Fuel Cell Auxiliary Power Units for Trucks

John Garbak,
Technology Development Manager
Hydrogen, Fuel Cells and Infrastructure Technologies

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Hydrogen, Fuel Cells and Infrastructure Technologies Program

Steve Chalk, Program Manager

Tia Alexander, Administrative Support

Technology Validation Manager - **Sigmund Gronich**

Education - **Christy Cooper**

Safety and Codes/Standards - **Neil Rossmeissl**

Hydrogen Production Team

Pete Devlin, Team Ldr.
Chris Bordeaux
Roxanne Danz
Matt Kauffman
Arlene Anderson
Mark Paster

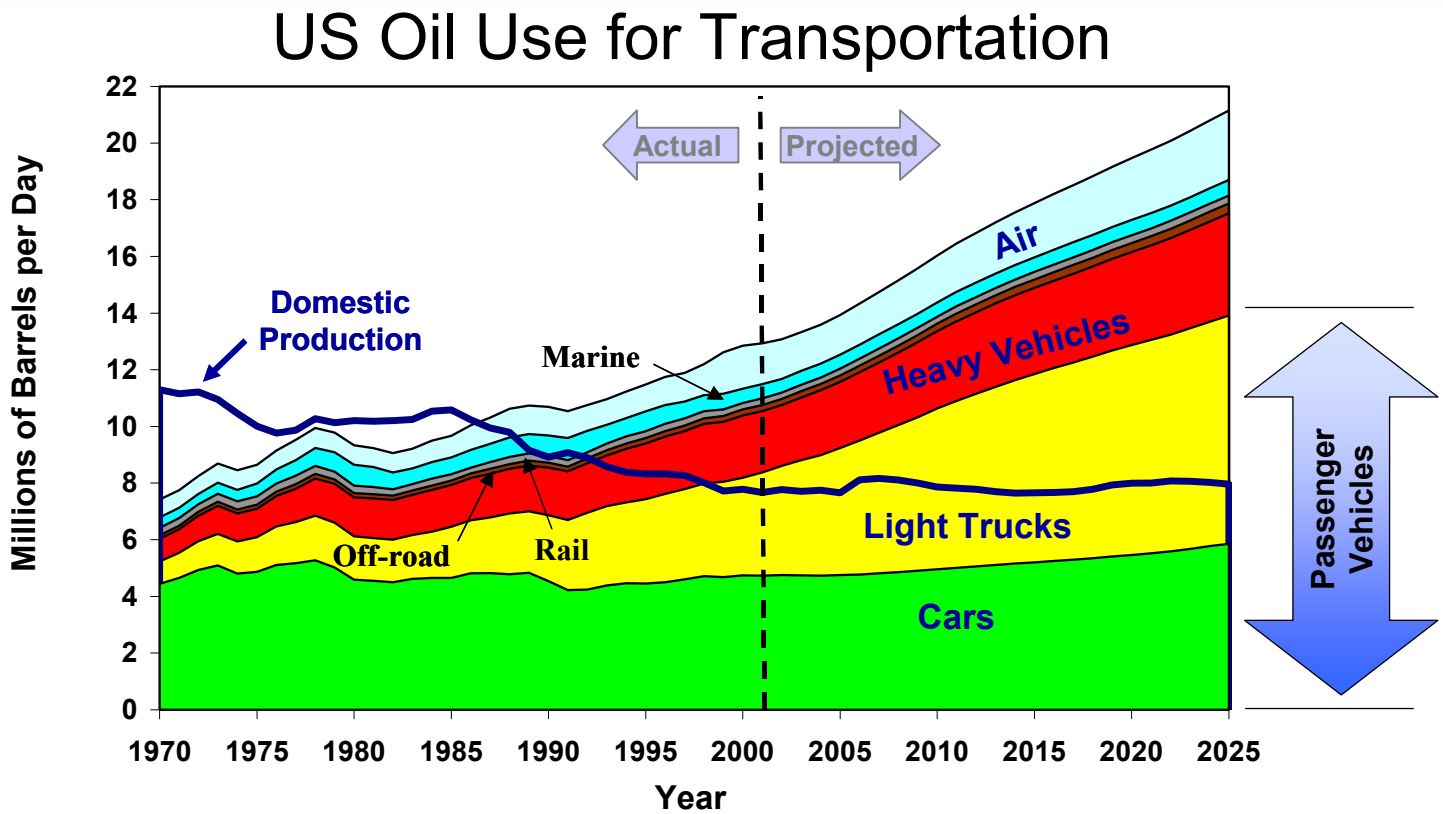
Hydrogen Storage Team

JoAnn Milliken, Team Ldr.
Lucito Cataquiz
1-2 Vacancies

Fuel Cell Team

Patrick Davis, Team Ldr.
Donna Ho
Valri Lightner
John Garbak
Kathi Epping
Nancy Garland

U.S. Energy Dependence is Driven By Transportation



Source: Transportation Energy Data Book: Edition 22, September 2002, and EIA Annual Energy Outlook 2003, January 2003

- Transportation accounts for 2/3 of the 20 million barrels of oil our nation uses each day.
- The U.S. imports 55% of its oil, expected to grow to 68% by 2025 under the status quo.
- Nearly all of our cars and trucks currently run on either gasoline or diesel fuel.

Why use APUs in Trucks

- A typical tractor-trailer truck idles an estimated 1,830 hours/year
- Typical fuel usage for idling is estimated to cost $1.17 billion/year and an estimated additional $1 billion is spent on engine wear and maintenance due to idling
- Energy efficiency increases and emissions reduction

Benefits of APUs in Trucks

Near-Term

- Reducing consumption of diesel fuel while idling by 80% with fuel cell APU would reduce consumption by 670 million gallons per year

- Emissions saving per truck are estimated to be 0.2-1 tons per year for NOx and 11-80 tons per year for CO_2

Long-Term

- Reducing parasitic energy losses by 50% while the truck is moving by replacing gear/belt-driven accessories with fuel cell-powered accessories would reduce fuel consumption by 480 million gal/year

Challenges to be addre

- Today less than 2,000 diesel/gasoline APUs are sold per year for Class 8 trucks because:
  - Installed cost of $5,000 - $8,000 is too high
  - Concerns about reliability
  - Noise is objectionable
- Applying fuel cell APU to a very cost sensitive market
- APU must have high reliability and durability (15,000 hours long-term)

Commercial Transportation Applications

- Class 6 - 8 Trucks 3 - 10 kW
  - Idle reduction, near-term
  - Replace gear/belt-driven accessories, long-term
- Recreational Vehicles 3 - 5 kW
- Refrigeration in long-haul Class 8 trucks 10 – 30 kW

On-going Activities

- TIAX Fuel Cell APU Study
- PNNL SOFC APU Analysis
- ANL Diesel Reforming
- ANL SOFC for Transportation APUs
- APU Solicitation

TIAX Fuel Cell APU Feasibility Study

- Possible APU applications for fuel cells were identified based on duty cycle, market size, and vehicle cost. The following vehicles meet the criteria:

Luxury light trucks	Refrigeration units (Class 3-8)
Law enforcement large cars	**Heavy-duty trucks long-haul**
Contractor special pick-ups	**Transit buses**
W PTO/utility trucks (Class 3-8)	Recreational vehicles

- APU applications shown in red were identified for conceptual design, layout and vehicle integration analysis based on both a short- and long-term outlook
  - Energy savings
  - Emissions savings
  - Cost savings
  - Accelerated fuel cell introduction

SOFC APU Analysis
- Modeling & Control -

- Develop a model of a complete SOFC APU
  - Perform studies for different configurations
  - Understand parameter interdependencies
  - Determine start up times, power availability, and effects of typical truck electrical system loads
- Develop a controller for a typical SOFC APU
  - Efficiently control APU parameters to provide adequate power for typical truck electrical loads
  - Understand what can be controlled and the effect on overall power generation efficiency

PNNL Project (cont)

Dynamic shock and Vibration Goals

- Quantify dynamic loads applied to SOFC stacks and APU units during operation of Class 8 trucks
  - Determine characteristics excitations and material properties
  - Construct models to determine mechanical stresses at operating temperatures
  - Perform parametric analysis to identify critical system components
- Establish APU shock/vibration limits and/or sufficient mount isolation based on stack component and cell interfacial strengths.

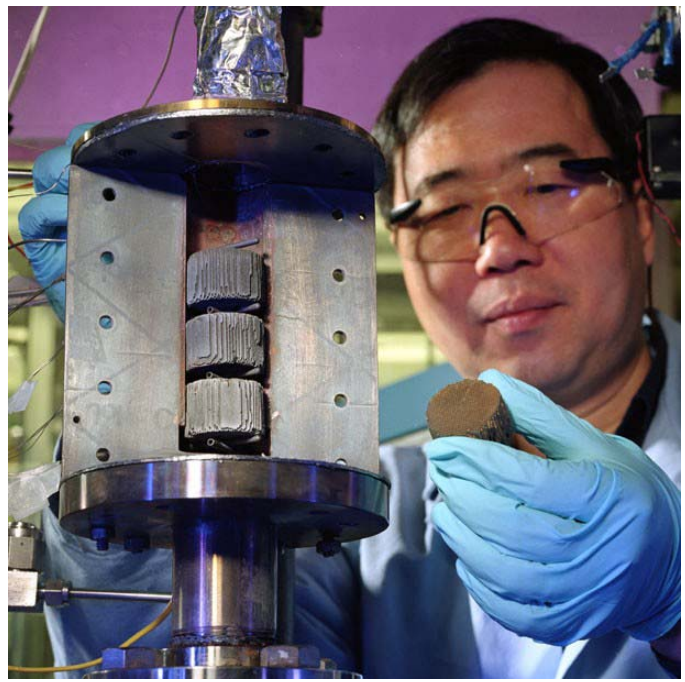
Demonstrated diesel reforming using direct fuel injection

Hydrogen produced by diesel reforming can be used in:

(a) fuel cell auxiliary power units

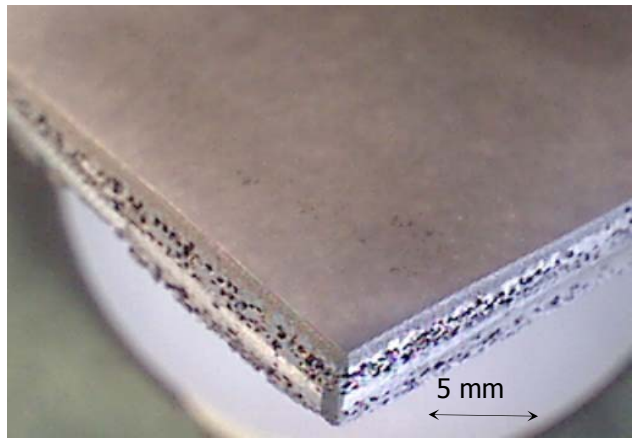
(b) diesel engine exhaust gas treatment (NOx reduction)

- Demonstrated diesel reforming in engineering-scale (1kWe) reactor
- 3-fluid nozzle developed for autothermal reforming of diesel
- Demonstrated conversion of diesel surrogates
  - Studying effects of fuel composition, temperature, O/C, H_2O/C, space velocity
  - Studying kinetics, catalyst durability, sulfur tolerance



Argonne Metallic bipolar plate-supported SOFC

- Objective: To develop an improved SOFC for APUs
  - Faster startup time and durability to temperature cycling
  - Improved vibration and shock resistance
  - Lower materials and manufacturing costs
- TuffCell Features:
  - Thin layers of expensive materials
  - Sintered in one step
  - High strength ceramic/metal composite
  - Simplified seals for stack building
- Current Progress:
  - Cells fabricated and tested achieve >250 mW/cm² power density
  - Mechanical tests show 4-fold improvement in strength
  - Short stacks (2-cell) are being built



New Solicitation

APU Validation Program

- Solicitation (GFO) to develop integrated APU system to validate operation under real world conditions
- Issued – April 9, 2003
- Proposals Due – June 5, 2003
- Awards - 4th Q FY 2003
- Program duration 2004 – 2007
- Budget – Up-to 9 million over 3 years for 3 cost shared projects
- Coordinated with 21st Century Truck Partnership

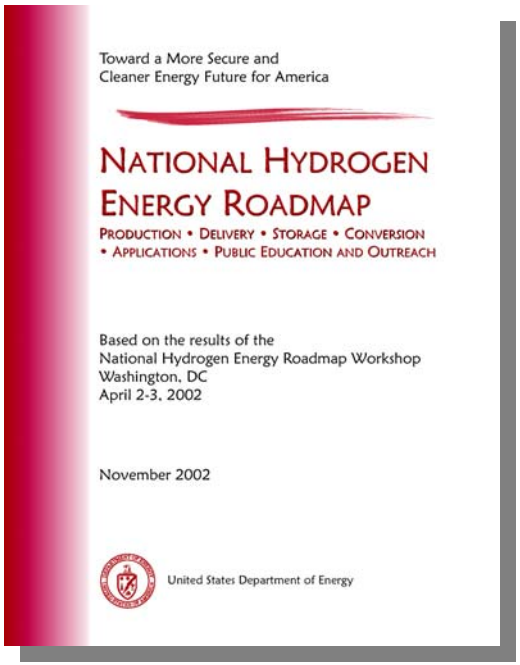
U.S. Department of Energy
Energy Efficiency and Renewable Energy

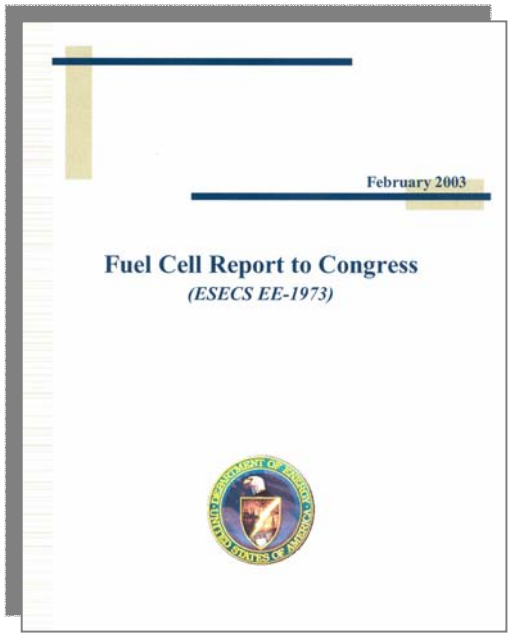
For More Information…

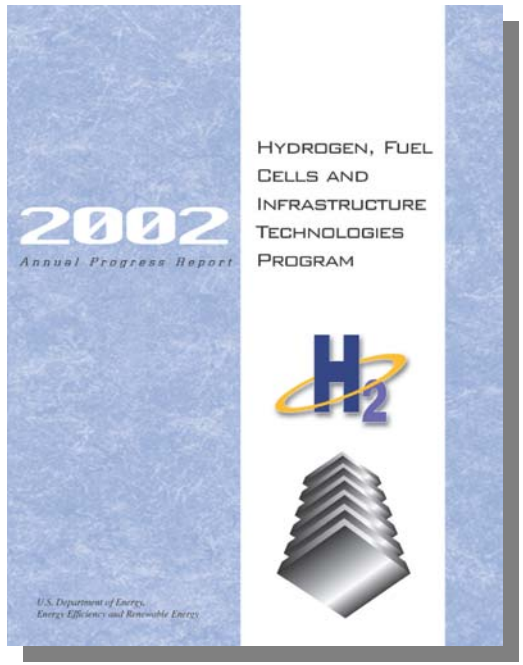
Patrick Davis,Team Ldr,Fuel Cells
EERE Hydrogen & Fuel Cells
202 / 586 – 8061
Patrick.Davis@ee.doe.gov

Steven Chalk, Program Manager
EERE Hydrogen & Fuel Cells
202 / 586 – 3388
Steven.Chalk@ee.doe.gov

John Garbak
EERE Hydrogen & Fuel Cells
202 / 586 – 1723
John.Garbak@ee.doe.gov







www.eere.energy.gov/hydrogenandfuelcells