GLOBAL ASSESSMENT OF HYDROGEN-BASED TECHNOLOGIES (TVP 13)

University of Alabama at Birmingham
and
Argonne National Laboratory

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Project ID # TVP13

Project Objectives

- Evaluate performance and emissions characteristics of hydrogen or hydrogen blend fueled vehicles.
- Assess impacts of hydrogen vehicle deployment on Southeast regional air quality.
- Evaluate the use of hydrogen fuel cells for stationary power generation.
- Assess infrastructure needs and costs for production and distribution of hydrogen in the Southeast.

Technical Targets and Barriers

- Technology Validation
  - Performance of hydrogen light duty vehicles (LDV's)
  - Performance and emissions profiles as functions of operating conditions and time
  - Hydrogen refueling infrastructure
  - Well-to-tank pathways and emissions
  - Life-cycle costs of distribution infrastructure

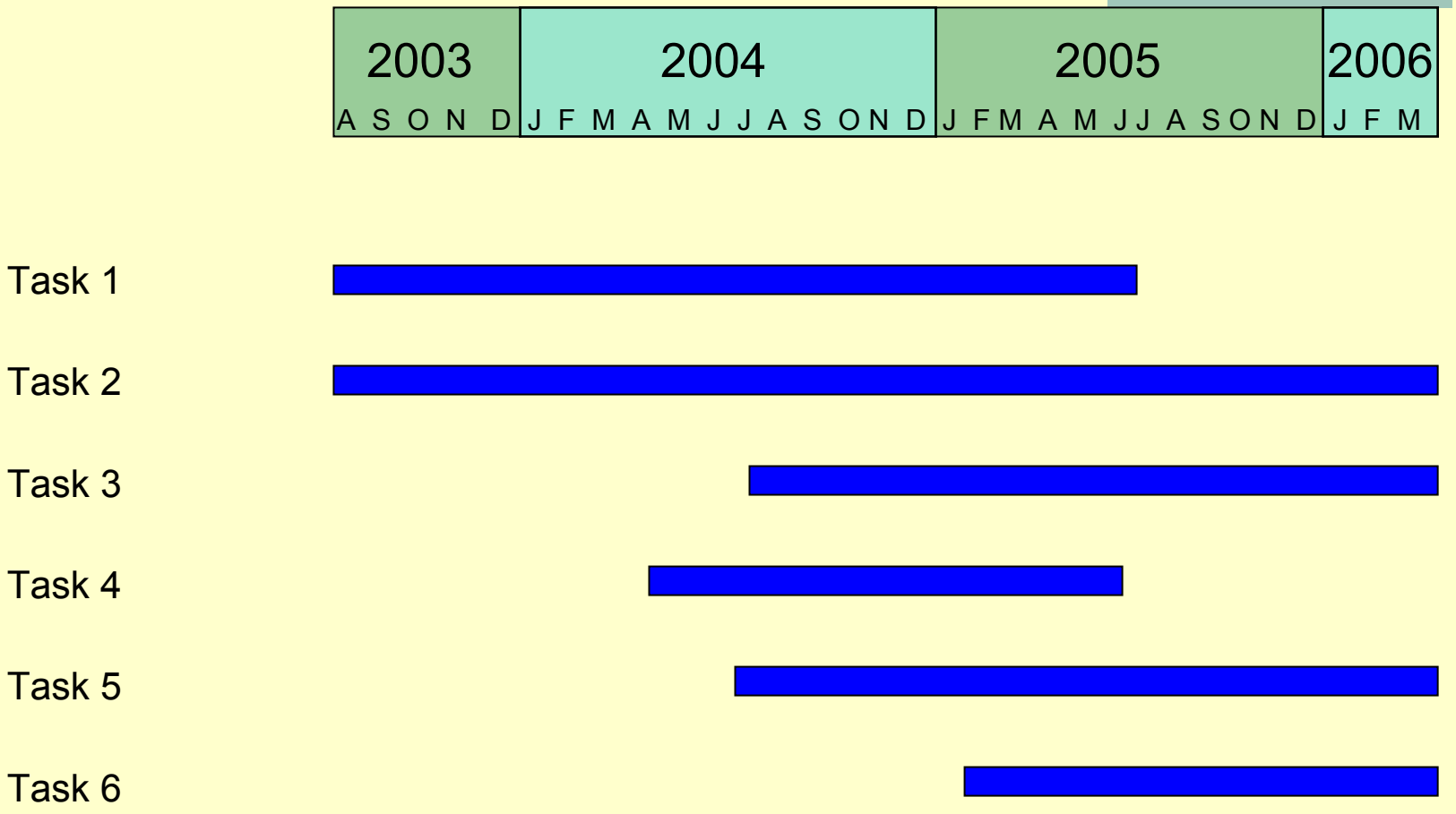
Hydrogen Codes and Standards

- Document national and local codes for storing and dispensing hydrogen

Funding

- Total Project Funding (FY ’02): $ 939,996
- Project performance period:
  8/2003 - 2/2006

Project Timeline



Interactions & Collaborations

- Argonne National Laboratory – Center for Transportation Research
  - Tasks 1, 2, 3, 4, and 5.
- US DoE – Atlanta Regional Office
  - Task 6
- Center for Transportation & the Environment
  - Task 6

Project Safety

- Argonne designed and built a just-in-time leak-proof fuel delivery system for the test cell.

- Installed detectors and controls to limit hydrogen concentrations to less than 1% (1/4 of the lower explosive limit).

Off-Board Fueling of the Hythane Truck

Task 1. Technology Evaluation of Hydrogen Light-Duty Vehicles

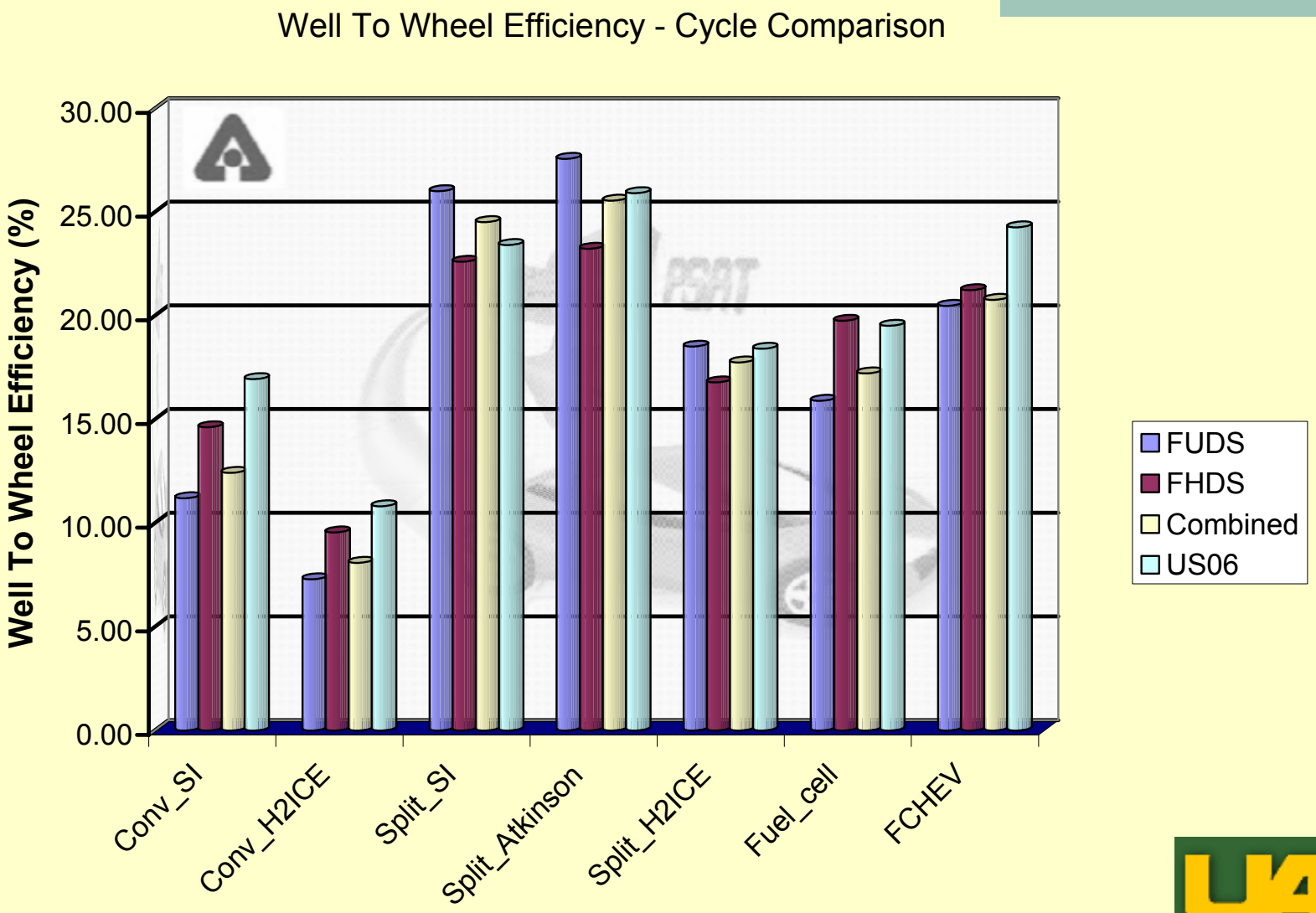
Objectives:

- Use simulation model to analyze a variety of hydrogen-fueled light truck configurations and assess their efficiency and performance as functions of operating conditions.
- Compare emissions and performance from the simulated hydrogen-fueled vehicles to baseline conventional vehicles
- Compare results from simulation and field testing to validate the simulation model for future applications

Task 1 - Accomplishments

- Analyzed candidate hydrogen-fueled vehicles in terms of efficiency, performance, and emissions. Vehicles included: hythane- and hydrogen-fueled internal combustion engines (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
  - Run cycles include FUDS, FHDS, US06, NEDC, Japan1015 & Performance

Task 1 – Well-to-Wheel Efficiencies



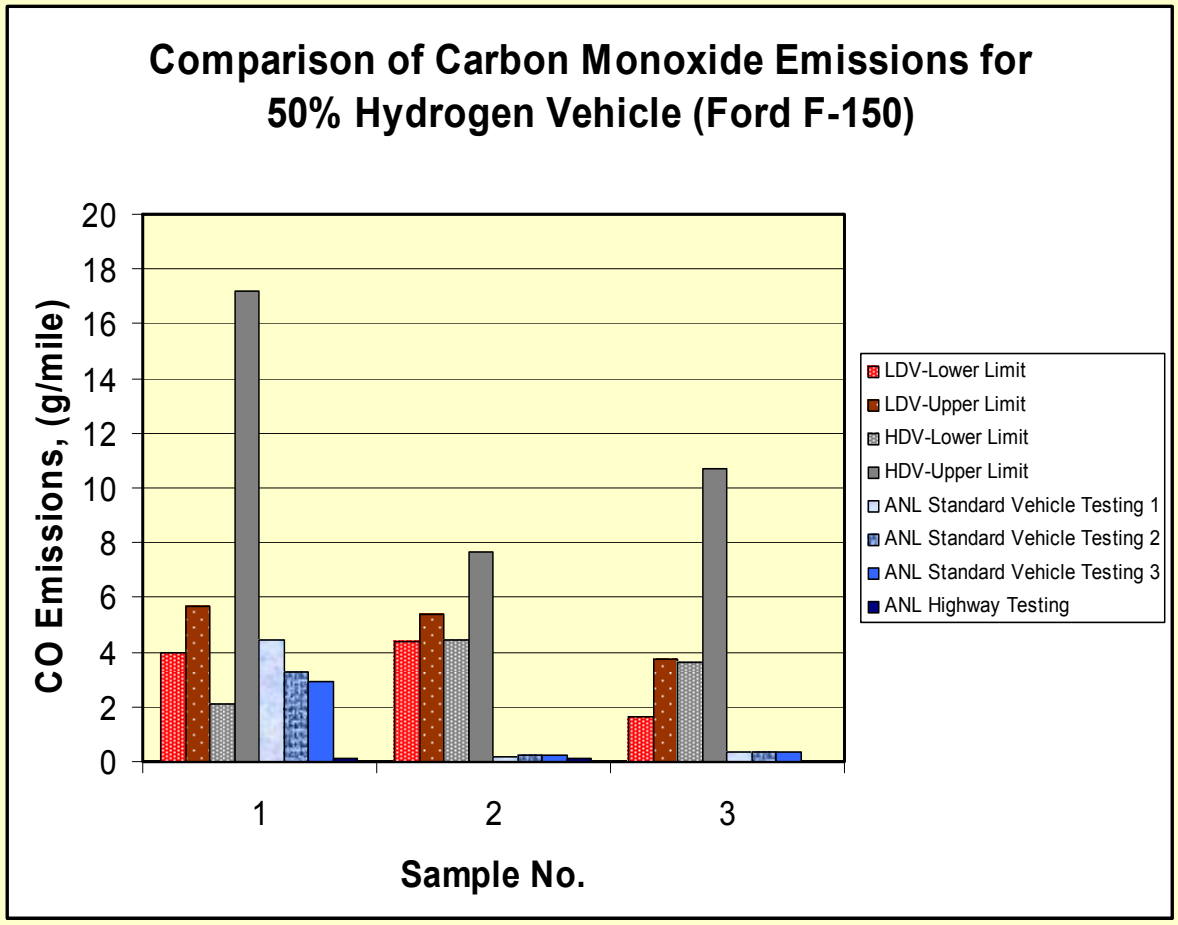
Task 2: Comparison of Performance and Emissions from Near-Term Hydrogen-Fueled Light-Duty Vehicles

Objective:

To determine and evaluate emissions performance of light-duty vehicles using compressed natural gas and hydrogen blends in internal combustion engines.

Emissions Testing of Ford F-150 at Argonne's PowerTrain Facility

Results of Emissions Testing Using 50% CNG/50% H_2 in Ford F-150s



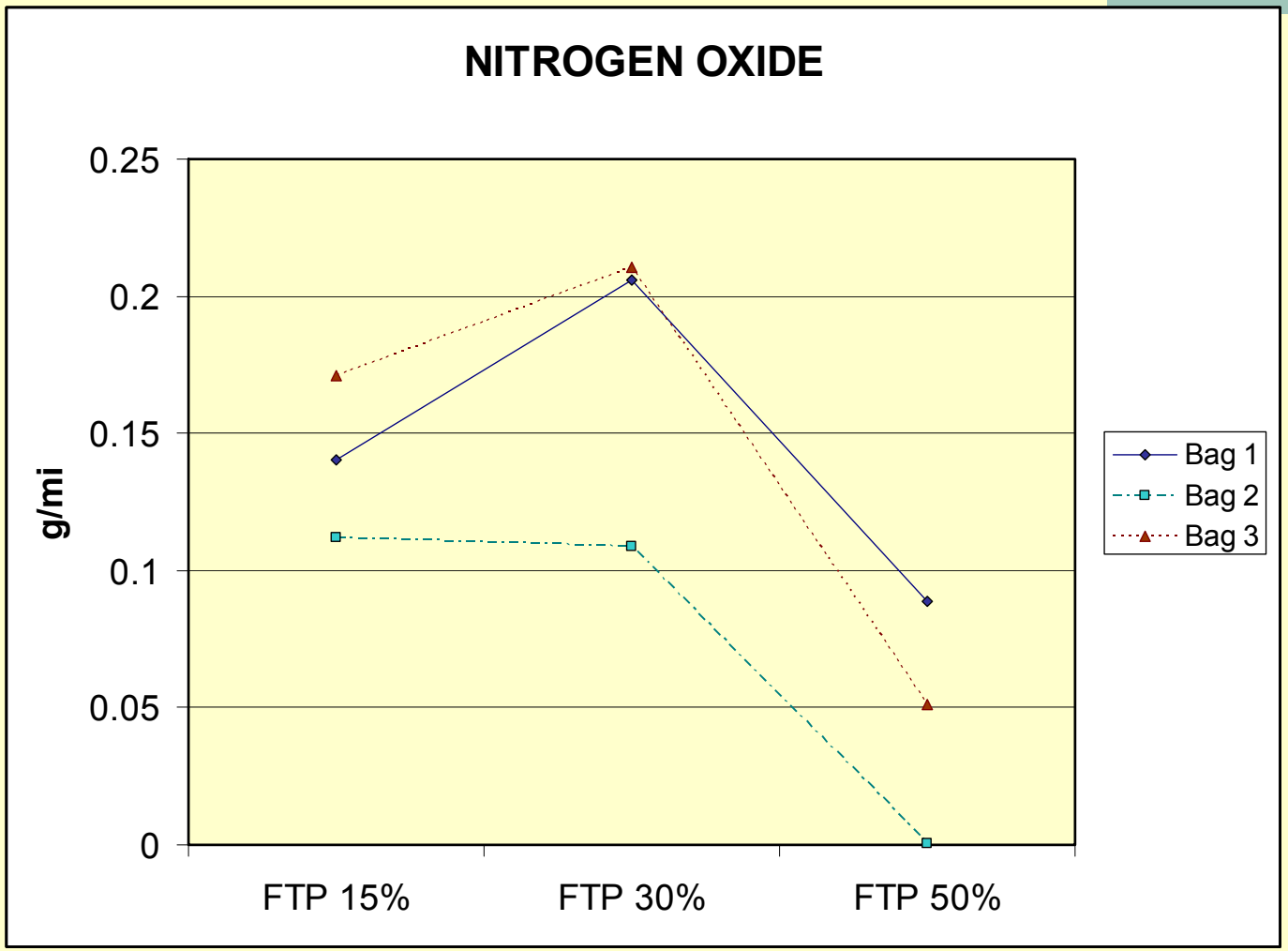
Task 2: Accomplishments

- A Ford F-150 was tested at Argonne National Laboratory using the dynamometer facility in their Transportation Technology R&D Center.
- The Ford F-150 was tested with hythane mixtures of 0%, 15%, 30%, and 50% hydrogen. 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 (NO_x), and particulate matter. The equivalent miles per gallon fuel consumption was also monitored.
- An advanced hydrogen feed system was installed at the Argonne test facility. The system was used to test a hydrogen powered 4WD Ford Explorer from the FutureTruck competition.

Task 2: Accomplishments

- CO and CO_2 showed a decrease with an increase in hydrogen concentration.
- NO_x emissions increased with an increase in hydrogen concentration.
- Hydrogen concentration did not have a significant effect on the total hydrocarbon emissions and the efficiency of the different driving cycles.
- Particulate matter emissions from CNG/ HCNG vehicles is negligible.

NO_X Emissions



Task 2: Future Work

- Testing of a 100% hydrogen fueled Ford F150 ICE in Summer 2005.
- Analysis and modeling of the emissions results for the various blends of CNG/H_2.

Task 3: Hydrogen Infrastructure Assessment and Deployment Needs

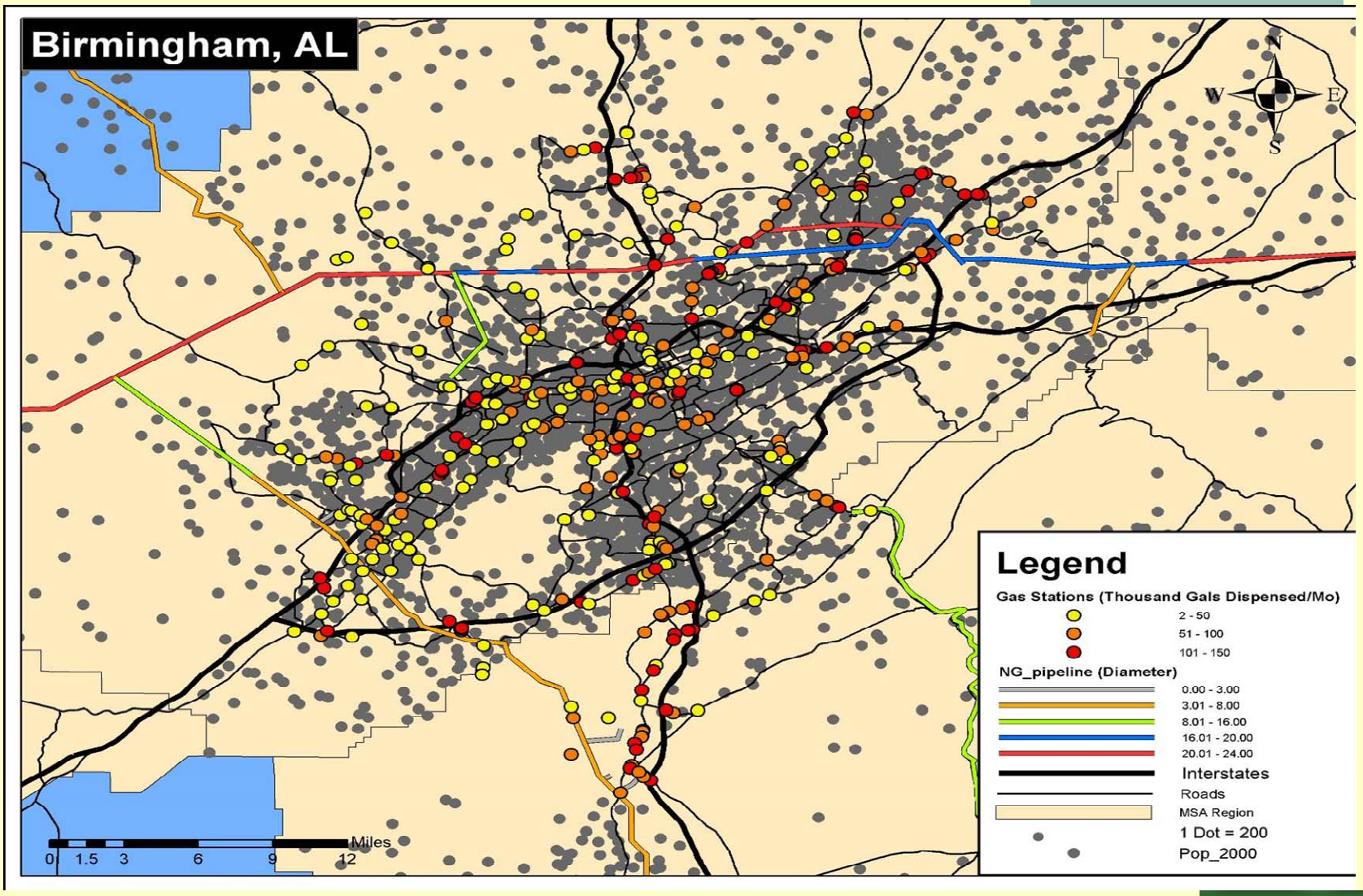
Objectives:

- Develop estimates of costs and resource requirements for the infrastructure needed to deliver hydrogen fuels to advanced technology vehicles in the Southeast.
- Document codes and standards relating to the siting, production, transport, and handling of hydrogen.

Task 3: Accomplishments

- Assessed current transportation demand for fuel and available fueling infrastructure in 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.

Assessing Future H_2 Demand and Infrastructure



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

Objectives:

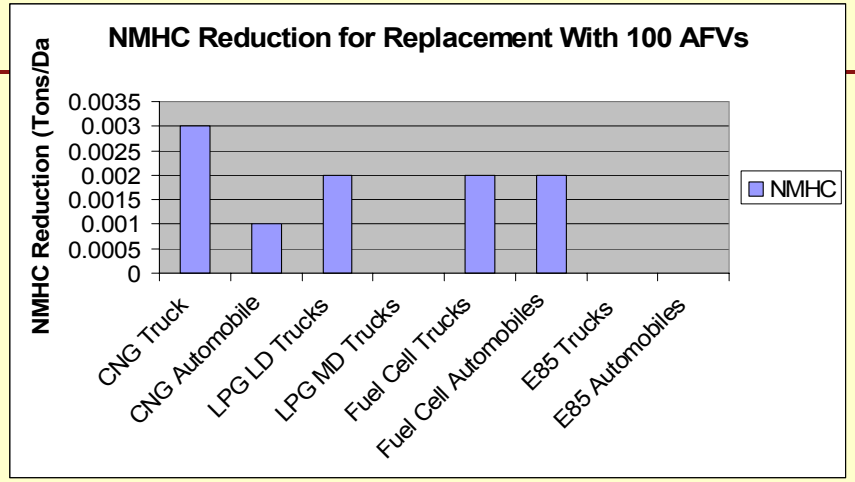
- Examine potential benefits of large-scale deployment of hydrogen-fueled vehicle technologies in the Southeast.
- Focus on NO_X reduction potential of hydrogen-fueled vehicles.
- Particular attention will be paid to the Birmingham metropolitan area.
- Adapt ANL's AirCred model for use in Birmingham.
- Provide support for the DOE Clean Cities activities of the *Central Alabama Clean Cities Coalition.*

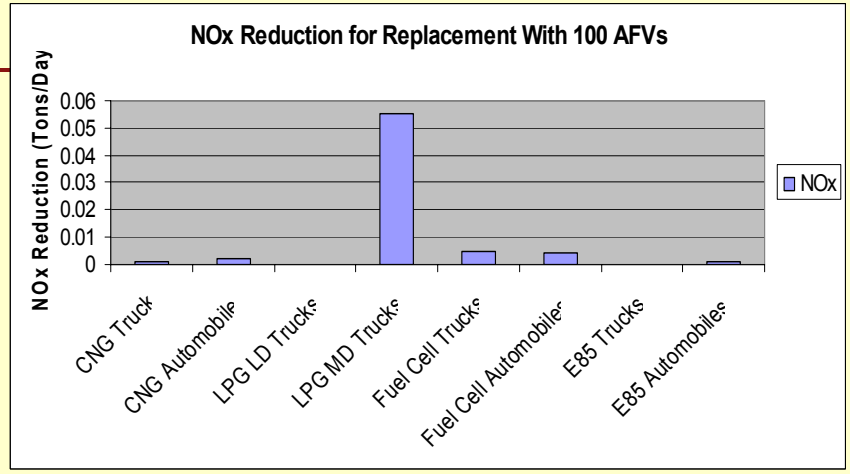
Task 4 - Accomplishments

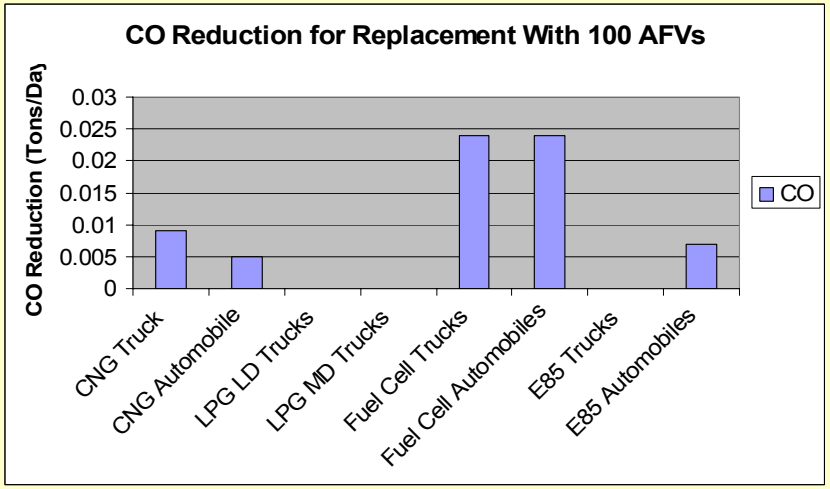
- Student performed hypothetical case studies of an alternative fuel vehicle (AFV) deployment in Atlanta, GA to examine range of AirCred outputs:
  - Case 1 – 100 of each type of AFV (CNG, LPG, electric, H_2, etc.) driven five days a week, 100 miles per day
  - Case 2 – 9999 of each type of AFV under 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 region

Task 4: Sample Results from Student AirCred Case Studies







- The AFV type with the highest average reduction per pollutant (at least two pollutants) was CNG trucks
- The pollutant with the highest average reduction per AFV type was NMHC
- The greatest overall reduction of pollutants attributable to fuel cell vehicles. CNG trucks and LPG medium duty trucks also appreciable

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

Objectives:

- Assess the ability of hydrogen production and utilization to be competitive with other forms of energy generation.

- Review various case histories involving the use of hydrogen-based fuel cells for electric power generation.

Task 5 – Accomplishments

- Increasing the fuel utilization increases the electrical efficiency but decreases the thermal efficiency.
- The electrical and thermal efficiencies are optimum at ~85% fuel utilization.
- At S/C>1, methane slip < 1%.
- High temperature membranes are suitable to generate high grade heat for useful cogeneration.

Task 5 - Future Work

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

Task 6. Establish the Southeastern Hydrogen Technology Consortium

Objectives:

- Form a coalition of public and private sector partners to promote hydrogen research in the Southeast.
- Promote demonstrations and deployments of hydrogen technologies is major urban areas.
- Provide education and outreach programs.