Installation of Ohio’s First Electrolysis-Based Hydrogen Fueling Station

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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

• Efforts began in 2011 to plan for and install 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 $\text{H}_2$ generation
• Demonstrate the terrestrial benefits of NASA-developed space technologies
• Demonstrate the commercial reality of using $\text{H}_2$ 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
  o GRC currently focused on improving reliability and efficiency of fuel cells for space and terrestrial applications
  o GRC currently develops advanced Non-Flow-Through PEM fuel cells and Solid Oxide Fuel Cells

• Advanced hydrogen sensors developed & commercialized through SBIR and STTR programs with GRC, Makel Engineering and CWRU
Why Hydrogen and Fuel Cells?

• $\text{H}_2$ can be used as fuel to power fuel cell buses, passenger vehicles and stationary power systems

• $\text{H}_2/\text{O}_2$ or $\text{H}_2/\text{air}$ 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\textsubscript{2} directly from water without harmful emissions

• Allows for on-site H\textsubscript{2} generation, as opposed to delivered H\textsubscript{2}, and eliminates the need to store large quantities of H\textsubscript{2}

• Generates quality H\textsubscript{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

• KSC provided a newer electrolyzer from decommissioned station in CA
• Electrolyzer uses city water and has internal de-ionization system to provide DI water to cell stacks
• Generates 0.99999 purity $H_2$
• Produces 12 kg/day (bus capacity 50kg)
  ○ Multiple units can be hooked up in parallel
Storage & Dispensing

• Generated H$_2$ is compressed to 6500 psi
• H$_2$ stored in 12-60 kg capacity modular storage tank array
• Stand-alone dispenser unit requires PIN input and dispenses H$_2$ fuel directly into tank on fuel cell bus
• H$_2$ 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
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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 has demonstrated the safe, efficient use of hydrogen as a fuel; generate data to determine the benefits of replacing a diesel bus with a fuel cell bus utilizing electrolysis-generated H$_2$
- GCRTA ran the bus 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 H$_2$ station
✓ 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
  o 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
Future Possibilities

- Hydrogen production could be increased with the addition of a larger electrolyzer or a second unit and additional storage

- Additional H$_2$ could mean support for more fuel cell buses

- Station components and technologies can be upgraded to improve performance and increase output

- Amenable to renewable energy sources, producing a zero-emissions “well-to-wheels” fuel
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Thank you for your attention

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