PEMFC Power System on Ethanol

Caterpillar Inc.

Thomas J. Richards
In 2003, a 10-15 kW stationary PEM fuel cell system will be field tested for 4000 hours at the Williams Bioenergy’s ethanol production facility in Pekin, Illinois.

The unit will be powered by corn-based ethanol and will produce AC power for the local grid.

The program examines the durability of a PEM based fuel cell system while operating on ethanol - a renewable fuel.

The program is a consortium among Nuvera, Caterpillar, and Williams Bioenergy with funding from DOE and the State of Illinois.
Ethanol: A Renewable

Economy

The U.S. ethanol industry has grown to over 2.3 billion gallons of production capacity, with plants located in 19 states.

Emission

The ethanol production process represents a carbon cycle, where plants absorb carbon dioxide during growth, "recycling" the carbon released during fuel combustion.

Other Reasons

- Helping the US Energy Balance
- Fighting the Carbon Cycle creation
- Economy boost to Rural America
- State Visibility (Midwest)
- Fuel Choice for Fuel Cells???
Program Overview

Program Partners

- Nuvera Fuel Cells
- Williams Bio-Energy

Program Sponsors

- Department of Energy
- IL Department of Commerce & Community Affairs

Program Objectives

- 2-Year Cooperative Program to:
  - Design/Fabricate/Test an Ethanol-based PEM Fuel Cell
  - Demonstrate Performance and Durability: 4000 hours
  - Remove Technical Uncertainties
  - Understand Correlation and Reduce Gaps between Stationary and Transportation Application
  - Data Collection to Evaluate Economic Feasibility
  - Assess Commercial Viability of Total System
Program Objectives

- Integrated PEM Fuel Cell System
  - Ethanol based Power Plant
  - 10-15 kW
  - 3-Phase 120/208 V_{AC} @ 60 Hz
  - Greater than 25% Target Efficiency
  - Operability & Performance
- Demonstrate 4,000 Durability
- Data Gathering as Baseline for Feasibility
  - Economic Study
  - Transportation & Stationary Correlation
Task 1.0
Power Module Design

Task 2.0
Power Converter Design

Task 3.0
Power Module Build

Task 4.0
Power Converter Build

Task 5.0
Site Preparation, System Integration & Shakedown Testing

Task 6.0
Fuel Cell Demonstration

Approach

Nuvera

Nuvera/Cat/Williams

Williams

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Durability Program

- **2-Year Cooperative Program:**
  - Design/Fabricate/Test 10-15 kW Ethanol-based PEM Fuel Cell
  - Demonstrate Performance and Durability: 4000 hours
  - Technology and Economic Feasibility Assessment

- **Ready to test in June 03**

[Images of fuel cell and fuel cell component]
Dimensions (mm):

- 1321 H x 1372 W x 762 D (Power Module)
- 304 H X 610 W X 914 D (Power Converter)

- DC Output Voltage (V): 55 to 100
- Startup Time (minutes): 20-40
- 25 to 90 % Load Response (s): 60
Accomplishments: Power Module

- Designed and built a fully integrated power system based on Model B fuel processor for ethanol operation
- Achieved afterburner free startup
- Eliminated need for reformate cleanup by eliminating ammonia formation
- Created new, robust control strategy for both reformer and fuel cell sub-systems
- Field unit demonstrated @ 11 kWe continuous output
- About 40 hr continuous run on integrated system; 125 hours total power in the laboratory
## Power Converter Accomplishments

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<th>Item</th>
<th>Target</th>
<th>Actual</th>
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<td>15 kW</td>
<td>16 kW</td>
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<td>Line interactive</td>
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<td>Acceptance test</td>
<td>100 hour</td>
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<td>Efficiency</td>
<td>93%</td>
<td>90%</td>
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Accomplishments: Test Site

- Utility interactive
- Ethanol availability
- Data acquisition system
- Remote monitoring, data backup & internet view
- Visitor parking & observation amenities
- Hazardous operations procedures in place
## Acceptance Test Criteria

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<th>Test Duration</th>
<th>Condition</th>
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<td>1 x 24 hour continuous</td>
<td>$\geq 15$ kWe</td>
<td>Cat power converter</td>
<td>Factory acceptance test/ Caterpillar</td>
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<td>3 x 24 hour continuous</td>
<td>$\geq 10$ kWe</td>
<td>Nuvera power module</td>
<td>Factory acceptance test/ Nuvera</td>
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<tr>
<td>500 hour combined continuous + interrupted</td>
<td>Any power</td>
<td>Nuvera power module</td>
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<tr>
<td>24 hour continuous</td>
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<td>1 x 8 hour continuous</td>
<td>Max flows</td>
<td>Williams Utilities (fuel / water / air)</td>
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Interactions

- Leverage Cat’s Fuel cell commercial program in power electronics/packaging
- Leverage underground mining machine fuel cell program
- Improved Cat electronics platforms and common design to DG equipment
- Extracting lessons and processes used for New Product Introduction (NPI) in commercial applications
- Cat’s life cycle cost analysis pro-format will be used in economic feasibility
- Constant communication with Nuvera’s commercial 4kW natural gas power system program and individuals
Contacts

Ahmed Amrani (Primary Contact), Thomas Richards
Caterpillar Inc.
Technical Center, P.O. Box 1875
Peoria, Illinois 61656 – 1875
(309) 578 3913, Fax: (309) 578 6113, E-mail: Amrani_Ahmed@cat.com

DOE Technology Development Manager: Kathi Epping
(202) 586 4725, Fax (202) 586 9811, E-mail: Kathi.Epping@ee.doe.gov

ANL Technical Advisor: William M. Swift
(630) 252-5964, Fax: (630) 972 4473, E-mail: Swift@cmt.anl.Gov