Fuel Cells: Available Today, Essential In Our Energy Future

Robert Rose
Fuel Cells 2000/
US Fuel Cell Council

Fuel Cells 2000/BTI

- U.S. nonprofit organization
- Leading non-aligned source for fuel cell information since 1993
- Award-winning services
- Education through outreach/publications/website
- www.fuelcells.org, www.fuelcellinsider.org

US Fuel Cell Council

- Trade Association of the Industry
- Supports commercialization for all applications
- Eight Working Groups
- International membership
- ~ 100 Members

An Emerging Industry

- 12,000+ units, 600+ vehicles

2006

- 22% gain to 8,647 employees.
- Global sales up 10% to $387 million
- Research spending up 4% to $829 million
  - voluntary reporting, 183 companies
- By 2030: 500,000 jobs (EU)
- By 2035: up to 1 million jobs (DOE – pending)

Public-Private Partnership

- Industry:
  - Research 2x to 3x government
  - Product development and commercialization
- Government:
  - Continued tax incentives for early purchasers
  - Strong research and technology validation component (cost, vehicle durability, fuel storage)
  - Consistent long term policy (EPACT 2005)

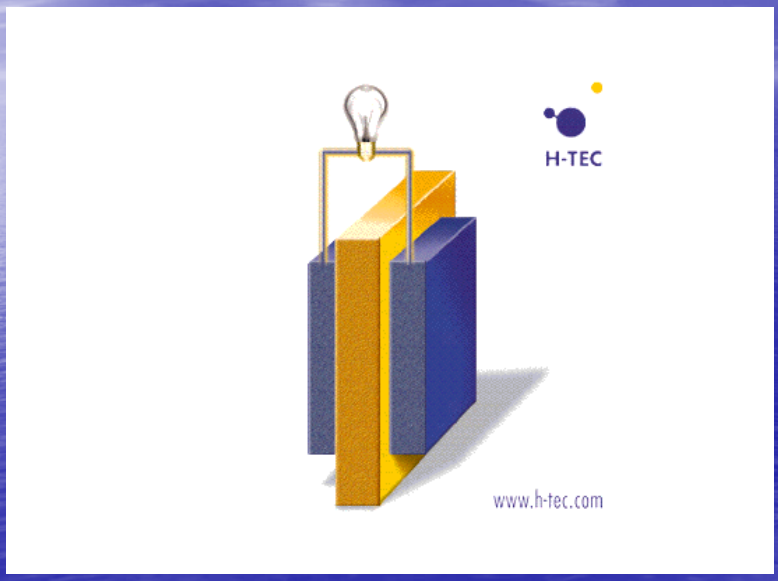
All the Options Need To "Win"

Fuel Cells - Defined

"Fuel Cells are electrochemical devices that convert the chemical energy of reaction directly into electrical energy."

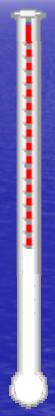
Fuel Cells: A Handbook

No Combustion



A Family of Technologies

Type	Efficiency	Operating Temp.
Solid Oxide	45-65%	800°C
Molten Carbonate	50%	650°C
Phosphoric Acid	40%	200°C
Alkaline	50-60%	80°C
Direct Methanol	40%	80°C
Polymer (PEM)	40%	50°C
Other		



Fuel Cells: Naturally Cleaner

- Low / Zero Emissions
  - Pounds compared to tons
- High Efficiency Emissions
  - 40%+ to 60% electrical, 80%+ CHP
- Low CO_2
  - Reductions of 40% with natural gas, up to 100%
- Wide Range of Applications
  - Grid independent, grid connected, grid support, battery alternatives, vehicles
- Wide range of fuels, including renewable fuels

Fuel Flexibility

Hydrogen
  Reformed from compounds
  Separated from water
Natural Gas - CH_4
Propane - C_3H_8
Reformed Methanol
Direct Methanol
Ethanol
Ammonia

Biofuels
Waste gases
Diesel / Jet Fuel (Military Priority)
Gasoline
Naphtha
Sulfur free distillate
Liquid Natural Gas

Road to Renewable

- Anaerobic digester gas – landfills, treatment plants, breweries
- Solar/Wind electrolysis
- Grassroots – homeowners installing PV/hydrogen systems

Fuel Cell Systems You Can Buy Today

- Available:
  - 200, 250, 400, 500 kW CHP
    - Multi-megawatt available with scaling
  - 1 - 25 kW Generators (PEM)
  - Educational Units
  - Battery chargers, APU's
  - Battery alternatives

Field Demonstrations

- Various Specialty sizes (PEM, SOFC)
- 1-10 kW residential units (PEM, SOFC)
- Telecommunications, 911/Radio Towers
- Small portable (PEM, DMFC)
- Battery alternatives
- Vehicles (early customers, USPS, FedEx)
- Materials Handling (Wal-Mart, Michelin, DOD, others)
- Residential (3000+ in Japan)

Performance

- Power generation systems in the field since early 1990's
  - Units achieving 65,000+ durability even in stand-alone operation
  - Some new units will carry 80,000 hour guarantee
    - 12 Units purchased for Ground Zero
  - Systems are saving money and carry other benefits
    - UPS at credit card processer (one outage loses $ millions)
    - Central Park Police Station (cheaper than grid electricity)
    - Postal Facility in Alaska (Saving $800,000 and avoiding downtime)
    - Sierra Nevada Brewery (Saved 20%)

Value

- Competitive today on life cycle basis
  - Backup systems, fork lifts
- Efficiency and reliability equate to energy savings over time
- *Combination* of benefits adds value
  - *Off grid capability, high reliability, flexible installation*
- Federal and (sometimes) state support
  - 30% federal installation incentive
- Costs are coming down
- Costs of competition is going up

Why Fuel Cells?

Portable Electronics Yearly Energy Usage

10,500+ W-hr

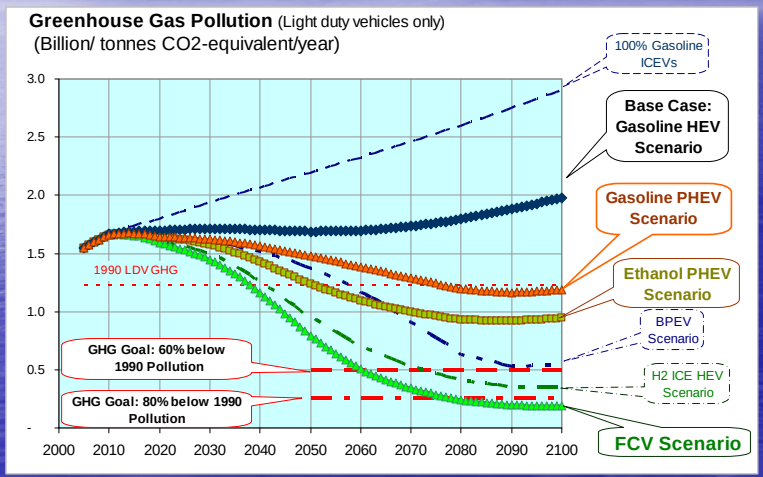
2010

Always On - Always Connected
3G – 4G
Large Color Displays
MP Camera & Flash
High speed data
TV-DBV
Games

In "High Power" mode more of the time

Motor Vehicles

All the Options Need to "Win"



NAS: Success Possible, Affordable

- "impressive technical progress"
- If biofuels, ICE + hybrids and FCV's all "win," motor gasoline demand could= zero
- Federal investment
  - $5 billion for RD&D
  - $8 billion for hydrogen infrastructure
  - $40 billion for vehicles (5 million by 2023)

The Next Generation

Toyota FINE-S

Honda
FCX

Exceptional Progress

- 600+ vehicles
- Honda: leasing in CA
- GM: 100+ vehicle consumer test

- 3X efficiency, 80 mpg+ (EPA)
- 500+ mile range
- Cold Start/vehicle storage
- Fuel Cell *and* H2 Cost reduction

Bus Demonstrations Worldwide

- CUTE: Europe
- Australia
- Iceland
- Tokyo
- CA, MI, FL

AC Transit reports 2x mileage, excellent performance

CH4 is a good interim feedstock

- Low carbon fuel (not low enough!)
- Mixed with water today to produce hydrogen – 50% renewable fuel
- 2x times cheaper than gasoline on energy equivalent basis
- Efficiency and emissions benefits in a fuel cell vehicle
  - (~30% CO2 benefit compared to Prius)

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