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Development of fuel cell buses and vehicles
Future Outlook

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Daimler's Roadmap to Sustainable Mobility

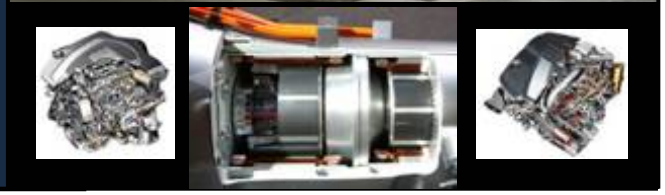
today → future

Zero-emission vehicles with fuel cell/battery drive

Improved & alternative fuels

Efficient cars

with efficient *power trains* with or without *hybrid modules*



Emission-free driving with fuel cell/battery-drive: potential for business innovation

Emission-fees

Congested urban areas

Zero-emission regions

Mega-cities

Fuel Cell Vehicles

>100 FCVs in customer hands

Enablers

- <u>Technology/components</u>:
  - Battery (esp. Li-Ion)
  - Fuel-cell stacks
  - Hydrogen storage
  - Electric engines
  - Power electronics

Battery-electric veh.

Smart ed

Motivation to Develop Fuel Cells and Hydrogen Technologies

Why fuel cell technology as alternative powertrain?

- Higher efficiency than ICE
- Zero emission in terms of GHG and limited emissions (NO_x, …)
- High torque leads to better acceleration
- Low noise (especially important in urban areas)

Why hydrogen as an alternative fuel?

- Diversity of feedstock, i.e. provide a secure energy supply
- Reduction of GHG emission, i.e. increasing share of renewable energy sources

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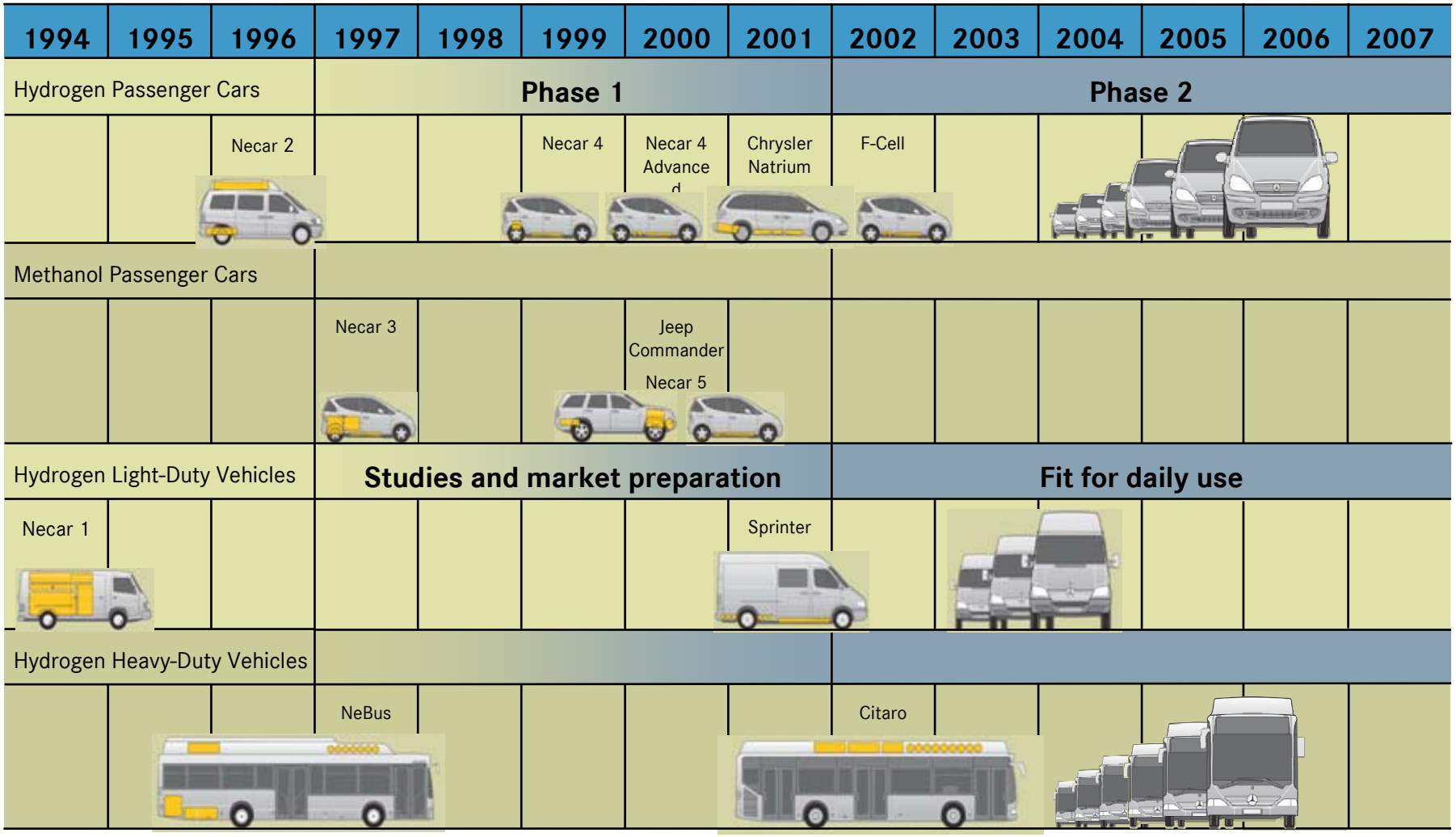
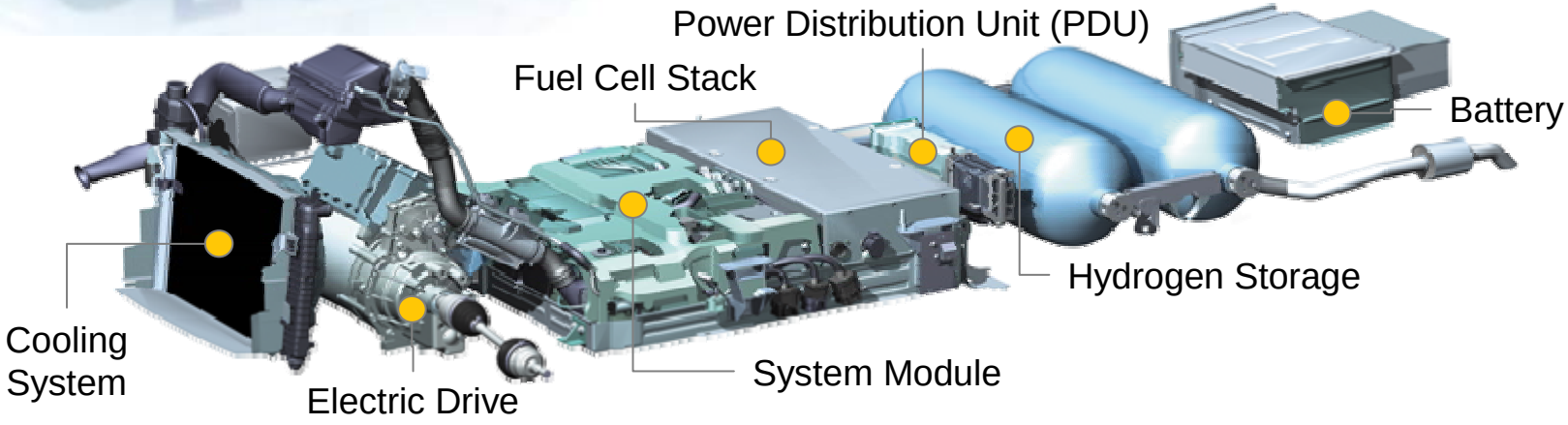
History of Daimler's Fuel Cell vehicles



F-Cell: Current Fuel Cell Vehicle Generation of Daimler

Specifications:	
Vehicle type	Mercedes-Benz A-Class (extended version)
Fuel cell system	PEM - 72 kW (97 hp)
Drive	Electric motor Power (Continuous / Peak): 45 kW / 65 kW (87hp) Max. torque: 210 Nm (156 ft.-lb.)
Fuel	Hydrogen (35 MPa / 5,000 psi)
Range	150 km (93 miles / NEDC)
Max Speed	140 km/h (87 mph)
Battery	NiMh, air-cooled, Power (Continuous / Peak): 15 kW / 20 kW (27hp); Capacity: 6 Ah, 1.2 kWh



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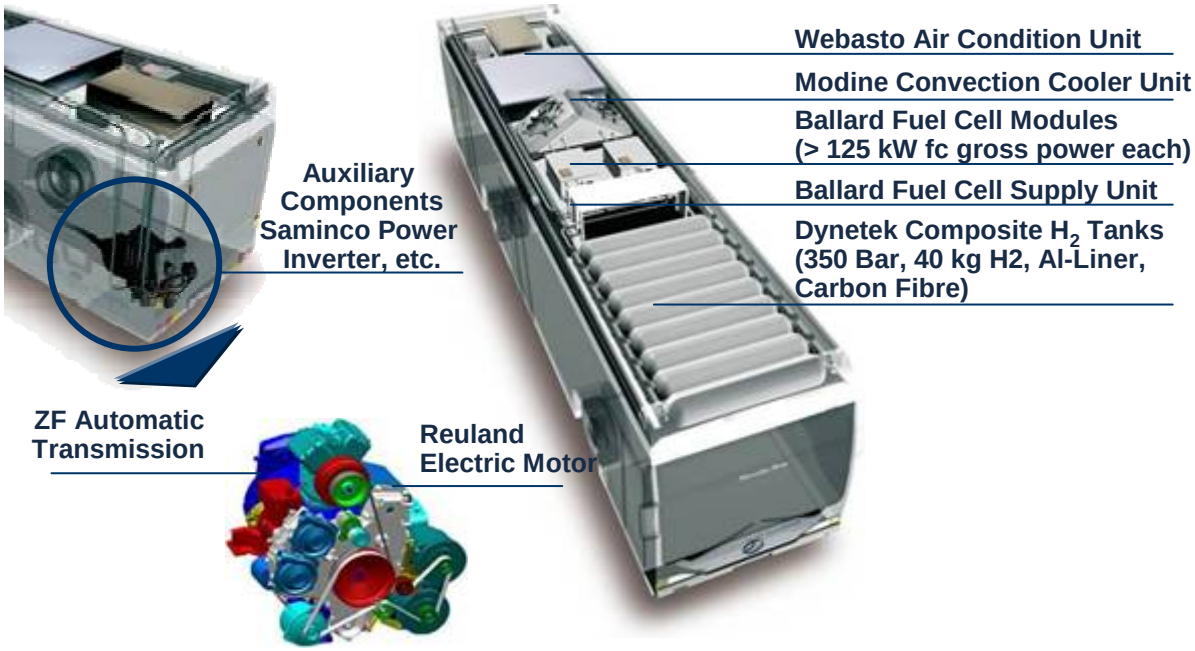
Technical Design of the Mercedes-Benz Fuel Cell Citaro

- The design is based on Standard Mercedes-Benz Citaro series model (12 m version)
- Outside dimensions stayed unchanged except height (3.70 m) due to roof mounted fuel cell drive train and fans of the cooling module.
- Additional 3 tons of extra load for the fuel cell drive system. Suspension has been adapted to accommodate higher weight and tendency to roll.



Specifications:

- Fuel cell gross power: > 250 kW
- Net Shaft power: 205 kW
- Transmission: 6 speed automatic transmission
- Tank Capacity:
  > 40kg H_2 at 35 MPa
- Range: > 200km
- V_{max}: up to 80 km/h (elec. ltd.)
- Weight empty / loaded:
  14.2 tons / 18 or 19 tons
- Passenger capacity: up to 70

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Worldwide leading Experiences with Daimler's Fuel Cell Vehicles

60 F-Cell vehicles in customer hands	37 Buses (Citaro) Europe, Australia, China	3 Sprinter with UPS Europe, USA
		
~ 1.780.000 km	~ 2.025.000 km	~ 64.000 km
~ 51.500 h	~ 133.400 h	~ 2.400 h

*Data March 2008

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Benefits of Fuel Cell Vehicle Fleet Operation

- **Technology validation**
- collection of operational data
- Data analysis: use collected data to analyze operation
  - improvement of current vehicles
  - development of next generation
- **Market preparation**
- Infrastructure build-up: cooperation with infrastructure providers
- Customer acceptance: make experiences with passenger vehicles and buses in everyday operation
- Service infrastructure: develop maintenance concepts for Fuel Cell Vehicles and buses
- Environment
  - Codes & Standards: definition of OEM independent standards
  - Politics: feedback for departments of environment regarding progress of FCV development

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Daimler's Fuel Cell Technology Roadmap

Bus

Generation 1
Technology Demonstration

Generation 2
Customer Acceptance

Future Generations

Passenger Cars
Lead Application

2004 – **Generation 1**
Technology Demonstration
F-Cell

2009 – **Generation 2**
Customer Acceptance
B-Class F-Cell

Generation 3
Cost Reduction I

Generation 4
Market Introduction
Cost Reduction II

Generation 5
Mass Production

Sprinter

Generation 1
Technology Demonstration

Generation 2
Customer Acceptance

Future Generations

Daimler is dedicated to commercialize Fuel Cell Vehicles

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Generation 2 (Customer Acceptance)
B-Class F-Cell – limited production in 2010

Specifications B-Class F-Cell:	
Vehicle type	Mercedes-Benz B-Class
Fuel Cell System	PEM, 80 kW (90kW)
Drive	permanent magnet Power (Continuous / Peak): 70 kW/100 kW (136hp) Max. torque: 320 Nm
Fuel	Compressed Hydrogen (700 bar / 10,000 psi)
Range	400 km (250 miles)
Max Speed	170 km/h (106 mph)
Battery	Li-Ion (Mn), Power (Continuous / Peak): 24 kW / 30 kW (40hp); Capacity: 6.8 Ah, 1.4 kWh

Future: Challenges
- Weight
- Reliability and lifetime
- Hydrogen storage
- Freeze start
- Cooling
- Policy framework & financial planning
- Cost

B-Class
- Higher stack lifetime of 2000h
- Increasing of power (65kW⇨100kW)
- Higher reliability
- Longer range (160km⇨400km)
- Freeze start ability below 0°C
- Li-Ion battery
- Decrease component costs

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Outlook on Market Introduction
F600 HyGenius

Specifications F600 HyGenius:	
Vehicle type	Research Vehicle
Fuel cell system	PEM 66 kW
Drive	Electric motor Power (Continuous / Peak): 60 kW / 85 kW (87hp) Max. torque: 350 Nm
Fuel	Compressed Hydrogen (700 bar / 10,000 psi)
Range	>400 km (>250 miles)
Max Speed	174 km/h (109 mph)
Battery	Li-Ion, Power (Continuous / Peak): 30 kW **/** 55 kW (75hp) Capacity: 1.5 kWh

- 40 % smaller stack*
- Over 30 % more power*
- Up to 66 % more torque*
- Consumes equivalent of 2.9 litres of diesel per 100 km
- Can be started at temperatures as low as minus 25 °C
- Li-Ion high voltage battery implemented

*Compared to current F-Cell vehicle (based on A-Class)

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