

Ohio's First Electrolysis-Based Hydrogen Fueling Station

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Fuel for Thought
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Project Background

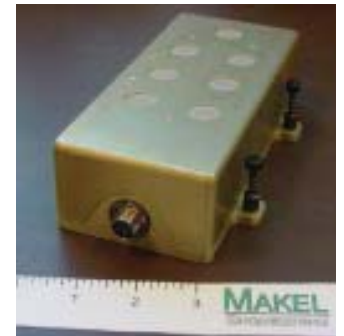
- Efforts began in January 2009 with grant awarded to Ohio Aerospace Institute by the Cleveland Foundation to design a hydrogen fueling station
- OAI purchased hydrogen fueling station equipment from Burlington, VT
 - Equipment was decommissioned and shipped to Cleveland for refurbishing and installation
- Planning efforts began in 2011 to install a fueling station at Greater Cleveland RTA Hayden bus garage

Project Goals

- Install an operational hydrogen fueling station that demonstrates electrolysis as a safe and reliable means of H₂ generation
- Demonstrate the terrestrial benefits of NASA-developed space technologies
- Demonstrate the commercial reality of using H₂ in a fuel cell-powered bus
- Support clean energy efforts

Integration of NASA Space Technology

- NASA has developed fuel cell technology for space applications since Gemini and Apollo
 - GRC currently focused on improving reliability and efficiency of fuel cells for space and terrestrial applications
 - GRC currently develops advanced Non-Flow-Through PEM fuel cells and Solid Oxide Fuel Cells, and advanced electrolyzers
- Advanced hydrogen sensors developed & commercialized through SBIR and STTR programs with GRC, Makel Engineering and CWRU



Why Hydrogen and Fuel Cells?

- H₂ can be used as fuel to power fuel cell buses, passenger vehicles and stationary power systems
- H₂/O₂ or H₂/air fuel cells eliminate harmful emissions – they produce only water, electricity and heat
- Replacing diesel and gasoline-powered vehicles would reduce dependence on fossil fuels

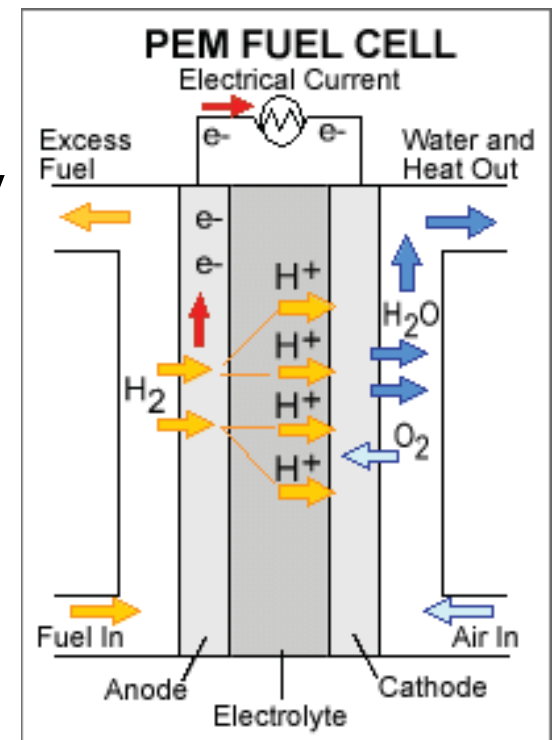
But how do we get the hydrogen we need?

Why Electrolysis?

- Electrolysis is a safe, clean method of producing H_2 directly from water without harmful emissions
- Allows for on-site H_2 generation, as opposed to delivered H_2 , and eliminates the need to store large quantities of H_2
- Generates quality H_2 at purity levels acceptable for use in fuel cell-powered vehicles
- Compatible with renewable energy sources

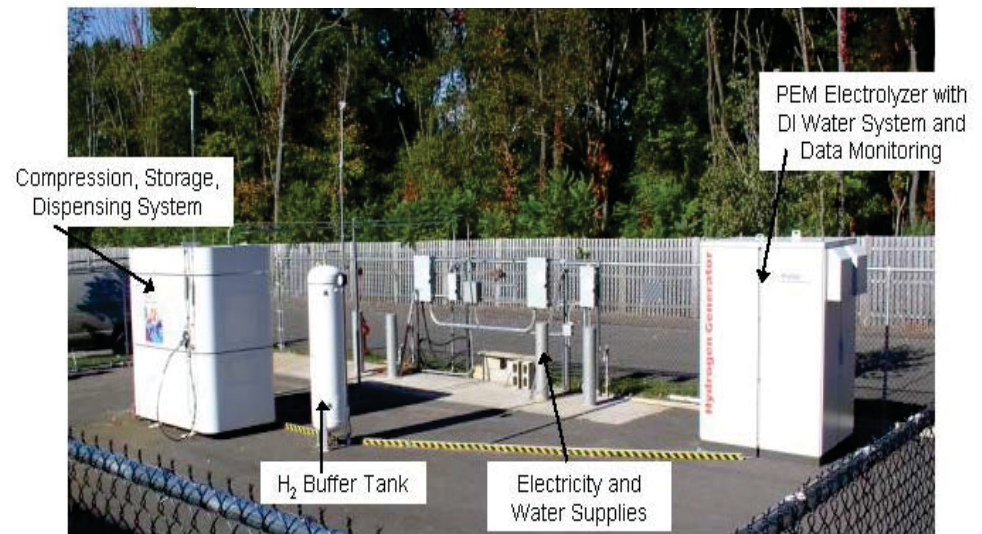
How Does a Fuel Cell Work?

- A Proton Exchange Membrane (PEM) fuel cell converts the chemical energy of reacting hydrogen and oxygen gases to electrical energy, with only heat and water as byproducts
- A fuel cell will run continuously as long as fuel is available



Fueling Station Equipment

- Originally installed in 2006 in Burlington, VT by DOE and BP
- Principal Components
 - PEM Electrolyzer from NASA KSC
 - Compressor
 - Storage tank array
 - Hydrogen dispenser



PEM Electrolyzer from Proton On-Site

- NASA KSC provided a newer electrolyzer from de-commissioned station in CA
- Electrolyzer uses city water and has internal de-ionization system to provide DI water to cell stacks
- Generates 0.99999 purity H₂
- Produces 12 kg/day (bus capacity 50kg)
 - Multiple units can be hooked up in parallel to increase output

Storage & Dispensing

- Generated H₂ is compressed to 6500 psi
- H₂ stored in 12-60 kg capacity modular storage tank array
- Stand-alone dispenser unit requires PIN input and dispenses H₂ fuel directly into tank on fuel cell bus
- H₂ production and compression is automatic, driven by the storage tank pressure

Installation Site

- GCRTA's Hayden bus facility, E. Cleveland
 - Previously operated CNG buses
 - Infrastructure in place to house and maintain a fuel cell vehicle
- Located adjacent to Louis Stokes rapid station at Windermere, on the GCRTA's red line





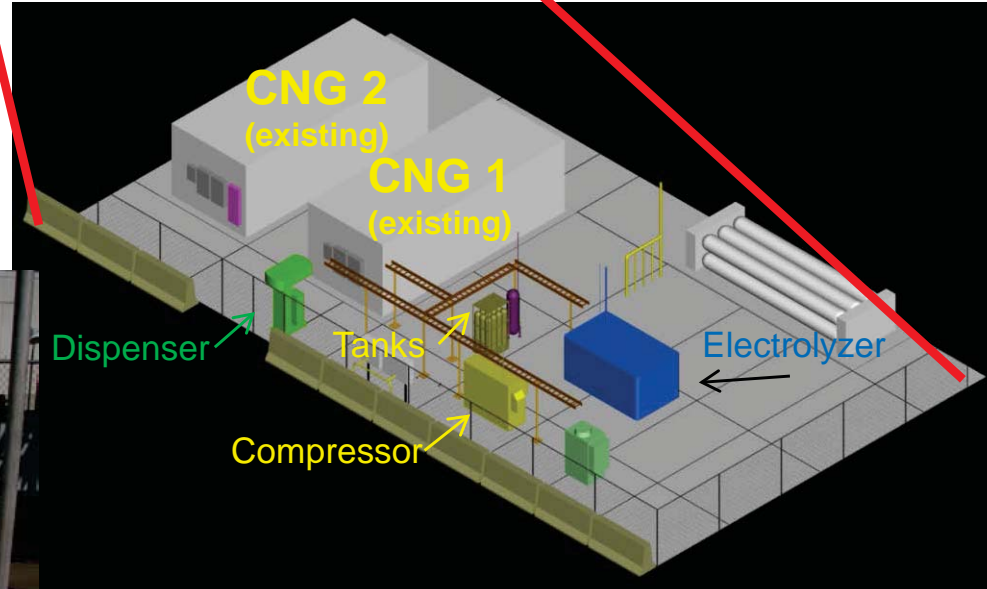
Tanks



Dispenser



Electrolyzer



Administration



Hydrogen Dispenser



Storage Tank Array and Compressor



Hydrogen Fueling
Station
at GCRTA Hayden
Bus Garage
in East Cleveland, OH

Fuel Cell Bus Demonstration

- GCRTA leased a VanHool fuel cell bus from UTC Power (ClearEdge) through March 2013
 - Bus demonstrated the safe, efficient use of hydrogen as a fuel; generated data to determine the benefits of replacing a diesel bus with a fuel cell bus utilizing electrolysis-generated H₂
- Bus ran in revenue service roughly 60-80 miles/operating day, mostly on the #1 St. Clair route and other routes out of the Hayden garage
- GCRTA provided operational feedback to UTC/ClearEdge for Nutmeg Project under the FTA
- Bus was refueled as needed from H₂ station



C-2012-5105



C-2012-5105



C-2012-5114
Photo by Michelle Murphy

National Aeronautics and Space Administration
Glenn Research Center at Lewis Field

- ✓ H₂ powered PEM fuel cells eliminate harmful emissions
- ✓ Only water and heat as byproducts
- ✓ Virtually silent bus operation due to replacement of diesel engine with fuel cell
- ✓ Reduction in moving parts means higher efficiency – less energy is lost as waste heat
- ✓ Helps to reduce America's dependence on fossil fuels when H₂ fuel is generated via electrolysis combined with renewable energy sources



Project Challenges

- Public feedback to the project was a mixture of positive/negative prior to installation
 - Public meetings were held to educate the public and discuss safety concerns
- Permitting process and pushback from city offices and officials
- Technical issues experienced with equipment and fuel cell bus; unfamiliarity with fuel cell bus operations and reliance on external support

Project Successes

- Fueling Station successfully installed and operational in October 2012
 - Demonstrated the safe, efficient production of hydrogen via electrolysis and its use in a fuel cell to power a bus
- GCRTA operated fuel cell bus for approx. 300 miles in training and revenue service
- Positive feedback from GCRTA bus operators and mechanics
- Positive rider feedback and media coverage

Current Status

- GCRTA's fuel cell bus lease expired and ClearEdge no longer supported mobile fuel cell applications – bus went to Flint, MI
- Fueling station equipment was shipping to NASA Kennedy Space Center for installation at Cape Canaveral

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 - NASA Kennedy Space Center

Thank you for your attention

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