The Emerging Hydrogen Economy
Why do we need storage ?

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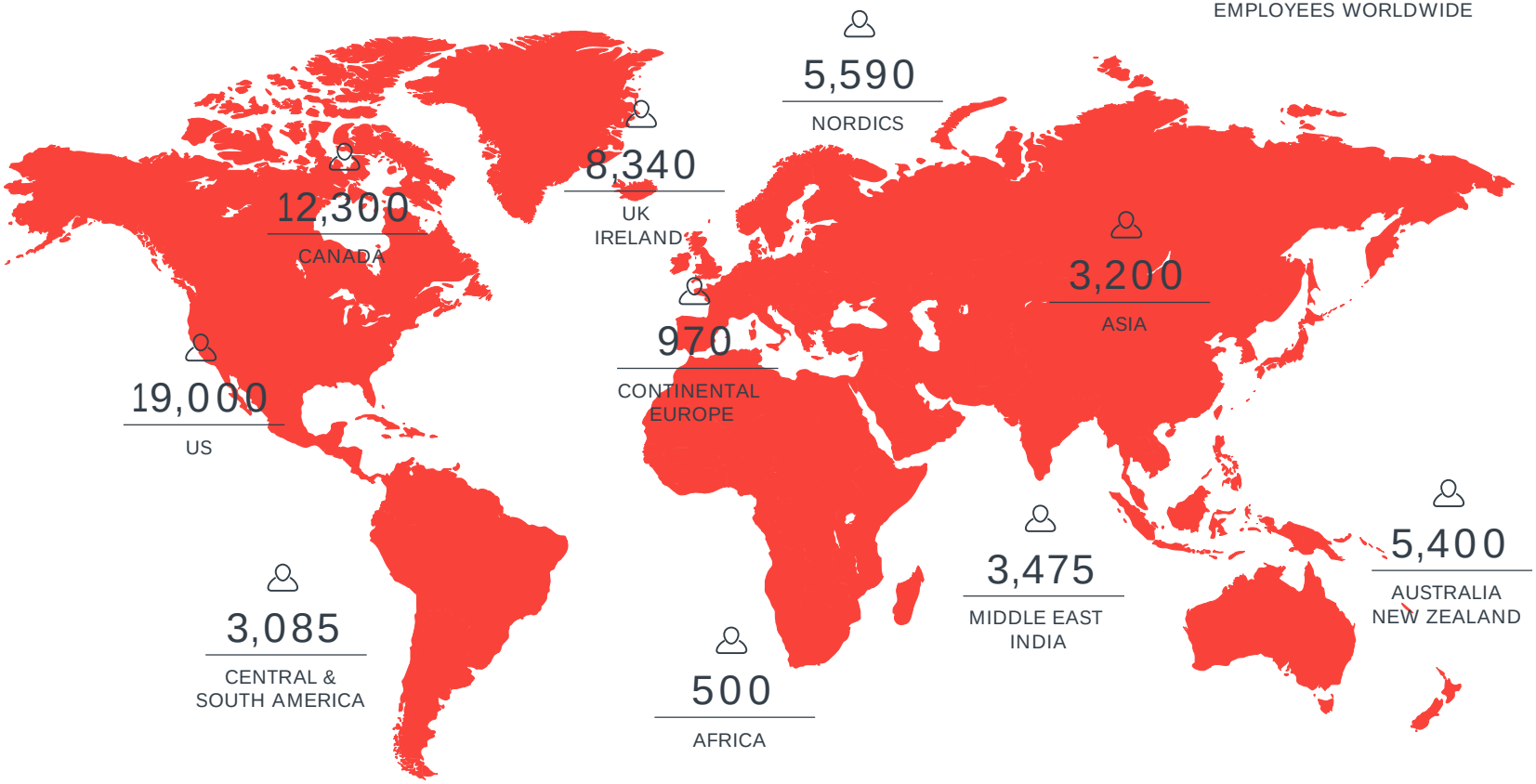
SVP. USA National Market Leader - Hydrogen
2023

WSP - International Agility

~70,000

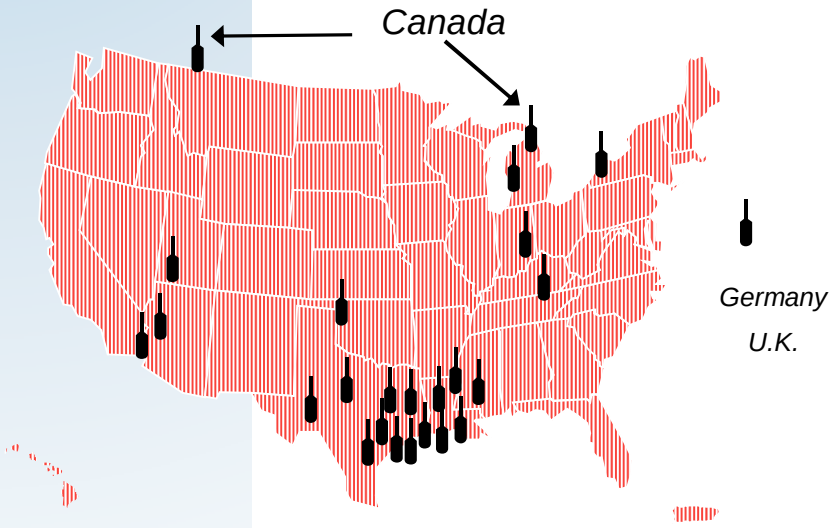
EMPLOYEES WORLDWIDE



Figures as at June 29, 2019
*Note: Total staff figures also includes 425 employees from Louis Berger International

WSP experience in developing salt caverns

40+ Years of Design and Construction Management Experience.
Including a 1 Mm3 H2 cavern for Air Liquide in 2015.
Previously known as PB-KBB, Fenix & Scisson and Parsons Brinckerhoff

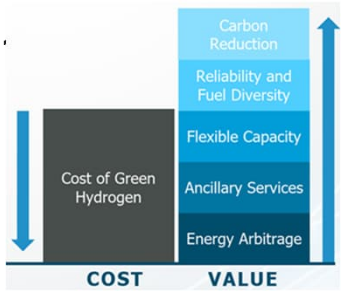


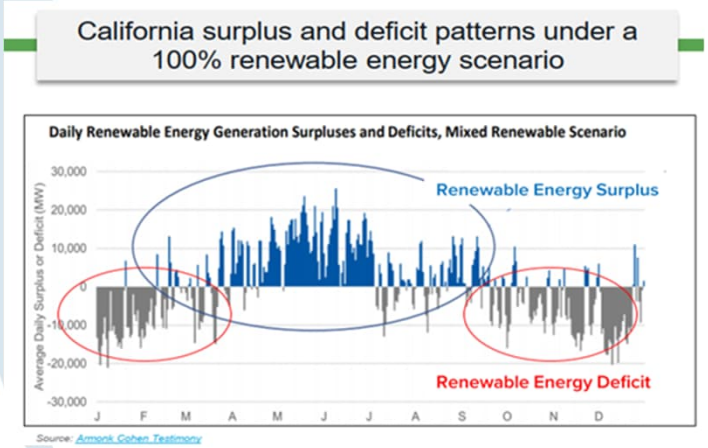
Total of more than 200 salt caverns

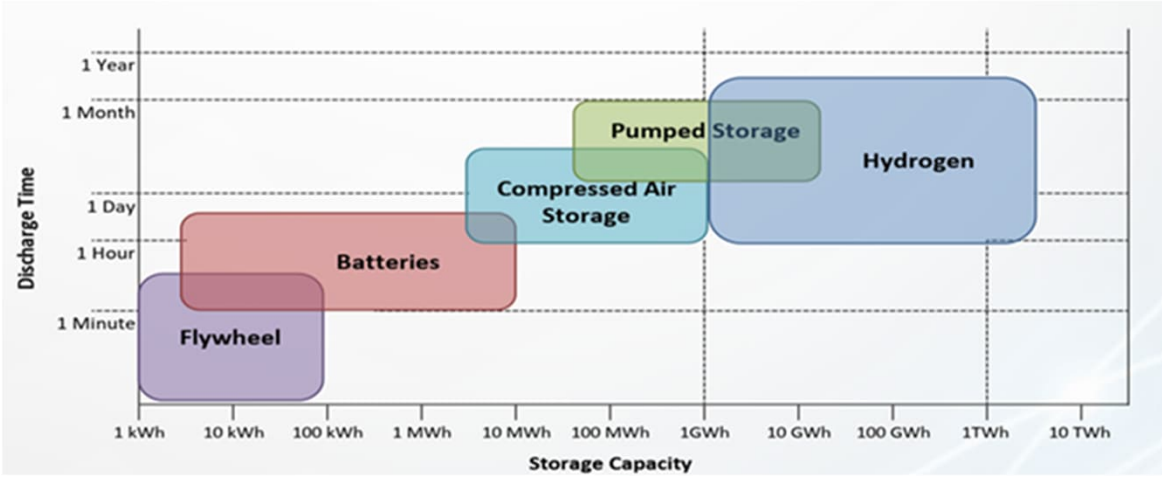
Salt Caverns – crude oil, NGL including ethane, ethylene, petrochemicals, LPG, refined product, feedstocks	173
Salt Caverns – natural gas, hydrogen, CAES	56
Salt Caverns, Chemical Feedstock - brine production	15
Hard Rock Caverns – propane, butane; 235MM Bbl total	83
Leach Plants – 126,000 total hp	21
Gas Compressor Stations – 163,000 total hp	11
Brine Disposal Wells – Over 50 miles total drilled depth	60
Industrial Disposal Wells	30
Acid Gas Disposal Wells	7

Market trends alignment in favor of hydrogen.

- Market is aiming at significantly reducing CO_2 emission.
- Solar and wind power generation increasing rapidly and cost per KWh decreasing.
- Market shows significant periodic surplus-deficit pattern.
- Cost of electrolysis is dropping quickly with mass-scale production units.
- Efficiency of natural gas / H2 turbines improving.





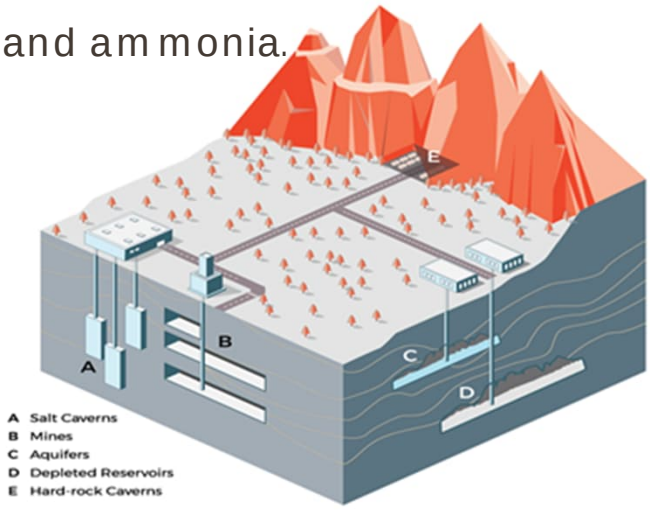


What is new? Why now?

Geological Energy Storage. Driving factors

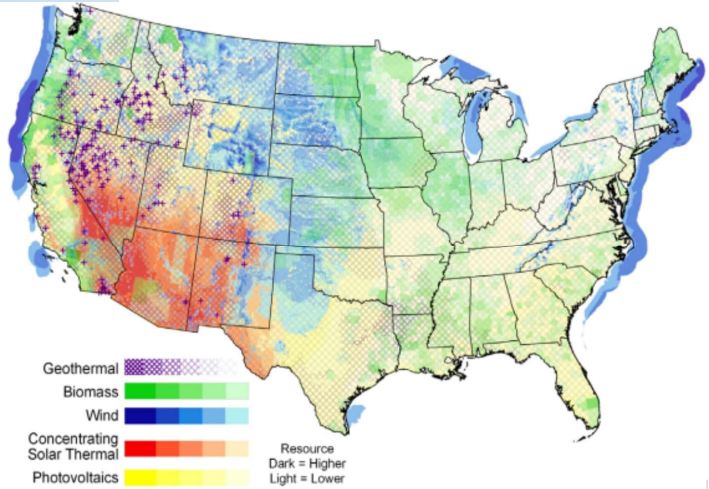
- Increase usage of renewable energy sources.
- Target to reduce amount of curtailment energy & better integration of RE.
- Increased distance between energy generation and consumption hubs.
- Looking at solving energy demand variance through the year.
- New technological developments.
- Export market -New energy carriers such as hydrogen and ammonia.
- Salt cavern storage is the most cost-efficient solution.

  Potential LCOS 0.30-0.60 $/Kg H2 (*)

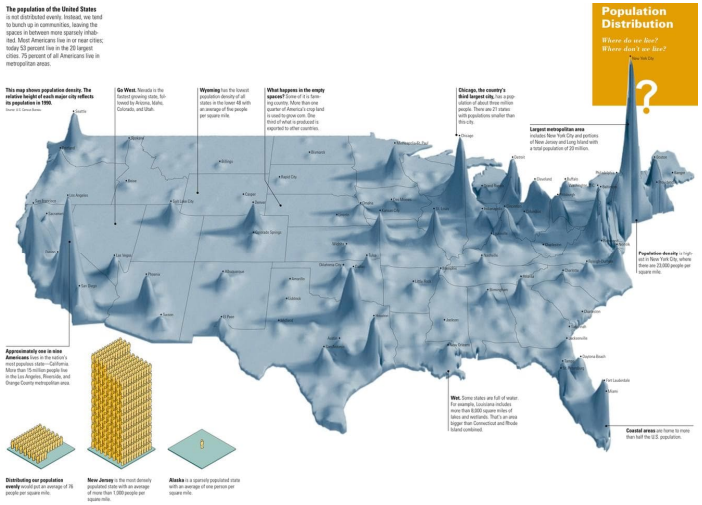


H2 for Energy Storage. Driving factors

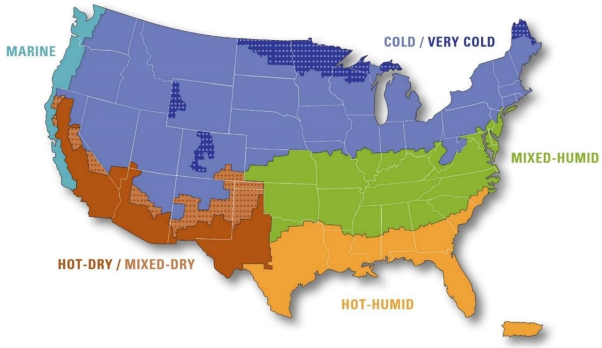
Renewable energy sources

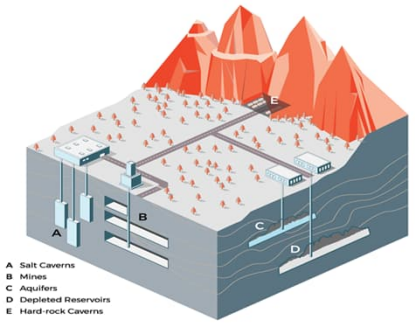


Population density



Seasonable variance





ACES Delta (UT) Green Hydrogen UGS Project

The ACES-Delta project converts renewable power into green hydrogen that can be stored in commercial-scale solution mined caverns. This stored hydrogen becomes an energy reserve that can be released to produce fuel for electric power generation at any time.

- World's largest green hydrogen storage project.
  - Total of 9 MMbbls or ~1,4 Mm3. Total storage capacity of ~ 20,000 metric tons
- *Future Ready*. Helping society to advance the decarbonization process of the industry.
- Use excess electricity from the western United States region's renewable generation assets to produce renewable green hydrogen.
- Energy storage perspective, both caverns will hold the equivalent of *300 GWh* of carbon-free dispatchable energy.
- According to the EIA in 2020, current installed battery storage across the U.S. is 1.2 GWh.
- Would be the 4th and 5th hydrogen caverns developed in the USA.

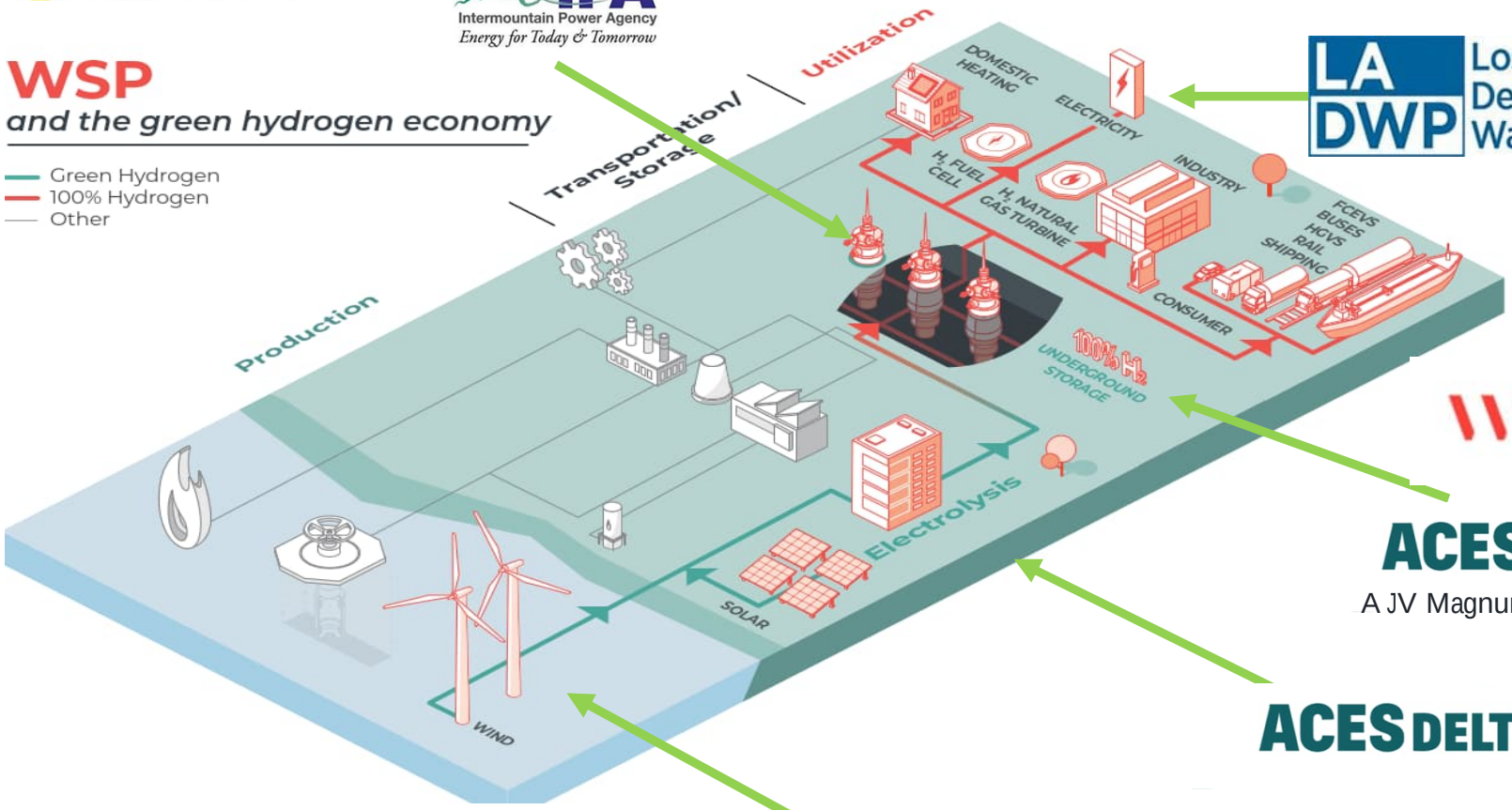
U.S. DEPARTMENT OF ENERGY

IPA Intermountain Power Agency *Energy for Today & Tomorrow*

WSP

and the green hydrogen economy

Green Hydrogen
100% Hydrogen
Other



LA DWP Los Angeles Department of Water & Power

ACES DELTA
A JV Magnum + Mitsubishi

ACES DELTA

IPA Intermountain Power Agency *Energy for Today & Tomorrow*

20.000 tones of Green Hydrogen Storage

EPCM + Commissioning

Case Study
WSP USA
H2 Projects

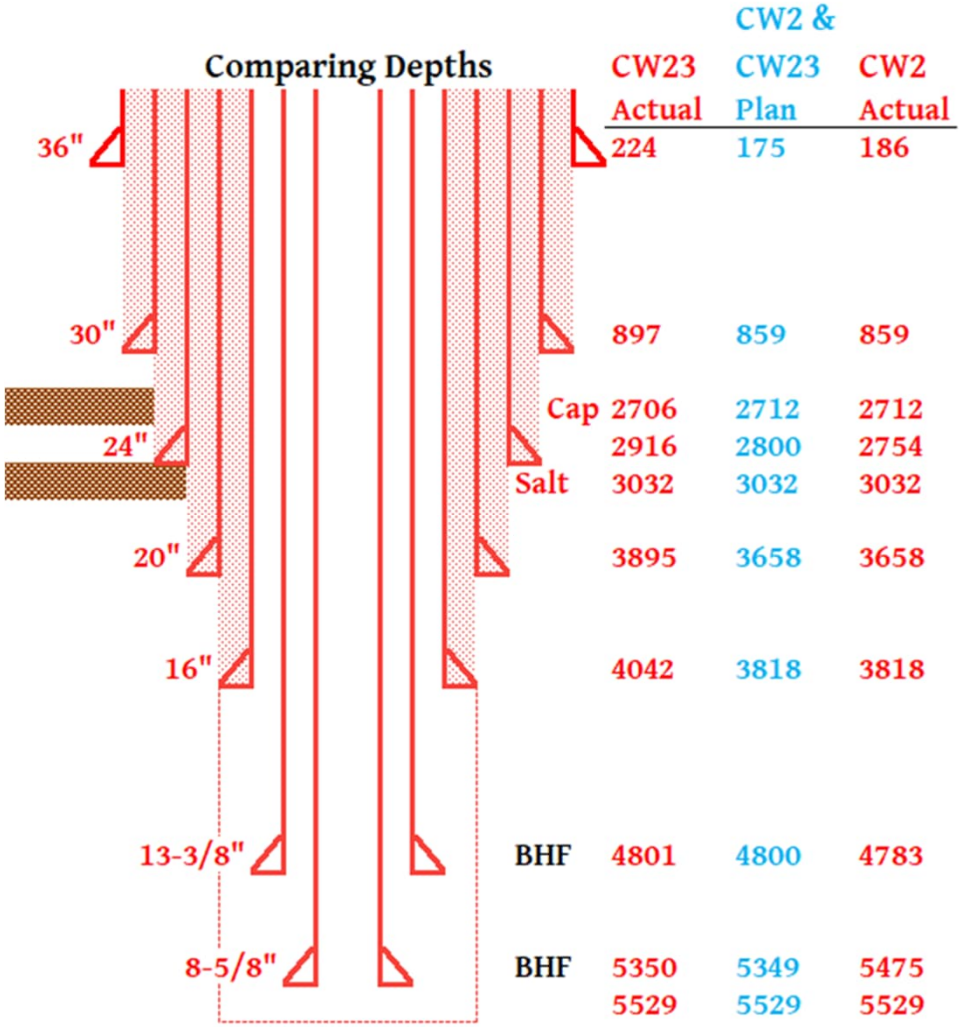
Bases of design

ACES DELTA

III. Cavern Characteristics

- Last Cemented Casing Depth..... 3,520 ft
- Maximum Operating Pressure Gradient ..... 0.80 psi/ft
- Minimum Operating Pressure Gradient ..... 0.30 psi/ft
- Total Gas Capacity at 4.45 MMB Net Leached Volume..... 9.36 x 10^6 kg
- Roof Depth ..... 3,720 ft
- Total Depth ..... 5,350 ft
- Maximum Cavern Diameter ..... 222 ft
- Total Leached Volume..... 4.85 to 6.0 MMB
- Net Leached Volume ..... 4.45 to 5.5 MMB

Planned vs Actual Casing Depths

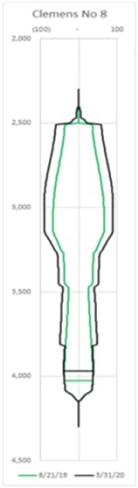


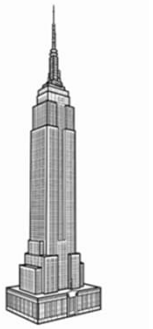
	CW23 Actual	CW23 Plan	CW2 & CW2 Actual
	224	175	186
	897	859	859
Cap	2706	2712	2712
	2916	2800	2754
Salt	3032	3032	3032
	3895	3658	3658
	4042	3818	3818
BHF	4801	4800	4783
BHF	5350	5349	5475
	5529	5529	5529

Project Status

- Engineering innated 2021
- Field work started June 2022
- Both wells currently drilled to a depth of 1.700m.
- 41cm production casing set at ~1.300m.
- Total of 120 drilling days per well.
- MIT conducted
- Solution mining to start April 2023 @ 19.000 liters/min.
- Cavern #1 to be completed July 2025 #2 by Dec 2026

Fun fact...





Cavern #8

Roof:	2,400’
Floor:	3,968’
Total height:	1,568’
Average Diameter:	120’

Empire State Building

Total height: (without antenna)	1,250’
Dimensions (base):	187’ by 424’

Leach plant equipment, leaching wellhead and hole opener

Looking Ahead at the Hydrogen Economy / storage

A McKinsey & Company report estimated the hydrogen economy could generate $140 billion in annual revenue by 2030, projecting that hydrogen could meet 14% of total domestic energy demand by 2050.

As renewable energy becomes more efficient and commonplace, excess capacity during non-peak demand can be increasingly used to generate hydrogen, thus “storing” energy.

Analyzing market behaviour from the natural gas sector, 10-15% of the total annual hydrogen consumption may have to be stored at any given moment.

Thank you!

Andres Fernandez
USA Market Leader Hydrogen

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