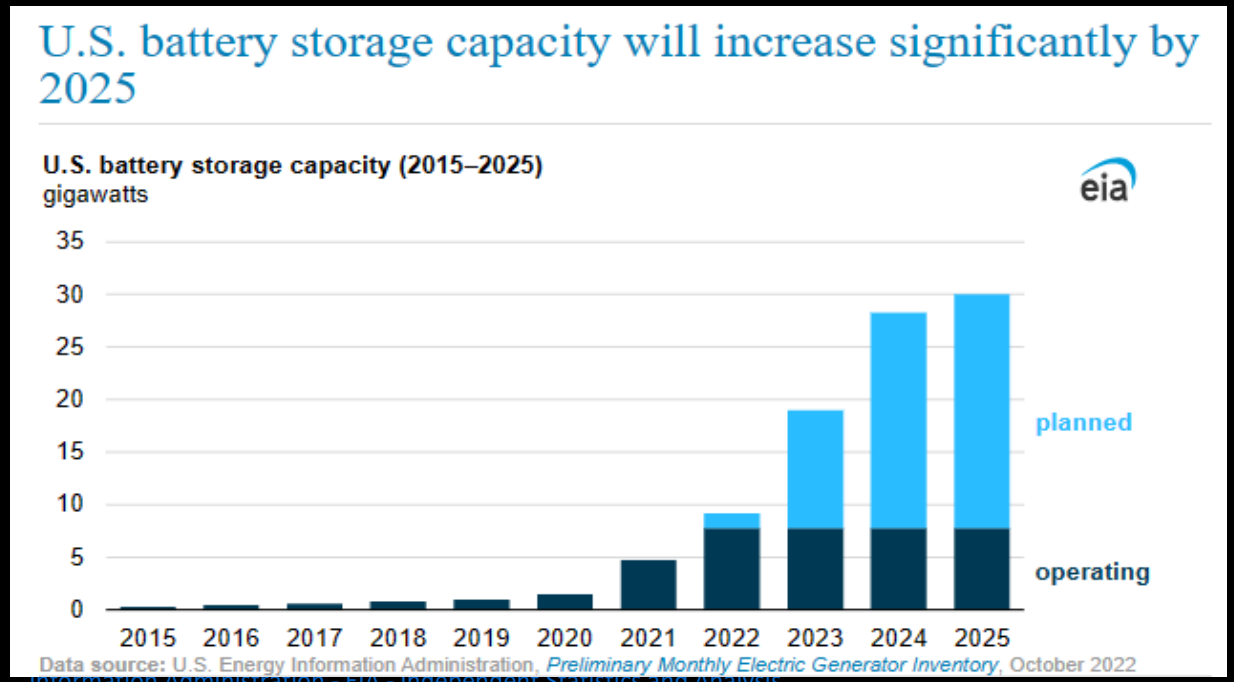

Geothermal Energy Machinery
and Systems (GEMS) Workshop

Nov 29, 2023 to Nov 30, 2023
San Antonio, TX

# Long-Duration Energy Storage Deep in the Earth with Ability to Scale Now

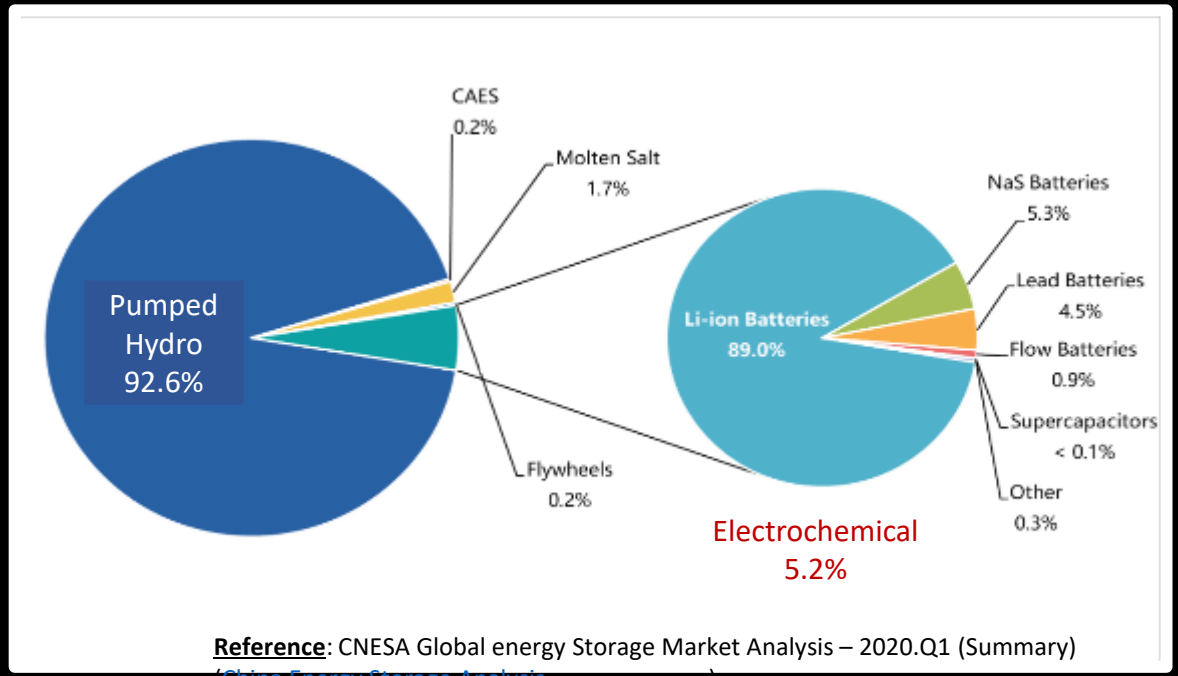
***Lev Ring, Sage Geosystems***

# U.S. battery storage capacity will increase significantly by 2025




Information Administration - EIA - Independent Statistics and Analysis

# Is there an alternative to long term PSH?




**Reference**: CNESA Global energy Storage Market Analysis – 2020.Q1 (Summary)

China Energy Storage Analysis

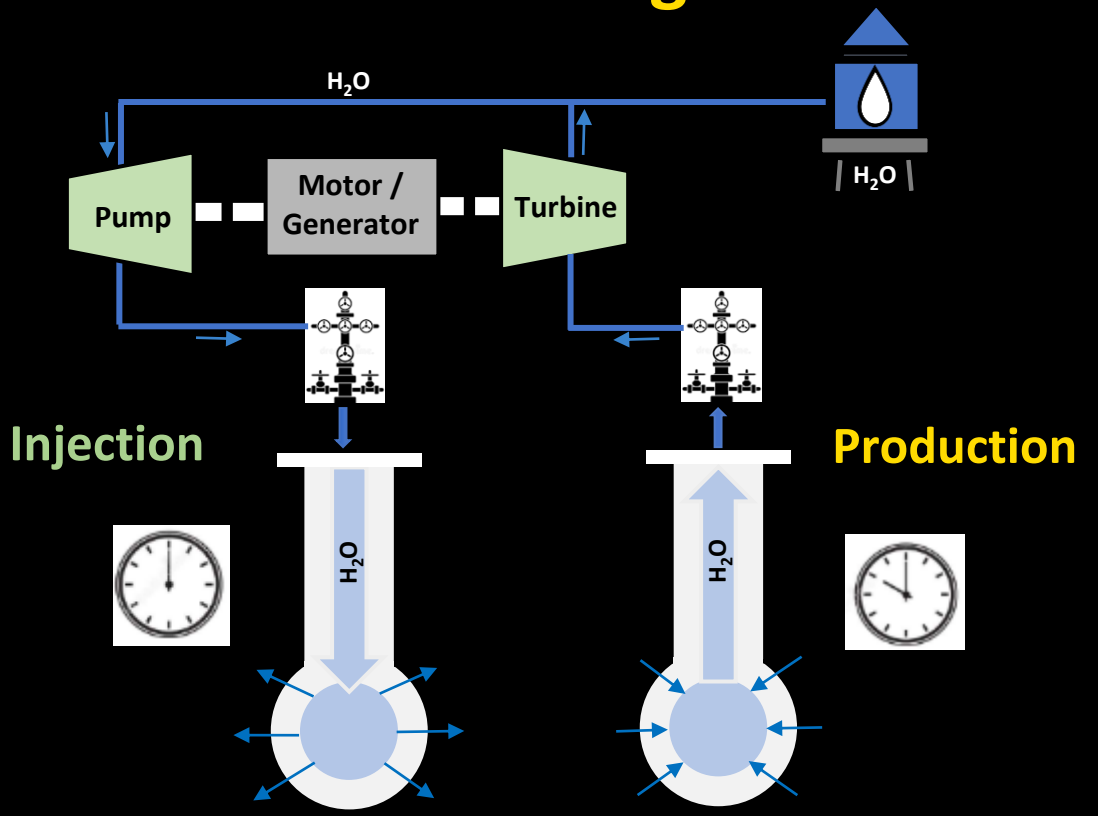
## Projected Needs for Energy Storage in the U.S.

- Power plant owners plan to significantly increase utility-scale storage capacity (by 22GW) over next 3 years
- Currently there is 7.8GW utility-scale storage with need for 30GW by end of 2025

- Projected to change the U.S. electric grid generating portfolio (much like solar has)
- Adds stability to variable energy sources such as wind and solar
- > 75% of 22GW new installations will be in Texas (7.9GW) and California (7.6GW)

# How Does Energy Storage Work?

## Mechanical Storage

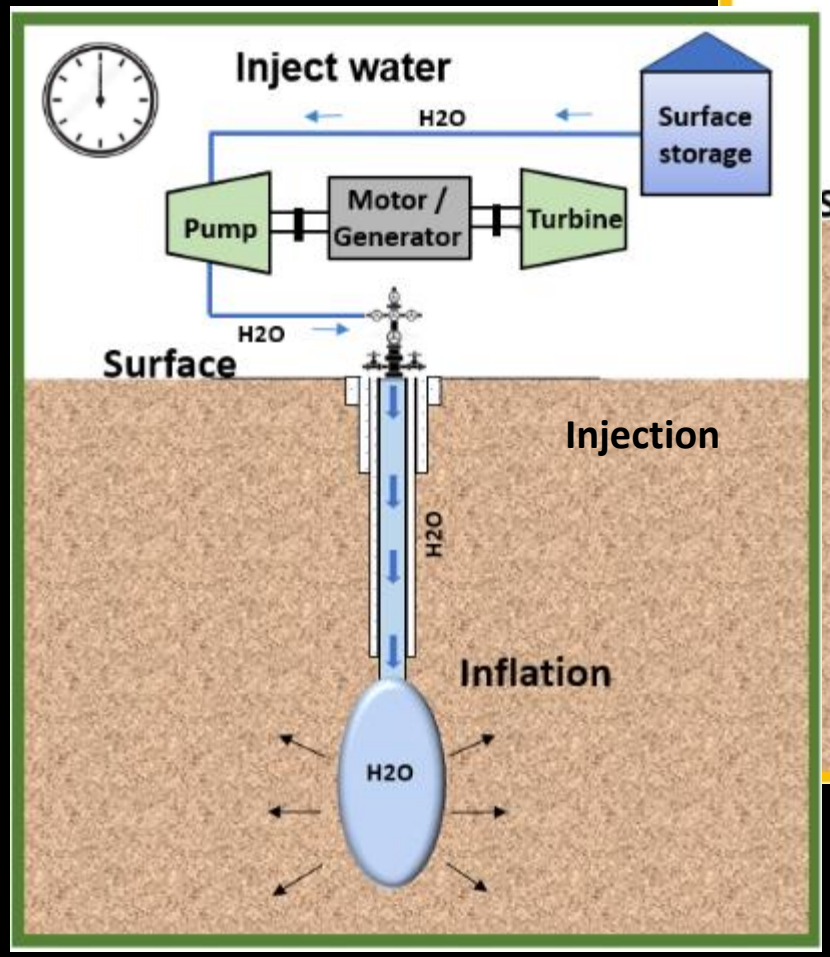


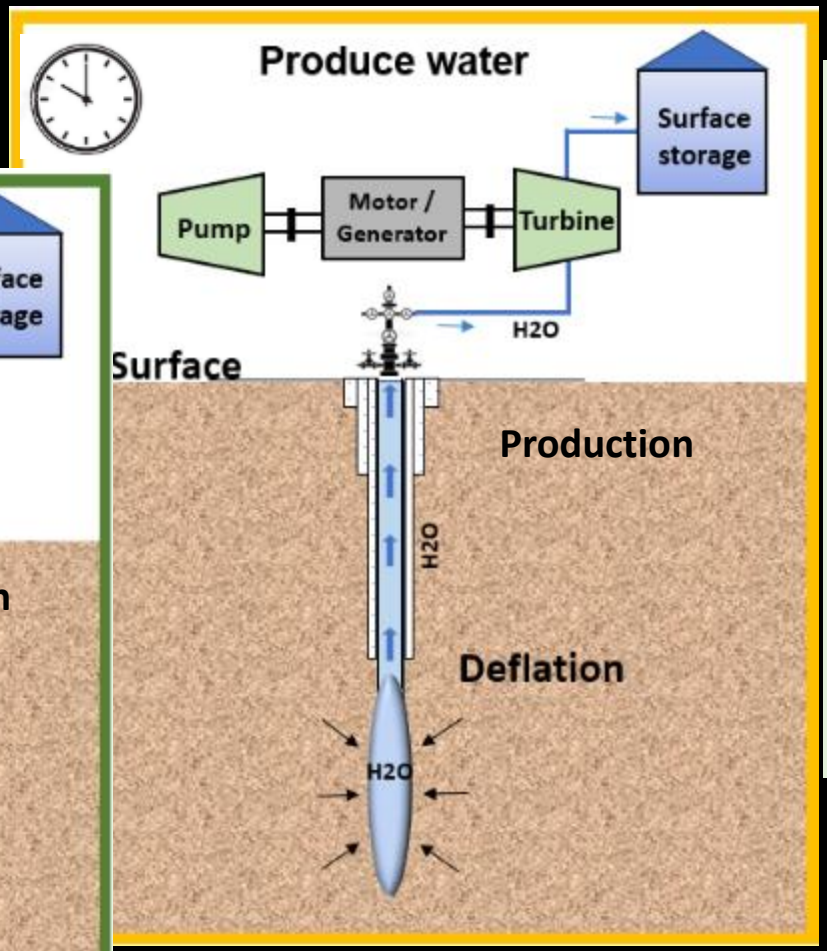

**Harvesting *pressure* with 70% RTE**

## Comparison to PSH

- Ability to scale < 100MW
- Not geographically limited
- Smaller footprint
- Higher energy density
- Weeks vs. decades to permit
- Cost-competitive at scale

# Mechanical Energy Storage: How much power we can generate?



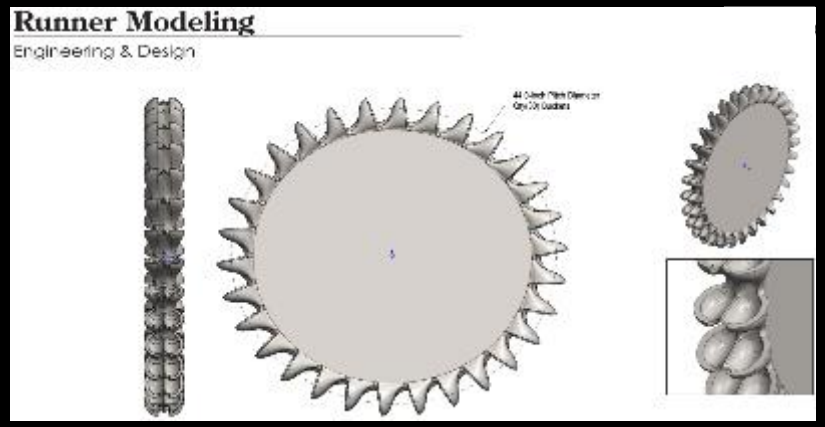

| | |
|---|---|
| *Flowrate Out* | = 45 bpm (120 L/sec) |
| *Surface Pressure* | = 4000 psi (27.5 MPa) |
| ***Gross Power*** | **= 3.289 MW** |
| *Turbine Efficiency* | = 90%, |
| ***Net Power*** | **= 2.96 MW** |
| *Production Time* | = 4 hours |
| ***Energy Recovered*** | **= 11.84 MWh** |
| *Round Trip Efficiency* | *= 70%* |
| ***Energy Stored*** | **= 16.91 MWh** |

**Harvesting *mechanical energy* with 70% RTE**

# High-Pressure Pelton Turbine

Impulse-type water turbine invented in the 1870s by American inventor Lester Allan Pelton

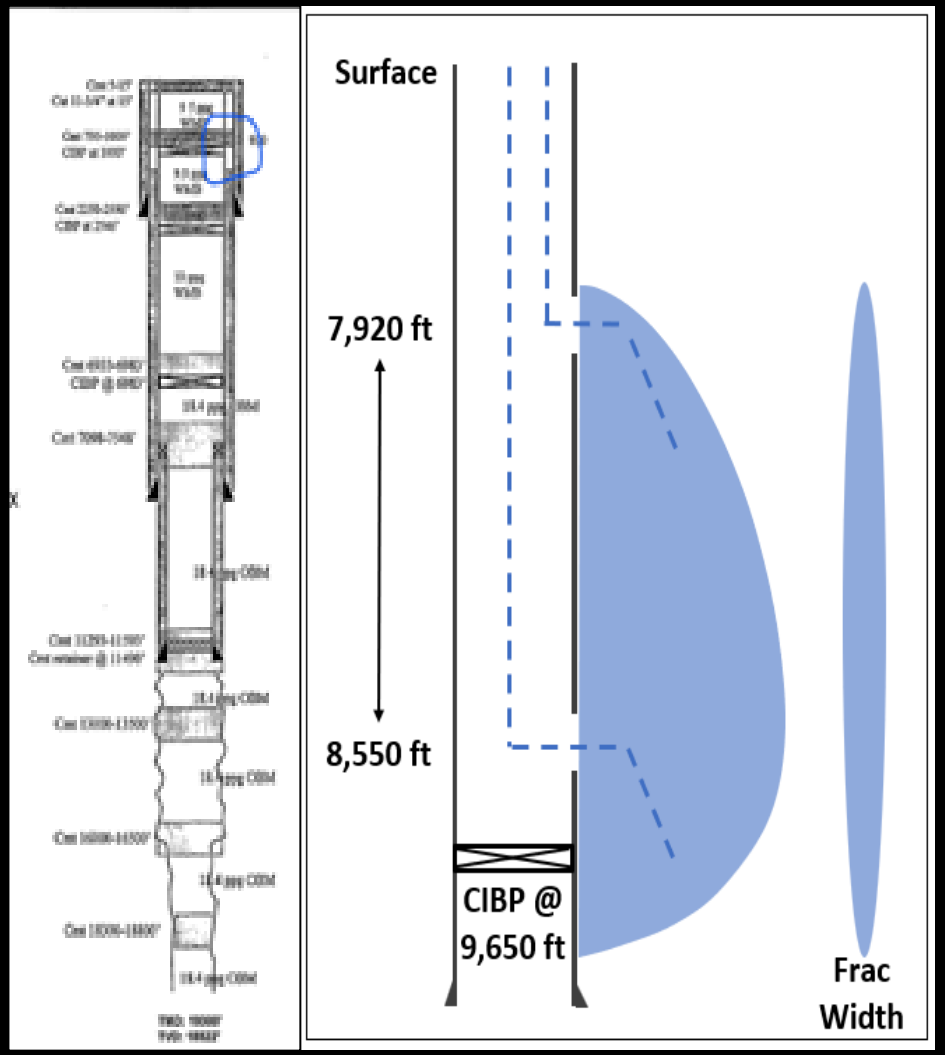
Sage's high-pressure Pelton turbine



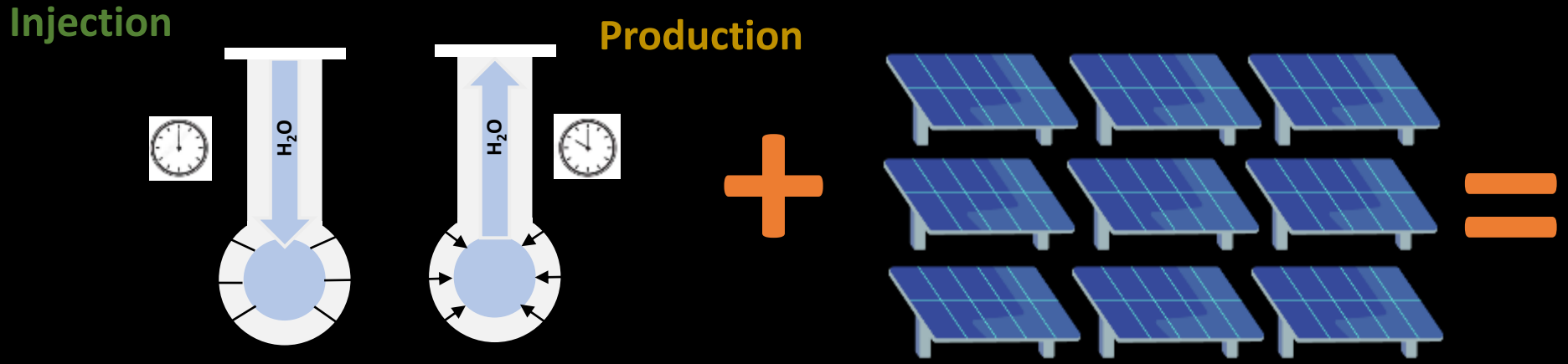

- Sage is upgrading the Pelton turbine commercial design to 5000 psi (3MW)
- Scale-up to 30+MW will be a techno-economic decision
  - Build larger Pelton turbines and/or
  - Manifold together

# 30 MW Energy Storage Facility

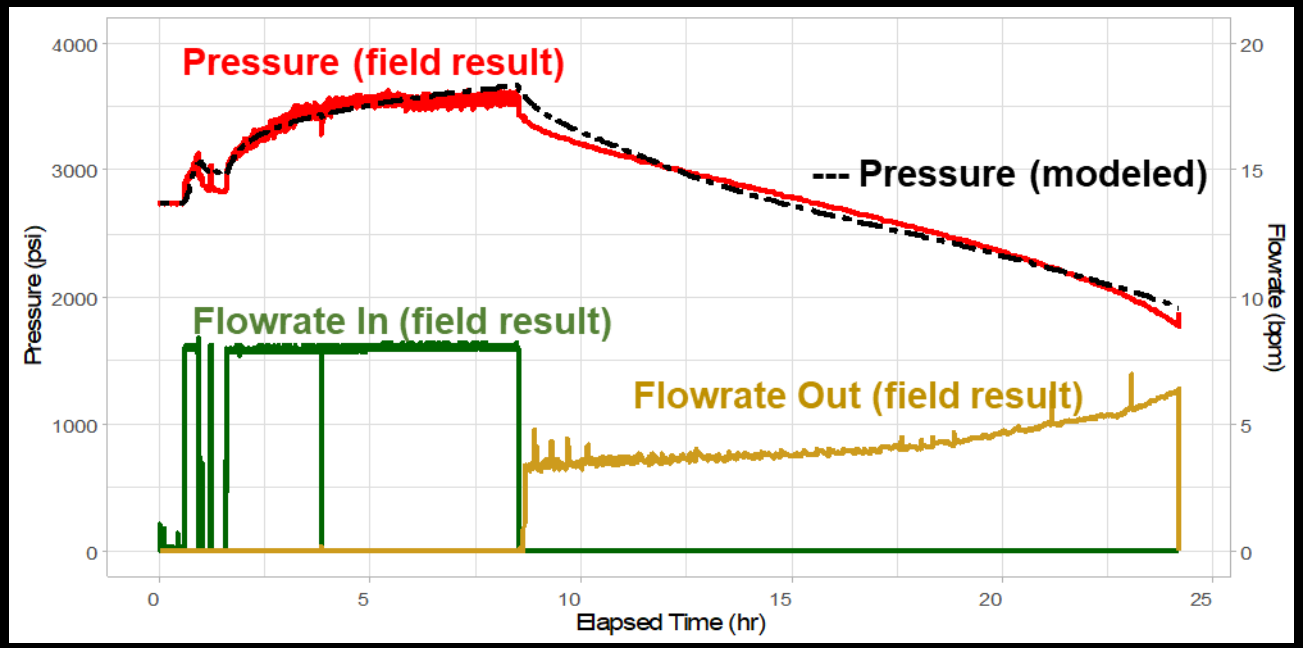
# Energy Storage Demonstration in Starr County, TX




# Application 1: Mechanical Storage + PV Solar = 24/7 Baseload

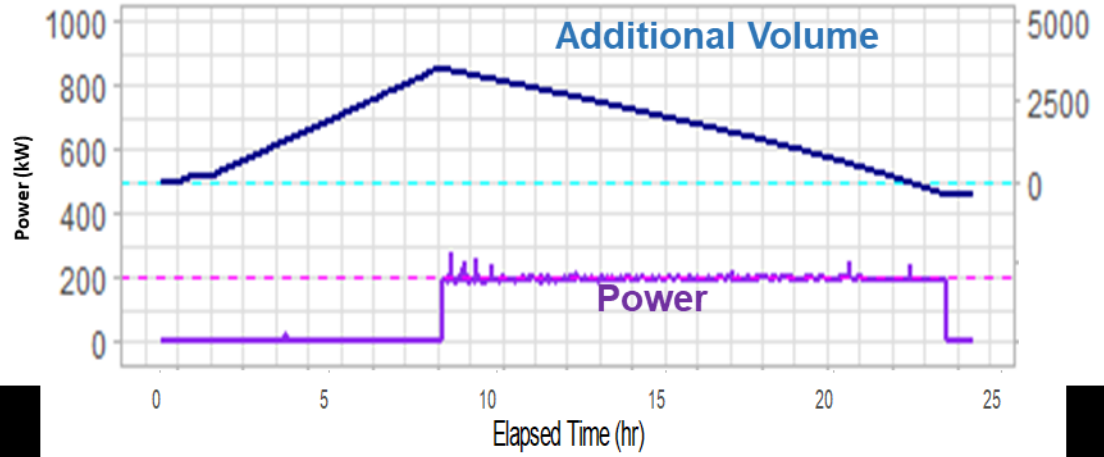



**24/7 Baseload**




**Field test yielding:**

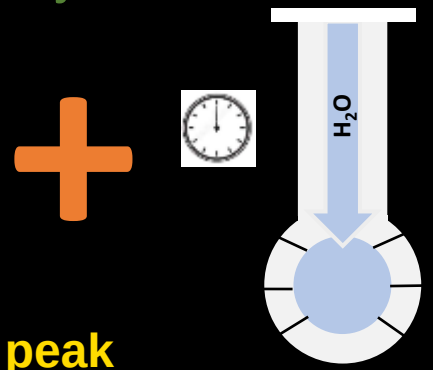
**17.5 hours generation of constant 200 kW power**



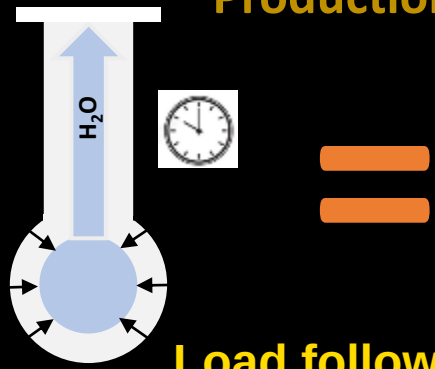
# Application 2:
# Utility Grid Arbitrage using Mechanical Storage

**Texas ERCOT Grid Profile**

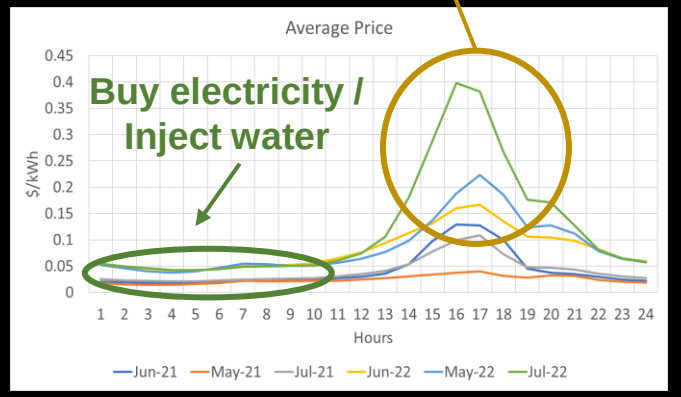
Injection



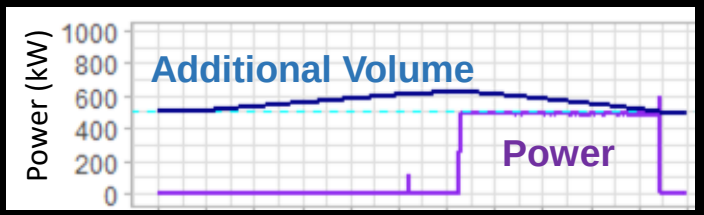

Production



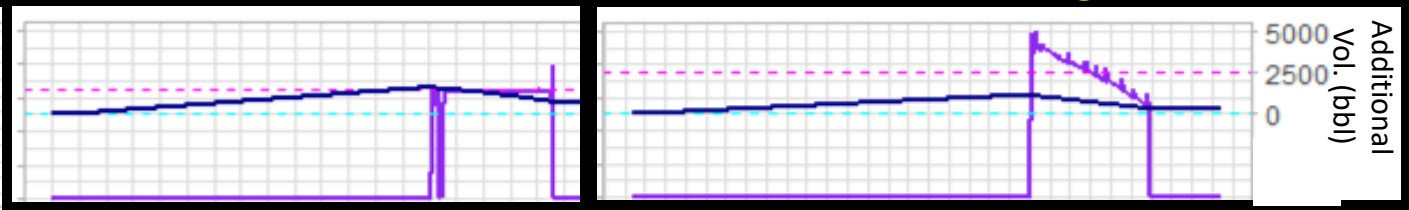

Produce water / Sell electricity

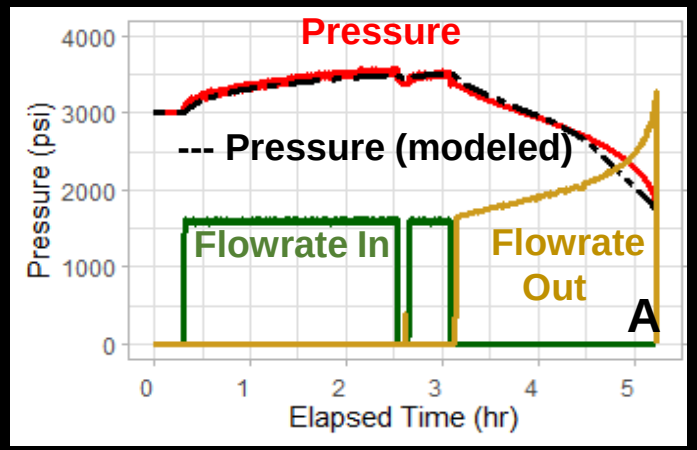


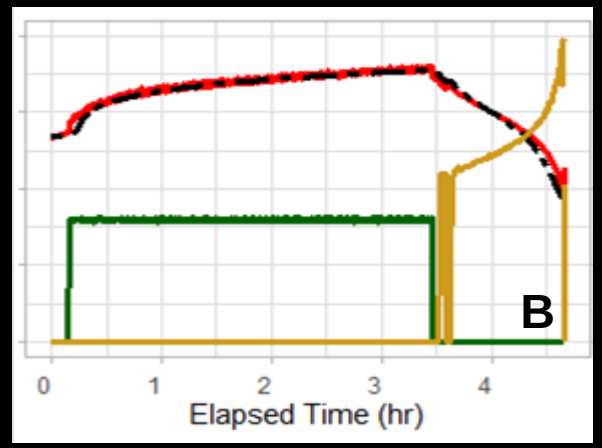

Catching the peak

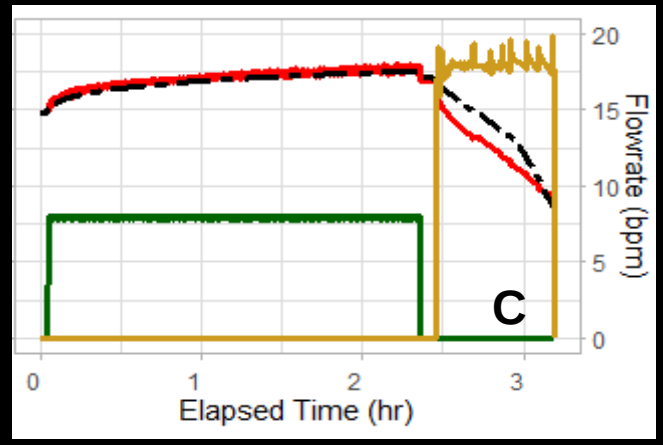



Load following




## Field tests yielding:

**A:** 2 hours generation of constant 500 kW power

**B:** 1 hour generation of constant 650 kW power

**C:** 1MW peak power in 45 minute power generation

# Sage's Mechanical Storage - Upfront Capital & LCOS

## Beats Pumped Storage Hydro & Lithium-ion batteries

- Rapid payout
- IRR = 20 to 30%

*Sage's EarthStore™*

| FOAK | NOAK |
|---|---|
| **$2.5-3.5mln per MW (Any Duration)** | **$2.0-2.7mln per MW (Any Duration)** |
| LCOS = $0.03-0.04/kWh | LCOS = $0.02-0.03/kWh |

| *PSH* | *Lithium-ion batteries* |
|---|---|
| **$2.6mln per MW (Long Duration)** | **$3mln per MW (Duration < 4 hrs)** |
| LCOS* = $0.06-0.18/kWh | LCOS* = $0.25-0.30/kWh |

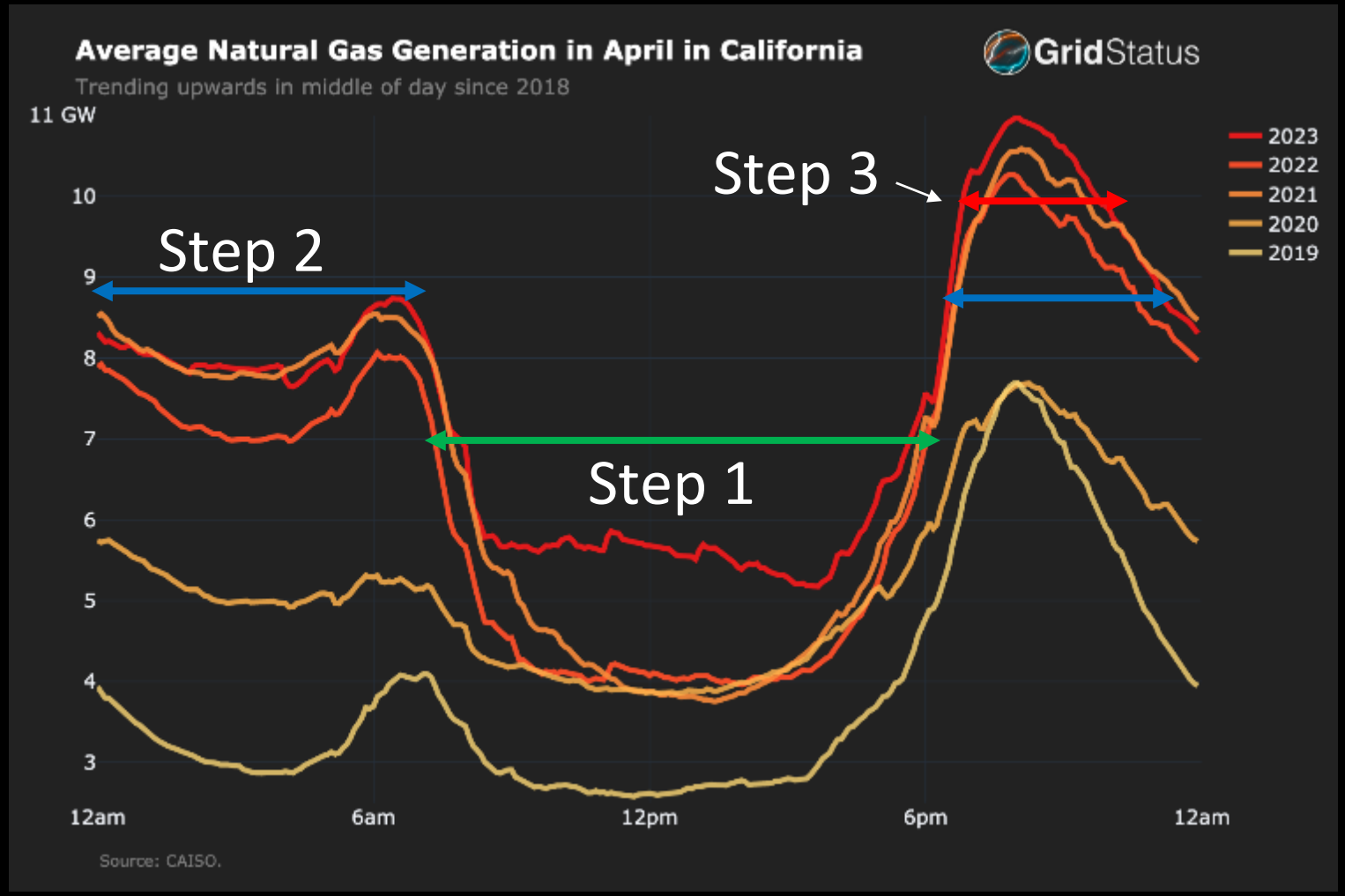
*Navigant Research 2Q 2019 – Comparing the Costs of Long Duration Energy Storage
20190626_Long_Duration Storage_Costs.pdf (slenergystorage.com)

# How Do We Replace Natural Gas with Green Energy?

**Step 1**: Add 7GW of solar to replace natural gas during the day from 6am to 6pm

**Step 2**: Add EarthStore paired with 14GW of solar to charge the storage system during the day and then replace **9GW** of natural gas at night from 6pm to 6am

**Step 3**: Use lithium-ion batteries for the 2GW shortage from 6pm to 10pm




Scale: 1 well = 3MW; 3,000 wells =9GW

Texas: 20,000 O&G wells /year

# QUESTIONS - THANK YOU