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Eco-Mobility 2014, Wien

Daimler´s road to FCEV market introduction

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Daimler AG

Responsibility for our Blue Planet

Growing world population

Growing mobility need

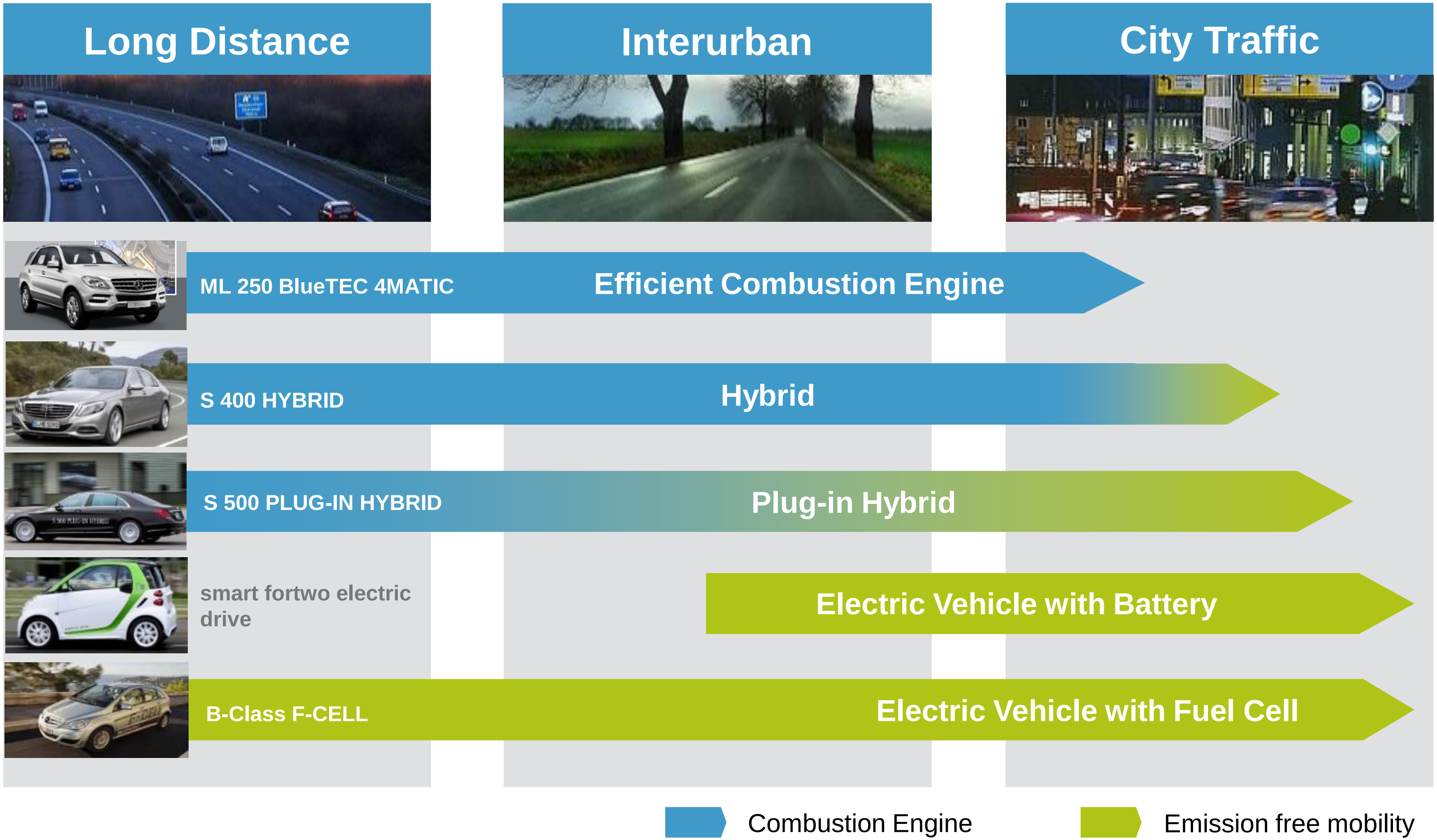
Ecological Awareness

Limited resources

Climate change

- Worldwide rising demand for mobility will increase CO_2 emissions
- Fossil resources are limited and will therefore become more expensive

The Powertrain Portfolio for the Mobility of Tomorrow



Our Roadmap to a Sustainable Mobility

Highly Efficient Internal combustion engines

A 180 CDI BlueEFFICIENCY

3,6

l/100 km
92 g CO2/km

Full and Plug-In Hybrids

S 500 PLUG-IN HYBRRID

2,8

l/100 km
65 g CO2/km

Electric vehicles with battery and fuel cell

B-Class Electric Drive
smart electric drive
B-Class F-CELL

0

l/100 km
0 g CO2/km

FCEV and BEV Characteristics

Electric Vehicles with Batteries

Common Strengths

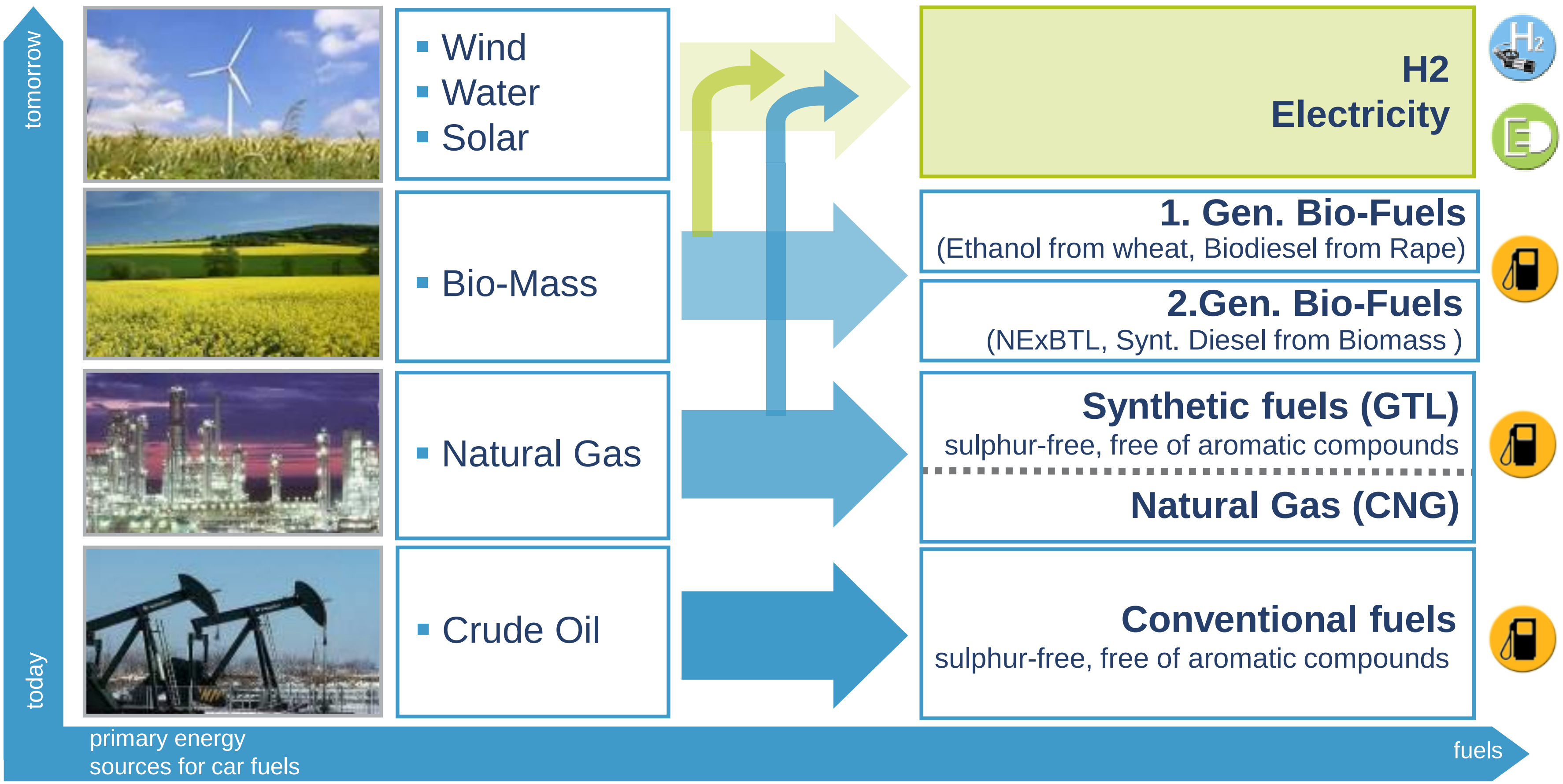
- Reduction of greenhouse gas with zero emission vehicles
- Efficient energy usage
- Independence of oil
- Drive and comfort with electric drive
- Low noise emissions

Electric Vehicles with Fuel Cells

	Electric Vehicles with Batteries	Electric Vehicles with Fuel Cells
Strengths	• Highest energy efficiency and lowest greenhouse gas emissions of all drive trains	• Short refueling time and thus unlimited range • Fuel cell drivetrain suitable for car and bus applications
Challenges	• High charging time • Inexpensive and long-lasting batteries • Supply of carbon-free electricity • A nationwide charging system	• Component costs • Inexpensive and long-lasting fuel cells • Supply of carbon-free hydrogen • A nationwide refueling system

For future emission-free mobility, both drive train technologies will be needed!

Variety of sources to produce fuels for passenger cars



➢ **Potential to store the fluctuating energy and support the energy change in Germany**

H_2 Production Pathways with the Potential of Producing a Significant Amount of Hydrogen

Natural Gas Reforming

- **Production capacity in petrochemistry** is usable on short term
- Moderate CO_2 reduction

Biomass Gasification

- **CO_2 neutrality**
- Sustainable, reduction of dependencies
- Competition among different applications (synthetic fuels, stationary use)

Renew. Electr. Electrolysis

- Many big offshore wind parks already planned
- **Hydrogen is a means of storage for excess electricity**
- Good energy and CO_2 balances at the same time

Nuclear Electr. Electrolysis

- Good CO_2 balance
- Trend towards an extension of nuclear energy capacity
- **Very unfavourable energy chain and limited resources**

Coal Gasification

- Largest fossil energy resources
- **Only usable if CO_2 capture and storage is technically and economically feasible**

Hydrogen as a Byproduct

- In certain chemical processes (chlorine alkali electrolysis) hydrogen is produced as a by-product
- Short term production capacity in chemical industry
- Little energy input and costs, moderate CO2 reduction, limited capacity

Hydrogen as a by-product of the chemical industry as well as hydrogen from natural gas can cover a significant part of the H2 demand during the phase of introduction of FC vehicles

➔ gradually switch to regenerative H2

Best CO2-Balance (green) | Highest Capacity (yellow)

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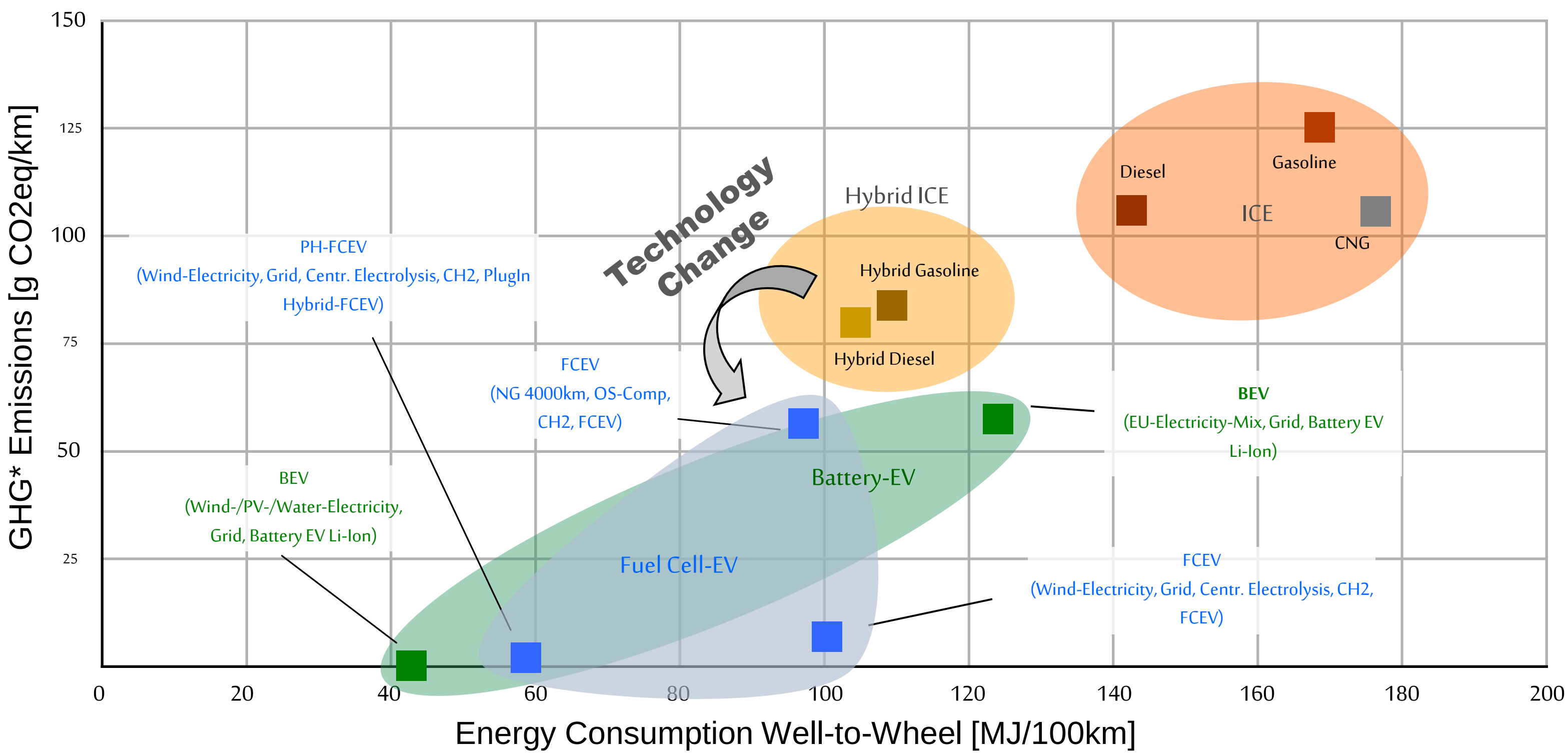
CO_2- and Energy comparison

Fuel Cell: High range (>500 km), short refueling time (3 min), Applicable for different vehicle concepts

Battery: Optimal operation in compact cars for the city traffic (100-150 km), Recharging over night



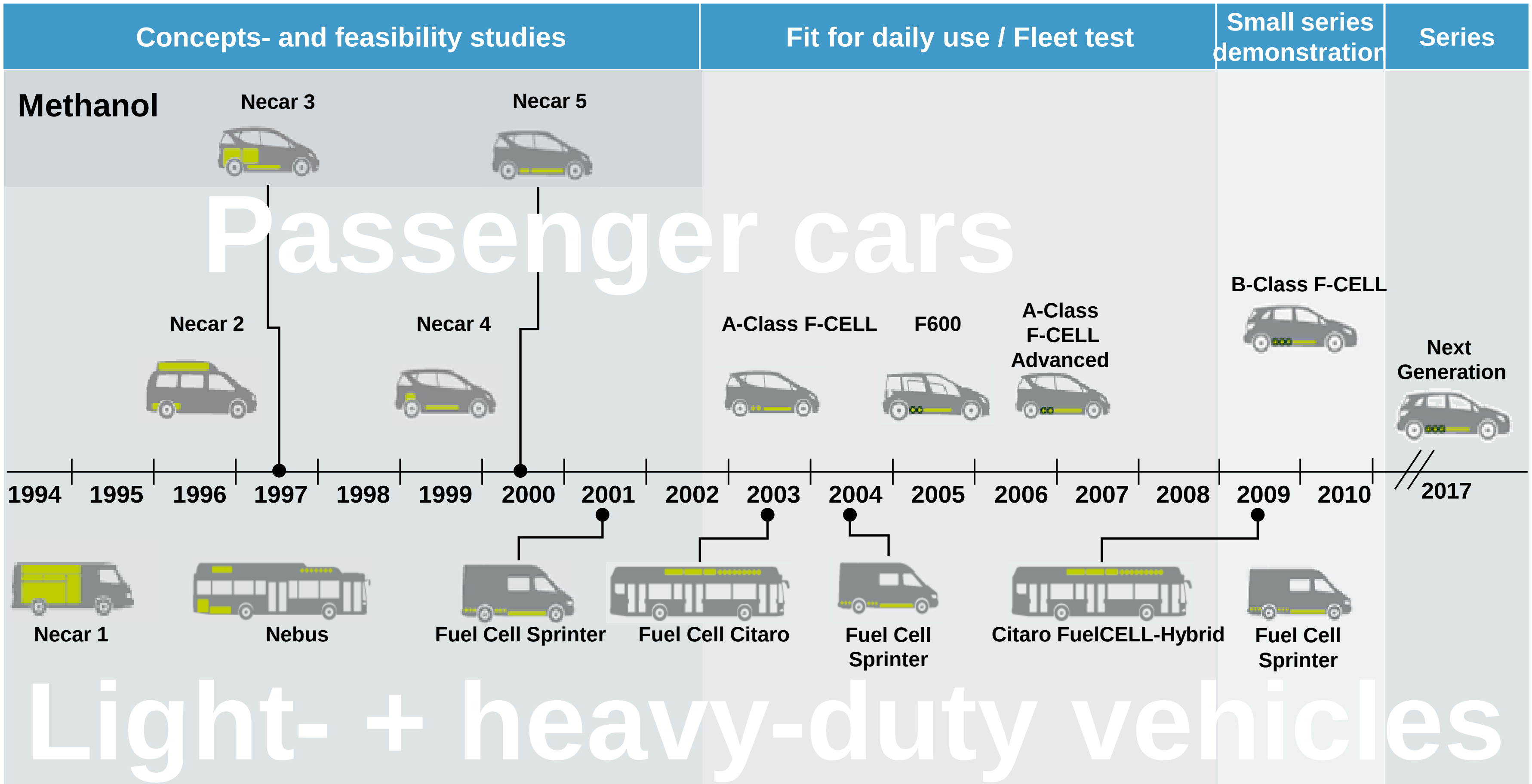
*GHG: Green House Gas

Source: JRC/EUCAR/CONCAWE (2013) WtW Report, Version 4

Electric drive trains are a real step to reduce energy consumption and green-house-gas emissions. Using EVs means a significant step forward.

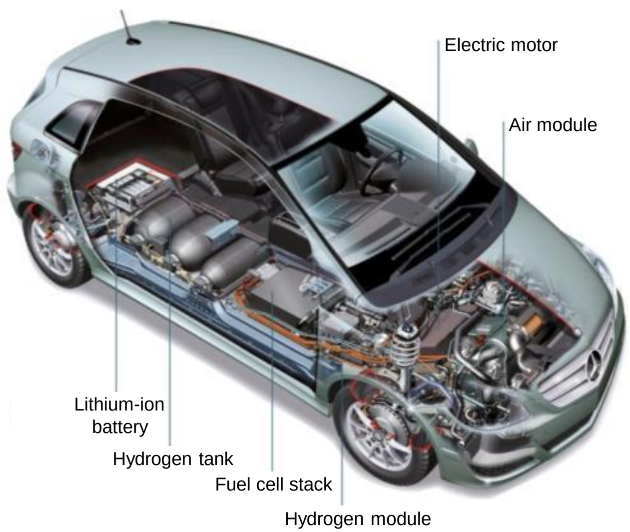
Activities of DAIMLER AG within Fuel Cell Vehicles

History of Fuel Cell Vehicles - almost 20 years of Experience



The Current Generation of Fuel Cell Vehicles

B-Class F-Cell:



Specifications*	
Vehicle	Mercedes-Benz B-Class F-Cell
Fuel Cell System	PEM, 90 kW (122 hp)
Engine	Output (Cont./ Peak) 70 kW / 100 kW (136 hp) Max. Torque: 290 Nm
Range	380 km (NEDC)
Top Speed	170 km/h
Acceleration 0-100 km/h (0-60 mph)	11.4 sec
Battery	Lithium-Ion
Li-Ion Battery	Output (Cont./ Peak): 24 kW / 30 kW (40 hp) Capacity: 6.8 Ah, 1.4 kWh

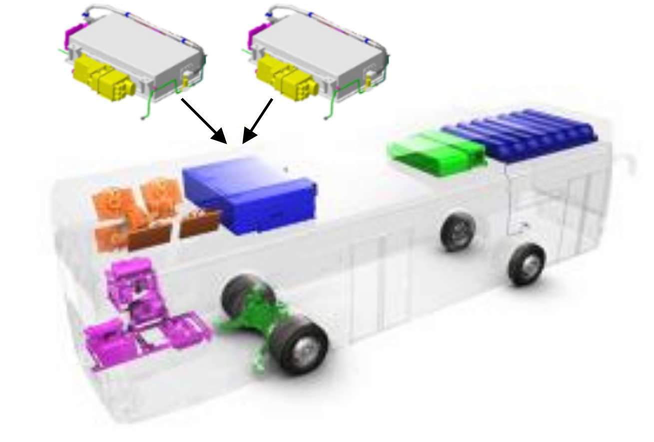
The Current Generation of Fuel Cell Buses –

"Driving the Future" becomes Reality

Specifications*	
Vehicle	Citaro FuelCELL-Hybrid
Fuel Cell System	120 kW (const.) / 140 kW (max.)
Engine	Output (const. / max.): 2 x 80 kW / 2 x 120 kW
Range	> 250 km
Hydrogen Storage	35 kg Hydrogen (350 bar)
H_2-Consumption	10 – 14 kg / 100 km
HV-Battery	26,9 kWh, Output 250 kW
Efficiency FC-System	58 - 51 %

Citaro FuelCELL-Hybrid:

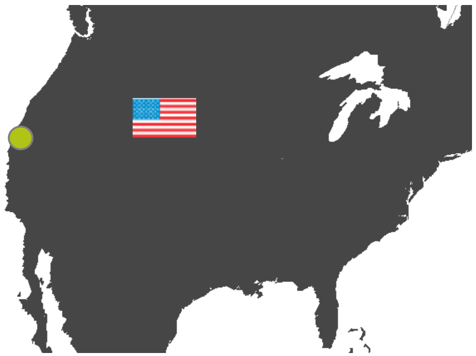
2 Fuel Cell Systems also used in B-Class F-CELL



Market Preparation – Worldwide Fleet Operation

Fleet Demonstration with the Current Generation of Fuel Cell Vehicles

North America & Europe 200 B-Class F-CELL



Fleet Demonstration

- **70 F-CELL California**

Fleet Demonstration

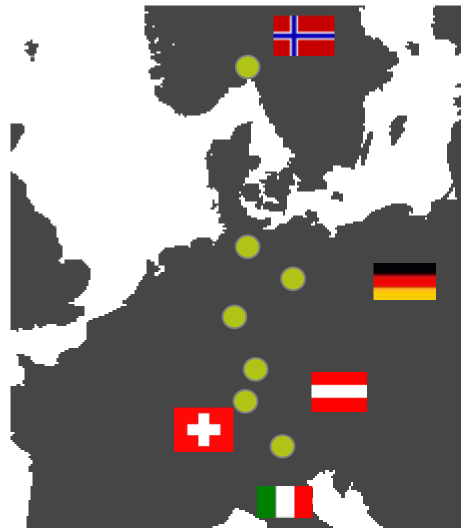
- **10 F-CELL Oslo**

Fleet Demonstration

- **20 F-CELL Hamburg**
- **40 F-CELL Berlin**
- **10 F-CELL Frankfurt**
- **20 F-CELL Stuttgart**
  F-CELL Wien

ca. 30 F-CELL Internal Car Pool

Europe 23 Citaro FuelCELL Hybrid busses



Fleet Demonstration [1)]

- **4 Busses Hamburg**
- **4 Busses Stuttgart & Fellbach**
- **2 Busses Karlsruhe**
- **5 Switzerland**
- **8 Busses Italy (5 Bolzano, 3 Milano)**

Small Series A-Class F-CELL (60 Units)
vehicle miles travelled > 2.230.000 km

Small Series B-Class F-CELL (200 Units)
vehicle miles travelled > 3.300.000 km

Small Series Citaro FuelCELL (36 Units)
vehicle miles travelled > 2.150.000 km

Small Series Citaro FuelCELL-Hybrid (23 Units)
vehicle miles travelled > 700.000 km

Successful daily operations in customer hands

Mercedes-Benz B-Class F-CELL – Customer voices …

I am fascinated by the torque and the silence.

My next vehicle will be a fuel cell car again.

It is such a smooth ride.

My 13year old kid "forced" me to demonstrate the car at school to his class mates. The FCEV was clearly the most special car around.

over 3 Mio. km driven in customer hands

I expected a Mercedes - and I got a Mercedes.

I never experienced any restrictions because it is a gas vehicle. I frequently take the F-CELL on the ferry.

I am driving the future. Literally.

After driving a FCEV, you don't want to get back to your old car

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Technology: Demonstration of technical maturity

Mercedes-Benz F-CELL World Drive 2011!

- 125 days
- 14 countries
- 3 B-Class F-CELL
- Appr. 30,000 km per vehicle
- 29 Legs
- 2 refuellings per day
- Up to 1,000 km per day

DAIMLER AG demonstrated the reliability and technical maturity of their B-Classes F-CELL and their leadership in this technology.

Remaining Challenges of the Fuel Cell and Hydrogen Technology

Technology

- Power density
- Cooling system
- Hydrogen storage
- Durability

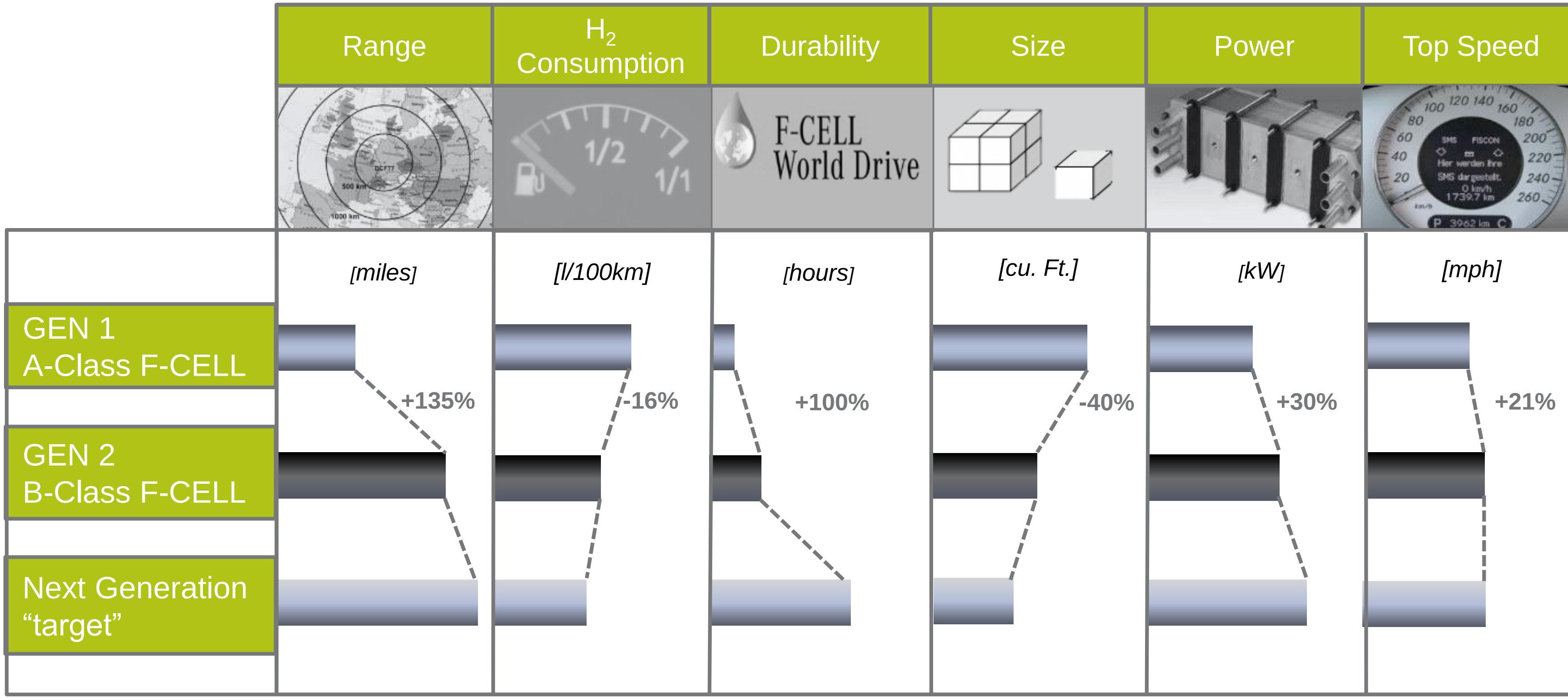
Costs

- Fuel cell system & stack
- Electric engine
- H_2 tank system
- Infrastructure
- Hydrogen costs

Infrastructure

- Reliable refueling technology
- Build-up of an area-wide infrastructure
- H_2 production at competitive prices
- Availability of renewable produced hydrogen

Technical Advancements of Daimler's Fuel Cell Vehicles



From generation to generation great technical improvements in numerous technical areas.

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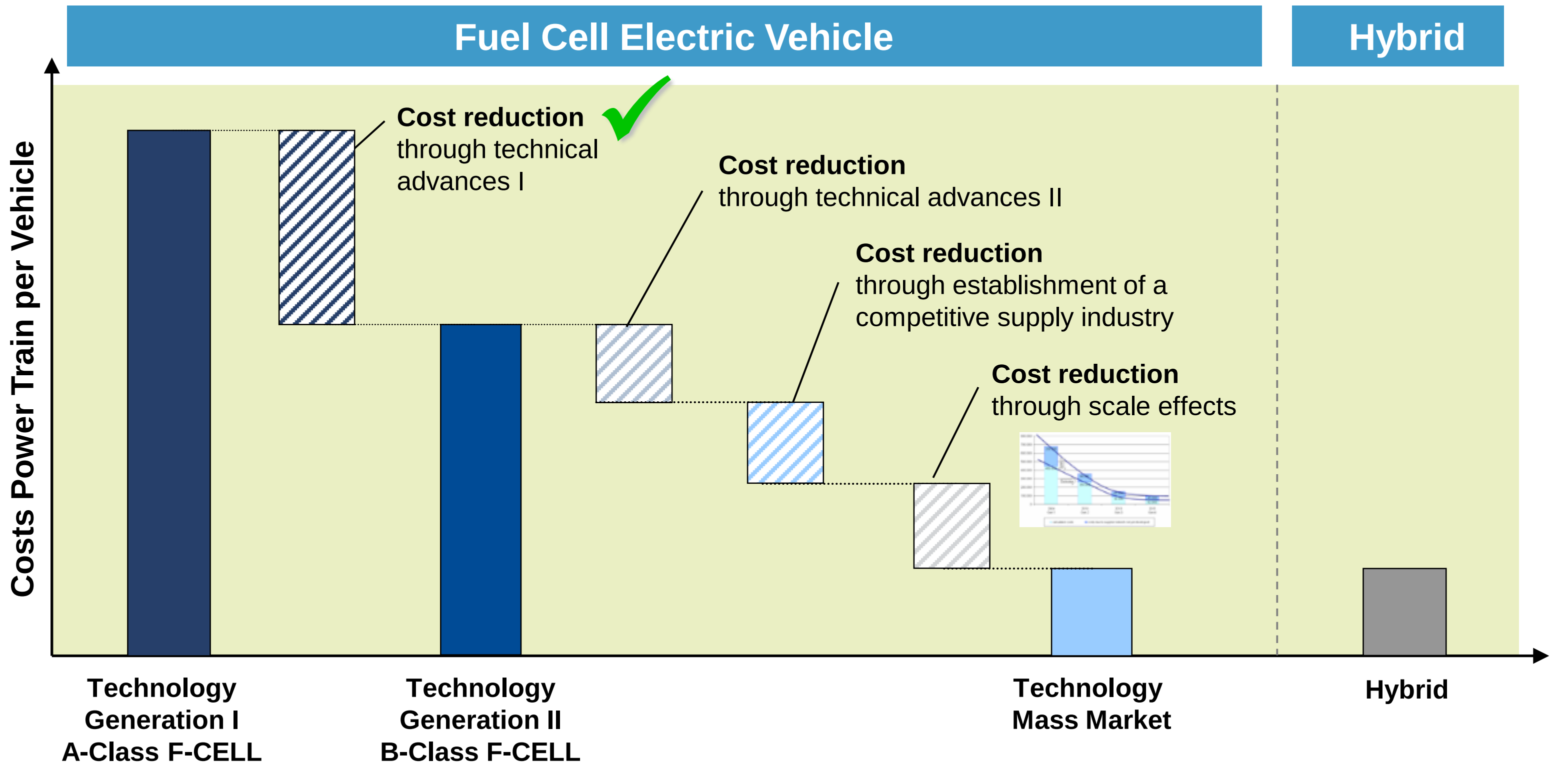
Cost Potentials of the Fuel Cell Technology



- The cost for the fuel cell power train are currently much higher than those from conventional drive systems. They can be reduced considerably through scale effects and technology advances.
- A reduction of the costs on the level of conventional drive trains is possible.
- Regarding the TCO[1] comparable values to conventional drive systems are reachable.

1) Total Cost of Ownership

Packaging of Fuel Cell System

Today (B-Class F-CELL)

Future Technology Target

Reduction of ~ 30%

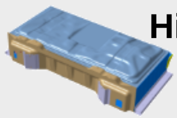
Through a further modularization of the fuel cell specific components, the packaging of future generations of FC vehicles will be simplified.

➔ The significantly more compact dimensions would allow a accommodation in the engine compartment of a conventional vehicle.

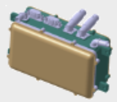
Modular Strategy for Different Propulsion Systems and Vehicles is the Basis for Economic Success!

smart fortwo electric drive

1x



High Energy Battery
16,5 kWh / 30 kW



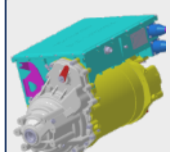
Onboard-Charger
3,3 kW

2x

A-Class E-CELL

1X

Citaro FuelCELL-Hybrid



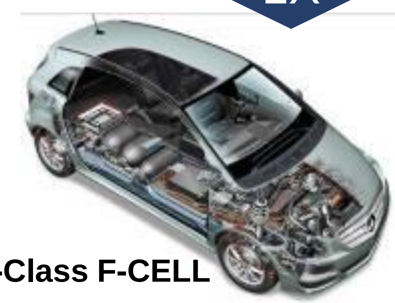
Integrated Powertrain (IPT)
E-Machine, Gearbox, Power-Electronics
100 kW / 290 Nm

1X

2x FCS

Fuel Cell System (FCS)
80 kW

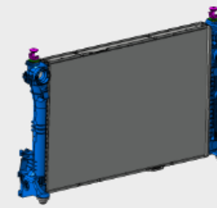
H_2 Tank System
Size-adaption (4kg / 35kg)



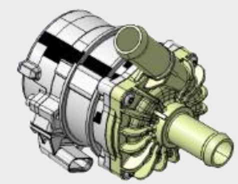
B-Class F-CELL

Further partially commonized parts

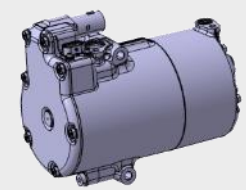
Main Radiator



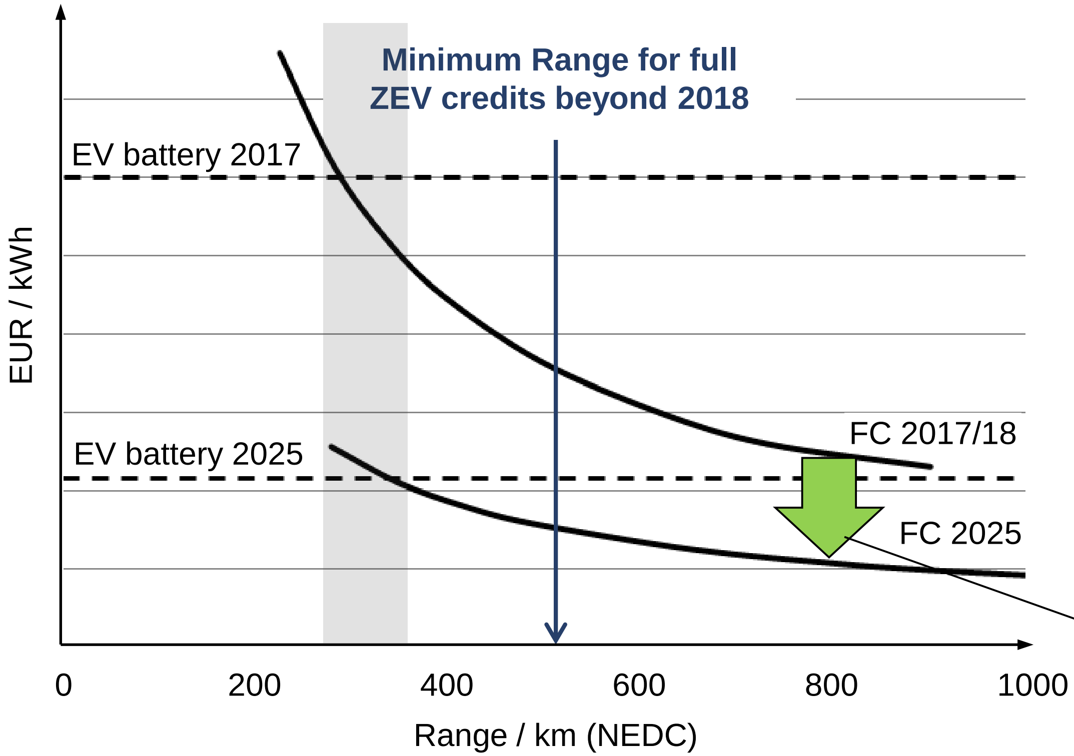
EE Cooling Pump



Electric AC-Compressor



FCEV and BEV
Comparison of cost per kWh electrical energy source



Cost for Fuel Cell propulsion: Include FC-stack plus FC-system, HV-battery and hydrogen storage system similar to function of EV-battery for comparison.

- Higher volume
- More mature supplier market
- Technology improvements

- At approx. 350 km Fuel Cell propulsion is less expensive than EV-battery propulsion

Daimler's Fuel Cell Technology Roadmap

Electric vehicles with fuel cell & battery

Fuel Cell

Bus

Generation 1 ✓
Technology Demonstration
Citaro Fuel Cell

Generation 2 ✓
Customer Acceptance
Citaro FuelCELL-Hybrid

Future Generations

Passenger Car

Generation 1 ✓
Technology Demonstration
A-Class F-CELL

Generation 2 ✓
Customer Acceptance
B-Class F-CELL

Next Generation
Mass Production
Market Introduction
Cost Reduction

Sprinter

Generation 1 ✓
Technology Demonstration

Generation 2 ✓
Customer Acceptance

Future Generations

Battery

Passenger Car

Generation 1 ✓
Technology Demonstration
smart fortwo electric drive (Gen I)

Generation 2 ✓
Customer Acceptance
smart fortwo electric drive (Gen II)

Generation 3 ✓
Market Introd. / Cost Red.
smart fortwo electric drive (Gen III)
B-Class Electric Drive

Generation 4
Mass Production

Daimler is dedicated to commercialize electric vehicles with fuel cell

Electromobility with batteries and fuel cells is already a reality today **A total of nine locally emission free vehicles today**

Infrastructure: The way to an area-wide H2-Infrastructure

(Example Germany)

Chicken-Egg Dilemma

No vehicles without the infrastructure, no infrastructure without vehicles

I — Clean Energy Partnership (2002-2016)

CEP

H_2 and FC Demonstration project in following federal states: Berlin, Hamburg, Hessen, Nordrhein-Westfalen and Baden-Württemberg

II — H_2 Mobility (since 2009)

H_2 Mobility

Initiative for build-up of nationwide H_2-Infrastructure. Development of a business plan and joint venture negotiations were the first steps

III — Daimler/Linde Cooperation (until 2016)

THE LINDE GROUP DAIMLER

20 new H_2 fuelling stations are planned in Germany in a cooperation with The Linde Group and Daimler AG. The first station will be built in 2013

IV — H_2 Mobility Joint Venture (from 2013)

H_2 Mobility

Transformation of H_2 Mobility to a Joint Venture

Infrastructure: CEP and other existing 700bar H2 Stations

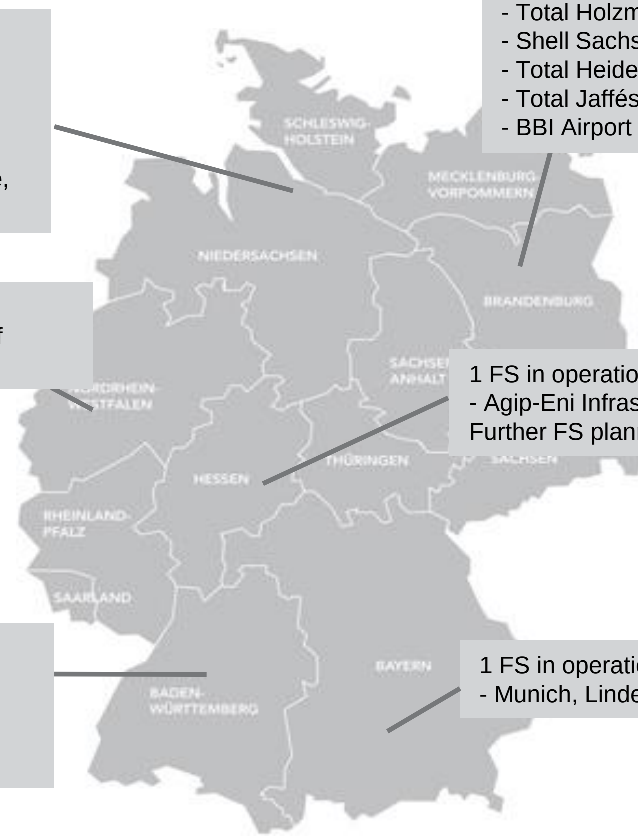
(Example Germany – 16 FS already in operation)

FS Heerstraße (Total), Berlin

FS Holzmarktstraße (Linde / Statoil / Total), Berlin

FS Heidestraße (Linde / Total), Berlin

FS Sachsendamm (Shell), Berlin



3 FS in operation:
- Total Cuxhavener Str
- Vattenfall HafenCity
- Vattenfall Hummelsbüttel

1 FS in approval process:
- Shell Bramfelder Chaussee,

Further FS planned

5 FS in operation:
- Total Heerstr.
- Total Holzmarktstr.
- Shell Sachsendamm
- Total Heidestraße
- Total Jafféstraße
- BBI Airport

1 FS in operation:
- Air Liquide Düsseldorf

Further FS planned

1 FS in operation:
- Agip-Eni Infraserv, Fra/Höchst

Further FS planned

4 FS in operation:
- OMV Stuttgart
- KIT Karlsruhe
- ISE Freiburg
- EnBW Stuttgart Talstr.

1 FS in operation:
- Munich, Linde

FS HafenCity (Vattenfall / Shell), Hamburg

FS Cuxhavener Str. (Total), Hamburg

FS Bramfelder Chaussee (Shell), Hamburg

FS Höherweg (Air Liquide), Düsseldorf

FS = Fuelling Station

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Daimler Commitment: 20 H_2-refuelling stations as a catalyst for the market introduction of fuel cell technology

Key Facts

- 20 new H_2 refuelling stations (FS) will be built from 2013 jointly by Daimler and Linde with support of federal government
- Refuelling stations primarily in „high-density“ regions (e.g. Baden-Württemberg), metropolis and corridors
- Germany as first country, which will get an area-wide H_2-infrastructure

Approximate allocation of 20 FS

Discussions with retail partners and location agreements

20 H2-refuelling stations until 2015

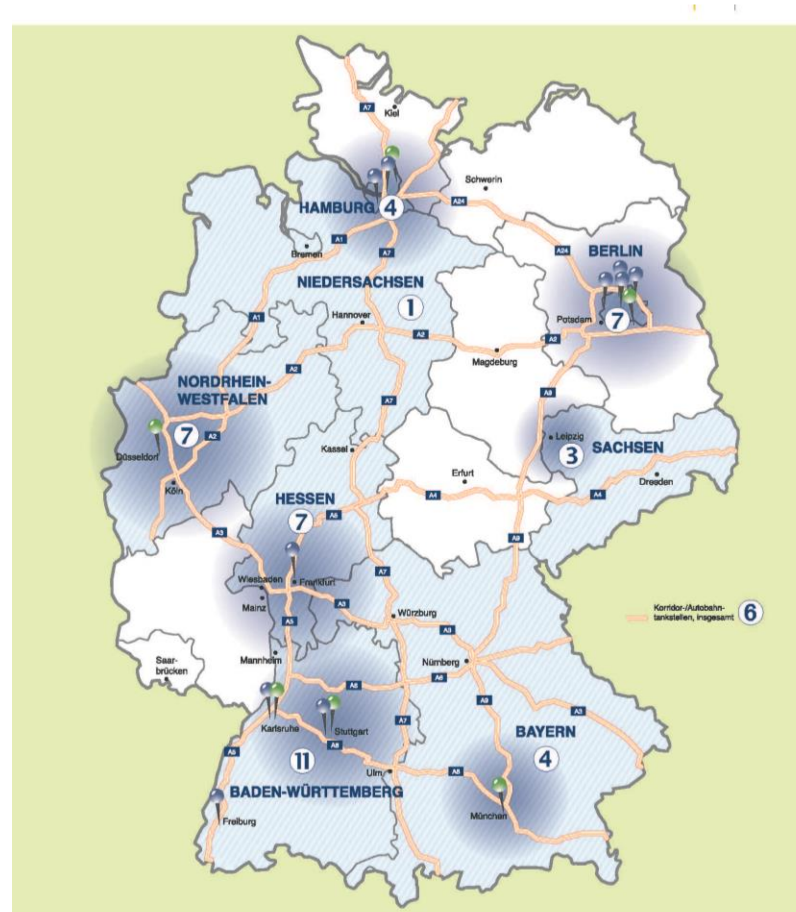
2011 | 2012 | 2013 | 2014 | 2015

H_2 Mobility Joint Venture

Hydrogen refuelling stations in Germany (700 bar)

2013: 15 HRS

2015: 50 HRS



source: CEP, Daimler AG

H2-Mobility Initiative in Germany

Build-up of a HRS-Network until 2023

Partners of Initiative

Shell | TOTAL | Linde | OMV | AIR LIQUIDE | DAIMLER

Development-Plan

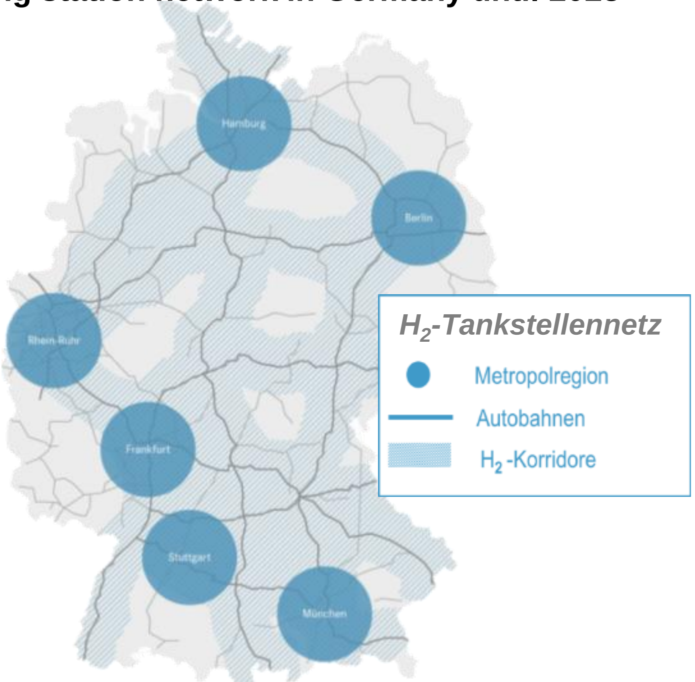
Build-up of a hydrogen refueling station network in Germany until 2023

Unitl 2023 ….

~ 400
public accessible HRS to be build-up in Germany

~ 90
km distance between HRS on the Highways and around the Lighthouse-Regions

> 10
HRS available in Metropolitan areas



Joint Initiative of Oil-Industry, Gas-Industry and OEMs with governmental support to built a Joint Entity that owns (built-up and operate) H2-Infarstructure

The Joint Entity is an independent alliance that imposes clear commitments to its partners

The objective is the market development to overcome the initially negative business case and launch to an independent and functioning Hydrogen-Market

Technical Configuration of a Hydrogen Fueling Station

Status quo of hydrogen filling stations:

- Pre-cooling down to -40° Celsius
- Pressure of hydrogen: 350 and 700 bar
- Standardized refueling process (SAE TIR J2601, ISO/TS 20100) using infrared data interface for communication vehicle <> filling station (SAE J2799)
- Refueling time: approx. 3 minutes for the B-Class F-CELL (ca. 4 kg hydrogen)
- Standardized hydrogen filling connector (SAE J2600, ISO/FDIS 17268)
- Hydrogen fuel quality (SAE J2719, ISO/FDIS 14687)
- Unitized construction / scalable

Thanks for your attention!