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Wind-to-H2; Palm Springs windplant conversion; Gaseous Hydrogen pipelines

Additional submitted attachment is included below.

Alaska Applied Sciences, Inc.
Box 20993, Juneau, AK 99802-0993

24 Jan 17

RE: CEC 17-HYD-01, 30 Sept 17 workshop

Dear Matthew Ong, Phil Cazel, and California (CA) Hydrogen Colleagues,

Please accept my "stakeholder input" comments in advance of the 30 Sept workshop, for its objective:

To inform a future renewable hydrogen production solicitation utilizing Emerging Opportunities funding, staff will seek stakeholder input on:

- *Current inventory and future demand for renewable hydrogen transportation fuel,*
- *Renewable gas and electricity projects that are candidates for renewable hydrogen generation systems,*
- *Optimal siting and capacity of a renewable hydrogen generation facility, and*
- *Existing and future options for generating and distributing renewable hydrogen.*

" Implementation Strategies for Production of Renewable Hydrogen in California " is a good match for the "Emerging Opportunities" component of the " 2017-2018 Investment Plan Update for the Alternative and Renewable Fuel and Vehicle Technology Program " because:

1. As the Trump Administration retards USA progress in decarbonizing our total energy supply, that urgent responsibility devolves to states and cities, and to their citizens, and to private enterprise, and to philanthropy.

2. Enough Hydrogen fueling stations will soon be in place, and enough FCHEV's (LDV's, buses, trucks) soon on the road, to tax present supplies of Hydrogen fuel " ... made from eligible renewable energy resources". Developing new sources, especially technically innovative ones, will require several years, so CEC's investigation and investment in research, development, and demonstration (R&D&D) should begin soon.

3. If CA achieves both its electricity sector RPS and its transportation sector "80 in 50" goals, it will need more CO2-emission-free (CEF) renewable energy (RE) for Hydrogen for transportation fuel than electricity for the Grid. See attached posters from Windpower 2016 and Solar 2016 conferences: "Bigger Market ..." . By 2050, CA may need ~ 7 million metric tons per year (MMTPY) of high-purity Hydrogen transportation fuel, which would require the full annual energy capture of ~ 250 GW of combined wind and solar nameplate generation, as FCHEV's displace BEV's for all road vehicles except for light-duty, short-haul service.

4. This ~ 7 MMTPY gaseous hydrogen (GH2) fuel demand will require a new, dedicated, high-purity, underground pipeline system for gathering, transmission, and distribution, with the important bonus of MWh-scale, no-cost energy storage in the pipeline network by pressurizing the "Hydrogen Grid" (H2-Grid) up to Maximum Allowed Operating Pressure (MAOP, typically 100 bar = 1,500 psi) when RE-CEF input exceeds demand, allowing customer consumption to depressurize the H2-Grid to a minimum pressure range. This pipeline network will require ~ $ 50-60 billion investment in years 2025 - 2050, as shown on the chart in upper-right of the attached Windpower and Solar posters. Source: UC Davis, ITS-NextSTEPS, "The Hydrogen Transition", Fig. 17. http://steps.ucdavis.edu/files/08-13-2014-08-13-2014-NextSTEPS-White-Paper-Hydrogen-Transition-7.29.2014.pdf Planning for this pipeline network should begin now.

5. We do not know what linepipe material will be safe and economical for this new GH2 pipeline system, which will probably be subject to frequent and perhaps large pressure fluctuations consequent of the wind, solar, and other variable generation (VG) feeding it.
This presents an R&D&D opportunity that is apparently not being pursued. Smart Pipe, Houston, may be able to manufacture polymer-metal composite linepipe with a thin, non-structural, aluminum or copper Hydrogen

permeation barrier in the pipe wall, solving multiple Hydrogen embrittlement and corrosion problems. But, this would need to be a funded R&D project, with Smart Pipe or others.

6. Large, new land areas beyond the electricity transmission grid service will consequently be opened for "Distributed, Autonomous" (DA, i.e. with no connection to nor energy delivery to the electricity grid) wind and solar energy capture, for production of Hydrogen and / or other fuels, which will require new pipeline systems, for GH2 and / or for other fuels. Underground pipelines may be easier to site and permit, and may cost less -- capex per MW-km capacity and O&M cost per km per year -- than overhead electricity lines; they will certainly cost less than underground electricity transmission lines.

7. Aggregating adequate land and rooftop area within CA to satisfy the total CA demand for RE-CEF energy may be difficult, requiring imports from contiguous states or the Great Plains, via new GH2 or NH3 pipelines or large, new electricity transmission lines.
What is the optimal mix in year 2030 - 2050, for CA's total energy supply ? Capacity of a 36" diameter, 800 km long GH2 pipeline, without midline compression, 100 bar MAOP, is 8,000 MW ~= 6,000 MTPD (Metric Tons Per Day) ~= 2.2 MMTPY

8. This may be an ideal opportunity for CEC to join a "High Impact Study" at NREL's Energy System Integration Facility (ESIF), by which to model CA's total energy system, by which to answer the question in (6), above: What is the optimal mix of electricity and hydrogen in 2050 ?
Please see the attached DRAFT application for the "High Impact" ESIF study. Although the submission date is 27 January, CEC might join the project later.

9. GWh-scale electricity storage will remain costly; GWh-scale storage is available today at < $ 1.00 / kWh capex and low O&M cost as GH2 in large, deep, solution-mined caverns in domal salt and in large, steel, refrigerated, "atmospheric", liquid NH3 tanks on-grade.
New pipeline networks will be needed to interconnect them.

10. CEC should invest in pioneering research, development, and demonstration (R&D&D) projects, including statewide RE-CEF energy systems, to accelerate the availability of RE-CEF Hydrogen fuel from in-state as well as out-of-state sources. "Current inventory" includes hundreds of still-operating wind turbines which are near, or beyond, the PTC-earning ten years and / or the PPA termination date.

For example, our company, Alaska Applied Sciences, Inc. (AASI) owns a 13-turbine windplant in Palm Springs, which we have proposed converting to deliver all of its captured wind energy as Hydrogen fuel for local markets, with no connection to nor energy delivery to the SCE grid. This is "optimal siting" for early, modest production.

See attached Small Business Voucher (SBV) application for $ 300 K assistance from NREL for proof-of-concept for a novel technology to reduce the cost of wind-to-Hydrogen production from "DA" windplants. AASI also submitted a Full Application to ARPA-E via the 2015 "OPEN" FOA, for $ 3 million, for full conversion of this windplant, via a custom-designed, simplified electrolysis plant integrated with the novel wind turbine generating system, for wind-to-Hydrogen cost reduction. AASI will gladly supply the 45-page ARPA-E Technical Volume.

Full AASI windplant conversion could be within 18 months; 11,000 - 15,000 kg GH2 Hydrogen fuel per year; Sunline Transit, Thousand Palms, is an obvious potential customer. Delivery would be by tube trailer to Sunline or other markets. Market supply potential:

a. Convert other windplants "post PTC" or "post PPA", including older turbines, to "curtailed only" or dedicated Hydrogen fuel production, with or without Grid connection;
b. Convert extant PV plants "post PTC" or "post PPA" to "curtailed only" or dedicated Hydrogen fuel production, with or without Grid connection;

c. Wind and PV OEM's are motivated to design generation equipment optimized for "DA" production of Hydrogen fuel.

This AASI project, at either the $ 300 K proof-of-concept or the $ 3 million full-windplant-conversion level, would be an appropriate "Emerging Opportunities" investment; it could begin wind-to-Hydrogen production within 6 months of NREL's readiness to proceed. This would be an early source of wind-generated Hydrogen fuel in Southern CA, while researching and demonstrating a unique, novel, potentially-valuable, scalable, RE-CEF technology. The NREL team agrees that this is an important R&D&D project; eager to proceed, if funded.

Project and technology success would reward CEC's investment with a valuable technology for commercialization, in CA and beyond.

11. As demand for RE-CEF Hydrogen fuel builds, early GH2 pipeline infrastructure might be built upon underutilized or out-of-service extant pipelines in CA. These might be repurposed for GH2 transmission and distribution from diverse RE-CEF sources:

a. To reduce the cost of GH2 fuel dispensing stations, by replacing on-site Hydrogen generation or costly truck delivery;

b. Perhaps by relining the pipelines with a polymer-metal composite, high-pressure, hydrogen-embrittlement-resistant material such as that pioneered by Oak Ridge National Laboratory (ORNL) and Hydrogen Discoveries, Inc. Smart pipe, Houston, may be able to fabricate such linepipe, but an R&D&D program would be required to develop, test, and certify such material. www.smart-pipe.com CEC might want to fund, or collaborate upon funding, this R&D&D program, so that a GH2 pipeline network technical solution is available, at a credible cost estimate, when we need it.

c. The Questar Southern Trails pipeline, western portion, might be a candidate for such repurposing. http://www.questarpipeline.com/indexSTP.php " Questar Pipeline announced it has terminated plans to recommission the western segment of the Southern Trails Pipeline as a crude-oil transport pipeline and commenced a process to divest the asset. Questar's objective is to sell Southern Trails by the end of 2016. " Morris Jackson [Morris.Jackson@questar.com] Business: (801) 324-2472, Mobile: (801) 808-8587 Steve Chapman, Coordinator Special Communication Projects, Questar Corporation, at 801-324-5548. We have no business interest in Questar.

12. Solar PV plants may be similarly dedicated to RE-CEF production of Hydrogen fuel, without connection to nor energy delivery to, the electricity grid. PV panels produce direct current (DC), which electrolysis stacks require. PV panel arrays can be configured for optimum matching to electrolysis stacks, to reduce the cost of solar-source Hydrogen fuel at the PV plant gate. Solar, wind, and other dedicated Hydrogen fuel production facilities would share the same GH2 pipeline network.

13. If California (CA) is to meet both its electricity sector RPS and transportation sector "80 in 50" goals it will need large, new sources of RE-CEF Hydrogen fuel from wind and solar plants, and perhaps from other sources. The need for RE-CEF Hydrogen fuel production in CA is imminent. CEC should be planning for this, now, and sponsoring increasing amounts of the R&D&D necessary to bring important, diverse, new technologies and energy systems concepts to market and deployment in CA. The CEC "Emerging Opportunities" and other technology R&D&D programs should be greatly expanded, perhaps via VW receipts.

Given the workshop objective: " Strategies that can lead to increased and more cost-effective in-state production and distribution of renewable hydrogen transportation fuel ", I propose:

a. The following discussion topics

b. From (10), above: State of CA investment in our company's (AASI) proposed technically-innovative conversion of its Palm Springs windplant to dedicated delivery of all its captured wind energy as Gaseous

Hydrogen (GH2) fuel, with no connection to nor energy delivery to the SCE Grid, for tube trailer transport to local GH2 fuel markets.

The energy industry has five options for producing RE-CEF Hydrogen fuel, in CA and beyond:

1. Water electrolysis of otherwise-curtailed electricity generation from wind, solar, and other RE-CEF sources, whereby curtailment is caused by ISO refusal to accept electric energy in the Grid, or by very low or negative prices for Grid delivery;
2. Water electrolysis of electricity generation from wind, solar, and other RE-CEF sources dedicated to C-free fuel (Hydrogen and / or Anhydrous Ammonia (NH3)), with no connection to nor energy delivery to the electricity grid;
3. Water electrolysis of electricity from RE-CEF sources "boosted" in electrolysis efficiency by available high-temperature, low-cost heat, as may be made available by nuclear fission generation stations, extant and future;
4. Direct photochemical water splitting, as in:
    a. Artificial photosynthesis: the first step thereof;
    b. Biological processes: algae, for example.
5. Gasification of biomass with CCS or CCU (Carbon Capture and Sequestration or Utilization)

Water feedstock for the above must be explicitly considered. Water electrolysis requires 9 kg of H2O per kg H2.

Best wishes for the 30 Jan 17 workshop, which should also inform the February 07, 2017 Pre-Application Workshop - GFO-16-901- Research and Demonstration to Decarbonize Transportation Fuels
http://www.energy.ca.gov/calendar/index.php?com=detail&eID=2853

Thank you for your consideration.

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http://www.energy.ca.gov/altfuels/2017-HYD-01/

https://efiling.energy.ca.gov/Ecomment/Ecomment.aspx?docketnumber=17-HYD-01

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The NREL R&D team agrees, a 1 MWe input electrolysis plant, capable of including all 13 turbines in AASI's windplant, with "close-coupling" of stack(s) to the windplant DC bus, without grid connection, would be an important R&D project.

Our quotations in 2015, from Hydrogenics and ProtonOnsite and ITM Power for such a custom-designed 1 MWe input electrolysis plant were ~ $ 1.5 million, including custom engineering to:

a. Eliminate the transformer-rectifier subsystem
b. Integrate controls with the SEIG and wind turbine controls into a single SCADA for the complete wind-to-H2 system, without grid connection.

As presented in our budget for the 2015 ARPA-E "OPEN" FOA Full Application, this AASI full-windplant project would require ~ $ 3 million of risk-sharing capital, ideally from federal or State of CA sources or from private enterprise. It had to include:

a. PV-battery backup power subsystem for wind-to-H2 system controls
b. New hardware components
c. Windplant repairs and upgrades
d. NREL Cooperative Research And Development Agreement (CRADA)

At ~ $ 6 - 10 / kg H2 plant gate delivery price, it would produce significant revenue, but not enough to cover debt service on a $ 3 million commercial loan. So, AASI continues to search for risk-sharing funding, for either:

- $ 300 K "proof-of-concept" minimum project, per our Small Business Voucher (SBV) application, using two used Proton OnSite H6m electrolysis plants and two or three of our Palm Springs turbines, or
- $ 3 million for the full-scale project with the custom-designed electrolysis plant.

On the same ~ 70 hectare site as the AASI windplant, in North Palm Springs, are five, GE 1.6 MW turbines owned by NextEra, a Florida Power and Light (FPL) subsidiary. They deliver to the SCE grid via a Power Purchase Agreement (PPA).

Perhaps NextEra would like to supply their turbines' output, or a fraction thereof, to an electrolysis plant, for multi-MW scaleup.

Wintec Energy Ltd. and D&E Land Company, who own the site, have their office in Palm Springs. They have been in the wind industry for 25 years, and know it well.

Videos of AASI's operating Palm Springs windplant are at:

- https://vimeo.com/160472532
- https://vimeo.com/86851009

Bill Leighty's conference presentation on this project:

- https://vimeo.com/126045160

Bill Leighty's presentation at Windpower 2015:

- https://vimeo.com/128484940

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Bill Leighty's presentation at the 21st World Hydrogen Energy Conference , Zaragoza, ES, June 2016:

- https://vimeo.com/172485189

Bill Leighty's presentation at the National Hydrogen Association annual meeting, May 2010, advocating a Hydrogen pipeline R&D&D pilot plant:

- " Begin Now: Design and Build a Renewables-Source Hydrogen Transmission Pipeline Pilot Plant " https://www.youtube.com/watch?v=fND9S7Llvqk&list=UU_fKB5GeOPhfrEaNhjwZgvQ

Bill Leighty's co-authored research papers, posters, and presentations on alternatives to electricity systems for RE-CEF energy, pro bono for The Leighty Foundation: www.leightyfoundation.org/earth.php

Update on the Southern Trails Pipeline Oil Conversion Project http://www.questarpipeline.com/indexSTP.php

Questar Pipeline announced it has terminated plans to recommission the western segment of the Southern Trails Pipeline as a crude-oil transport pipeline and commenced a process to divest the asset. Questar's objective is to sell Southern Trails by the end of 2016.

For questions about the conversion project, please contact Steve Chapman, Coordinator Special Communication Projects, Questar Corporation, at 801-324-5548.

Questar Southern Trails pipeline:

Morris Jackson [Morris.Jackson@questar.com] Business: (801) 324-2472 Mobile: (801) 808-8587

Steve Chapman, Coordinator Special Communication Projects, Questar Corporation, at 801-324-5548.

CEC: Pre-Application Workshop, GFO-16-901 : February 7, 2017 , 10:00 a.m.

http://www.energy.ca.gov/contracts/other_research.html#GFO-16-901

California Energy Commission, Imbrecht Hearing Room (formerly Hearing Room B), 1516 9th Street, Sacramento, CA 95814

To join the WebEx meeting, go to https://energy.webex.com and enter the meeting number below:
Meeting Number: 929 796 247 , Meeting Password: meeting@10

Deadline for Written Questions: February 9, 2017 by 5:00pm
Deadline to Submit Application: April 3, 2017 by 5:00pm
APP DOCS: http://www.energy.ca.gov/contracts/GFO-16-901/