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A Bigger Market than the Electricity Grid ? Solar-source Hydrogen Fuel for California Transportation and Combined Heat and Power (CHP)

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By year 2050, to achieve its statutory RPS and "80 in 50" (80% reduction in CO2 emissions from transport sector, below 1990, by 2050) energy goals, California must procure the full output of about 438 GW of combined nameplate wind and solar energy or its equivalent -- about 20 x the 2015 total installed capacity in CA. ~ 58% of that will be Hydrogen transportation fuel, if ITS-STEPS at UC Davis is correct: in 2050 fuel cell vehicles will predominate in personal, bus, and truck service; BEV's are limited to short-distance, light-duty service. In 2050, Hydrogen fuel will be a bigger market for renewable energy than the electricity grid. In California, in the 12 months ended Oct 2017, 440,000 MWh of wind and solar energy was curtailed and lost; converted to high-purity Hydrogen via electrolysis, that would have fueled about 70,000 fuel cell light duty vehicles (LDV's) -- typical passenger cars and SUV's we all drive.

Therefore, we should now think "beyond electricity", to capture a larger market for wind energy than the electricity grid, to carefully consider using underground pipeline networks, for transmission, storage, and distribution of the Carbon-free fuels -- Gaseous Hydrogen (GH2) and liquid anhydrous ammonia (NH_3) -- for solving renewable energy's (RE) Big Three technical and economic problems, at lower capital and O&M costs than we can achieve with electricity systems:

1. Gathering and Transmission: from diverse, stranded, remote, and rich renewable energy (RE) resources, such as solar and wind
2. Annual-scale Firming Storage: so that variable RE becomes annually firm and dispatchable
3. Distribution, Integration, and End-use: for an annually-firm supply of quality, CO2-emissions-free energy for all uses and sectors

We should now design and optimize complete RE fuel systems, based on GH2 and NH3, at local to continental scales, from sunlight, wind, and water resources, to dispatchable energy services delivered for ALL energy uses:

- Conversion, Transmission, Combined-heat-and-power (CHP): for both stationary and transportable uses
- Generation, Gathering, Firming storage, and end use: transportable and CHP Carbon-free fuels, as well as electricity

This enables very low cost energy storage: less than $ 1.00 / kWh capital cost:

- Gaseous Hydrogen (GH2) in large, deep, solution-mined salt caverns, where the salt geology is available: Gulf of Mexico coast
- Liquid Anhydrous Ammonia (NH_3) in large, refrigerated, "atmospheric", carbon steel surface tanks, extant in the Corn Belt
- Interconnected via continental underground pipelines, adding "free" storage by packing the GH2 pipelines (not liquid NH3 lines)
- At lower cost than any contemplated “electricity” storage technology, components, or systems

Pipelined GH2 and NH_3 fuels free those wind and solar plants, which would be dedicated to delivering all their captured RE as GH2 and NH_3 fuels to pipelines, from the capital and O&M costs of generating and delivering grid-quality AC or DC electricity: the required complex generators and power electronics, field transformers, cables and substations, transmission lines.

To achieve this goal, we must overcome these obstacles:

- Earth’s richest RE resources are often stranded, far from markets with no transmission
- Markets and infrastructure for the C-free fuels -- Hydrogen and Ammonia -- do not exist for GH2; are inadequate for RE - NH3
- We cannot achieve this entirely via electricity, and should not try to do so; “Smart Grid” is primarily demand side management (DSM); it adds no inherent or physical new transmission nor energy storage capacity , and only slight effective new capacity.

Therefore, we should now design and build pilot solar plants for both GH2 and NH_3 as complete, optimized, RE systems, by which to:

- Discover and demonstrate scalable technical proof-of-concept and economic advantages
- Explore optimum system topologies for sources, components, infrastructure, and fuels end-uses
- Motivate private-public collaboration to conceive RFP’s and RFQ’s for these pilot plants
- Capture the very large nascent market for CO2-emissions-free transportation fuel, in California and beyond

Humanity’s urgent goal is to transform the world's largest industry from ~ 85 % fossil to ~ 100 % renewable, greenhouse gas (GHG) - emissions - free energy sources, as quickly as we prudently and profitably can: to "Run the World on Renewables", perhaps including some nuclear fission or fusion. Therefore, we should now design these alternatives to, and adjuncts to, the electricity grid:

- Wind and solar PV plants converting all RE, at their sources, with no grid connection, to GH2 or NH_3 fuels
- Deliver these C-free fuels via underground pipelines for transportation and CHP, accessing very-low-cost energy storage

RE-source NH_3 : http://www.wired.com/2016/05/chemical-reaction-revolutionized-farming-100-years-ago-now-needs-go/