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Train-IN 2006

Session 1.3: Introductory Lectures

The Technological Steps of Hydrogen Introduction

Dr. J. Töpler

25th – 29th September 2006
Ingolstadt

CV – Dr. J. Töpler

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1946	Born
1976 - 72	Study of Physics at Technical University Aachen
1972 - 77	Scientist at Research Centre Jülich, Dr.rer.nat (Main Topic: Solid State Physics)
1977 - 06	Member of Daimler-Benz/DaimlerChrysler - Research (Main Topic: Hydrogen application and storage
1988 - today	Lecturer of „Regenarative Energies“ at the Technical University in Esslingen
2000 - today	Member of Editorial Bord of „Fuel Cells- from Fundamentals to Applications“
2002 - today	Member of the bord of German Hydrogen and Fuel Cells Association (DWV) (2003 Chairman)

1.3 The Technological Steps of Hydrogen Introduction

Deutscher Wasserstoff- und Brennstoffzellen-Verband

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- The Technological Steps of Hydrogen Introduction, Dr. J. Töpler, 45 min

Abstract:

On the basis of the actual energy situation with decreasing ressources and increasing environmental problems the necessity of regenerative energies are discussed as well as hydrogen as a secondary energy carrier with high potentials for different applications as mobile, stationary or portable applications or APU‘s. The state of the art of these applications is shown and the concepts for further developments are presented.

In this context some European projects (mainly funded by the EU) for H_2-application and - infrastructure are descibed.

Finally the way of cooperations in the EU for the further progress in these developpments are lined out.

1.3 The Technological Steps of Hydrogen Introduction

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- Actual Basic Situation of Energy Supply
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  - **- Mobile**
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  - **- Portable Applications**
- Infrastructure
- Conclusions

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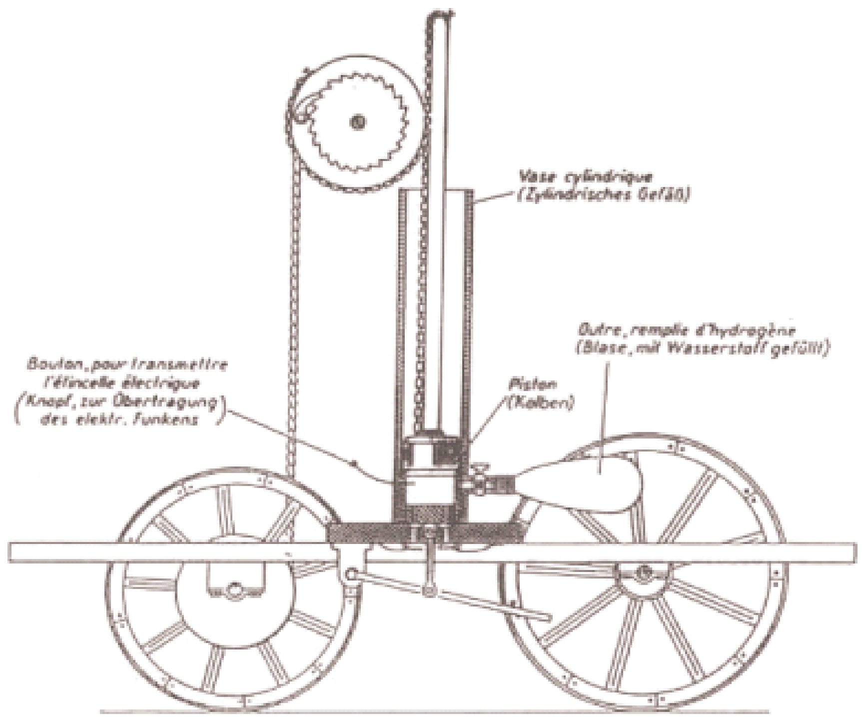

Darstellung eines Kraftfahrzeugs von Rivaz mit einem atmosphärischen Flugkolbenmotor, nach der Patentschrift vom 30. Januar 1807; Rivaz bezeichnete die Idee seines Motors als Anwendung der „Pistole, dit de Volta“

The first technological step to hydrogen application

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Actual Basic Situation of Energy Supply:

- The availiability of fossil primary energies is limited to years

  with increasing efforts for exploitation
- The energy need will increase and will aggravate the situation
- The climate change due to CO_2-emisssion is immense right now with increasing tendency
- Fossil energy carriers are raw materials for organic chemistry

  ⇨ too valuable for combustion only
- The introduction of a new energy system needs generally about

  years for the first 10% of market penetration (Marchetti et al., 1980)

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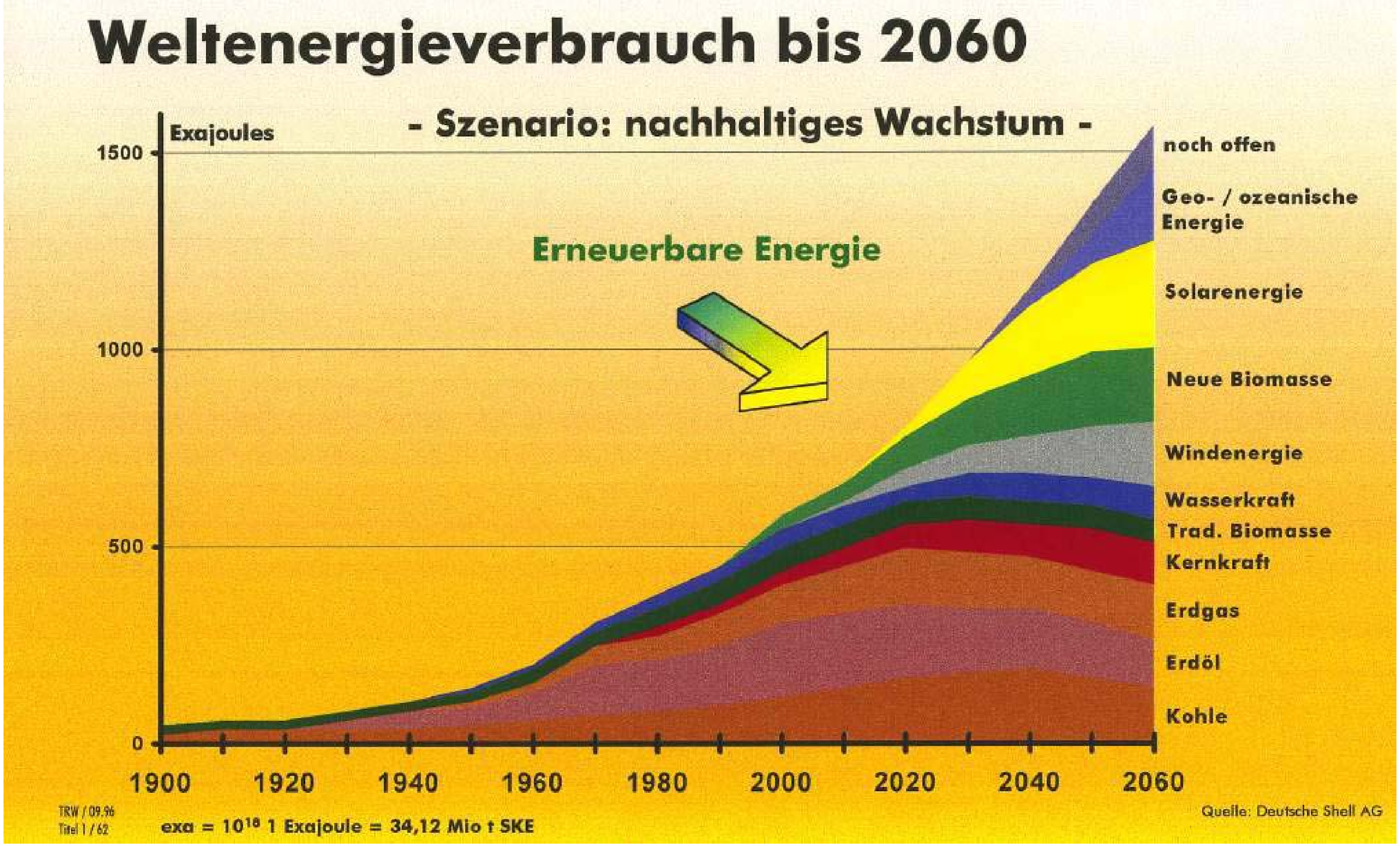

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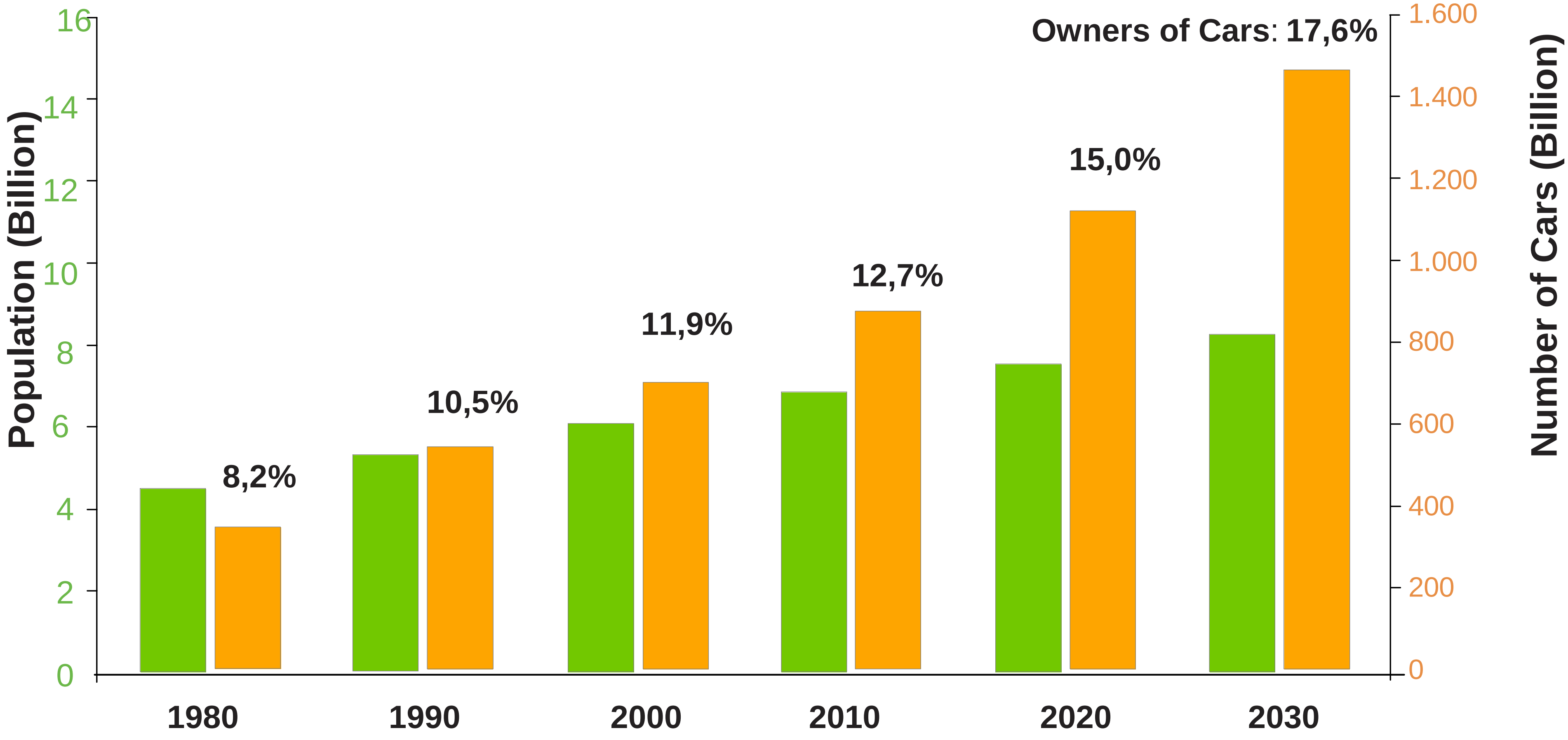


World Population and Number of Vehicle

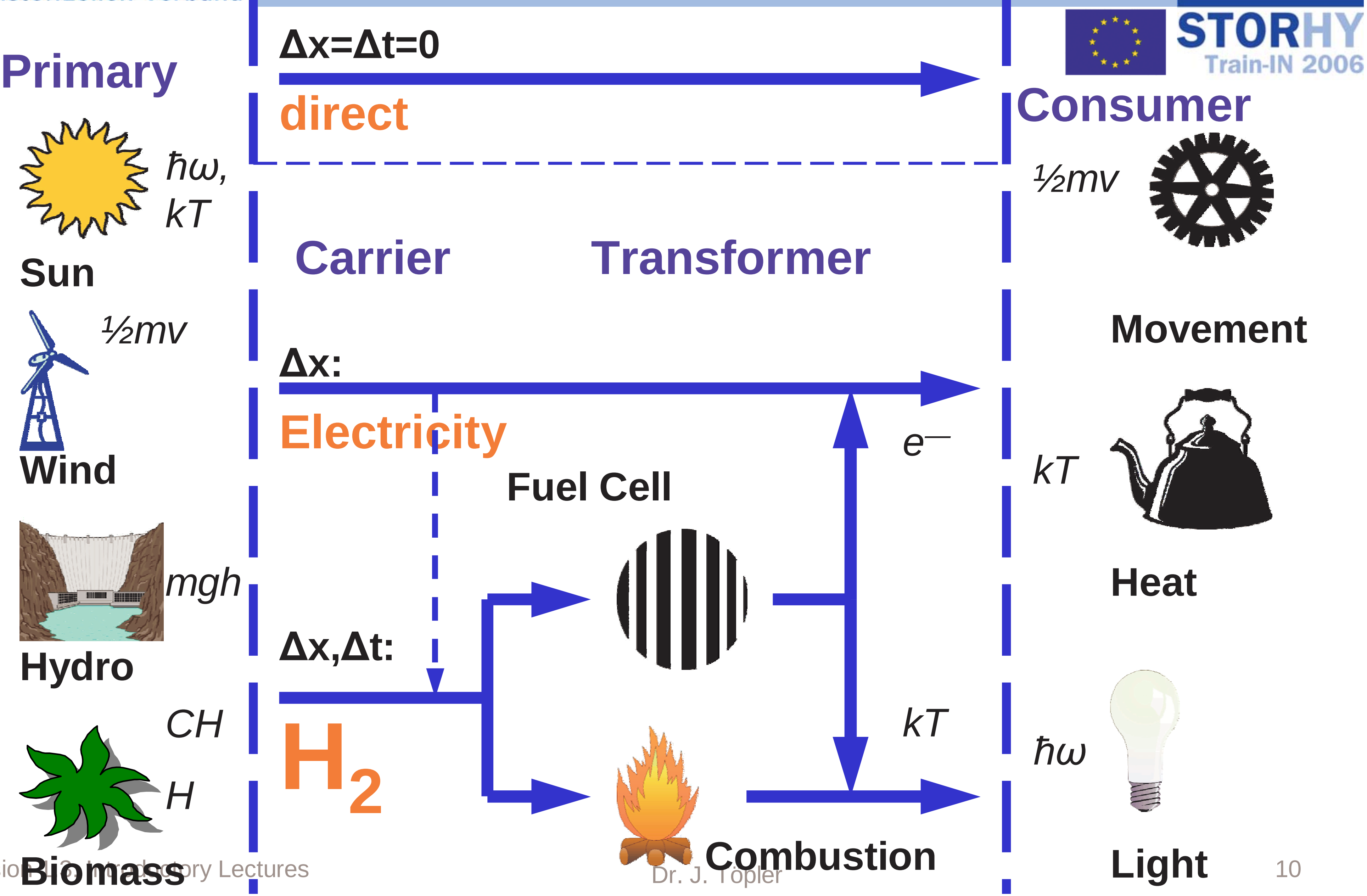
Source: GM/Opel

Consequence:

It is very urgent to proceed to regenerative energies

- free of CO_2 (if necessary via primary energies with less CO_2)
- with hydrogen as secondary energy carrier, which can be stored, transported and used by different methods and high efficiencies

The role of hydrogen



The role of hydrogen

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First Applications of Hydrogen :

- ***Mobile*** applications in urban busses, vans and passenger cars (internal combustion engines or fuel cells)
- ***Auxilary Power Unit (APU)*** for vehicles (busses, trucks, special cars with additional electricity), airplanes or ships
- ***Stationary Applications*** in decentralised utilities for power generation and heating
- ***Portable Applications*** in Laptops, Cameras etc.

H2-Vehicles: Potential System-Combinations for Propulsion and Storage

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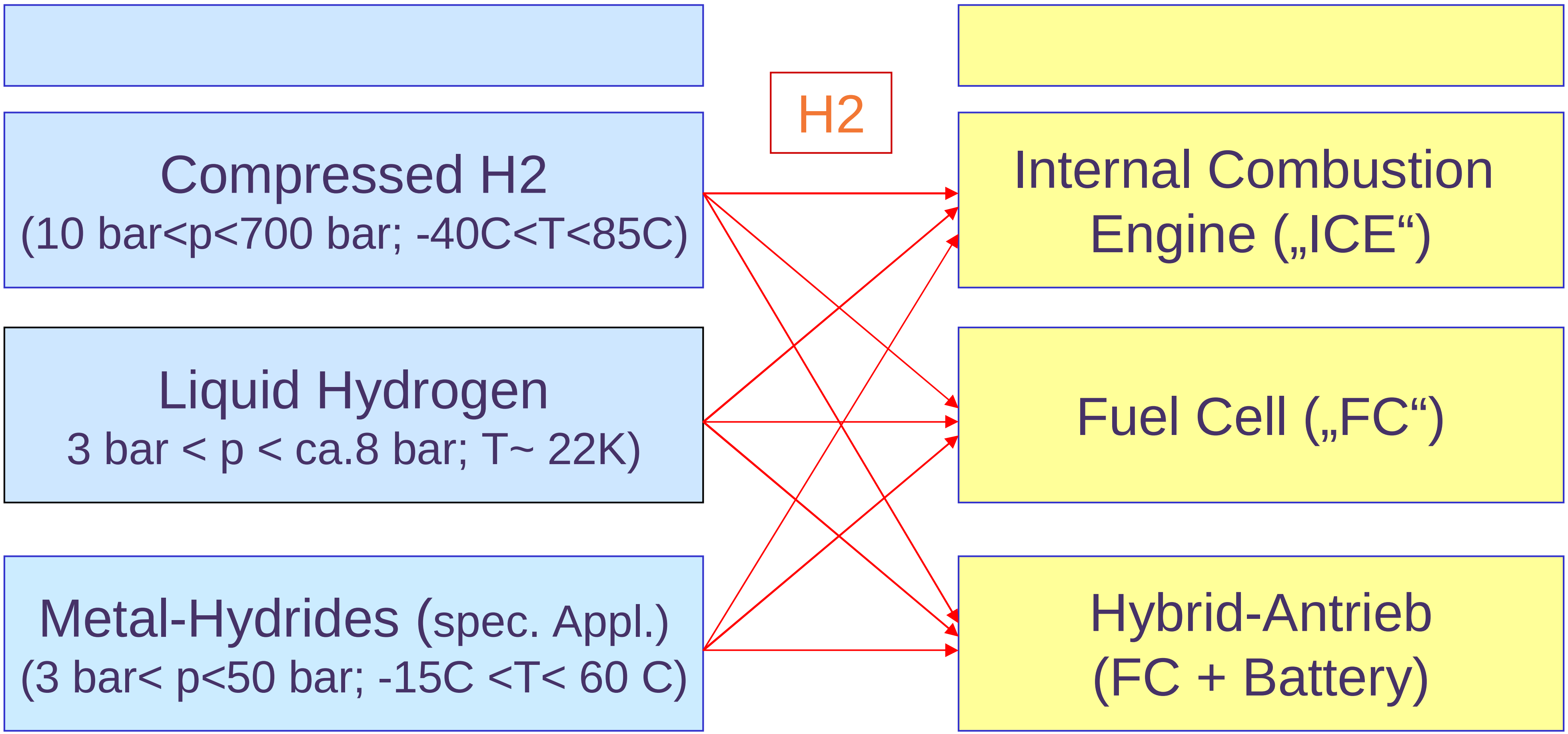
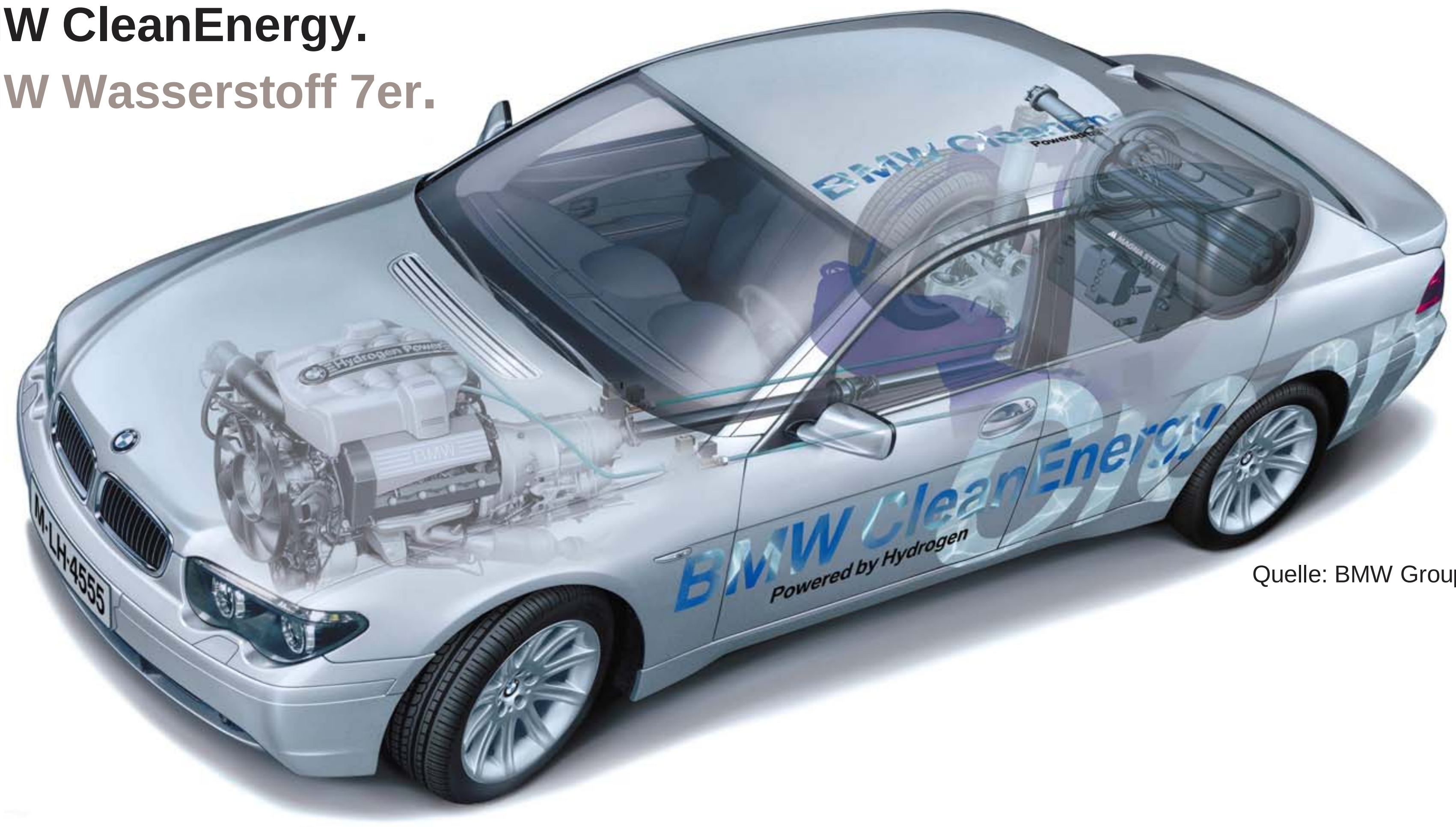


Hydrogen Application in Passenger Cars

BMW CleanEnergy.

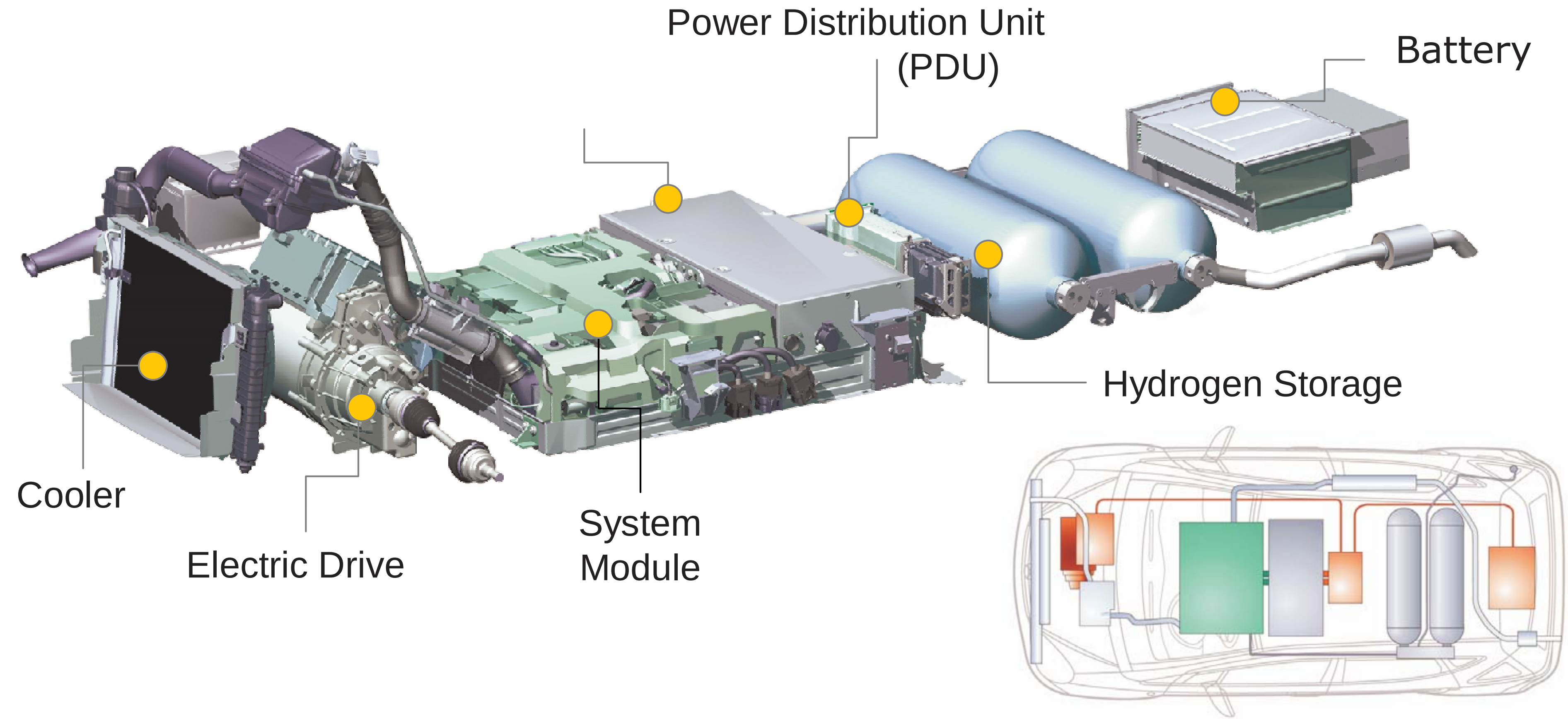
BMW Wasserstoff 7er.



Quelle: BMW Group

Hydrogen Application in Passenger Cars

DaimlerChrysler, FCell Packaging



DaimlerChrysler: Citaro-Bus, Packaging

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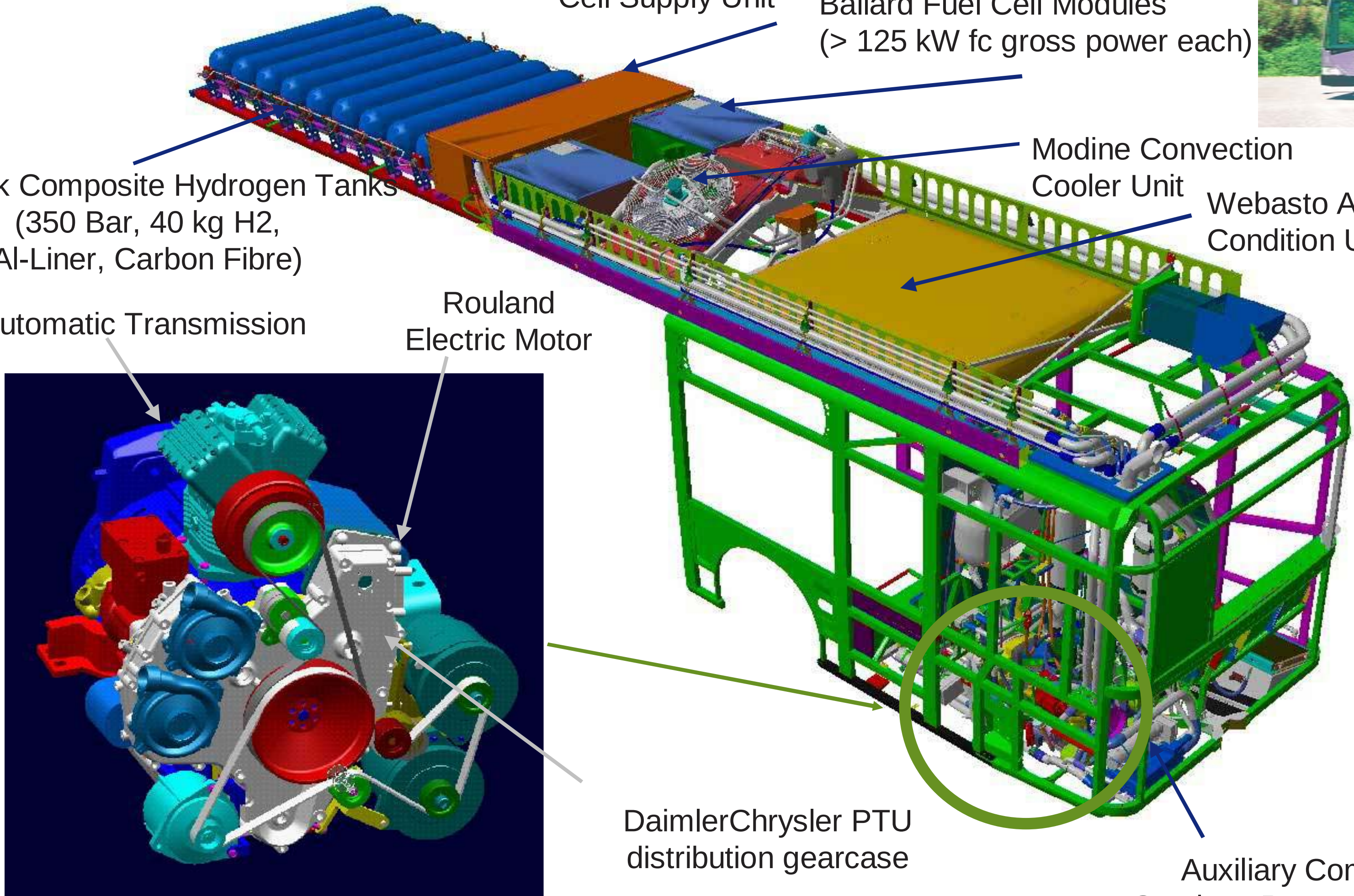
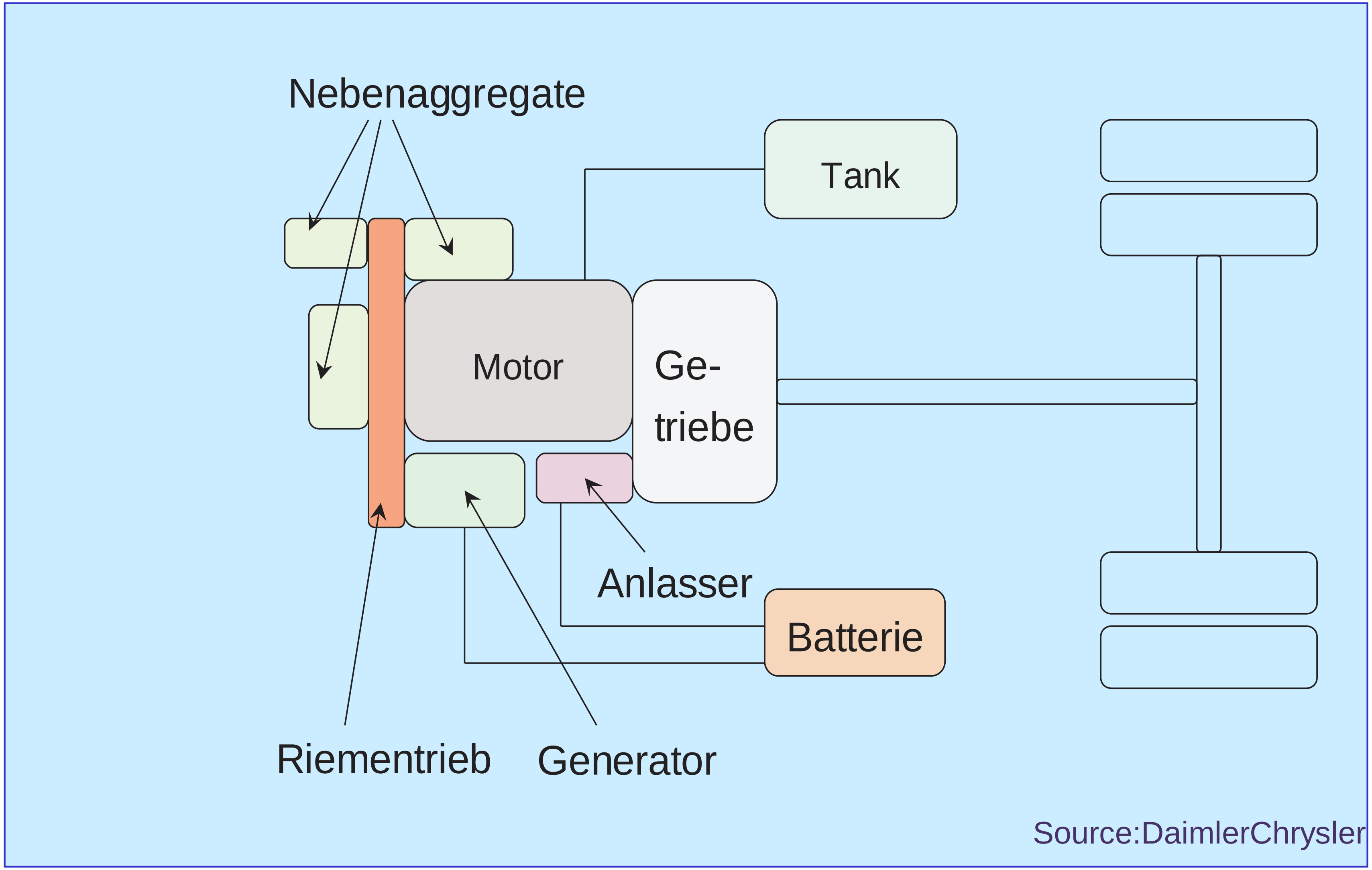


Energy system of trucks: conventional system



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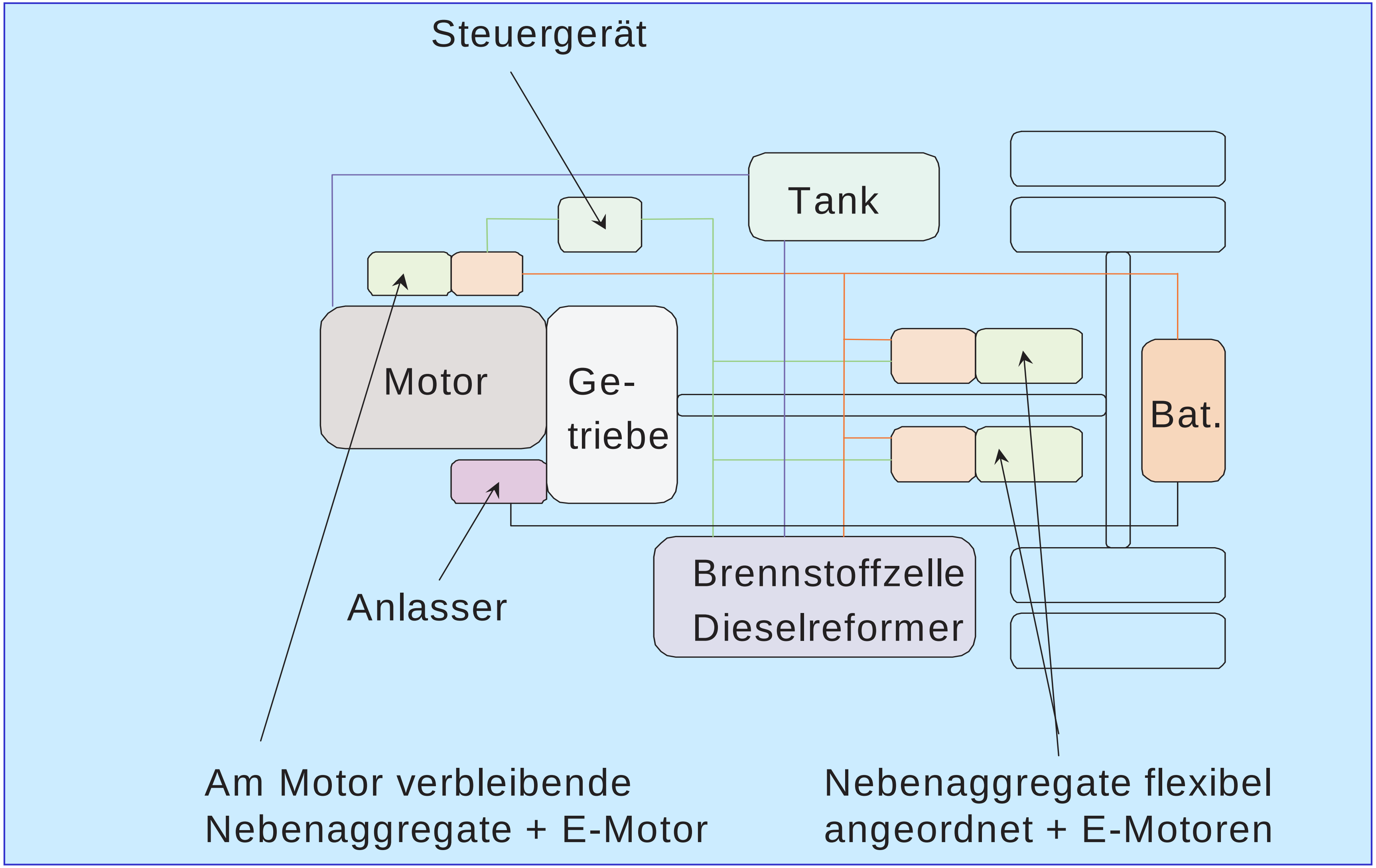
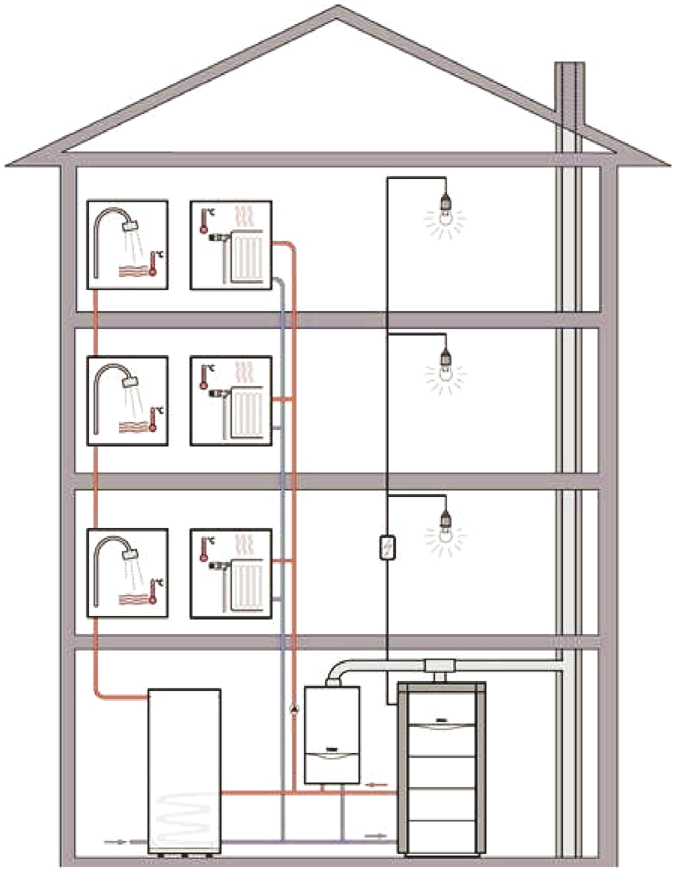


Domestic Fuel Cell Application for Europe

Fuel Cell Heating Appliances



Key Elements

- Domestic Combined Heat and Power (DCHP, Micro-Cogeneration)
- Grid connected
- Central heating and hot water production
- Intelligent hot water storage management
- Condensing peak heater
- Digital communication and control

PEM Fuel Cell Heating Applicance

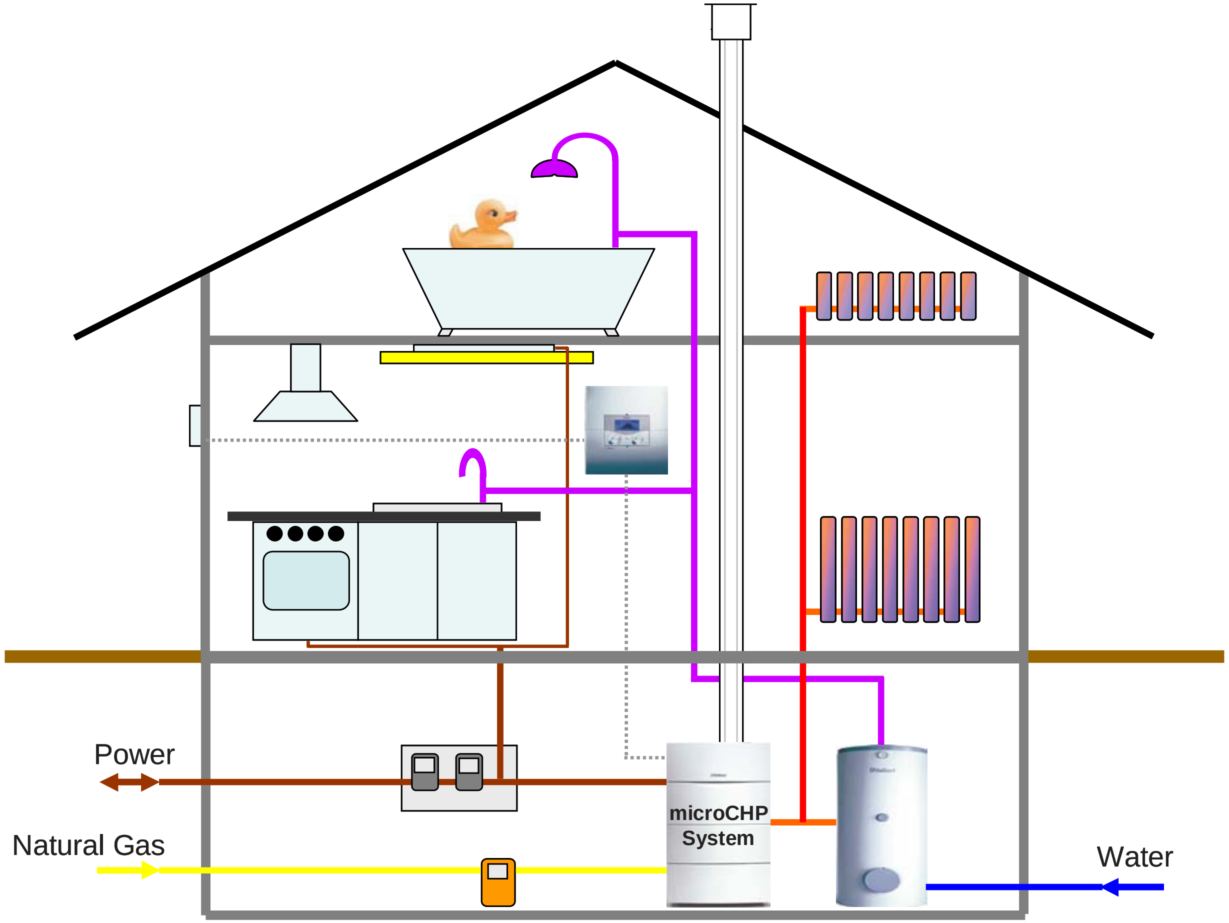
Electrical Output	1 - 4.6 kW_{el} grid parallel
Thermal Output	1.5 - 7 kW_{th} plus ~ 25 - 280 kW_{th} peak heater
Electric Efficiency	> 30 %
Total Efficiency	> 80 %
Application	Multi-family house, small business

Fuel	natural gas
System Lifetime	15 years, 80.000 h
Maintenance	2 years (annual inspection)
Exhaust Temperature:	max. 75 °C

Source:Vaillant

System schematic microCHP for a single family home

SOFC Fuel Cell Heating Appliance



Source: Vaillant

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Low Temperature System

High Temperature System

The PEMEAS high temperature MEA combined with Plug Power's unique system design deliver a greatly simplified system.

Source: Vaillant

1.3 The Technological Steps of Hydrogen Introduction

- Surplus of Hydrogen (By-Product) in chemical industry
- Electrolysis from electricity of power-plant reserves for regulation or surplus of other sources (e.g. wind)
- Decentralised production from natural gas (less CO_2)
- Production from biomass (CO_2 - neutral)
- Production from coal with subsequent CO_2 -sequestration
- In a log term scale: production from regenerative primary energy sources

Hydrogen is the best synthetic fuel for a sustainable mobility free of emissions

Locations of cheap H_2- Production (By-Product of Chemical Industry)

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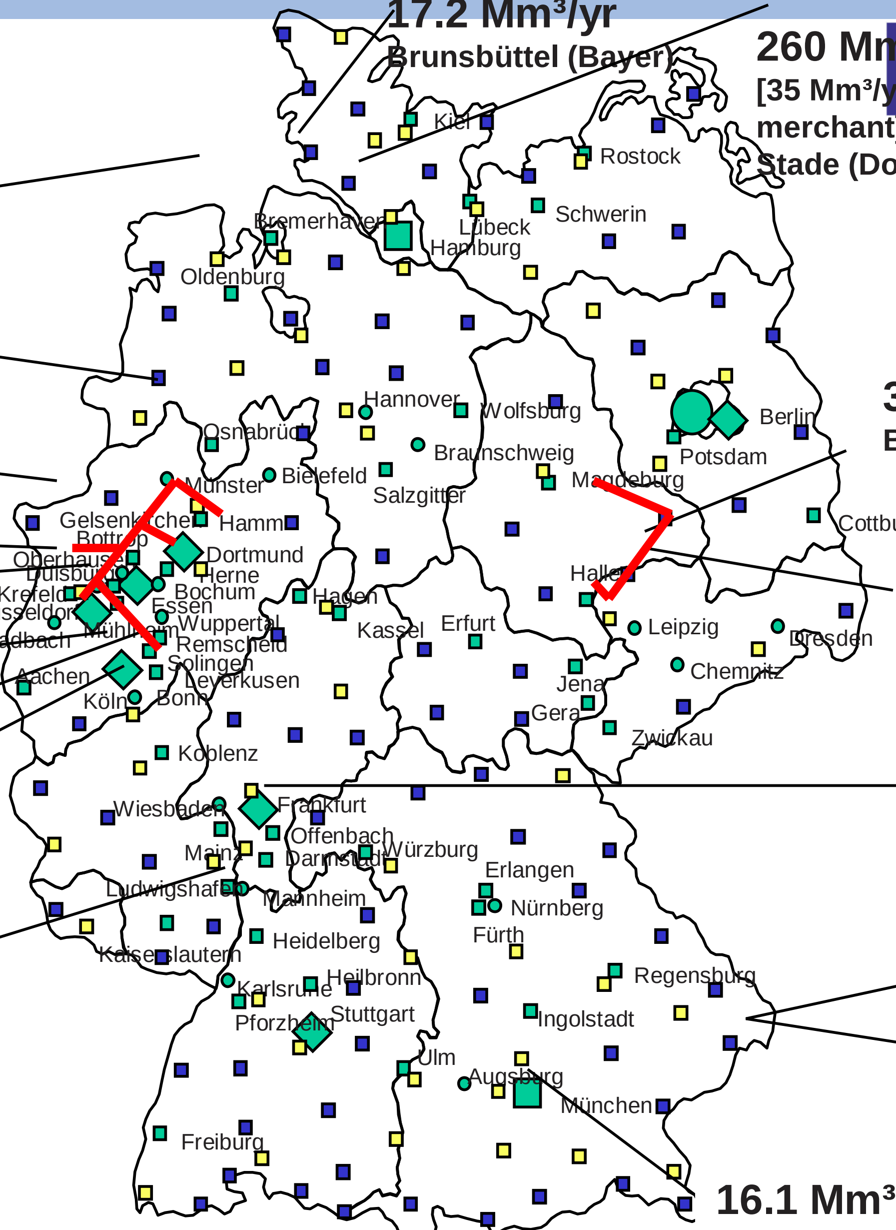
(for first vehicle fleets or merket niches)

Total: ~ 1 Billion Nm^3/yr



17.2 Mm^3/yr
Brunsbüttel (Bayer)

260 Mm^3/yr
[35 Mm^3/yr merchant]
Stade (Dow)

37.6 Mm^3/yr
Wilhelmshaven (ICI)

28.8 Mm^3/yr
Ibbenbüren (Elektrochemie Ibb.)

62.1 Mm^3/yr
Rheinberg (Solvay)

50 Mm^3/yr
Krefeld (Bayer)

86.1 Mm^3/yr
Dormagen (Bayer)

118 Mm^3/yr
Cologne (Air Products, ECE, Degussas)

85.4 Mm^3/yr
Leverkusen (Bayer)

43.4 Mm^3/yr
Hürth (Hoechst)

78.1 Mm^3/yr
Ludwigshafen (BASF)

33.9 Mm^3/yr
Bitterfeld (Chemie AG)

57.7 Mm^3/yr
Schkopau (Buna AG)

30-50 Mm^3/yr
(Hoechst-Infraserv)

20.8 Mm^3/yr
Gendorf (Hoechst)

45.3 Mm^3/yr
Burghausen (Wacker)

16.1 Mm^3/yr
Gersthofen (Hoechst)

Source: LBST 1998

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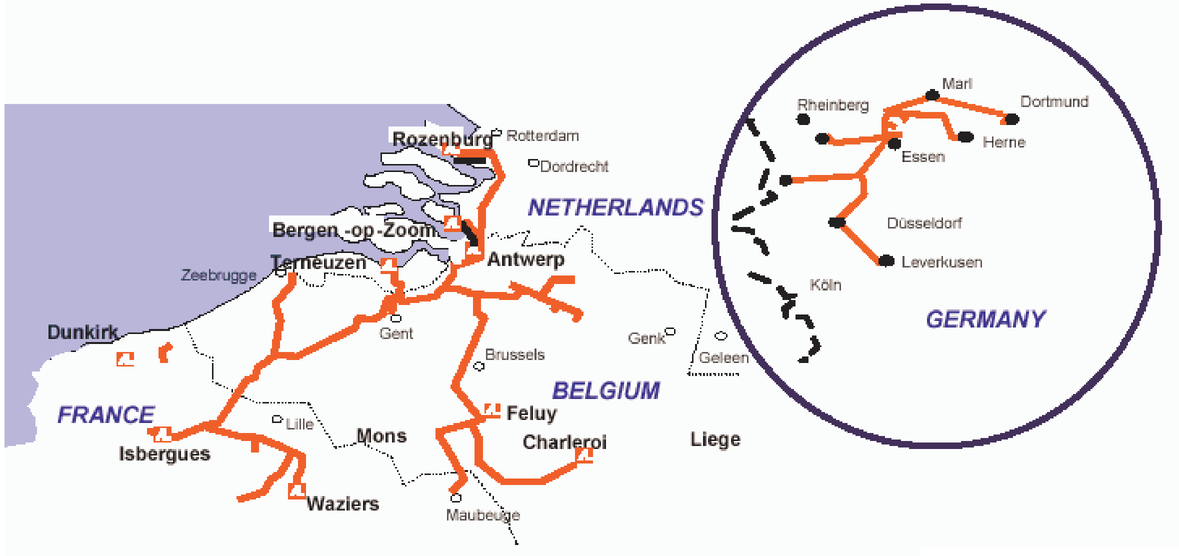
Air Liquide North Europe



Leuna H_2-Pipeline, Linde

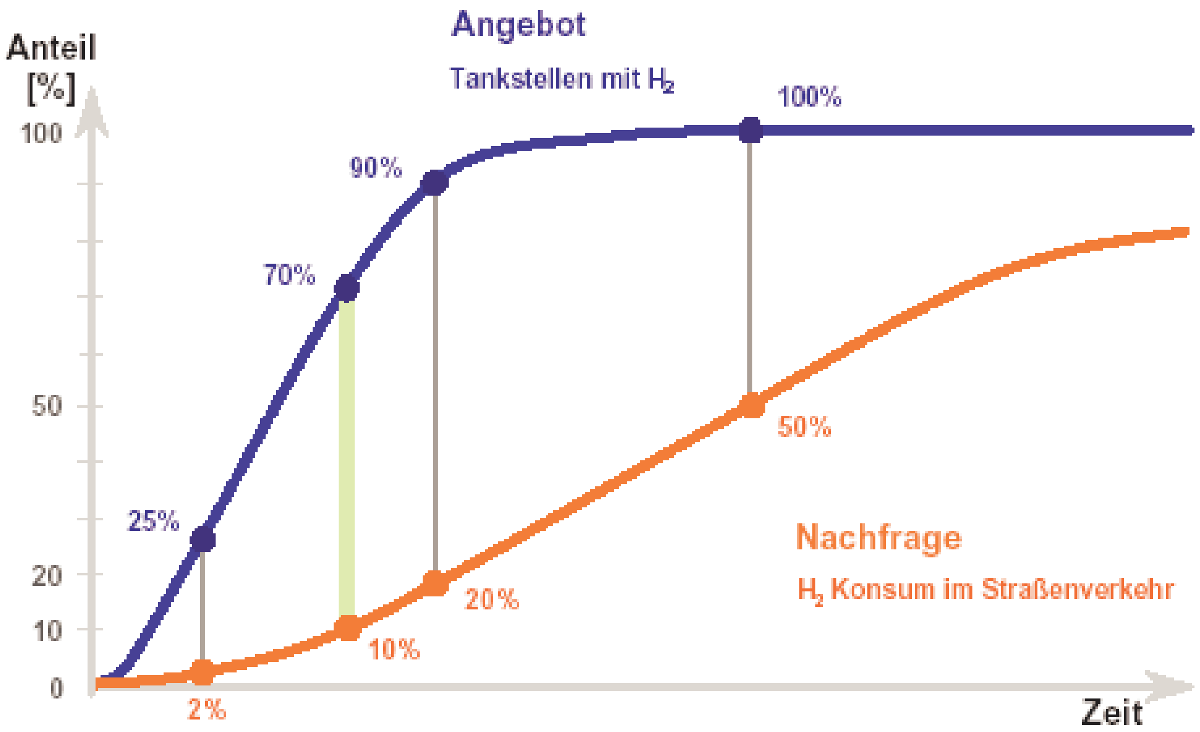
Belgium-France-NL
H_2-Pipeline, Air Liquide

Air Liquide:		
Belgium, France, NL	966 km	10 MPa
Germany:		
Rhein-Ruhr Pipeline [operative since 1938]	240 km	1.1/ 2.3/ 30 MPa
Leuna-Merseburg, Linde	100 km	2-2.5 MPa
Air Products Pipelines:		
Europoort, NL	50 km	
UK:		
ICI Teeside	16 km	5 MPa
Sweden:		
Chemical Industry	18 km	0.5-2.8 MPa

Source: Air Liquide, Linde

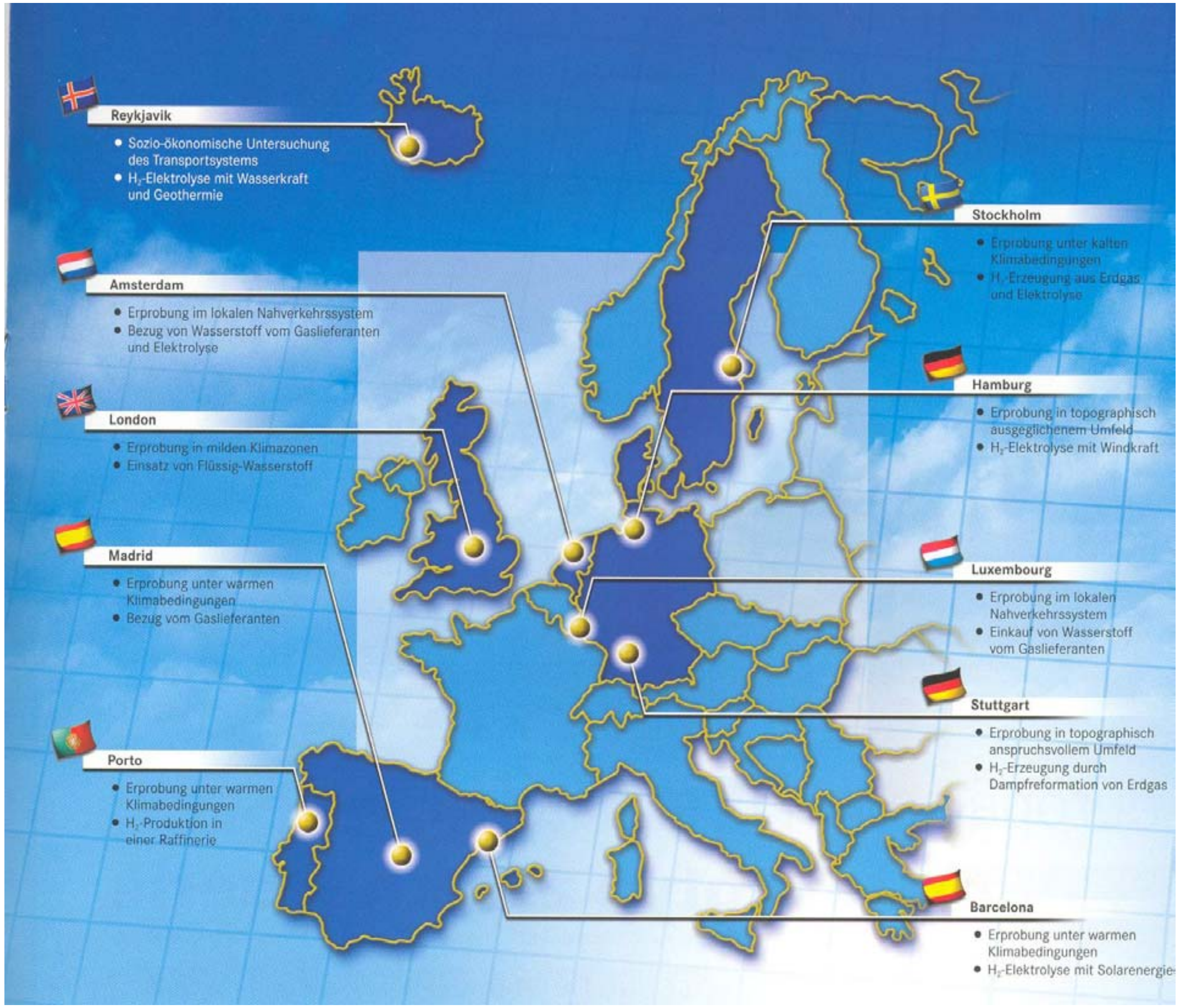
Needs of H2- Filling stations with respect to H2- vehicles

Abbildung 5-1: Vorfinanzierung der Wasserstoffinfrastruktur: Eine flächendeckende Infrastruktur muss vorhanden sein, bevor Wasserstoffautos auf dem Massenmarkt angeboten werden [Linde, 03]



CUTE-Projekt (Clean Urban Transportation Energy)

- 3 FC- busses in each city
- Different hydrogen Productions



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H2 Highway

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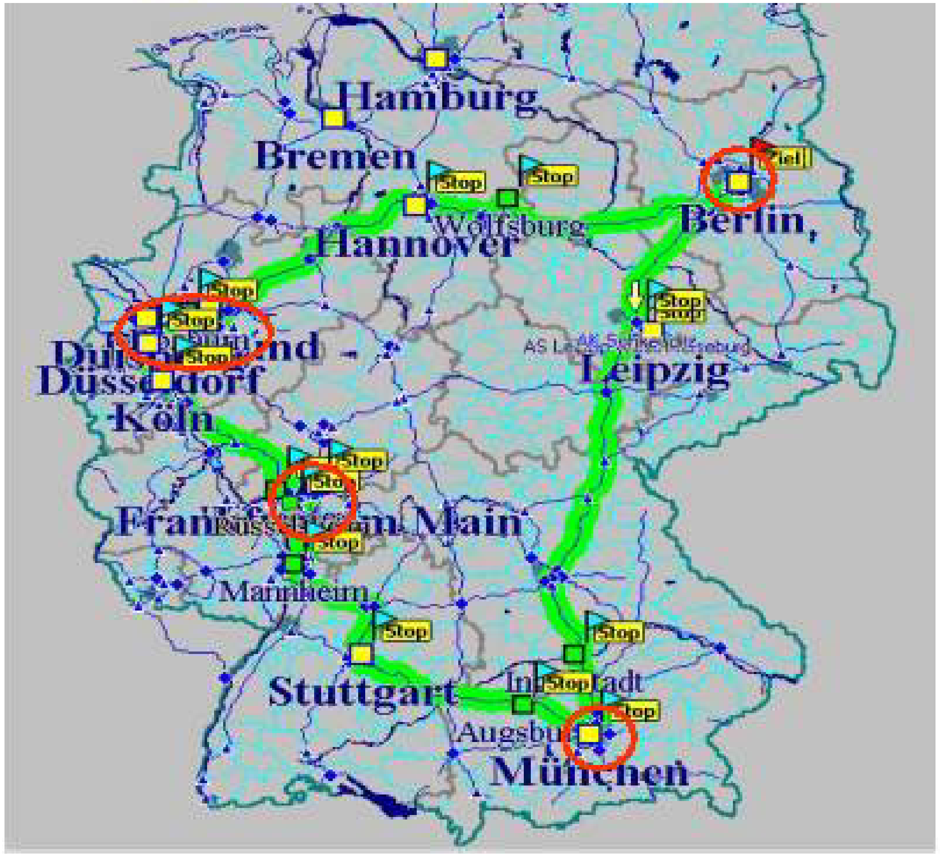
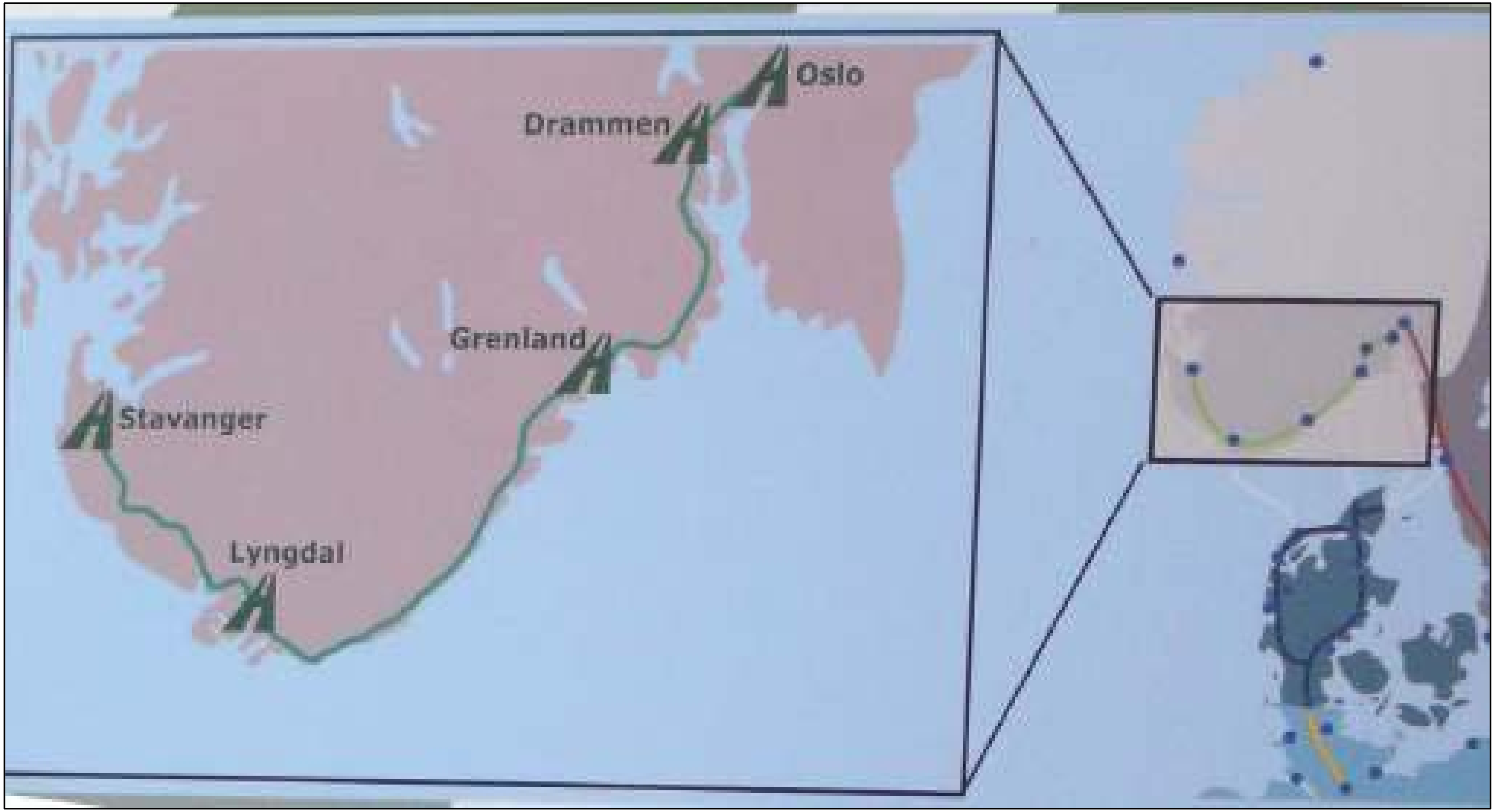
Hydrogen Logistic - H_2 Highway

Berlin
Wolfsburg
Hannover
Bochum
Düsseldorf
Köln
Wiesbaden
Frankfurt
Rüsselsheim
Mannheim
Stuttgart
Augsburg
München
Ingolstadt
Leuna
Leipzig



40 "H2 pumps" on the Highway about 2000 km

Proposal for a H2- highway in Norway: Stavanger-Oslo



Perspectives of market penetration of H2- vehicles

Hydrogen driven Passenger Cars

European Car fleet = 300.10^6 vehicles

HyWays

Total share car fleet [%]	2010 *	2020	2030	2040	2050
HyWays High**	-	3,3%	23,7%	59,5%	89,7%
HyWays Low***	-	0,7%	7,5%	23,6%	47,7%

10.10^6 Vehicles

* Demonstration vehicles and fleets

** démarrage en 2015

*** démarrage en 2020

→ 2.10^6 vehicles/yr

Roadmap of EU

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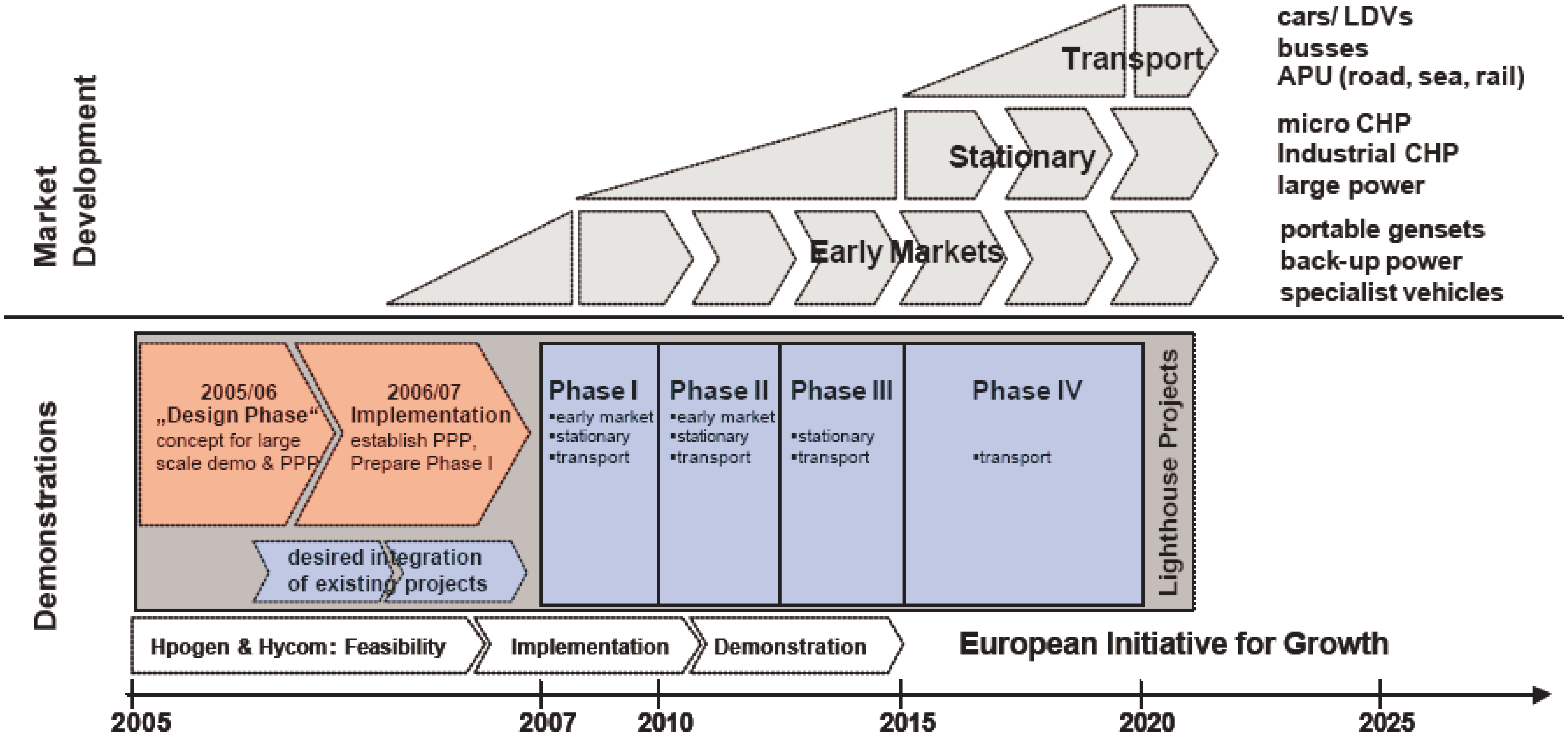
Roadmap of EU

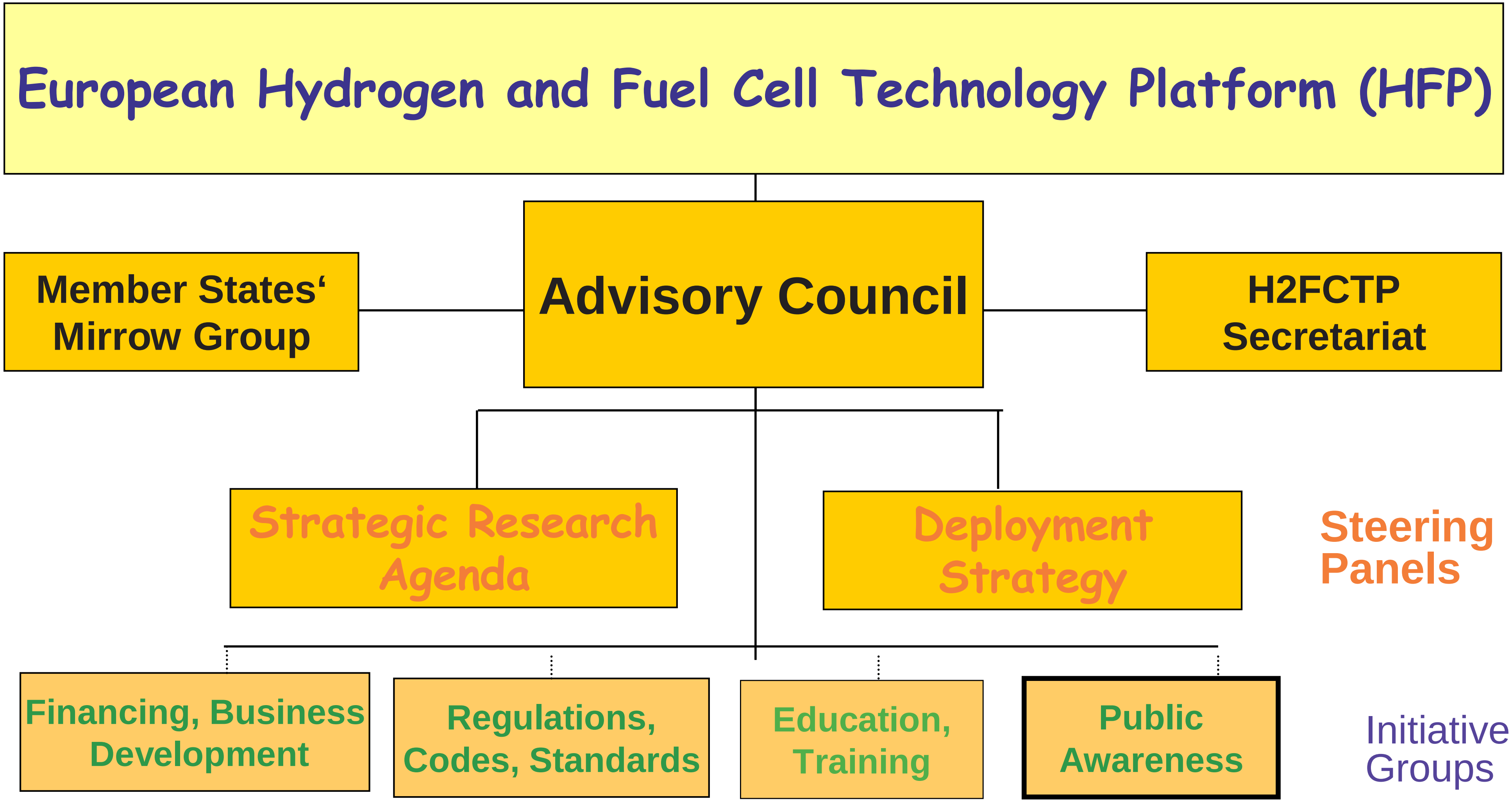
Hydrogen and Fuel Cell Technology Platform
www.HFPeurope.org



Summary

- The price of H_2 will perhaps be higher than for conventionel energies, but it will represent the real value of energy
- Strong efforts for saving energy will be necessary
- International cooperations will be imperative for cost sharing in development, for common standards and regulations and for systems of infrastructure and supply
- The cooperation of policy and economics is absolutely necessary for the basis of legal conditions as well as for safety or decisions

Overview HFP



Handicaps to market penetration of H2: human imagination

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DWV

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Thank you for your attention !

And visit us on our web-side

www.dwv-info.de

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