FUEL CELLS IN LOCOMOTIVE APPLICATIONS

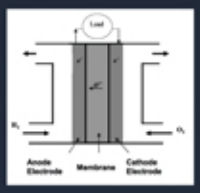
Liping Guo, Pradip Majumdar, David Schroeder, Donald Zinger
College of Engineering and Engineering Technology
Northern Illinois University

Potential Railroad Energy Saving

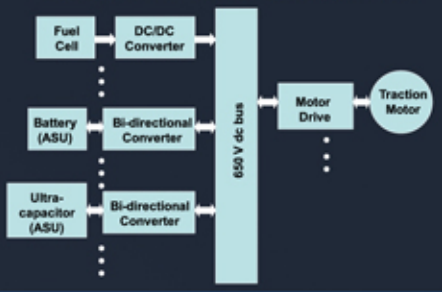
- Railroad large energy user
  - approximately 4 billion gallons of diesel annually
  - In 2005 the cost of fuel approximately twice annual profits
- Fuel cell in locomotive
  - Replace conventional diesel engines
  - Implementation depends on application

Focus on Solid Oxide Fuel Cell (SOFC)

- Compared to proton exchange membrane (PEM)
  - More flexible fuel choices
  - Higher temperature better for application
  - No expensive metal catalyst
  - Lower activation losses; higher current efficiencies
- Compared to molten carbonate fuel cell (MCFC)
  - Solid electrolyte; compact
  - Higher operating current and power density



Electrical Power Distribution



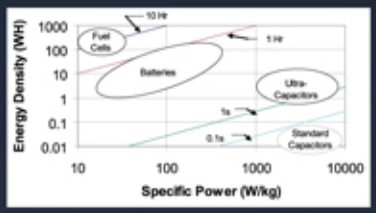
Locomotive Application 1 – Switcher

- High dynamic power swings
- Low average power - 50 Hp

Fuel Choice -- Bio-Diesel

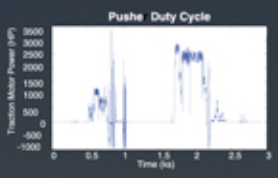
- Advantages
  - Higher energy density than hydrogen
  - Renewable
  - Minimal safety impact
- Disadvantage
  - Soy diesel – high phosphorous content
  - Needs cleanup
  - Gasification required

Balancing Energy and Power Needs



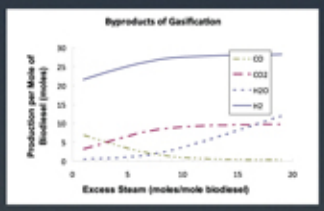
Locomotive Application 2 – Pusher

- Aid up hill
- Short range
- High power for long periods



Gasification Analysis

- Concern about reduction of CO



Summary Table

	Switcher	Pusher	Long Haul
Auxiliary Storage Units (ASU)	•Large ~ 50 kWH •~800 kW •Combine ultracapacitors and batteries for dynamics	•Very large ~ 750 kWh •May combine ultracapacitors and batteries	•Only needed for startup •Small
Fuel Cells	•Supply average power •~38 kW	•Supply total shift energy •Large power ~ 1.5 MW	•High power •~ 2 MW •Use 4 – 500 kW

Locomotive Application 3 – Long Haul

- Long range
- High power for extended periods
- Few starts and stops

Continuing Work

- Optimizing between fuel cell and ASU
- Coordinating power flow
  - Between fuel cell and ASU (switcher and pusher)
  - Between multiple fuel cells (pusher and long haul)
- Developing fuel cell models
  - Accurate analysis of system
  - Better understanding of thermodynamic balance of plant