PEI Wind-Hydrogen Symposium
Charlottetown, PEI
June 22-24, 2003

HYDROGENICS

clean efficient quiet versatile hydrogen

The Wind-Hydrogen and Fuel Cell Opportunity

Jonathan Dogterom

Contents

- Introduction to Hydrogenics
  - Products and Strategy
  - Regenerative Systems
  - Value Proposition
- Hurdles to Fuel Cell Adoption
- Hydrogen Infrastructure
  - Methods of Production
  - Centralized or Distributed
- Benefits of Combining Fuel Cells and Wind Turbines
- Hydrogenics' Recent Achievements and Near-term Goals

Hydrogenics Corporation

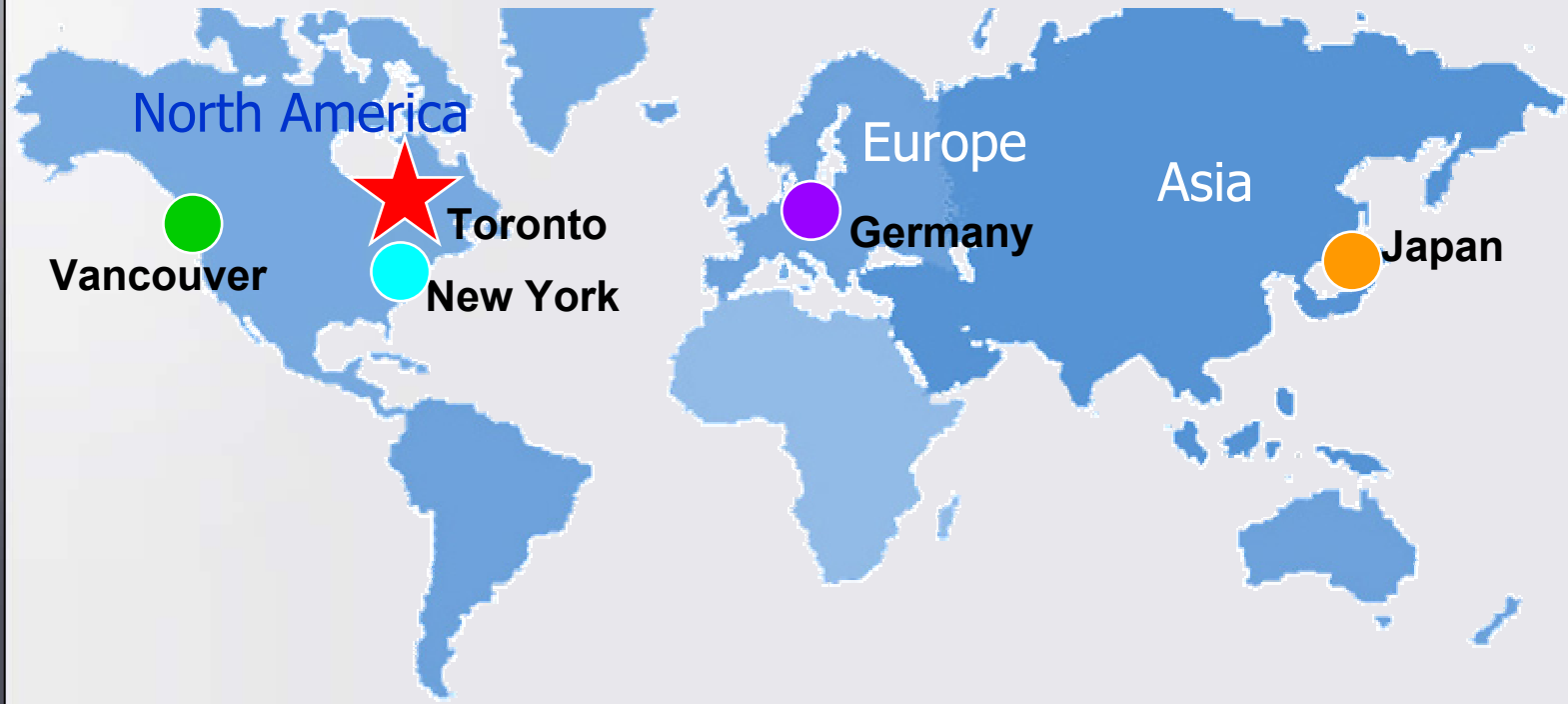
Our mission is to accelerate the development and commercialization of

Fuel Cell Technology

for clean power generation.

To achieve this, our team continually seeks out viable markets and finds innovative ways to integrate this technology into operational systems efficiently with maximum results.

International Sales & Service Network



- Hydrogenics – Toronto Headquarters
- Hydrogenics – Vancouver, B.C.
- Hydrogenics – New York Office
- Hydrogenics – Japan Office
- Hydrogenics – Europe (Germany)

Two Strategic Business Units

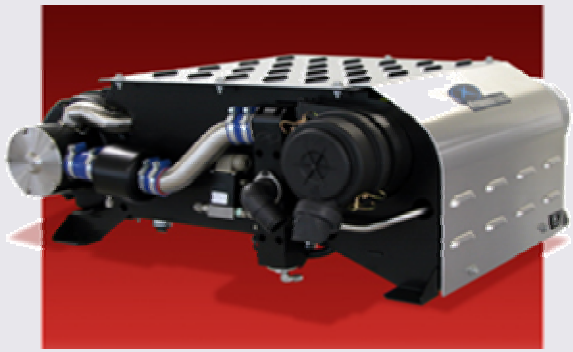
Test Products

- Equipment
- Testing Services

GREENLIGHT power technologies

Power Products

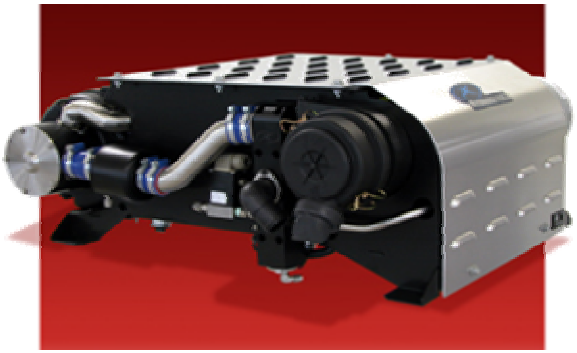
- Power Generation
- H_2 Generation
- Engineering Services
- Seal - in - Place



HYDROGENICS

Power Products based on Two Building Blocks

Fuel Cell Power Modules



- DC power & water (H_2O)
- 500 W to 60 kW (out)

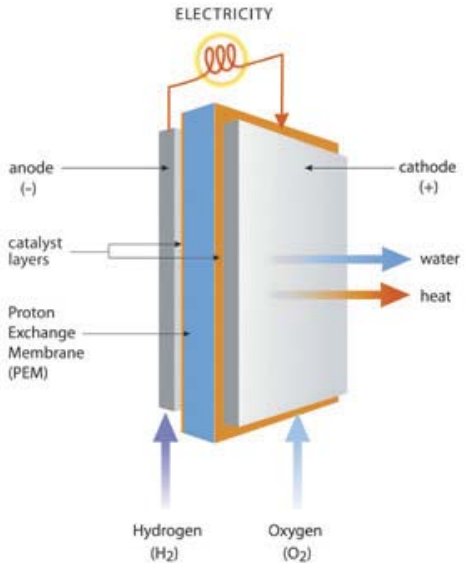
Electrolyzer Modules

- H_2 gas and O_2
- 4kWe to 140 kWe (in)

Fuel Cell Power

From Cells to Stacks to Power Modules

The PEM Fuel Cell



- **Single cell provides only emission is heat and water**

The Fuel Cell Stack

- **Multiple cells layered to create a stack**

The Fuel Cell Power Module

- **Heat and water mgmt**
- **Gas humidification**
- **S/W and H/W controls**
- **Power conditioning**
- **Fuel mgmt**

HYDROGENICS

Two-Pronged Fuel Cell

Distribution Strategy

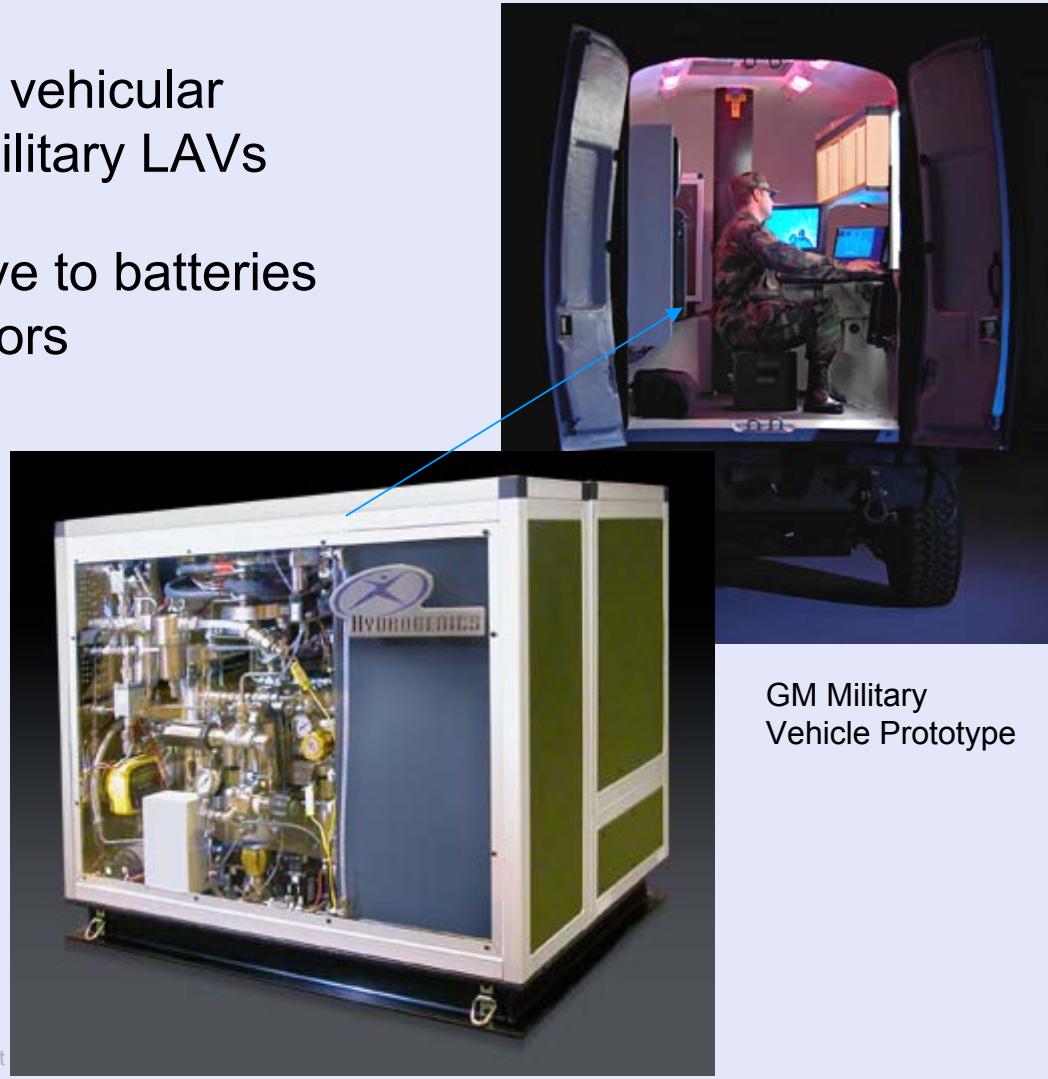
1. **Modules integrated into Original Equipment Manufacturer products**

2. **Complete operational systems delivered to end-users**

HyPORT- E

5 kW Regenerative Fuel Cell Auxiliary Power Unit

- Auxiliary power for vehicular applications e.g. Military LAVs
- Attractive alternative to batteries and diesel generators
- Modular and scaleable



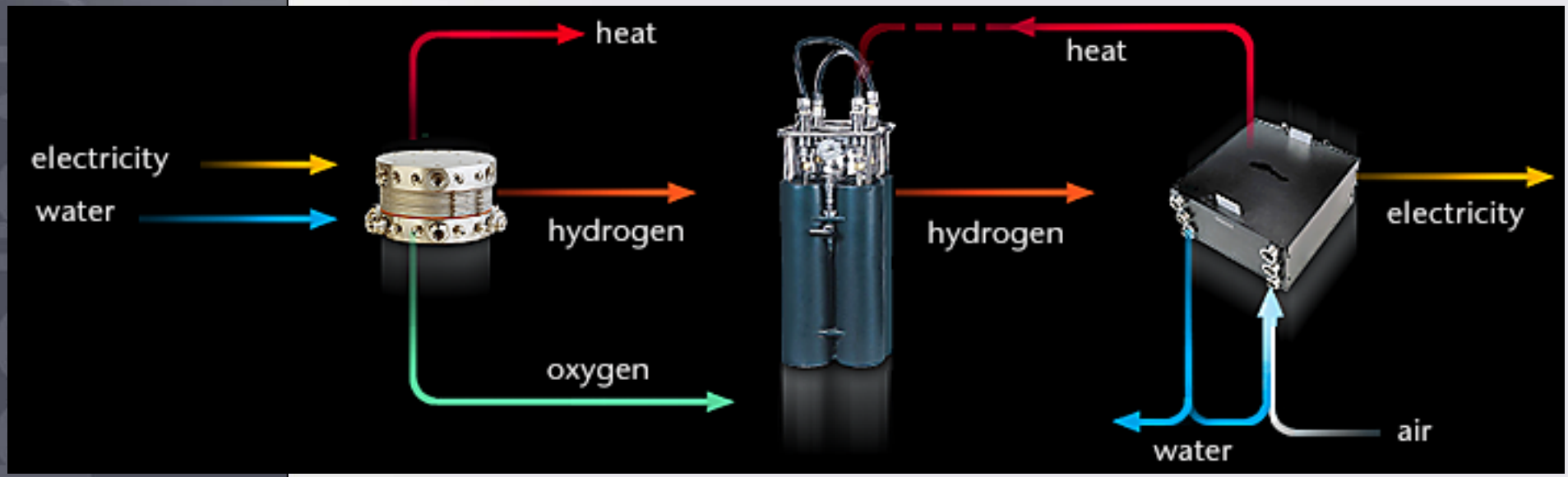
GM Military Vehicle Prototype

Regenerative Fuel Cell Systems

Today's self-fuelling solution for intermittent applications

Hydrogen Generation
(Electrolysis)

Power Generation
(Fuel Cell)



A truly sustainable energy solution when used with solar, wind or hydro-electric power

HYDROGENICS

Providing Value Propositions for Fuel Cells

SOCIO-POLITICAL & ENVIRONMENTAL BENEFITS INCLUDE:

- Reduced dependence on foreign oil supplies
- Enabling large scale adoption of renewable & clean energy sources
  - Sunlight, wind, run-of-river hydro, geothermal, nuclear

HYDROGENICS

Hurdles to adoption of fuel cells

- High cost
- Lack of hydrogen infrastructure
- Unproven durability
- Hydrogen storage issues
- Undeveloped codes and regulations regarding safety
- Undeveloped codes and regulations regarding installation & operation

- In order to introduce fuel cells into viable markets today we must develop value propositions where there is market pull based on the benefits that fuel cells offer

Hydrogen Infrastructure

Key considerations affecting implementation

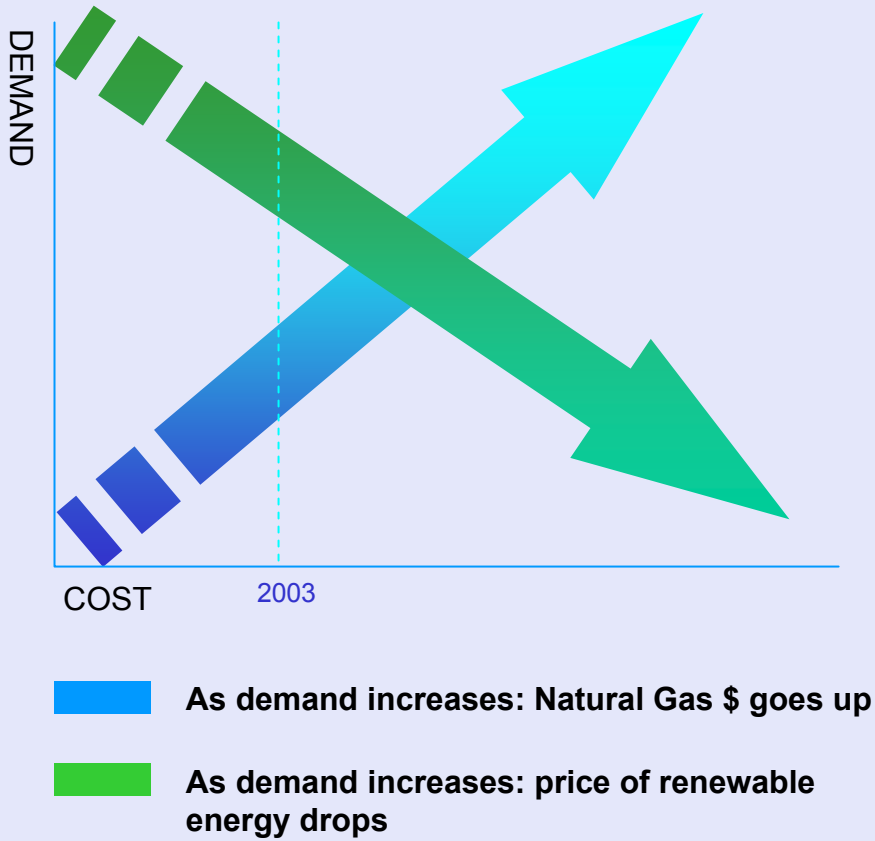
- Methods of Production
  - Hydrocarbon Reformation – Natural Gas
  - Electrolysis - Electricity
    - Grid Power
    - Renewable Energy
  - Depends on Localized Commodity Price and Availability

- Centralized or Distributed
  - Location and Application Specific

HYDROGENICS

Outlook on Hydrogen Production Cost

- Renewable energy provides a stable and continually decreasing cost for hydrogen production.
- The cost of natural gas is continually rising (and will continue to rise as reserves are consumed).



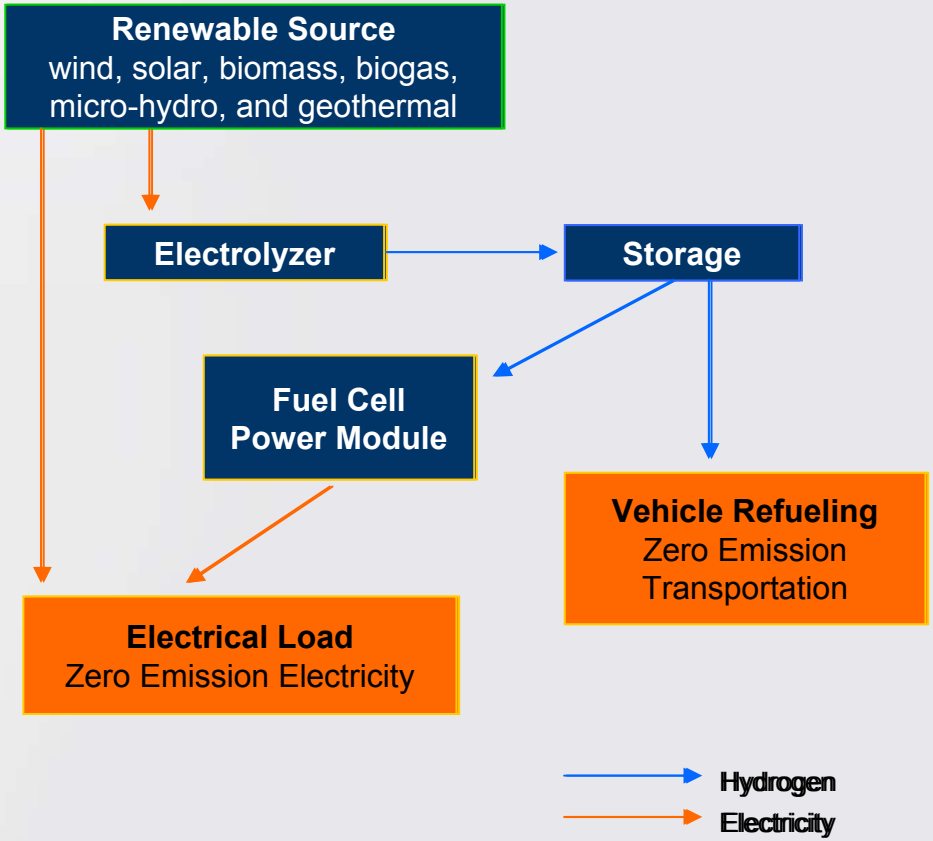
Progress moves towards Decentralization

Industry	Decentralization Trend			Consumption Trend
Communication	Landline	→	Wireless	↑
Computing	Centralized Mainframe	→	PC	↑
Power	Centralized Generation	→	Distributed Generation	↑
	Low $ / performance	→	**High $ / performance**	

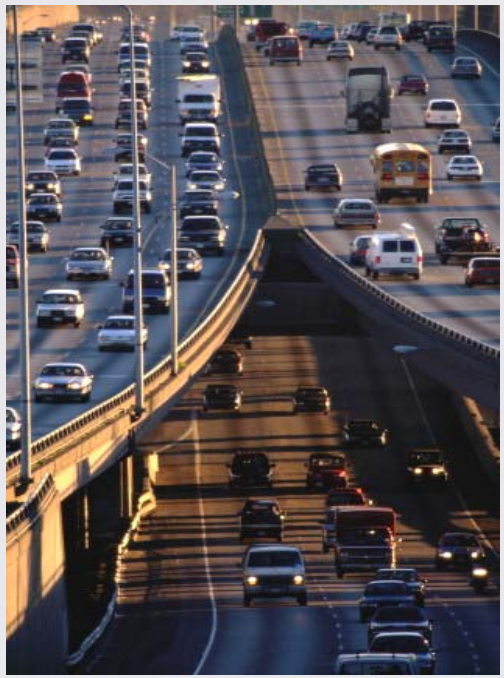
Progress

Benefits of combining
Fuel Cells and Wind Turbines

- Eliminate the barriers associated with intermittent energy sources



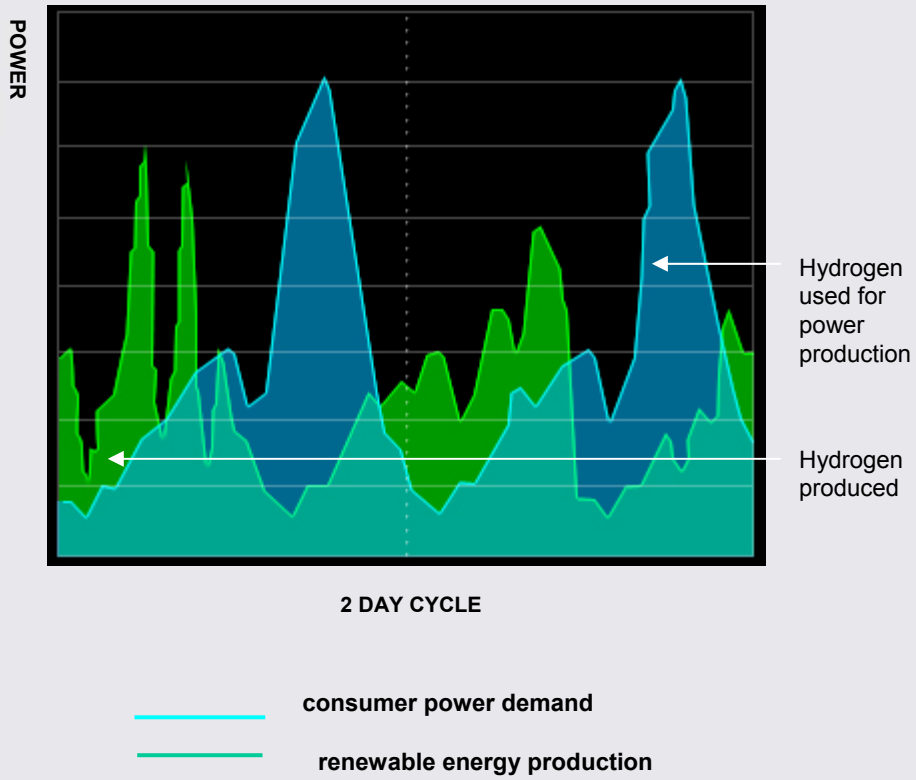
- Opens up the transportation energy market to renewable sources



Sequence of Operation

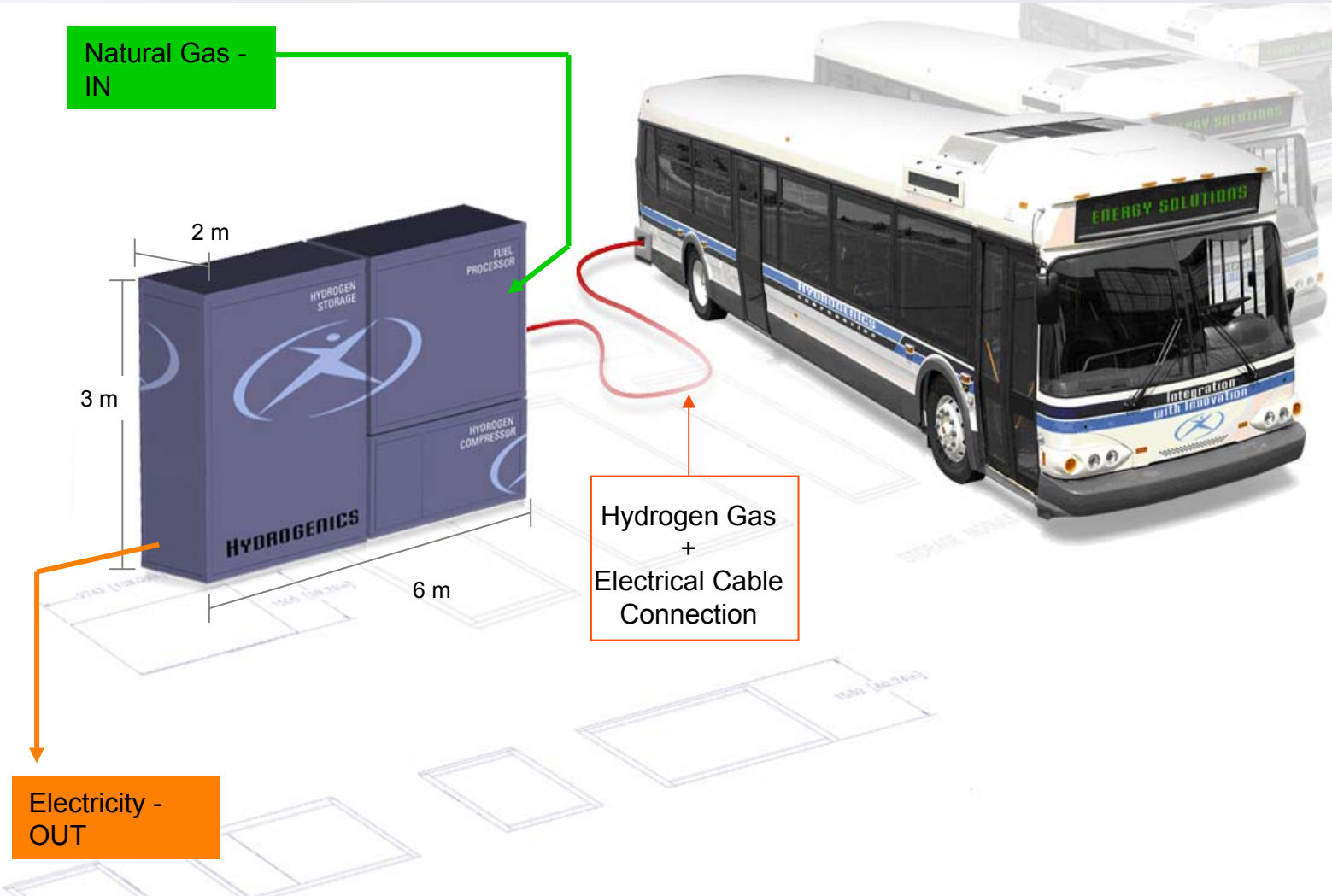
System sizing can ensure that there is always enough hydrogen to meet the load

– resulting in a 100% renewable energy supply.



HySTAT Power Generator / Refueler

Fuel Processor + Compressor + Storage + 50kW FC + Cable/Hose Interface



Electrolyzer Development

Large active area electrolyzer (701E)

Achievement:

- 40% increase in power density
- 30-40% cost reduction
- Significant parts reduction

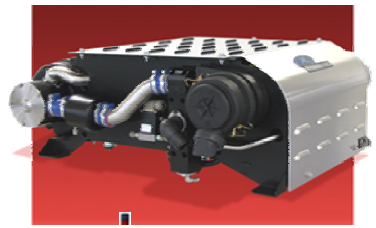
Performance target:

- 10 slpm/cell at operating voltage of 1.91 VDC
  (50 cell stack = 500 slpm)
- Exceeded this target in Q1, 2003
- Durability testing in progress

HYDROGENICS

Summary

- **Focusing on launch of Power Products business**
  - Developing 2 core building blocks
  - Developing distribution channels
- The potential of renewable energy to produce hydrogen creates a stronger value proposition for both **fuel cells and wind turbines**
- Hydrogenics is finding innovative ways to **integrate these technologies** efficiently and with maximum results



PEI Wind-Hydrogen Symposium
Charlottetown, PEI
June 22-24, 2003

HYDROGENICS

clean efficient quiet versatile

Thank you!