September 24, 2009

U.S. Department of Energy
ARPA-E Program/*Request for Information*
1000 Independence Ave., SW
Washington, DC 20510

Greetings:

On behalf of the members of the National Hydrogen Association (NHA), we would like to suggest some ideas for consideration as DOE designs and builds its new ARPA-E program. We thank you for creating an opportunity to provide carefully considered ideas. Consistent with several provisions of the *Energy Policy Act of 2005* (EPAct 05), *Energy Independence and Security Act of 2007*, and the *American Recovery and Reinvestment Act of 2009* (ARRA 09), DOE has a broad range of authorities to assist the commercial deployment of advanced energy technologies. As explained in your RFI of August 31, 2009, ARPA-E's mission is to identify, nourish and quicken the pace of deployment of critical and innovative components of domestic energy supply and demand systems.

Recollecting some of the legislative history of this in preparation for the eventual authorizing law (*America COMPETES Act of 2007)* is instructive. Recall that Sec. 1821 of EPAct provides for a "Study of Best Practices for Energy Research and Development Programs", to be performed by the National Academy of Public Administration—to evaluate management methods, including an ARPA program for DOE. Energy and Natural Resources staff seriously considered designing a pilot program along with EERE's Hydrogen Fuel Cell and Infrastructure Technologies Program, but settled on the report in Section 1821—which was not actually done. Eventually, momentum built within the Senate and House for simply authorizing ARPA-E in 2007.

ARPA-E Concept—Advanced Renewable Transportation Fuels, Category 2
Hydrogen and fuel cells have been premium public investments in a very promising family of advanced technologies that will dramatically reduce emissions, help solve our dependence on imported oil, and evolve substantial new industries. They are a critical component to a balanced portfolio of zero emissions, transportation and distributed generation solutions. The Congress has reaffirmed this strategic approach in RD&D and market transformation in their deliberations on the FY 10 DOE budget.

DOE has substantial authority for RD&D and market transformation for hydrogen and fuel cells. Over the last ten years, their innovative programs have advanced the state of technology and brought down costs. DOE's industrial partners have made key investments, helping to move several products toward market readiness. Yet there remain areas that need some real innovation, and the ARPA-E program could make a great contribution. Hydrogen and fuel cells represent a family of advanced technologies that must be deployed in concert to yield the greatest benefits, and the ARPA-E mission is perfectly consistent with the needs of

this fuel cycle. Further, the Department of Defense, under its history of DARPA advanced technology competitions, in 2008 conducted a "Wearable Power" contest, won by a H2FC device.

The ultimate configuration of a hydrogen and fuel cell vehicle (H2FCV) fuel cycle would include a completely renewable source of H2, marketed in widespread refueling stations to a vehicle fleet or cluster hub of zero emission hybrid, electric drive fuel cell vehicles and stationary power plants. Renewable H2 could also be utilized in internal combustion engines, or blended with biofuels in advanced plugin hybrids or in heavier diesel equipment like buses, trucks, construction or farm equipment. Since H2 has been a common industrial chemical used mainly in refining gasoline and making fertilizers, making, storing and transporting it in special circumstances for these markets is well understood. The economics of producing it from natural gas are also well known, yielding gallon of gas equivalent (GGE), ex tax plant gate costs ranging from an estimated $2.50/kg to $7/kg.

The challenge Although an efficient, cheap and well-understood, volume production method of making gaseous H2, steam reforming of natural gas still creates carbon emissions at some stage of production—around ½ of that of the conventional petroleum refining process for gasoline, matched with a Zero Emission Vehicle (ZEV) at its end use. The U.S needs a reliable, efficient, carbon-free method of making and delivering H2 in large quantities, consistent with California's zero emission vehicle (ZEV) and low carbon fuel standards.

ARPA–E should invest in solving this fundamental Category 2 systems problem in the following way:

- Design and issue a competitive FOA in early FY 10, with advice from EERE and DOD, that buys this renewable H2 component of a fuel cycle for a specific application in a vehicle fleet owned by either federal or state governments, and requires completely unconventional methods of production—and **covers the RD&D cycle from laboratory to a scalable, economically feasible, deliverable fuel**
- Teams of industry, national laboratories, universities and startup companies should be favored—with cost shares determined without prejudice under Sec. 988 of EPAct 05, where the Secretary is authorized to negotiate nonfederal cost shares below 50% for demonstration and commercial projects
- The fuel/life/well-wheels cycle must be as close to possible carbon-free, greatly exceed the technical, cost and efficiency evaluation criteria now used by EERE and utilize only domestic U.S resources, while meeting purity, codes and standards and pressure requirements, and capable of making renewable H2 in volume at a **target cost of $1.50-$2.00/GGE, vs. present estimates of $10-$25/GGE**
- Such a project could be funded over a two-three year period with a combination of appropriated funds, participation from EERE and DOD—the project should be cost-effective at a total of $35-45 million
- In order to save costs and enhance the cumulative value of the five years of public and private investments of the EERE Technology Validation program—as a learning demonstration—integrate fuel production into its vehicles and infrastructure, as it has established very effective systems evaluation and data analysis protocols, consistent with the intent of EPAct 05 Sec. 808 (b) Systems Demonstrations

- In parallel, fund at $5-10 million a competition under H-Prize from EISA 07 Sec. 654, for systems and prototypes—optimizing momentum and speed of this innovative ARPA-E renewable H2 initiative
- Potential areas of interest include, but are not limited to: synthetic biological approaches to creating novel, highly productive fermentative or photosynthetic organisms for the production of low cost, high energy density, infrastructure compatible liquid and gaseous fuels; and thermochemical and catalytic approaches for direct conversion of biomass to this type of fuels production—that may also consume combustion CO2 in the biological production process
- Further technical breakthroughs for high pressure solar electrolysis could include efficient sizing of compressors for gaseous H2 at higher pressures that utilize separation membranes which reduce the diffusion of H2 and O2 across the membranes to acceptably lower levels without significantly reducing process efficiency; and electrical isolation tubing that can operate at elevated pressure without unacceptable diffusion of H2 into the machine environment
- Upon project completion, provide further review for Congress that recommends optimal tax incentive and loan or grant approaches to ready renewable H2 for markets.

Other important technical challenges for ARPA-E are suggested by the confluence of legislation, Congressional hearings and DOE RD&D projects that could readily employ what has been learned by these programs, leading to producing cheap, efficient H2 in commercial quantities and revealing critical economic feasibility parameters:

- Coal/CCS synthetic gas mixtures with H2 hythane from IGCC plants
- H2 as a storage medium to dampen and firm solar/wind electricity variability and grid congestion
- IGCC cofiring with biomass
- H2FC combined heat and power in federal LEED buildings
- High pressure, elevated temperature electrolysis of seawater or waste/gray water in high demand, low fresh water availability areas—leading to net additions of fresh water from H2FCVs to arid hydrologic cycles—Los Angeles, Phoenix, Mideast allies

Our industry and research community are always available for further discussion of these concepts. We see a fully-developed ARPA-E program within DOE as a formidable practical mechanism for achieving rapid deployment of concepts moving from lab to street. Ultimately, the market is the prize, and as the RD&D programs succeed they need to transform themselves to embrace commercial goals. ARPA-E can build from DOE's traditional programs, strategically selecting those technologies and advancements that show great promise and need rapid maturing. For further questions or comments, please contact us at (202) 261-1307, or hinklej@hydrogenassociation.org .

Sincerely,

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