THANK YOU!

• Honorable Michael F. Currie – Minister Development and Technology
• Mark Belfry – PEI Energy Corporation
• All Islanders who have shown us such PEI hospitality
Presentation Goals and Agenda

Agenda

• Hydrogen Market Today
  • Getting Hydrogen to the end user
• Applications of Hydrogen Storage
  • Storage the Key to H2 Products
  • Storage the Solution for Infrastructure
• Hydrogen Storage Future Challenges
Hydrogen Market Today

- Production
- Markets
Hydrogen Market: Current Global Demand

**Captive**
- 95%
- 43.5 million tonnes per year

**Merchant**
- 5%
- 2.5 million tonnes per year

Footnotes: Based on world demand of 46 million tonnes of hydrogen
Source: Analyst & Investor Seminar Air Liquide in the Hydrogen Market
December 2001

Global H2 demand is approximately 46 million tonnes per year
H2 Production Today

3 Main Methods:
• Steam Methane Reforming (SMR)
• Partial oxidation
• Water Electrolysis

[Diagram showing the percentage breakdown of H2 production methods: 80% Natural Gas, 15% Coal, 4% Water Electrolysis, 1% Other]
Hydrogen: Current Merchant Demand N.A.

Footnote: Based on 1.25 million tonnes

Source: Interview with Karen Campbell, Air Products and C-219 Hydrogen as a Chemical Constituent and as an Energy Source, Edward Gobina, Business Communications Company, Inc.
Applications for Hydrogen Storage

- Storage the Solution for Infrastructure
- The Great Debate: Centralized vs. Distributed Production??
- Storage the Key to H2 Applications
Dynetek History

1991
• Founded and incorporated in Campbell River, B.C. R&D work begins on Advanced Lightweight Fuel Storage Systems™ A Canadian Company.

1995-1998
• Introduced DyneCell® Fuel Storage Systems to the market
• Mitsubishi Corporation acquired a 15% interest in Dynetek

1999
• 47,000 sq. foot state of the art production facility built in Calgary, Canada

2000-2001
• Public on the Toronto Stock Exchange (TSE: DNK)
• Signed multiyear purchase and supply agreement with Ford Motor Company
• Expanded the Calgary manufacturing site to 70,000 sq. feet & completed production facility in Germany

2002
• Commissioned significant additional production capacity in Calgary
• Achieved QS 9000 certification
• Successful third party testing of 12,500 psi fuel storage cylinder
Dynetek Products: Cylinders and Systems

**DyneCell Cylinders**

- Lightest CNG cylinder on the market with a metallic liner
- Highest storage capacity of all lightweight designs
- Non-permeable, seamless aluminium liner
- Non-reactive with Hydrogen
- Significantly safer by design
- Very flexible in size configurations
- True fast-fill capabilities
- 5.7 % Wt. Density @ 350 bar
Hydrogen Storage: Requirements

- **Weight Density** \( (\text{kg hydrogen} / \text{storage system weight}) \) 5.7%
- **Volumetric Density** \( (\text{kg Hydrogen} / \text{storage system volume}) \) 2.4%
- **Reliability** \( (\text{low parts count, simple design, mature technology}) \) YES
- **Infrastructure** \( (\text{compatible with available / planned infrastructure}) \) YES
- **Safety** \( (\text{in normal operation and emergency situations}) \) YES
- **Service Life** 15 yrs
- **Cost** \( (\text{purchase and operative}) \) High capital cost – low operating cost
- **Refueling time** \( (\text{fast filling}) \) YES
THE GREAT DEBATE!!

CENTRALIZED H2 Production

DISTRIBUTED H2 Production

LEGEND
- H2 pipeline
- CNG pipeline
- Modular Storage
- Stationary Storage
THE GREAT DEBATE!!

CENTRALIZED H2 Production

DISTRIBUTED H2 Production

Dybetek Solutions Today
Hydrogen Supply: Distributed Production

A) Peak Power to the Grid
B) Off-Peak Power – Store Hydrogen
C) Convert H2 back to Power
D) Sell H2 for Applications

Produce Electricity from the Wind

Courtesy: Stuart Energy

Advanced Lightweight Fuel Storage Systems™
Infrastructure: Hydrogen Fuelling Station

Hydrogen Storage Module

the power of hydrogen

ADVANCED LIGHTWEIGHT FUEL STORAGE SYSTEMS™
Storage Solutions for Infrastructure

Bulk Gas Transport

ADVANCED LIGHTWEIGHT FUEL STORAGE SYSTEMS™
Portable Refuelling for Demonstration Projects
Applications for Hydrogen

- Portable
- Auxiliary Power Stationary & Transport
- Bus, Fleet
- Car, Truck, etc.
- Excavator, Truck, etc.
- Ship
- Airplane

Timeline:
- 2000
- 2010
- 2020
Applications: Fuel Cells for Fleet Vehicles

Vehicle Model: Citaro City-bus
H2 Storage Capacity: 43 kg
Service Pressure: 350 bar /5075 psi
Approx. Driving Range: 300km
Number of Vehicles: 30
Location: Europe, North America, Australia
Application: Fuel Cell or H2 ICE Cars

- Simplicity of design
- Proven technology and reliability
- Fast fill capability
- Moderate system cost
- Low operation cost (maintenance & H2 gas compression)
- Reasonable storage densities
- Good safety characteristics
- Compatible with available infrastructure
- Long service life
Application: Auxiliary Power

Auxiliary Power Fuel Cells

- Power all electric systems
- Silent
- Reduced Motor Idling

Recent product releases by Hydrogenics & GM

http://www.media.gm.com/
Application: Combined H2 Fuel Station & Commercial Back Up Power

Vehicle Refuelling

Indoor H2 Storage
Applications: Fuel Cells for Power & Heat

- Home Power supply
- Home Heat supply
- Hydrogen for the Fuel Cell vehicles

Input: Natural Gas

Heat, Power

H2

Plug Power

Advanced Lightweight Fuel Storage Systems™
Applications: Fuel Cells for Telecom Power

- 127,000 Wireless cell sites
- 195,000 Wireline Remote Terminals (RT), Huts and Controlled Environment Vaults (CEVs)
Hydrogen Storage Future Challenges
Hydrogen Storage: Technical Challenge - % Fuel Wt / System Wt.

Hydrogen Storage: Compression

Hydrogen Compression:

- 2 stage compressor for 350bar (5000psi)
- 4 or 5 stage compressor for 700bar (10000psi)
- Low energy consumption (5% to 350bar, 10% to 700bar)
- Compressibility of hydrogen is close to ideal gas up to 350bar
- Approximately 25% loss of storage at 700bar due to lower compressibility

Compressed H2 (@21 deg. C)
- 3600 psi, 300K: 0.0175 kg/L
- 5000 psi, 300K: 0.0229 kg/L
- 10000 psi, 300K: 0.0393 kg/L

PV = nRT

CH2
Future of Hydrogen Storage

- Design engineers working on New Hydrogen Products
  - **Short term**: Gaseous will continue to be the primary source of supply to the sector, because it is easy, available, and adaptable to many platform designs
  - **Long term**: The challenge for the new designers will be to develop storage solutions, which meet the economic demands of the consumer and are designed for ease of use.
Of course if all else fails we could go back to Plastic Bags!!!
Storing Energy’s Future

Dynetek Industries Ltd.