Hydrogen for Transport
Internal Seminar

European Commission
Directorate General
Energy and Transport

Wednesday 25th January, 2006

Providing tomorrow's energy today

HYCHAIN MINITRANS – Niche Transport Vehicles

250 W

40 Vehicles

500 W

34 Vehicles

1 kW

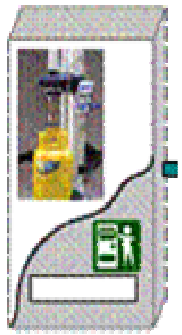
30 Vehicles

2,5 kW

44 Vehicles

10 kW

10 Vehicles



3 Dispenser

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HYCHAIN MINITRANS – Cargo Bike

Service company (maintenance, services, ..)
Logistic service, post service …
Municipal companies (local service, …)

ü **Flexible**
(no need of driving license,
free of taxes, …)

ü **High efficiency**

ü **Low operation cost**

ü **Innovative design**

ü **Increased autonomy**
(min. 150 km),

ü **Power available for additional applications**
(cooling, lighting …)

ü **Quick refilling**
(using hydrogen cartridges)

ü **Respectful with the environment**
(emissions or noise)

Multifunctional tricycle	**Hawk Bikes** (Germany)
250 W Fuel cell	**Masterflex** (Germany)
2 Litres Cylinder @ 700 bar	**Air Liquide** (Germany)
Electronic, integration	**Masterflex** (Germany)

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HYCHAIN MINITRANS – Wheelchair

For disabled people centers, associations, residential homes for elderly, hospitals, airports, museums, and other public spaces

ü **Increased autonomy (50%),** compared to conventional electric wheelchairs

ü **20 % reduction in weight**, compared to conventional electric wheelchairs

ü **Lower recharging time** (less than 5 min)

ü **Use of renewable hydrogen**

Electric wheelchair	**Meyra** (Germany)
0.5 kW Fuel Cell	**Axane** (France)
1 x 700 bar H2 cylinder	**Air Liquide** (France)
Integration, engineering and testing	**Besel** (Spain)

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HYCHAIN MINITRANS – Scooter

Courier service, postal delivery (urban use), municipal police and others municipal services, individual user in urban spaces

ü Fuelled by **renewable hydrogen**

ü **Cleaner and quieter** than conventional combustion engine scooters

ü **Higher vehicle performance** than electric scooters based on batteries

ü **Battery recharging through the fuel cell operation** (no grid recharging)

Original scooter	**Derbi** (Spain)
1 kW Fuel cell	**MES –DEA** (Switzerland)
2 x 2 litres @ 700 bars	**Air Liquide** (France)
Power train, integration, engineering and testing	**Besel/Rucker** (Spain)

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HYCHAIN MINITRANS – Utility Vehicle

City Council Maintenance Services (e.g. garbage disposal, green spaces, cleaning) Public Urban transport ; Private companies of transport

ü **Light maintenance**

ü **No emissions**

ü Detachable generator for **auxiliary mobile power** or as **range extender,** more than 30% increased range

ü **Shorter recharging time** than a conventional electrical systems

ü **Lighter weighted and larger filling capacity** than similar electrical vehicle with batteries

Base vehicle	**VEM** (Italy)
3 kW Fuel cell system	**Axane** (France)
4 x 20 litres @ 300 bars	**Air Liquide** (France)
Integration	**VEM** (Italy)

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HYCHAIN MINITRANS – Shuttle bus

Public transport, historical areas, natural parks, university campus, industrial areas, airports, commercial centers, …

ü Hybrid propulsion, **more silent and cleaner than Diesel propulsion**

ü Can use exclusively **renewable energies**

ü **Light maintenance**

ü **Lower recharging time** (less than 5 min)

ü **No emissions**

ü **Increased autonomy > 18h** (actually 4-8 h)

Hybrid Minibus		**Tecnobus** (Italy)
10 kW Fuel Cell		**Enkat** (Germany)
150 litres @ 350 bar		**Dynetek** (Germany)
Electronic and integration		**Enkat** (Germany)

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Learning process

- Learning process of the HYCHAIN demo project:
  - **Homologation and Certification process** in 4 EC countries
  - Small **series production planning** and **realization**
  - **Experience** of H2FC vehicles in the hands of **common people**
  - Maintenance issues that arise and **how to solve** them
- Questions that are expected to be answered:
  - Can HYCHAIN help accelerate the further development of codes and standards
  - What is the public acceptance level of mini vehicles based on fuel cells?
  - How reliable can the vehicles be in the hands of end users from the general public?
  - What other design issues will arise that will require solving?

State-of-the-art of the technology

- Prototype vehicles have been made in most cases
  - Base systems designed
  - The technology works and is promising

  But:

- To enable ultimate goal of series adoption by OEM vehicle manufacturers
  - Need further iterations to improve the systems
  - Need extensive field testing and validation in real everyday operation
  - Need experience with “many of” the vehicle in fleet operation

Project Partners Motivations

- Fuel cell developer objectives are:
  - Market fuel cells to:
    - OEM's
    - System integrators
  - In:
    - early-adopting/near-term markets
    - strategic demonstration markets
- Example for Hydrogenics:
  company mission statement is
  "to accelerate the commercialization of fuel cell technology"
  - HYCHAIN is conceived to facilitate rapid commercialization

Project Partners Motivations

- HYCHAIN supports the strategy of fuel cell developers in the following ways:
  - Validates the FC technology in wider geographic, climactic and cultural markets
  - Demonstrates FC technology to wider general public to build acceptance and market pull
  - Demonstrates FC technology to OEM clients to build acceptance for integrating into wider products and market introduction
  - Wider number of vehicles helps reduce cost and accelerates statistical validation

Motivation: small vehicles

- Concept:
  - Start modest scale
  - Keep it simple
  - Iterate
  - Scale up
- **Low costs**
  - FC size (kW) proportional to € cost
  - **Lower capital investment**, **lower financial risk**
- **Large fleet sizes** of smaller vehicles more easily affordable
  - Can prove MTBF and fleet issues faster Other Advantages:
- **Minimized** H2 consumption, **operation costs**
- Relatively **fast progress**
  - More readily available components, large components tend to need customization
- Relatively **Low Technical Risk**
  - Small fuel cell systems more widely available and further advanced
- **Same learning**
  - Learning is much the same with small systems as with large
  - Large FC systems are usually multiple stacks anyway!

Objectives continued

- Set basis for cross-project cooperation within the "Hydrogen for Transport" family and other projects
  - Would each project be able to solve all the problems on their own
  - Or would they be more efficient and effective working coordinated?
- Compare the EU activities with those taking place in other parts of the world (e.g. USA, Japan, etc.)
  - Strengths
  - Weaknesses

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Thank You!

- Thank You!

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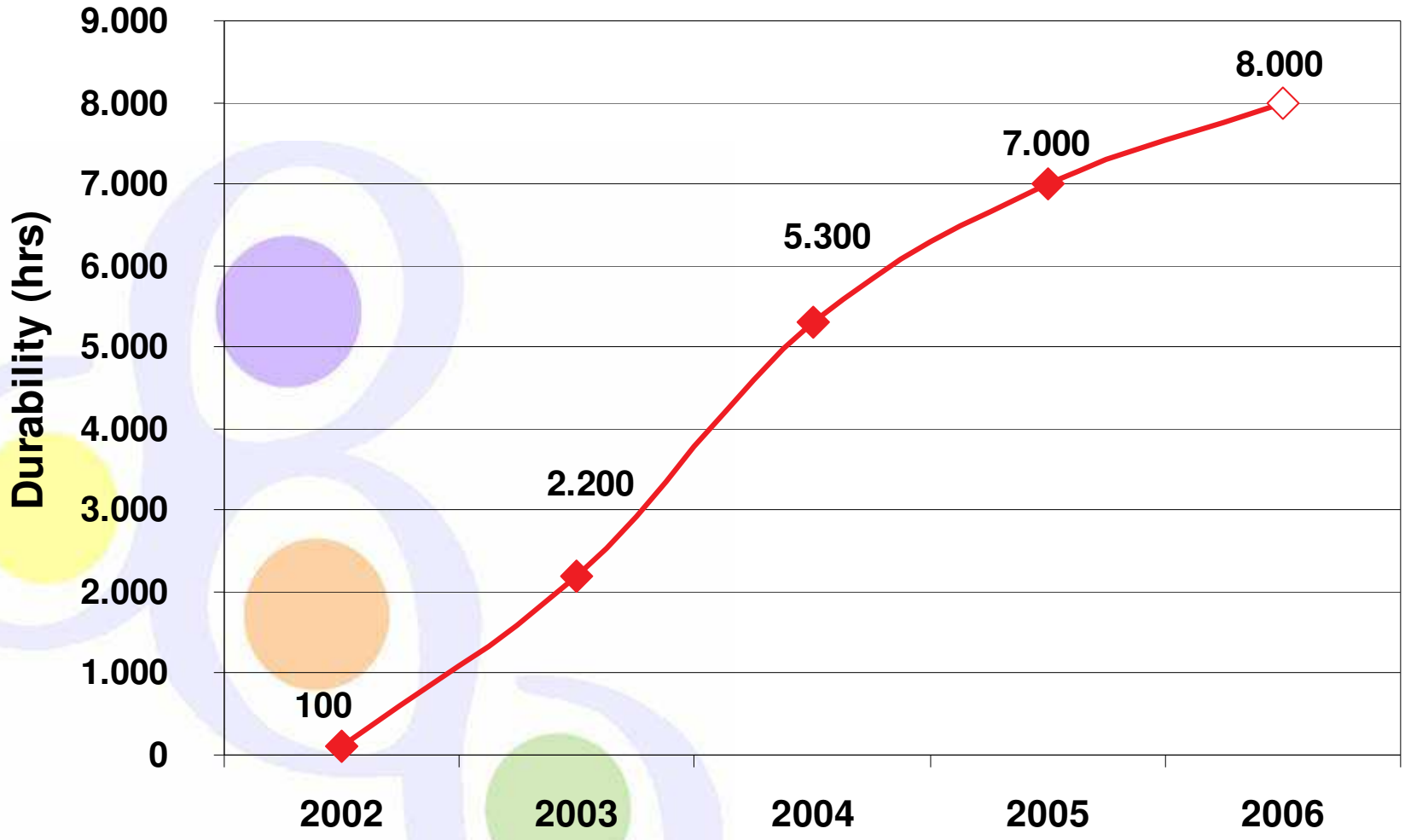
State-of-the-Art of the Technology

- FC System Example:

- Hydrogenics HyPM 10 status 01/2006:
  - Design frozen and launched in November 2003
  - Extensively tested in the laboratory for wide ranges of driving cycles, parameters, durability
  - Integrated and tested successful in over dozen different vehicle types
  - System Warranty 1,000 hrs
  - Published expected stack lifetime 2,000 hrs
  - Latest Start/Stops achieved 6,000 cycles (single system)
  - Latest Durability achieved 8,000 hrs (single system)

State-of-the-Art of the Technology

HyPM 10 System Durability Testing*



* Data from laboratory bench testing on a single system with modulated load cycle

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“Shortcomings” - Obstacles to Market Introduction

Obstacles to H2 FC Market Introduction:	Hydrogenics current status for early test markets:
Functionality	à Suitable for early niches
Durability	à Suitable for early niches
Reliability	à Suitable for early niches
Unknowns requiring **experience** for the end user and Manufacturer alike ✓ Long-term **Operation** ✓ Long-term **Maintenance**	à Requires demonstrations
Availability of Fueling **Infrastructure**	à Requires demonstrations and market introduction
Approvals and certifications	à Depends on market demand, developing codes and standards
Costs ✓ System, operation, maintenance, spares parts	à Costs still too high due to raw material costs, lack of automated high volume production

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