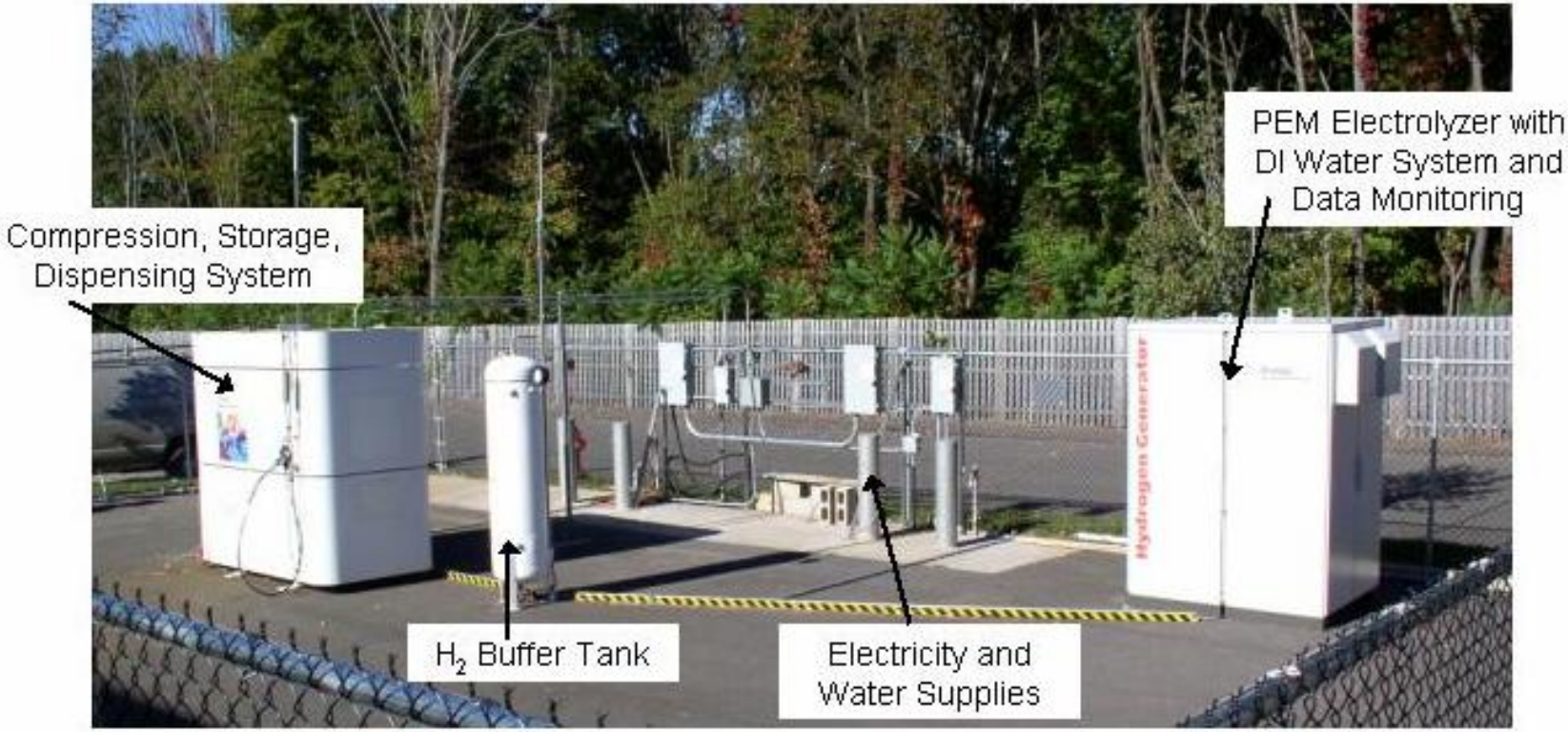
Hydrogen Fueling Station at Proton Energy – Wallingford, CT



NASA Hydrogen Power & Fueling Stations - How it can work

Opportunity

A hydrogen fueling infrastructure is being implemented across the U.S. by the DOE and auto companies

Information about hydrogen production, storage, and safety is being sought by government agencies, private industry, and auto companies

The Bush Hydrogen Fuel Initiative calls for $350 million in funding for new hydrogen research projects.

An initial investment of $1.1M by NASA may (in under one year):

- Position all Centers within the growing hydrogen infrastructure,
- Bring additional funding for cutting-edge projects
- Provide immeasurable public visibility and satisfaction

NASA Hydrogen Power "Working Group":

Headquarters (HQ):
Paul Robert, Willie Gookin, Rich Wickman

Kennedy Space Center (KSC):
H.T. Everett, Eric Dirschka, David Bartine

White Sands Test Facility (WSTF):
Harold Beeson, Stephen Woods, Larry Starritt

Stennis Space Center (SSC):
Eric Ross

Marshall Space Flight Center (MSFC):
Cedreck Davis

Johnson Space Center (JSC):
Mike Ewert

Langley Research Center (LaRC):
Bobby Charles
Grady McCoy

Ames Research Center (ARC):
Mark Lacy

Goddard Space Flight Center (GSFC):
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Suggested direction for NASA

(Coordinate with the DOE on all below)

Hydrogen power production at each Center

- Use Centers' region-unique **renewable power** to generate

(Each Center demonstrates hydrogen production in its own way)
(Use Center-related projects to borrow/integrate tech ideas)

Hydrogen fueling, using hydrogen power production

- Demo sites for car companies in close proximity to existing infrastructure
- Secure NASA sites for U.S. hydrogen infrastructure

NASA is uniquely positioned

NASA dispensing units at 2+ locations will attract the car companies.

KSC and GRC are close to sited fueling locations: Orlando and Florida's east coast; Detroit and Toledo.

NASA Centers across the U.S. – secured – various climates for testing cars. R&D possibilities unique to each Center.

H.T. Everett (KSC) and Harold Beeson (WSTF) are nationally-known hydrogen experts. Plus, NASA's existing experienced hydrogen culture.

SSC and MFSC have resident expertise in hydrogen systems and existing internal hydrogen infrastructure. They are also experts in testing and development.

Paul Prokopius (GRC) has connections with car companies and the DOE, and is a member of the CA Fuel Cell Partnership - Vehicles and Fuels Working Group.

NASA is part of the White House's Interagency Task Force, working to convert the government to a hydrogen economy.

Additional avenues
- Attractive to car companies, DOE

Military installations throughout the U.S.

- Getting off the grid – also a Homeland Security issue
- Working with NASA to become sustainable
- Will add to building / attracting hydrogen infrastructure

Local community collaboration (plus outreach/PR benefits)

- e.g., Earth Day Coalition has worked with the airport near GRC re: hydrogen fueling stations – the airport is interested
- Green Energy Ohio – Alternative power organization with NASA ties
- Great Lakes Science Center wants regenerative fuel cell hydrogen generation
- May use wind power on Lake Erie (Fletcher Miller at GRC – wind project)

Congresswoman Marcy Kaptur

- Wants “anything hydrogen” for GRC’s Plum Brook facility
- Interested: Bowling Green municipality, University of Toledo

NASA benefits

when NASA creates hydrogen fueling stations

Positions NASA Centers as hubs within the new hydrogen infrastructure

Displays NASA work in practice vs R&D (as NASA does with shuttle launches and fuel cells)

“Makes it real” regarding hydrogen power for the American public – “It is happening.”

Provides a visible return for their tax dollar to the American public

Displays a visible NASA commitment to sustainability

Reduces fueling costs for NASA, especially if produced with renewable energy

NASA benefits
when NASA produces hydrogen

Alternative power to reduce U.S. dependence on foreign oil

Returning NASA to the cutting edge of alternative fuel technology

Creating technology transferable to the space mission; evaluating storage/fueling techniques prior to lunar/Mars applications

Increasing tech transfer and networking with local communities

Creating an outreach tool for public support of hydrogen power

Reducing hazardous emissions and greenhouse gases = Stewardship

Providing data re: hydrogen production, storage, dispensing, and safety

Reducing NASA's utility costs when hydrogen is produced with renewable energy

NASA benefits

when NASA creates hydrogen fueling stations

Fueling stations will attract the California Fuel Cell Partnership, which has immense value:

– Big players / valuable networking

– They help all members with:

- Permitting
- Standardization
- Hydrogen purity
- Much more

Government agencies had been working to join.
Currently in: DOE, NIST, DOT, DOD

NASA benefits - COSTS

By generating fuel with renewable energy,
NASA can save the cost of high-priced petroleum
– both for fuel and for electricity to generate hydrogen

- 45 kWh of electricity = 1 kg of hydrogen
  (= roughly 1 gallon of gas energy equivalent)

- 45 kWh X $.10 per kWh = $4.50 per gallon

- A fuel cell car engine is 3X more efficient than a gas engine
  (about 75 mpg) $4.50 / 3 = $1.50 per gallon

- $1.50 (est.) per gallon is the cost of generation <u>without renewable energy</u>
  (For example, using a photovoltaic field and a working electrolyzer at GRC, the cost would be much lower.)

NASA's progress-to-date toward hydrogen cars:

- Over the past 2 years, Dr. Bartine (Chief Technologist at KSC) had obtained Ford and Honda vehicles on-site for a short time.

  Dialogues continue about lease and demo vehicles.

- Recently, GRC contacted Chrysler, GM, and Ford.
  All responses were the same:

  If NASA establishes hydrogen stations within the cars' 160-mile range, they would welcome the opportunity to use the NASA stations.

NASA's hydrogen generation capabilities:

- KSC purchases bulk liquid hydrogen - most of it is made from natural gas.
  - KSC could use vented hydrogen from liquid hydrogen storage tanks until a better source is available, although not in full-scale production.

- SSC, MSFC, and WSTF also have vented hydrogen.
  - SSC's hydrogen is a waste product of a chemical plant in Alabama
    - This would be considered "green" (recycled hydrogen)
    - This offers possibilities for commercial replication in SSC's region
  - WSTF also has the potential for wind turbines to use as renewable energy when generating hydrogen.

- ARC can use CNG to make hydrogen.

- GRC could easily begin hydrogen production. GRC has an existing PV field and electrolyzer.
  - With $20K-$100K (more likely $20K), GRC could renewably generate hydrogen within a month or two.

How it can work – Steps toward hydrogen stations:

Phase I – (6-8 months)

1. Meet with the DOE and car companies – Awareness of NASA's direction
   - NASA HQ (including Chief Transportation Officer), KSC, GRC representatives
   - Awareness of NASA's funding, expertise, and locations / plus military locations
   - Ask the DOE to identify additional areas of interest for HPWG to accomplish

Concurrently implement #2-4:

2. Bring up electrolyzer at GRC and hook up to PV field ($20K-$100K)
   - Demonstrates renewable hydrogen generation to car companies, DOE

3. Initially, at KSC and GRC, install dispensers ($35K-$45K each)
   - KSC could operate fuel cell buses on hydrogen (convert buses) – high visibility

4. Set up a presentation among NASA's HPWG, the DOE, DOD, NIST, and car companies – Infrastructure suggestions
   - Map out – all hydrogen producers, potential stations, suggested infrastructure
   - HPWG provides ideas to address the DOE's areas of interest from the initial meeting

How it can work – Steps toward hydrogen stations:

5. Work toward vehicle leasing agreements. (Est. monthly rate $1K-$10K)
   - NASA will provide test data and lessons learned, to lower monthly rates

   - Additional costs of a fleet include: ~$250/600K for hardware, permits, etc. and ~$150/389K for manpower (10K/40K per year maintenance).

6. GRC and other Centers may be able to help WTSF+ develop wind power
   - Even if not currently suited for hydrogen cars, renewable power can be used for projects, to feed into the grid, or for general hydrogen production later

Phase II

1. Bring up 2 or 3 more Centers per year:
   SSC, MSFC, WSTF, ARC, JSC, LaRC, GSFC, etc.
   - Within the next year, see if (or plan in our presentation that) infrastructure moves closer to these Centers. (Or if car range is better)
   - Use vented hydrogen until a renewable source is developed
   - At WTSF, hydrogen power can be interfaced with the missile center

2. Revisit plans for remaining Centers

Other hydrogen possibilities

Hydrogen generation for any hydrogen-power project:

- Individual NASA R&D projects
- Base power
- Backup power (uninterruptible power supplies)
- Utility carts
- Lawnmowers
- Anything with an internal combustion engine could be modified

Can run on hydrogen directly or via a fuel cell

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