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Repurposing Gas Fields for Energy Storage

– How Compressed Air Energy Storage (CAES) Reviving the Depleted Rolleston Gas Field

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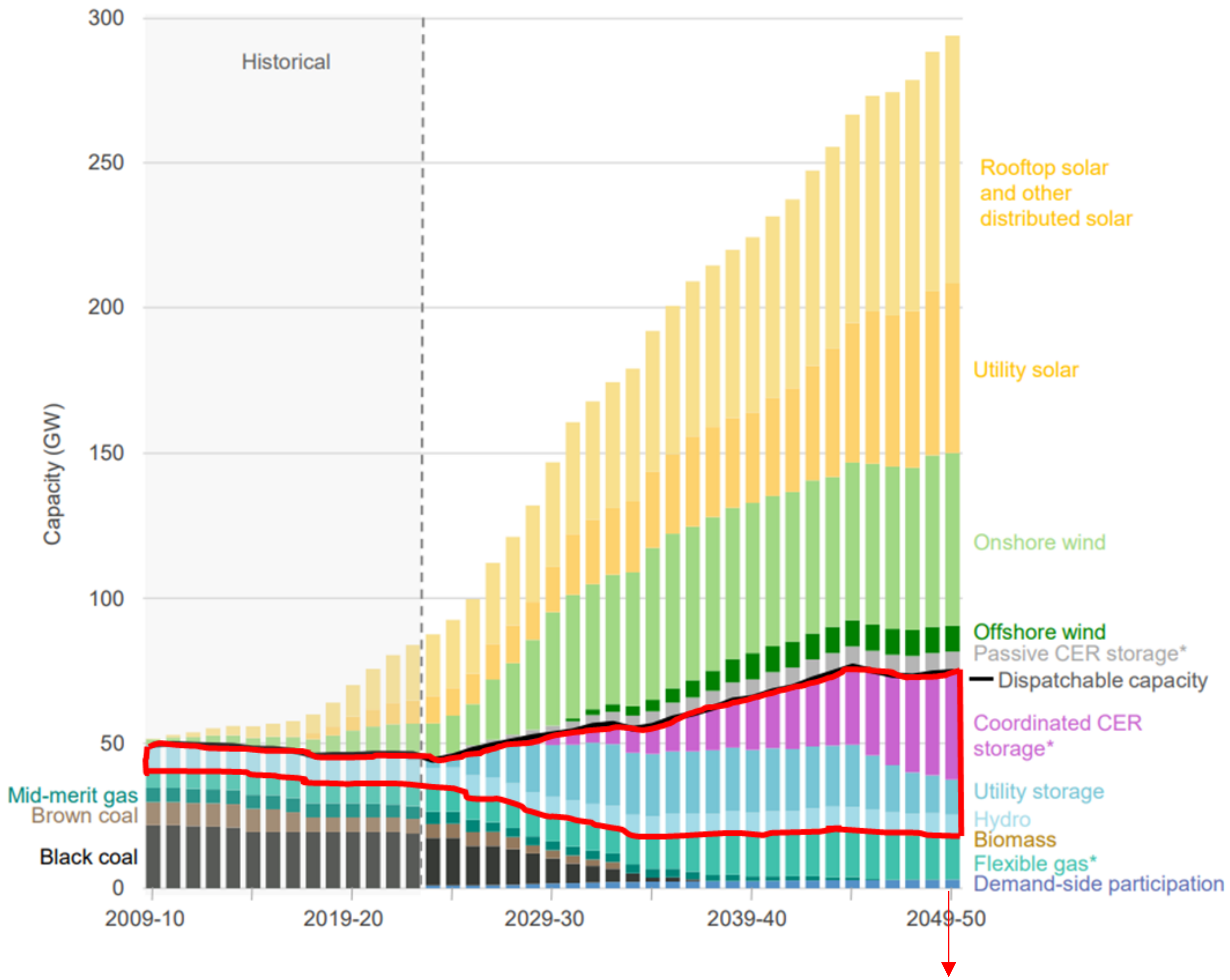
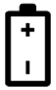
Australia's renewable energy targets towards net-zero emissions



49GW/646GWh
= **13.2 hours averagely**

Variable renewable energy & energy storage are highly demanded to achieve net-zero:

> 7-fold increase (from 8GW to 58GW)



> 20 times increase (from ~30GWh to 646GWh)

49GW/646GWh indicates an average duration of **13.2 hours – long duration energy storage is critical.**

By 2024, 2.3GW pumped hydro plants were operational, with up to 10 hours duration, in Australia.

Source: AEMO ISP 2024

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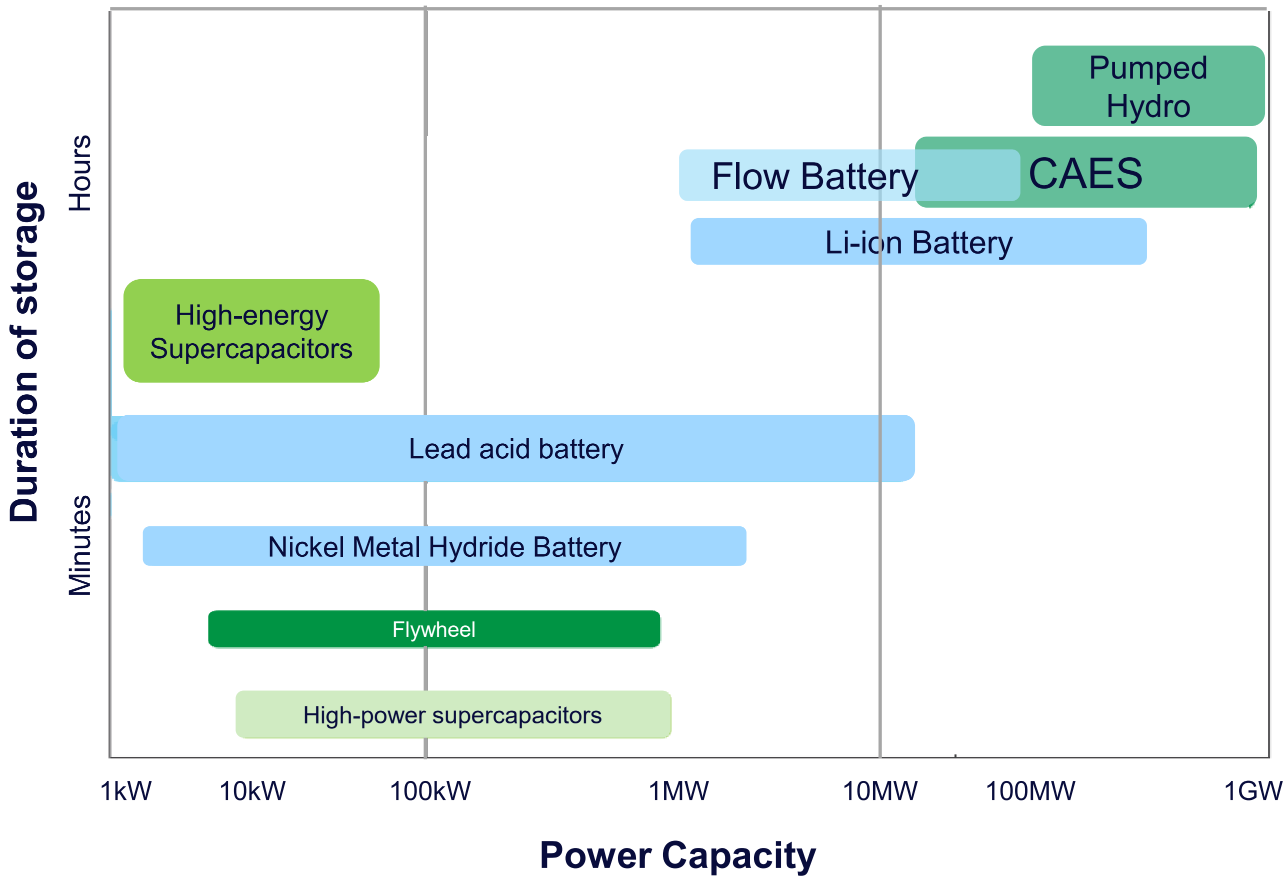
CAES is a large-scale long-duration energy storage



CAES is an alternative to Pumped Hydro

- Comparable capacity and duration
  - Power: **hundreds of MW**
  - Duration: **>8 hours**
  - Round-trip efficiency**:** up to **72%**

- Less environmental impact
  - Pioneer-Burdekin pumped hydro in QLD was ceased due to high cost and environmental impacts

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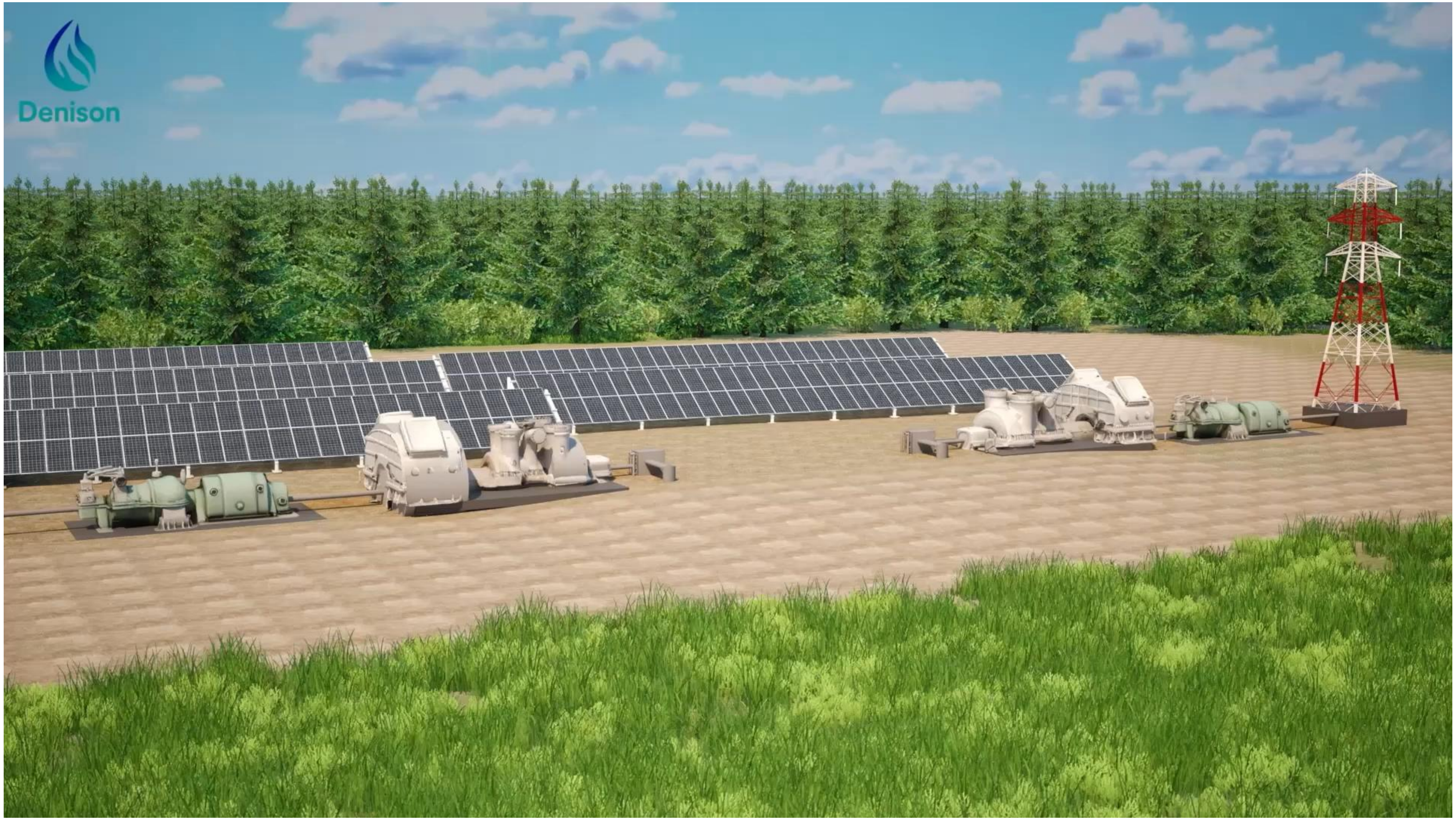
CAES – How it works in depleted gas reservoirs (DGR)



To watch this animated video, please click here.

600MW/7.2GWh CAES in Denison's DGR

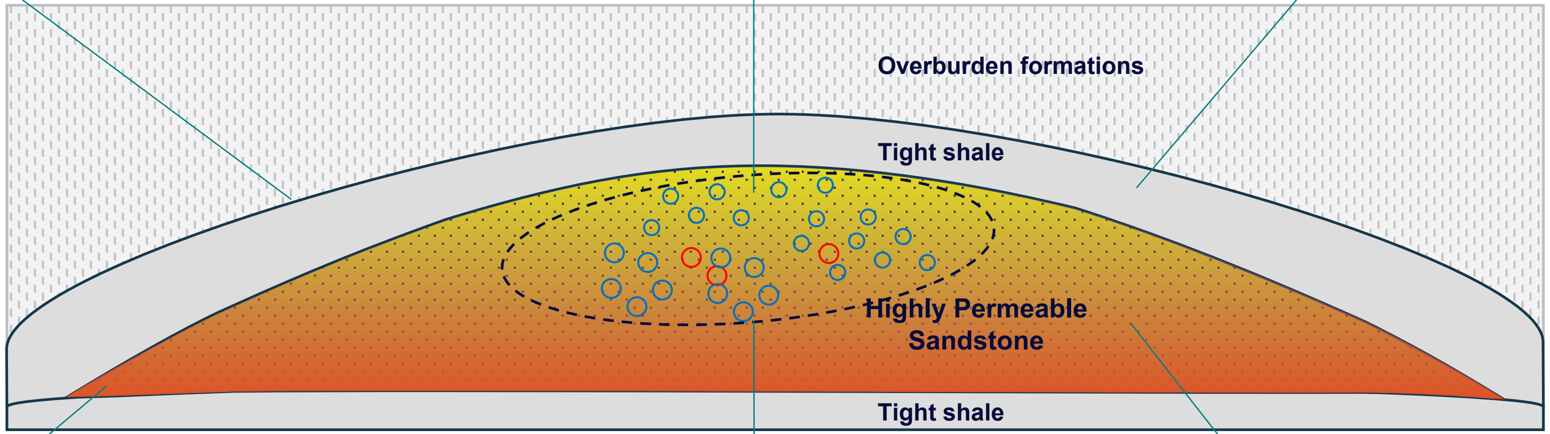
- Feasibility Study

Freitag in Rolleston gas field for a 600MW/7.2GWh plant

Trap: ✓
- a simple dome-type reservoir is preferred

Pressure: ✓
- reservoir pressure > 10 MPa

Caprock: ✓
- thickness > 15m
- mechanically stable



not to scale

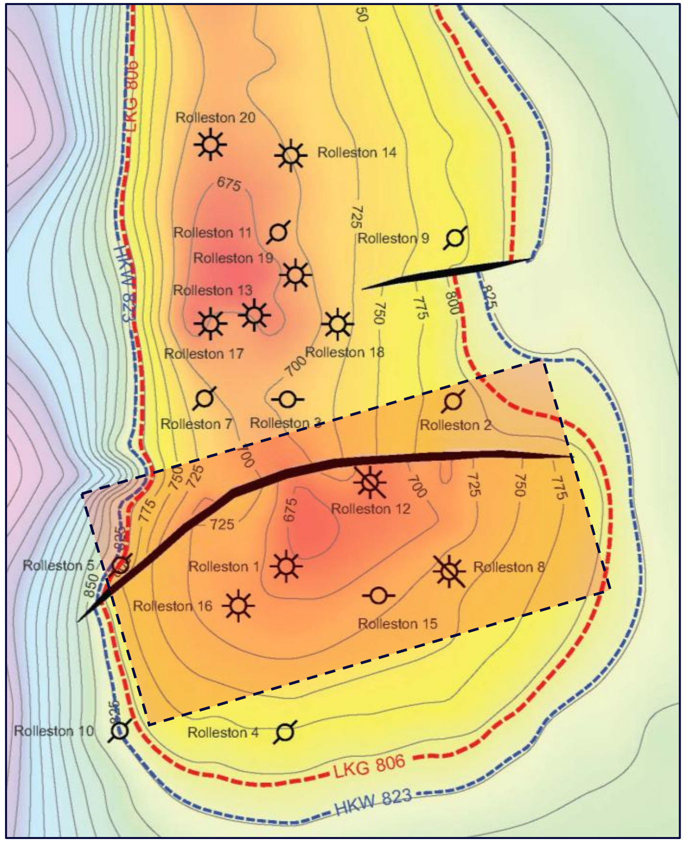
Drive mechanism: ✓
- volumetric type is preferred over water drive to avoid water encroachment

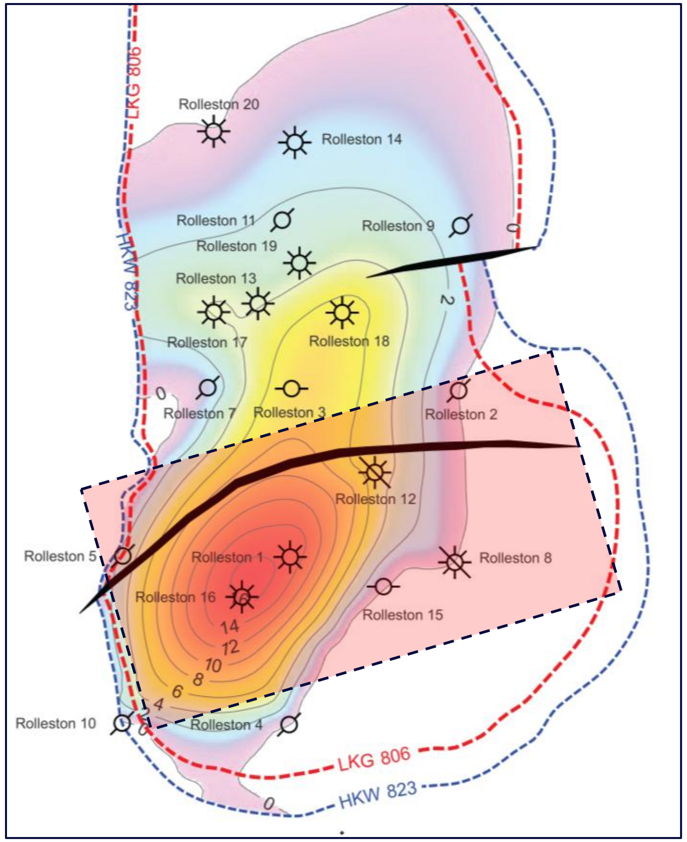
Gas:
- residual CH_4 concentration <5% to avoid combustion ✗

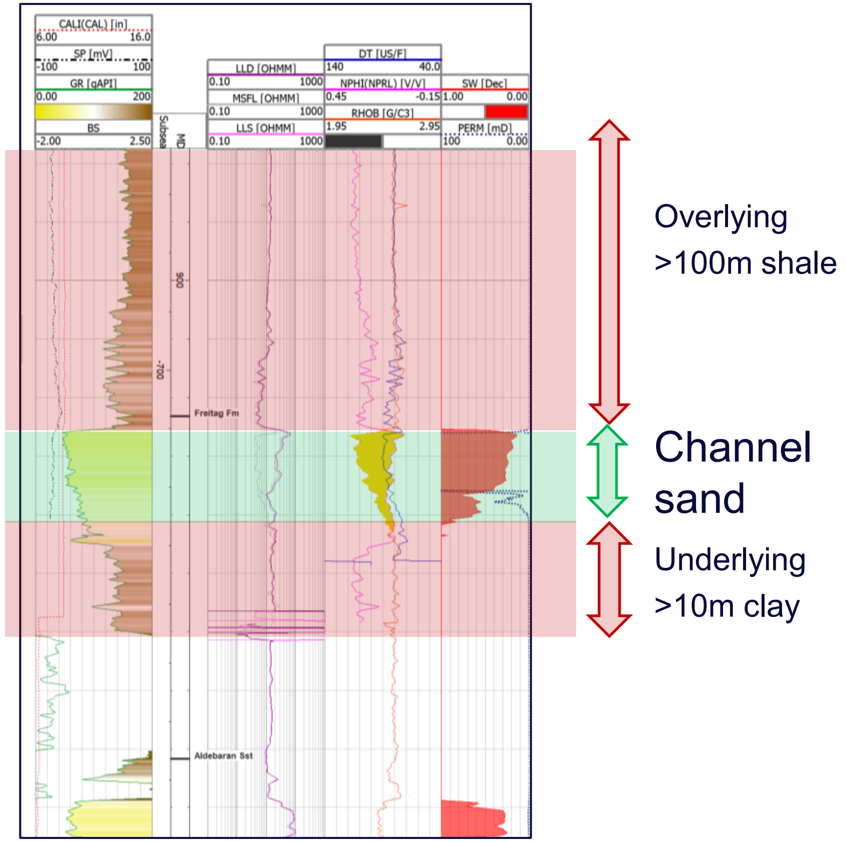
N_2 injection to sweep residual CH_4

Reservoir: ✓
- h: up to 16m
- Ø: > 20%
- k: 400-1,600 mD
- void volume: 8×10^6 m^3
- deliverability: 100 million sm^3/d ?

Reservoir qualities – Freitag in Rolleston gas field







Burial depth:

- ~900m – ~1000m below the ground surface
- four-way dip trap

Reservoir net thickness:

- 6m – 16m
- thickening up to the crest

Seal:

- fully wrapped by the thick overlain shale and underlain clay
- formed and sealing gas over millions years.

Reservoir Simulation – purposes

- **Reservoir deliverability**

  Can the selected reservoir produce adequate air to drive the turbine?

- **Number of wells needed**

  How many wells are needed for injection & withdrawal ?

- **Change of reservoir pressure**

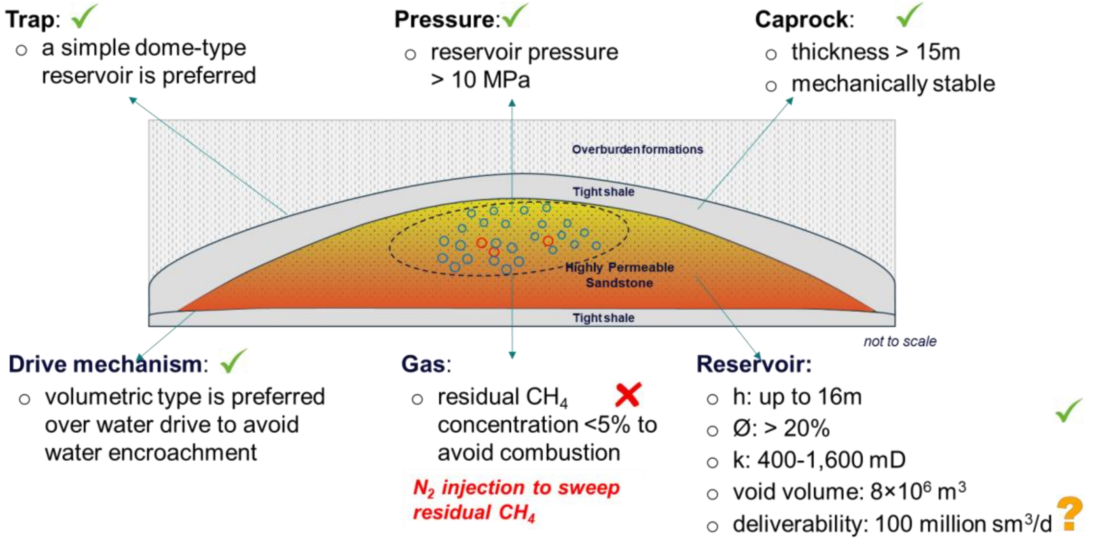
  Whether the change of reservoir pressure is abrupt?

- **Percentage of working air**

  What is the ratio of working air to the total?

- **Effect on existing fault**

  What is the effect on the existing fault to the north?



Simulator	tNavigator
Cells	44*69*10
Porosity	8%-25%
Perm	400-1,500 mD
Wells	42 injection/withdrawal wells
Well control	BHP: minimum 6MPa
Period	Alternative 12 hours injection and 12 hours withdrawal for 30 days
Assumption	Methane concentration <5%

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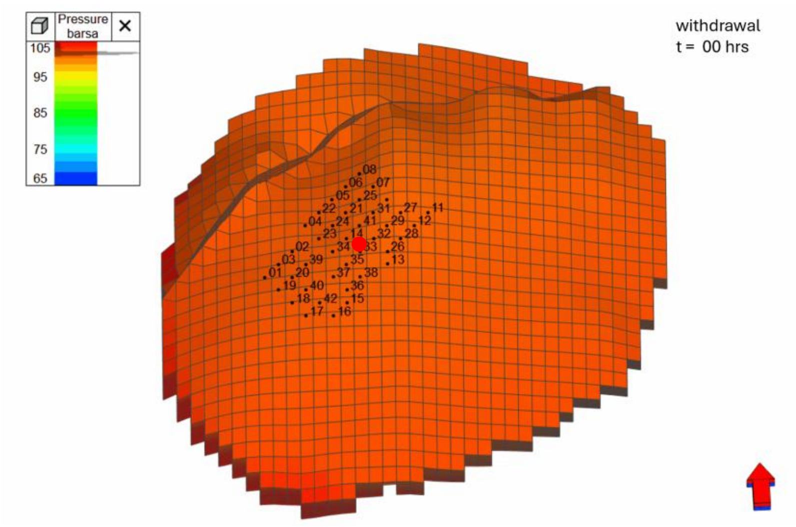
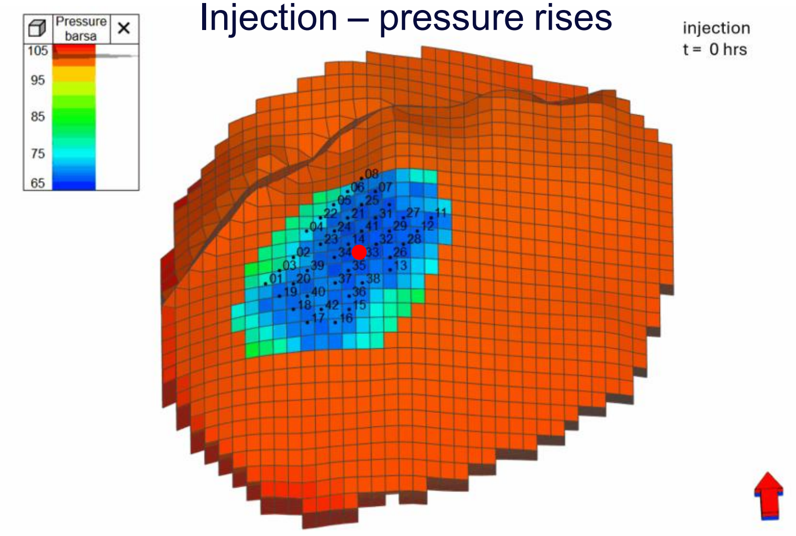
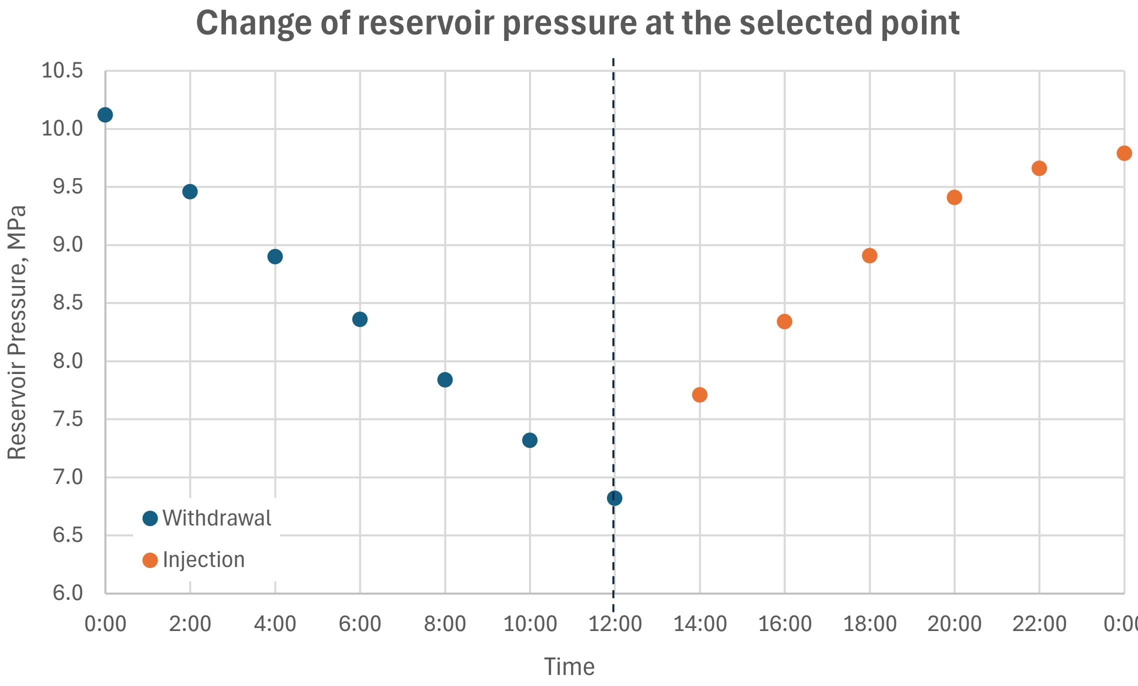
Reservoir Simulation – change of reservoir pressure

Withdrawal – pressure drops



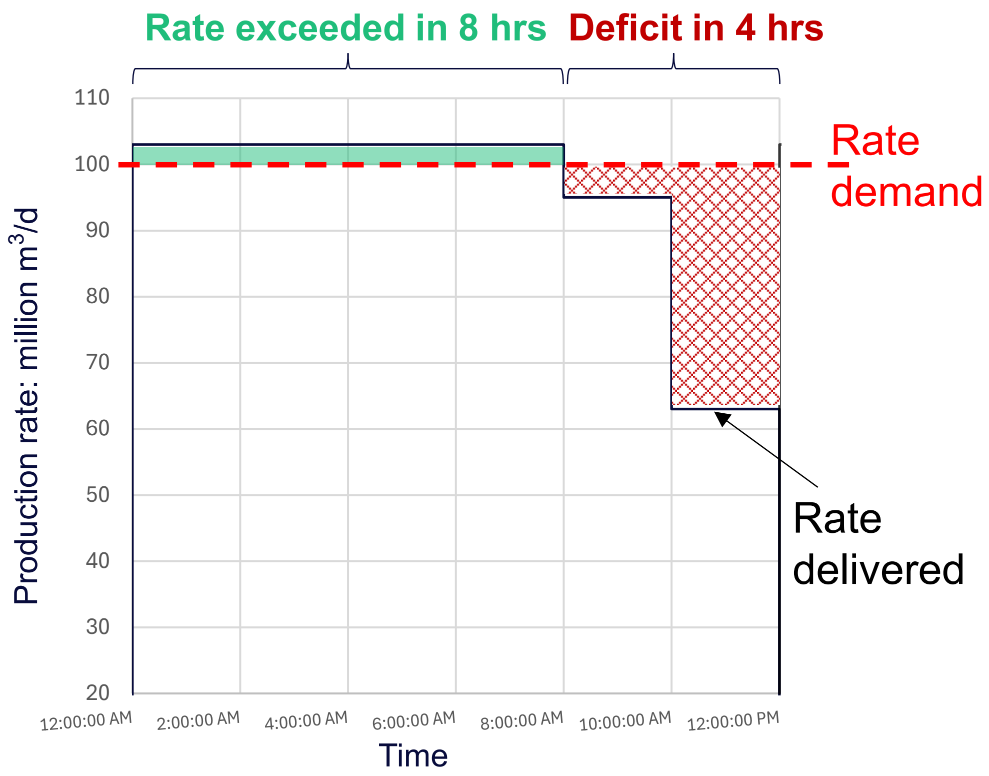
Injection – pressure rises



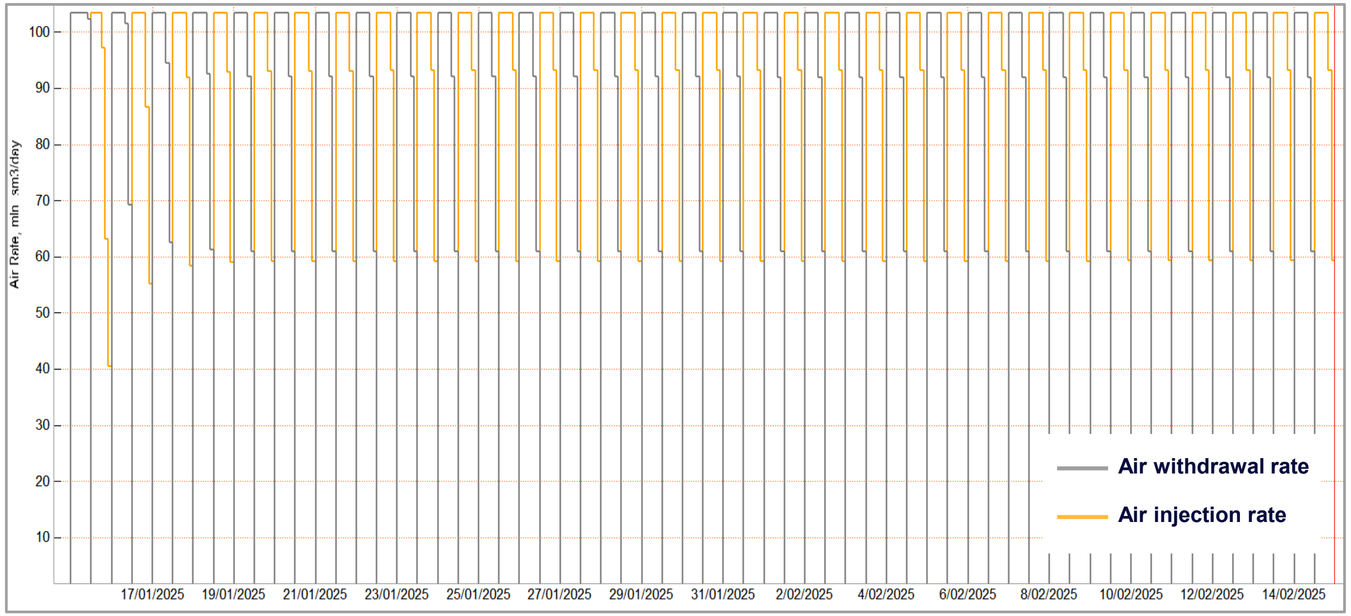


- 42 wells are deployed in the reservoir
- **No impact** on the fault in the north
- Recovered pressure (9.8MPa) **<** the original (10.1MPa)
- **No abrupt** change of reservoir pressure (dropping from 10.1 to 6.8MPa)

Reservoir Simulation – deliverability from 42 wells



Air withdrawal/injection rate in 30 days



- Adequate air delivered for 8 hours from 42 wells
- Working air is 6.3% of the total (50 million m^3/800 million m^3)
- More wells and/or improved well distribution could potentially deliver the demanded air for 12-hour sustainable generation, which requires further simulation.

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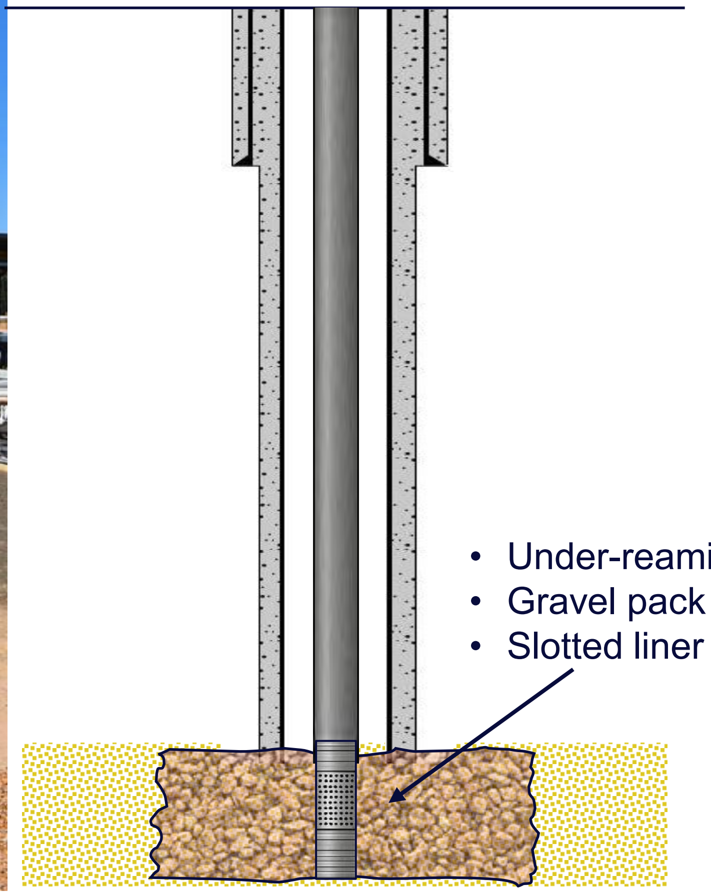
CAES in DGR – wells & surface facilities

Downhole diagram of wells



Existing facilities, including compressors, pipelines and wells could be reused.

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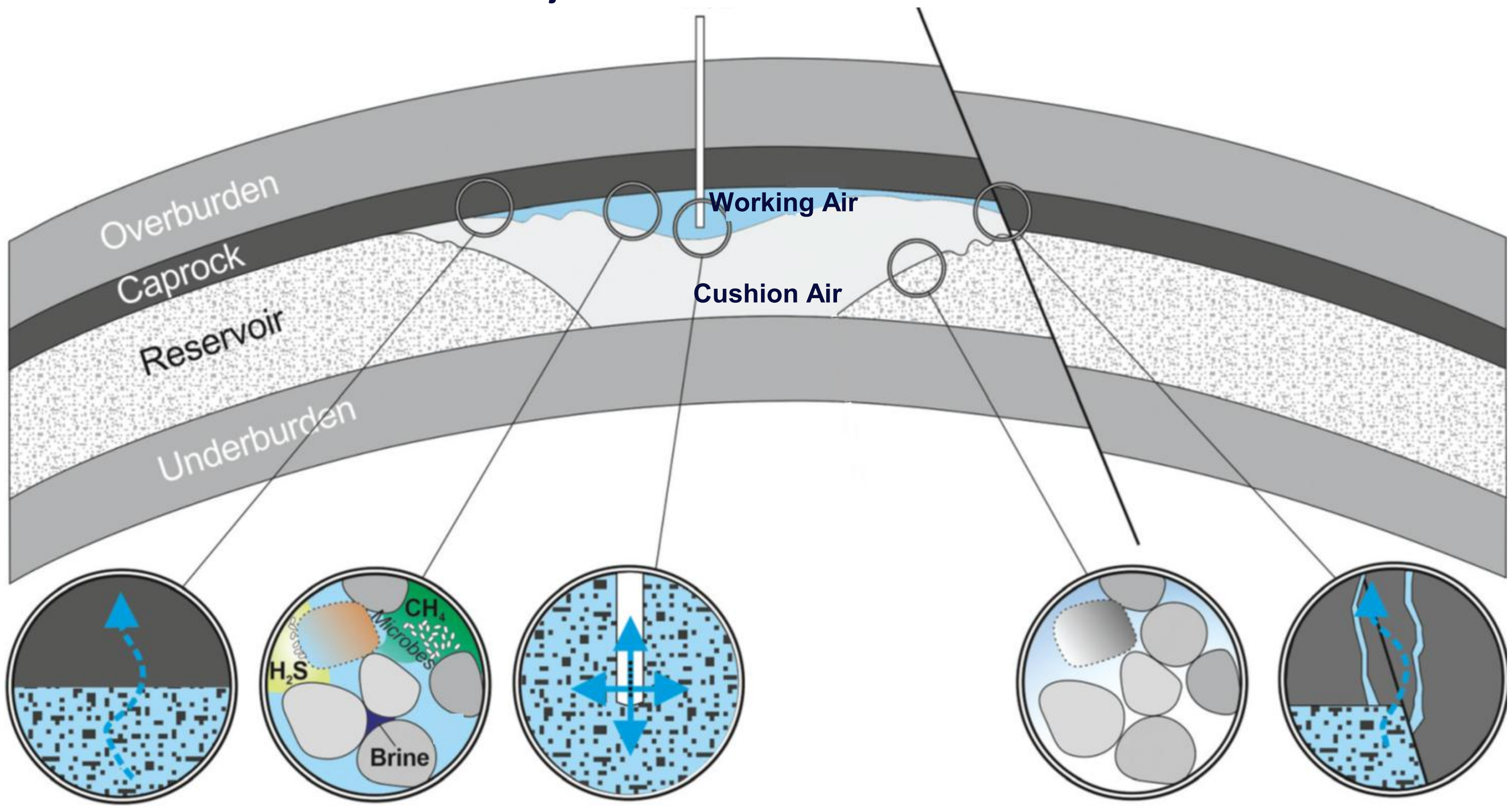
CAES in DGR – microscale studies

Cap rock

Reservoir

Air flow



Caprock:
- Capillary leakage
- Mechanical stability
- Altering stress condition

Multiphase:
- Air/CH_4 mixing
- H_2S hazard gas
- Gas/brine/rock interaction
- Scaling

Well:
- Well integrity
- Stress/strain changes
- Scaling

Multiphase:
- Fluid/rock interaction

Faults:
- Potential leakage
- Field stress change
- Altering stress condition

Source: modified after "Heinemann et al.(2021), Enabling large-scale hydrogen storage in porous media – the scientific challenges"

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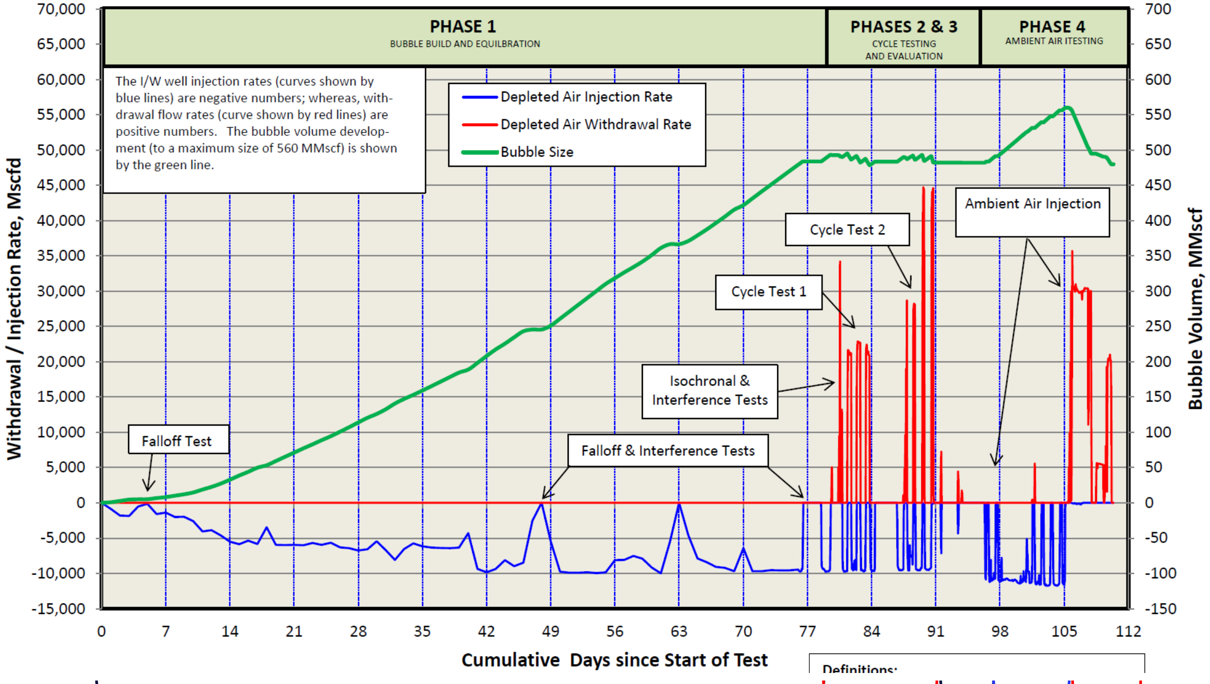
CAES in DGR – PG&E's 130-day trial



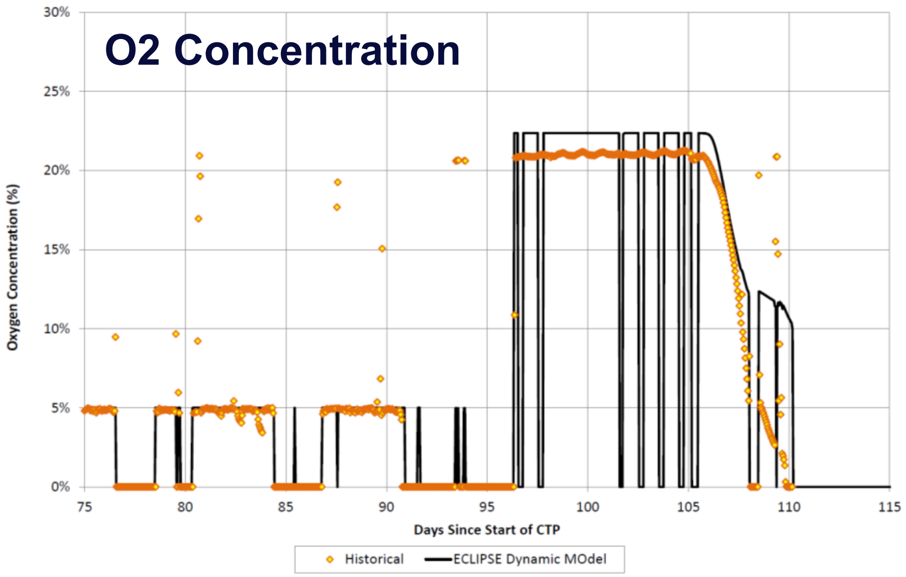
Day 1-80
N_2 Injection

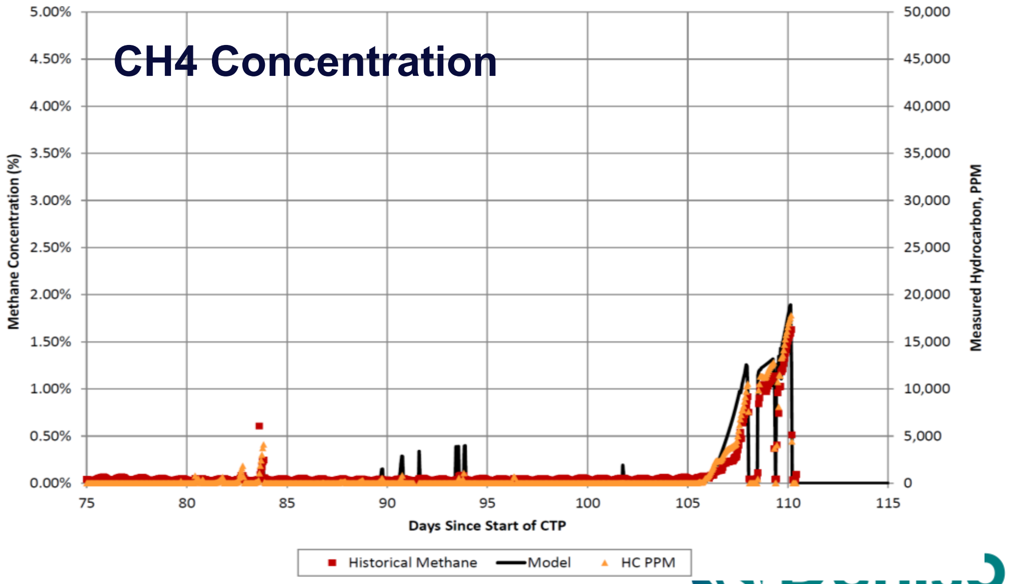
Day 81-91
Cycle testing

Day 97-106
Air Injection

Day 107-111
Air Withdrawal

Day 92-96
Data evaluation





CAES in DGR – System Characteristics

Large-scale and long-duration

Reviving depleted gas field & duplicable

Low CAPEX and low LCOS

The capital cost is about $200/kWh* and life-cycle LCOS is proximately $60/MWh#.

Grid stability

This large-scale CAES would help maintain grid stability.

Long lifespan

Up to 50 years, no harm to the environment.

Job opportunities

The project could create hundreds of job opportunities.

70%

time

No degradation

Stable round-trip efficiency ~70% over its project life.

Carbon reduction

The project will play a key role in reducing carbon emissions, creating a clean and sustainable future.

*,# *The calculation is from internal estimation based on assumptions.*

\# *LCOS estimation excludes charging cost.*

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Thanks
for your attention!