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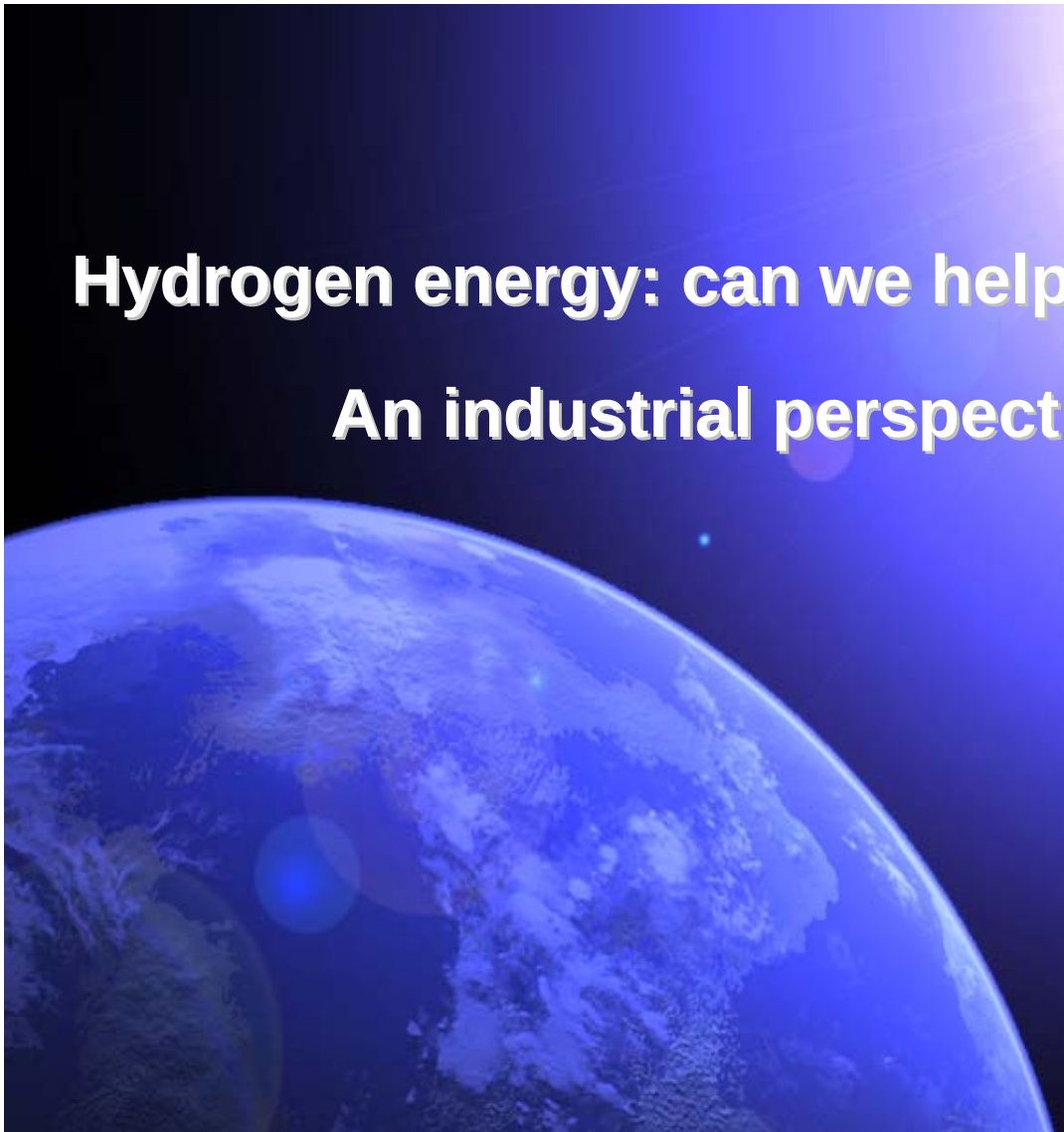
AIR LIQUIDE™

Hydrogen energy: can we help?

An industrial perspective.



IPHE
International Partnership for the Hydrogen Economy

Air Liquide in brief …

- **9,4 billion euro** sales in 2004

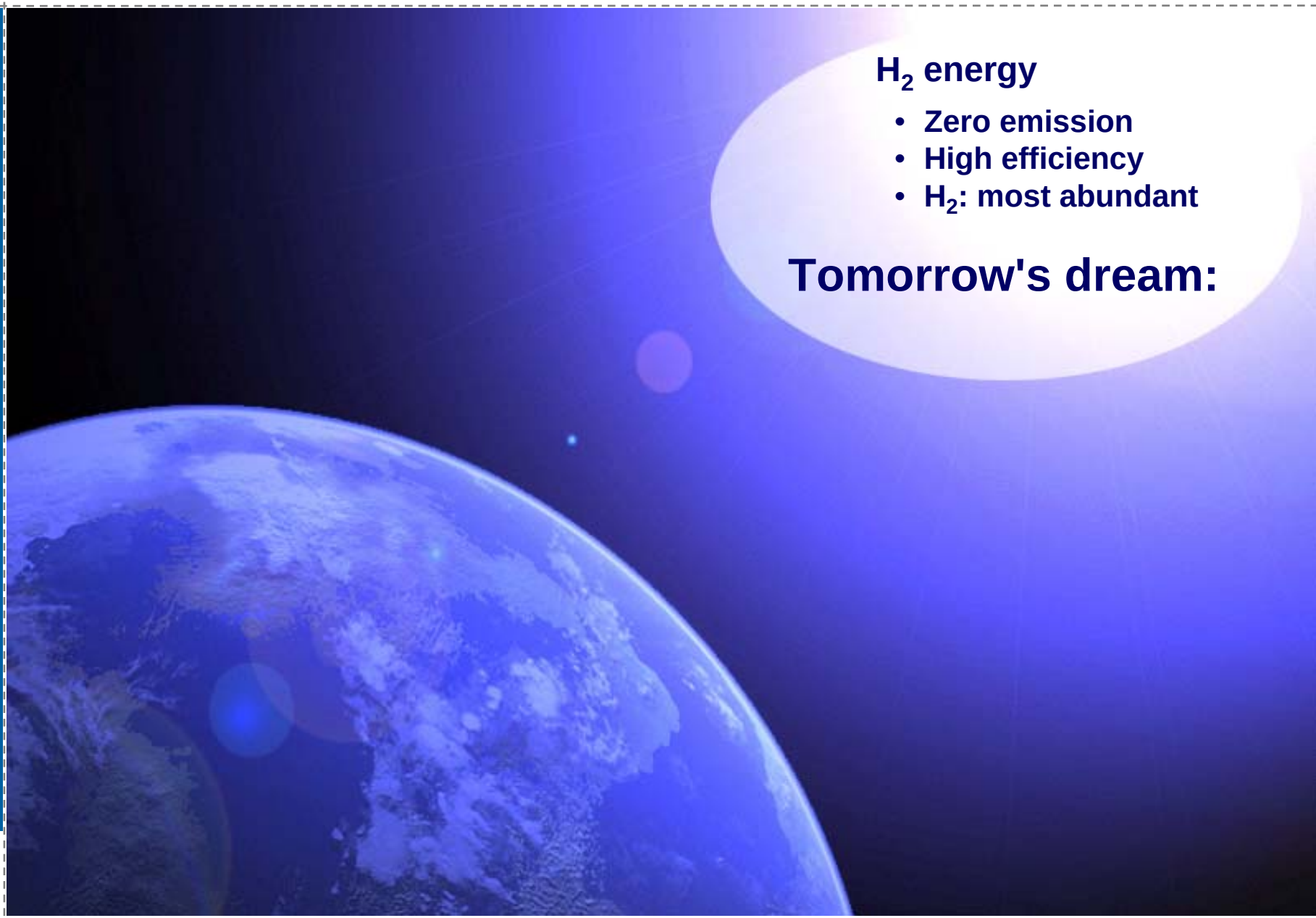
  (80% outside France)
- Over **35.000** employees
- Serving more than **1 million** customers …
- … in more than **65 countries**
- **8 R&D centers (US, Germany, France, Japan)**
- **6 Engineering Centers (US, Canada, France, Germany, China, India, Japan)**
- **350.000** shareholders

World leader in

industrial and **medical**

gases

Introduction



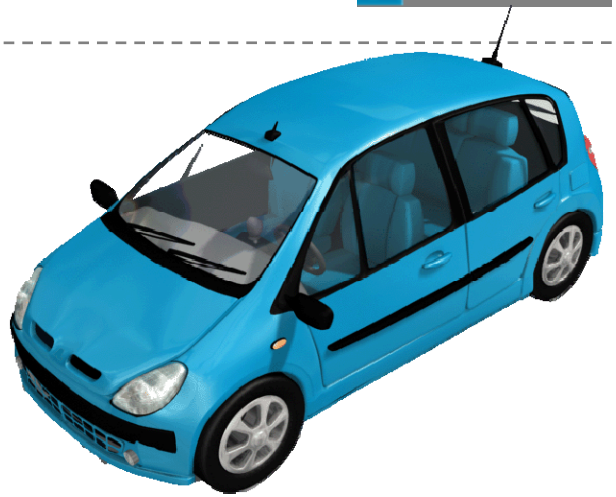
H_2 energy

- Zero emission
- High efficiency
- H_2: most abundant

Tomorrow's dream:

Tomorrow's dream

Key facts



- Today: 800 M° vehicles in the world
- 1.2 kg of H_2 to drive 100 km
- To fuel 8 M° vehicles: 21 B° m^3/years
  - Worldwide H_2 production: >500 B° m^3/years
- Today: 135 000 gas stations in Europe
  - Conversion of 10% to H_2: 10 B° €

Automotive is the only market that can drive long term technological developments

But
- Horizon 2040 ++
- How to jump start technology?

Introduction

H_2 energy

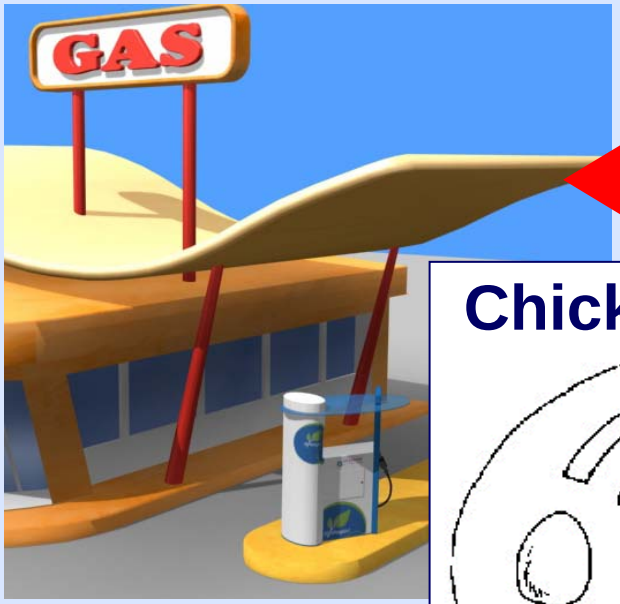
- Zero emission
- Alternative source
- H_2: most abundant
- High efficiency

Tomorrow's dream:

Today's reality:

- Developing technologies
- Limited "public" infrastructure
- Limited "carbon free" H_2 availability
- Safety, Public Acceptance
- Cost vs. market price

Technology development dilemma



Chicken & egg dilemma

Our Approach

Chicken & egg dilemma

Existing infrastructure

Other niche applications

Technology development dilemma

Existing infrastructure

Chicken & egg dilemma

Other niche applications

H_2 energy: Existing infrastructures

Production

SMR

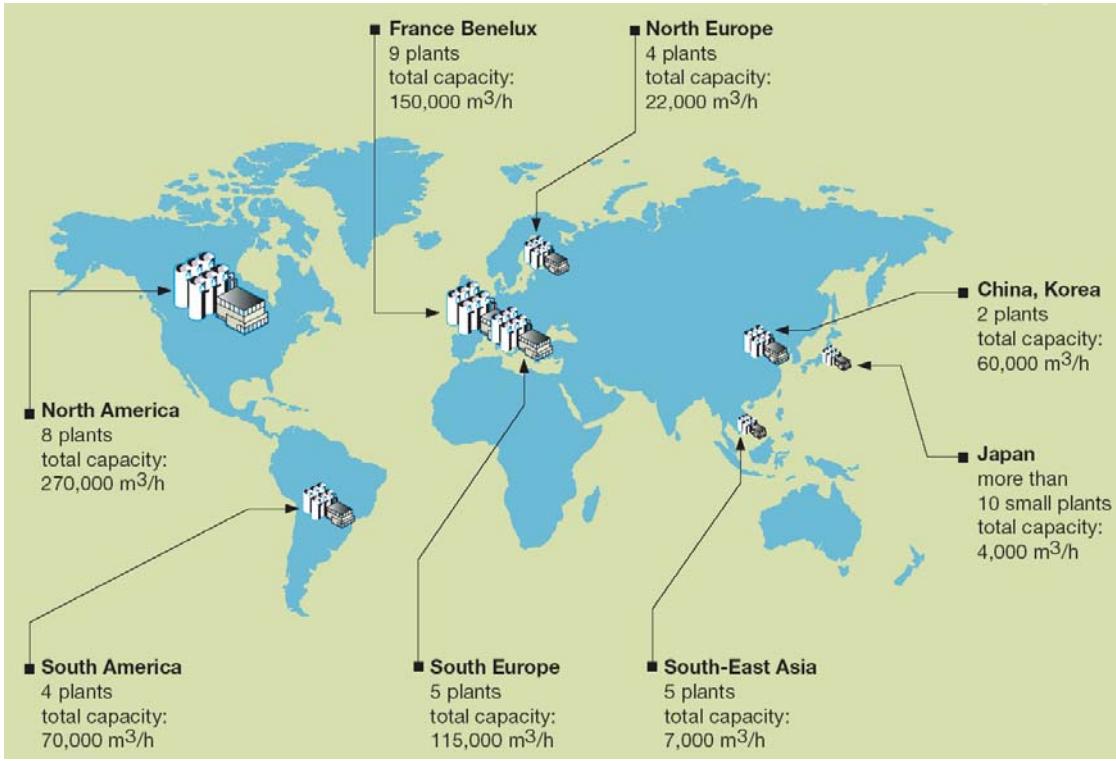
PSA

Hydrogen Production & Purification

SMR: Steam Methane Reformer

PSA: Pressure Swing Adsorption

> 200 Hydrogen production plants



H_2 energy: Existing infrastructures

Production

SMR

PSA

Distribution

Hydrogen Distribution

Cylinders

200 bars, 9 m^3 GH_2

Hundred of thousands cylinders

Trucks - Trailers

Cryogenic tanks:

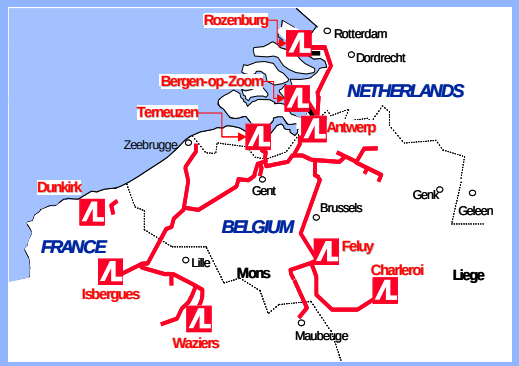
-253°C 40,000 m^3 GH_2

Tube trailer:

200 bar 2,500 to 6,600 m^3 GH_2

> 1000 trucks

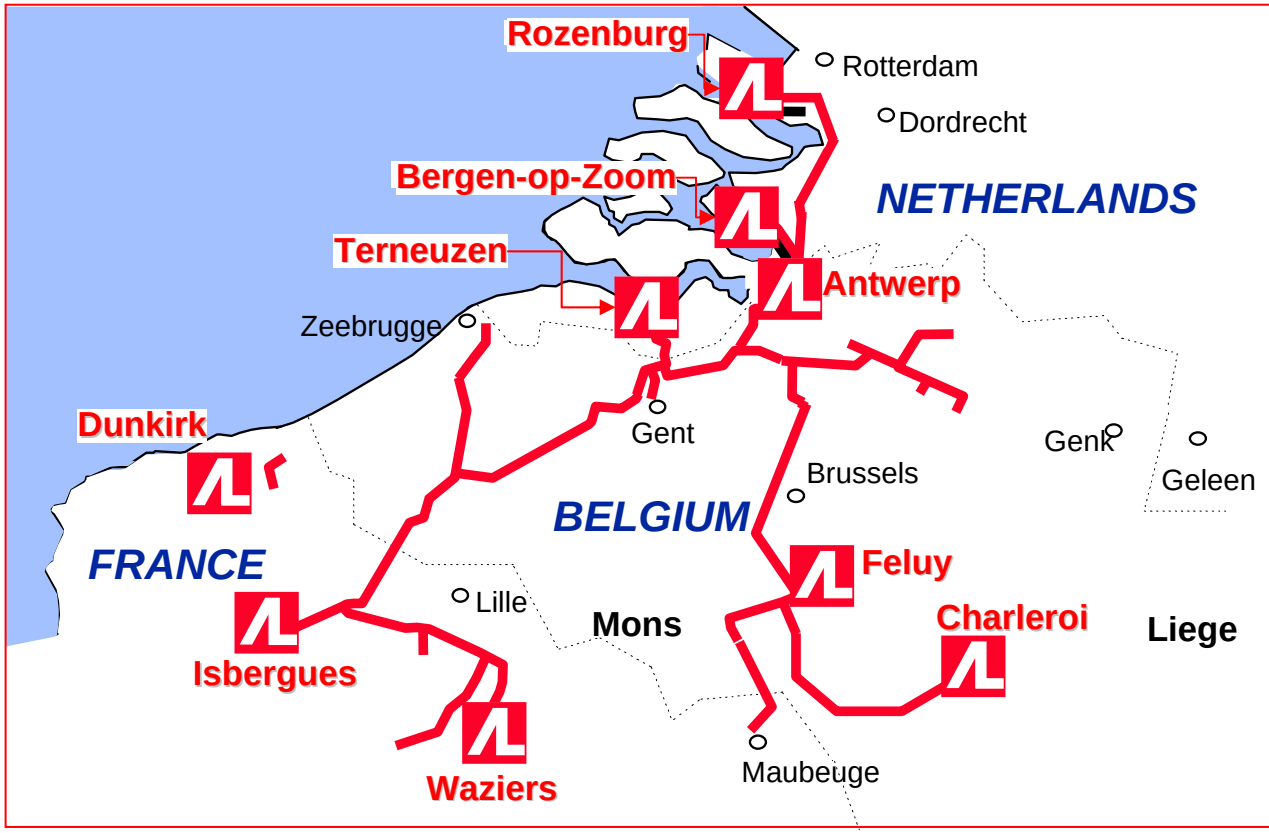
Pipeline



12 networks worldwide

> 1200 km of pipelines

Hydrogen network



Benelux:
The largest H_2 network in the world

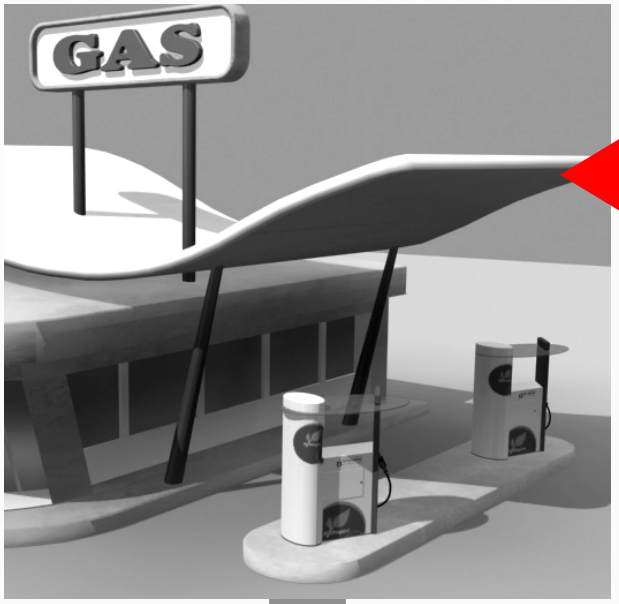
Hydrogen plant

Pipeline

12 H_2 network worldwide:

Benelux	Germany
Texas	South Korea
Louisiana	Thailand
France (x3)	Indonesia

Technology development dilemma



Existing infrastructure

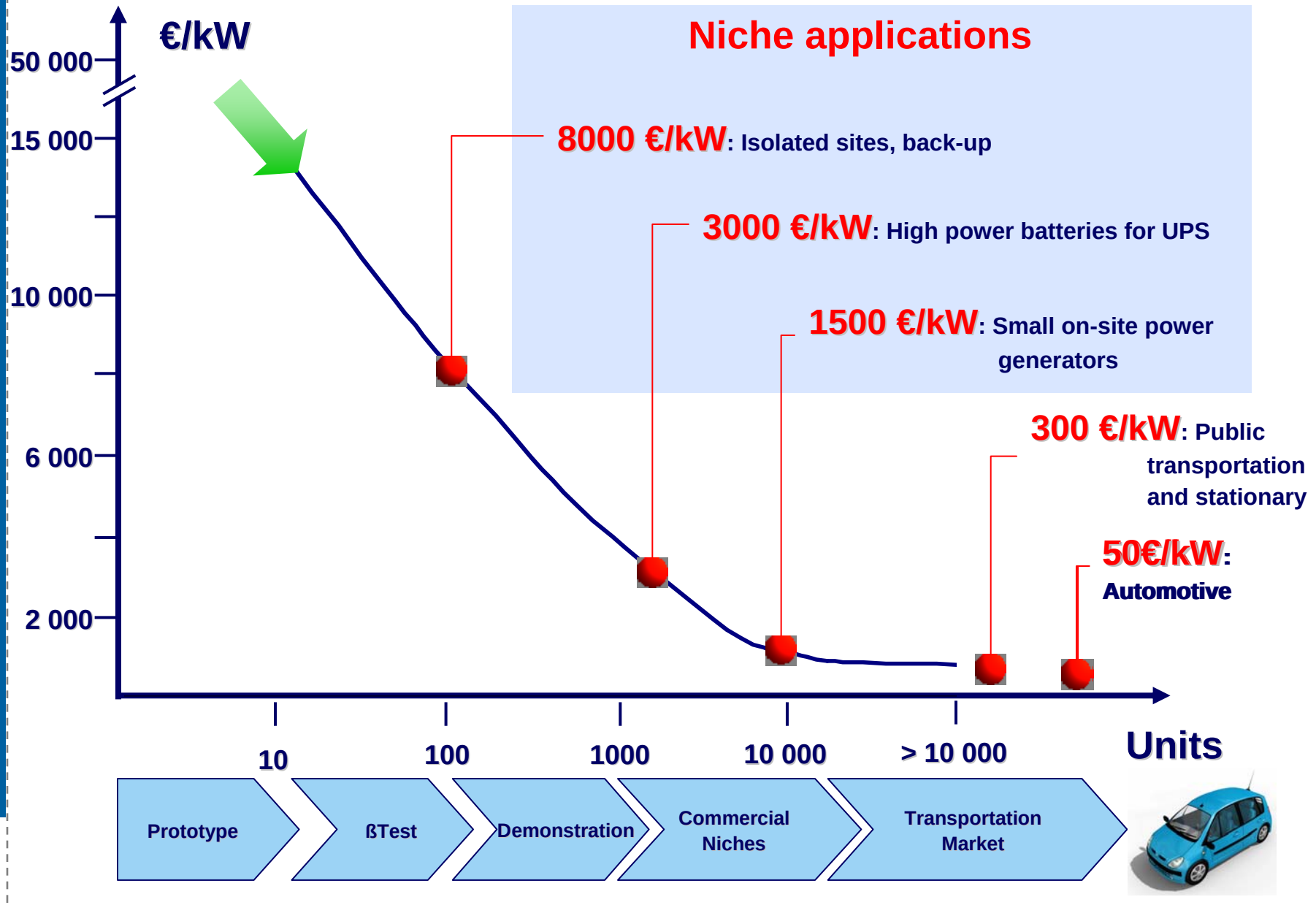
Chicken & egg dilemma

Other niche applications

Criteria for selection of niche applications

- Compatible with existing industrial H_2 infrastructure
- Market price in line with current technology
- Less stringent operating conditions than automotive market
- Easier public acceptance

How to identify niche applications ?



Air Liquide's Approach

- axane
  - A wholly owned Air Liquide subsidiary
  - Created in May 2001
- Located in Grenoble (France) AL high tech park

axane strategy

AIR LIQUIDE

Stationary

Base load supply
or UPS

Portable

All purpose generator
set applications

Integrated on board

On board system for APU
or vehicle propulsion

Example of niche application - 1

COMM PAC™

Stationary electric generator

- main power supply as based load
- emergency standby supply UPS

Technical specifications

• Net power	2,5 kW
• Overload capacity	5 kW for 1 second
• Noise	50 dba @ 1 m
• Weight (less fuel)	150 kg
• Dimensions	115 x 120 x 70 cm
• Operating temp.	- 20°C / + 45°C

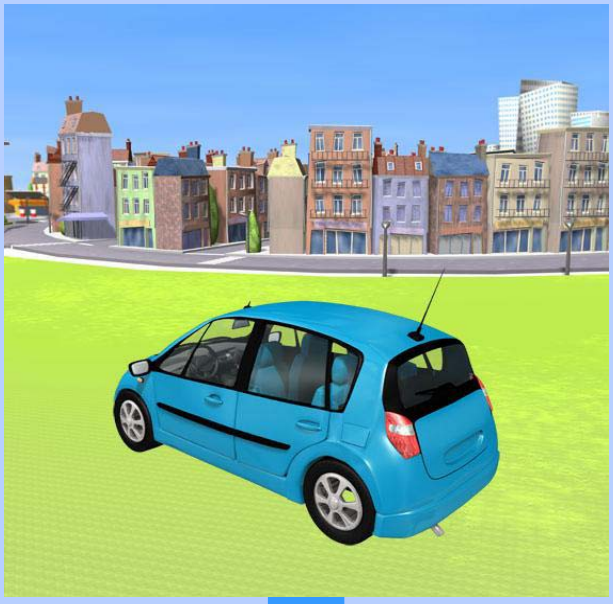
Hydrogen feed

• H_2	99.99 %
• Pressure	0.2 bar
• Consumption	0.7 Nm^3/h per kW

Technology development dilemma

Existing infrastructure

Chicken & egg dilemma



Other niche applications

What do we need?

- **On the road to industrialization**
  - **Development projects**
  - **Incentives**
  - **Regulations**

HYCHAIN Proposed Project

HYCHAIN: Full Hydrogen Economy implementation at small scale setting the framework for mass deployment

Fuel cell scooters

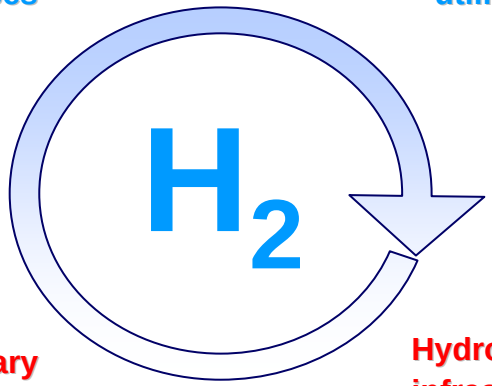
Fuel cell Wheelchairs

Hybrid minibuses

Transport fleets

Fuel cell utility car

Fuel cell city cars



Fuel cell Tricycles

Stationary

Hydrogen infrastructure

FP 6 - 2004 TREN.

Estimated budget
51 Million €

26 partners
4 European Regions in:

France
Spain
Germany
Italy

What do we need?

- On the road to industrialization

Research & Development

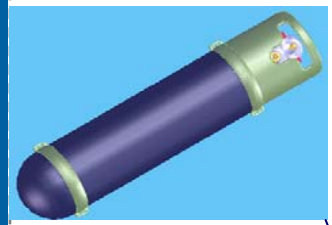
Production	Distribution	Fuel-cell
Improvement CO_2 sequestration H_2 alternative production	Composite packaging Hydrides & active materials	Improvements New PEM generation

Short Term

Long Term

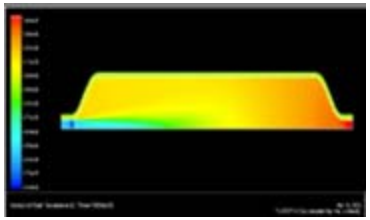
… leverage and coordination

Air Liquide H_2 Energy Technology Centers



New packaging

Filling stations



Storage modeling

Filling stations

H_2 fueled cars

Advanced storage

St-Ouen

Shanghai

Tsukuba

Harima

Montreal

Versailles

Chicago

Newport

Sassenage

Fuel-cell tests

Liquid H_2 storage

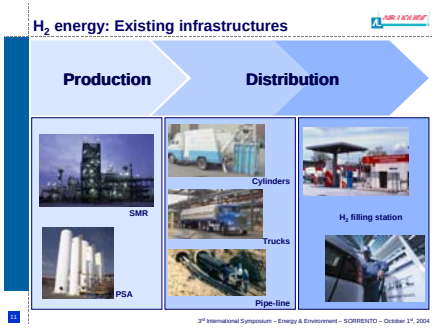
Membrane

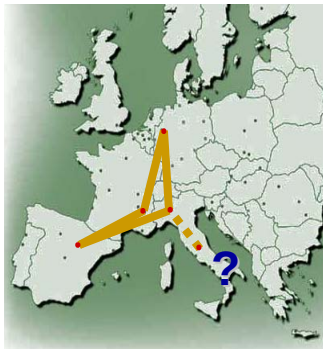
Fuel-cell

Conclusions

The dream can come true

- **Short term** market **opportunities** exists
- **Leverage** core technologies with niche applications
- **Key Issues:**
  - R&D coordination
  - Funding industrial deployment
  - Political push





Thank you