

Hydrail: Why Now?

3rd International Hydrail Conference
Catawba College, Salisbury, NC
August 13, 2007

Bob Rose
US Fuel Cell Council
Breakthrough Technologies Institute, Inc.



Fuel Cells 2000 / BTI

- U.S. nonprofit organization
- Established in 1993
- Promotes fuel cells from public interest perspective.
- Supported by foundations, grants and contracts
- www.fuelcells.org

US Fuel Cell Council

- Trade Association of the Fuel Cell Industry
- Supports commercialization for all applications
- Eight Working Groups
- International membership
- 110+ Members



A Call to Action



Burning Carbon

Burning carbon has brought us (most of us)
out of the darkness



Burning Carbon

- Resource consumption
- Despoilation
- Resource waste
- Air pollution - sickness
- Water pollution
- Dirt and grime - costs
- Building damage - costs
- Damage to plants and animals
- Reduced crop yields
- Atmospheric warming

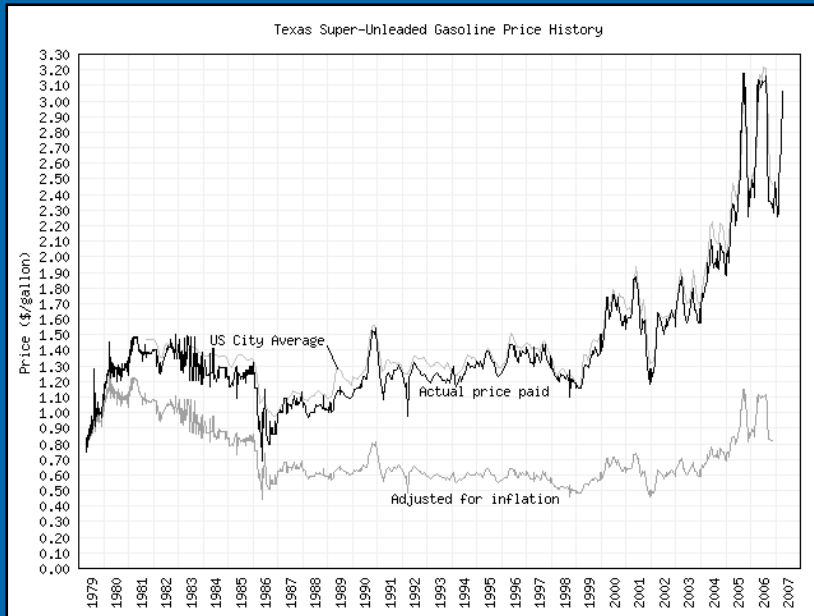


Geopolitical costs

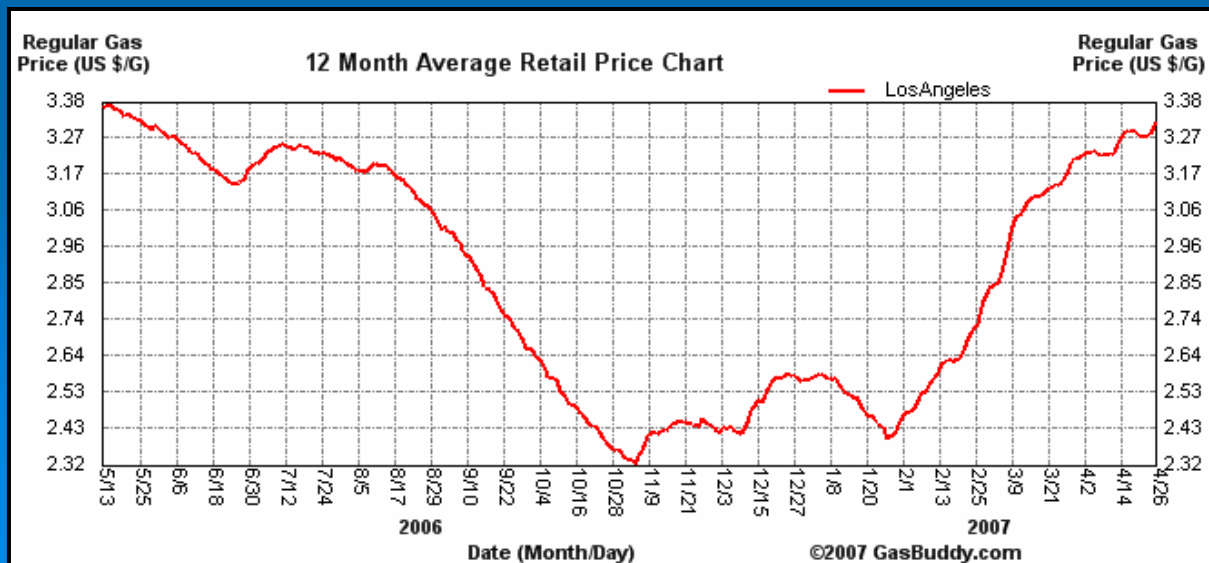
- Resource competition among nations
- Unequal economic prospects
- Supply anxieties



Economic costs



- Wealth transfer
- Corruption
- Price insecurity
- Cost of mitigation



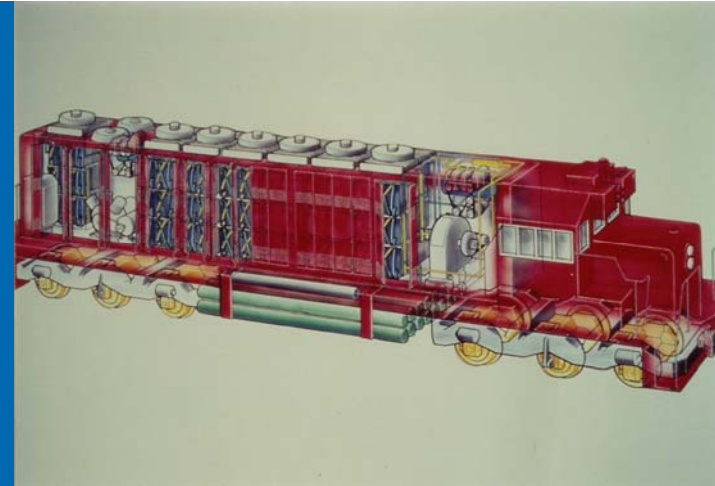
Our challenge

- Oil addiction*
 - US national security
 - Global Stability
 - Economic costs / energy competition
- Sustainable energy for growth
- Air, water and land pollution
- Global warming, climate instability

Not a cafeteria plan!

Solution:
Stop Burning Carbon





Fuel cells and hydrogen offer a pathway to low-carbon and ultimately zero carbon energy



Carbon Free Energy Future

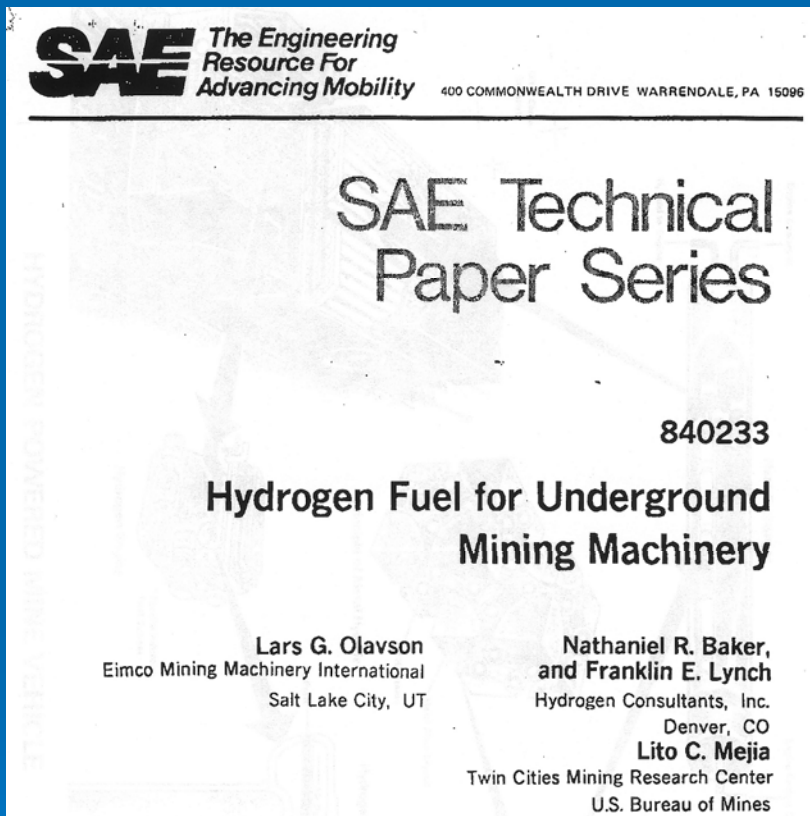
- Are we there yet? No
- Can we get there? Yes
- Will rail lead the way? Maybe
- What must we do to make the answer “Yes?”

A Long History



1957

A Long History



➤ 1970's

- Fuel Cells (JPL)
- Fuel Cells (EMD = Argonne)

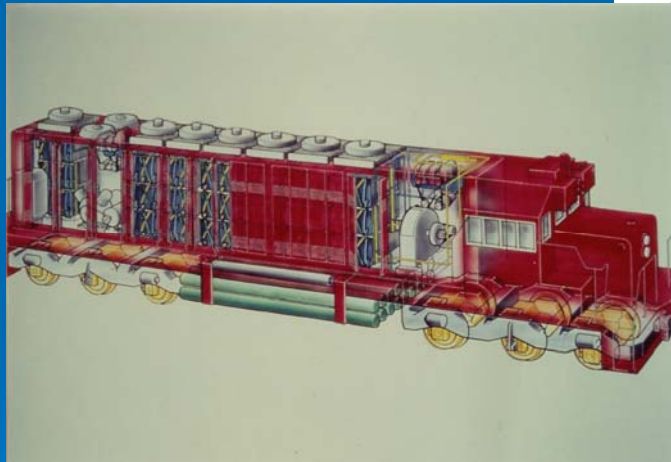
➤ Mid-80's

- Hydrogen combustion
- for mining
- Fuel cells (EMD, TRB)

Roger Smith (GM) committed to developing a locomotive in 1986

A Long History

- SCAQMD 1991-1995 ~50 participants
 - Preliminary spec
 - Potential applications: Switch Engines, Line Haul, APU



Ballard, SAIC



South Coast AIR QUALITY MANAGEMENT DISTRICT

21865 E. Copley Drive, Diamond Bar, CA 91765-4182 (714) 396-2000

April 9, 1991

South Coast Air Quality
Management District Board

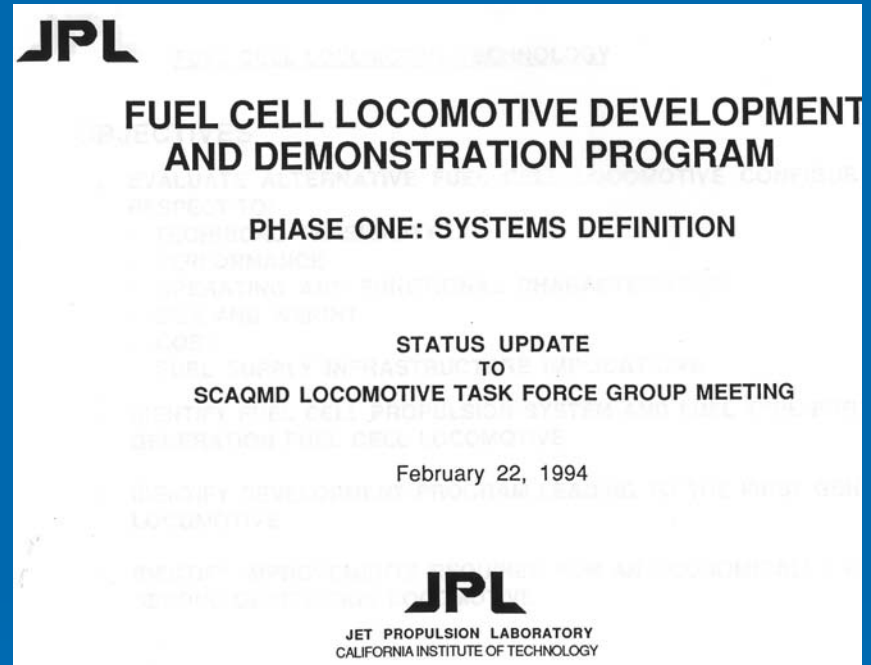
Recommendation to Establish the Locomotive Propulsion System Task Force

In the western United States, most locomotives use diesel engines to power electric drive systems. The electric motors for many locomotives in Europe, Japan, and the eastern United States are powered directly off the electricity grid through a system of overhead catenaries or underground cables. Regardless of the power source, basic electric propulsion systems are used in locomotives that haven't been significantly changed for many years.

Both the District and the Air Resources Board (ARB) have identified the need for progressively cleaner locomotive technologies in the Basin. The ARB is likely to

A Long History

- JPL Studies, 92-95
- 1995 conclusions:
 - LPG or clean diesel
 - NOT hydrogen
 - 45% efficiency
 - \$700-\$800 kW system cost
 - 2,000,000 mile durability



A Long History

RESEARCH AND DEVELOPMENT OF PROTON-EXCHANGE MEMBRANE (PEM) FUEL CELL SYSTEM FOR TRANSPORTATION APPLICATIONS

INITIAL CONCEPTUAL DESIGN REPORT

EDR 16194

Prepared for

Office of Transportation Technologies
Department of Energy

November 30, 1993

Under Sponsorship of U.S. Department of Energy
Contract No. DE-AC02-90CH10435



Allison
GAS TURBINE DIVISION
General Motors Corporation
P.O. Box 420
Indianapolis, Indiana 46206-0420



- US DOE
- Analysis in the 80's & 90's
- Appropriation 1994
- RFP 1995

Killed by program
managers

A Long History

- EMD/BTI Workshop ANL, 1998
- Briefing, AMTRAK, 2000

“What’s a fuel cell?”



A Long History

- 1990's: European Interest
- Siemens, ECN, LBST

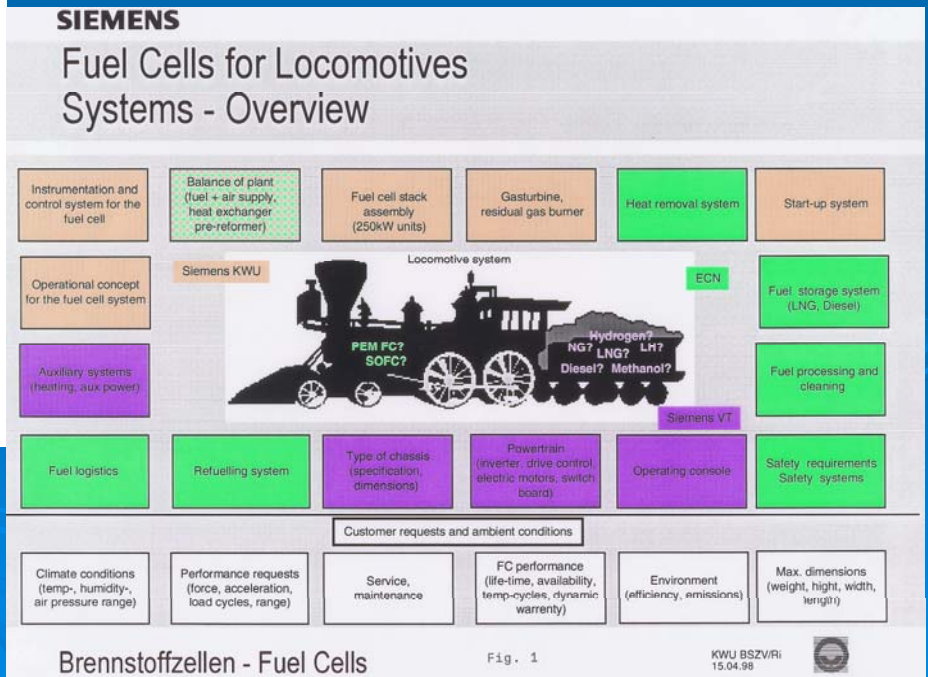
Fuel Cell Technology for Railway Vehicles

Interim Report

Stella Lindeke
Economic and Environment Division
UIC

for C12 Committee, UIC

December 1998



Some Players

- SAIC + Ballard
 - EMD, GE
 - UP, Santa Fe, BN
 - Amoco, Conoco, Unocal
 - JPL
 - Argonne
 - Allied Signal
 - UTC
- 

What Happened?

➤ Fuel cell industry

- Small market; No market?
- No apparent regulations driving market
- Distraction
- No/little research funding
- DOE withdrawal

What Happened?

➤ Advocates

- Technology readiness/lead time
- Prior commitment to other technologies
- Lack of customer interest
- Lack of developer interest
- Leadership

What Happened?

➤ Developers

- Technology readiness
- Prior investment in advanced technologies
- Lack of customer interest
- No coercive regulation
- Leadership moved on, retired

What Happened?

➤ Customers

- “radical” and new
- Cost-benefit
- Fuel inflexibility (remember GASRAIL?)
- No coercive regulation

Drivers Then, Drivers Now

- Compatible hybrid electric technology
- Weight less of a barrier
- Fuel tender possible
- Potential for increased efficiency (25% - 50%)
- Superior environmental performance
- quiet


Drivers Then, Drivers Now

- Developed and developing world expanding their systems
- China moving away from coal

Drivers Then, Drivers Now

- Potential economic case
 - Cost of electrification
 - Off-catenary expansion
 - modular – less costly to provide different power levels
 - Permits new configurations
- Regulatory pressure

New Economic Pressures

- In US, diesel costs increased 4X since 1990's
 - Security concerns: Grid failure kills the whole system
 - Cost of electrification
 - Operating Flexibility
- 

New Regulatory Pressure

- Pressure for regulation increasing
 - Ports and related infrastructure
 - “Environmental justice”
 - Particulate regulated as carcinogen (CA)
 - New concern about “ultrafines”
 - New concern about black carbon

Technical Progress

- 45% minimum efficiency vs 40%+
- \$700-800 kW vs PAFC, \$1500 (2008)
- Two million mile durability vs PAFC 80,000 hours (2008)
 - 1.6 million miles at 20 mph
- Fuel/Reformer?

JPL's cost of Diesel: \$4.68/mm Btu v ~\$16 today

Changing “Maybe” to “Yes”

- Technology
 - Durability
 - Cost
 - Settle fuel issues
- Economics
 - Fresh business case
 - Factor in new concerns
- Regulation
 - Pressure **MUST** be applied
- Leadership: That’s where **YOU** come in!

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