

# Transforming Grid-connected Wind and Solar Plants to Dedicated Hydrogen Fuel Production, Without the Costly Grid Connection

For both established and new windplants, PV plants, and wind + PV plants -- synergistic co-location and co-generation

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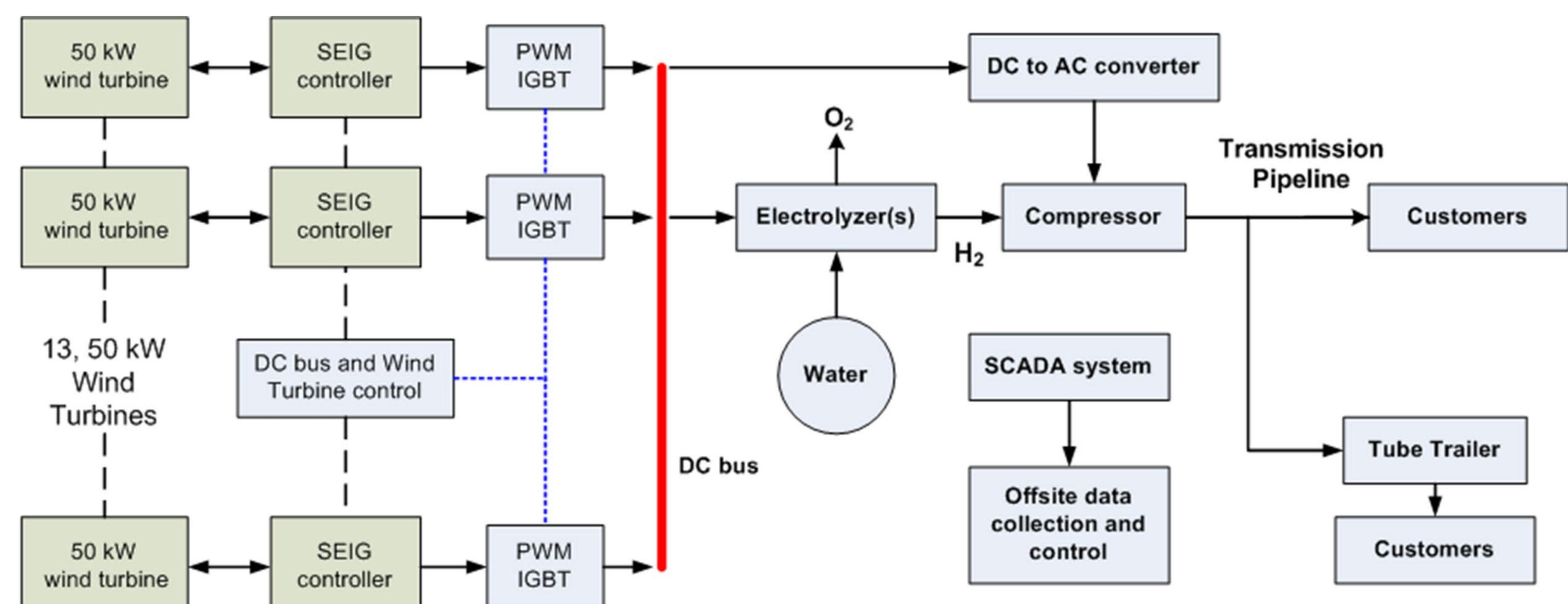


San Gorgonio Pass, Palm Springs, CA  
13, 50 kW turbines = 650 kW windplant test bed  
Squirrel cage induction motors as generators  
Proof-of-concept pilot plant for SEIG

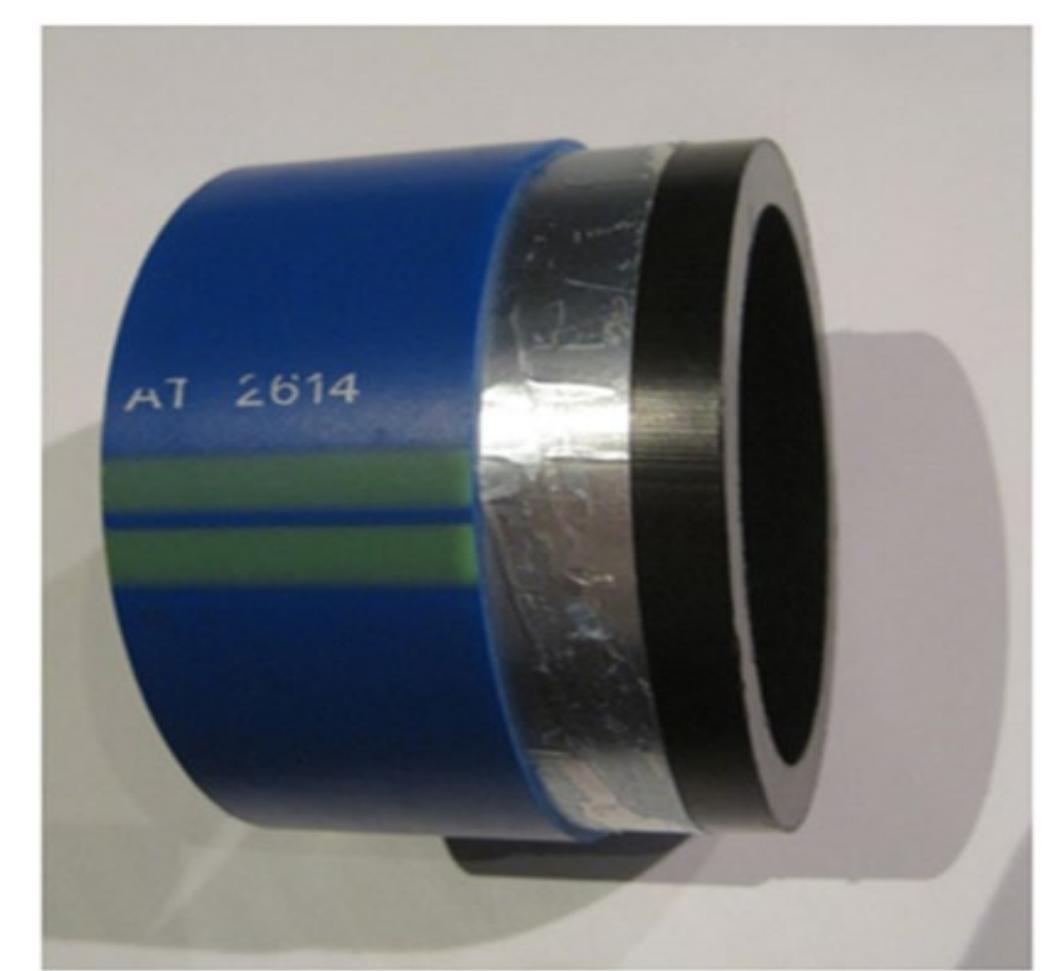
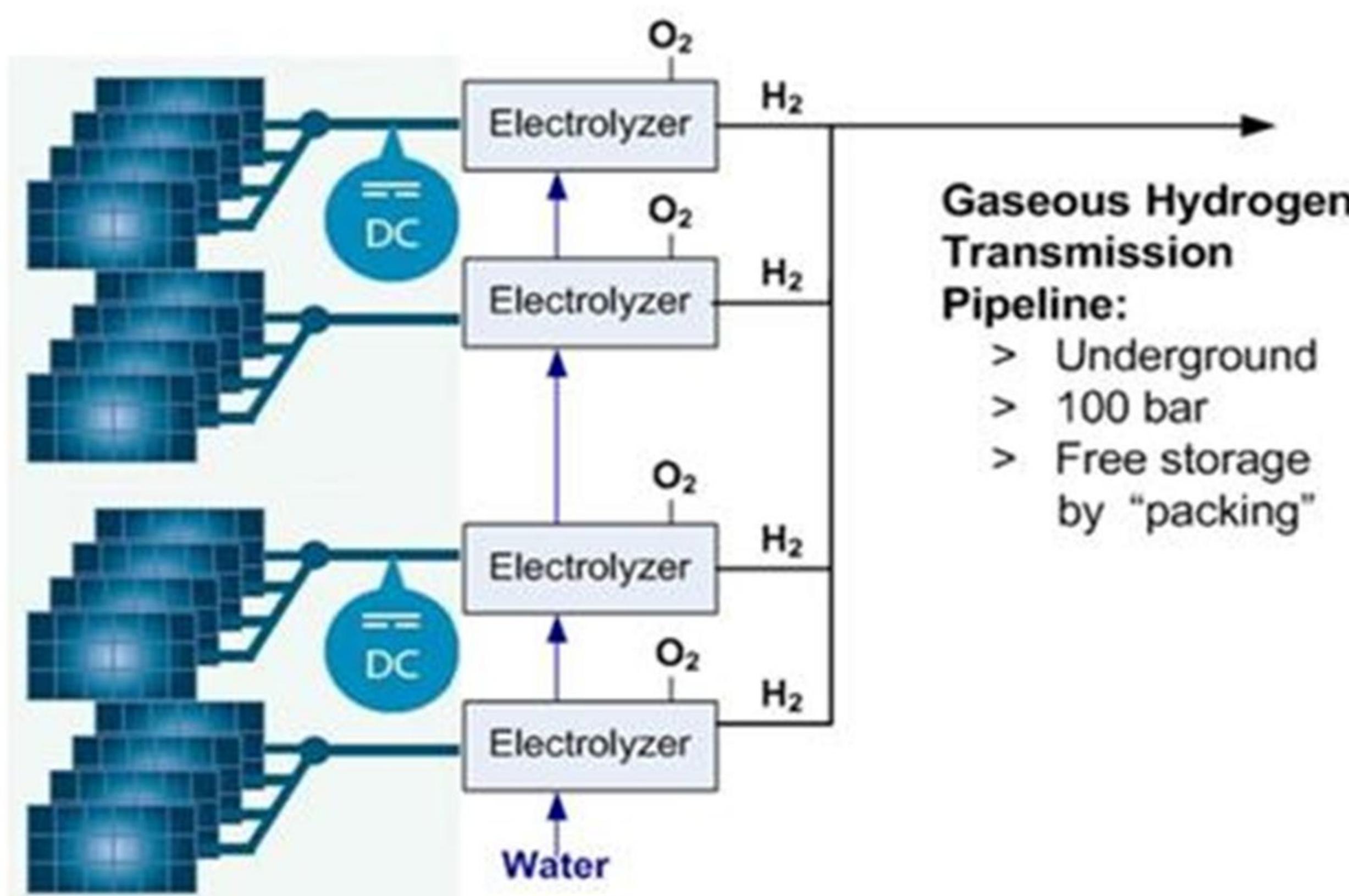
This windplant of vintage-1985, 50 kW turbines has delivered electricity to the SCE grid since 1991. The PPA has expired. We may reconfigure such windplants to deliver 100 % of captured energy as Hydrogen for fuel cell cars, buses, and trucks, with no costly PPA nor grid connection. We may thus eliminate curtailment, improve ROI.

Hydrogen gathering, transmission, and delivery is via a new, dedicated, high-purity, underground pipeline system, "packed" to maximum pressure, for very large, free energy storage.

In year 2050, California will need more CO2-emission-free (CEF) energy for Hydrogen transportation fuel than for the electricity grid. Co-located, co-generating, off-grid Wind + PV plants are simplified, at lower capex and opex, if dedicated to delivering only Hydrogen fuel.

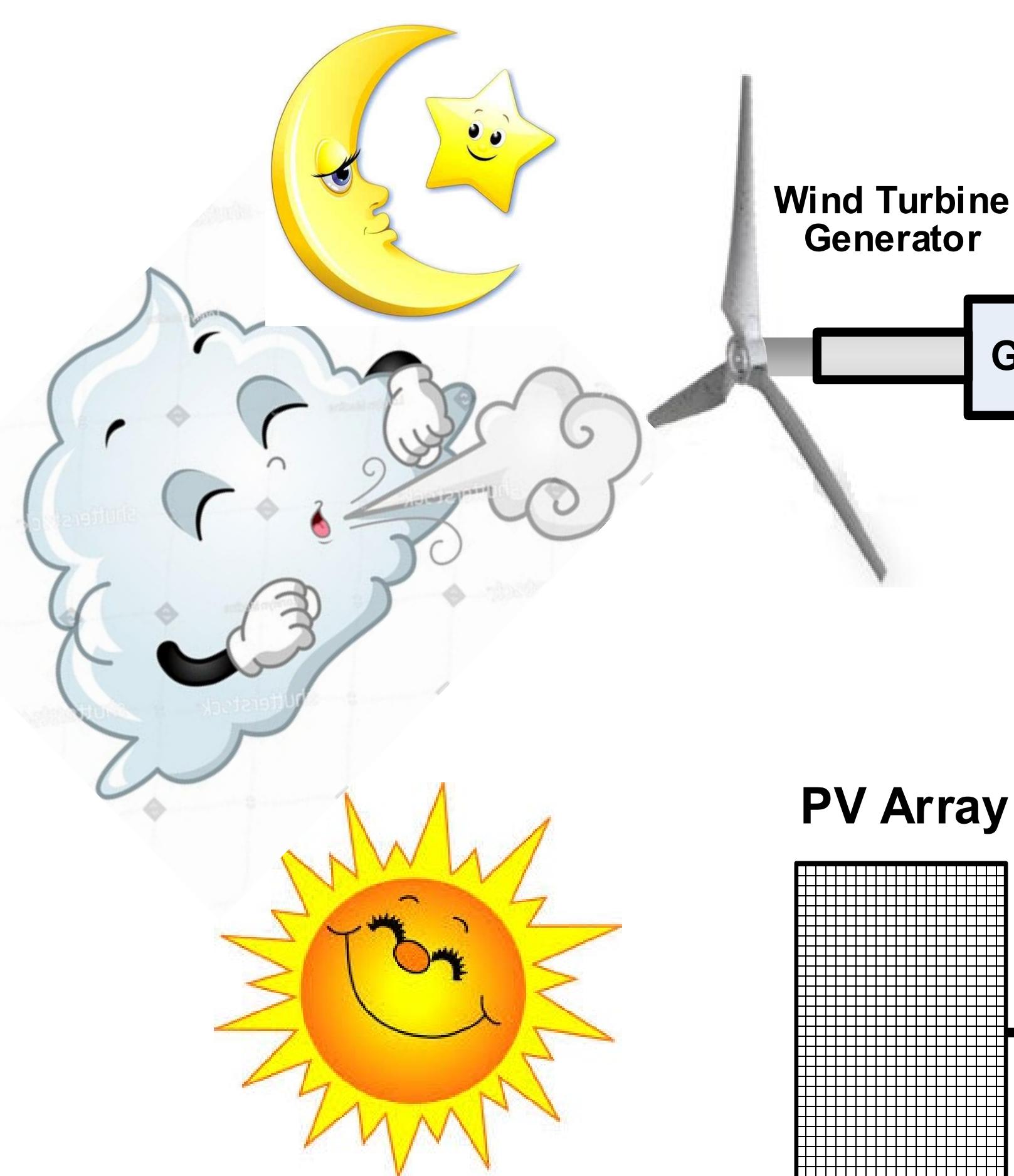


Turbines with simple, low-cost, rugged, induction motors operate in Self Excited Induction Generator (SEIG) mode with novel power electronics and controls, emerging from new R&D & Demonstration project. Three-phase "Wild AC" from the induction motor, rectified to "wild DC", directly to electrolysis stacks, eliminates the transformer - rectifier electrolyzer subsystem, integrating all controls in a single SCADA, reducing plant-gate Hydrogen fuel cost.



Gaseous Hydrogen Transmission Pipeline:  
> Underground  
> 100 bar  
> Free storage by "packing"

Gaseous Hydrogen Transmission Pipelines made of polymer-metal tubing with Al or Cu foil as the H2 permeation barrier will be immune to Hydrogen Embrittlement. A 1-meter-diam Hydrogen pipeline has a Capacity of 8 GW. Capex per GW-km of transmission service is lower than for electricity transmission lines. Gaseous H2 pipelines may be "packed" like NatGas pipelines are, for "free energy storage".



AC-DC Generator Side Constant V/Hz

Electrolyzer arrays are "dumb DC loads", fed "wild DC" from the off-grid PV strings and windplant. Wind turbines require the novel SEIG system for the low-cost, rugged, induction motors-as-generators.

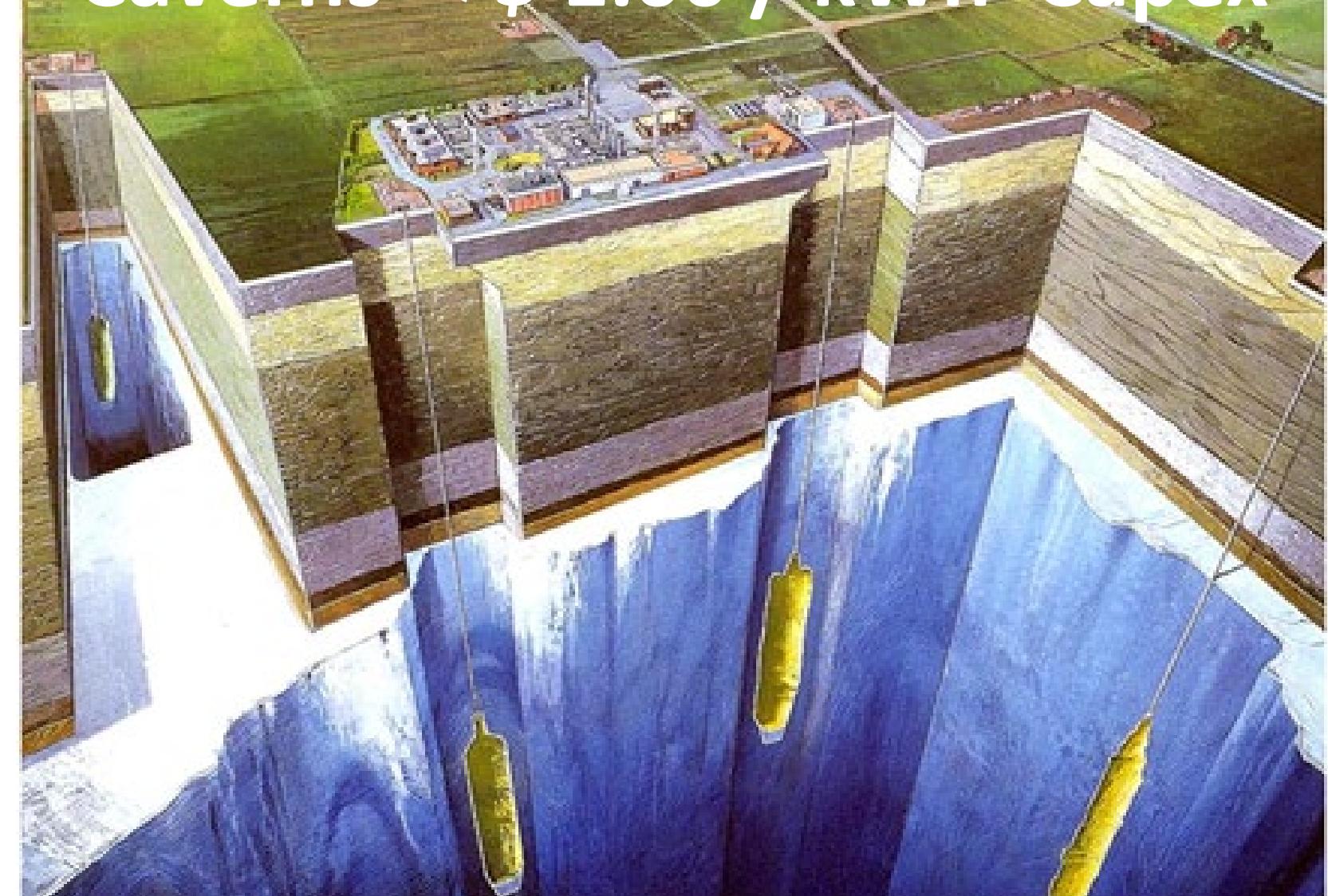
Off-grid wind and PV plants, and wind + PV plants, both in-service and new, may be dedicated to Hydrogen fuel production without the costly generating systems and infrastructure to deliver grid-quality AC or DC:  

- No inverters
- Simpler wind generating systems
- Less wire in the ground
- No substation
- No transmission line

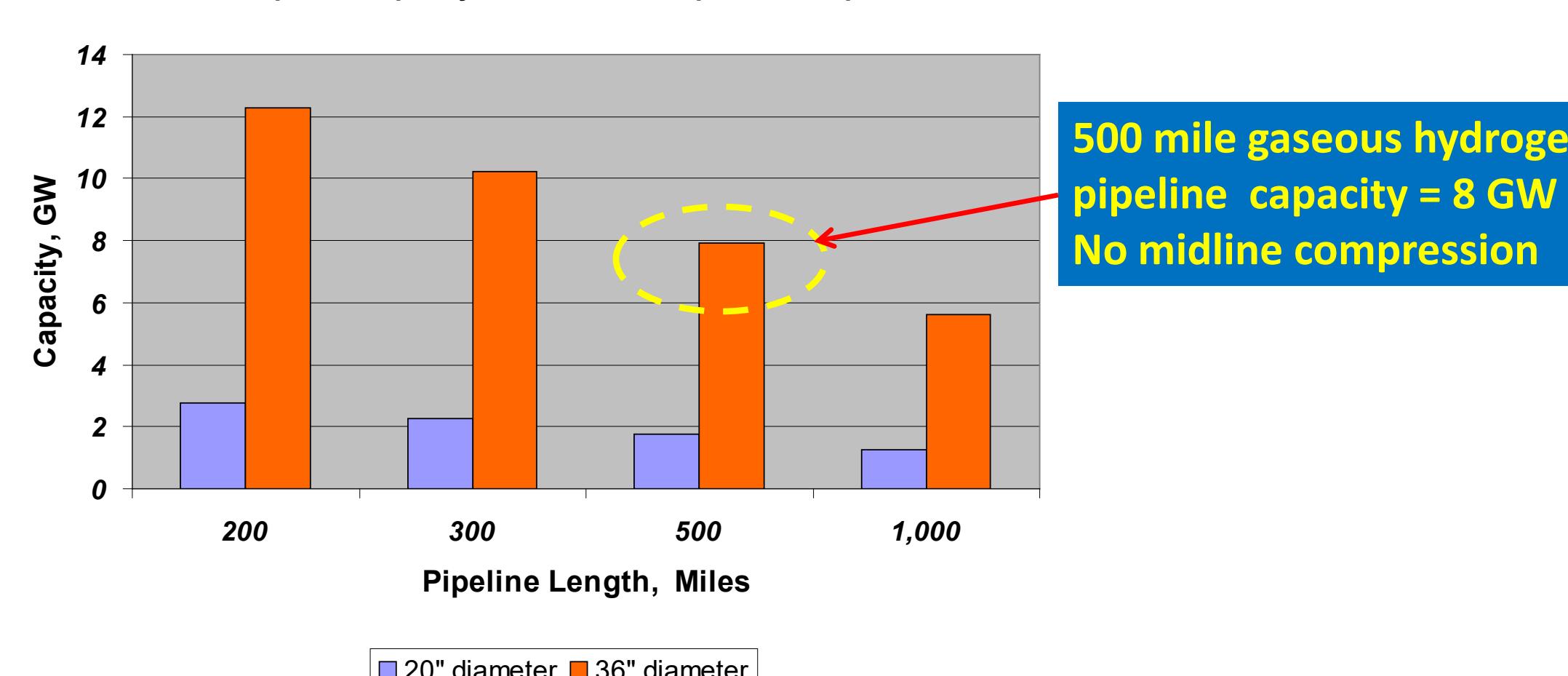
Hydrogen underground systems capex and opex is lower than for electricity systems:

- Transmission: ~ 50% lower \$ per MW-km
- Storage: < \$ 1.00 / kWh capex
- Underground pipelines and caverns protected
- Cyberattack resilience: long time constants, storage

Hydrogen Storage in Domal Salt Caverns < \$ 1.00 / kWh Capex



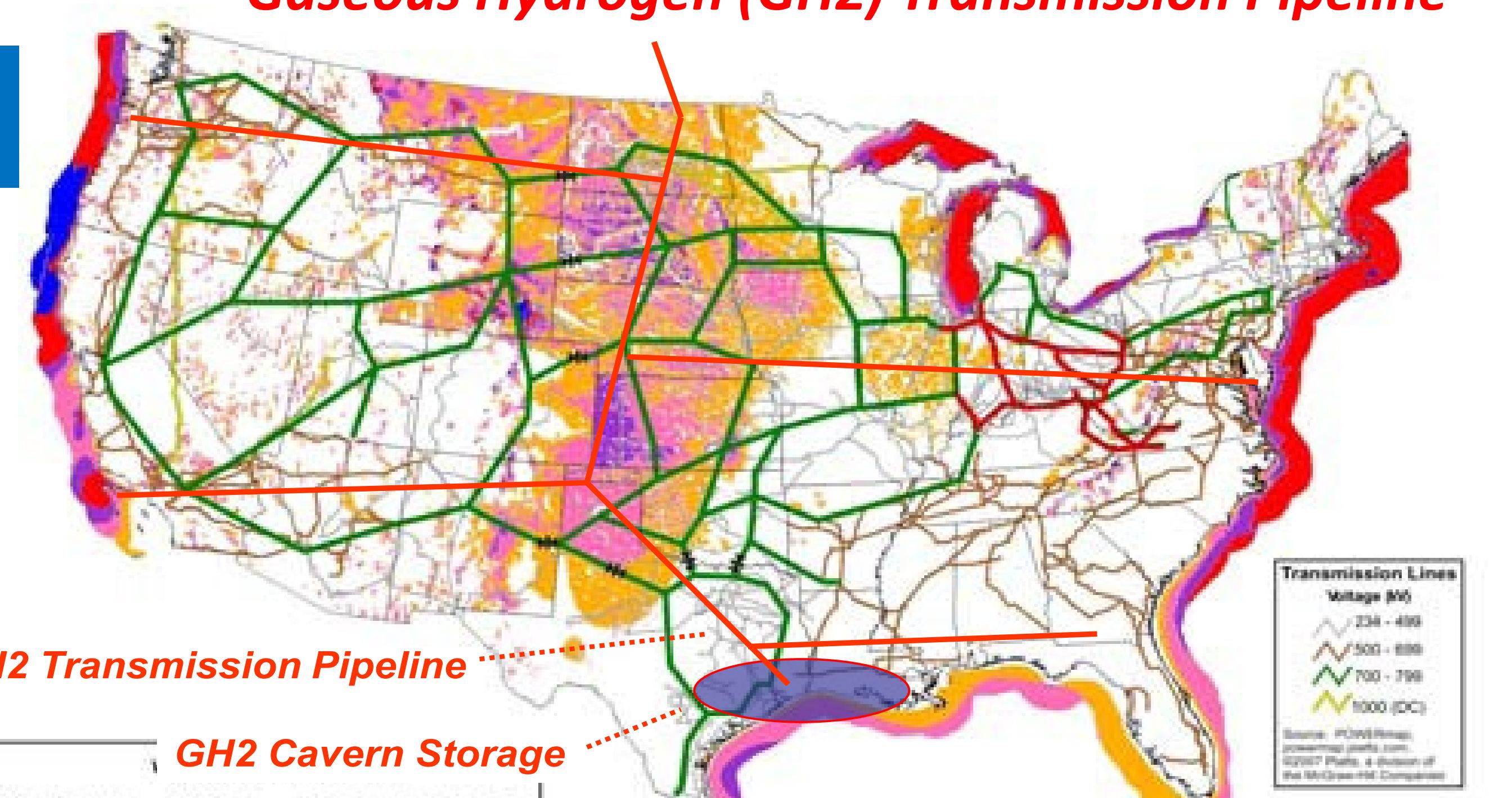
20", 36" GH2 Pipeline Capacity, 500 Miles, 1500 psi IN / 500 psi OUT



Annual-scale firming storage for < \$ 1.00 / kWh Capex. Each Gaseous Hydrogen (GH2) salt cavern:

- Stores ~ 92,000 MWh as ~ 2,500 Mt "working" H2
- "Full" at 150 bar = 2,250 psi
- Cavern top ~ 700m below ground
- 860,000 cubic meters typical physical volume
- \$ 15 M average Capex per cavern
- Capex = \$160 / MWh = \$0.16 / kWh

## Gaseous Hydrogen (GH2) Transmission Pipeline



The wind potential of the 12 Great Plains states is ~ 10,000 GW, which may be exported as Hydrogen fuel for transportation and CHP over thousands of miles in underground pipelines at lower cost than by electricity transmission. Hydrogen may be stored in Gulf Of Mexico salt caverns for < \$ 1.00 / kWh Capex.