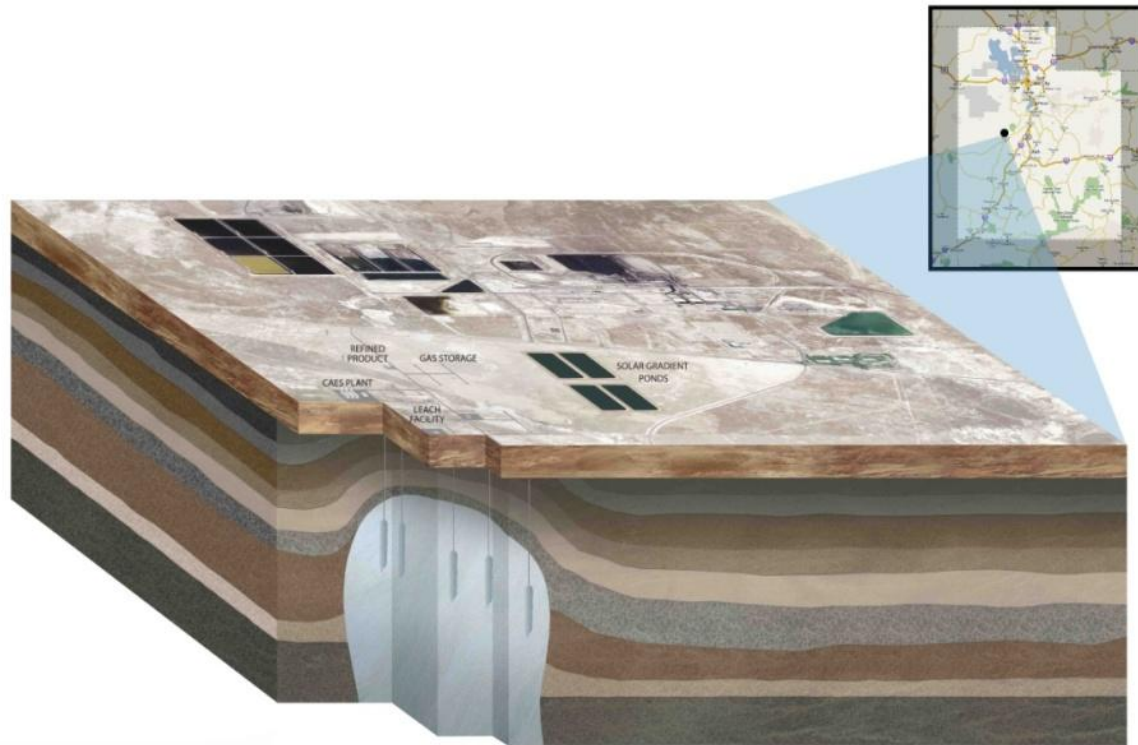


# Gas/Electric Storage Capabilities to Enable Renewables in the West

Platts Annual Power Storage Conference  
Houston, TX



**Western Energy Hub**

# What Makes it Unique?

*A Truly Integrated Energy Hub!*

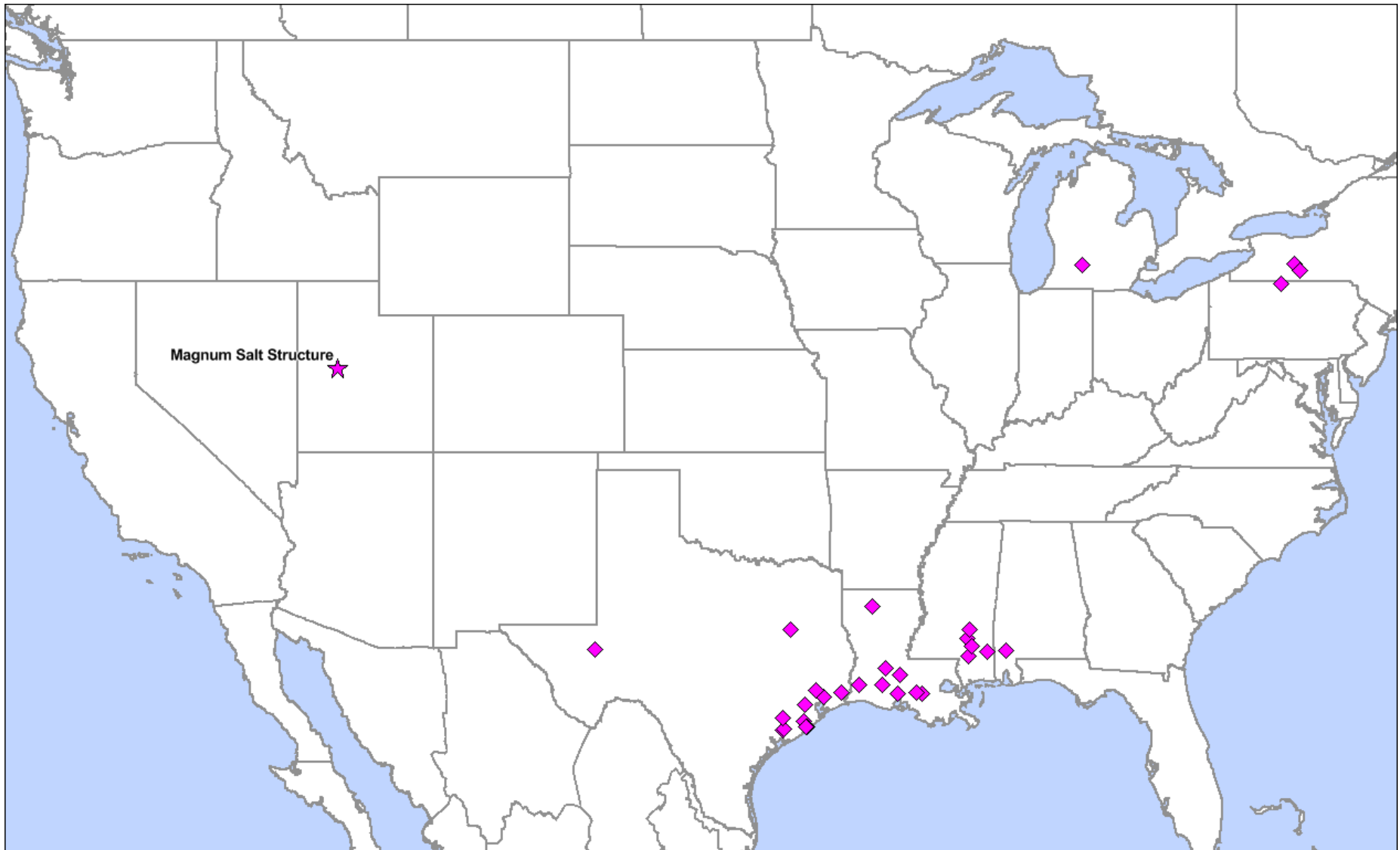


Phase I  • High Deliverability Natural Gas Storage

Potential  
Future  
Phases

- Compressed Air Energy Storage (CAES)
- Gas-fired Combined Cycle Power Generation
- Refined Products Storage
- Industrial Development

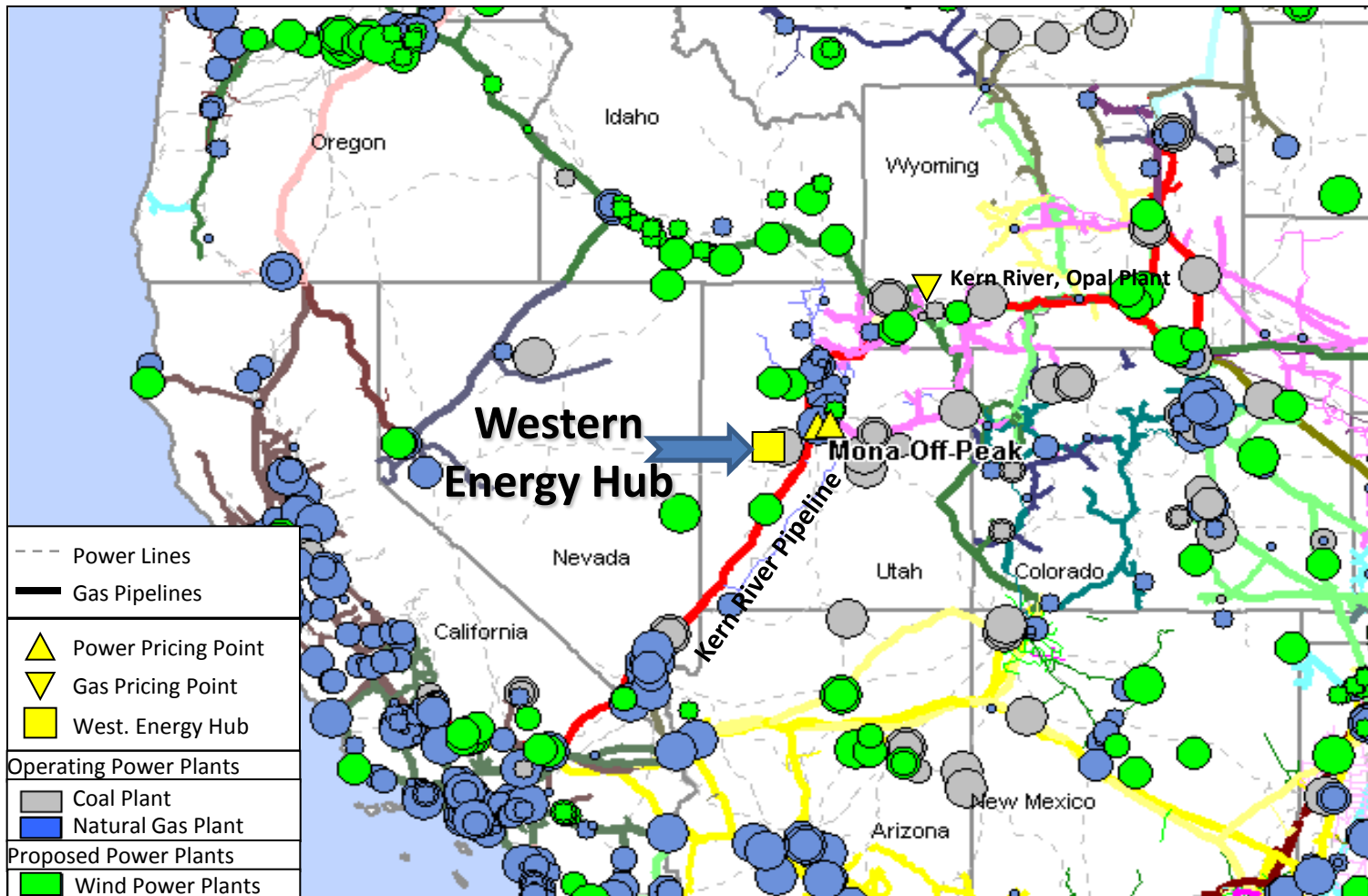
# Gulf Style Salt Storage In the Rockies



# Western Energy Hub's Strategic Location

## At a crossroads for gas and power infrastructure

- Western Energy Hub is working with “strategic” partners to create a “super hub” capable of serving existing and future natural gas and electric infrastructure balancing needs.

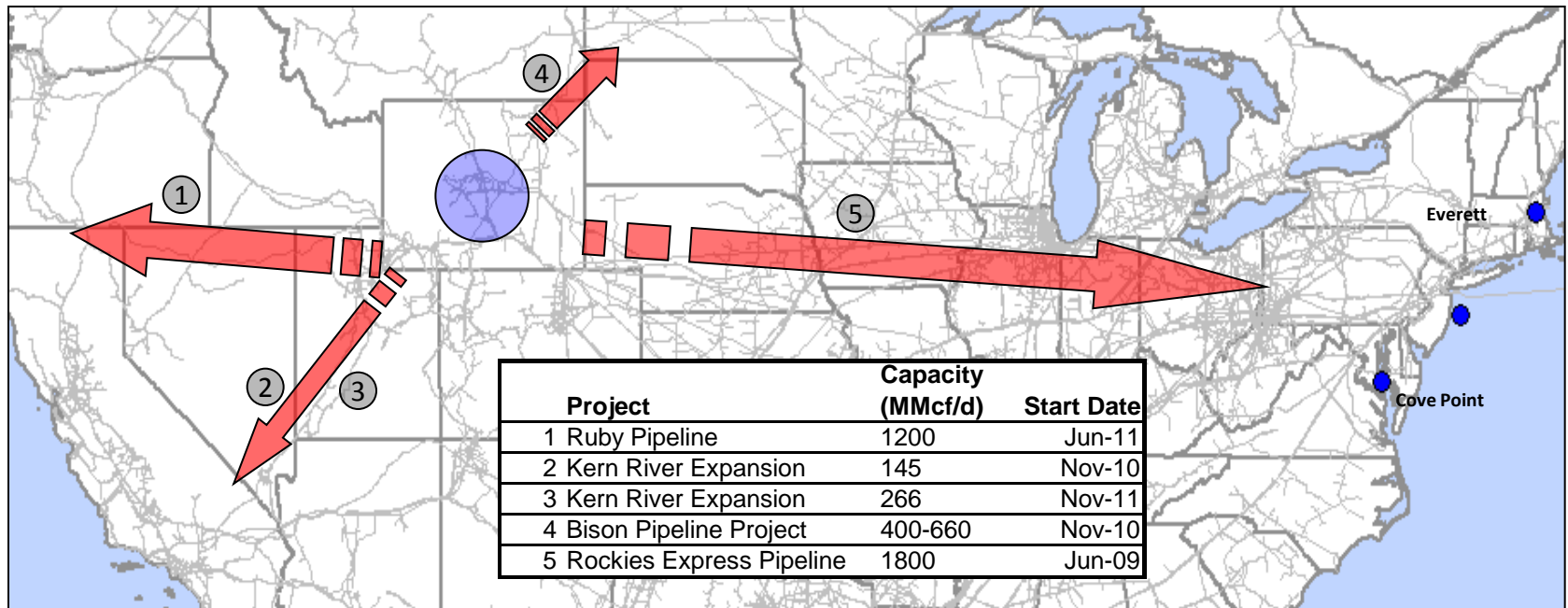


Source: Energy Velocity

# New Rockies Natural Gas Pipeline Export Projects

Opal is a major market hub greatly in need of storage

- Rockies pipeline projects will likely add 2 – 3 Bcf/d of new export capacity and greatly improve the flow of gas from the Rockies to other areas of the country. Since Rockies gas production is expected to keep pace with this new capacity, pipeline constraints should improve but will not be eliminated in the Rockies.
- Through new pipeline links, the Rockies will have exposure to nearly all major markets (Northern CA, Southern CA, Chicago and Midwest, Northwest and Northeast).

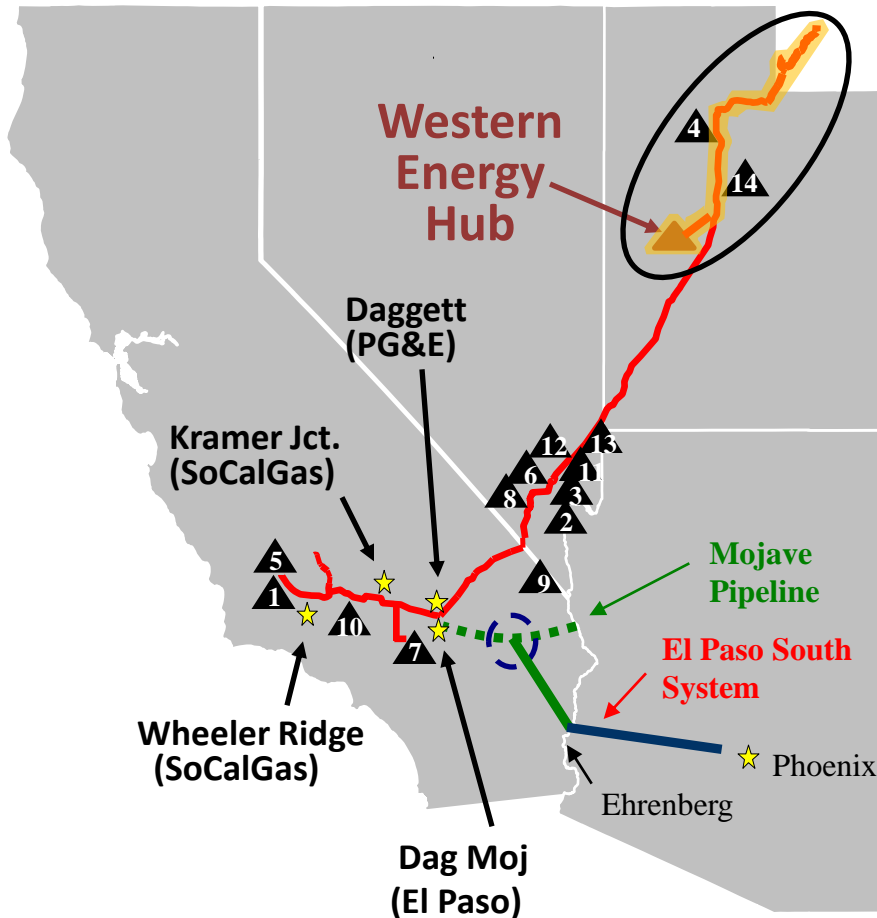


Source: Press Releases, Energy Velocity

# Pipelines can be Compared to a Hydro System

They are Simply a River of Gas Supporting Generation

## Power Plants and Interconnects



### POWER PLANTS

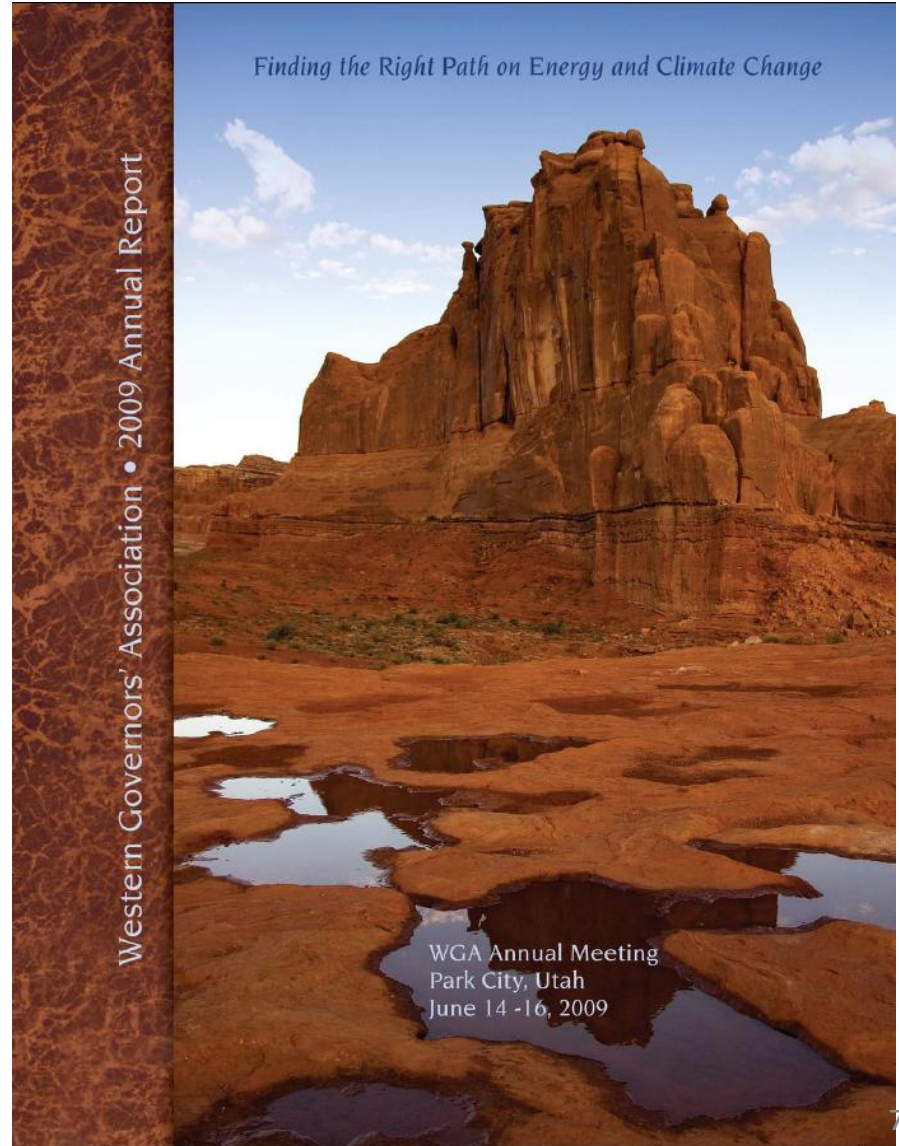
▲ In-service since 2001

PROJECT	MW
▲1 Sunrise (Edison Mission)	585
▲2 El Dorado (Sempra)	480
▲3 L.V. Cogen (Black Hills)	280
▲4 West Valley (PacifiCorp)	170
▲5 La Paloma (Complete Energy)	1,125
▲6 Apex (LS Power)	550
▲7 High Desert (Tenaska)	830
▲8 Silverhawk (Nevada Power)	570
▲9 Bighorn (Reliant)	570
▲10 Pistoria (Calpine)	750
▲11 Chuck Lenzie (Nevada Power)	1,200
▲12 Harry Allen (Nevada Power)	160
▲13 NCA 1 & 2 (NV Cogen Ass.)	170
▲14 Lake Side (PacifiCorp)	535
<b>TOTAL MW</b>	<b>7,975</b>

# Why Consider CAES Next?

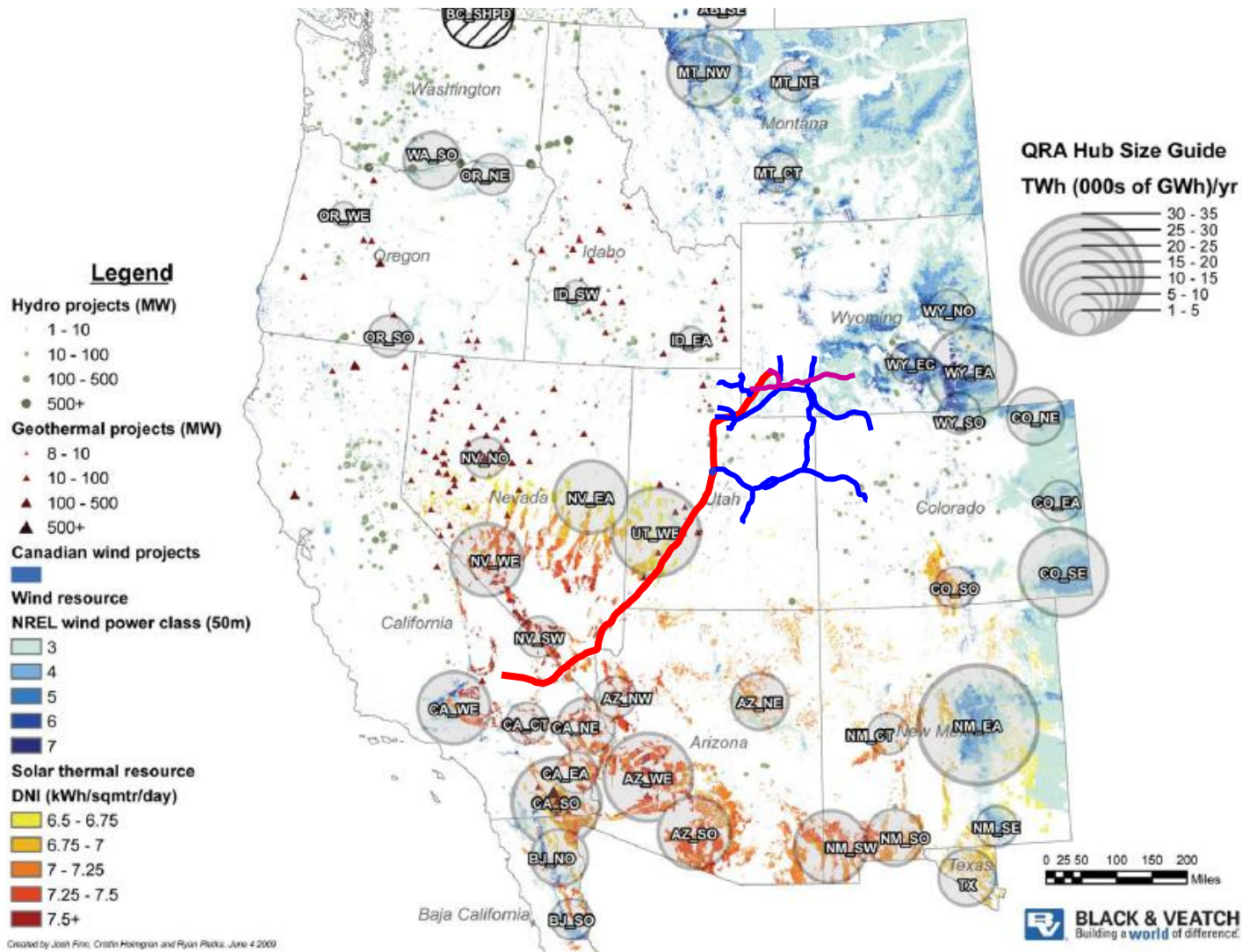
## *Compressed Air Energy Storage (CAES)*

- Renewable energy is intermittent
- Renewable energy generally is not produced during periods of peak demand
- CAES allows for the storage of renewable energy produced in off-peak hours and delivered during peak demand
- First Wind transmission lines cross the Hub's property
- Solar facility currently proposed for adjacent area



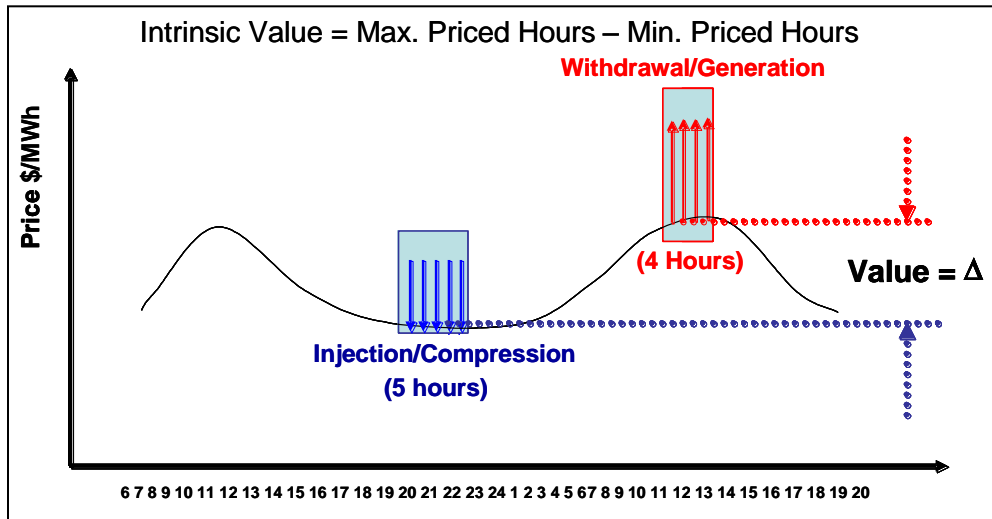
# Renewables Development Affects Rockies

## Volatility

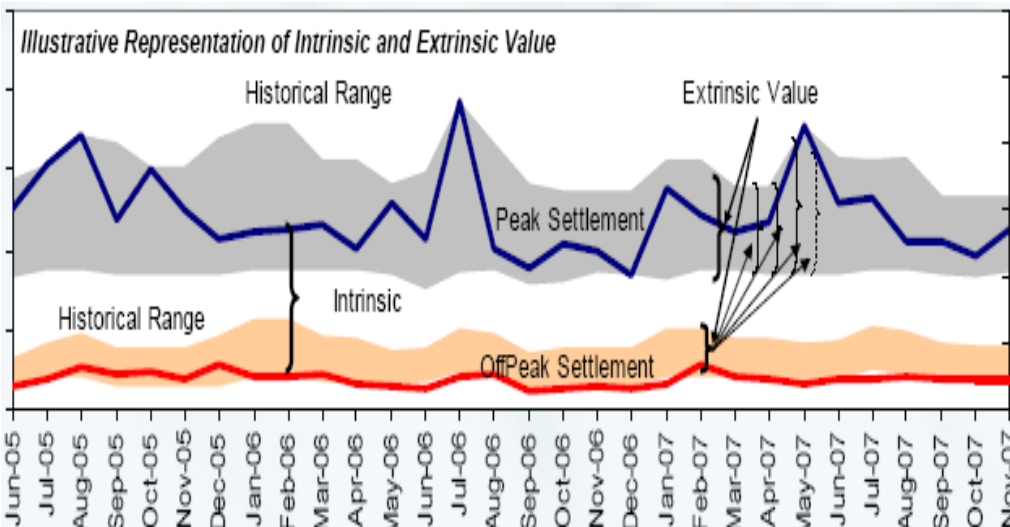


# CAES Intrinsic and Extrinsic Value Similar to Gas Storage

## Multiple dimensions to CAES value



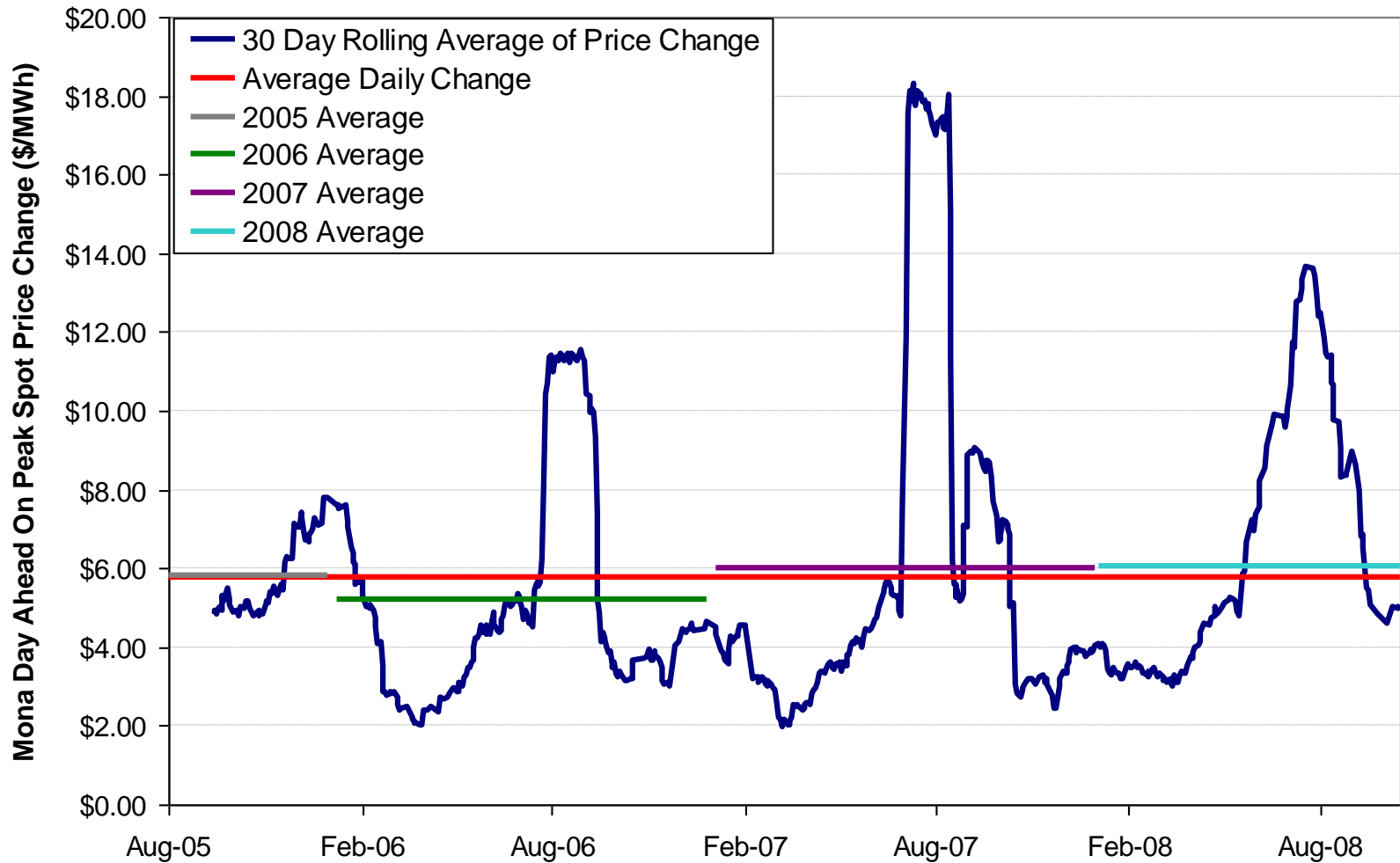
- Power bought off-peak when price is relatively low and sold on peak when price is relatively high.
- Intrinsic value is the spread between the cost of power to inject air (compress) and sale price of generated power (air withdraw).
- CAES can be conceptualized as pumped hydro with a heat rate. Flexibility in CAES operation typically greater than pumped hydro.
- Extrinsic value is derived from volatility and ability to lock in forward price spreads (Cash to Prompt and forward to forward).
- Volatility in power markets typically far greater than natural gas markets. In addition, Renewable Energy Credits offer potential revenue stream.



# Mona Price Volatility Supportive of CAES

Average daily price change for Day Ahead On-Peak Power

- Based on historical Mona Day-Ahead price data for On-Peak, volatility is trending higher.

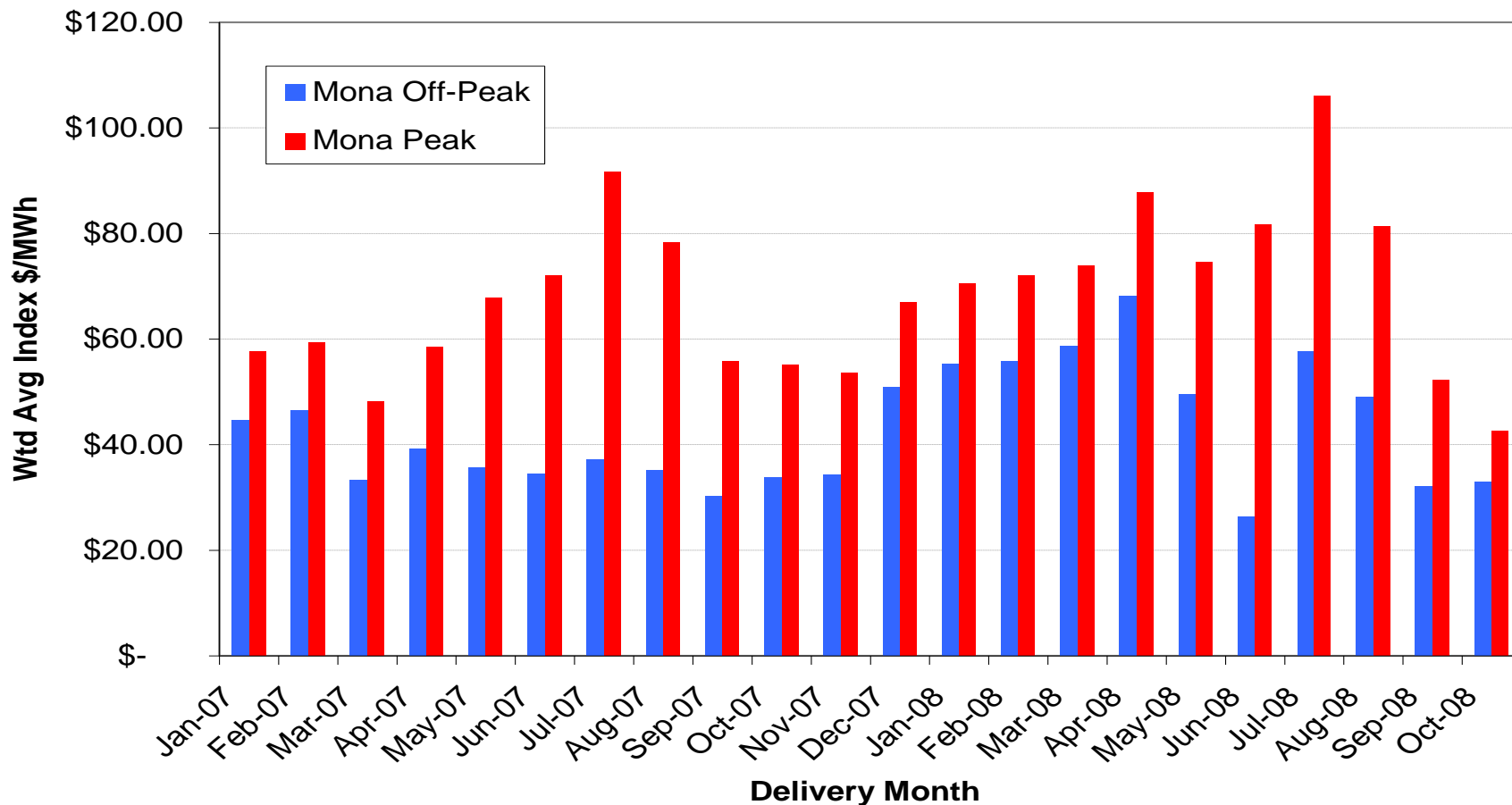


# Western U.S. Power Market Prices Likely to Support CAES

Average peak – off peak price spreads a fraction of full value

- More expensive natural gas driving higher on-peak prices in the West. Mona peak versus off-peak price spreads have averaged approximately \$50/MWh in summer. Growing wind resources will pressure off-peak prices.

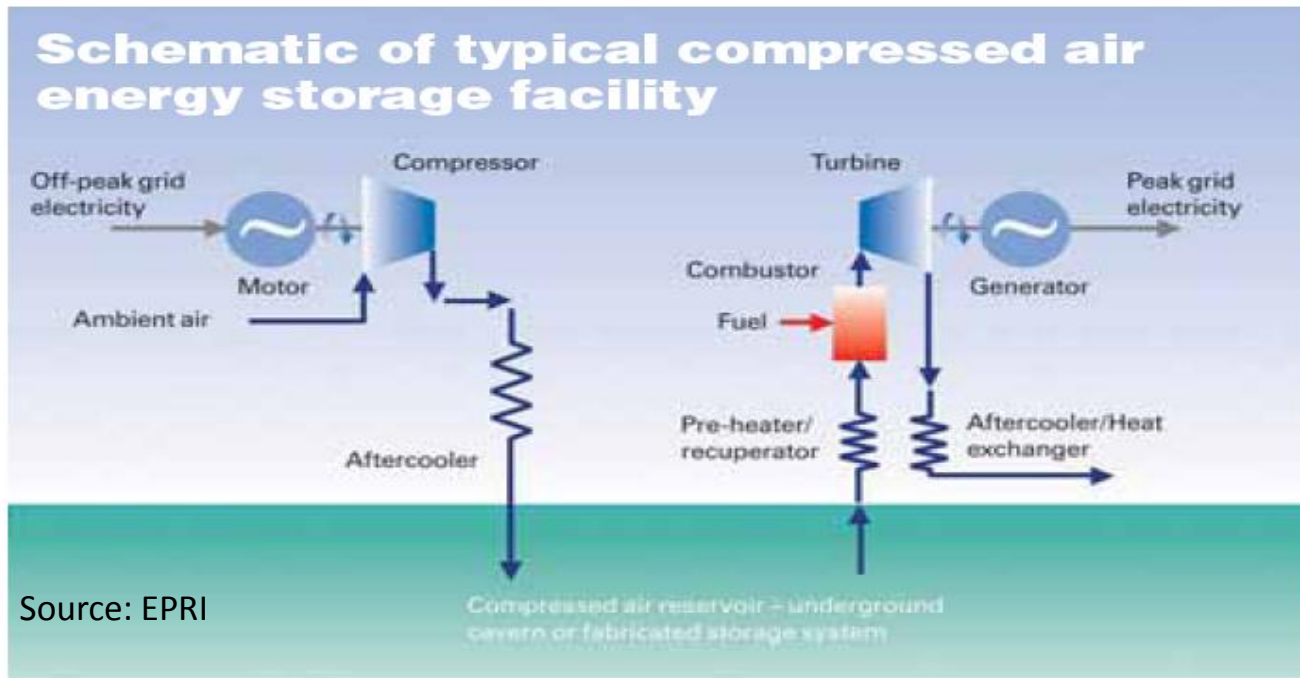
Monthly Average of Weighted Daily Index at Mona \$/MWh



# CAES Provides Grid Scale Power Storage

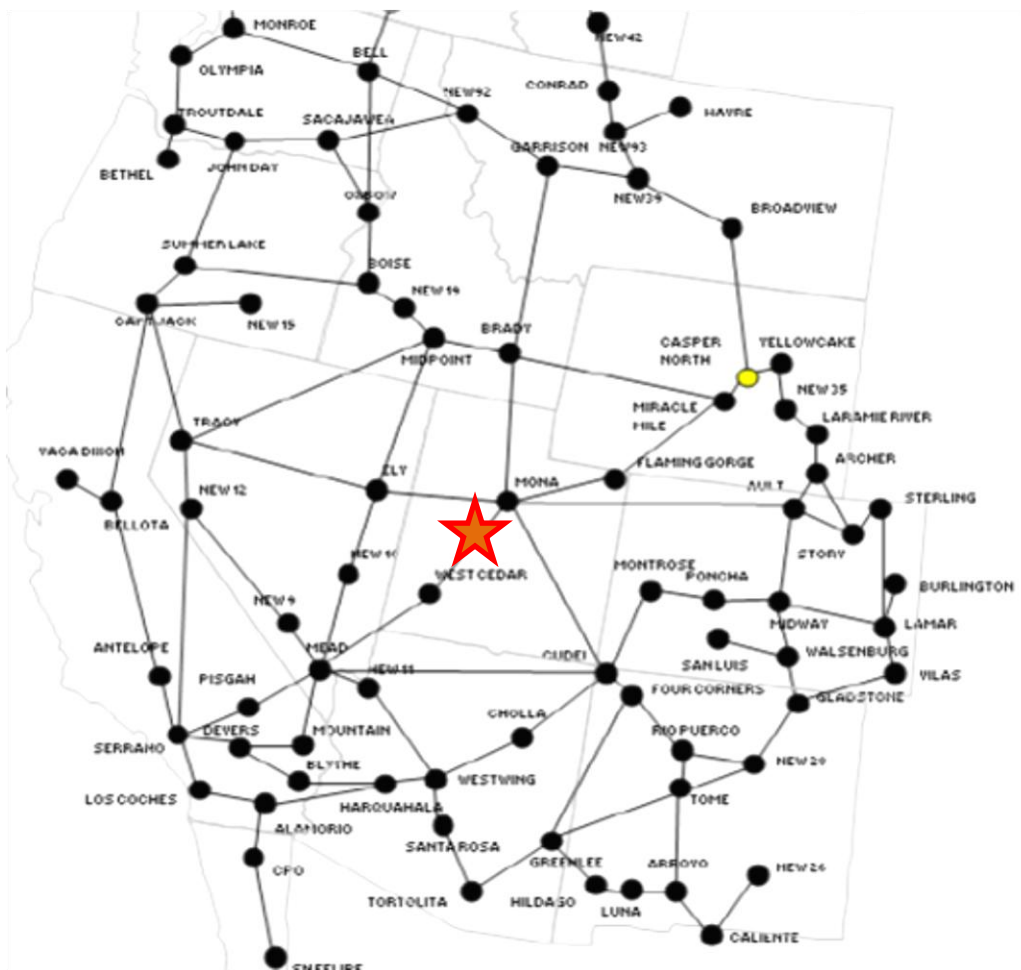
Critical technology for expanding renewable generation

- Stores energy by compressing air with motor driven compressors into an underground cavern, and generates electricity by releasing the compressed air, heating it and using it in the conventional gas turbine cycle.
- Operating CAES Plants: 110 MW McIntosh, Alabama and 290 MW Huntorf, Germany. Both compress air into excavated salt formations and have reliably operated for years.
- EPRI notes: “CAES plants can perform ramping duty to smooth the intermittent output of renewable generation sources as well as provide spinning reserve and frequency regulation to improve overall grid operations.”

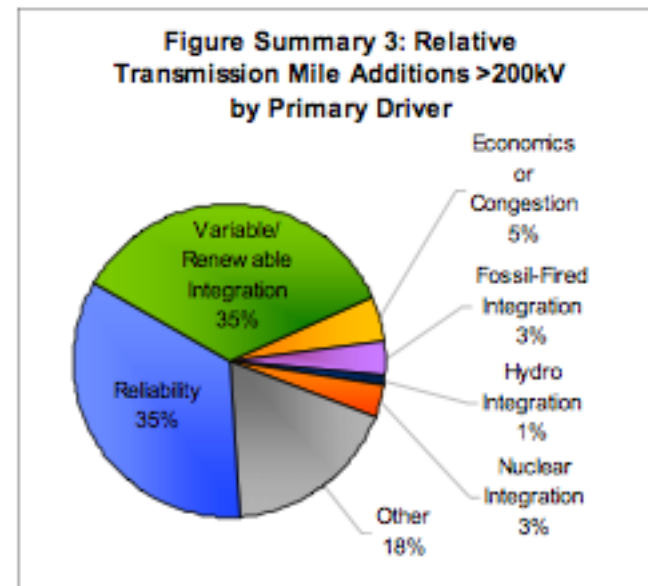
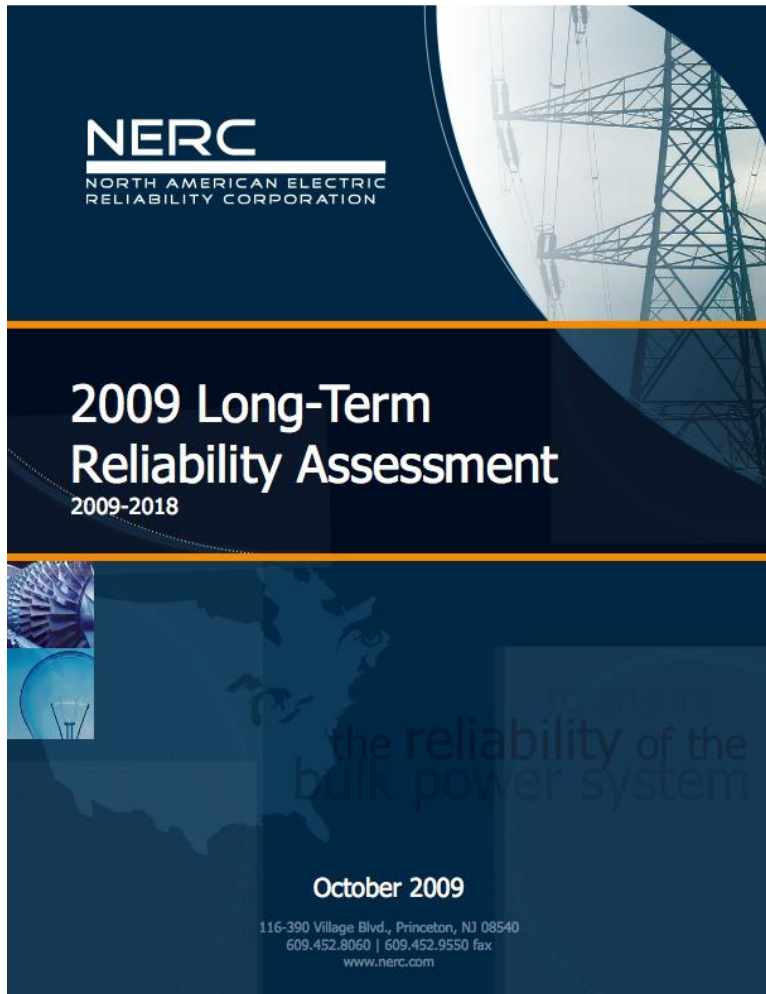


# Benefits of Electric Storage to the Western Electric Grid

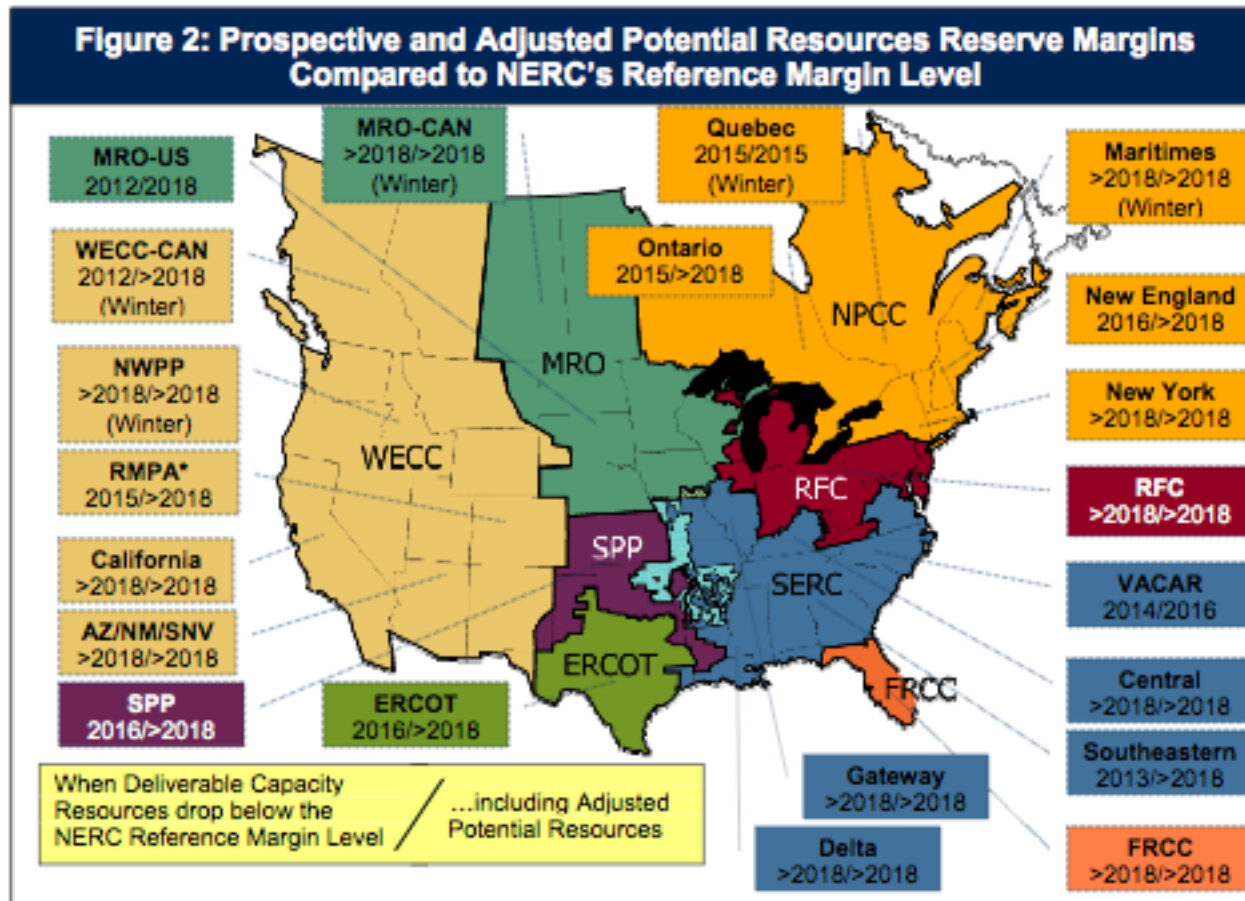
- Part transmission ... part generation asset
- CAES enables renewables
- CAES allows for firming and shaping of off-peak energy into *on-peak capacity and energy*



# NERC Reliability



# Spinning Reserve is Becoming a Scarce Commodity

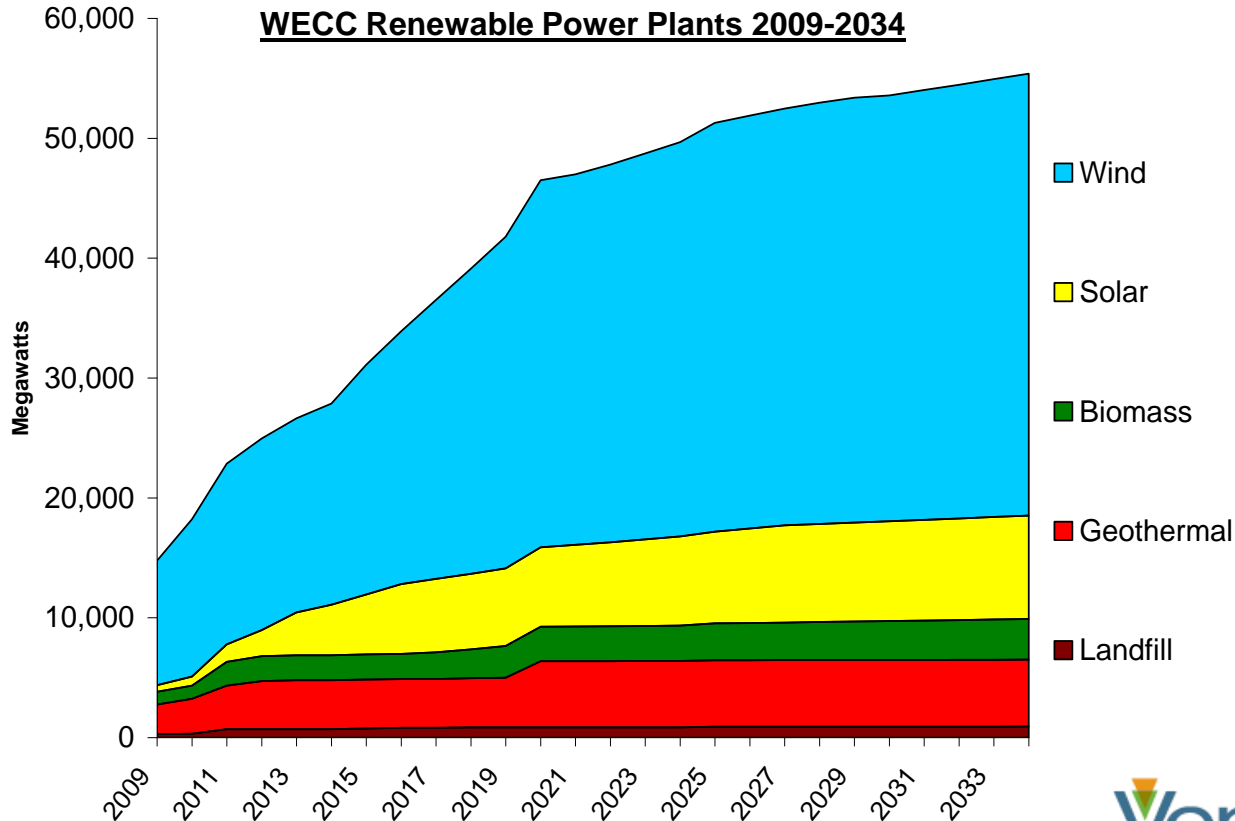


\* For more information on the WECC-RMPA subregion, refer to the WECC Highlights section of this report.

# Growth of Renewables in the West

Wind will Provide Much New Energy and Very Little New Capacity

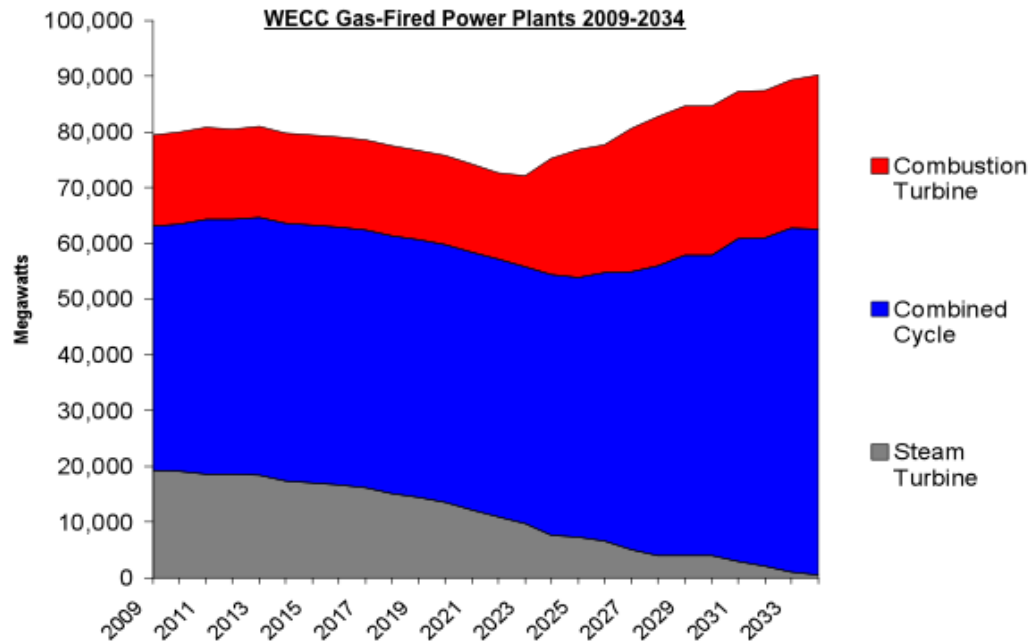
- ▶ **Ventyx forecasts 40,000 MW of renewable power additions in the western U.S. through 2034 with intermittent wind and solar power comprising over 85% of additions**



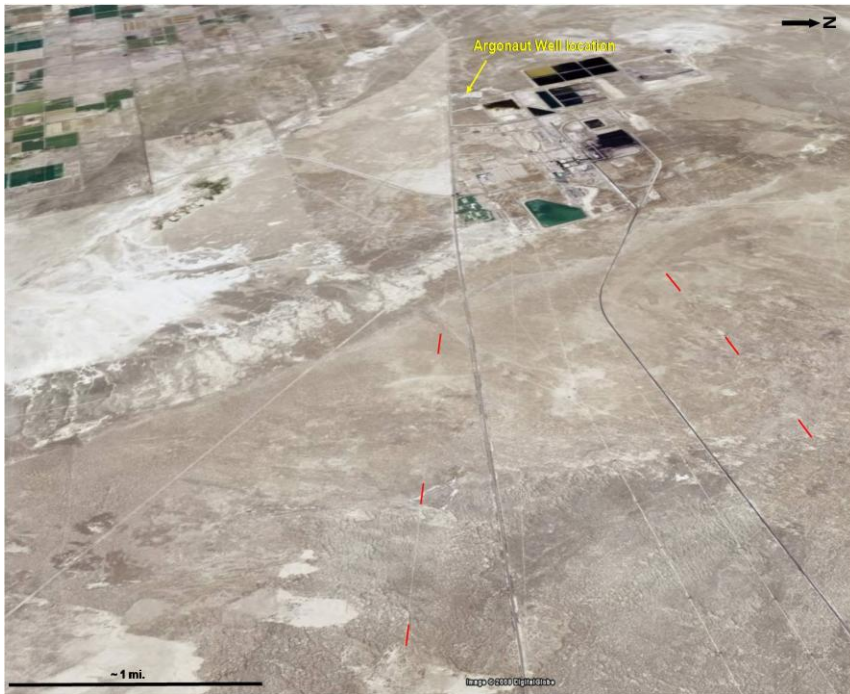
# Gas Will Provide Much of the Necessary New Capacity

## Forward Price Volatility – Natural Gas Power Generation

- ▶ Ventyx forecasts 30,000 MW of CC and CT natural gas-fired power generation additions in the western U.S. through 2034 while old, less efficient and less flexible gas-fired steam turbines are retired.



# Other Project Opportunities



- Combined cycle gas-fired generating facility
- Petroleum product storage
- Solar gradient ponds and power generation facility
- CO2 sequestration
- Industrial site development opportunities

**Abundant Real Estate Options**

# Summary

- Strategic centrepiece for meeting Western States' goals
- Provides for more reliable and lower cost operation of both the gas and electric grids
- Maximizes the development and utilization of renewable energy
- Provides a demonstrated template for others to follow





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