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Docket Number:	17-HYD-02
Project Title:	Hydrogen Station Network Future Approaches
TN #:	222058
Document Title:	Bill Leighty Comments Include dedicated gaseous hydrogen (GH2) pipeline networks
Description:	N/A
Filer:	System
Organization:	Bill Leighty
Submitter Role:	Public
Submission Date:	12/22/2017 4:52:36 PM
Docketed Date:	12/22/2017

Comment Received From: Bill Leighty
Submitted On: 12/22/2017
Docket Number: 17-HYD-02

Include dedicated gaseous hydrogen (GH2) pipeline networks

For Hydrogen-fueled vehicles to enjoy a significant or dominant role in the ZEV Mandate, CO2-emission-free hydrogen fuel will need to be gathered, transmitted, stored at low cost (by packing the pipelines), and distributed to fueling stations via a new, dedicated system and network of underground gaseous hydrogen (GH2) pipelines. Therefore, this project should explicitly include pipeline network modeling and planning, and also include describing the R&D path necessary to develop new linepipe materials for this GH2 network which will be immune to hydrogen embrittlement and hydrogen leakage, and economical to install in both new pipelines and in relining and repurposing extant pipelines. These pipeline systems should be imagined as gathering solar- and wind-source hydrogen from variable generation (VG) in renewables-resource-rich areas lacking electricity transmission -- within and from beyond California.

Additional submitted attachment is included below.

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

Bill Leighty, The Leighty Foundation, Juneau, AK wleighty@earthlink.net Poster download: http://leightyfoundation.org/w/wp-content/uploads/WP16-A.pdf

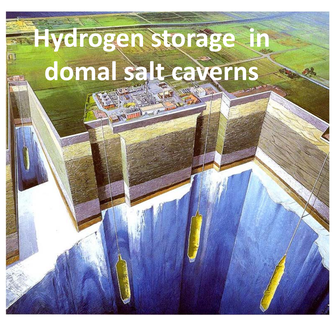
Hydrogen Transportation Fuel Demand California, year 2050 Million metric tons per year:

Light Duty Vehicles (LDV)	3.6
Trucking	1.6
Bus	1.4
Aviation and Other	0.8
Total	**7.4**

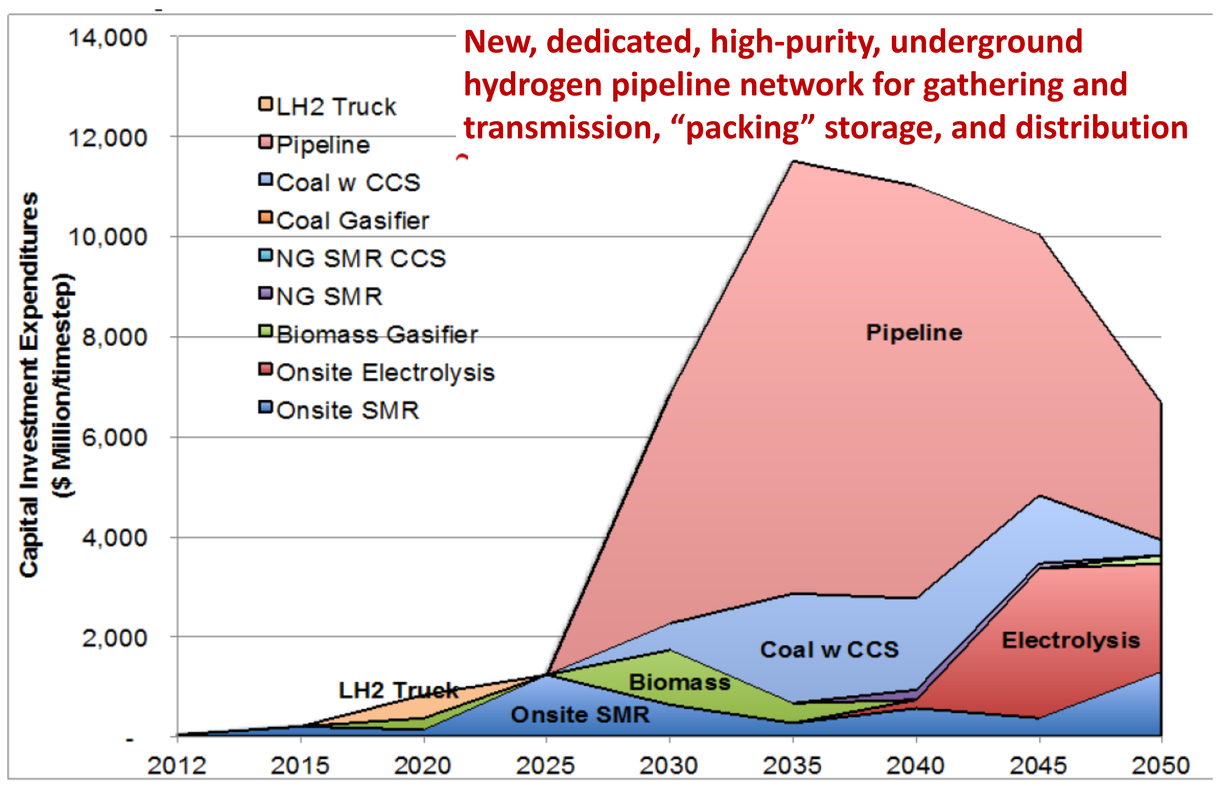
Source: interpret and extrapolate from several papers by ITS-STEPS, UC Davis

Reference: Year 2015	GW
Total installed nameplate wind generation in California (CA)	6
Total installed nameplate solar generation in California (CA)	12
ELECTRICITY: CA "Power Mix"	**GWh**
2014: Total electricity consumed	296,843
2050: Total electricity demand "Power Mix" is 130 % of 2014	385,896
ELECTRICITY in Year 2050: CA renewables	**GW**
Equivalent nameplate wind generation capacity @ 40 % CF	85
Equivalent nameplate solar generation capacity @ 35 % CF	97
TRANSPORTATION Hydrogen Fuel in Year 2050: CA renewables	**GW**
Equivalent nameplate wind generation capacity @ 40 % CF	126
Equivalent nameplate solar generation capacity @ 35 % CF	130
TOTAL CA RENEWABLE ELECTRICITY + TRANSPORT ENERGY in Year 2050	**GW**
Equivalent nameplate wind + solar + other @ CF (varies)	438

For Year 2050 Electricity + Hydrogen Transportation Fuel, California will need about:
- **210 GW = 35 times Year 2015 installed wind capacity in CA, *PLUS***
- **230 GW = 19 times Year 2015 installed solar electricity capacity in CA**



Annual-scale firming storage for < $ 1.00 / kWh capex
Each domal salt cavern:
- **Stores ~ 92,000 MWh as ~ 2,500 Mt "working" Hydrogen**
- **"Full" at 150 bar = 2,250 psi**
- **Cavern top ~ 700m below ground**
- **860,000 cubic meters each cavern physical volume**
- **$ 15 M average capex per cavern**
- **Capex = $160 / MWh = $0.16 / kWh**



Capital Investment for Hydrogen Fuel Infrastructure in California
$ 50 Billion cumulative investment : Transition to "green" Hydrogen for "80 in 50"
80 % reduction in CO_2 emissions from California transportation sector by year 2050
Source: Institute of Transportation Studies (ITS), STEPS program, UC Davis

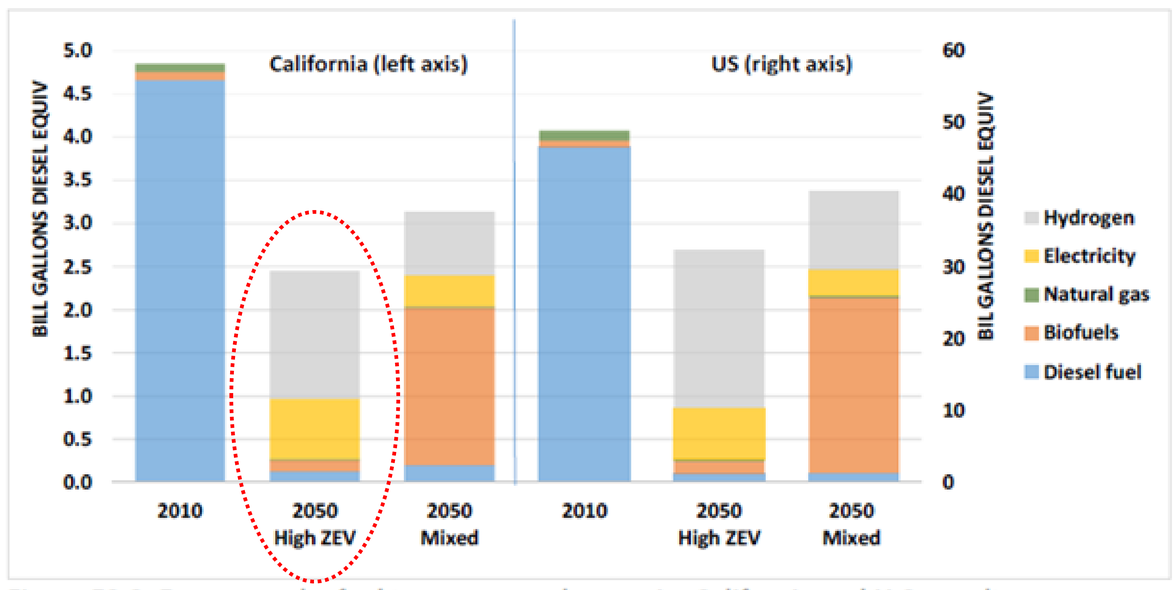
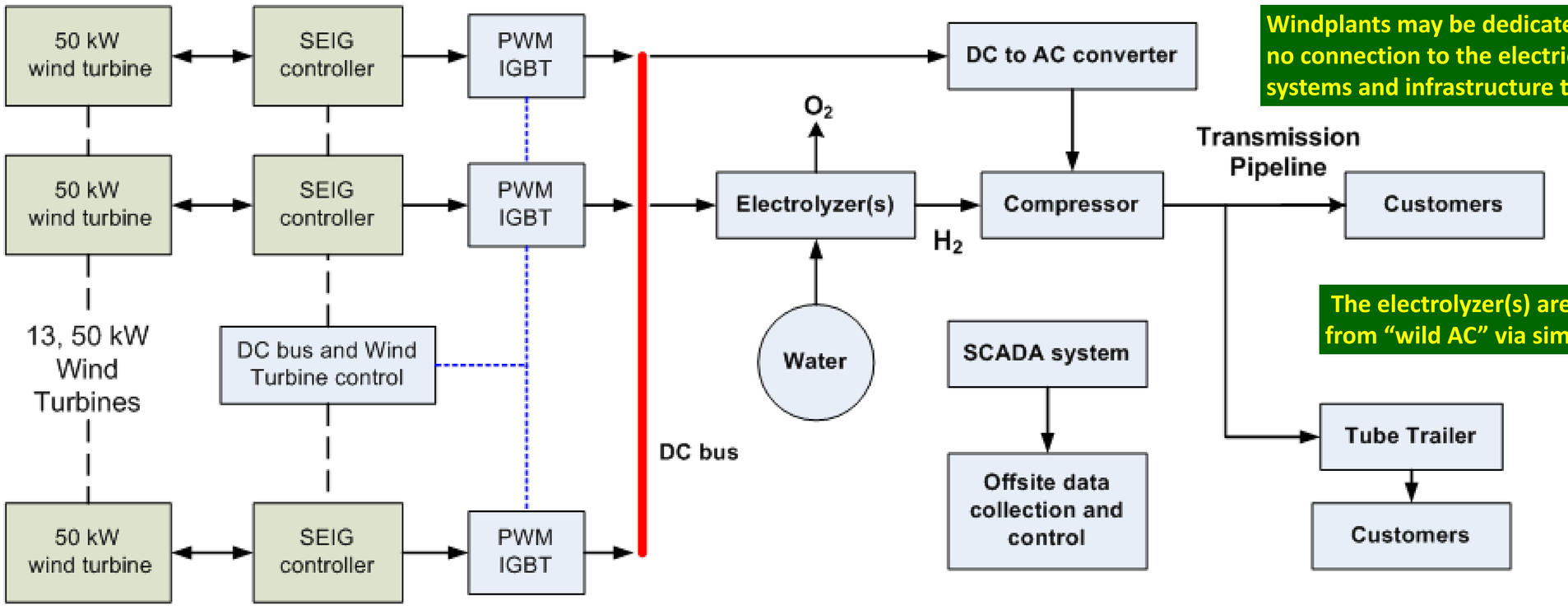


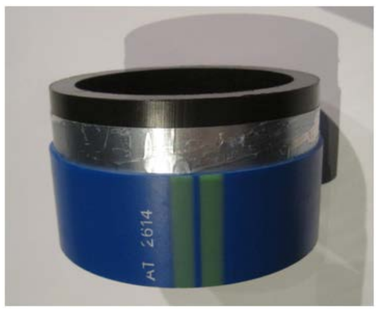
Figure ES-2. Energy use by fuel type, year and scenario, California and U.S. results

"Goods movement" trucking diesel fuel demand in Year 2050
California (left, red circle) and USA (right), High Zero Emissions Vehicle (ZEV) case
This is included in the "Hydrogen Fuel Demand" estimates on the poster's right side.
Source: Institute of Transportation Studies (ITS), STEPS program, UC Davis



Windplants may be dedicated to Hydrogen fuel production, with no connection to the electricity grid, without costly generating systems and infrastructure to deliver grid-quality AC or DC.

The electrolyzer(s) are a dumb DC load, fed "wild DC" from "wild AC" via simple power electronics and controls



Gaseous Hydrogen (GH2) transmission pipelines
Polymer-metal hybrid tubing concept sample, from Smart Pipe, Houston, www.smart-pipe.com May be made up to I meter diam for transmission; smaller for gathering and distribution lines. Fabricated in an on-site, trenchside factory in continuous, unlimited lengths, without splices. Has not been tested for 100 bar GH2 service. Probably immune to Hydrogen embrittlement.

Turbines with simple, low-cost induction motors are modified for Self Excited Induction Generator (SEIG) mode and closely coupled via simple, smart rectification on a DC bus to the electrolyzer stacks, via a SCADA system integrating the complete wind-to-Hydrogen plant, to reduce system complexity and capital and O&M costs.
This will reduce kWhe per kg Hydrogen and boost energy conversion efficiency, reducing plant gate Hydrogen fuel cost in several ways.