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F-Cell 2013

# Market Introduction of Electric Vehicles - Opportunities and Challenges

**Prof. Dr. Christian Mohrdieck, 30 September 2013**

Daimler AG

# Responsibility for our Blue Planet

Growing world population

Growing mobility need

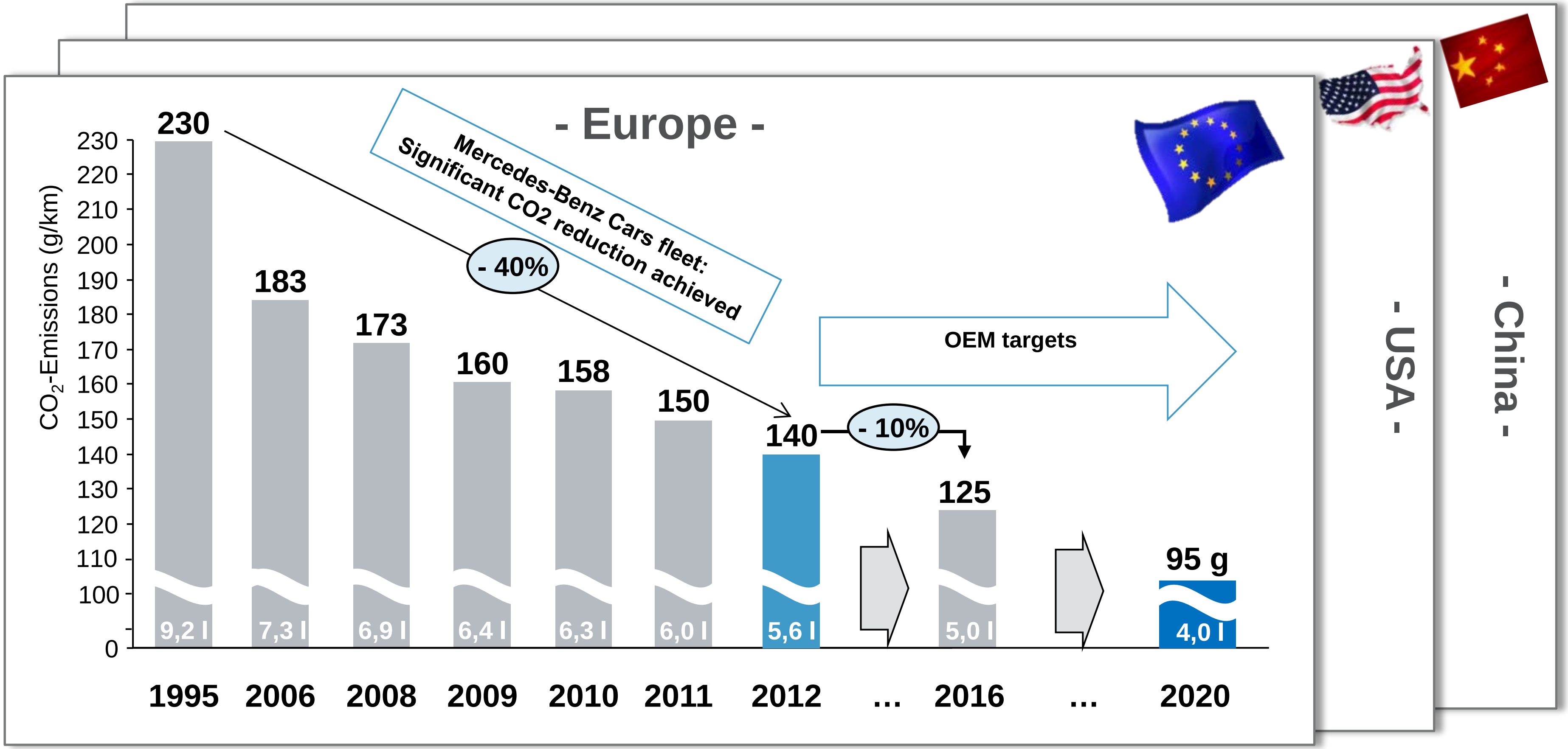

Ecological Awareness


Limited resources

Climate change

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

# Global regulations impose major challenges



# 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**

**3,0**

l/100 km
69 g CO2/km

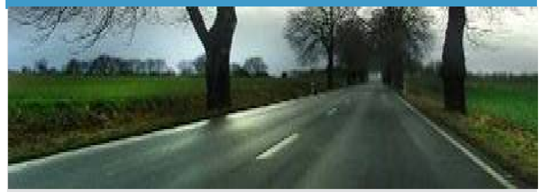
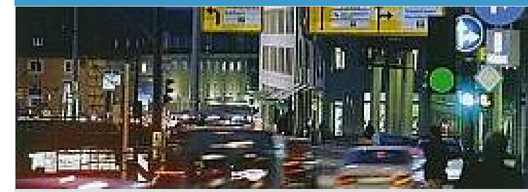
## Electric vehicles with battery and fuel cell

**B-Class electric drive**
**smart electric drive**
**B-Class F-CELL**

**0**

l/100 km
0 g CO2/km

# The Powertrain Portfolio for the Mobility of Tomorrow

| Long Distance | Interurban | City Traffic |
|---|---|---|
|  |  |  |

ML 250 BlueTEC 4MATIC — **Efficient Combustion Engine**

S 400 HYBRID — **Hybrid**

S 500 Plug-in HYBRID — **Plug-in Hybrid**

smart fortwo electric drive — **Electric Vehicle with Battery**

B-Class F-CELL — **Electric Vehicle with Fuel Cell**

Legend: Combustion Engine | Emission free mobility

# The new S 500 PLUG-IN HYBRID

## Driving pleasure, efficiency, comfort & safety at its best

245 + 80 kW

480 + 340 Nm

30 km electrical range

3 l/100km 69 g $CO_2$


**Emission-free driving in urban areas and pure driving comfort on long distances.**

# Daimler's Electric Vehicle 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

**smart**

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)***

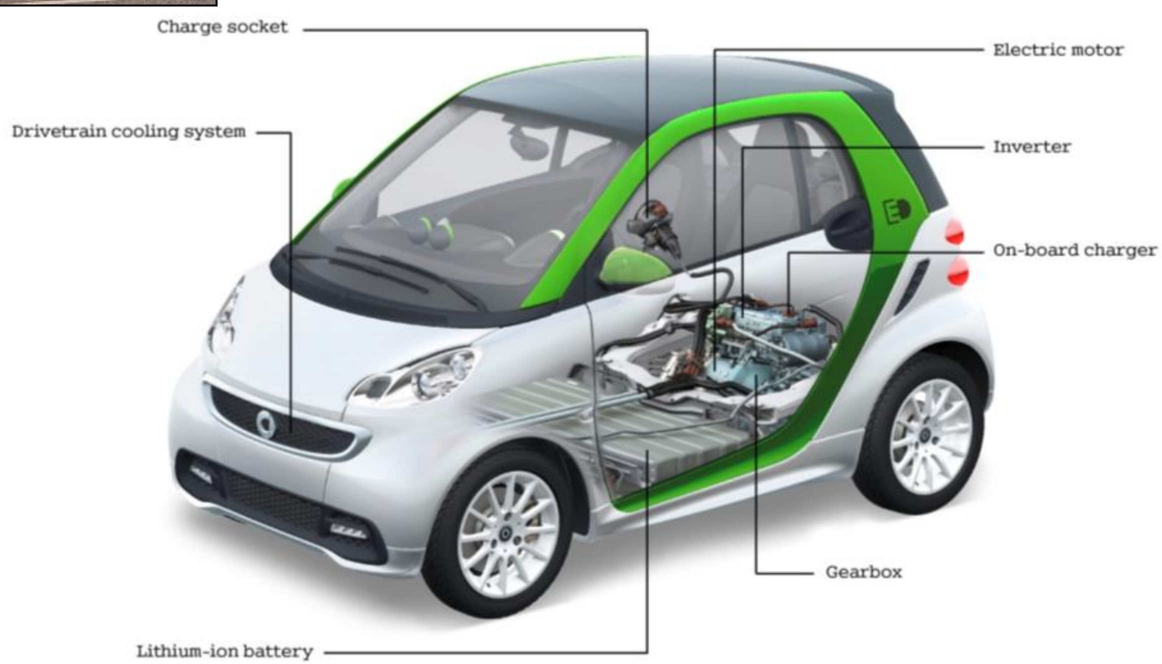
Generation 4
*Mass Production*

**Daimler is dedicated to commercialize electric vehicles with fuel cell**

# smart fortwo electric drive

## Overview of the electrical drive train components

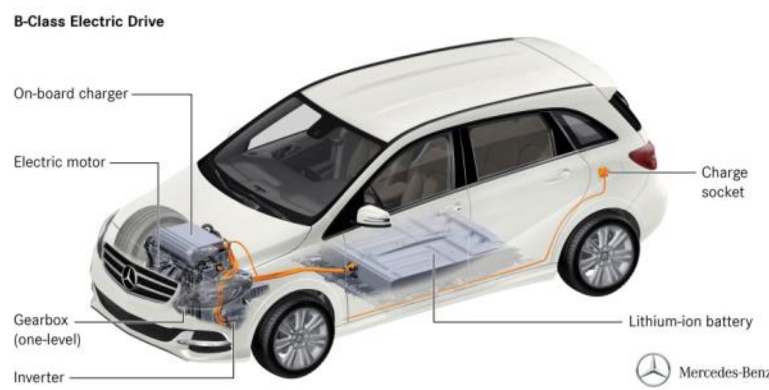

| Specifications | |
|---|---|
| **Vehicle** | smart fortwo electric drive |
| **Engine** | Max. Output: 55 kW (75 hp) |
| **Range** | 145 km |
| **Top Speed** | 125 km/h |
| **Battery** | Lithium-Ion Battery<br>Capacity: 17,6 kWh<br>Deutsche Accumotive |



# The New Mercedes-Benz B-Class Electric Drive

| Specifications* | |
|---|---|
| Vehicle | Mercedes-Benz B-Class Electric Drive |
| Launch | 2014: USA (followed by Europe) |
| Engine | 130 kW |
| Range | 200 km (NEFZ), 115 Miles (US City) |
| $v_{max}$ | 160 km/h (100 mph) |
| Acceleration<br>0-100 km/h (0-60 mph) | 7.9 sec |
| Battery | Lithium-Ion |
| Charging time:<br>100 km (NEDC) /<br>60 miles (US City) | ECE: 1,5 h @ 400V /<br>USA: 2 h @ 240V |

* preliminary values



# Technological Challenges of e-mobility

## 1 Leightweight construction

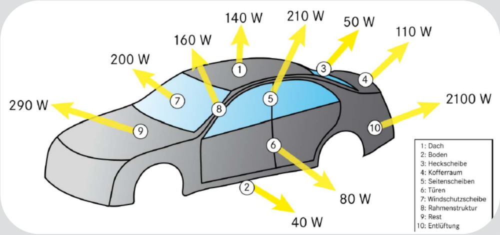
- Carbon Fibre Reinforced Plastic
- Intelligent Design
- Aluminium
- …

## 3 Energy Efficient E-Drive Components

- E-Drive
- Power Electronics
- Compressor
- …

## 2 Air Conditioning/Energy Management

- Cabin-Isolation
- Body-Near Air Conditioning
- Utilisation Of Waste Heat
- …




## 4 Battery Development

- Material/Cell-Chemistry
- Cooling
- Power Density
- …

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# History of e-mobility – limitations of battery technology prevented successful commercialization

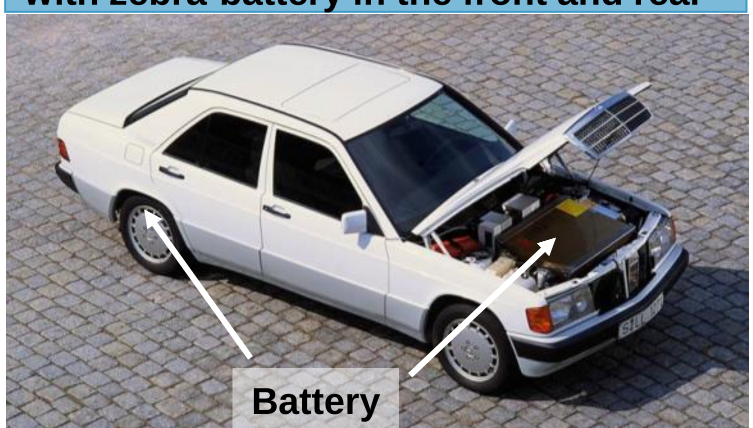
**Battery**

**Electric bus (1972)**
**with battery exchange (860 kg)**

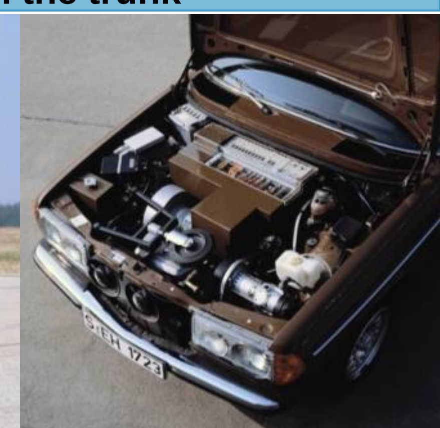

**Limitations:**

weight, size, cost: ↑ lifetime, energy: ↓

**„Baby Benz“, BR 190 (1993)**
**with zebra-battery in the front and rear**




**Sedan (1982)**
**with nickel-iron-battery (600 kg) in the trunk**

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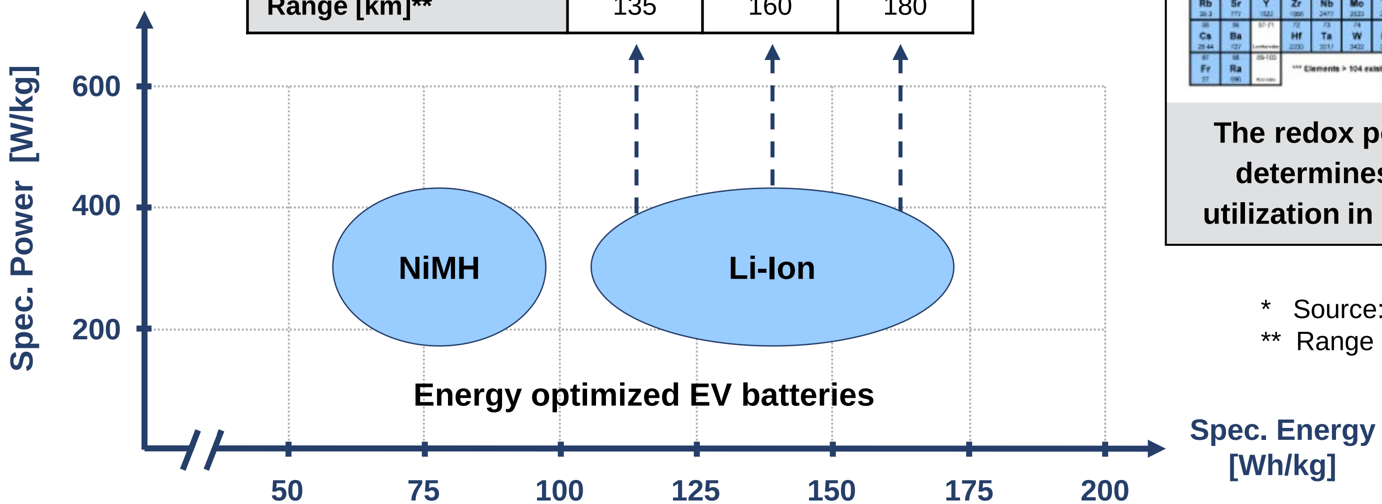
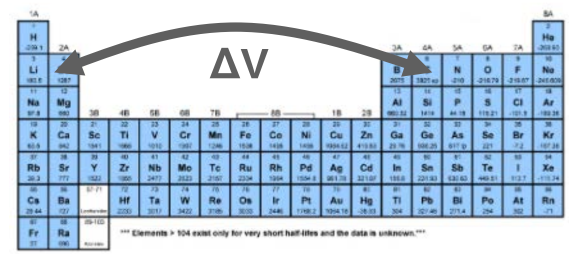
# Potential of High-Voltage Batteries

## Usable Energy of Cells in Dependence on Power

| Development potential of Li-Ion batteries* | | | |
|---|---|---|---|
| **Year** | 2010 | 2012 | 2017 |
| **Spec. Energy [Wh/kg]** | 120 | 140 | 160 |
| **Range [km]**** | 135 | 160 | 180 |




**Periodic Table of the Elements**




**The redox potential of the elements determines the capability for the utilization in batteries / accumulators**

* Source: Daimler AG, RWTH Aachen

** Range of the smart electric drive

- **The Li-Ion battery has limited potential concerning energy and power density**
- **Worldwide research programs with target of > 200 Wh/kg**
- **Promising battery concepts (e.g. LiS, $LiO_2$ ) are in early research stage**

# Challenges for the market penetration of e-mobility

**Developing next generation battery**

**Optimize energy and materials use**

**Secure raw materials supply**

**Infrastructure**


**Customer Acceptance**

schaufenster elektromobilität

Eine Initiative der Bundesregierung

**Incentives**

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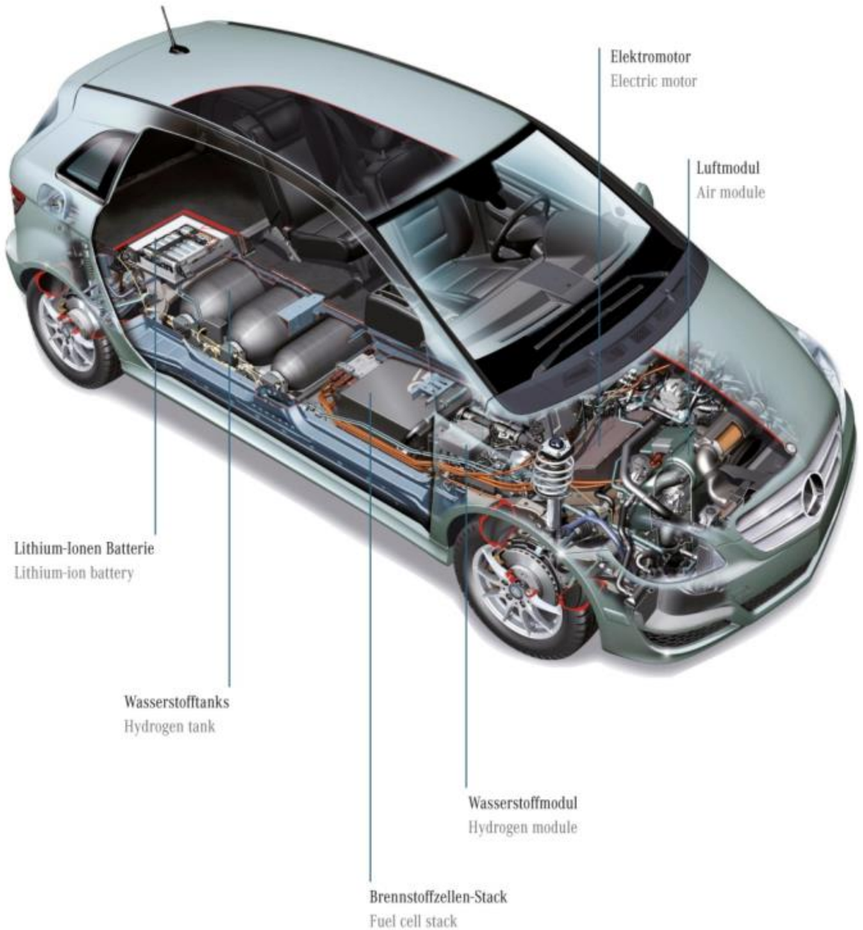
# The Current Generation of Fuel Cell Vehicles

## "Driving the Future" becomes Reality




| Technical Data | |
|---|---|
| Vehicle | Mercedes-Benz B-Class |
| Fuel Cell System | PEM, 90 kW (122 hp) |
| Engine | Output (Cont./ Peak) 70kW / 100kW (136 hp)<br>Max. Torque: 290 Nm |
| Fuel | Compressed hydrogen (70 MPa) |
| Range | 380 km (NEDC) |
| Top Speed | 170 km/h |
| Li-Ion Battery | Output (Cont./ Peak): 24 kW / 30 kW (40 hp)<br>Capacity: 6.8 Ah, 1.4 kWh |

# 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.

I expected a Mercedes - and I got a Mercedes.

over 3 Mio. km driven in customer hands

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

# Packaging of Fuel Cell System

## Today (B-Class F-CELL)

## Future Fuel Cell Engine

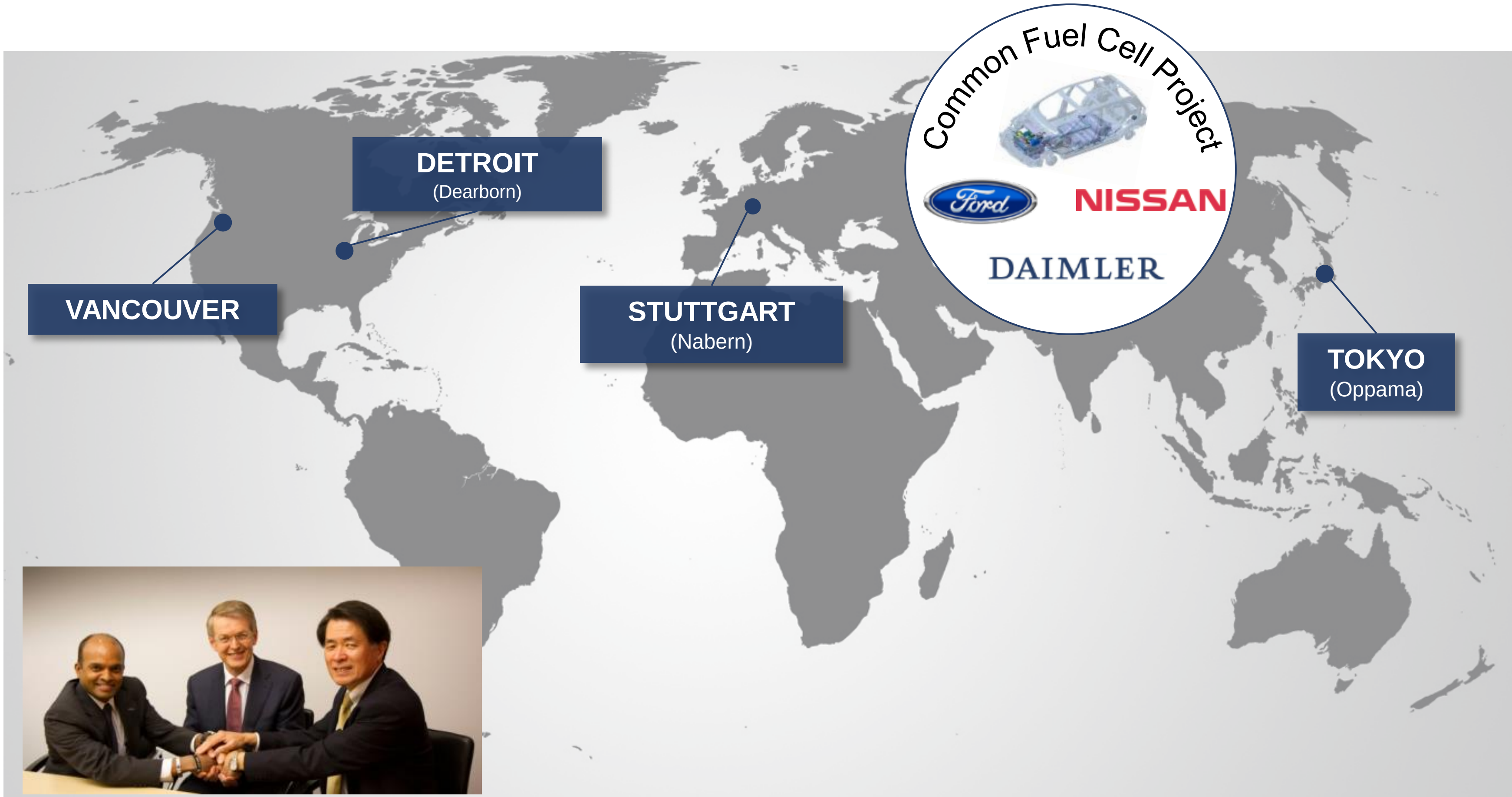
**Volume-Reduction of ~ 30%**

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.**

# Cooperation Nissan/Ford/Daimler

## Asia, Europe and US – Unique collaboration across three continents



# Cooperation Nissan/Ford/Daimler

**"The Hydrogen Vehicle for the World"**

- Joint development of a common fuel cell drive train
- Definition of global specifications and component standards
- Economies of scale by high volumes
- Acceleration of commercialization of FCEVs
- Clear signal to suppliers, policymakers and the industry in terms of further development of H2-infrastructure

**$H_2$-Infrastructure and market conditions are expected to be on an appropriate level by 2017. From 2017 onwards, we are planning for series production of F-Cell vehicles.**

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

# Thanks for your attention!

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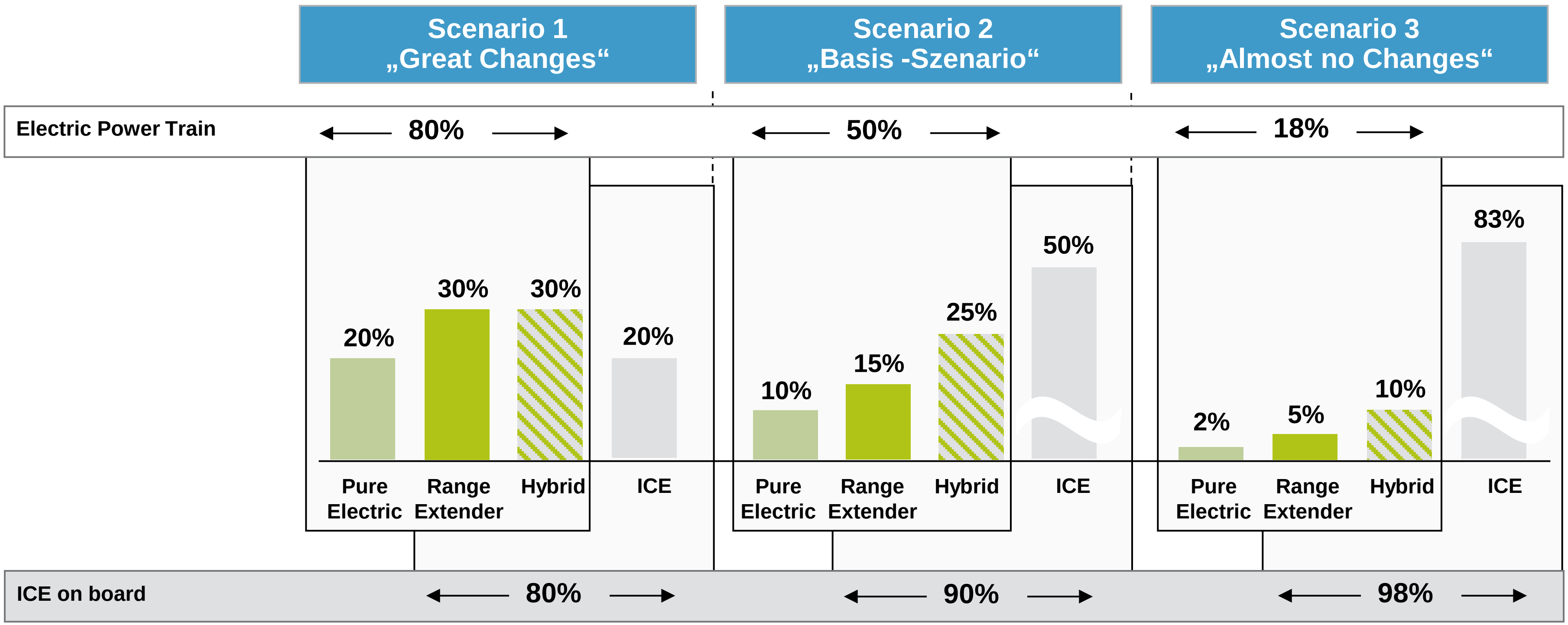
# The Trend to Electrification …

## Market penetration of electric vehicles in 2020 (Bain & Company 2010)




**Assumptions:**

| | | | |
|---|---|---|---|
| Oil price: | ▪ 300 US$ per barrel | ▪ 200 US$ per barrel | ▪ Under 100 US$ per barrel |
| Low Emission Zone: | ▪ All metropolis world-wide | ▪ In many metropolis | ▪ Barely introduced |
| Climate Chance: | ▪ Dramatic Chance | ▪ Significant Chance | ▪ In discussion |
| Subsidy: | ▪ 50-100 Mrd. US$ world-wide | ▪ 10-30 Mrd. US$ world-wide | ▪ Only localy |



Source: Bain & Company (2010), Graphic extended

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# Battery technology determines the success of e-mobility

| Criteria for market success | | Influencing factors | | | |
|---|---|---|---|---|---|
| | | Technology | | Politics | |
| | Battery | Drive unit with gear box and e-motor | Charging and interface | Standardization | Political environment |
| Range | X | X | | | |
| Charging time | X | | X | | |
| Driving characteristic | X | X | | | |
| Vehicle design | X | | | | |
| Cost / TCO | X | X | X | X | X |
| Safety | X | | | X | |
| Lifetime | X | | | | |
| Charging infrastr. | X | | X | X | X |

**The battery as key component has a significant impact on the customer acceptance and the highest proportion of value-added.**

# Challenges of the Fuel Cell and Hydrogen Technology

## Technology

- Power density
- Cooling system
- Hydrogen storage
- Durability

## Supplier Industry

- Development of a competitive component supplier network
  - Joint funding projects to address demands
  - Establishing and maintaining network


## Infrastructure

- Reliable refueling technology
- Build-up of an area-wide infrastructure
- H2 production at competitive prices
- Availability of renewable produced hydrogen

## Cost

- Fuel cell system & stack
- Power electronics
- H2 tank system
- Infrastructure
- Hydrogen cost