Large Stranded Renewable Energy: Alternatives to Electricity for Transmission and Low-cost Firming Storage as Pipelined Hydrogen and Ammonia Carbon-free Fuels

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

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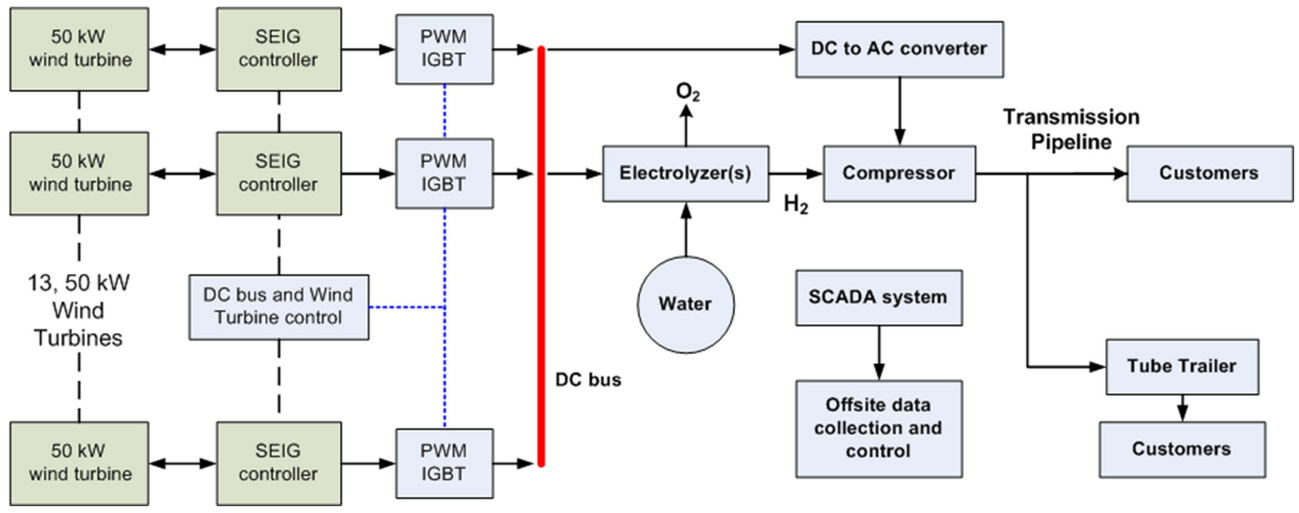
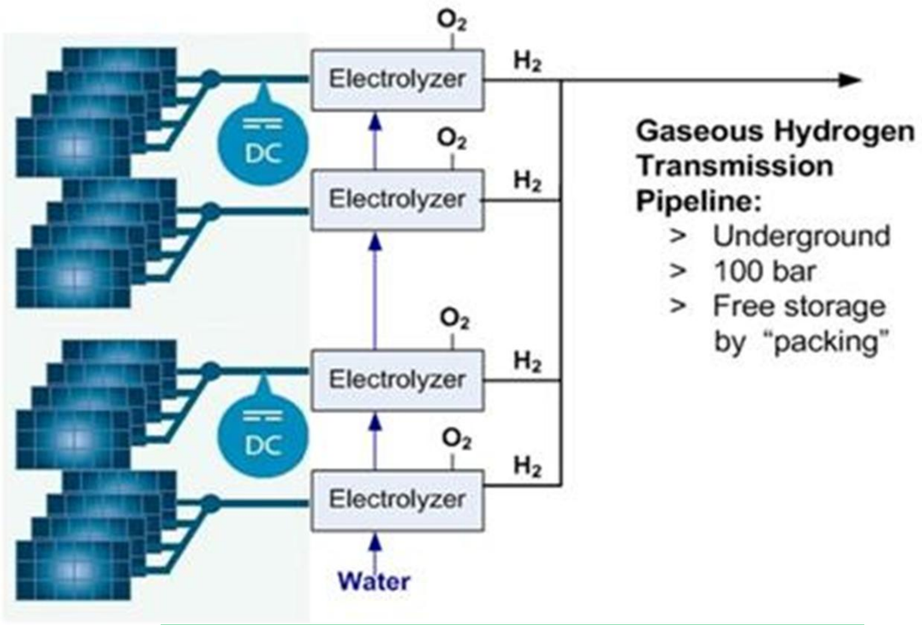
This windplant of vintage-1985, 50 kW turbines has delivered electricity to the SCE grid since 1991. The PPA has expired. We may reconfigure such windplants to deliver 100 % of captured energy as Hydrogen for fuel cell cars, buses, and trucks, with no costly PPA nor grid connection. We may thus eliminate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

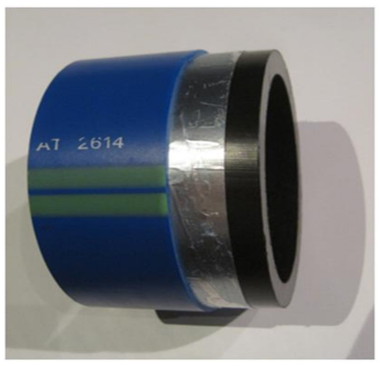
Hydrogen gathering, transmission, and delivery is via a new, dedicated, high-purity, underground pipeline system, "packed" to maximum pressure, for very large, free energy storage.

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.



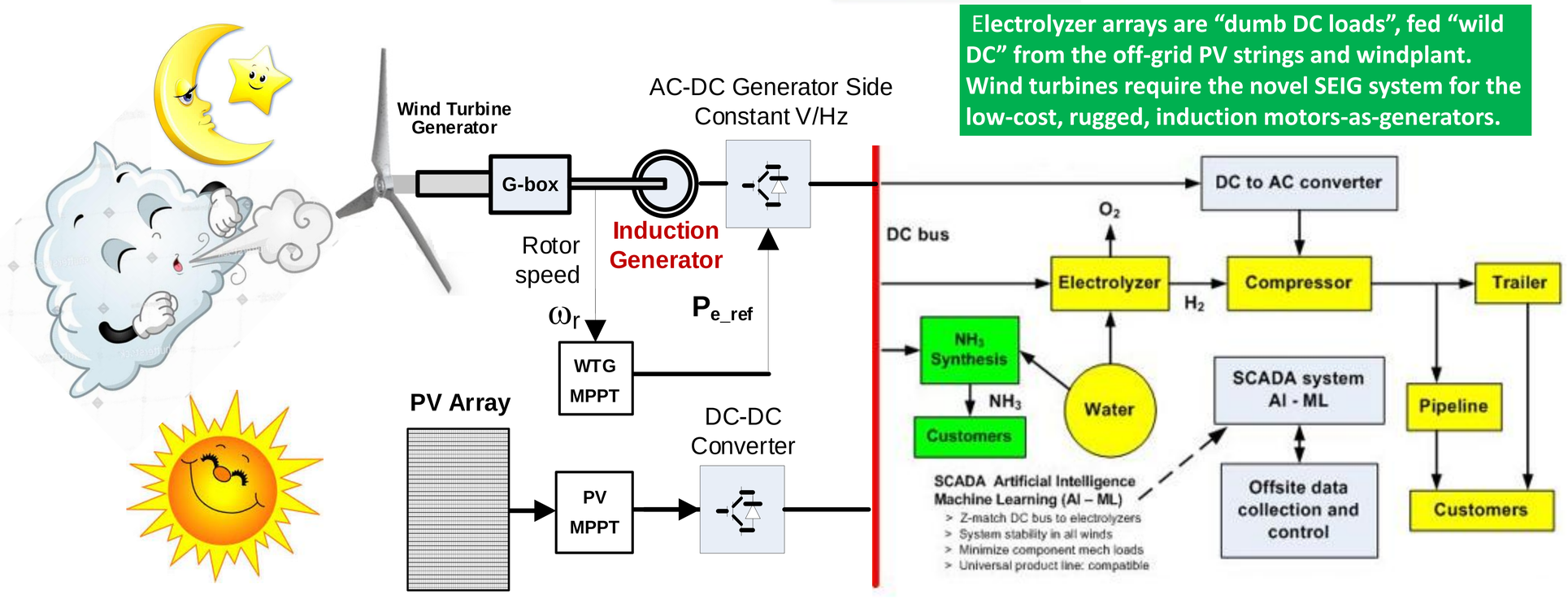
Turbines with simple, low-cost, rugged, induction motors operate in Self Excited Induction Generator (SEIG) mode with novel power electronics and controls, emerging from new R&D & Demonstration project. Three-phase "Wild AC" from the induction motor, rectified to "wild DC", directly to electrolysis stacks,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





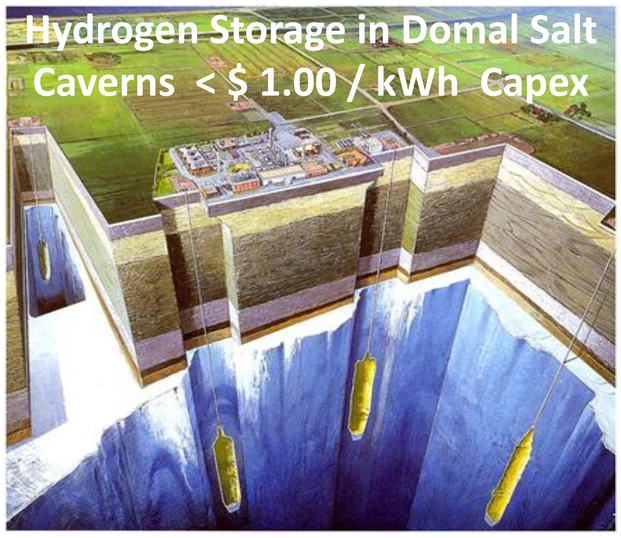
Gaseous Hydrogen Transmission Pipelines made of polymer-metal tubing with Al or Cu foil as the H_2 permeation barrier will be immune to Hydrogen Embrittlement.
A 1-meter-diam Hydrogen pipeline has a Capacity of 8 GW. Capex per GW-km of transmission service is lower than for electricity transmission lines. Gaseous H_2 pipelines may be "packed" like NatGas pipelines are, for "free energy storage".

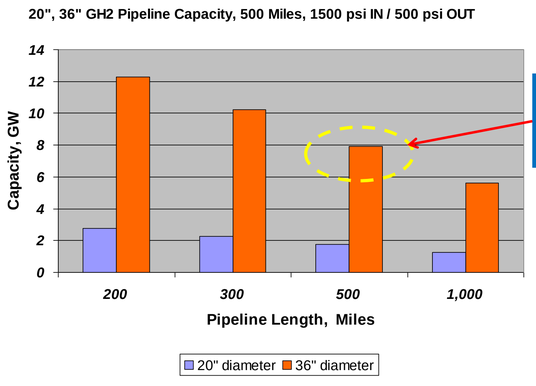
Electrolyzer arrays are "dumb DC loads", fed "wild DC" from the off-grid PV strings and windplant. Wind turbines require the novel SEIG system for the low-cost, rugged, induction motors-as-generators.



Off-grid wind and PV plants, and wind + PV plants, both in-service and new, may be dedicated to Hydrogen and Ammonia fuel production without the costly generating systems and infrastructure necessary to deliver grid-quality AC or DC:
- Simpler wind generating systems
- No inverters
- Far less wire in the ground
- No field transformers
- No substation, 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
- Cybertack resilience: long time constants, storage



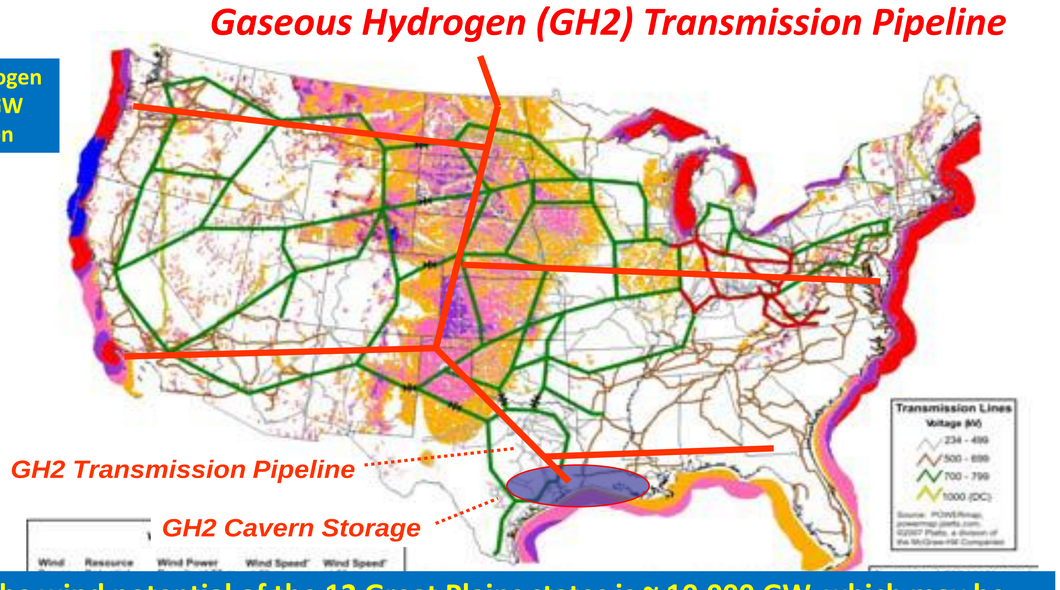


500 mile gaseous hydrogen pipeline capacity = 8 GW
No midline compression

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

- Stores ~ 92,000 MWh as ~2,500 Mt "working" H_2
- "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.