Matthias Altmann

Drivers for and Barriers towards a Hydrogen Based Energy System

L-B-Systemtechnik GmbH
Ottobrunn, Germany

Presentation overview

1. Introduction
   - Early Hydrogen Markets
2. Drivers in Road Transport Fuel
   - Technical Superiority
   - Security of Energy Supply
   - Climate Protection
3. Barriers in Road Transport Fuel
4. Conclusion

Introduction

Early Hydrogen Markets

- Portable applications
- Remote (grid independent) electricity supply using renewable energies
- Hydrogen microgrids for residential and small commercial applications (based on natural gas or LPG)
- Road transport fuel

Introduction

Portable Applications: Fuel Cell Fork Lift Trucks

World Market for fork lifts and other industrial vehicles is around 550,000 units per year (Western Europe: 34%, USA & Canada: 30%).

Source: LBST Fuel Cell Fork Lift Study, 1999

Siemens, Linde 1997

General Hydrogen 2003

Proton-Motor, Still, Linde 2003

Hydrogenics 2003

Introduction

Portable Applications: Fuel Cell Fork Lift Trucks

Drivers

- Largest electric vehicle market
- Quick „recharging“
- Easy replacement of batteries
- Potentially cheaper than batteries

Barriers

- Fuel cell reliability and lifetime
- Fuel cell costs
- Hydrogen storage (costs)

Introduction

Portable Applications: Consumer Electronics

Micro fuel cells: Broad commercialisation expected to start in 2004 (Toshiba, NEC). DMFC using methanol with reduced infrastructural requirements and PEMFC using hydrogen are developed in parallel.


Masterflex
FhG-ISE, 50 W_{el}


Motorola


Smart Fuel Cell


Toshiba, 12 W_{el}

Introduction

Portable Applications: Consumer Electronics

Drivers

- Longer operating times before „recharging“
- Quick „recharging“
- Costs are no issue

Barriers

- Hydrogen/methanol storage
- Hydrogen/methanol supply infrastructure
- Fuel cell miniaturisation

Introduction

Portable Applications: Portable Power

Ballard, 1,2 kW_{el}

Ballard, 1,2 kW_{el}

Voller Energy, 1 kW_{el}

AXANE, polar pack

Introduction

Portable Applications: Portable Power

Drivers

- Long operating times
- Silent and clean
- New applications

Barriers

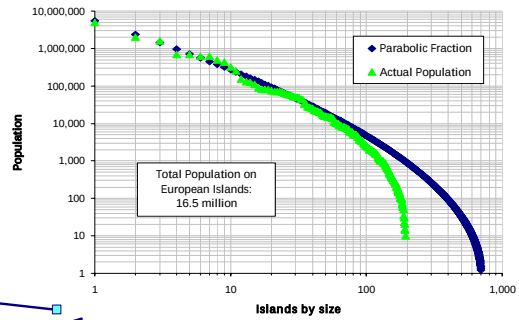
- Hydrogen supply infrastructure
- Fuel cell reliability and lifetime
- Fuel cell costs
- Hydrogen storage (costs)

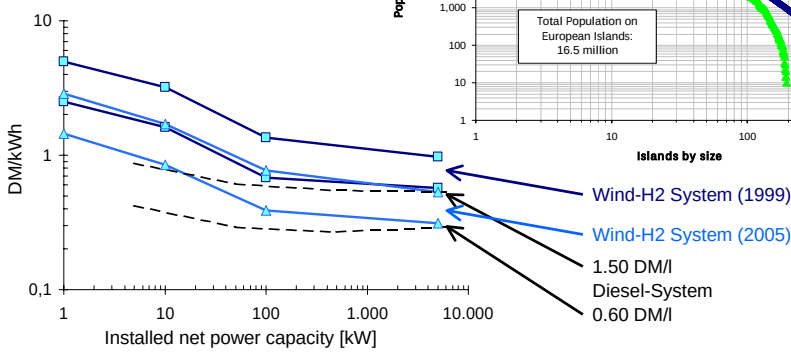
Introduction

Remote Electricity Supply: Wind-Hydrogen Systems

European Projects

- RES2H2 www.inta.es/RES2H2
- HSAPS MarketAnalysis www.hsaps.ife.no





Source: WHySE – Wind-Hydrogen Supply of Electricity, LBST, 1999

Introduction

Remote Electricity Supply: Wind-Hydrogen Systems

Drivers

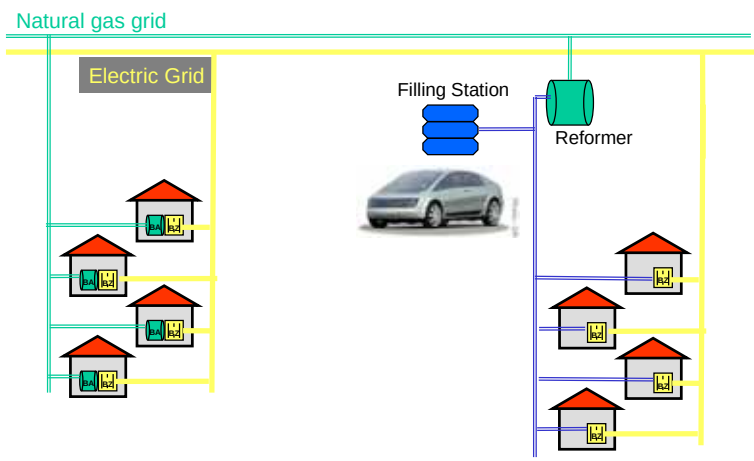
- High costs of conventional systems
- Silent and clean
- Large world-wide market

Barriers

- Fuel cell reliability and lifetime
- Fuel cell costs
- System integration and design
- Distribution channels and maintenance

Introduction

Hydrogen Microgrids: NG and LPG Based Fuel Cell Co-generation



Residential system
(operated by private user)

H2 microgrid
(operated by service provider)

Introduction

Hydrogen Microgrids: NG and LPG Based Fuel Cell Co-generation

Drivers

- Reduced FC system complexity and costs
- Potential synergies with road transport fuel

Barriers

- „All or nothing“ decision
- Fuel cell technology, especially lifetime
- Fuel cell costs

Introduction

Road Transport Fuel


GM/Opel


Toyota


Honda


Munich LH2 station


DaimlerChrysler


MAN


Toyota-Hino


Takamatsu H2 station


Hyundai


Ford


Nissan


California FC Partnership


BMW


DaimlerChrysler

Drivers in Road Transport Fuel

Superior Technology: „Rolling Electric Plug“

Source: DaimlerChrysler

Drivers in Road Transport Fuel

Superior Technology: New Vehicle Designs and „x-by-wire“

GM Autonomy

Toyota Fine-N

GM Hy-Wire

Drivers in Road Transport Fuel

Superior Technology: „Fun to Drive“

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Drivers in Road Transport Fuel

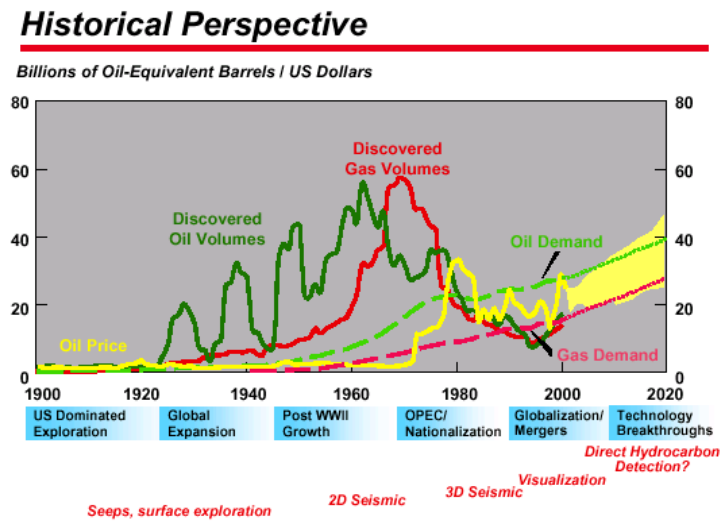
Superior Technology: Reduced Development Costs

Fuel cells are modular and scaleable.

Developing power trains with different power ratings or other characteristics from an existing, commercially viable fuel cell power train will require significantly less efforts than developing a new internal combustion engine.

Drivers in Road Transport Fuel

Energy Security: ExxonMobil: Oil Discoveries ↓ and Oil Prices ↑

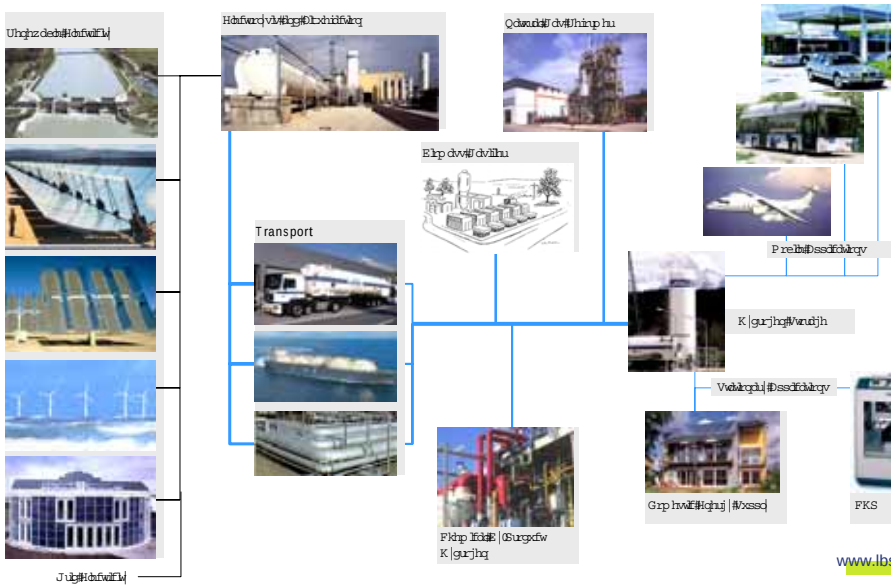


Average decline of oil discoveries since 1965: 3.5% per year

Source: The Future of the Oil & Gas Industry: Past Approaches/new challanges, Harry J. Longwell, 7.5.2002

Drivers in Road Transport Fuel

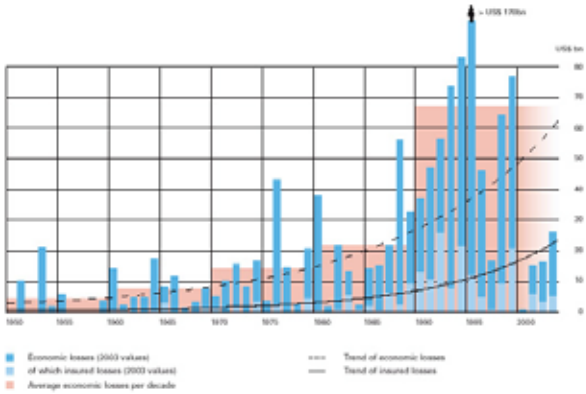
Energy Security: Hydrogen - Diversification and Infinite Energies



Drivers in Road Transport Fuel

Climate Change: Floods, Draughts Cause Economic Damage

Economic and insured economic losses
caused by natural catastrophes



Source: Munich Re, TOPICS geo - Annual Review: Natural Catastrophes 2003

Saxony, Germany: 2002

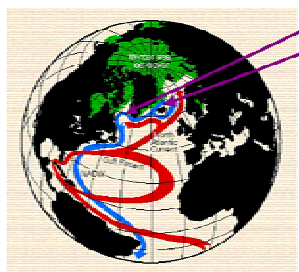
Saxony, Germany: 2003

Drivers in Road Transport Fuel

Climate Change: Abrupt Collaps of Thermohaline Circulation

"We have created a climate change scenario that although not the most likely, is plausible, and would challenge United States national security in ways that should be considered immediately."

Cartoon Version of the North Atlantic Themohaline Circulation



Two main centers for sinking of cold and salty waters (deep water formation): around Labrador Sea and Irminger Sea

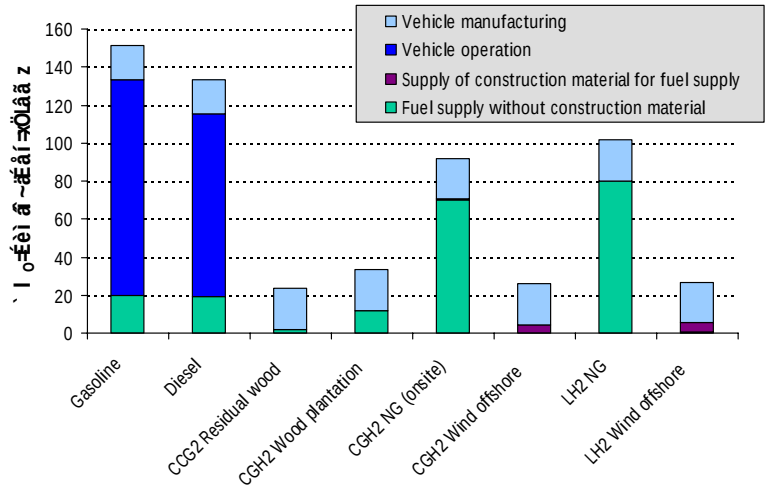
Surface oceanic currents are in RED
The flow of North Atlantic Deep Water (NADW), with a maximum overturning flow at a depth of about 2000 meter, is in BLUE

(Adapted from Rahmstorf, 1997, Nature, vol. 388, 825-826)

„An Abrupt Climate Change Scenario and Its Implications for United States National Security", Peter Schwartz & Doug Randall (GBN), October 2003 for the US-Department of Defense

Drivers in Road Transport Fuel

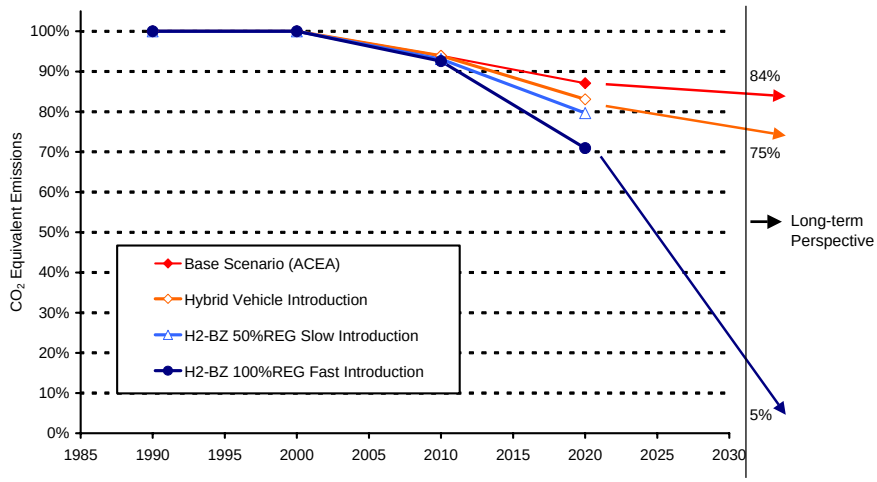
Climate Change: Well-to-Wheel GHG emissions of Hydrogen



Fuel consumption of vehicles and energy requirements and GHG emissions for vehicle manufacturing:
Weiss, M., A.; Heywood, J., B.; Schafer, A.; Natarajan, V., K.; MIT: Comparative Assesment of Fuel Cell Cars; February 2003
Fuel supply: EUCAR, CONCAWE, JRC, IFP, LBST: Well-to-Wheels analysis of future automotive fuels and powertrains in the European context; January 2004

Drivers in Road Transport Fuel

Climate Change: GHG scenarios for Germany for Hydrogen



Source: LBST, Comparison of different propulsion systems in private transport in terms of energy saving and reduction of greenhouse gases, April 2002, www.lbst.de/propulsion

Barriers in Road Transport Fuel

Technical Barriers

- Fuel cell lifetime
- High power density, low platinum load, sufficient lifetime and mass manufacturability in one stack technology
- **Fuel cell operating temperature**
- Fuel cell system complexity
- **Hydrogen storage technology**
- Hydrogen storage mass manufacturability

Barriers in Road Transport Fuel

Economic Barriers

- Fuel cell manufacturing costs
- Hydrogen onboard storage manufacturing costs

Barriers in Road Transport Fuel

Regulatory Barriers

- Hydrogen vehicle approval in some countries not possible
- Hydrogen vehicle approval requirements not harmonised on European or international level
- Hydrogen filling station requirements are prohibitive in some countries
- Hydrogen filling station requirements are not uniform throughout single countries
- Standards for hydrogen filling station components, refueling interface and hydrogen vehicle components required

Regulations = legal requirements, codes of practice etc.
Standards = voluntary agreements to support the free exchange of goods and services

Barriers in Road Transport Fuel

Market Barriers

- Hydrogen refueling infrastructure

BUT:

„The necessary hydrogen supply infrastructure, on the other hand, can well be built up on economic terms. Market development strategies therefore should give highest attention to the technologies and the economics of the vehicle sector. A chicken-and-egg issue therefore does not exist if market entry conditions are properly organised.“

Source: Market Development of Alternative Fuels, Report of the Alternative Fuels Contact Group, December 2003

Conclusion

- Drivers are powerful
- Very different motivations point in the same direction
- Different stakeholders (industry, policy making, environmental NGOs etc.) have common goals

- Barriers are important
- Barriers require joining and co-ordination of efforts by all stakeholders

- Efforts will be rewarding in economic and environmental terms

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Thank you for your attention!

For more information about Hydrogen and Fuel Cells please visit

www.HyWeb.de