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## RD&D needed for Hydrogen and Ammonia fuel production, transmission, and delivery from dedicated "distributed" wind and solar sources via underground pipelines

*Additional submitted attachment is included below.*

2 Nov 16

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Comment on Docket #: 16-ALT-02 Project Title: 2017-2018 Investment Plan Update for the Alternative and Renewable Fuel and Vehicle Technology Program (ARFVTP)

ARFVTP Colleagues,

This is a followup to my phoned comments near the end of your 27 Oct meeting, in which I suggested that the Investment Plan (IP):

1. Should reallocate ~ $ 10 million to support R&D and Demonstration (RD&D) projects by which to share the technical risks of introducing new technologies for lower-cost production, transmission, storage, and integration of Renewable Energy (RE) source, CO2-Emissions-Free (RE-CEF) Hydrogen ($H_2$) and Anhydrous Ammonia ($NH_3$) carbon-free fuels, for transportation and for stationary CHP, harvested from "distributed" (without electricity grid connection) wind and solar energy conversion equipment which is:

- Dedicated to H2 and NH3 fuel production, with no connection to, nor energy delivery to, the electricity Grid;
- At large, "centralized" plants, which may be far from available electricity transmission;
- At smaller, "distributed" plants, which may or may not be connected, as Distributed Energy Resources (DER), to the distribution realm of the Grid,
- Requiring a new, dedicated, underground, high-purity, pipeline system(s) for $H_2$ and / or $NH_3$ fuels, for gathering, transmission, storage, and distribution, as examined in the Page 1 poster, based on published research by Institute of Transportation Studies (ITS), UC Davis: http://leightyfoundation.org/w/wp-content/uploads/RFI-Comments-POSTERS-5-2Nov16.pdf

I cannot recommend from what ARFVTP budget allocations in the extant Update this ~ $ 10 million should be reallocated. Perhaps Table 13, Page 41, "Biofuel" should be the source.

2. Should embrace the vision of the USDOE's Request for Information (RFI) DE-FOA-0001655:
H2@SCALE (HYDROGEN AT SCALE): DETERMINING RESEARCH, DEVELOPMENT, AND DEMONSTRATION (RD&D) NECESSARY FOR CLEAN HYDROGEN PRODUCTION TO ENABLE MULTISECTORAL DEEP DECARBONIZATION

Webinar: http://www.energy.gov/eere/fuelcells/downloads/h2-scale-potential-opportunity-webinar
RFI: https://eere-exchange.energy.gov/default.aspx#FoaId962c3a0a-3bd1-4331-af59-678214bb27d5

If California (CA) succeeds in both its RPS electricity sector goal and its "80 in 50" transportation sector goal, it will need as much as 7 million tons per year of high-purity, RE-CEF $H_2$ and / or $NH_3$ transportation fuel by year 2050, assuming that Hydrogen-fueled FCEV's are far more prevalent than BEV's, for LDV, bus, and goods movement, by 2050. CA probably cannot supply this total RPS plus transport energy via electricity systems alone, or perhaps even primarily, nor should it try. This will require RE-CEF $H_2$ and / or $NH_3$ "at scale".

See my responses to USDOE's Request for Information (RFI) DE-FOA-0001655 :

> http://leightyfoundation.org/w/wp-content/uploads/RFI-H2@SCALE-Comments-DOE-0001655-2Nov16.pdf
> http://leightyfoundation.org/w/wp-content/uploads/RFI-Comments-POSTERS-5-2Nov16.pdf

Harvesting this quantity of Hydrogen transportation fuel, for CA in 2050, will require a very large land area, within CA and probably beyond, most of which is not served by electricity transmission of adequate capacity, or by none at all. The State of CA and the diverse energy companies that serve it must decide how to invest in new electricity infrastructure vis-a-vis new $H_2$ and / or $NH_3$ fuels infrastructures systems. The IP should therefore invest in RD&D projects designed to inform these investment decisions.

3. Should recognize Anhydrous Ammonia ($NH_3$) carbon-free fuel as "the other Hydrogen", as perhaps a more technically- and economically-attractive Hydrogen carrier, storage medium, and fuel than $H_2$ .
USDOE has explicitly included $NH_3$ in its current ARPA-E "REFUEL" FOA. The ICE, CT, and Direct Ammonia Fuel Cell (DAFC) operate well on $NH_3$ , which can also be produced from "distributed" RE-CEF sources, without Grid connection, but requiring repurposing of some extant pipelines plus some new pipeline infrastructure.
I have attended ten of the thirteen annual conferences of the NH3 Fuel Association; helpful presentations at:
> https://nh3fuelassociation.org/
> https://nh3fuelassociation.org/events-conferences/

The three considerations, above, are all important for "Hydrogen Refueling Infrastructure", IP Page 50, because pipeline delivery of $H_2$ and / or $NH_3$ fuels, at large scale, would be higher capacity and less costly than truck delivery and would eliminate the dispensing stations' costly capital components required to produce and store fuel(s) on-site. $H_2$ could be economically recovered from liquid $NH_3$ fuel, for FCEV's, on demand.

However, equipment and systems optimized for wind-to-Hydrogen and PV-to-Hydrogen are not available, requiring RD&D projects such as the proposed "distributed" wind-to-Hydrogen conversion of the small Palm Springs windplant owned by our company, Alaska Applied Sciences, Inc. (AASI) It could produce 11,000 to 16,000 kg of fuel-cell-grade Hydrogen fuel per year, but requires R&D, ideally by NREL, for this test bed to develop the power electronics and controls enabling lower-cost production, transmission, and storage of $H_2$ and / or $NH_3$ fuels without connection to the SCE Grid. AASI has partnered with NREL, Sunline Transit, the major electrolyzer companies, and others on an unsuccessful Full Application to the 2015 ARPA-E "OPEN" FOA for this conversion project. In October, AASI partnered with two national labs, a university, and two other companies in an ARPA-E "REFUEL" Full Application. AASI has also applied for Small Business Voucher (sbv.org) funding for this project, via NREL. AASI would like to apply for risk-sharing funding from a State of CA source such as ARFVTP.

We therefore suggest that you reallocate a significant part of the IP budget for RD&D projects preparing for large-scale demand for RE-CEF $H_2$ and / or $NH_3$ fuels by year 2050, for transport and fixed CHP, motivated by:

- USDOE "H2@SCALE" RFI;
- USDOE ARPA-E "REFUEL" FOA
- ITS-STEPS, UC Davis, paper on their imagined "The Hydrogen Transition" scenario: http://steps.ucdavis.edu/files/08-13-2014-08-13-2014-NextSTEPS-White-Paper-Hydrogen-Transition-7.29.2014.pdf

I have co-authored and presented research papers on alternatives to electricity systems for RE-CEF energy, *pro bono* for The Leighty Foundation, for fifteen years, most recently at the World Hydrogen Energy Conference, Zaragoza, Spain:

- http://leightyfoundation.org/w/wp-content/uploads/WHEC-2016-Zaragoza-C.pdf.pdf
- https://vimeo.com/172485189

AASI has delivered MWh from its Palm Springs windplant to the SCE Grid for over twenty years, while I have done most of the turbine and windplant maintenance.

Thank you for your consideration.

Bill Leighty