Fuel Cell Energy Solutions

September 28, 2011

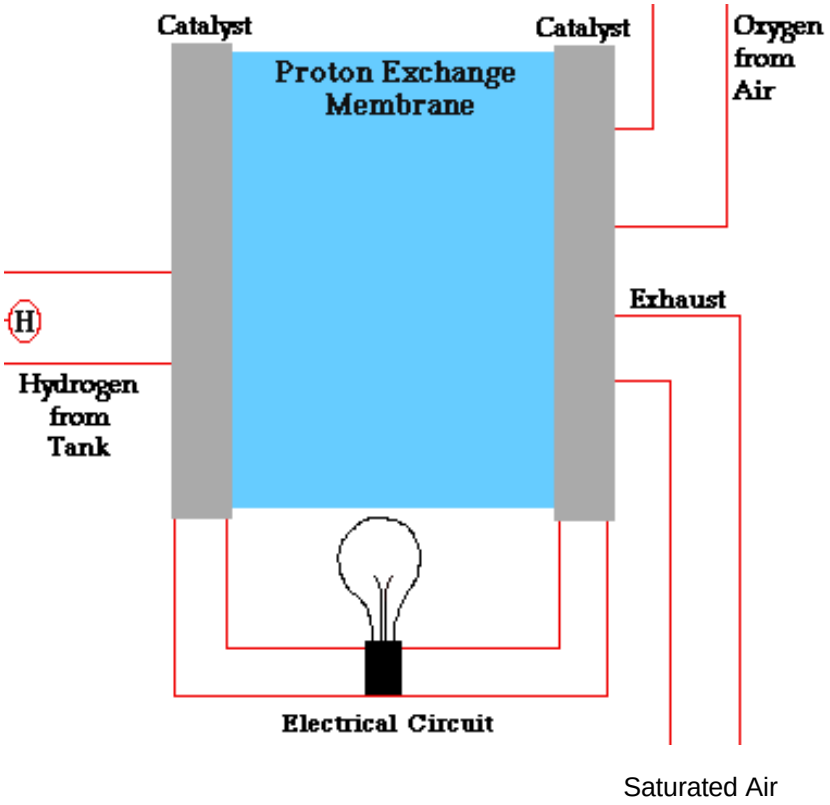
CommScope Cabinet Solutions

- **1972** Western Electric and Bell Labs begin cabinet manufacture
- **1984** AT&T – Bell Telephone divestiture
- **1996** AT&T spins off Lucent Technologies
- **2000** Lucent Technologies spins off Avaya
- **2004** CommScope acquires Avaya Cabinet Division

CommScope Cabinet Solutions

- Over 35 years experience
- Active Electronics and OSP Power Integrator
  - Over 400,000 units worldwide
  - Extensive Product Testing
- Success in Knowledge of the Network
  - Patents in thermal management, environmental protection, battery cooling, and electromagnetic interference shielding

Fuel Cell - PEM Technology

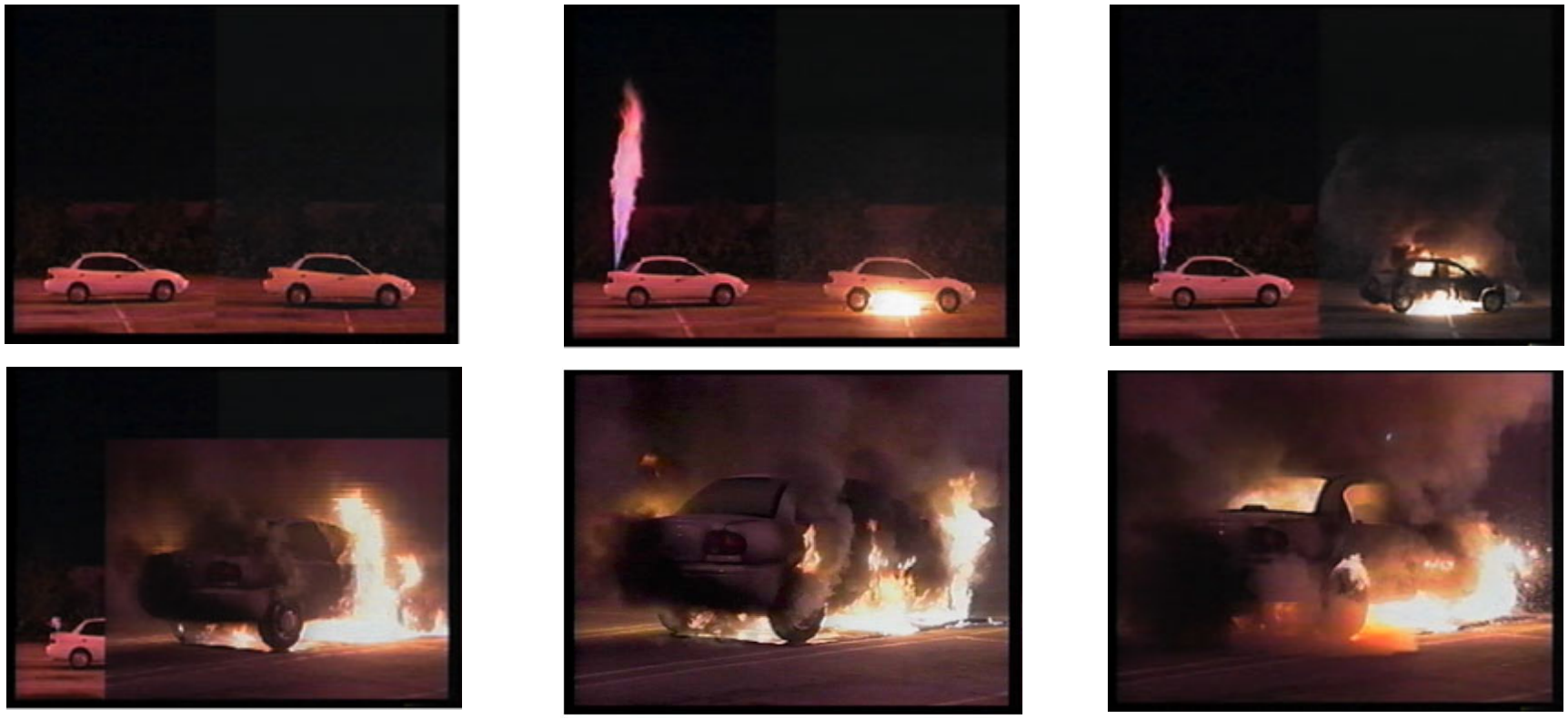


- A fuel cell is an electro-chemical conversion device that produces DC electricity, water and heat using hydrogen as fuel and oxygen in the air
- A device which produces continuous power as long as hydrogen and oxygen are delivered
- High efficiencies because chemical energy is converted directly to electrical energy

Understanding Properties of Hydrogen

Property	Hydrogen	Methane	Propane	Gasoline Vapor
Buoyancy (density relative to air)	0.07	0.55	1.52	3.4 - 4.0
Molecular Diffusion Coefficient (cm^2/sec)	0.61	0.16	0.12	0.05
Flammability range (vol % in air) LFL - UFL	4.1 - 75	4.7 - 17	1.7 - 10	1.4 - 8
Explosive range (vol % in air) LEL - UEL	18 - 59	5.7 - 14	2.7 - 7	1.4 - 3
Most easily Ignitable Mixture (vol % in air)	29	9	5	2
Explosive energy (relative to H2 by vol)	1	3.5	10	22 +

Hydrogen Safety

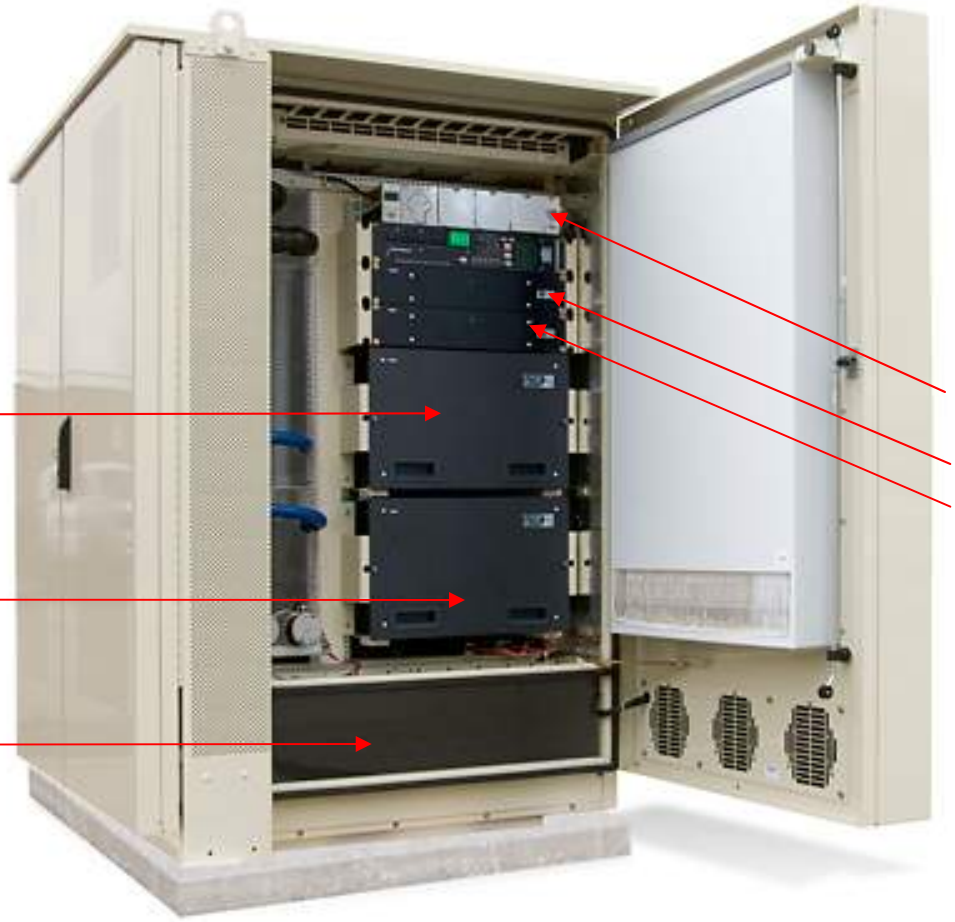


- **Fuel Leakage Simulation conducted by Dr. M. Swain, University of Miami**
- **Hydrogen Fuel Cell vehicle shown on left side, Gasoline powered vehicle shown on right side**
- **The Hydrogen powered vehicle was undamaged; the Gasoline powered vehicle had severe damage**

Hydrogen Fuel Cell Safety Standards

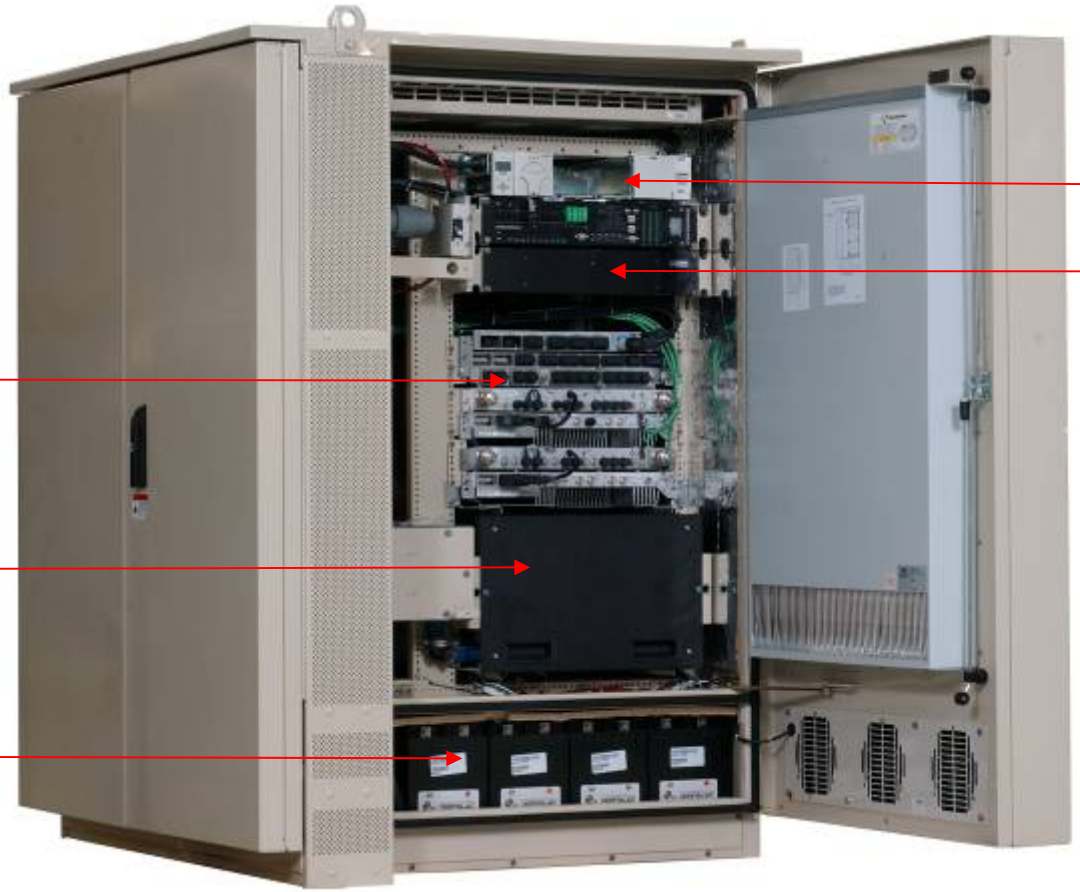
- ANSI/CSA America FC1-2004, Stationary Fuel Cell Power Systems
- NFPA 853 – Standard for Installation of Stationary Fuel Cell Power Plants, 2003
- NFPA 55 – Standard for Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Container, Cylinders, and Tanks, 2005
- NFPA 496 – Standard for Purged & Pressurized Enclosures for Electrical Equipment, 1998
- CGA E-11 – Standard for Stationary Compressed Gas Cylinder Discharging Manifolds for Working Pressures up to 3000 PSI
- CGA – G-5.4 – Standard for Hydrogen Piping Systems at Consumer Locations
- ASME/ANSI B31.3 – Process Piping Code

8kW and 16 kW Gen 1 Fuel Cell Cabinet



Cabinet dimensions: W 45” (1143mm) x D 52” (1321mm) x H 63” (1600mm)

8kW Gen 1 Fuel Cell with Integrated Radio



Cabinet dimensions: W 45” (1143mm) x D 52” (1321mm) x H 63” (1600mm)

Stand Alone Hydrogen Storage Cabinet
(16 cylinders – 128 kWh of backup)

1.1m (W) x 1.2m (D) x 1.6m (H)

- (16) Standard cylinders configured in two banks of eight
- Automatic switchover from one bank to another
- Pressure regulator, manifold, flexible hoses, check valves, and safety relief valve included
- Provides 8 hours of backup for 16kW load or 16 hours of backup for 8 kW load
- Storage Cabinet can be located next to the Fuel Cell Cabinet or up to 300 feet away
- Hydrogen pressure continuously monitored. Automatic e-mail alert is sent to hydrogen distributor when a bank is nearing depletion

Gen 2 Fuel Cell Solutions

- Cabinet Dimensions
  - W: 45.3 in (1150 mm) with 8 cylinders
  - W: 28 in (711 mm) without cylinders
  - D: 38 in (965 mm)
  - H: 72 in (1829 mm)
- Fuel Cell
  - Max Power: 5kW, 8kW, 10kW or 16kW
  - Voltage: 42-56 VDC or 21-29 VDC
  - Output connected directly to load (no DC-DC converter); reduces complexity and improves system efficiency
  - Optional integrated hydrogen storage space for (8) cylinders providing 64 kWhrs of backup power (shown)

Gen 2 Fuel Cell Solutions

Shown with optional integrated
8 cylinder compartment
W 45” (1150mm) x D 38” (965mm) x 72” (1829mm)

Shown without optional integrated
8 cylinder compartment
W 28” (711mm) x D 38” (965mm) x 72” (1829mm)

Hydrogen Availability and Supply

- Hydrogen is readily available at a relatively low cost – Electrolysis or Chlor-Alkali plants are typical sources
- Chlor-Alkali plants manufacture chlorine and caustic soda, which are base chemicals for a variety of different industries – textile, plastics, detergents, etc.
- Pure Hydrogen is a by product of Chlor-Alkali plants
- Over 3200 Hydrogen distribution centers in US. Hydrogen cylinders are delivered on site by hydrogen distributors

Alarms (abridged list shown)

- **Cabinet**
  - **Door Intrusion**
  - **Power Major – DC Power Plant**
  - **Power Minor – DC Power Plant**
  - **AC Fail / Battery on Discharge**
  - **Miscellaneous Minor**
- **Fuel Cell**
  - **Fuel Cell Major**
  - **Fuel Cell Minor**
  - **Low Fuel**
  - **Miscellaneous Minor**
- **Above alarms reported as contact closures (dry contacts)**
- **Ethernet also available**

Fuel Cell – Customer Objectives?

- **Why interested in hydrogen fuel cell technology?**
  - Reduce CO2 emissions
  - Reduce energy consumption
  - Minimize impact on environment by transitioning to a low-carbon renewable energy
  - Tax credits
  - Reduce maintenance costs
  - Reduce truck rolls to site
  - Eliminate batteries
  - Eliminate diesel generators
  - Lower TCO
  - Remote monitoring of available backup power
  - Eliminate or reduce diesel fuel usage
  - Reduce footprint
  - Quicker power backup start times
  - Unlimited start/stop cycles
  - Unlimited shelf life
  - Reliability
  - Efficiency

Fuel Cell – High Level Technical Requirements?

- **What are the basic technical requirements?**
  - Total power demand of site
  - Frequency of outages
  - Duration of outages
  - Existing or new sites
  - Lease or own sites
  - Shelter or outdoor cabinets
  - Outdoor, indoor, pad or rooftop
  - Number of sites
  - Geographical location of sites
  - Available space
  - Operating voltage (24V or 48V)
  - Deployment schedule
  - Decision process
  - Critical price points
  - ROI parameters

CONCLUSION

POWER BACKUP SOLUTION OF THE FUTURE
AVAILABLE NOW

CLEAN, EFFICIENT AND RELIABLE!

Thank You