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*DOE Natural Gas/Renewable Energy  
Hybrids Workshop  
Session II*

**H. Frank Gibbard, CEO  
H Power Corp.**

**Hydrogen Fuel Cell Systems**

National Renewable Energy Laboratory  
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# *Agenda*

- ◆ H Power and its business
- ◆ Hydrogen-powered fuel cell hybrids
- ◆ Backup systems for telecommunications and other uses
- ◆ Stationary power from renewable resources

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# *What is H Power Corp.*

- ◆ Founded 1989
- ◆ Headquarters in Clifton, NJ
- ◆ Production Facilities: Belleville, NJ & St. Laurent, Quebec
- ◆ Leading developer of proton-exchange membrane (PEM) fuel cells
  - International company with over 200 employees
- ◆ Large and growing target markets
  - Rural, residential and backup power
  - Portable and mobile power
  - Telecommunications backup power
- ◆ First to commercialize PEM fuel cells – sale to NJ DOT
- ◆ \$81 million contract for residential fuel cell product



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# *Our Product Sectors*

- ◆ We design and manufacture PEM fuel cell systems ***with immediate commercial markets.***

## 1. On-Site Stationary Power Units (1-25 kW)

Homes

Farms

Small Businesses

Backup Power

## 2. Portable and Mobile Power Units (sub-kW and multi-kW)

Communications

Battery Replacement

Range Extenders for Specialty Vehicles

Non-propulsion Transportation

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# *Practical Fuel Options for Today's Target Markets*

- ◆ Hydrogen, for portable, mobile and backup fuel cell systems
  - Compressed gas
  - Metal hydride storage
- ◆ Stationary, residential power
  - Propane, for rural residences, far from the grid
  - Natural gas, for areas with gas pipeline service

# Field Experience – Variable Message Sign

PowerPEM  
VMS50  
Variable  
Message  
Sign Backup  
Power Unit



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# *VMS Field Experience*

- ◆ About 70 years of years of field experience accumulated on 55 units
- ◆ Time in service ranges from 1 to 4 years
- ◆ No sign failures attributable to fuel cell system failure
- ◆ Comprehensive inspection revealed some system problems, mostly due to faulty maintenance procedures

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# *PEM Fuel Cells for Telecom Backup Power*

- ◆ Advantages over batteries:
  - Smaller, lighter, nontoxic, lower maintenance, higher reliability, greater high-temperature tolerance
- ◆ Advantages over generator sets
  - Quieter, lower maintenance, no toxic emissions
- ◆ Some auxiliary power source needed for “instant-on” operation
  - Small battery, supercapacitors, flywheel

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# *PEM Fuel Cells for Telecom Backup Power*

- ◆ Fuel considerations
- ◆ Natural gas
  - Unlimited operation time if supplied by pipeline
- ◆ LPG
  - Long operating time (dense energy source)
  - Requires fuel replenishment
- ◆ Hydrogen
  - Enables smaller, less expensive, more reliable operation
  - Startup time in seconds or minutes vs. 0.5 hour for hydrocarbon fuels with fuel processor
  - Requires fuel replenishment unless combined with electrolyzer

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# *H Power and Air Products Cooperation*

- ◆ Hydrogen fuel infrastructure – a major enabler of PEM fuel cell commercialization
- ◆ H Power has products and prototypes that can operate on hydrogen gas, from 50 W to 10 kW
- ◆ Air Products is the world's leading supplier of hydrogen as the compressed gas

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# *H Power and Air Products Cooperation*

- ◆ Marketing studies to define major commercialization opportunities
- ◆ Areas of concentration
  - Telecommunications backup power
  - Portable and mobile systems from 50 W to 1,000 W
- ◆ Goal: create a business that installs, monitors, and services hydrogen-powered fuel cells for multiple applications

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# *Field Experience*

## *100-W Systems for Telecom Backup*

Packaged 100 W Power  
Supply Containing Stack and  
Air Pump being Supplied to  
Fortum (formerly Neste) in  
Finland for Remote  
Telecommunications  
Photovoltaic System Backup



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# *Fortum (Neste) Packaged Fuel Cell Photovoltaic Backup System*



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# *Fortum Test System*

- ◆ Tests of H Power Fuel Cell Subsystems Conducted in Finland Since 1996
- ◆ Photovoltaic array rated at 100 W
- ◆ Battery: 12V, 100 Ah
- ◆ Load: 12 V, 10 W
- ◆ Fuel Cell: Airbreathing stack, 1996-97, pumped air 1998-present
- ◆ Hydrogen Storage: two, 50-liter/200 bar

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# *Fortum Test Site*



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# *Field Experience of Fortum*

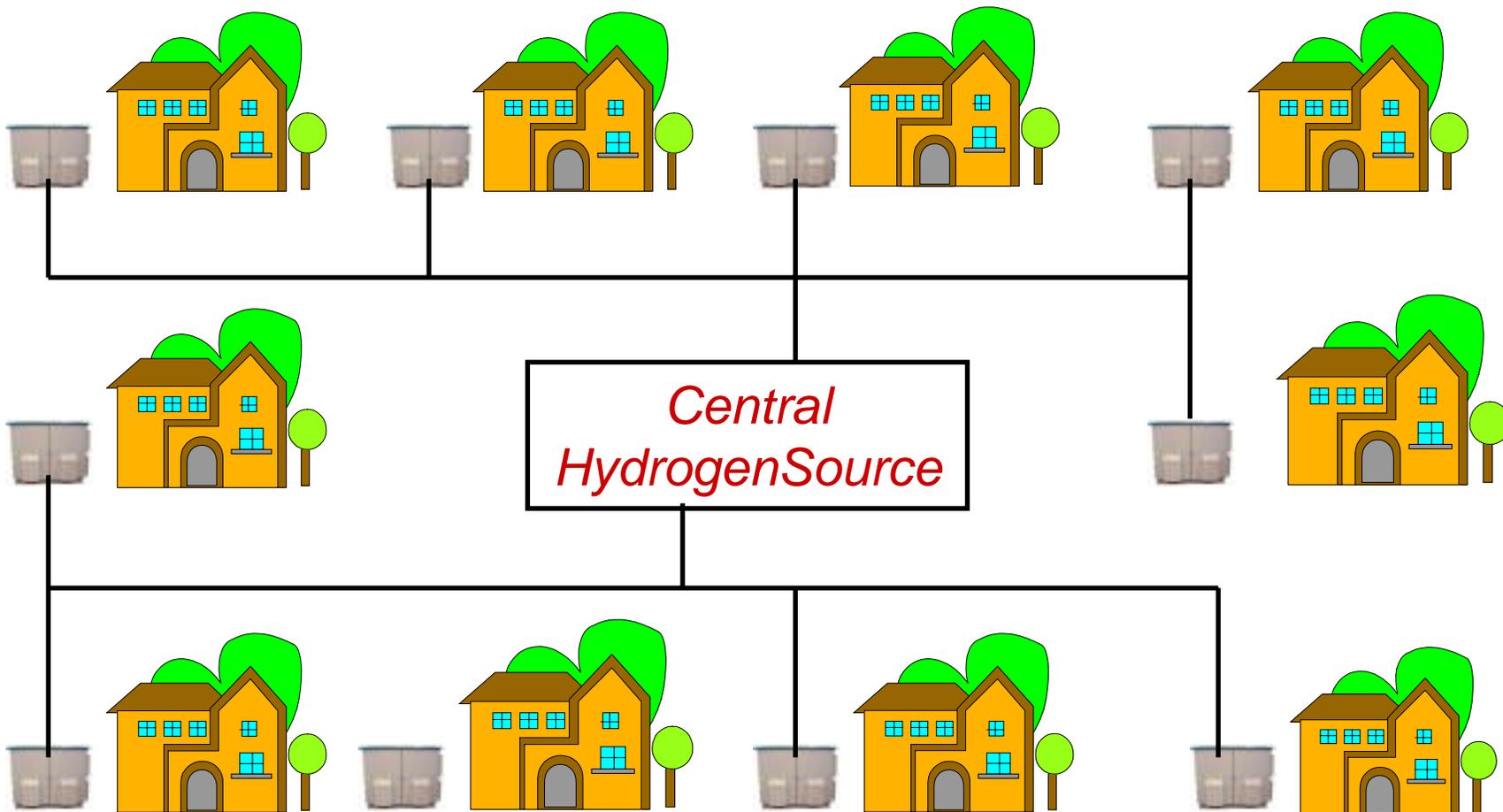
- ◆ “A PV system with a fuel cell based back-up is technically a very promising candidate for small loads in high latitudes if the system price can be made reasonable.”

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# *Central Hydrogen Generation, Distributed Fuel Cells*

- ◆ Generate Hydrogen by Renewable Methods:
  - Biomass
  - Solar PV + Electrolyzer
  - Wind + Electrolyzer
- ◆ Generate Hydrogen from Fossil Fuel
  - Steam reformer
- ◆ A few hydrogen pipelines exist; fuel cell generators for stationary power using this fuel could make electricity for only about \$0.04/kWh based on fuel cost alone.

# Distribute Hydrogen, Not Electricity



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## *Using a Waste Stream of Hydrogen in a Cogeneration System*

- ◆ Fortum Oy/NAPS integrated an H Power fuel cell into a 3-kW residential cogeneration system
- ◆ Waste hydrogen from a chlor-alkali plant was available
- ◆ The system delivered:
  - 3 kW of electricity
  - More than 3 kW of heat for hot water
  - Surplus electricity to the available electric grid
- ◆ This demonstration could be a stand-in for a variety of hydrogen-generation technologies



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# *Use of Hydrogen from Renewable Resources*

- ◆ Use solar PV or wind power, with excess stored through electrolysis as hydrogen
  - Advantage: any quantity of energy can be stored by varying tank capacity or hydride amount
  - Disadvantage: round-trip electrical energy efficiency is low compared to batteries or pumped hydro; total energy recovery can be improved through CHP
- ◆ Biomass conversion to hydrogen-rich fuel
  - Advantage: closes the carbon cycle
  - Disadvantage: pure, high-quality hydrogen steam required

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# *Conclusions*

- ◆ Hydrogen-based hybrid fuel cells systems have been commercialized using solar power, batteries and FC's
- ◆ Hybrid vehicles with on-board battery chargers and range extenders have been demonstrated
- ◆ A stationary power fuel cell system working with a waste hydrogen stream, and with net metering, has been demonstrated