Pacific Northwest
NATIONAL LABORATORY

Digging in: Optimizing Operations

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July 10th, 2025

U.S. DEPARTMENT OF ENERGY BATTELLE

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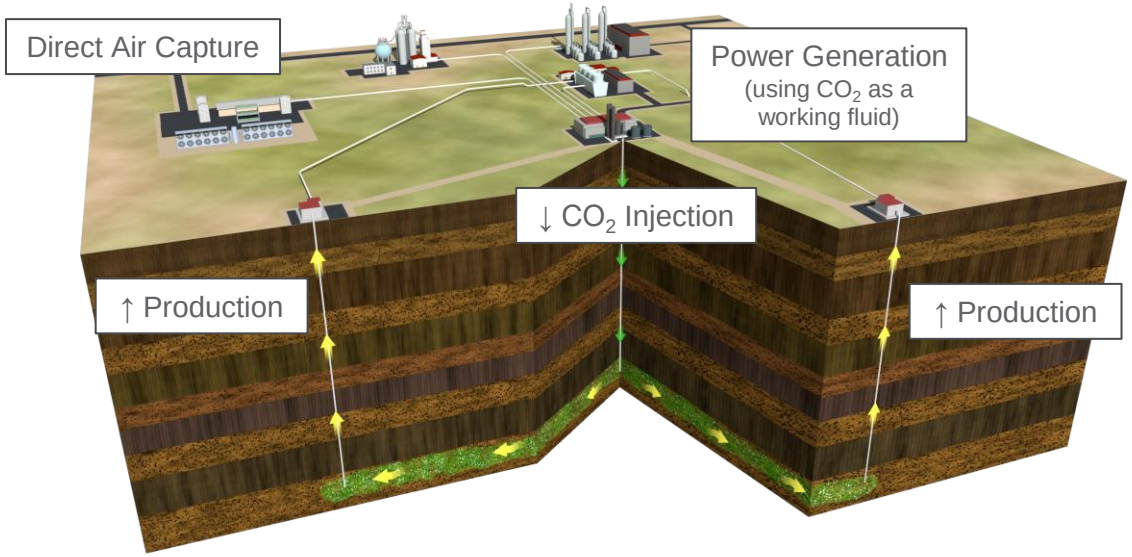
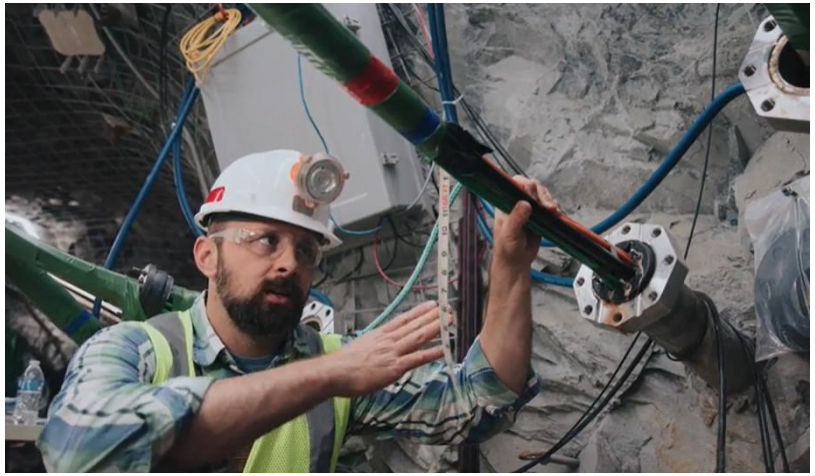
How do we get to commercial scale?

- Analogues
  - CO_2 EOR (Enhanced Oil Recovery)
  - Unconventionals (shale gas)
  - Geothermal & EGS (Enhanced Geothermal Systems)
  - Dedicated CO_2 storage
- Co-benefits and collocation opportunities
- Optimization challenges & opportunities

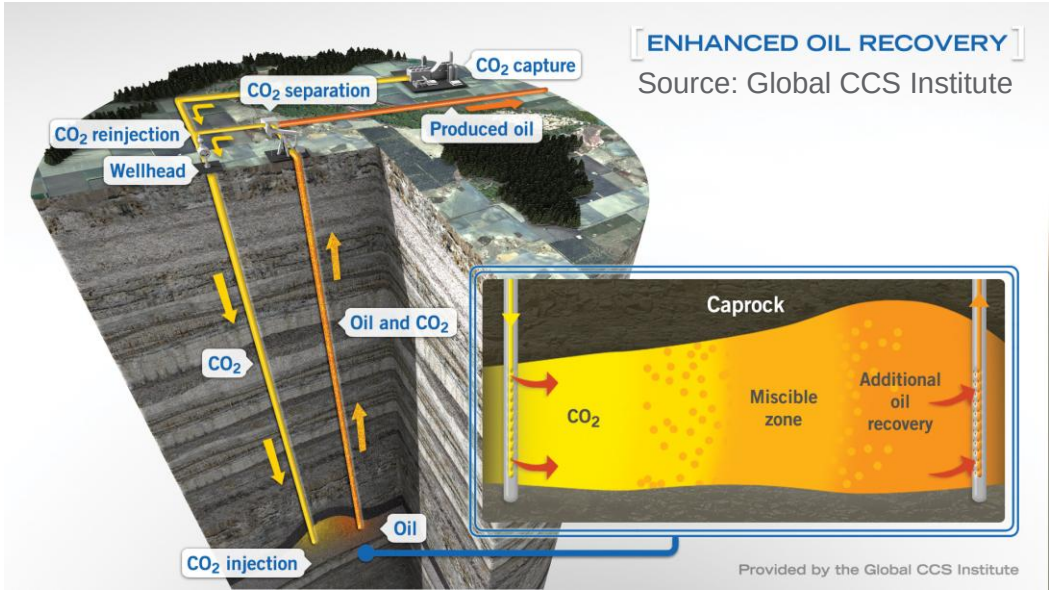


Source: PNNL

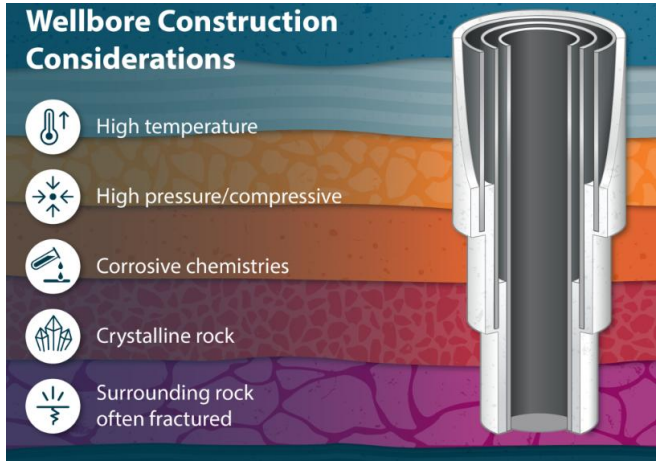


Operational challenges

- Adapt Operational Knowledge
  - O&G: Unconventionals, EOR, Gas Storage
  - Geothermal & EGS: Hard Rock Drilling
  - CO_2: Predictive modeling
- Informed Monitoring
  - Characterization & modeling
  - Defining the reservoir zone: capacity
  - Build on traditional monitoring techniques: tracers, seismicity, pressure, etc.,
- Regulatory requirements uncertain



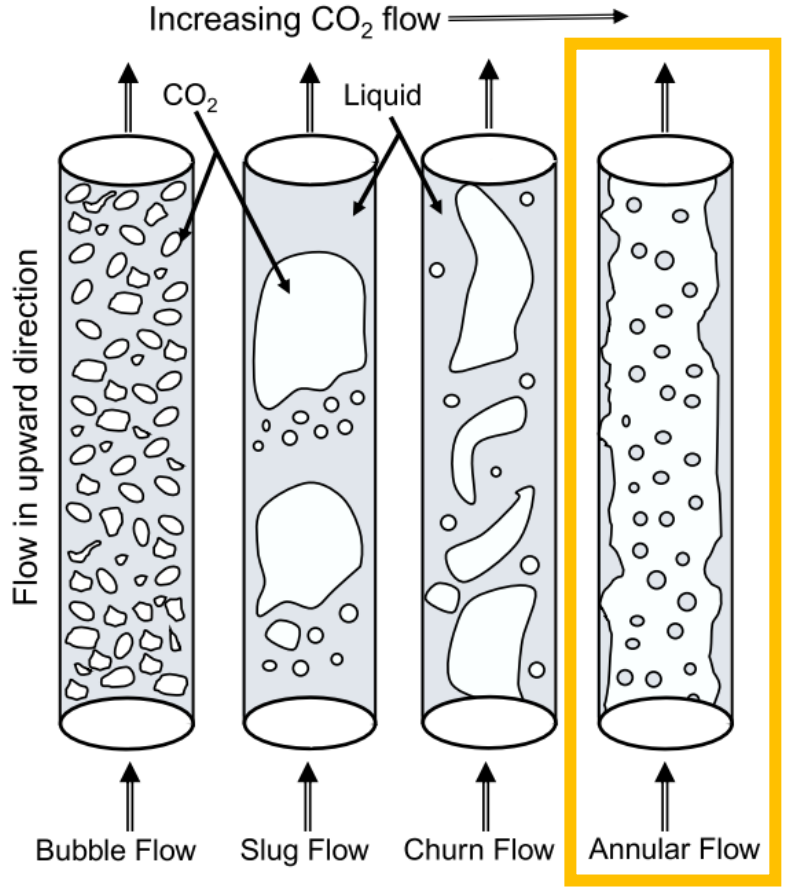
Source: Global CCS Institute



Source: DOE GTO

Optimization opportunities

- Harnessing Geologic Complexity
  - Designing a “closed loop” system
  - Reservoir geometry, heterogeneity, reactivity
  - Reservoir integrity
  - Two is better than one
- Operational efficiencies
  - Field Development and Well Spacing:
    - ✓Maximize thermosiphon effect, reduce pumping
    - ✓Minimize water influx and thermal depletion
    - ✓Maximize CO_2 flowrates
  - Pressure Management: Water conservation, beneficial re-use



Source: Modified from Ezekiel et. al., 2022

Key Takeaways

- This is an optimization challenge
- We know how to move fluids in the subsurface
- Dynamic pressure and thermal environment
- Regulatory environment: Dedicated storage? Geothermal?
- There is no free lunch, but there seems to be an opportunity to co-optimize storage and energy generation, resulting in increased ROI
  - Techno-economics: how many wells to generate economic power? What about CO_2 capture?