H_2-Based Road Transport in Comparison

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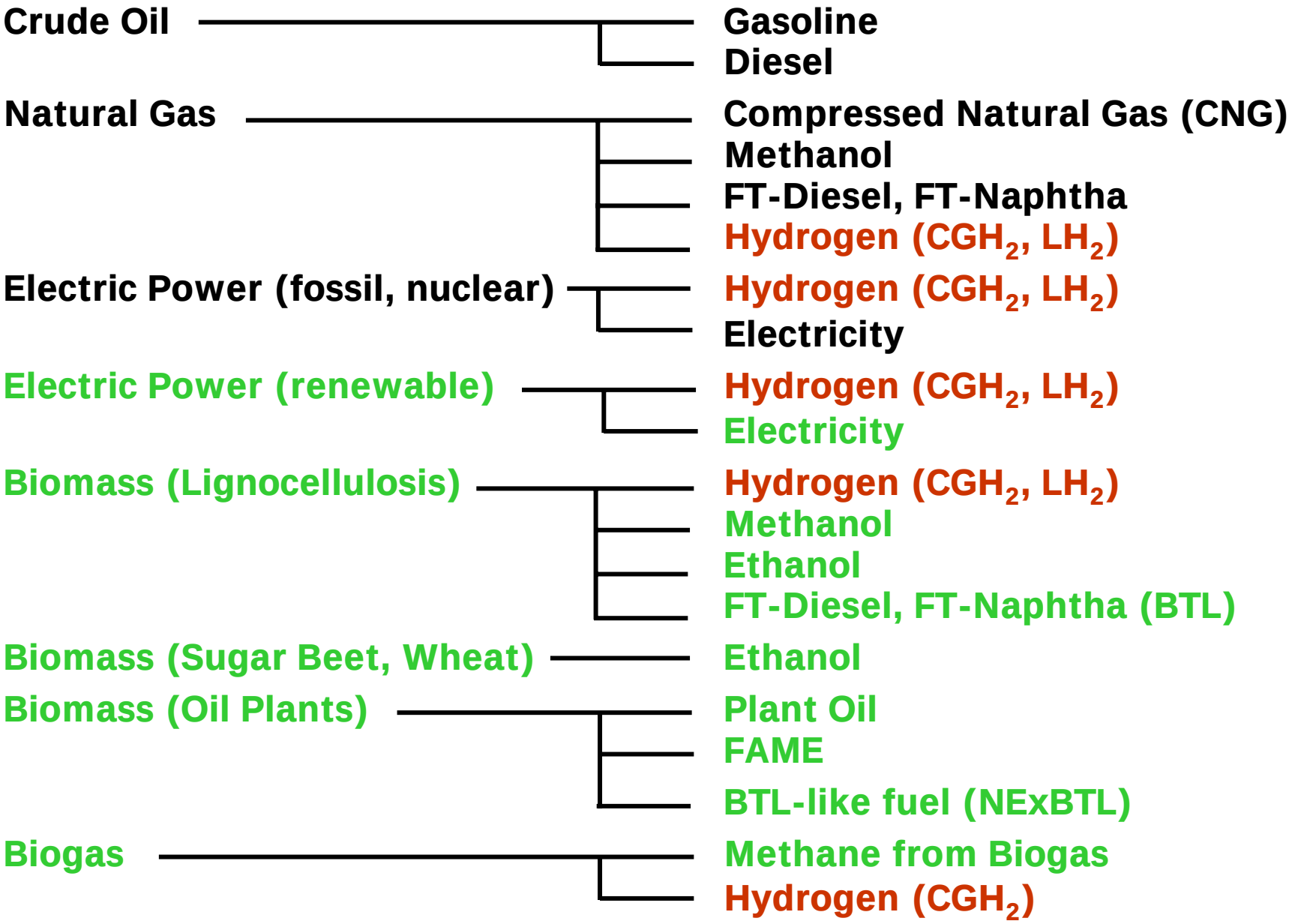
Well-to-Wheel Automotive Fuel Supply Pathways

Automotive Energy Supply Pathways



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Sustainability criteria for biomass derived fuels

LBST sustainability criteria nomenclature for certification

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1. Environmental	1.1 Climate	1.1.1 GHG balance
		1.1.2 Carbon sinks
	1.2 Biodiversity	1.2.1 Biodiversity
	1.3 Local environmental effects	1.3.1 Air quality
		1.3.2 Soil quality, erosion
		1.3.3 Water quality and resources management
2. Social	2.1 Social well-being	2.1.1 Social well-being of employees and local population
		2.1.2 Health and safety
		2.1.3 Pay and conditions for employees, trade unions
		2.1.4 No child employment
		2.1.5 No discrimination
		2.1.6 Women's rights
3. Economic	3.1 Local economic effects	3.1.1 Local prosperity
	3.2 Economic sustainability	3.2.1 Long-term economic and financial viability
4. Cross-cutting issues	4.1 Competition with food/ other indirect effects of land use change	
	4.2 Good Governance	
	4.3 Good Agricultural Practice	
	4.4 Biotechnology	4.4.1 Genetically modified organisms

In order to avoid collateral damages caused by ‘problem hopping‘, comprehensive **sustainability due diligence** is needed.

Well-to-Wheel Analyses – H_2 – Conventional ICE

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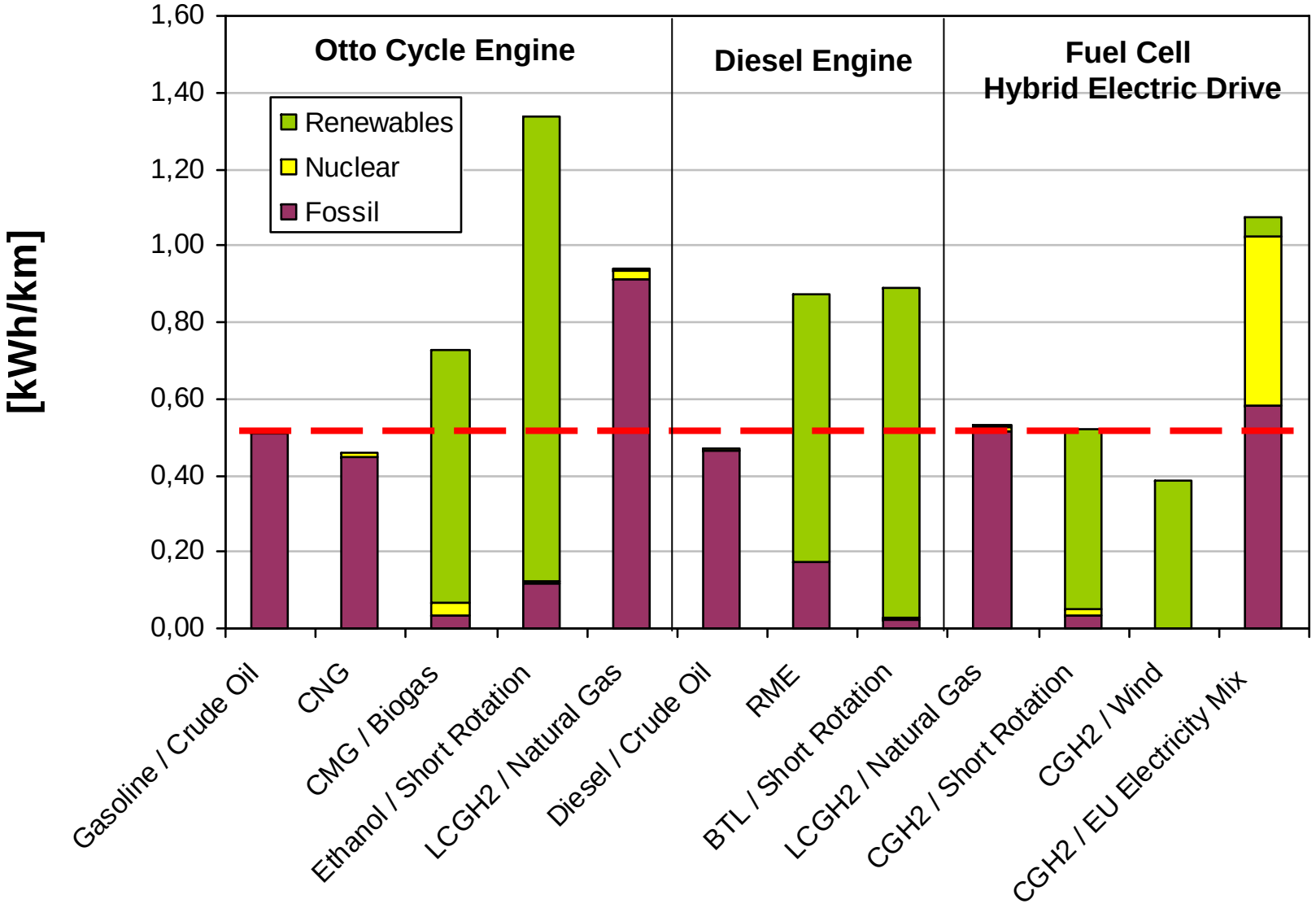
Energy Use



Hydrogen produced from natural gas, from biomass or from wind electricity used in FCVs is as primary energy efficient as conventional powertrain/ fuel combinations ….

Reference vehicle: VW Golf

Compilation: LBST

Remark: Battery electric vehicles are 2.5 times as fuel efficient as a hydrogen FCV

Well-to-Wheel Analyses – H_2 – Conventional ICE

Greenhouse Gas Emissions

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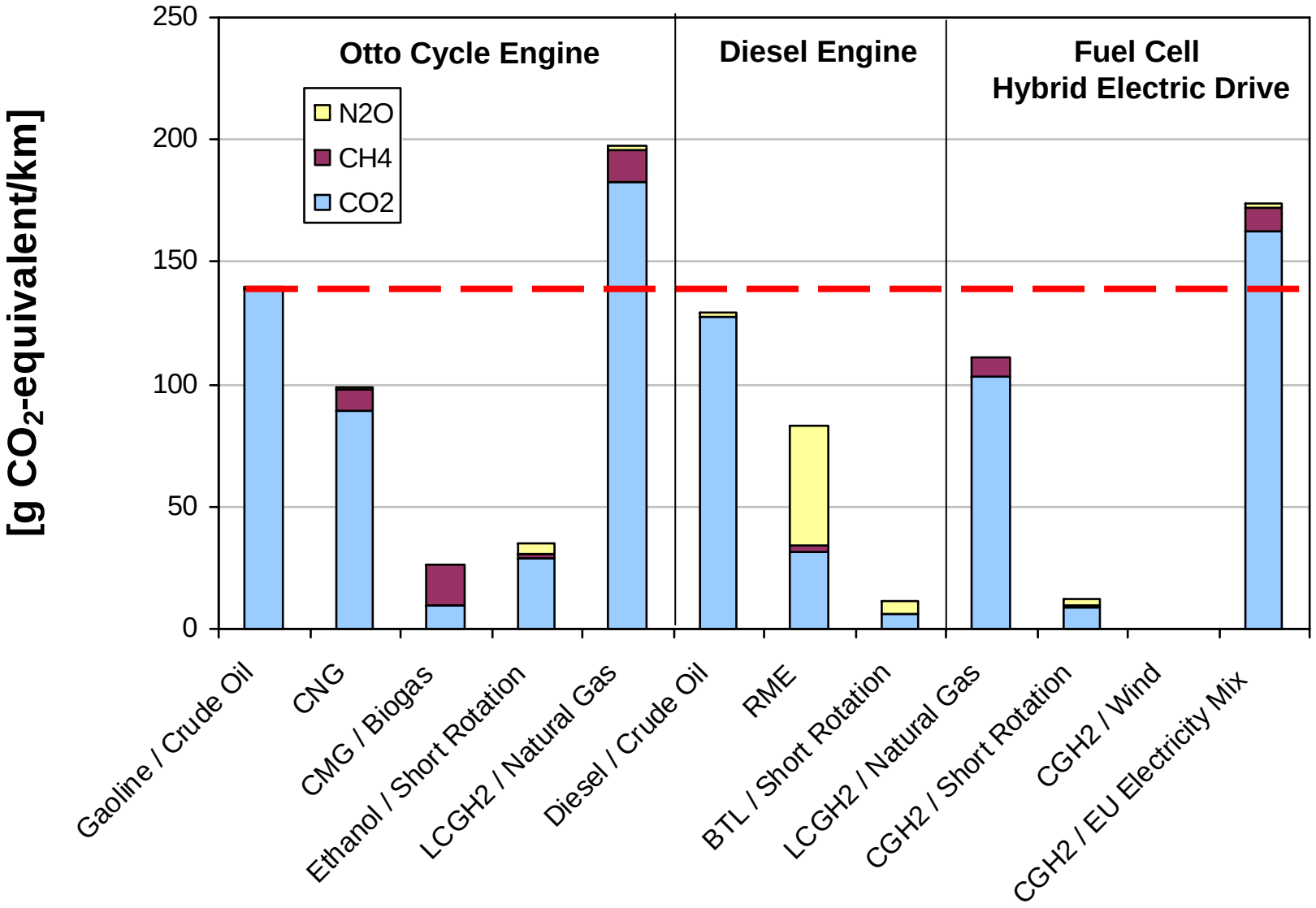

…. But already in the case of natural gas as a source hydrogen has 25% lower greenhouse gas emissions.

Reference vehicle: VW Golf

Compilation: LBST

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Fuel costs versus GHG emissions
"Well-to-Wheel", hybrid

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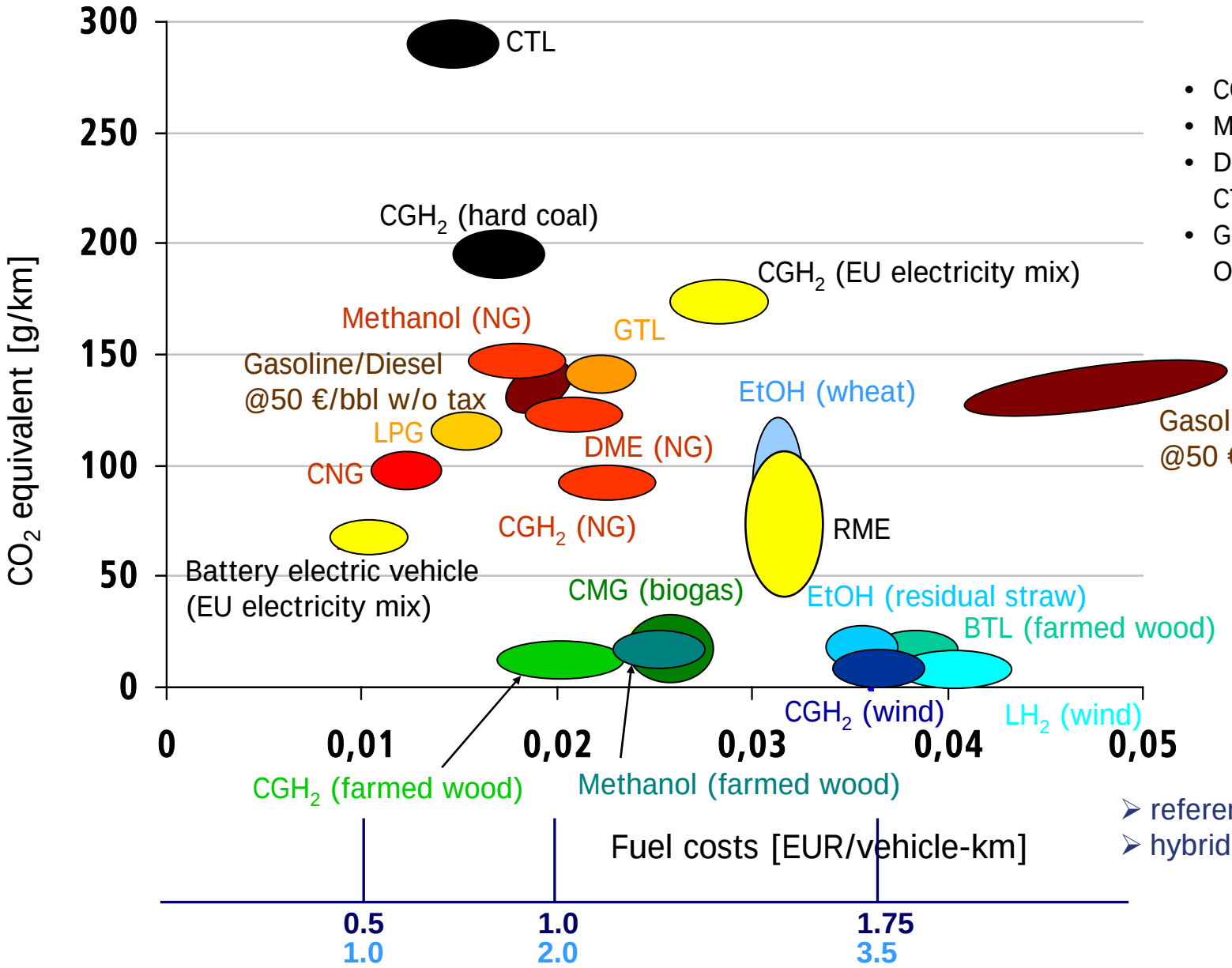

- CGH_2, LH_2: FC
- Methanol: FPFC
- Diesel, RME, BTL, GTL, CTL, DME: Diesel ICE
- Gasoline, ethanol, CMG: Otto ICE

- reference vehicle VW Golf
- hybrid

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Number of Passenger Cars (hybrid) which can be supplied per ha

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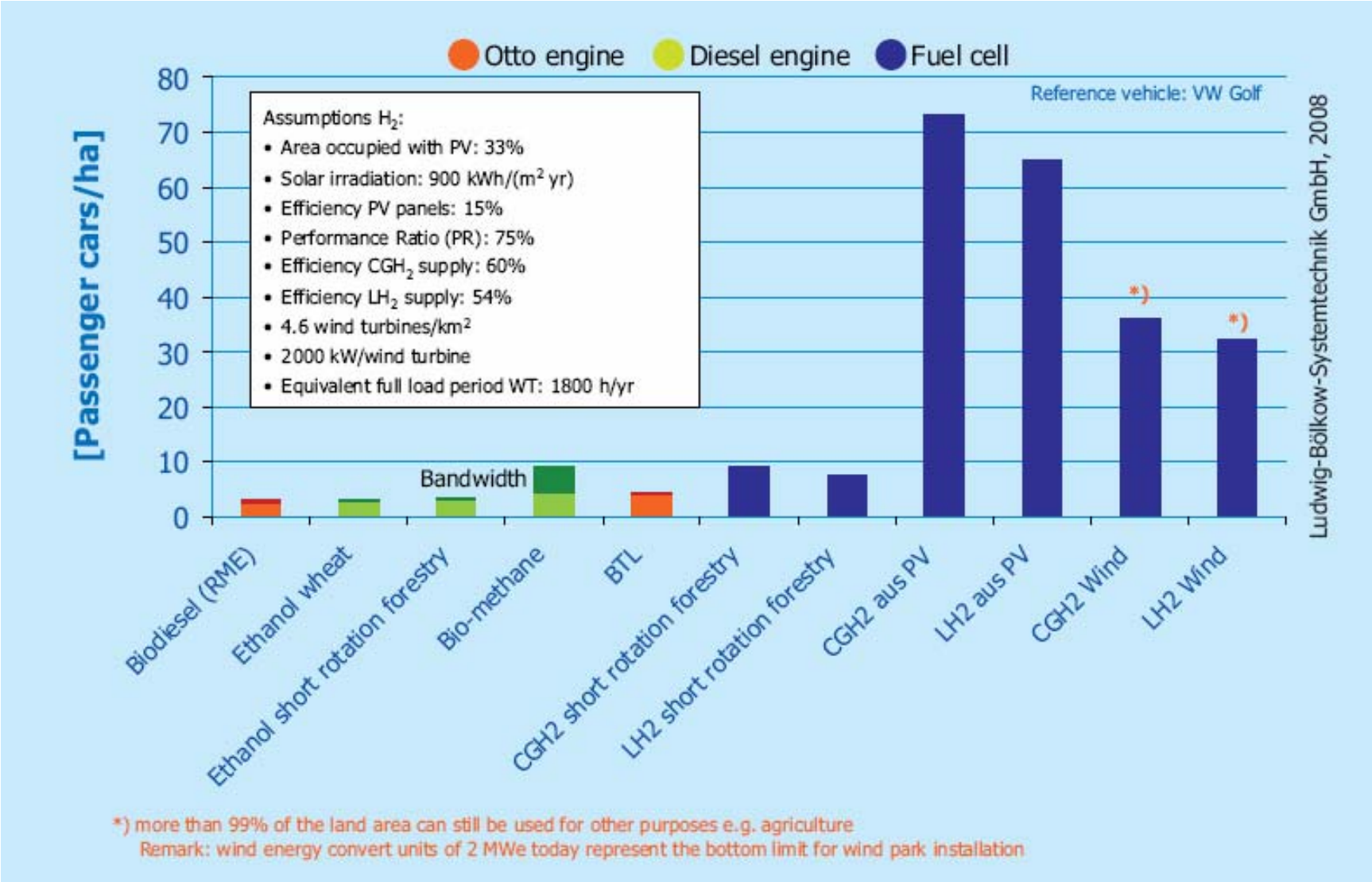

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New Efficient Powertrains and Vehicle Concepts

ICE Powertrain Hybridisation – State-of-the-Art

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Hybrid vehicles with internal combustion engine (ICE) and electric motor

Picture: Toyota Prius

FC Powertrain Hybridisation – State-of-the-Art

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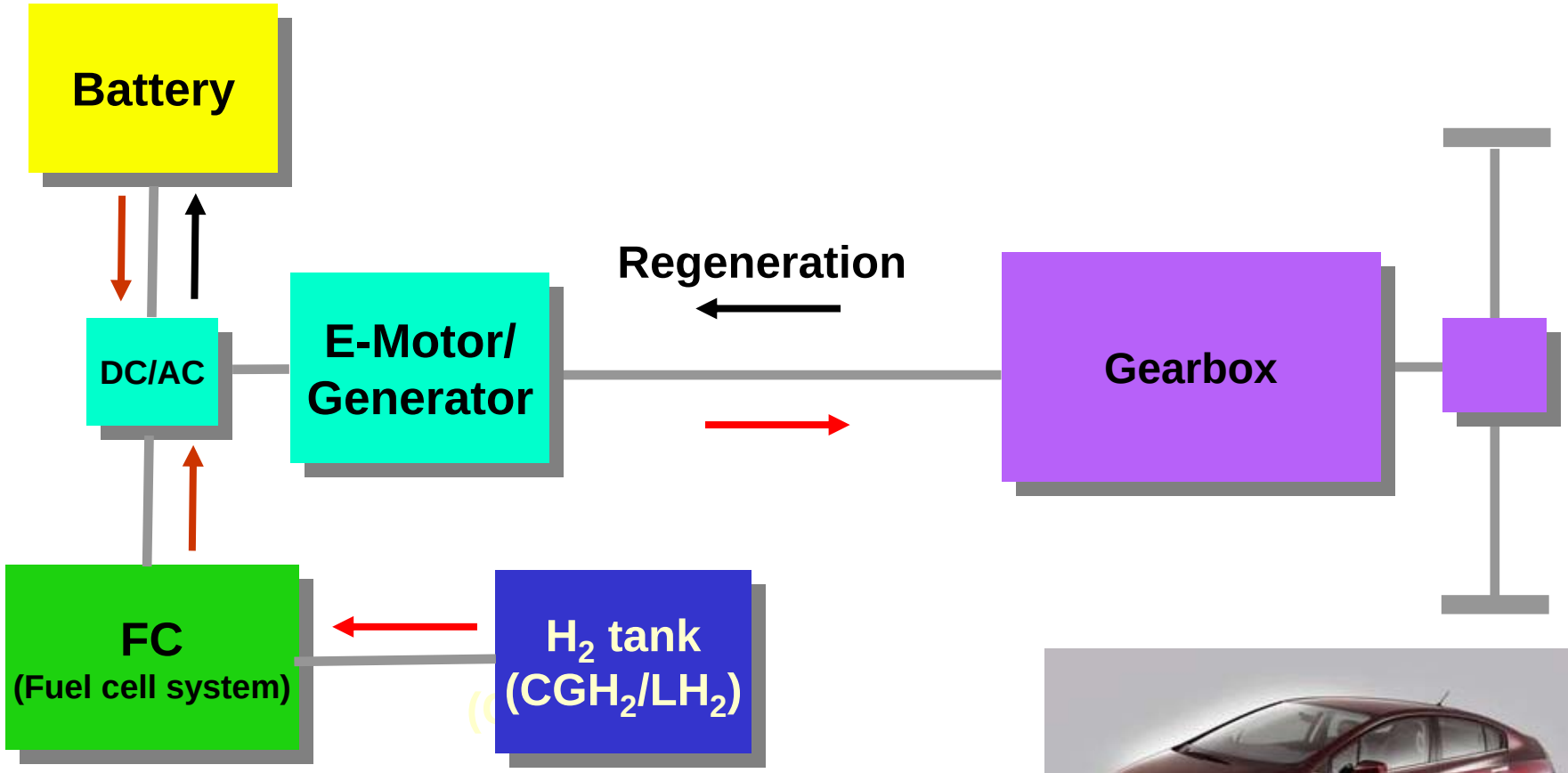
Hybrid vehicles with fuel cell (FC)



Picture: Honda FCX Clarity

Comparison of storage densities [500 km]

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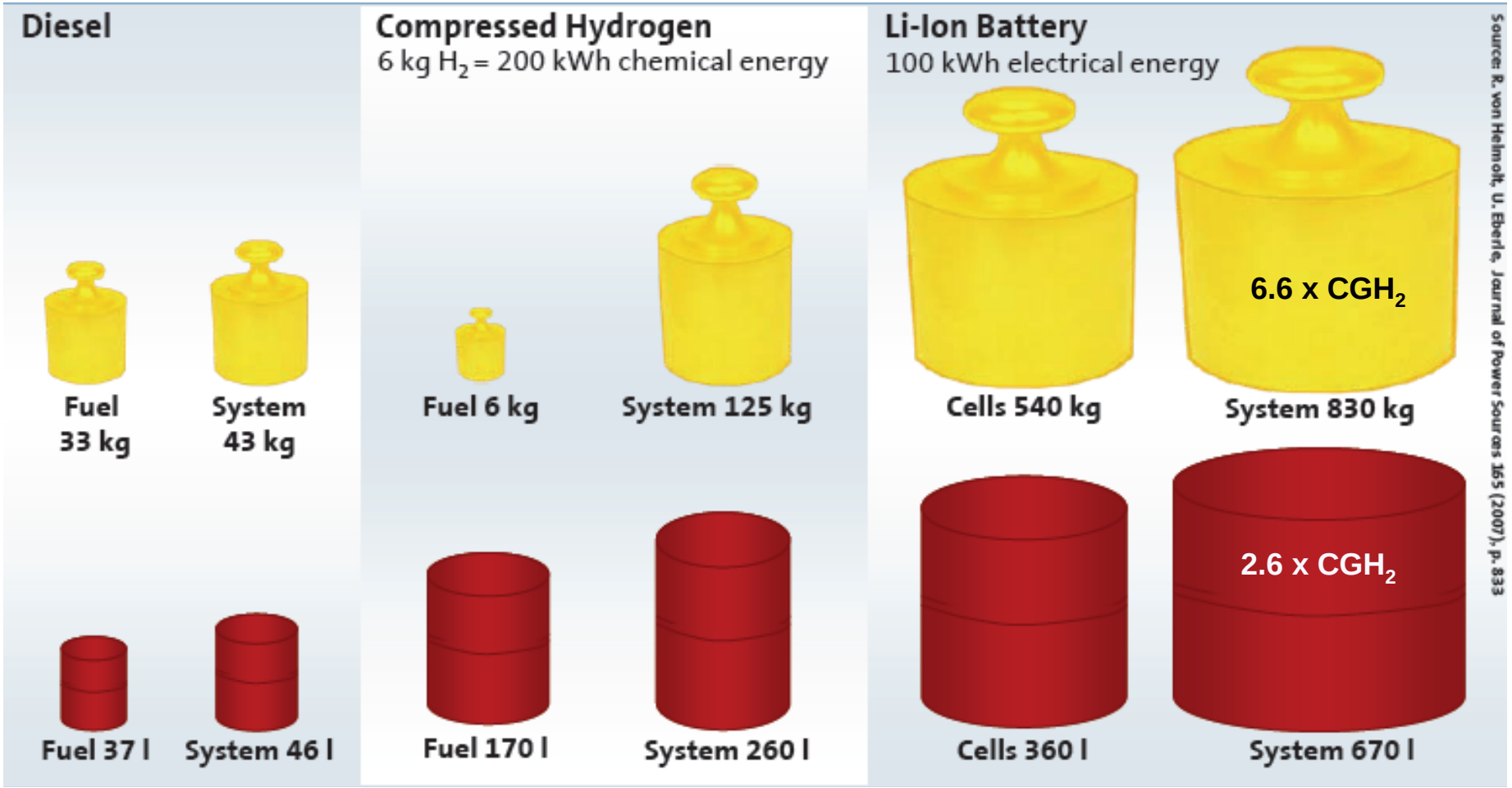

Source: Dr. Rittmar von Helmolt - TechGate Vienna - 13.12.2007

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Hydrogen Supply

Roadmap and Action Plan

HyWays
The European Hydrogen Energy Roadmap

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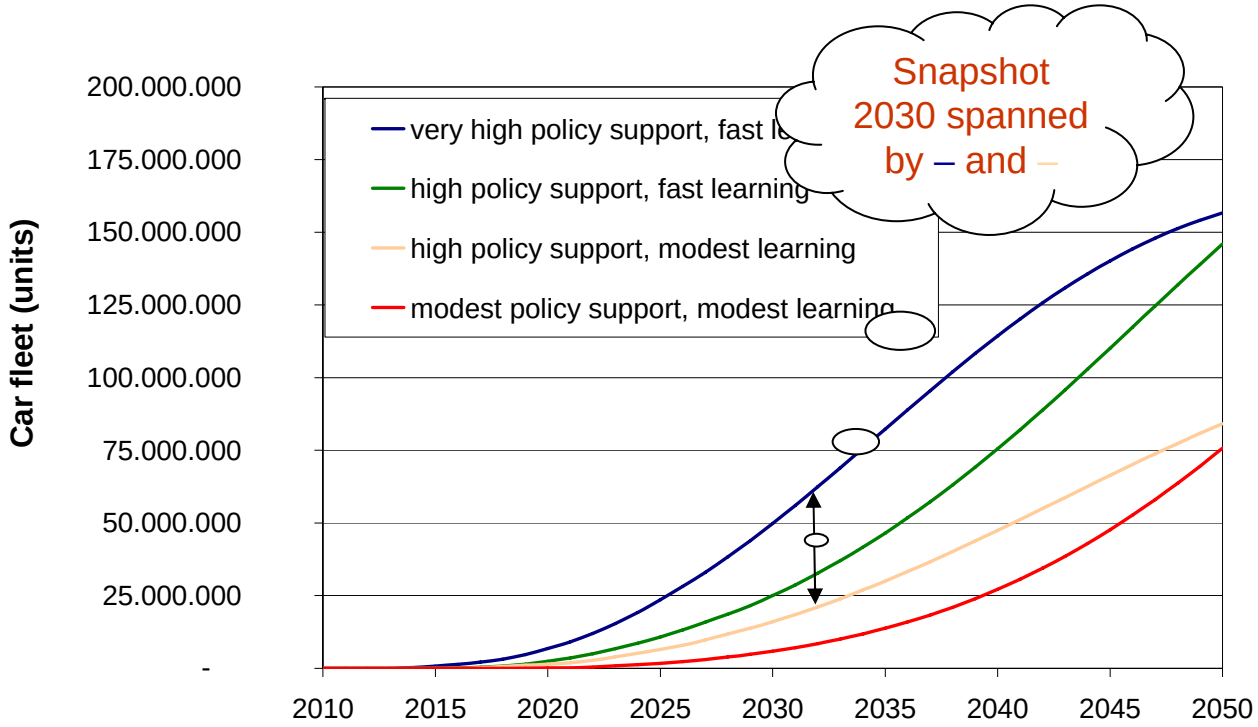
Vehicle fleet targets: Snapshots 2020 & 2030



HyWays passenger car fleet targets for EU15	"Snapshot 2020" (HFP)	"Snapshot 2030" (HyWays Proposal)
Lower bound Requires high policy support!	1 million	15 million
Upper bound Requires extreme policy support!	5 million	50 million
What could happen with modest policy support	*0.1 million*	*5 million*

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Spatial coverage of fuelling stations

HyWays
The European Hydrogen Energy Roadmap

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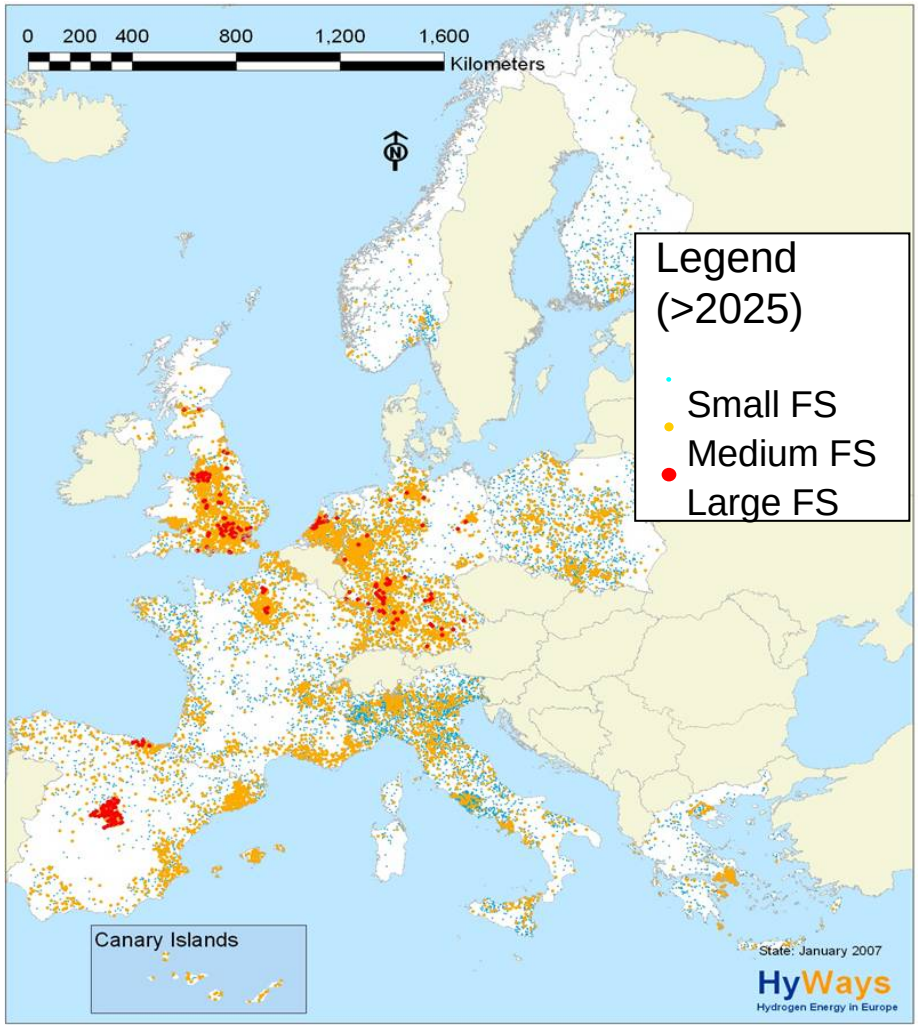

Example: fuelling stations spatial coverage for 8% vehicle penetration

- First phase (2010-2015):
  - A limited number (400) of small H_2 stations
  - serving around 10.000 H_2 cars (25 cars/station in average)
  - for corridors another app. 500 small fuelling stations would be required
- Demand develops (2015 – 2025):
  - also bigger filling stations will come in
  - between 13,000 and 20,000 H2 stations and 10 mill. H_2 vehicles in Europe.
- Massive rollout of H_2 (post 2025):
  - Gradually, same patterns as today's conventional refuelling network is reached

Structure of the investments in a hydrogen economy of the six HyWays countries

HyWays
The European Hydrogen Energy Roadmap

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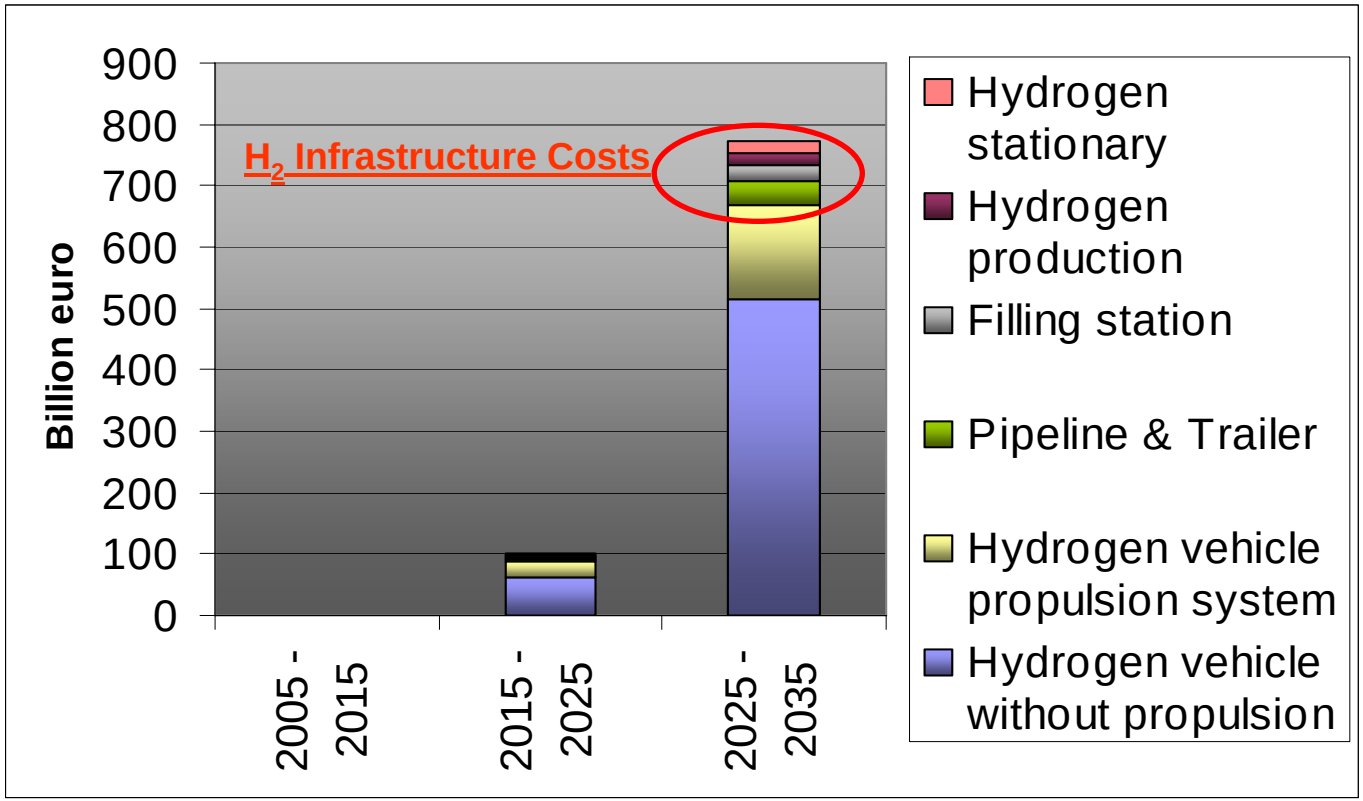


(cumulative investments for a ten-year period, hydrogen high penetration scenario, based on 6 HyWays Phase I member countries: D, F, I, GR, N, NL)

Interpretation of results:

- More than 60% of the invest costs have to be brought up for the conventional part of the vehicle
- about 20% are for the H_2-specific onboard part of the vehicle (e.g. FC and storage)
- about 15% are for the H_2 production, transport, distribution and dispensing

Hydrogen Propulsion – State-of-the-Art

A Class F-Cell 2004

B Class F-Cell 2005

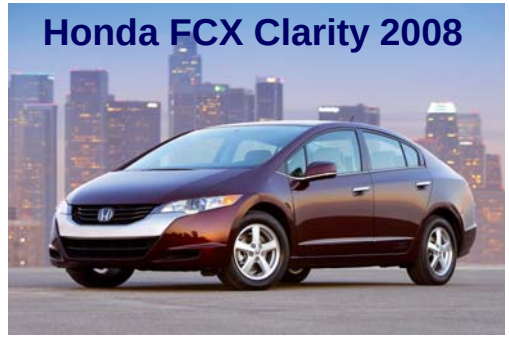

B Class F-Cell 2008


BMW Hydrogen 7


FCX Clarity Vehicle Assembly at Honda New Model Center 2008.06.16


FCX Clarity Vehicle Assembly at Honda New Model Center 2008.06.16

FCX Clarity Vehicle Assembly at Honda New Model Center 2008.06.16


Honda FCX Clarity 2008

Thank you for your attention !

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For further information
on hydrogen and fuel cells:

www.HyWeb.de — Basic information on H_2 and fuel cells + newsletter (operative since 1996)

www.h2mobility.org — Overview of all H_2 and fuel cell vehicles worldwide (operative since 2000)

www.h2stations.org — Overview of all H2 refuelling stations (operative since 2000)

www.energiekrise.de — Overview of the availability of fossil energy sources (operative since 2000)