



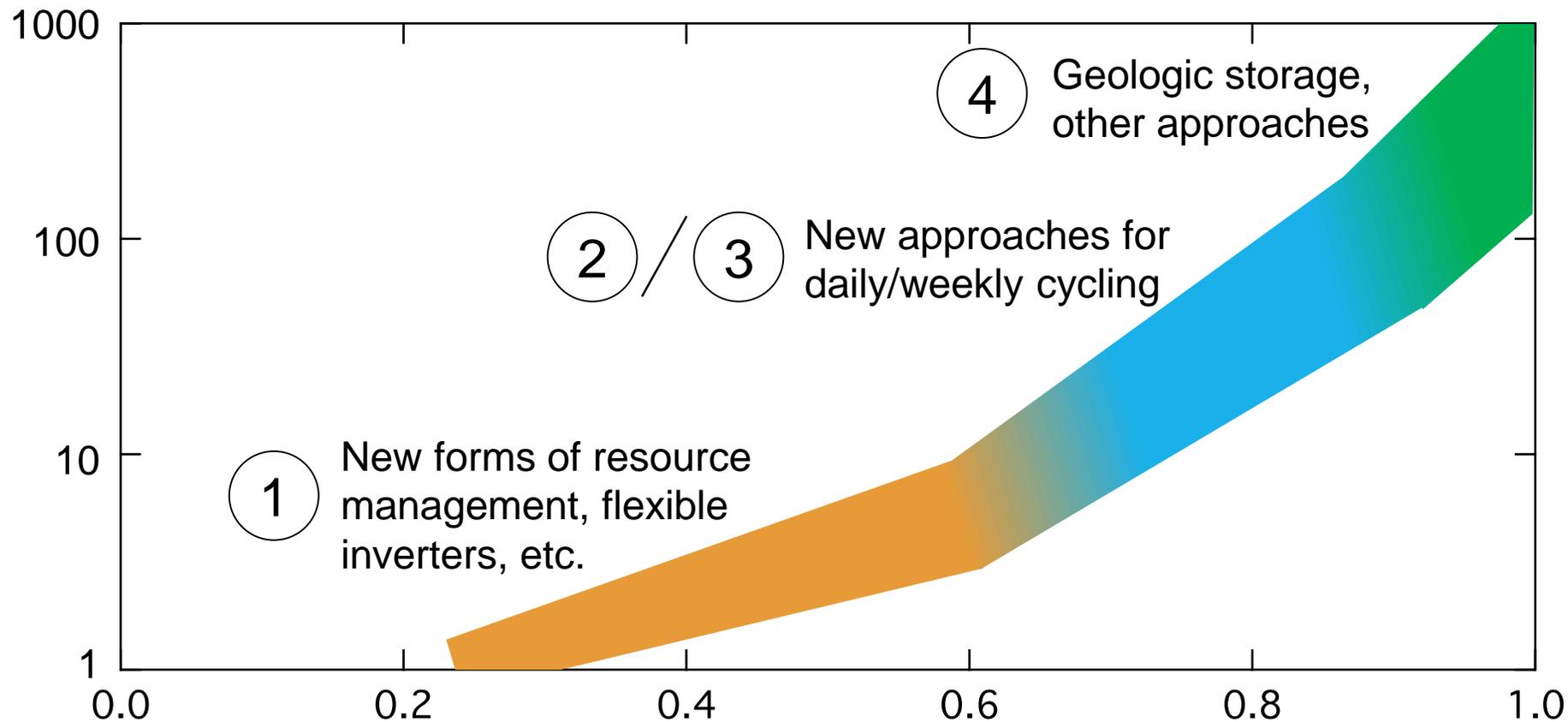
Teaching old wells new tricks: *Reserves for the modern grid*

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March 14, 2018

Several presentations cover challenges of adding wind and solar

Storage duration (hours at rated power)



Fraction of annual energy from wind and solar in a large grid

Uncovering large, latent resources



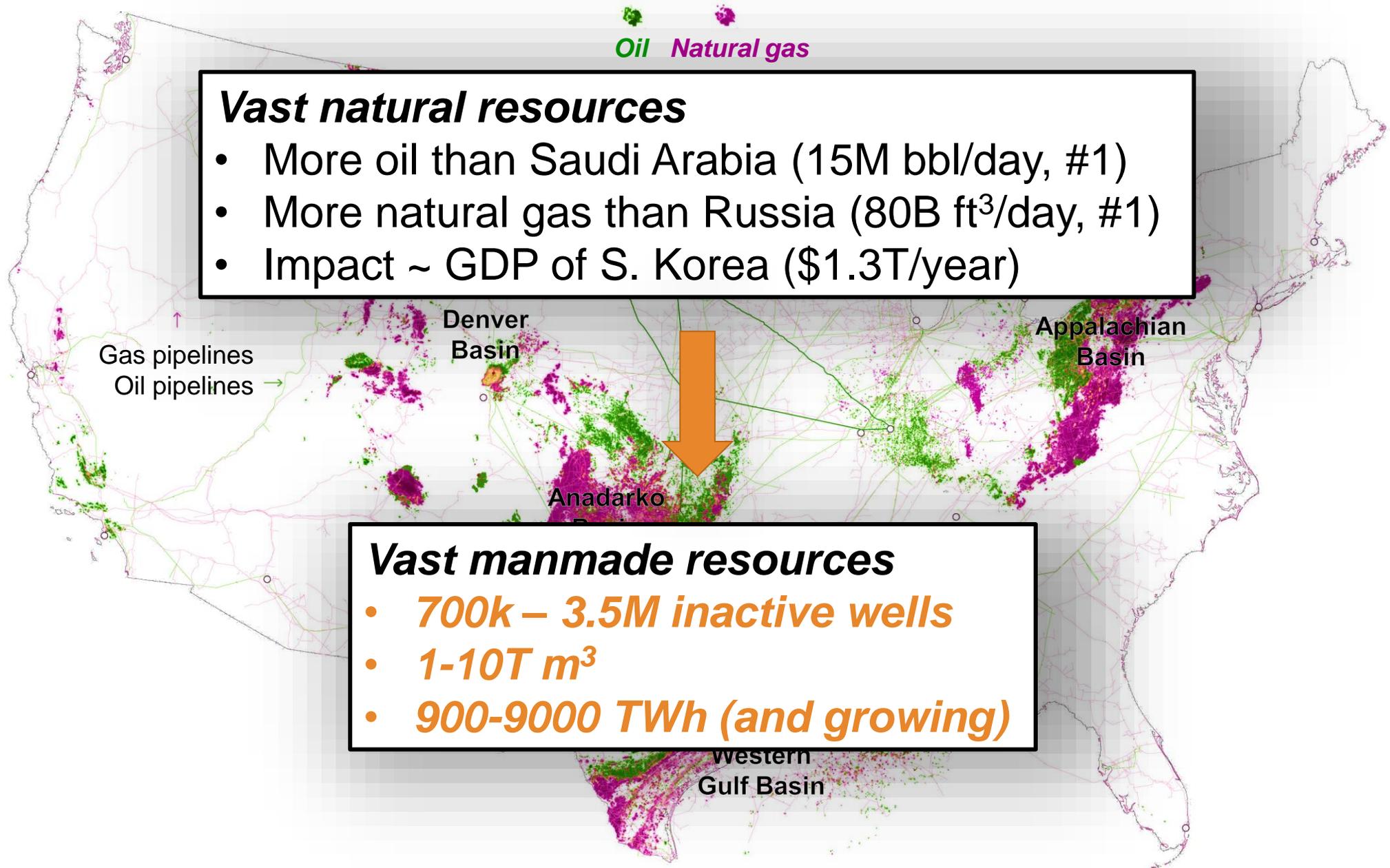
>\$60B valuation
>7M drivers



\$52B in ad revenue
“Audience of one”



725k new jobs
Defeated peak oil

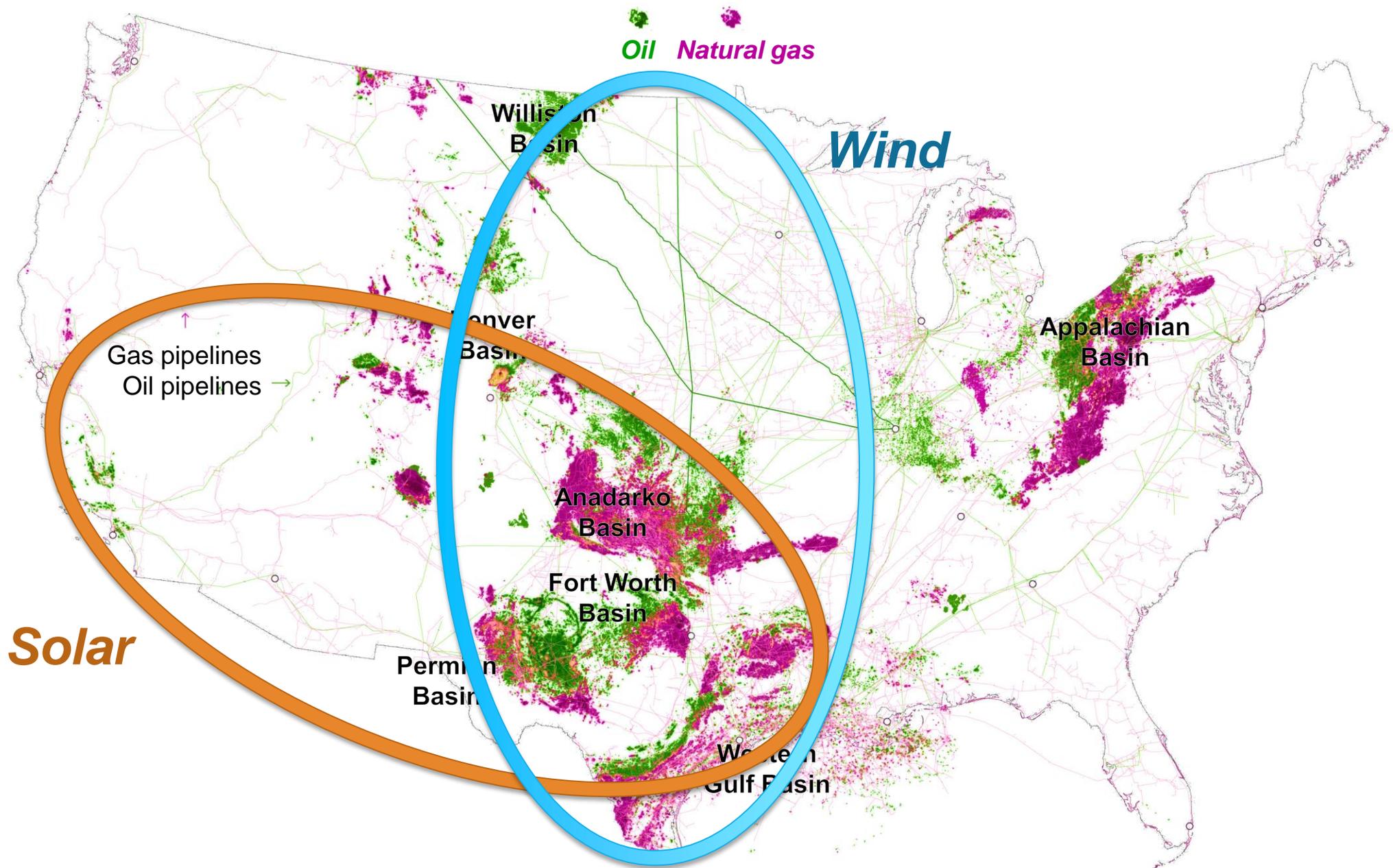


Vast natural resources

- More oil than Saudi Arabia (15M bbl/day, #1)
- More natural gas than Russia (80B ft³/day, #1)
- Impact ~ GDP of S. Korea (\$1.3T/year)

Vast manmade resources

- ***700k – 3.5M inactive wells***
- ***1-10T m³***
- ***900-9000 TWh (and growing)***



"The United States of oil and gas," *Washington Post*, 2017
 Fractracker.org; King and King, *SPE Prod. & Ops.*, 2013; PwC; EIA; World Bank

Let's unleash depleted wells as an energy storage resource

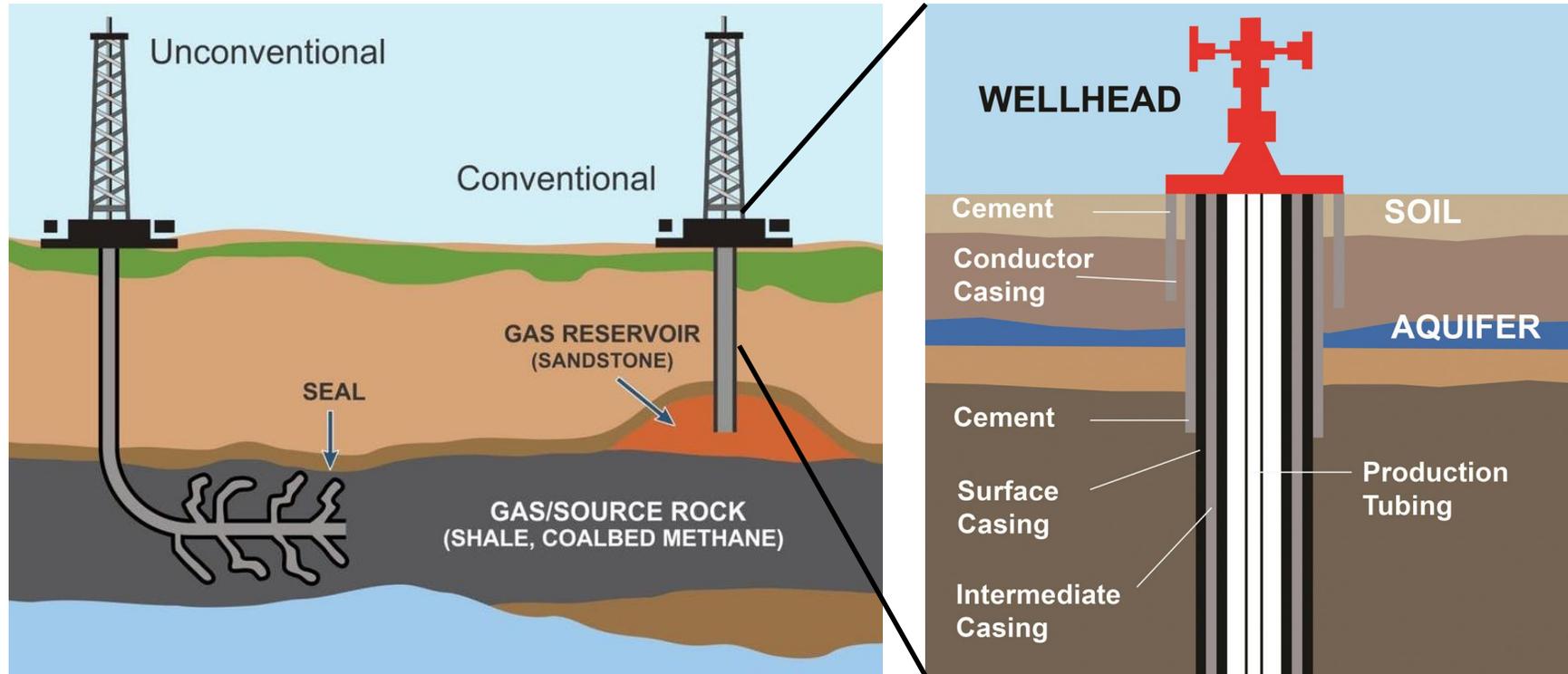
- ▶ Oil & gas know-how
- ▶ Storage concepts
- ▶ Creative adaptations



***Second life as
“electron reserve”***



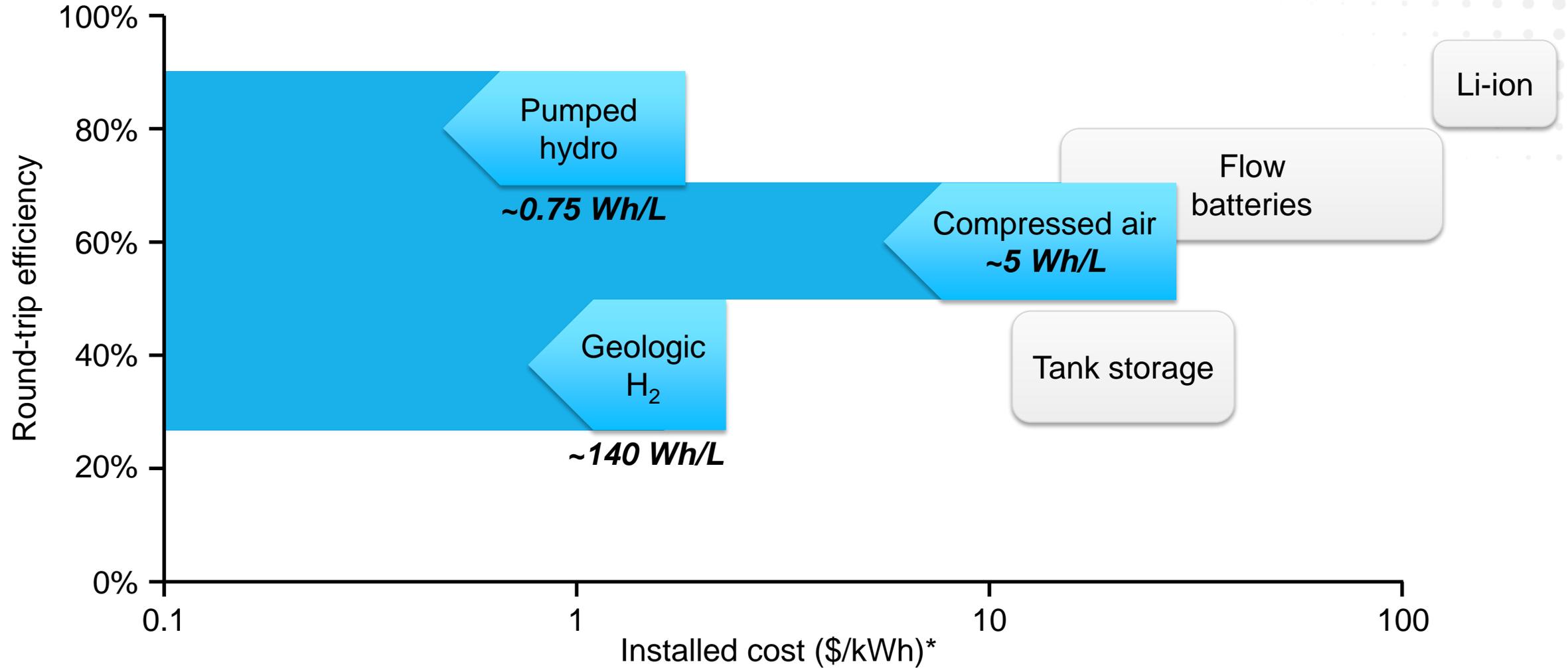
Oil & gas wells are large, premade containers



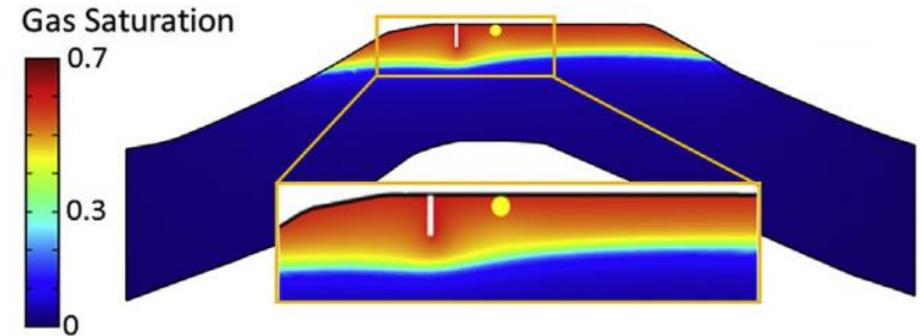
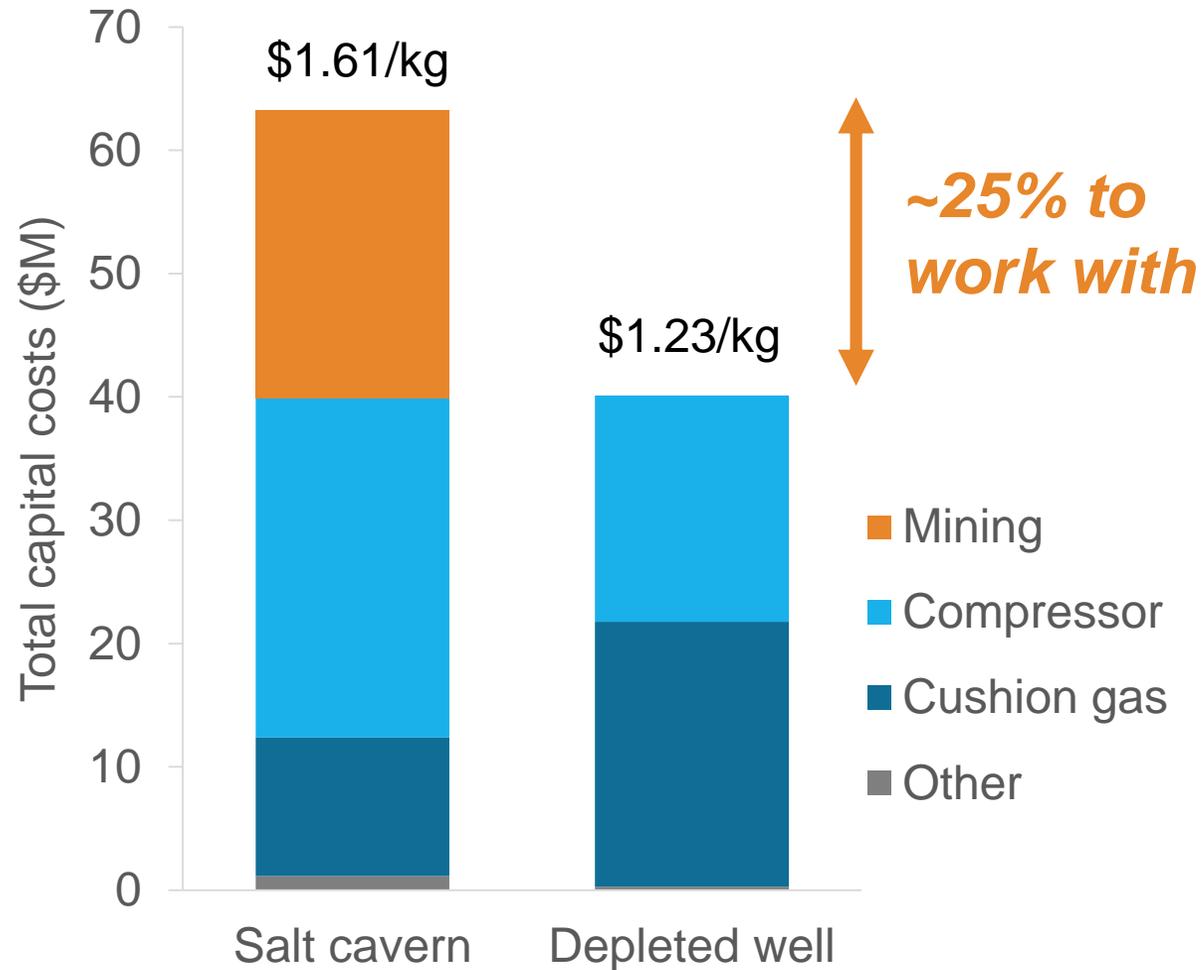
Features:

- ▶ ~1M-10B m³
- ▶ 10-100+ bar
- ▶ 15-30% porous
- ▶ Surveyed and drilled
- ▶ Infrastructure built

Goal: shed cost, keep efficiency



Geologic hydrogen: cheap and cheaper



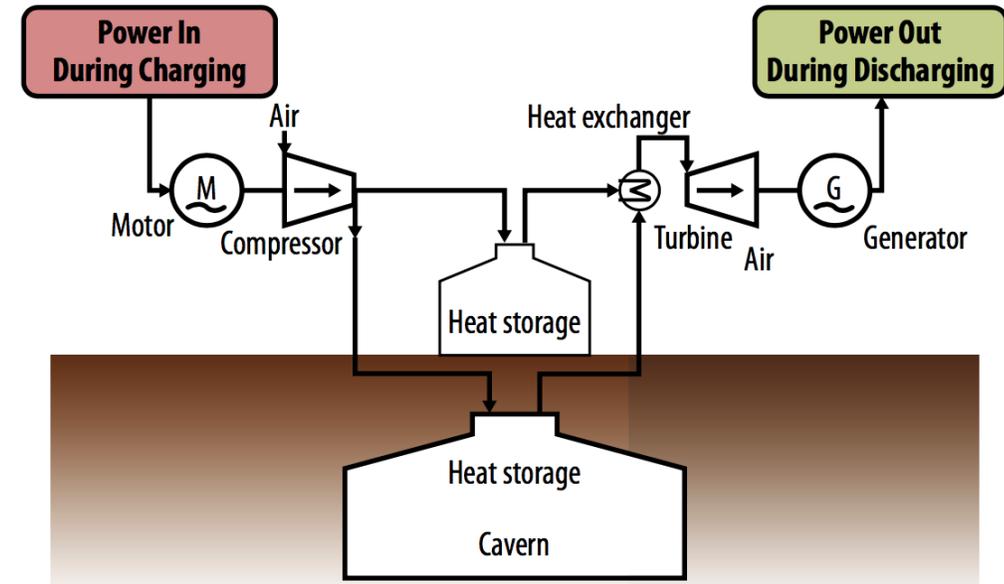
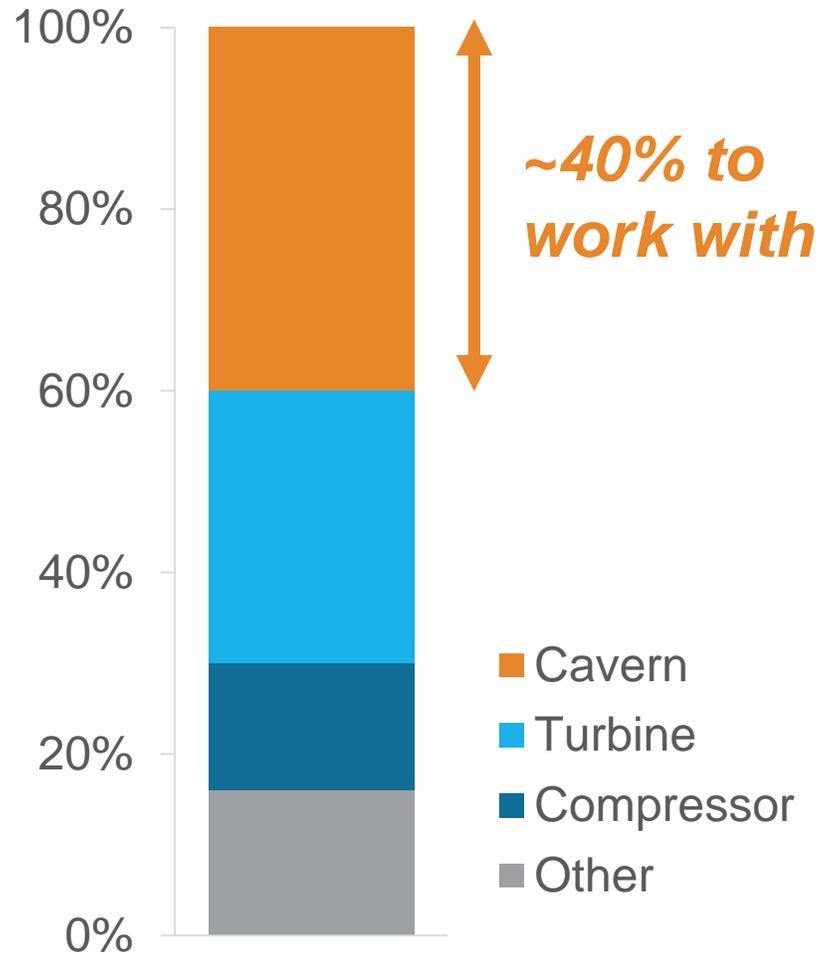
Features:

- ▶ Free mining and infrastructure
- ▶ 5-year head start

Challenges:

- ▶ Parasitic processes
- ▶ Slow mass withdrawal
- ▶ NG/H₂ mixtures

Compressed air (CAES) has similar trade-offs

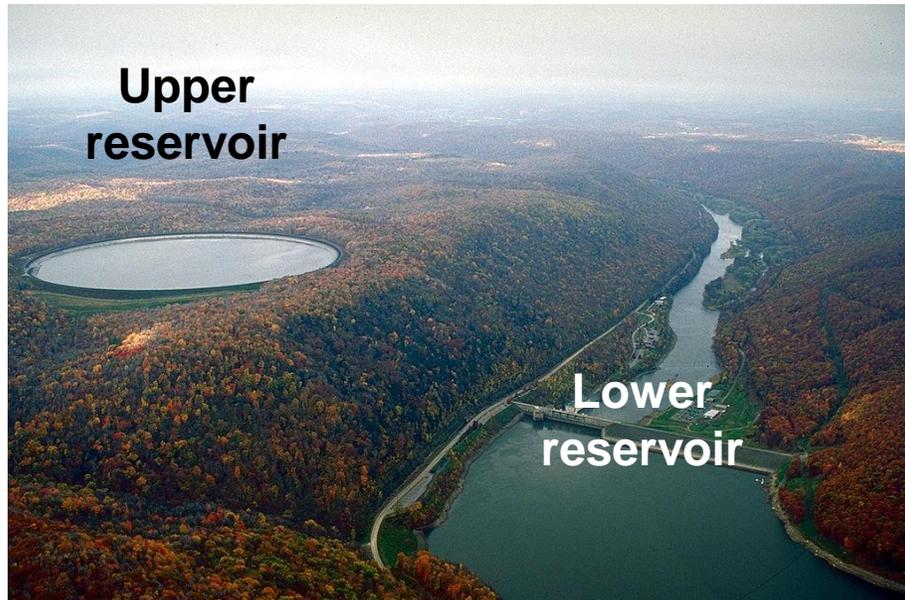


Challenges:

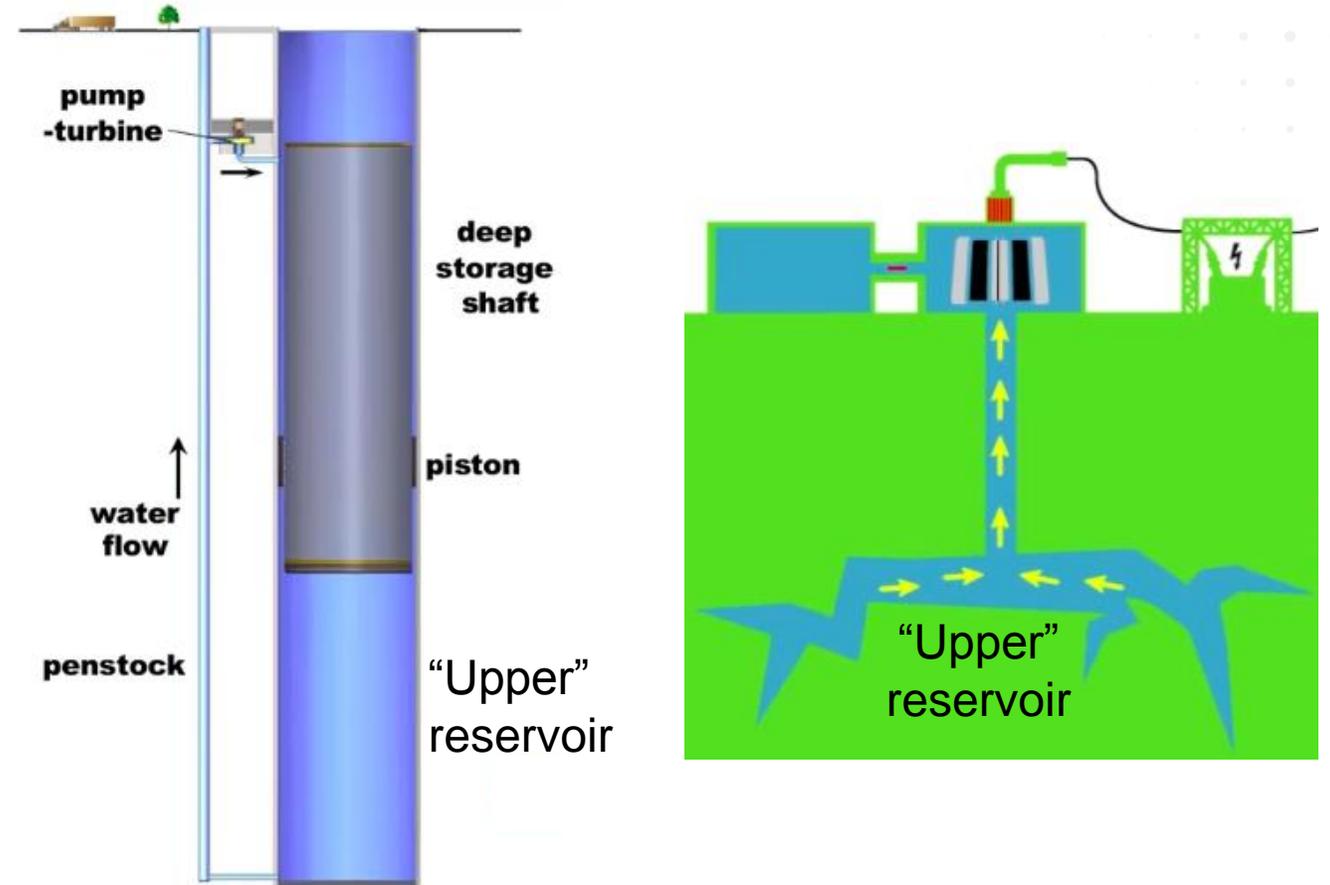
- Can residual NG be monitored and used for reheating?
- Is heat storage feasible long-term?
- How do you lower lower financial risk?

Underground pumped hydro: “down is up”

Traditional

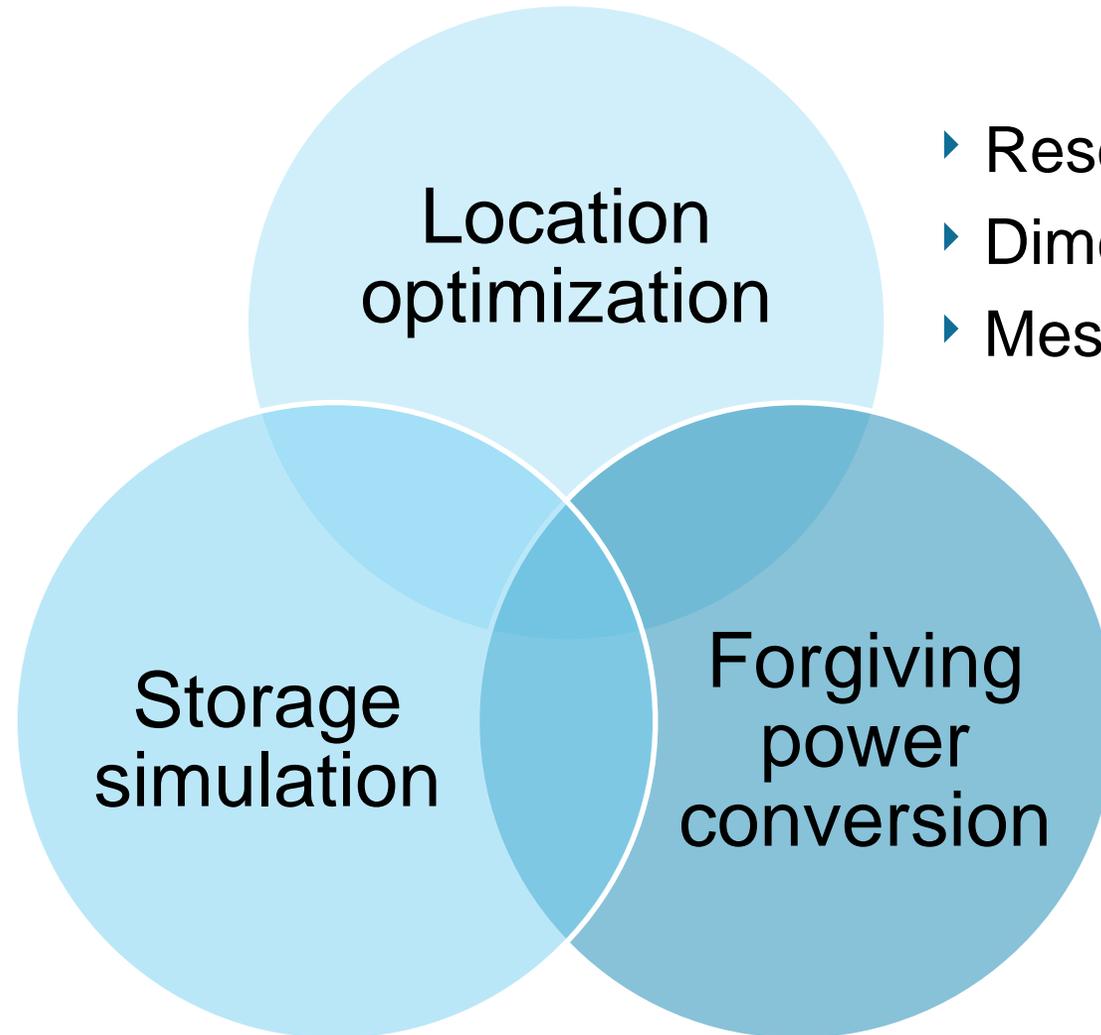


Underground concepts



Innovations needed

Interdisciplinary teams!



- ▶ Resource availability
- ▶ Dimensions, state of repair
- ▶ Messy input data

- ▶ Cost projection
- ▶ Loss minimization
- ▶ Safety

- ▶ NG/oil
- ▶ Water
- ▶ Sulfur compounds

The background of the slide is a photograph of an oil field at sunset. The sky is a gradient of orange and yellow, with the sun low on the horizon. In the foreground, the silhouettes of numerous oil pumpjacks (jack-o'-lanterns) are visible against the bright light of the setting sun. The pumpjacks are arranged in rows, and their mechanical parts are clearly outlined. The overall scene is industrial and atmospheric.

Thank you!

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