Dynetek Industries Ltd.

Solutions for Hydrogen Storage and Distribution

The PEI Wind-Hydrogen Symposium

June 22 to 24, 2003

Don Fraser, Bulk Transport Manager

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

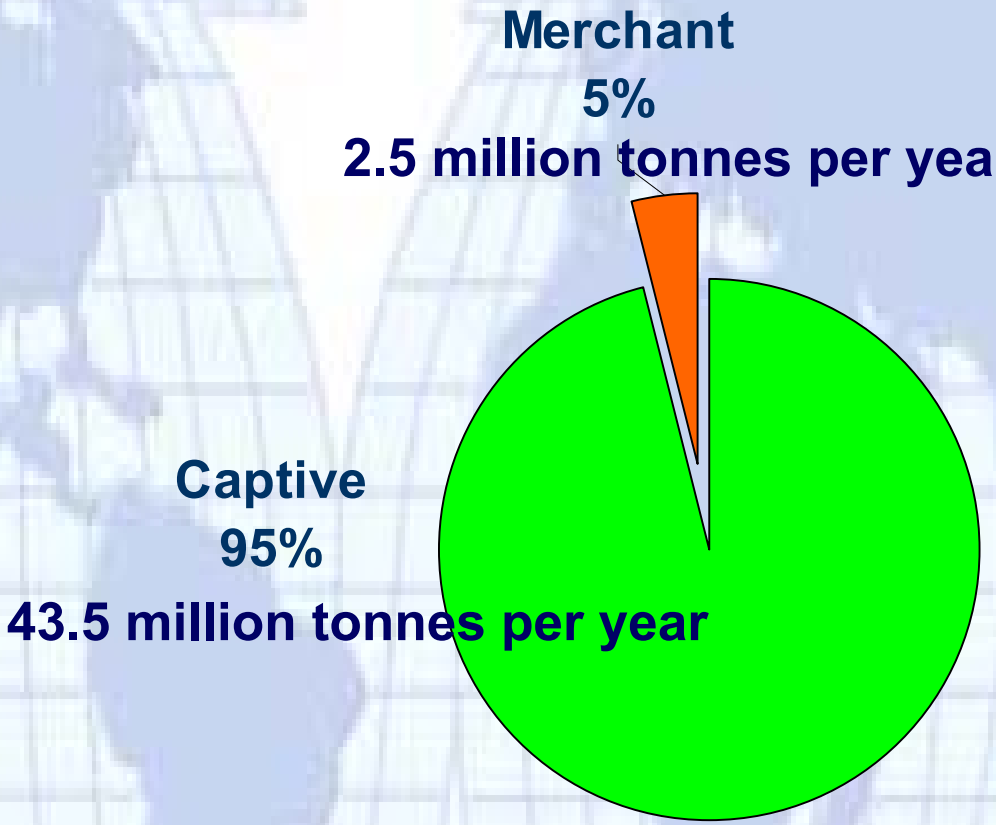
Agenda

- 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



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

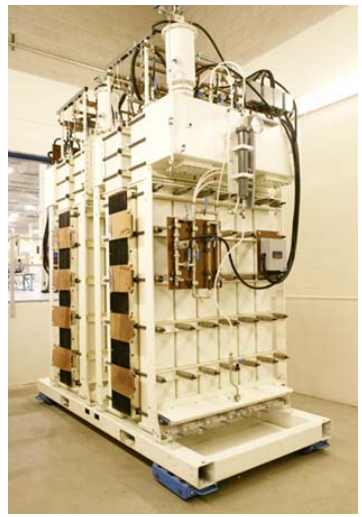
H2 Production Today

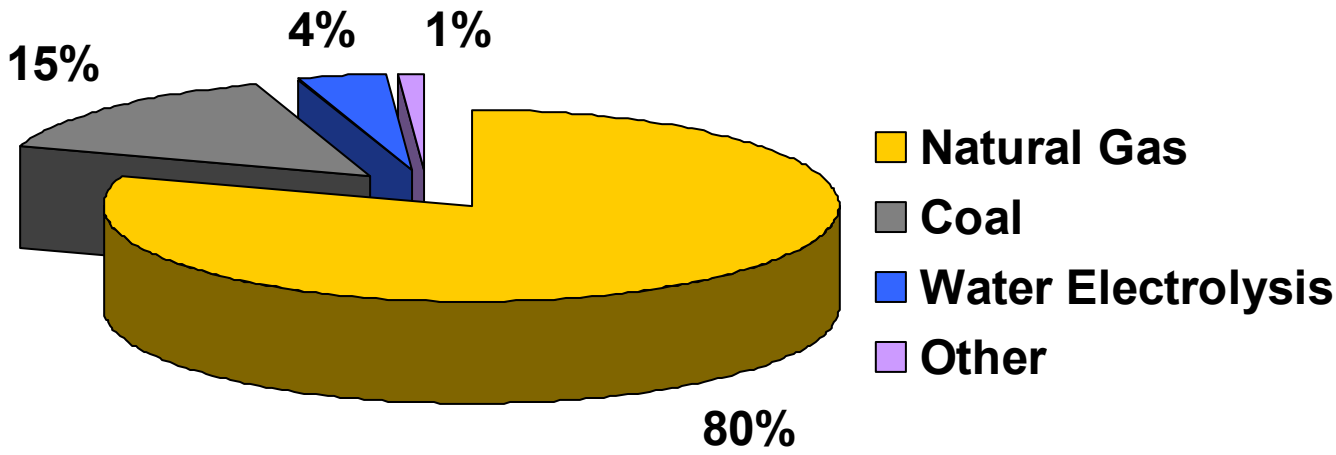
3 Main Methods:

- **Steam Methane Reforming (SMR)**

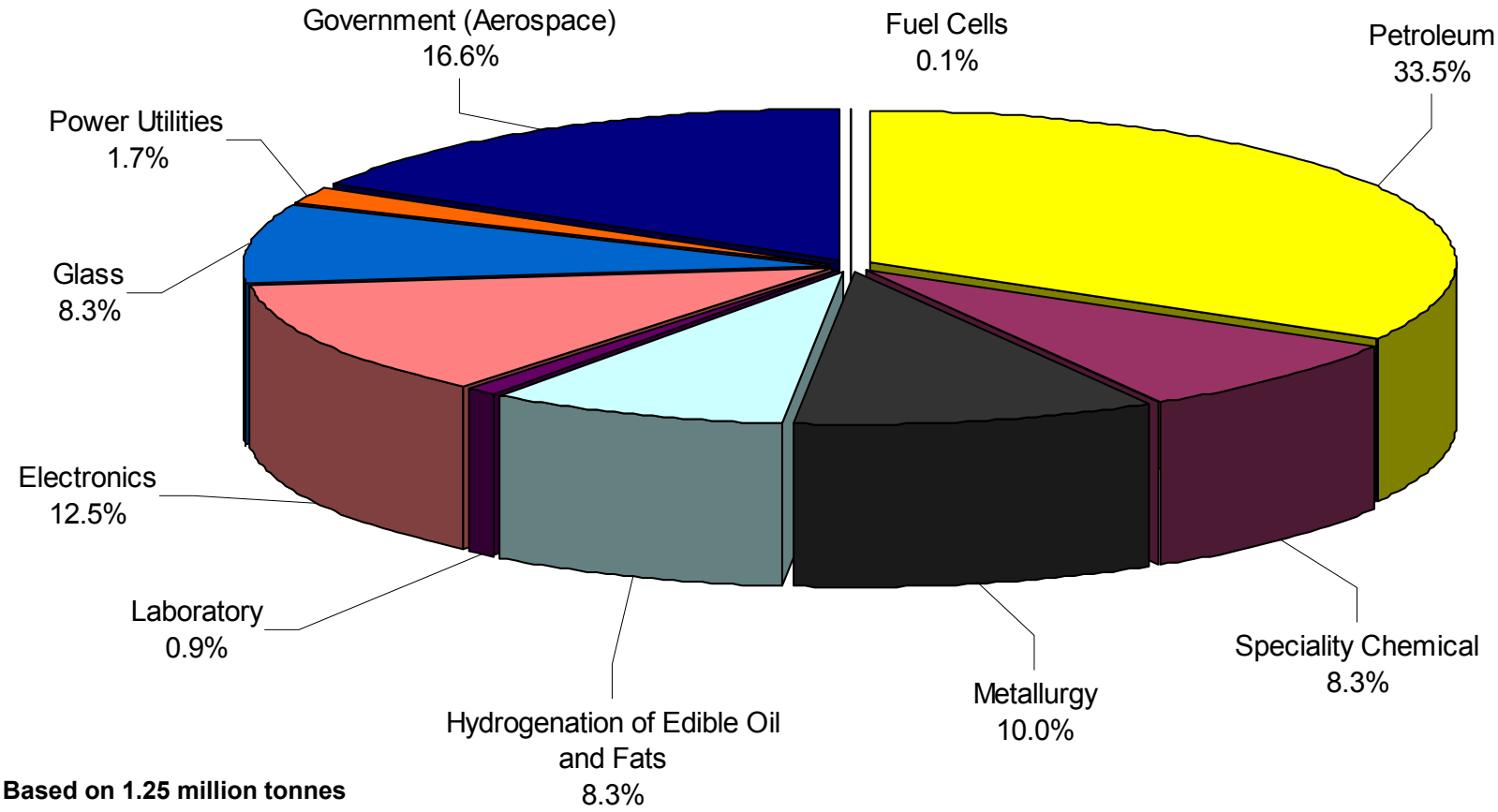
- **Partial oxidation**

- **Water Electrolysis**





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 a 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

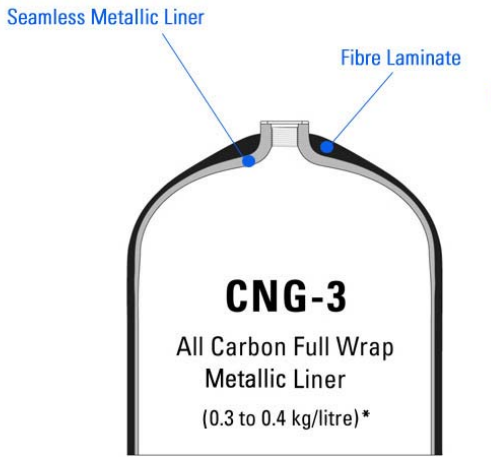
2000-2001

- 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

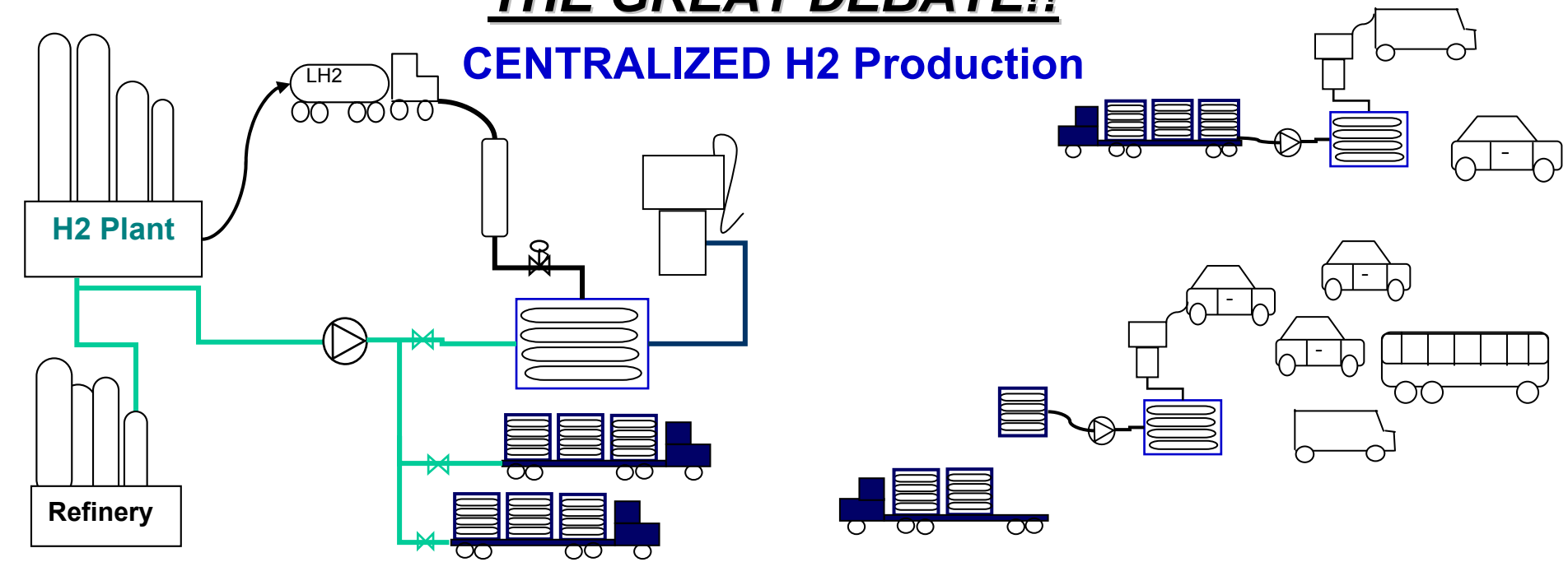
- **Lightest CNG cylinder on the market with a metallic liner**
- **Highest storage capacity of all lightweight designs**
- **Non-permeable, seamless aluminium liner**
- **Non-reactive with Hydrogen**
- **Significantly safer by design**
- **Very flexible in size configurations**
- **True fast-fill capabilities**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

Hydrogen Storage: Requirements

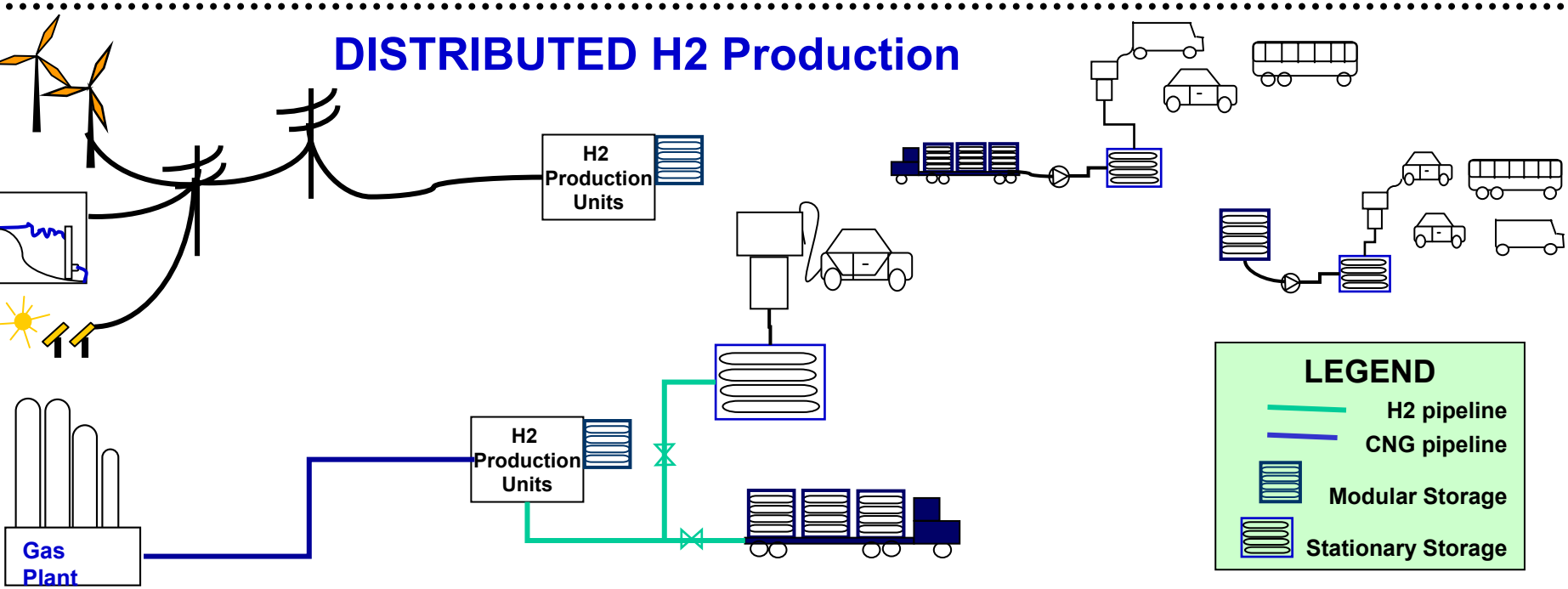
- **Weight Density** *(kg hydrogen / storage system weight) 5.7%*
- **Volumetric Density** *(kg Hydrogen / storage system volume) 2.4%*
- **Reliability** *(low parts count, simple design, mature technology) YES*
- **Infrastructure** *(compatible with available / planned infrastructure) YES*
- **Safety**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

THE GREAT DEBATE!!

CENTRALIZED H2 Production

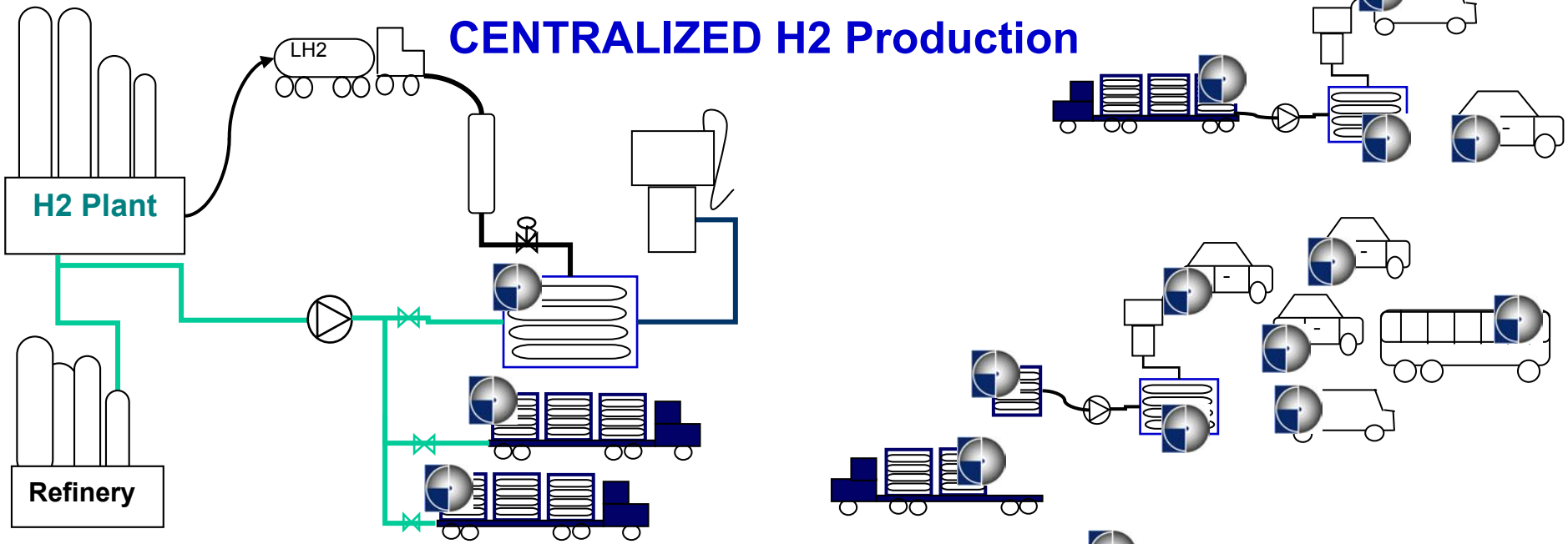


DISTRIBUTED H2 Production

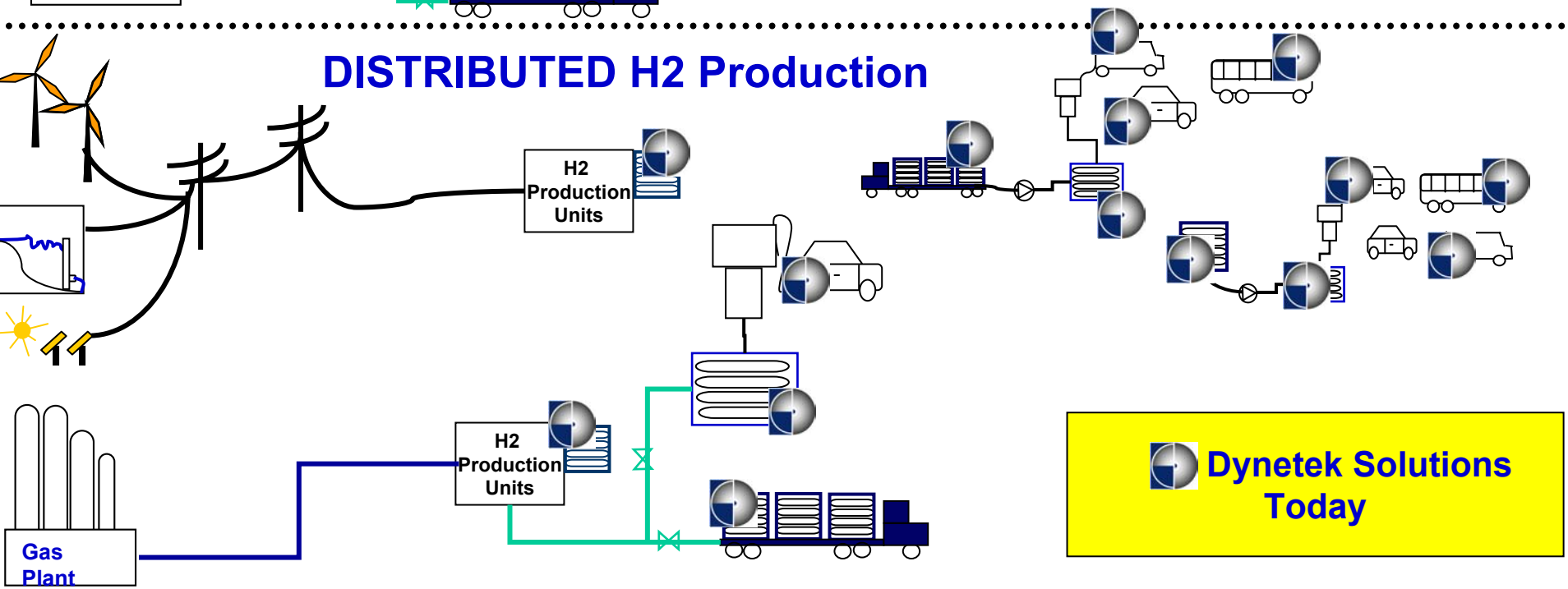


THE GREAT DEBATE!!

CENTRALIZED H2 Production



DISTRIBUTED H2 Production



Dynetek Solutions Today

Hydrogen Supply : Distributed Production

Produce Electricity from the Wind

A) Peak Power to the Grid

C) Convert H2 back to Power

B) Off-Peak Power – Store Hydrogen

D) Sell H2 for Applications

Courtesy: Stuart Energy

Infrastructure: Hydrogen Fuelling Station

Hydrogen Storage Module

stuartenergy

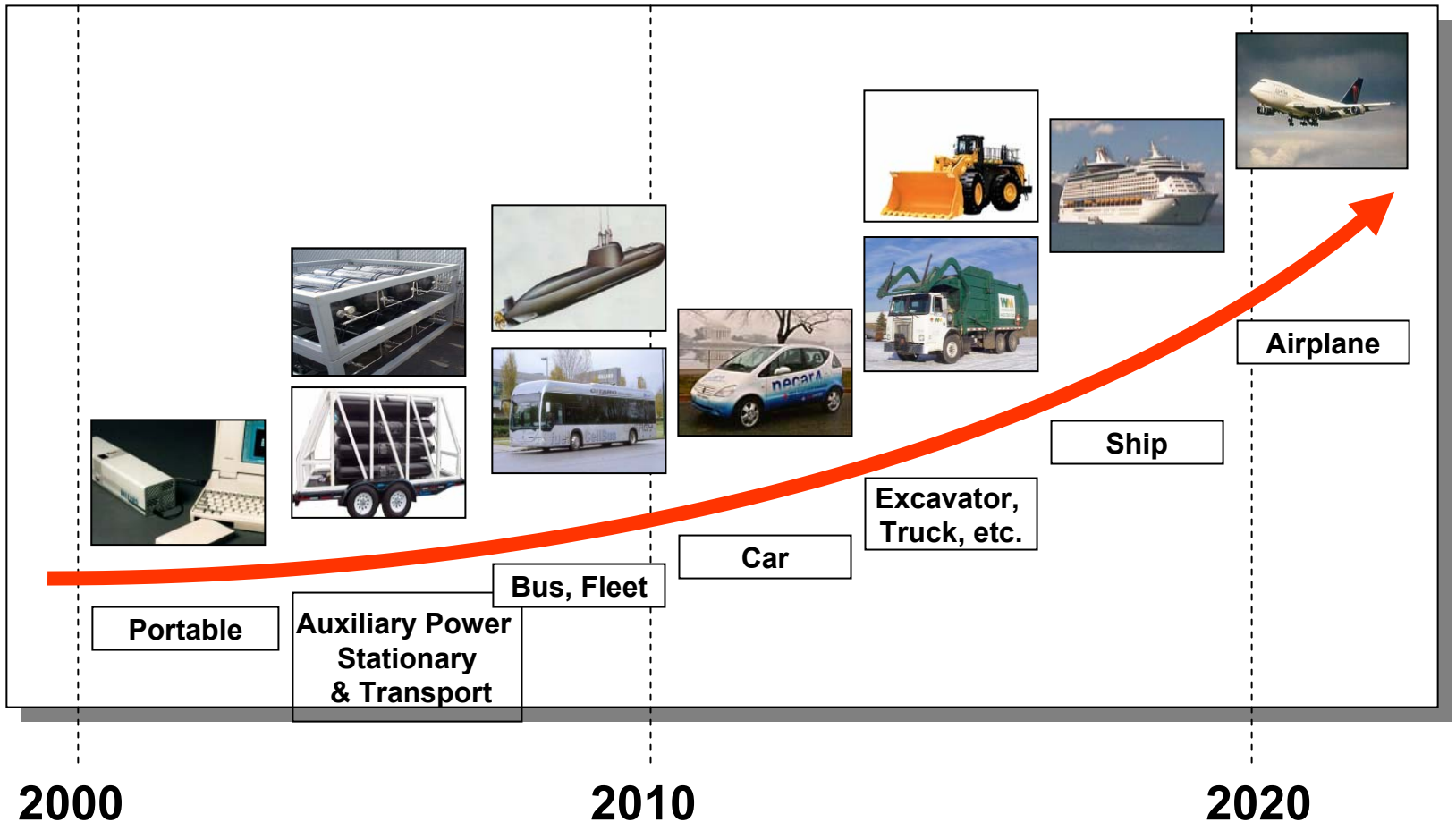
the power of hydrogen

Storage Solutions for Infrastructure

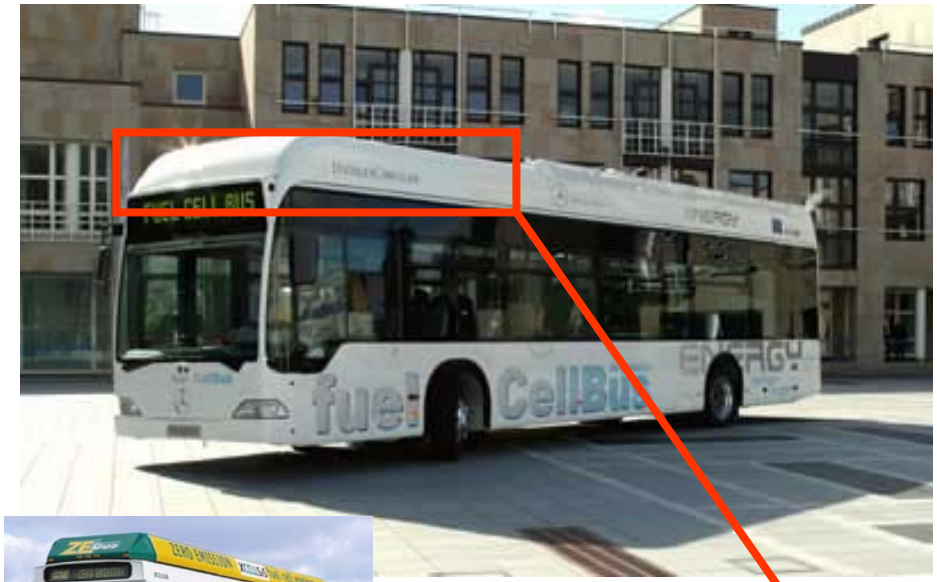
Bulk Gas Transport

Portable Refuelling for Demonstration Projects

Applications for Hydrogen



Applications: Fuel Cells for Fleet Vehicles



Vehicle Model: Citaro City-bus

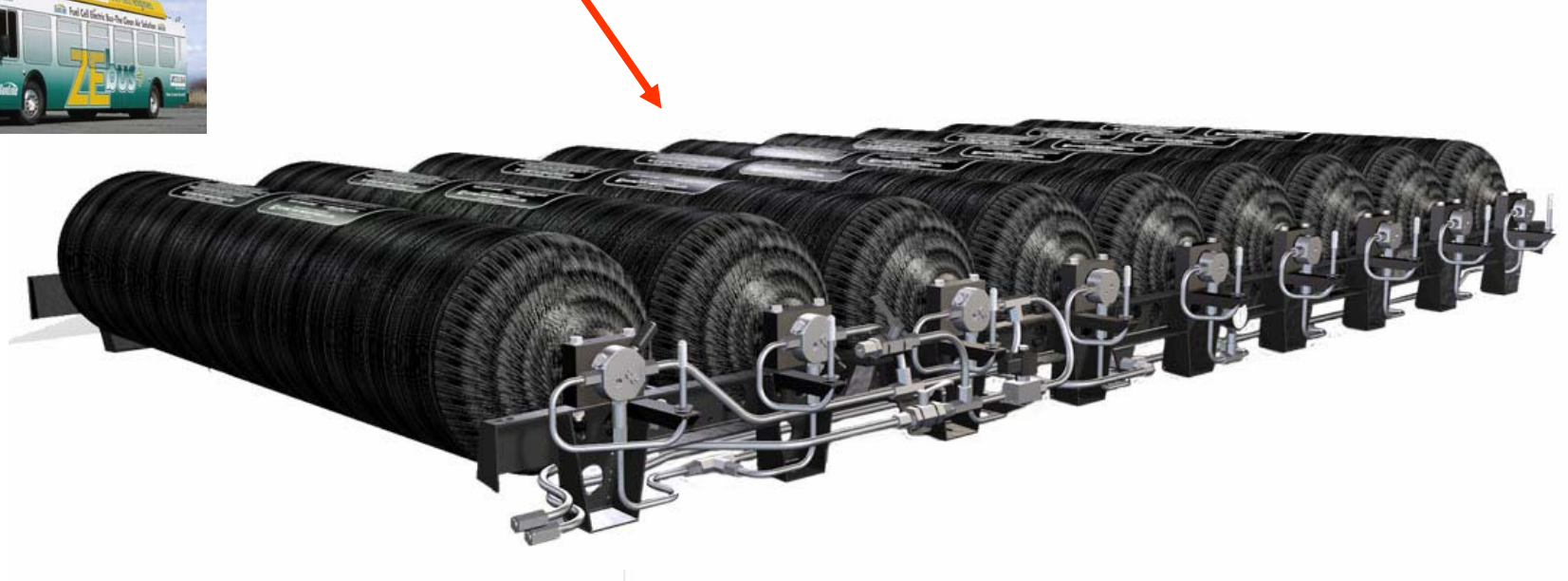
H2 Storage Capacity: 43 kg

Service Pressure: 350 bar /5075 psi

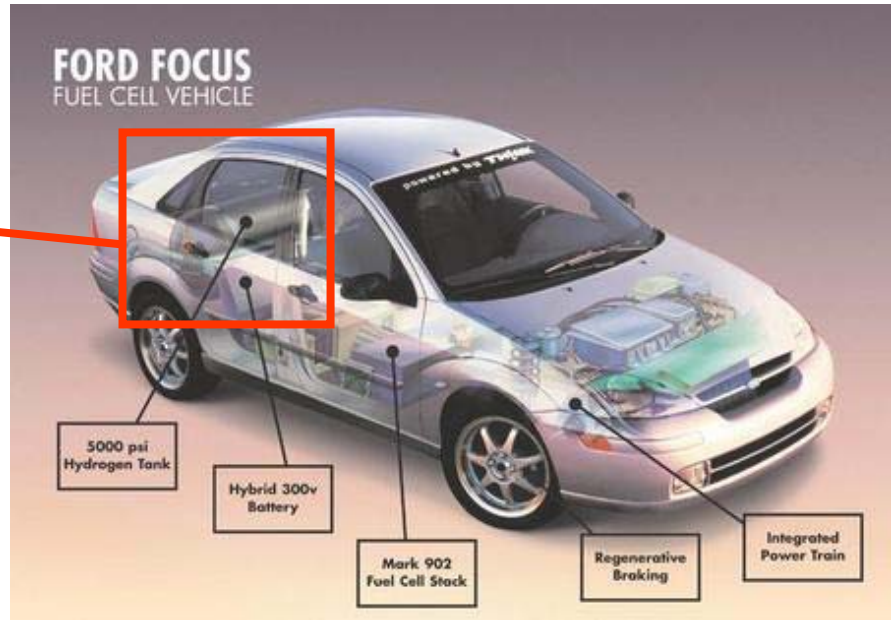
Approx. Driving Range: 300km

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

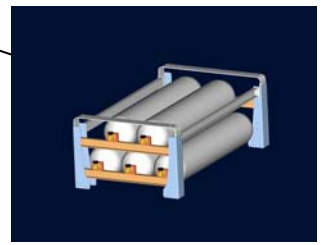
Indoor H2 Storage

Applications: Fuel Cells for Power & Heat

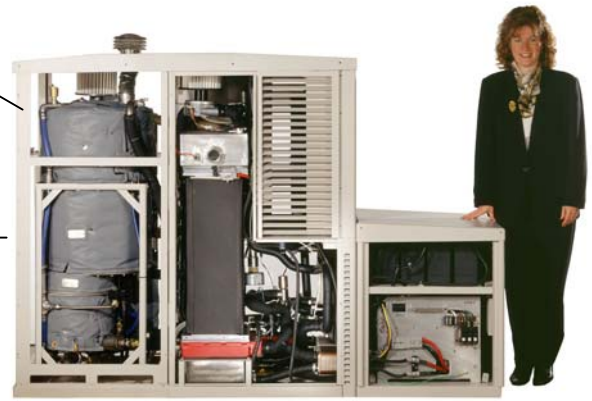
- Home Power supply
- Home Heat supply
- Hydrogen for the Fuel Cell vehicles

Input: Natural Gas

Heat, Power



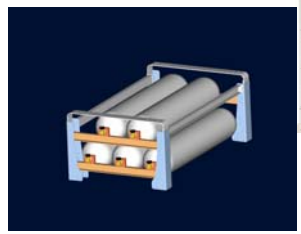
H2



Applications: Fuel Cells for Telecom Power

- 127,000 Wireless cell sites
- 195,000 Wireline Remote Terminals (RT), Huts and Controlled Environment Vaults (CEVs)

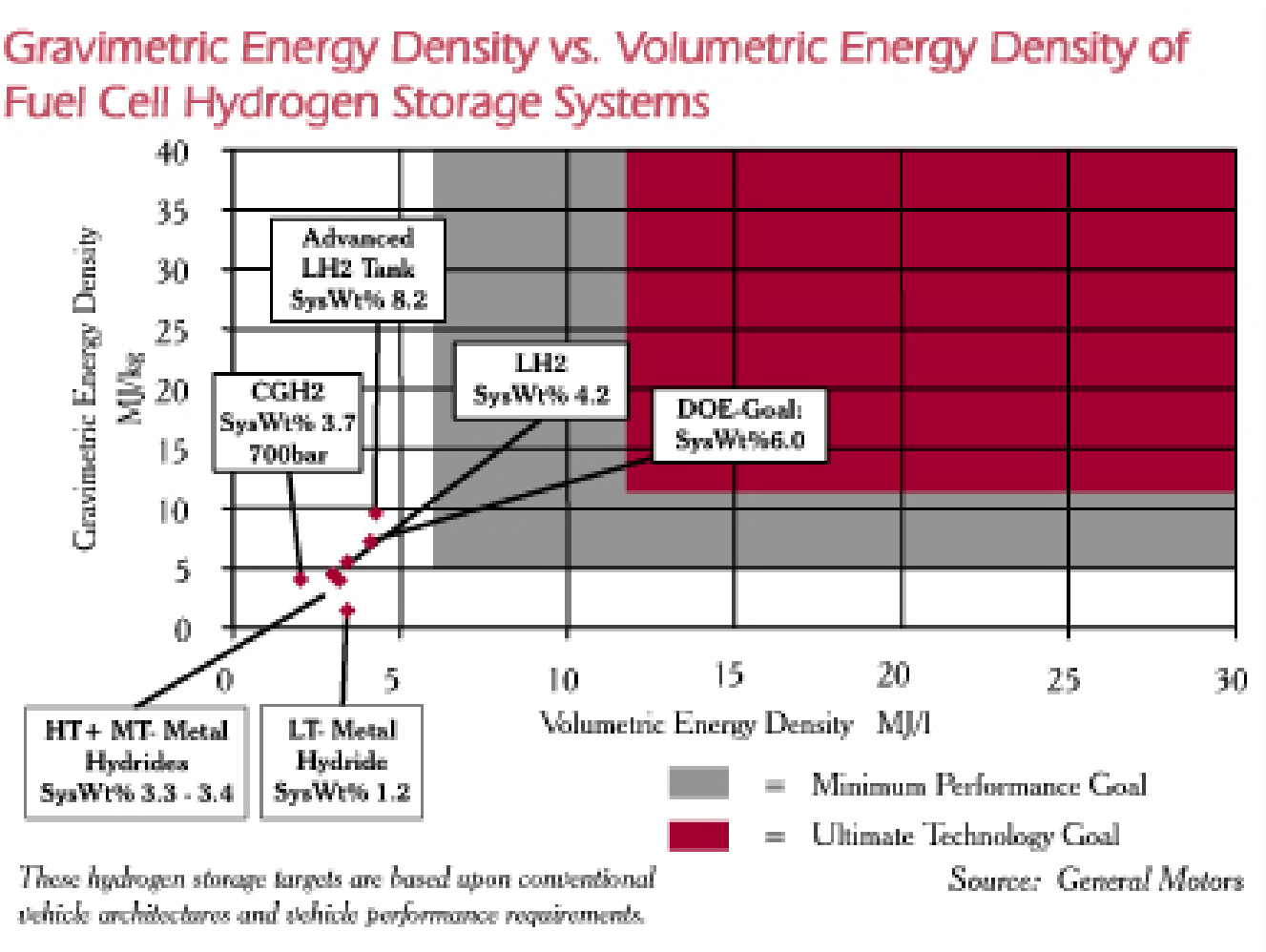
High speed ADSL



plug power
FUEL CELL SYSTEMS

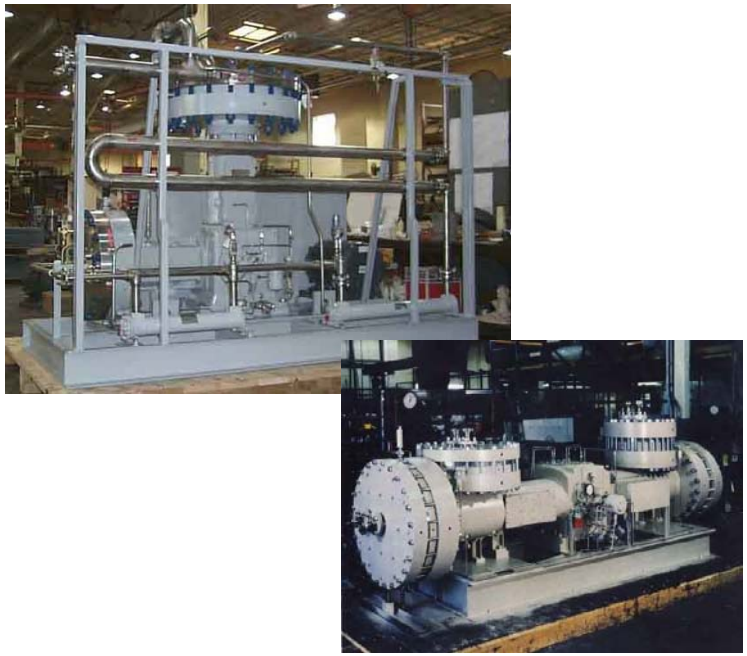
Hydrogen Storage Future Challenges

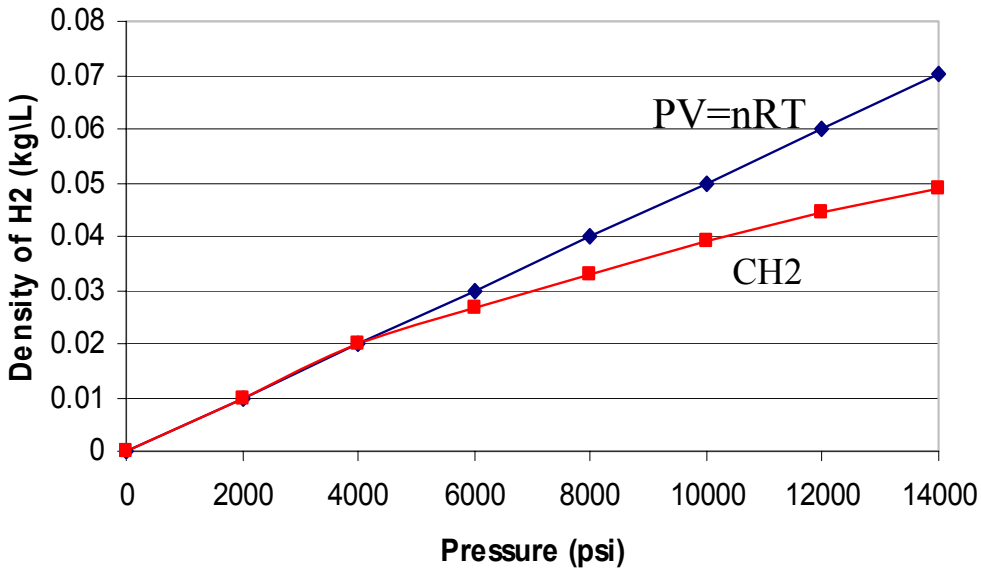
Hydrogen Storage: Technical Challenge - % Fuel Wt / System Wt.



http://www.eere.energy.gov/hydrogenandfuelcells/pdfs/national_h2_roadmap.pdf

Hydrogen Storage: Compression





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

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**

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!!!

Bulk Storage

Bulk Transportation

Storing Energy's Future

Dynetek Industries Ltd.