

# NUVERA

FUEL CELLS

THE FUTURE OF ENERGY®

## Introduction to Nuvera Fuel Cells

Presentation to

hydrail conference  
May 6, 2005



milan italy | cambridge usa

**Nuvera Confidential**

[www.nuvera.com](http://www.nuvera.com)

# Company Background



**Global Developer ::  
PEM Fuel Cell Systems**



**Commercialization Approach ::  
Multi-Product Platform**

- Hydrogen Power Systems for Industrial Vehicles and Equipment
- Natural Gas Power Systems for DG, Cogeneration
- On-Board Gasoline Fuel Processors and Fuel Cell Stacks for Automotive

## Corporate Shareholders

AMERADA HESS CORPORATION



GRUPPO DE NORA



**RENAULT**

# Strategic Market Focus Summary

Market		Nuvera Approach
Industrial Power	Industrial Vehicles & Equipment, Chlor Alkali	OEM Businesses H2e™, FORZA™, PowerTap™
Distributed Generation	CHP	Fully Integrated Fuel Cell Power Modules "Avanti" (with distribution partners)
Automotive	Light Duty	Nuvera Automotive Platform Fuel Cell or Fuel Processor Component Supplier

Commercialization  
Timeframe

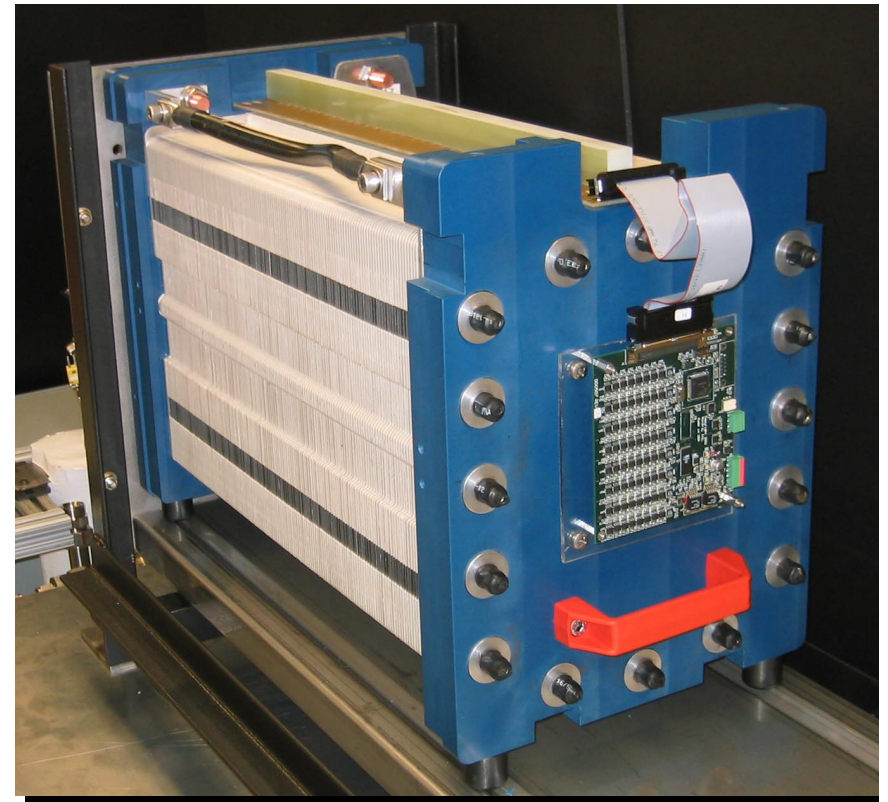
2005 – 2007

2007 – 2008

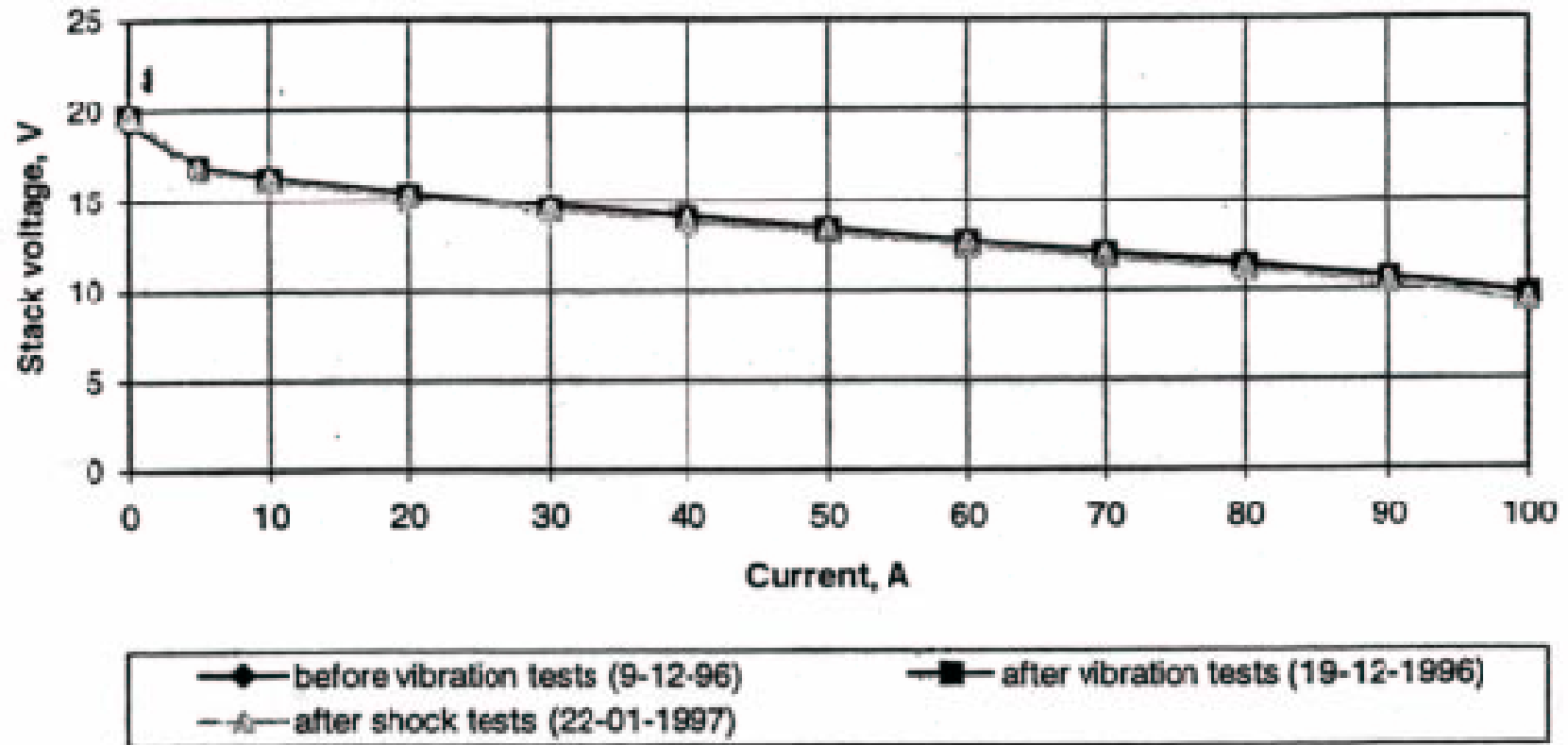
2010 

# Nuvera's PEM Stack Differentiators

- ➔ **Metallic Bipolar Plate**
  - Low Cost
  - Thinner than graphite
  - Robust, resistant to shaking and vibration
- ➔ **Servicability Via Replaceable cells**
- ➔ **Direct Water Injection (DWI) Advantages**
  - Low Cost
  - Durability



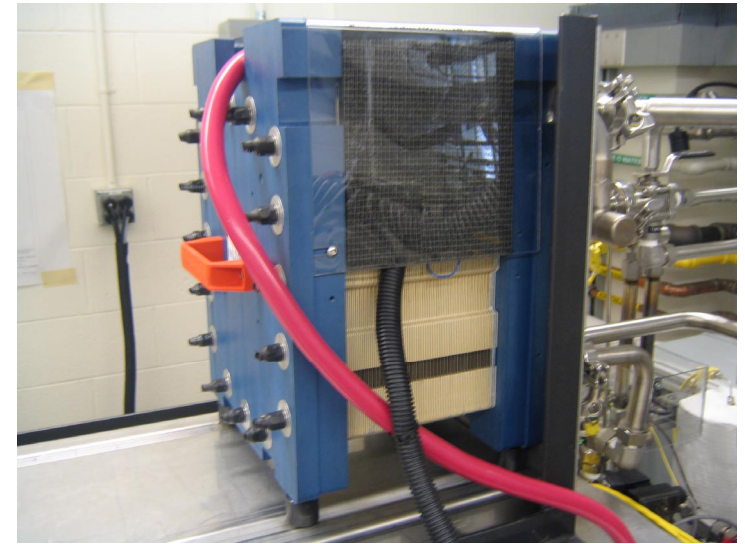
# Shock & Vibration Data (Danish Navy)





# Stack Durability – Lab and Field Data

- Over 5,000 hr laboratory operation of the fuel cell
- 2 microV/h/cell voltage decay rate projects to a 36,000 hour life



- 4,500 km of field testing – Fiat FCV with Nuvera Stack
- 1V decay (out of 264V) over 4,500 km

# Fuel Cell Advantages for Locomotives

## ➔ Over Diesel Engine

- Torque
- Efficiency
- Noise
- Emissions

## ➔ Over Batteries

- Energy Capacity
- Recharge Time

**fuel cells have particular advantage in non-attainment areas**

# Fuel Cells for Locomotives

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- ➔ Higher capital cost than diesel electric or AC traction

**BUT**

- ➔ Less than 20% difference in life cycle cost
  - Initial capital cost
  - Fuel production and delivery
  - Locomotive O&M



# Experience With Locomotive Applications

Both projects are managed by Vehicle Projects, LLC



- **3.6 ton mining locomotive**
- **17 kW Nuvera's PEM fuel cell**
- **Successful operation in harsh conditions**



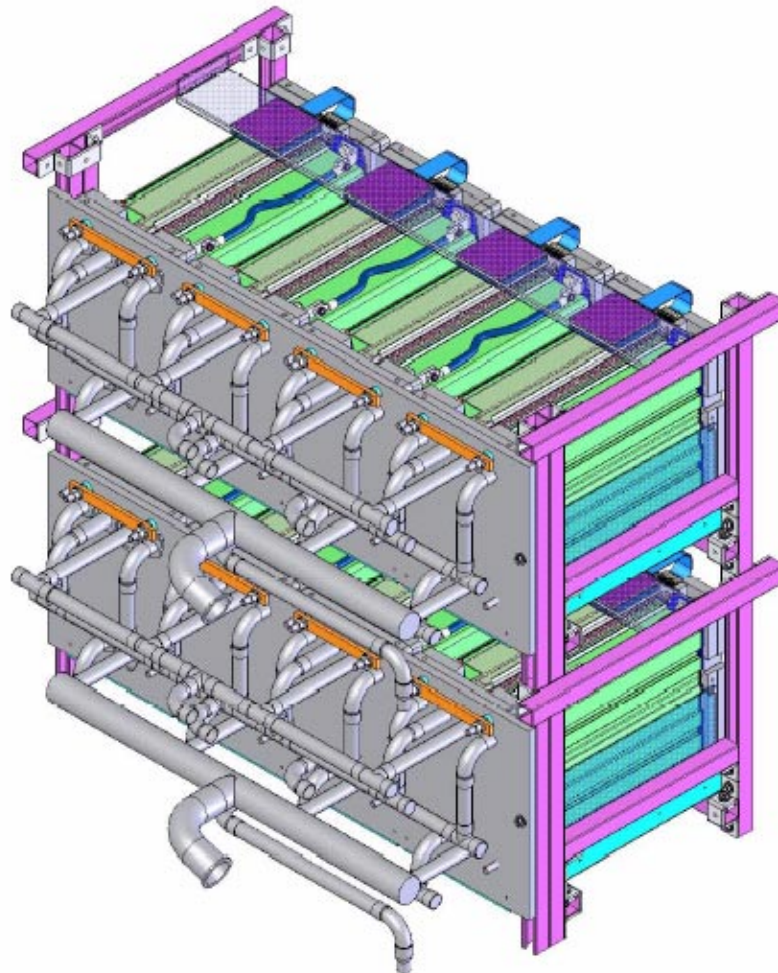
Caterpillar-Elphinstone diesel base vehicle

- **23 ton mine loader**
- **90 kW Nuvera's PEM fuel cell**
- **Testing to commence soon**

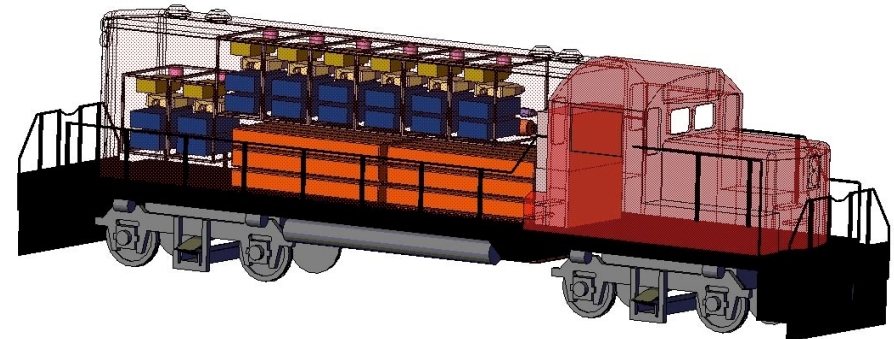
**Our experience with locomotive applications is second to none**

# Defense Locomotive With Nuvera's 1.2 MW PEM Fuel Cells

*Largest PEM fuel cell vehicle in the world!*



- Eight stacks of ~19 kW each
- Eight power modules
- DWI technology
- metallic bipolar plate



Conceptual design of fuelcell road-switcher employing 1.2 MW PEM fuelcells (blue) and storage of 250 kg of hydrogen as a reversible metal-hydride (orange)

# Contact

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**Prashant S. Chintawar**  
**Executive Director**  
**Nuvera Fuel Cells, Inc.**  
**T (617)245-7560**  
**F (617)245-7511**  
**[chintawar.p@nuvera.com](mailto:chintawar.p@nuvera.com)**

***We will lead the hydrail revolution!!***