A Study of the Feasibility of Utilizing Fuel Cells to Generate Power for the New Haven Rail Line

Photo courtesy of ConnDOT

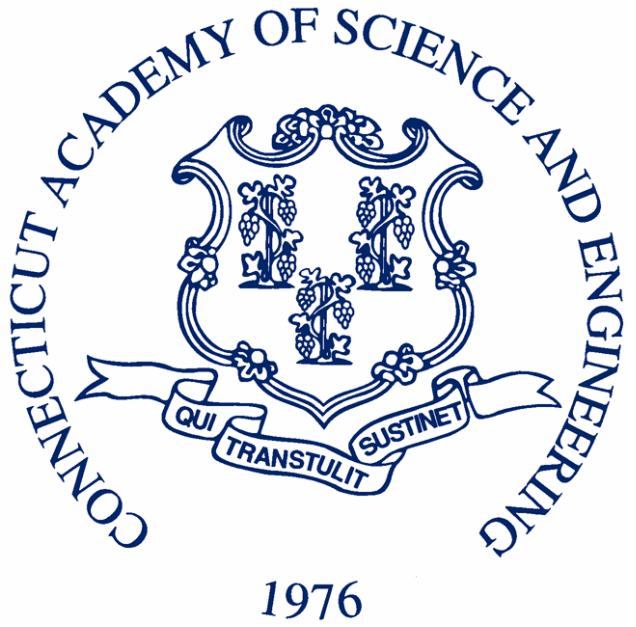
ConnDOT Research

- **Manages 100+ active projects**
- **20% conducted in-house**
- **Since 2002, CASE has conducted technology scans and feasibility studies for ConnDOT**

www.ct.gov/dot/research

RECENT ACADEMY STUDIES CONDUCTED FOR CONNDOT

- **Preparing for the Hydrogen Economy: Transportation**
- **Improving Winter Highway Maintenance: Case Studies for Connecticut's Consideration**
- **Information Technology Systems for Use in Incident Management and Work Zones**
- **Demonstration & Evaluation of Hybrid Diesel-Electric Buses** *(ConnDOT & CTTransit)*
- **A Study of Railcar Lavatories & Waste Management Systems**



A Study of the Feasibility of Utilizing Fuel Cells to Generate Power for the New Haven Rail Line

STUDY BRIEFING
Connecticut General Assembly
October 10, 2007

REQUIREMENT FOR STUDY

- **Public Act No. 06-136, Section 19 from 2006 CT Legislative Session:**

- ***"The Department of Transportation shall study the feasibility of building a fuel cell power station to generate power for the New Haven Line. Such study shall include, but need not be limited to, a plan for generating a large percentage of the line's peak power needs, as well as serving as a backup in times of emergencies...."***

Report to the General Assembly on or before January 1, 2008

STUDY EFFORT

- **Connecticut Academy of Science and Engineering (CASE) conducts study for ConnDOT**
  - Academy Study Committee
  - Academy Member Peer Review
  - Governing Council Provides Consent to Public Release of Study Report
  - Rick Strauss, Executive Director
- **CASE Study Manager**
  - Joe King, Study Manager

STUDY EFFORT (2)

➢CASE Study Committee

- **A. George Foyt**, UTRC (ret.) (*CASE Member*)
- **Trent Molter**, CT Global Fuel Cell Center
- **Kenneth Reifsnider**, University of South Carolina; Formerly – UCONN, CT Global Fuel Cell Center; Study Committee Chairman (*CASE Member*)
- **Alan J. Rice**, AIG Global Marine and Energy
- **Keith Spitznagel**, LOGAN Energy Corporation
- **Robert Walker**, Metro-North Railroad
- **Rich Walsh**, Connecticut Light & Power
- **George R. Wisner**, Wisner Associates (*CASE Member*)

SUMMARY OF KEY FINDINGS & SUGGESTIONS

- **New Haven Line ideally suited to demonstrate fuel cell application to meet rail needs**
  - Part of largest US commuter rail system
- **Among largest electricity consumer of State owned or operated facilities**
- **Yard power, station power applications similar to other ConnDOT applications**

SUMMARY (2)

- **Maintenance yard and passenger stations may have competitive economics at fuel cell cost goals**
- **Traction power may be competitive at cost goals with use of heat and other incentives**
- **Significant incentives can improve competitiveness**
  - Renewable energy certificates
  - Capacity credits from ISO-NE
  - On-site Renewable Energy Incentives from CCEF

FOCUS ON STATIONARY POWER

- **Limited experiments with on-board fuel cell power plants in Japan and US, but requirements are more stringent than those for buses and automobiles**

- **Current significant New Haven Line investment is in rail vehicles and power supplied by overhead catenary systems**

NEW HAVEN LINE STATIONARY POWER REQUIREMENTS

- **53,000 kW demand growing to 67,000 kW by 2015:** Represents one of the largest users of power accounting for 0.5% of electric energy consumption in Connecticut
- **Multiple Uses**
  - Traction: Total demand of 48,000 kW provided through three supply points
  - Stations: Total demand over 3,000 kW
  - Maintenance Yards: 2,000 kW growing to 16,000 kW by 2015
  - Control and Signaling: 100 kW

FUEL CELL BASICS

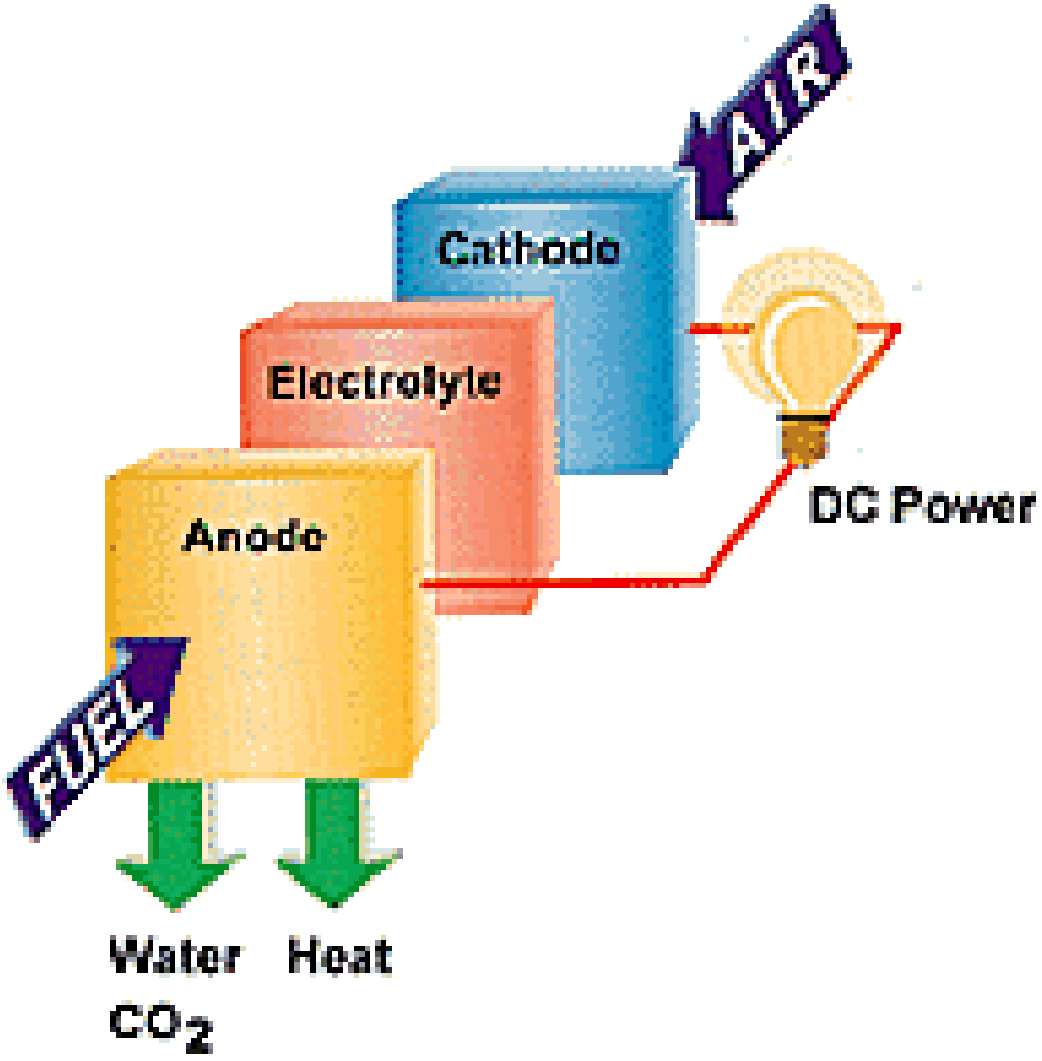


Diagram Courtesy of the U.S. Department of Energy

TRACTION POWER

Photo courtesy of ConnDOT

TRACTION POWER

- **Total demand of 48,000kW**
  - Catenary voltage reinforcement from parallel feeder at 13 wayside substations
  - Requires 12.5 kilovolt, single-phase power — *modification of current fuel cell products*
- ***No need for additional facilities through 2020 —*** *Current supply points at Cos Cob, Sasco Creek and Devon with future supply point at New Haven*

TRACTION POWER (2)

- **No existing requirement for back-up power**
- **No use of fuel cell heat at co-located rail facilities along the Line**
  - Potential for use of heat at other buildings along the Line
- **Installation siting may be difficult**
- **Installation at wayside substations may reduce both voltage and energy loss**

STATION POWER

Photo courtesy of ConnDOT

STATION POWER

- **New Haven and Stamford stations require 800kW and 700 kW, respectively**
  - Power is 480 volt — three-phase (*like current fuel cell products*)
  - Opportunity for use of fuel cell heat
  - Emergency power needed for passenger safety, disabled access (*fuel cell power with grid back-up = very reliable alternative)*
  - Garage addition planned for New Haven will add 200 kW with emergency generator

STATION POWER (2)

- **Other stations have power levels similar to large homes**
  - No emergency power needs
- **New Stations planned at West Haven, Fairfield, Orange**
  - West Haven will have parking garage

MAINTENANCE YARD POWER

Photo courtesy of ConnDOT

MAINTENANCE YARD POWER

- **New Haven and Stamford maintenance facilities require 640kW and 1,270 kW, respectively**
  - Power is 480 volt — three-phase
  - Opportunity for use of fuel cell heat
  - Emergency generators for safety & critical operations

MAINTENANCE YARD POWER (2)

- **Expansion of New Haven yard will add 14,000 kW demand in a number of buildings through 2015**
  - Opportunity for use of fuel cell heat
  - Emergency generators and Uninterruptible Power Systems with total capacity of 2,500 kW
  - Limited space indicates rooftop installation required

CONTROL AND SIGNAL POWER

- **Total demand of 100 kW**
  - 12.5 kilovolt, 100 Hz power not consistent with current fuel cell products
  - No use for fuel cell heat
  - Emergency back-up power in-place
- **Not considered further**

STUDY FOCUS ON PRIMARY POWER WITH NATURAL GAS FUEL

- **Molten Carbonate, Phosphoric Acid and Solid Oxide Fuel Cell Activities are focused on primary power generation**
  - FuelCell Energy and UTC Power offer the only commercial products
  - Other companies are developing products for this application

FUEL CELL POWER PLANT CHARACTERISTICS

	Molten Carbonate FuelCell Energy	Phosphoric Acid UTC Power
Ratings (kW)	300, 1,200, 2,400	200, 400
Electrical/Overall Efficiency (%)	47/83	40-42/85-90
Size (lbs per kW/sq. ft. per kW)	178-256/2.2-4.0	159-208/2.3-3.5
Start time (hrs)	72	5
Cell Stack Life (current/future) Years	3/5	5/10
Power Plant Experience (Million Hrs)	0.8	8

ROOFTOP INSTALLATIONS

Rooftop Installation of 250 kW FuelCell Energy Power Plant Sheraton Hotel, New York City, NY
(Photo courtesy of FuelCell Energy)

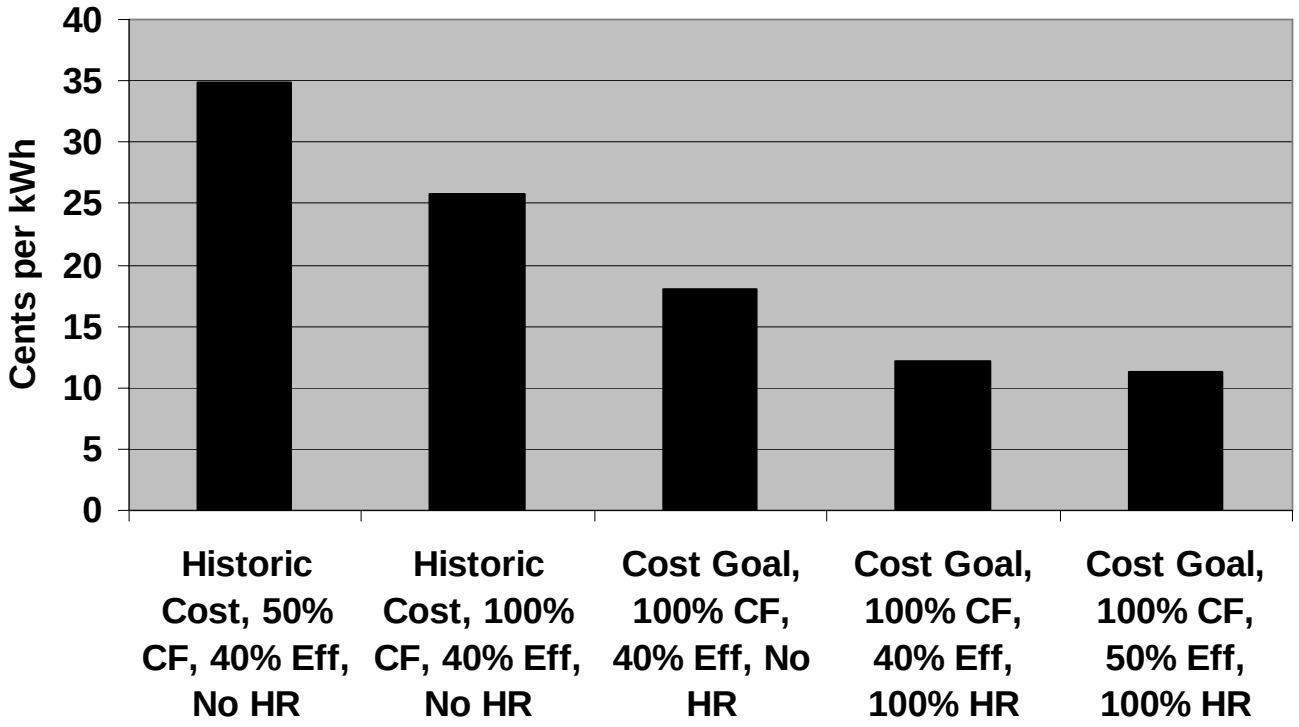
Rooftop Installation of 200 kW UTC Power Plant Corona Yard, NY
(Photo courtesy of UTC Power)

LARGER INSTALLATIONS

Installation of 1,200 kW FuelCell Energy Power Plant Torrington, CT
(Photo Courtesy of FuelCell Energy)

Installation of seven UTC 200 kW Power Plants Total Capacity - 1,400 kW Verizon's Garden City, NY
(Photo courtesy of UTC Power)

COST OF ELECTRICITY SCENARIOS: FUEL CELL COST FACTORS



Cost of Electricity – Cents per kWh
CF= Capacity Factor; HR= Heat Recovery; EFF= Efficiency

ADDITIONAL HYDROGEN-FUELED BACK-UP POWER CONSIDERATIONS

- **Proton Exchange Membrane Fuel Cells are primarily focused on vehicle power and standby-power using hydrogen fuel**
  - UTC Power, Plug Power (NY) and ReliOn (WA) are key manufacturers
  - Consider for use for back-up power for smaller passenger stations.

APPLICATION OF FUEL CELLS TO THE NEW HAVEN LINE

- **Incentives needed until cost goals are achieved**
- **Requirements for Best Economics**
  - Use for fuel cell heat
  - Operate fuel cells at rated capacity
  - Opportunity to eliminate new emergency power facilities
  - Installation space available

FAVORABLE APPLICATION OF FUEL CELLS TO THE NEW HAVEN LINE

- **New Haven**
  - New maintenance yard buildings
  - New station parking garage
- **Traction power at or between wayside substations with opportunity to use fuel cell heat** (*Energy Improvement Districts*)

ECONOMICS

- **Maintenance yard and passenger stations may have competitive economics at fuel cell cost goals**
- **Traction power may be competitive at cost goals with use of heat and other incentives**
- **Significant incentives can improve competitiveness**
  - Renewable energy certificates
  - Capacity credits from ISO-NE
  - On-site Renewable Energy Incentives from CCEF

WHAT ARE THE FINANCING OPPORTUNITIES?

- **CT may be able to lease or purchase energy service from a third party to eliminate investment requirement**

- **Public Act No. 07-242 has bonding authorized for energy management improvement in state buildings**

WHAT ARE THE CAPITAL REQUIREMENTS?

- **<u>Minimum</u> investments**
  - Critical power needs - New Haven yard buildings: $1M - 4.5M
  - New Haven and Stamford stations: $1M - $2M
  - Traction power: $4 - $27 million
  - Could be offset with CCEF incentives

ARE THERE OPPORTUNITIES FOR FEDERAL FUNDING ?

- **Funding from DOE not available for commercial power plants**
  - May be available for combined hydrogen/ heat/ electricity power plant being developed by FuelCell Energy in part with DOD funds
  - May be available for combined cycle or Solid Oxide Fuel Cell power plants

ARE THERE OPPORTUNITIES FOR FEDERAL FUNDING ? (2)

- **DOT & DHS funds are allocated to states and no funds specifically directed at electric power for rail exist**
  - Requires competition with other uses for these funds by CT on cost/benefit basis

REMAINING EFFORT TO PREPARE BID PACKAGE

- **New Haven yard**
  - Upgrade estimates of electric power and heat demand in new buildings
  - Assess roof top installation
- **Station power**
  - Identify location possibilities at New Haven
  - Assess combining electric loads at New Haven

REMAINING EFFORT TO PREPARE BID PACKAGE (2)

- **Traction power**
  - Assess benefits of providing power between supply points
  - Assess land cost, installation cost for locations with most benefit on voltage uniformity/line losses
  - Monitor Energy Improvement Districts, Homeland Security power situation

REMAINING EFFORT TO PREPARE BID PACKAGE (3)

- **General**
  - Select best applications on basis of detailed economic analysis
  - Determine whether to purchase, lease or secure energy service

CONCLUDING REMARKS

- **New Haven Line ideally suited to demonstrate fuel cell application to meet rail needs**
  - Part of largest US commuter rail system
- **Among largest electricity consumer of State owned or operated facilities**
- **Yard power, station power applications similar to other ConnDOT applications**