Buffering the Grid with Compressed Air Energy Storage

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Energy Storage provides Energy

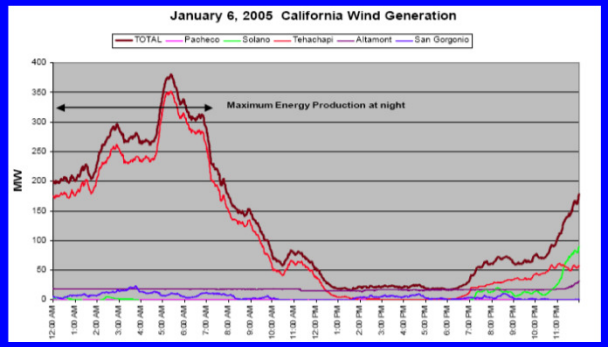
when it is needed

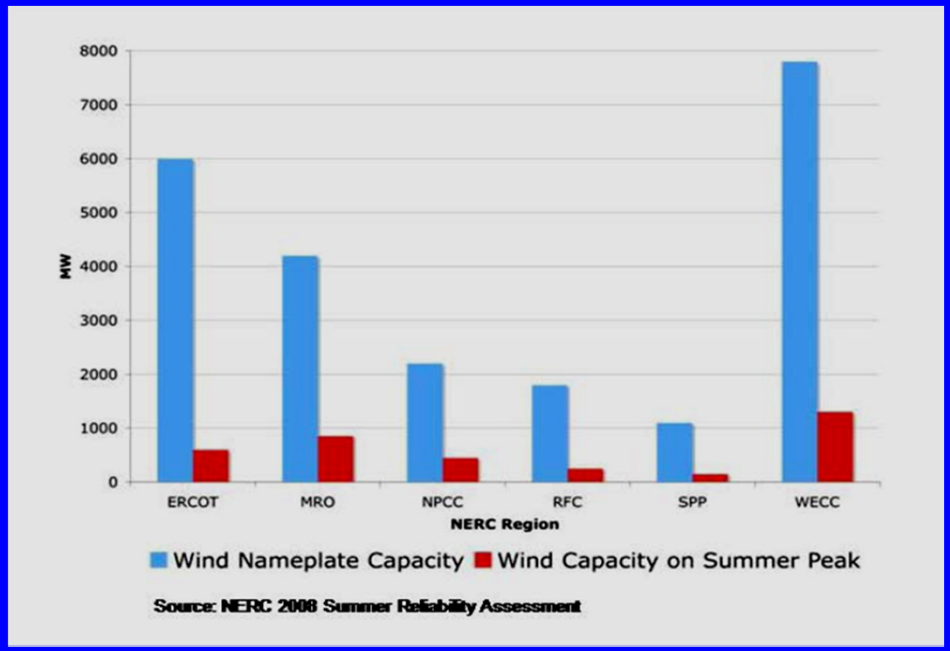
just as Transmission provides Energy

where it is needed

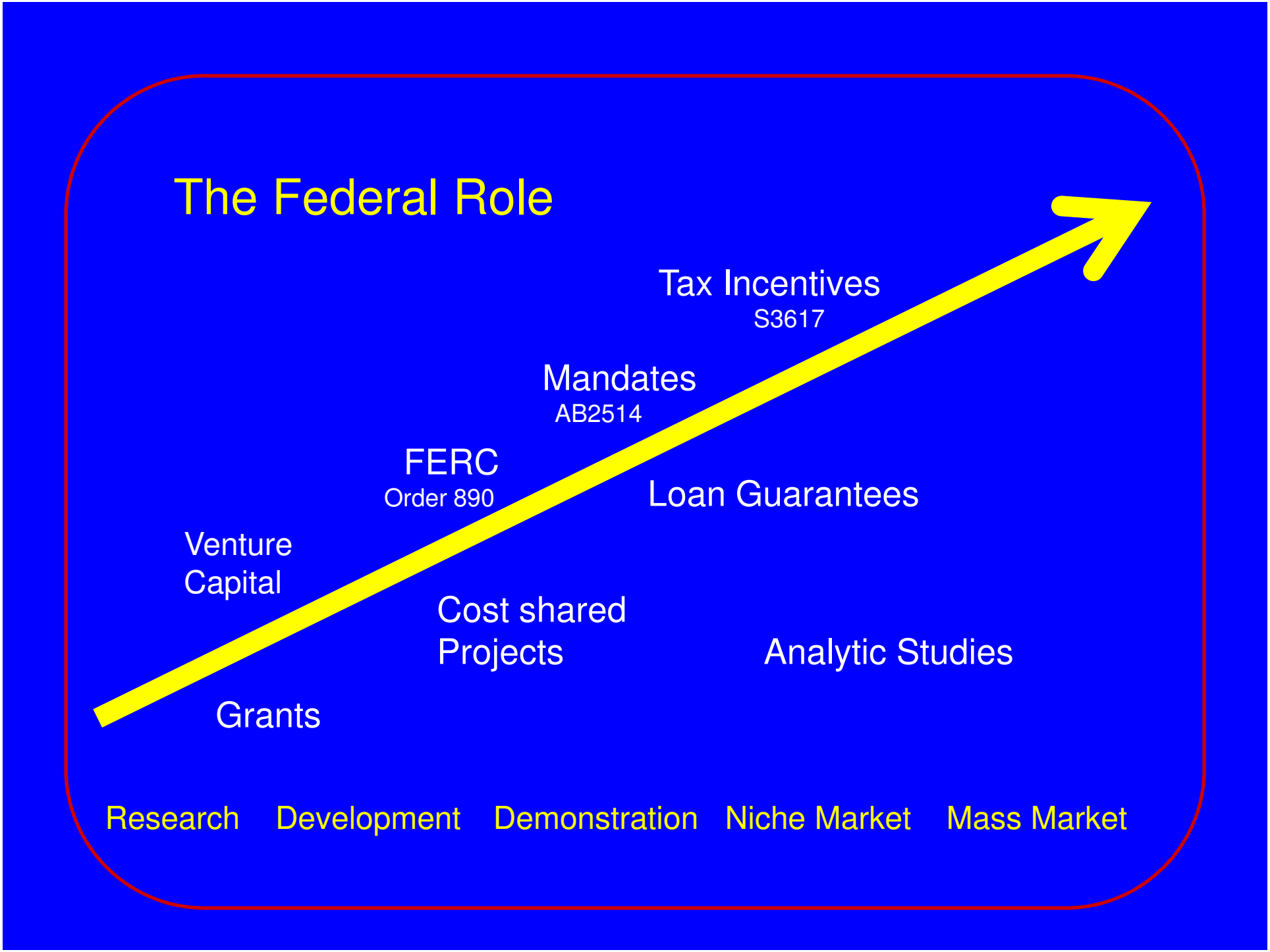
29 States have Renewable Portfolio Standards (RPS) Requiring 10-40% Renewables

On Peak Wind - the Reality!

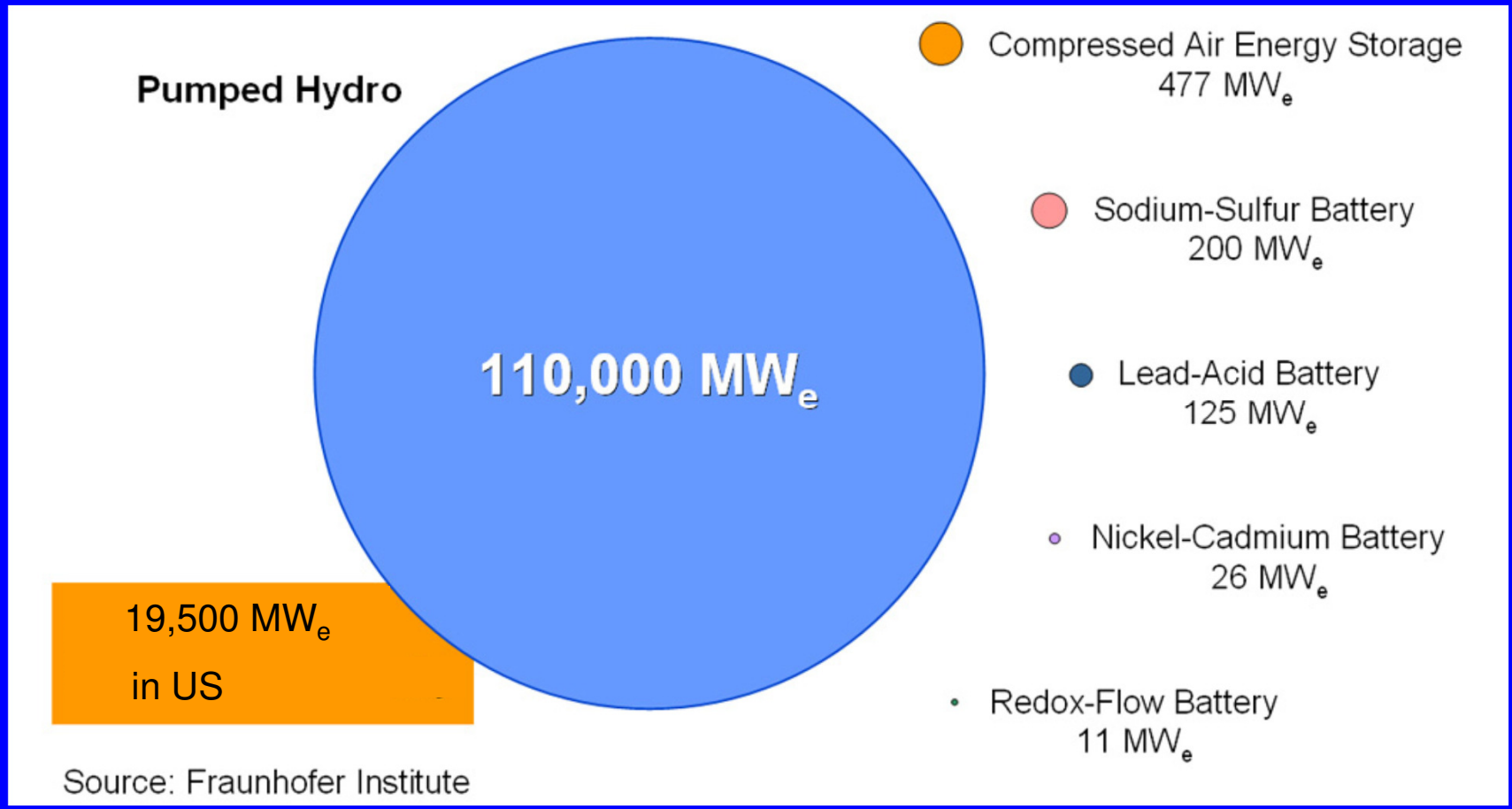




Cost effective Energy Storage yields better Asset Utilization


The Federal Role
Tax Incentives
S3617
Mandates
AB2514
FERC
Order 890
Loan Guarantees
Venture
Capital
Cost shared
Projects
Analytic Studies
Grants
Research
Development
Demonstration
Niche Market
Mass Market

Worldwide installed storage capacity for electrical energy



Note: Pumped hydro represents 2.5 percent of U.S. electrical baseload capacity.

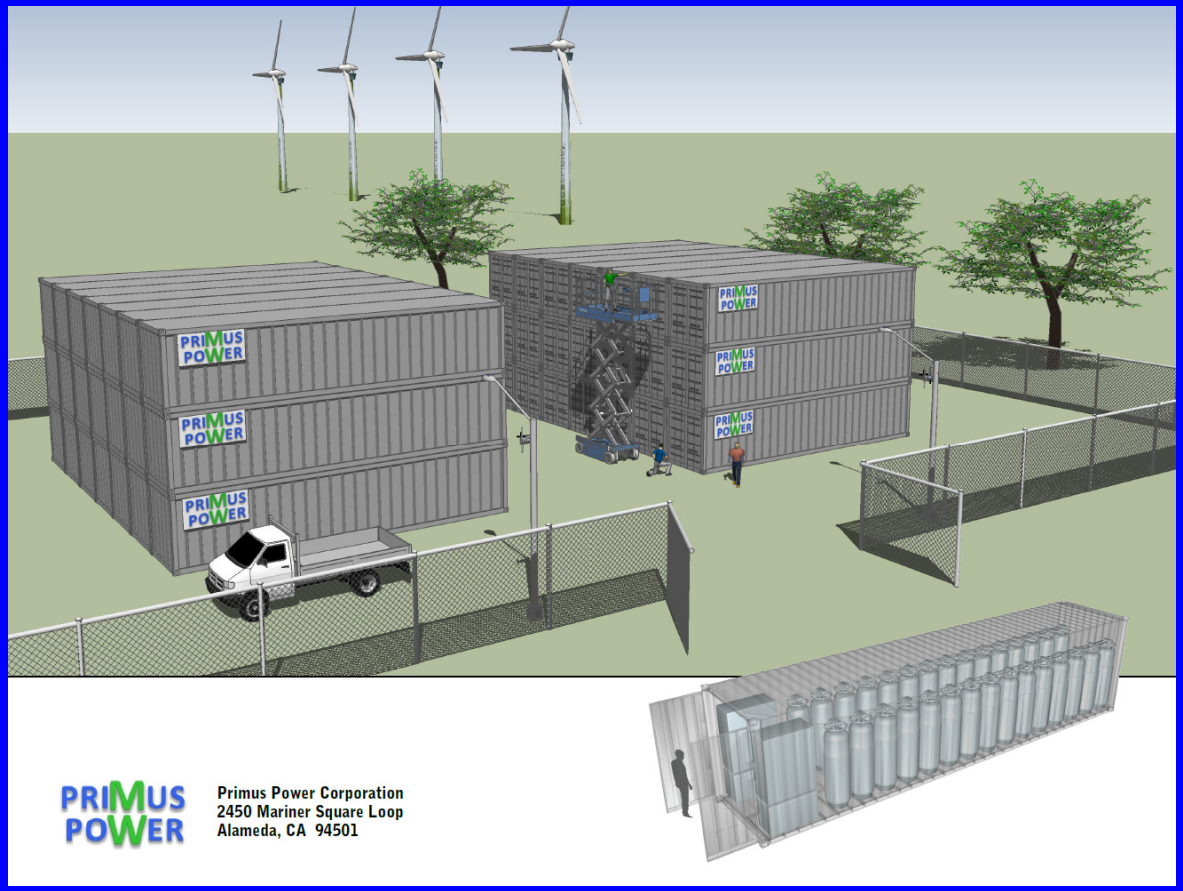
Pumped Storage Hydro-Electric Power

Ameren: Taum Sauk, Missouri,
440MW re-commissioned May, 2010

US – 20 GW
EU – 32 GW
US Proposed:
15-30 GW

ARRA- Primus Power:

25MW / 3hr battery plant for the Modesto, CA Irrigation District, firming 50MW of Wind, replacing $75M of Gas fired Generation.



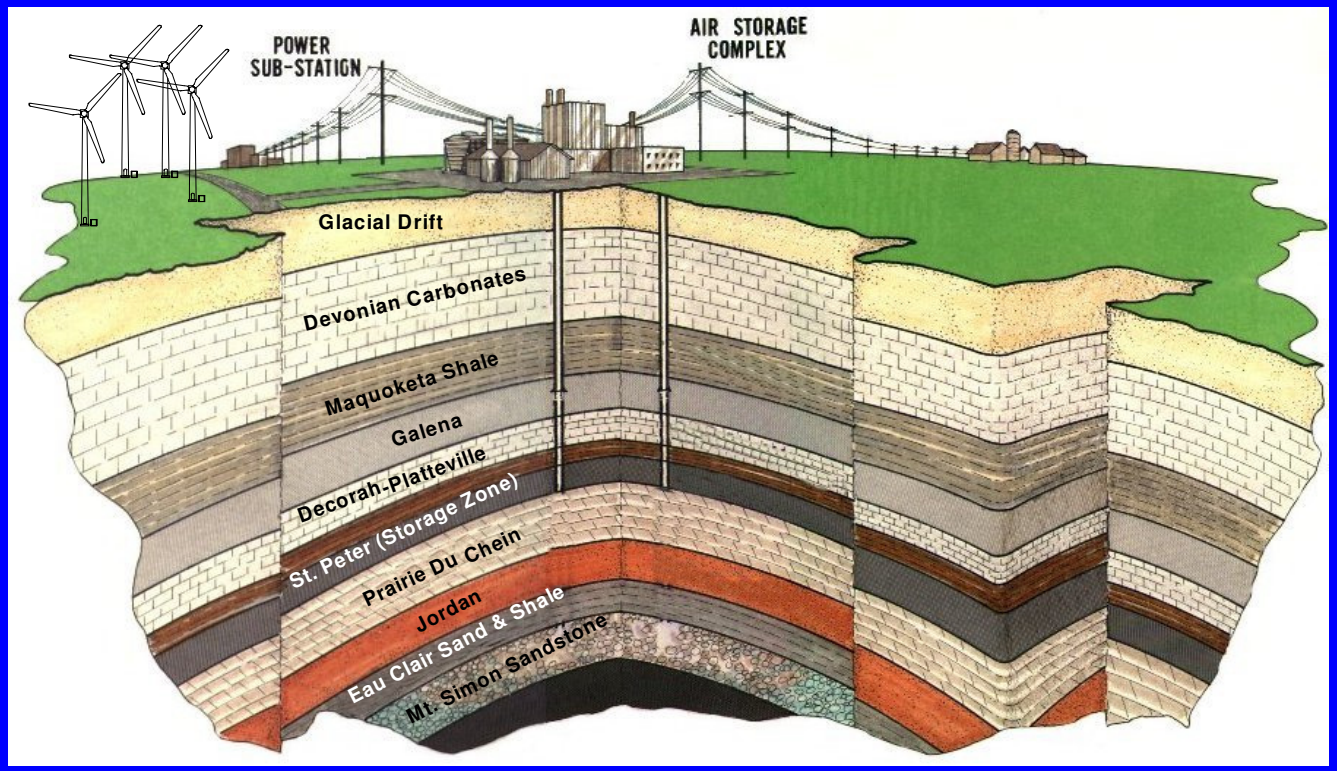
Large Battery + Renewable Projects in Hawaii, Texas, West Virginia, …..

Compressed Air Energy Storage CAES

Inexpensive Off-Peak Power to Compress Air for Storage in Aquifers, Salt Domes or Caverns, Abandoned Oil or Gas Wells.
On-Peak, Compressed Air is used as Input for Gas Turbine Compressor, increasing Efficiency

McIntosh, Alabama, 1991, 110 MW

Huntdorf, Germany, 1978, 290 MW



Underground Aquifer Storage

Extensive Research on Aquifer Storage conducted for DOE at PNL

DOE CAES Aquifer Test:
Pittsfield, Ohio (1984)
10m X 200m Air Bubble
in porous Sandstone

Iowa Associated Municipal Utilities and ISEP decided to install 270 MW of Aquifer Compressed Air Energy Storage (CAES) utilizing a 23,000 MW of Wind Potential in MISO

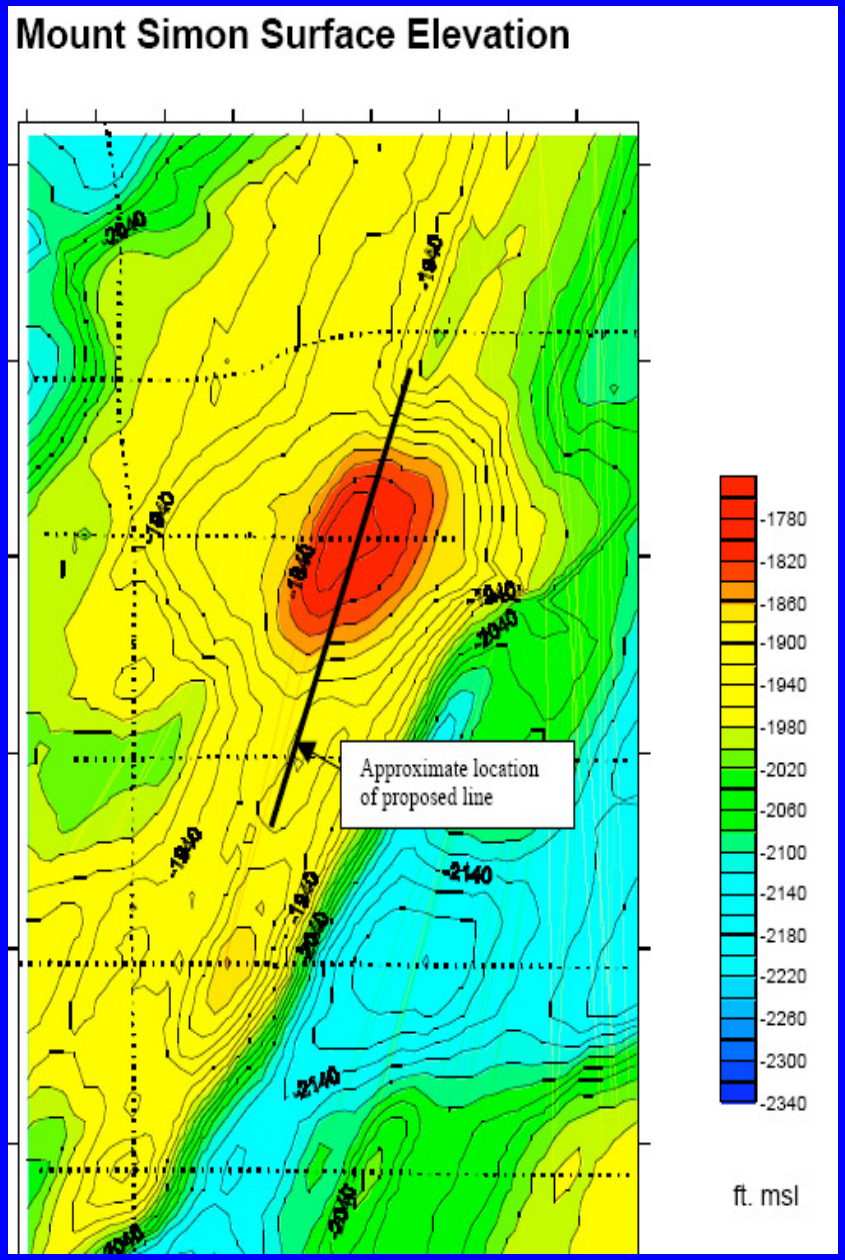
DOE Provided $2.9 M in Funding for:

- Reservoir Investigation
- Market Research
- Subsurface Technology
- Wind Farm Project
- Alternate Fuel Study
- Power Project
- Sandia Technical Support

After diligent and extensive Search

a good Site with a good Aquifer was found

However:
Drill Tests showed inadequate Geology!



ARRA – PG&E:

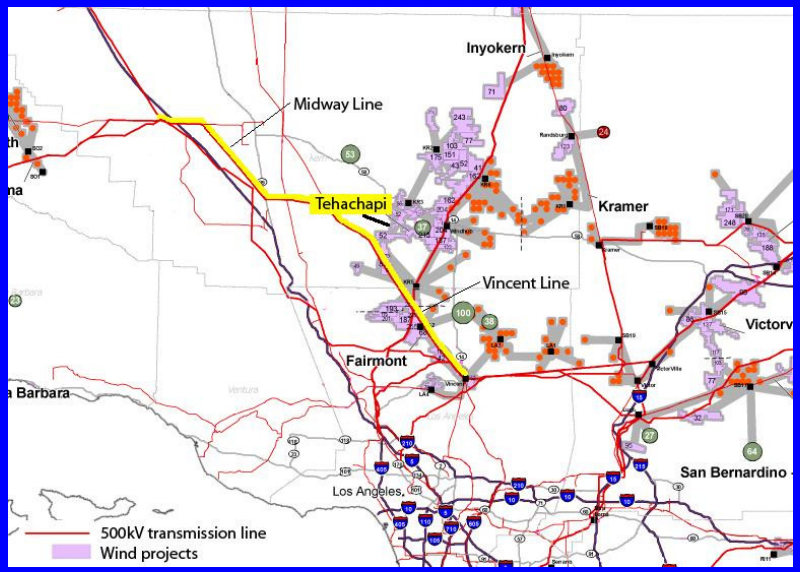
300 MW / 10hr Compressed Air Energy Storage Facility in Tehachapi, CA

Depleted Gas Wells

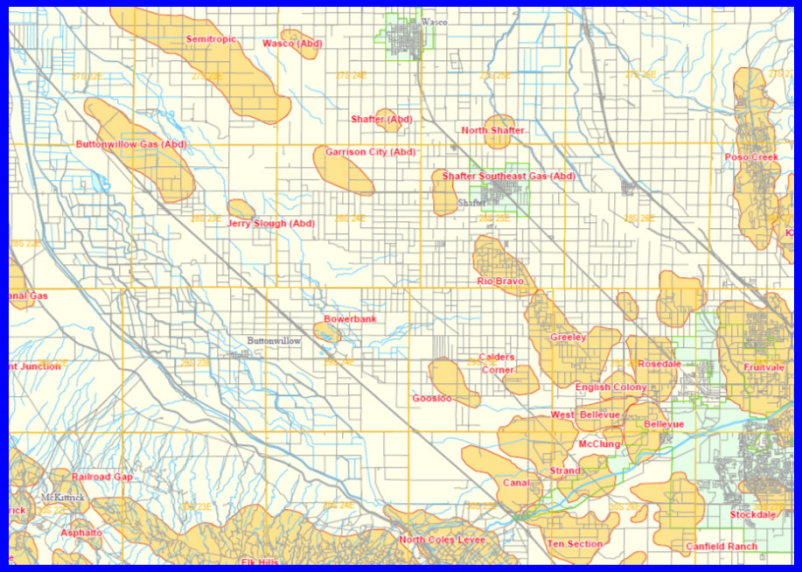
Gas Pipe Line

Existing 500kV Transmission Line

4 500 MW New Wind in 4-5 Years



Location of Wind Resources



Location of Depleted Gas Fields

ARRA - NYSEG:

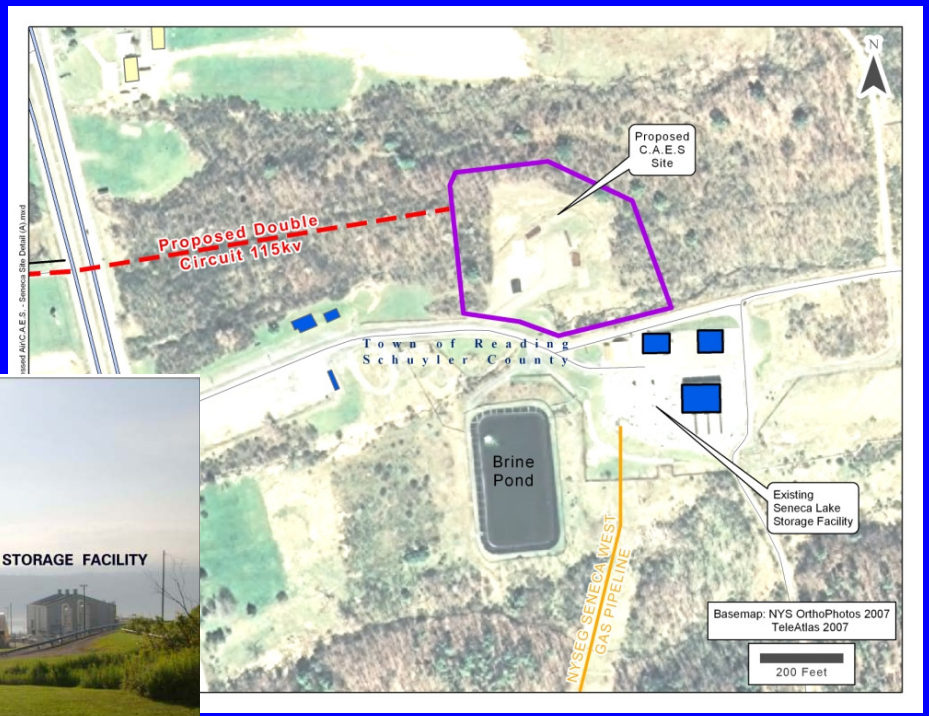
180 MW / 10hr Compressed Air Energy Storage Facility in Watkins Glen, NY

Layered Salt formation

Gas Pipe Line

Transmission Line

Installed Wind Generation!



2 CAES Projects (PG&E and NYSEG)= 450MW in Stimulus Package!

ARRA - SustainX:

Development of Isothermal CAES

A site-anywhere solution – eliminates lengthy siting and risk associated with geologic storage

Superior thermodynamics – eliminates reliance on natural gas

Isothermal efficiency of 95% compared with 54% for adiabatic technique

Higher pressure and efficiency make pipe-type storage cost effective

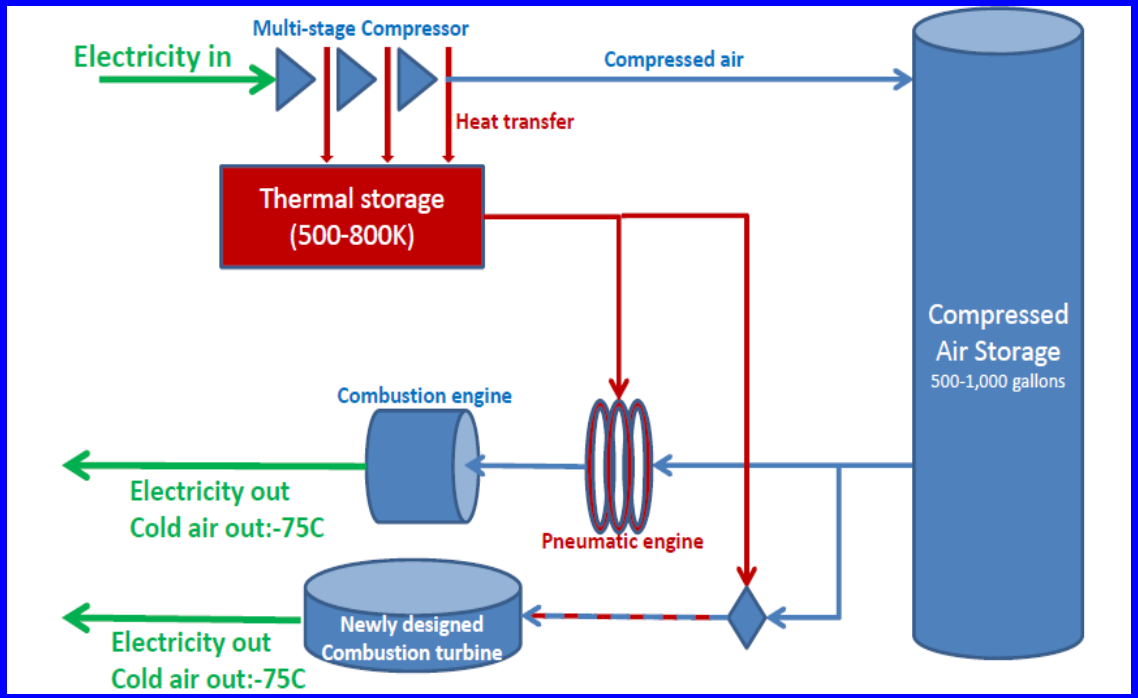
A patented and demonstrated, low-cost, long lifetime ***energy*** storage solution

Small-scale CAES System with Thermal Storage

University of Arizona – AzRISE is building a 10 kW quasi-adiabatic CAES system with tank storage and thermal management to be tested for load shifting on the grid with single-axis PV modules and Li-based (SAFT) batteries

Novel Developments

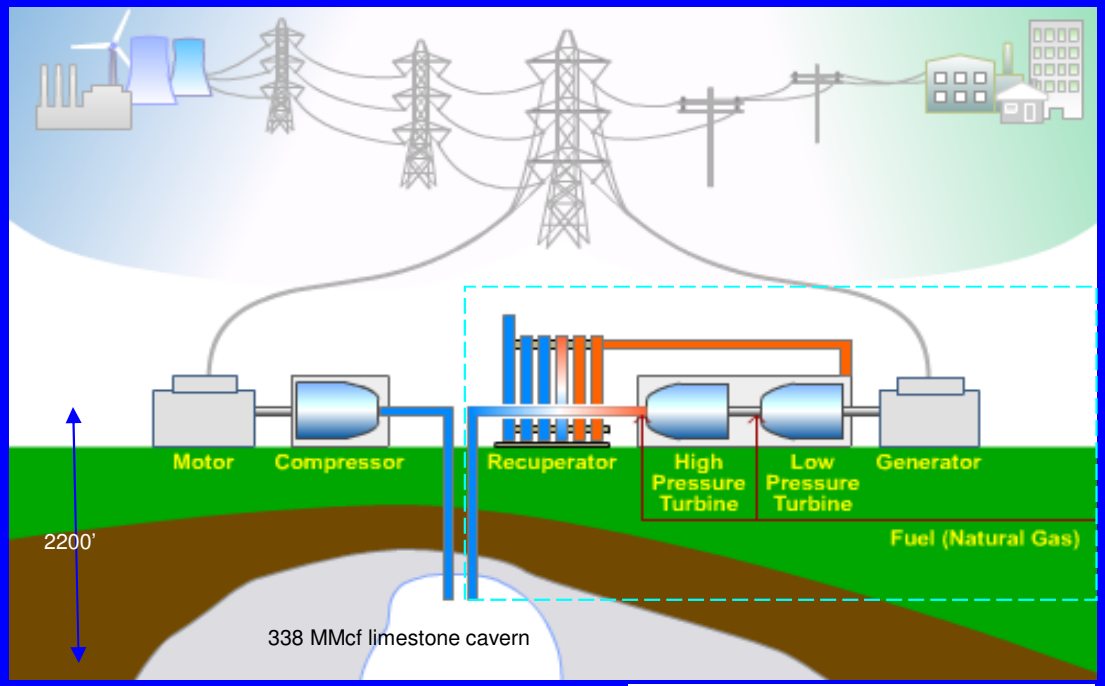
- Heat capture in compression stage
- Thermal storage
- Novel pneumatic engine design
- Novel combustion turbine design
- Potential high efficiency operation
- Plan to reduce natural gas use by more than half.
- Scalable to 10 MW



Norton, OH Compressed-Air Energy Storage Project
Cost-effective, environmentally sound

FirstEnergy

Fully dispatchable as load by PJM using power to compress air



- Using a mined limestone cavern, 2200ft deep, 338 Mft^3 volume
- Up to 2,700MW capacity
- Permit issued, site preparation work underway