VIII.A.7 Global Assessment of Hydrogen-Based Technologies*

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**Congressionally directed project*

Objectives

- Synthesize the state-of-practice for four potential hydrogen-based technologies.
- Compare performance, emissions, and fueling characteristics of the four technologies (instrumentation).
- Compare the four technologies in light of their potential role in a full-scale deployment.
- Assess hydrogen infrastructure needs to support deployment (at local and regional level).
- Offer education and training programs to increase the knowledge of the new technologies.
- Increase the awareness of the new technologies through various mechanisms; such as promotional materials for public media, a web-site, college programs, and a Hydrogen Fair in the southeast to demonstrate the various vehicle technologies, pumping stations, hydrogen storage, safety issues, etc.

Technical Barriers

This project addresses the following technical barriers from the Technology Validation section of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

- A. Vehicles
- C. Hydrogen Refueling Infrastructure
- E. Codes and Standards

Approach

- Evaluate candidate hydrogen-fueled vehicles for near and long-term use in the Southeastern U.S. in terms of their efficiency, performance, and emissions.
- Conduct rigorous performance and exhaust emissions testing of hydrogen technologies: 1. Internal combustion engine (ICE) vehicles fueled with hydrogen-compressed natural gas (CNG) fuel mixtures (15-50% hydrogen, 50-85% CNG); 2. ICE vehicles fueled with pure hydrogen; 3. Hydrogen powered fuel cell vehicles.

- Estimate resource requirements and costs for the infrastructure needed to deliver new fuels to advanced technology vehicles. Argonne National Laboratory's (ANL's) CHAIN model will be used to develop cost estimates and define additional hydrogen pathways.
- Evaluate the ability of the vehicle technologies described previously to contribute to improved air quality in the Southeast, with special attention given to the Birmingham metropolitan area.
- Determine the feasibility of using hydrogen fuel cell technologies for electric power generation and its potential impacts on air quality.
- Establish The Southeast Hydrogen Technology Consortium to examine ways to establish a hydrogen infrastructure in the southeast and enhance the infrastructure and application of the technology.

Accomplishments

Task 1 - Technology Evaluation of Hydrogen Light-Duty Vehicles

- Analyzed candidate hydrogen-fueled vehicles in terms of efficiency, performance, and emissions. Vehicles included: hydrogen/CNG- and hydrogen-fueled ICEs, hydrogen-fueled hybrid electric propulsion, and direct hydrogen fuel cells.
- Used PowerTrain System Analysis Toolkit (PSAT) model to evaluate:
  - Varying vehicle mass, frontal area, and drag coefficient in pre-selected steps
  - Operation over various driving cycles

Task 2 - Comparison of Performance and Emissions from Near-Term Hydrogen-Fueled Light-Duty Vehicles

- A Ford F-150 light-duty truck was tested at ANL using the dynamometer facility in their Transportation Technology R&D Center.
- The Ford F-150 was tested with mixtures of 0%, 15%, 30%, and 50% hydrogen in natural gas. Testing in the near future will involve 100% hydrogen.
- Emissions data were collected for carbon monoxide (CO), carbon dioxide (CO_2), total hydrocarbons (THC), nitrous oxides (NOx), and particulate matter. The equivalent miles per gallon fuel consumption was also monitored.
- An advanced hydrogen feed system was installed at the ANL test facility. The system was used to test a hydrogen powered Ford Explorer from the DOE FutureTruck competition. CO and CO_2 showed a decrease with an increase in hydrogen concentration.
- NOx emissions increased with an increase in hydrogen concentration.
- Hydrogen concentration did not have a significant effect on the THC emissions and the efficiency over the different driving cycles.
- Particulate matter emissions using hydrogen/CNG are negligible.

Task 3 - Hydrogen Infrastructure Assessment and Deployment Needs

- Assessed current transportation demand for fuel and available fueling infrastructure in the Birmingham region.
- Assessed future H_2 demand and potential supply infrastructure (pipelines, pressures, capacities).
- Have begun analysis of well-to-wheel emissions profiles for various hydrogen production and delivery scenarios.
- Compiled codes and standards for a prototype hydrogen fueling station in Birmingham, AL.

Task 4 - Comparison of Deployment Potential of Four Hydrogen-Fueled Light-Duty Vehicle Technologies

- Performed hypothetical case studies of alternative fuel vehicle (AFV) deployment in Atlanta, GA to examine range of AirCred (Air Quality Credits calculation software tool developed by ANL) outputs:

  - Case 1 – 100 of each type of AFV (CNG, LPG, electric, H_2, etc.) driven five days a week, 100 miles per day
  - Case 2 – 9999 of each type of AFV under same conditions
  - Emissions credits were compared to determine relative benefits of different AFV types
- Future intended efforts include:
  - Setting up AirCred for analyses in Birmingham, AL
  - Incorporating results of Task 3 into a GREET simulation for Birmingham and surrounding regions

Task 5 - Use of Fuel Cell Technology for Stationary Electric Power Generation

- In support of analysis and assessments, an extensive fuel cell system model (called GCTool) developed by ANL will be used.
- Using GCTool, the system will be modeled, to evaluate potential changes in components or trade-offs in operating parameters, thereby optimizing the fuel cell system for maximum performance.