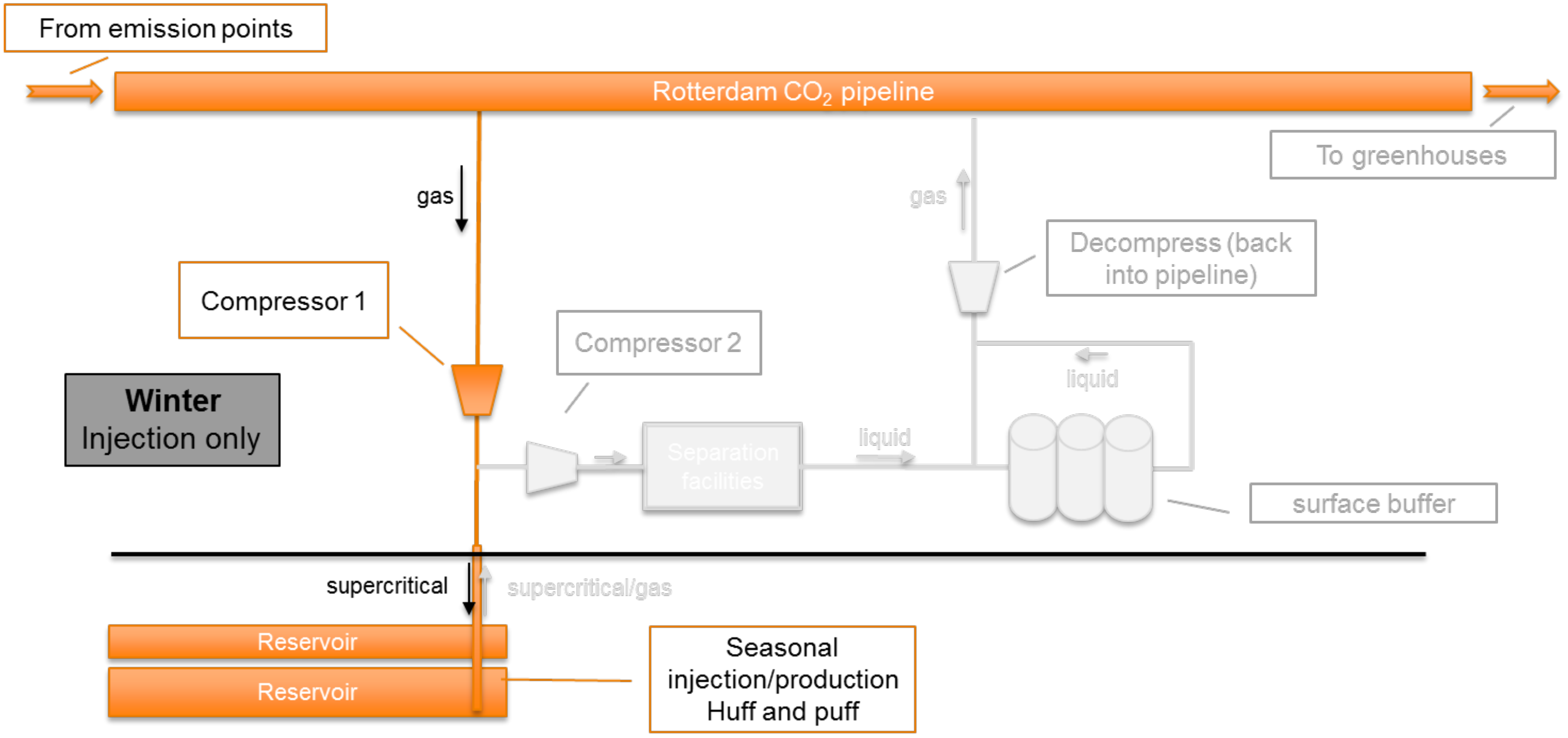


Buffering in Q16-Maas reservoir

- The Q16-Maas reservoir provides an excellent opportunity
  - Small in storage size (max 1 Mtonne)
  - Just offshore Rotterdam
  - Operated from onshore
  - Hydrocarbon production ends in 2020



Schematic layout of buffer design for Q16-Maas



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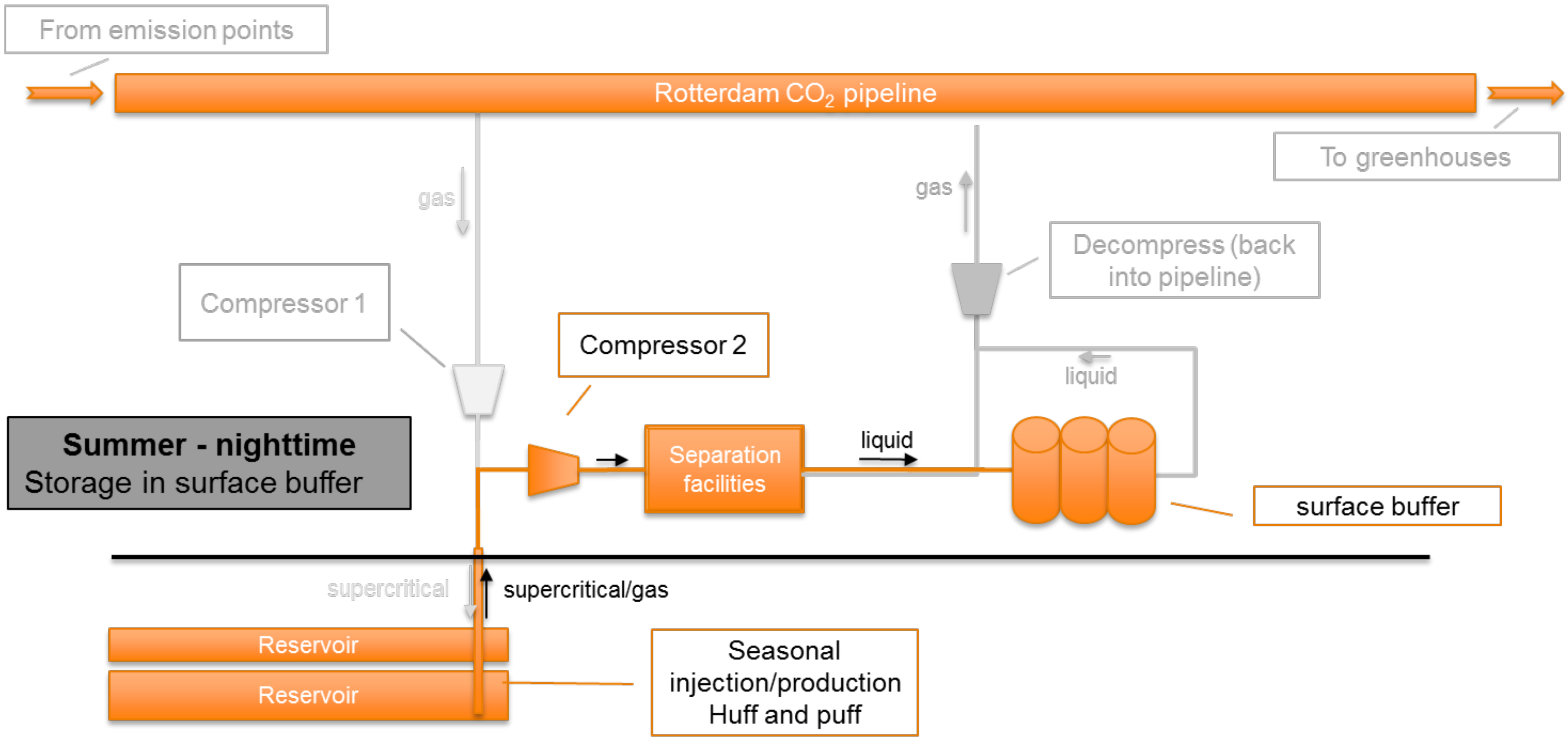

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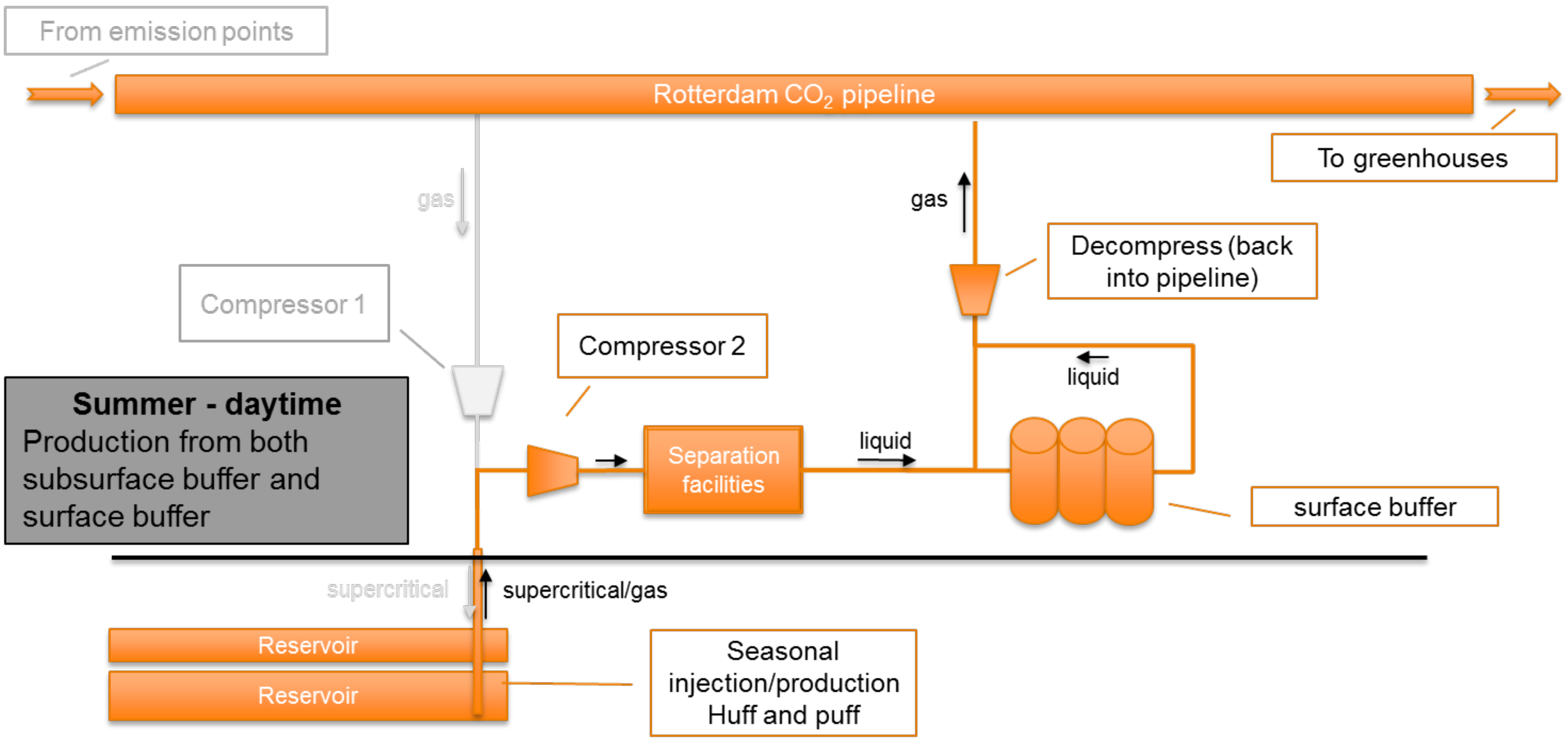
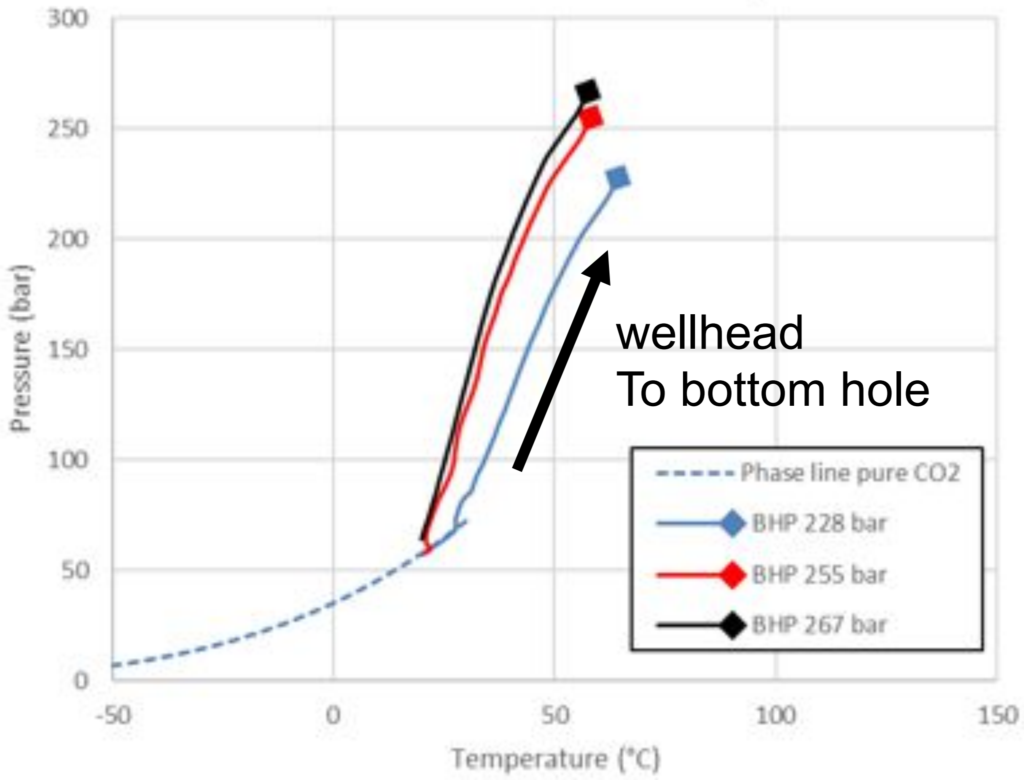


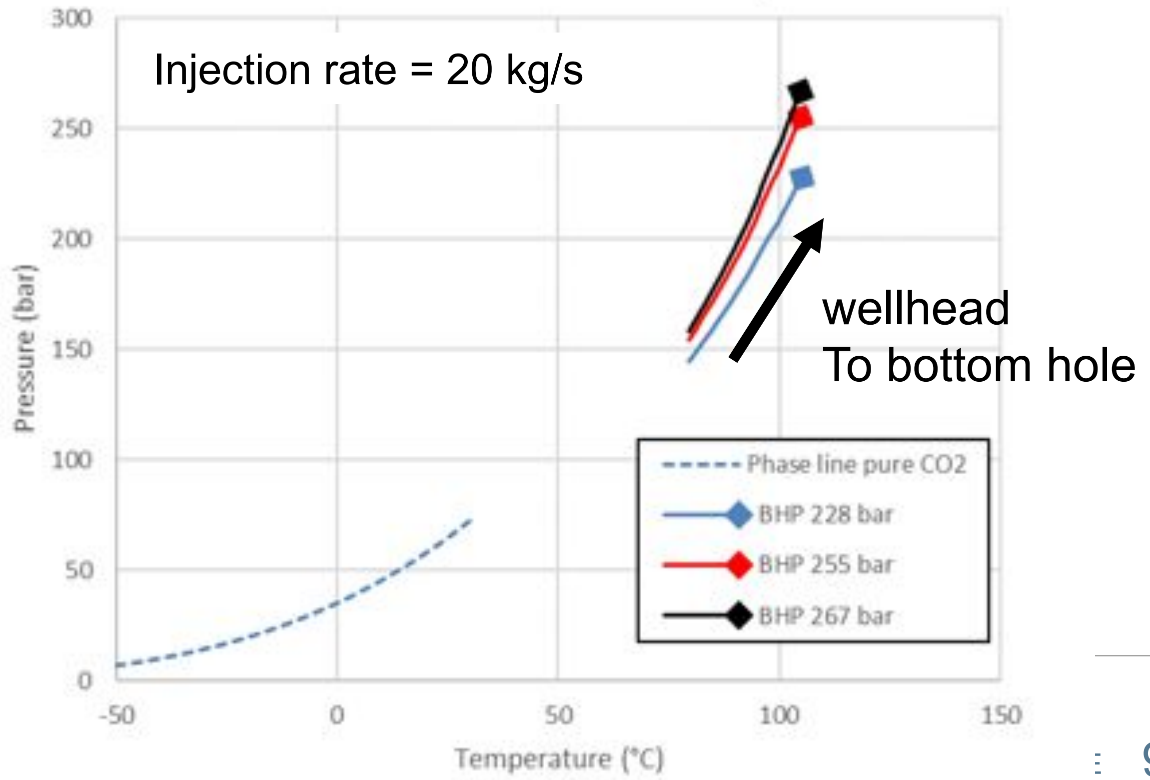
Injection conditions – in the well

- Injection rate 20 kg/s = 72 tonne/hour > maximum rates constrained by back-production
- From wellhead to bottomhole, pressure and temperature increase
- Cold or warm injection? Warm injection requires larger compressor

Cold injection
Wellhead T = 20°C, bottom hole T = 57°C



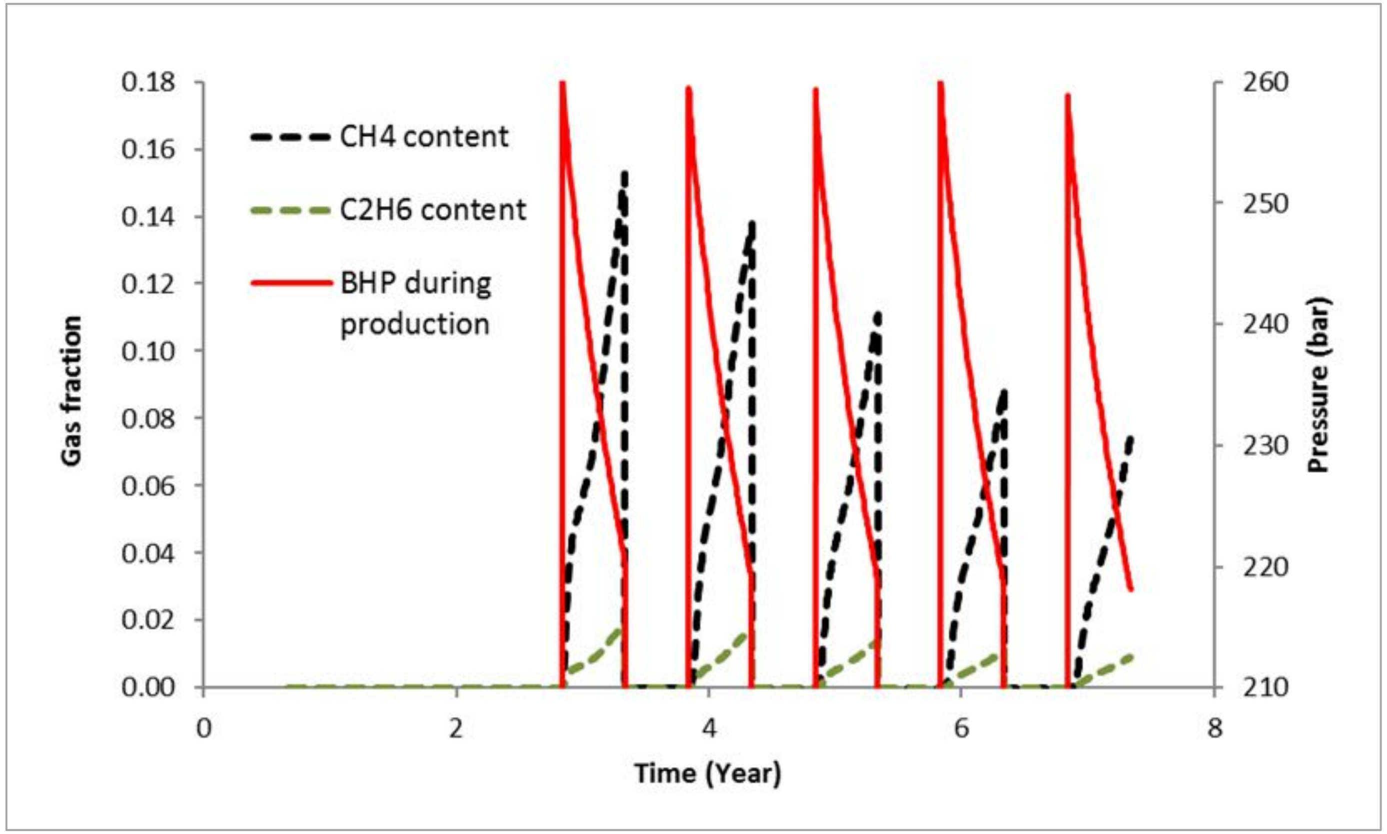
Warm injection
Wellhead T = 80°C, bottom hole T = 105°C



Q16-Maas - Reservoir simulations with Eclipse and GEM

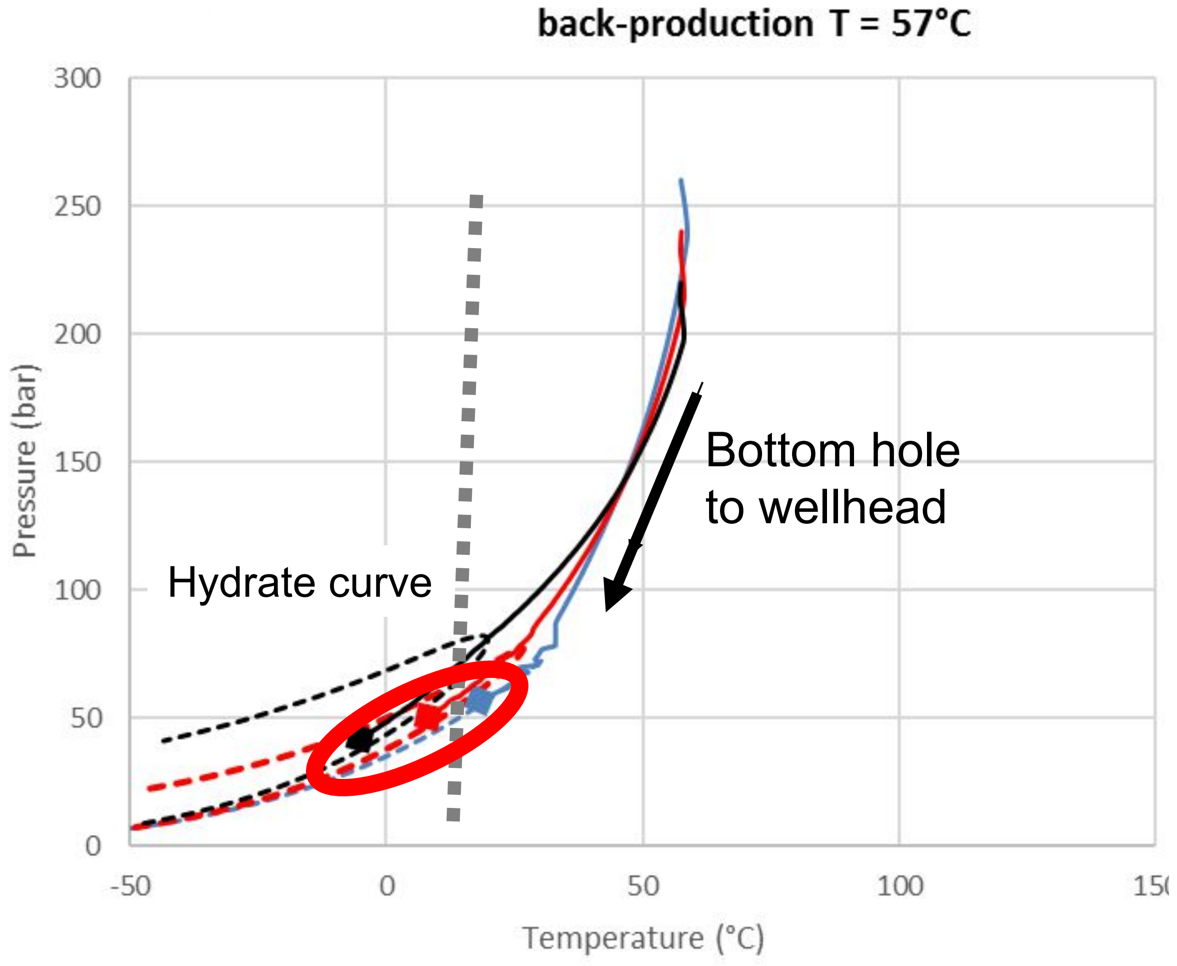
- Warm injection scenario: injection at reservoir T
- 6 months injection @ 20 kg/s = 316 ktonne CO_2
- 6 months back-production at the same rate

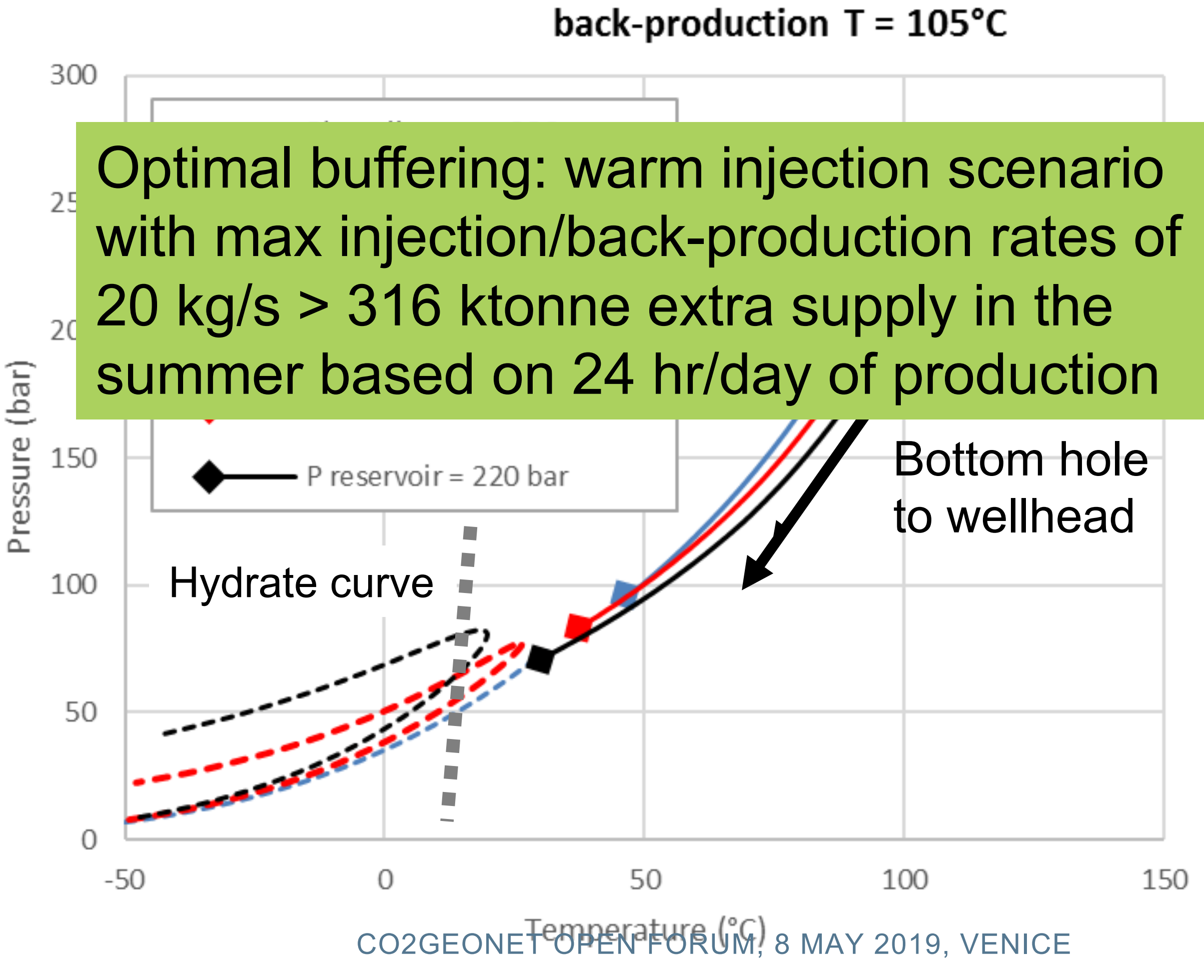
- Back-produced CO_2 contaminated with hydrocarbons, and saturated with water
- Back-production conditions change within each cycle and with each consecutive cycle



Q16-Maas - Back-production conditions – in the well

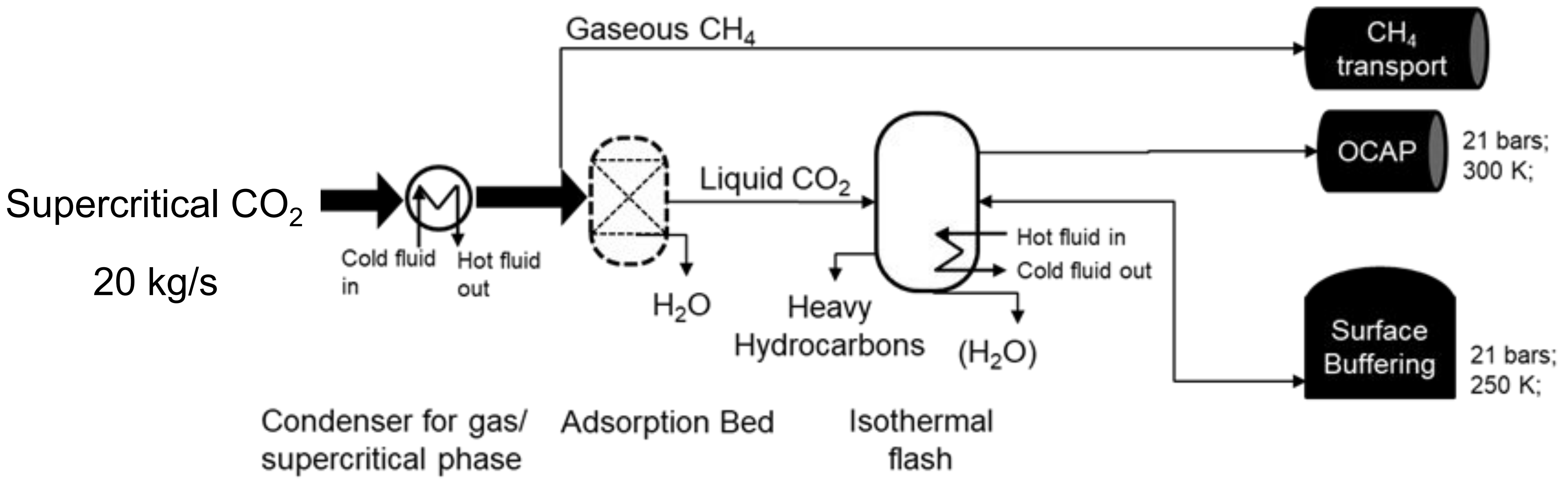
- Assumption: back-production T of impure gas stream is equal to bottom hole injection T
- High temperature scenario lowers risk of two-phase flow and hydrate formation at wellhead





Optimal buffering: warm injection scenario with max injection/back-production rates of 20 kg/s > 316 ktonne extra supply in the summer based on 24 hr/day of production

Cleaning facilities to remove impurities



Equipment	Costs
Condenser (and heat exchangers)	
Adsorption and flash separator	3.4 M€
Buffering storage (w/o cooling)	1.4 M€
Operating costs (w/o extra cooling)	1.4 M€
Levelized cost	**~3 €/tonne**

Cost-benefit analysis

CO_2 supply to greenhouses can be increased from 500 to 816 ktonne/yr with the geological buffer

Rough cost estimates based on 10 cycles of back-production:

- Injection facilities for warm injection: ~7 €/tonne
- Clean-up facilities and surface buffer: ~3 €/tonne

Total costs: 10 €/tonne of CO_2

Current CO_2 price ~50 €/tonne for 500 ktonne

Adding buffer costs >> ~60 €/tonne for 316 ktonne

>> Average price 54 €/tonne while current commercial foodgrade CO_2 price is 70-100 €/tonne

Additional turnover for pipeline operator: ~20 M€/yr

Geological buffering for re-use – key messages

- Buffering in Q16-Maas for re-use in greenhouses seems technically possible and economically attractive

- Geological buffering could be interesting to solve mismatch in temporal supply and demand
- Only on the longer term and for higher volumes, otherwise a surface tank could be sufficient.

- Buffer and re-use volumes are relatively low, but a good business case might support development of initial storage sites
- Demonstration of technology will help building

  confidence of stakeholders

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Questions? Ask me now or email me later: marielle.koenen@tno.nl

ENOS

Enabling Onshore CO_2 Storage

www.enos-project.eu

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