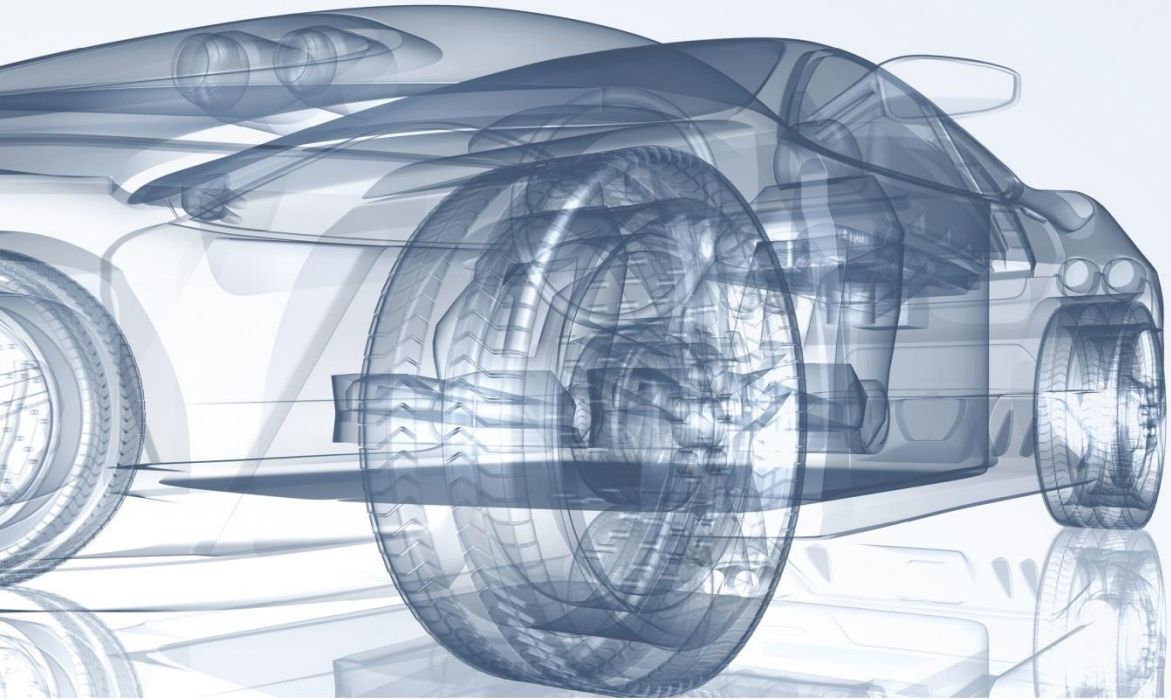
evs 30



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October 9–11, 2017

Messe Stuttgart, Germany

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Fuel cell plug-in hybrids:

Long-distance emobility with batteries and fuel cells

Dr.-Ing. Jörg Karstedt,
Coordinator Emobility

EVS 30, Stuttgart, 9.10.2017

Fuel cell plug-in hybrids:
Long-distance emobility with batteries and fuel cells

- ZBT – A brief introduction
- Fuel cells in automotive applications
- Development of a fuel cell plug-in hybrid: Reference project BREEZE

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Zentrum für BrennstoffzellenTechnik GmbH
The hydrogen and fuel cell center

Research and development: Fuel cells, hydrogen and battery technology

- Focus on industry demand
- Independent service provider and R&D partner
- Share holder: University of Duisburg-Essen
- 100 full time employees

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Infrastructure:

- 1200 m² laboratory
  - Flexible test benches
  - Advanced measurement and analytics
  - Chemical laboratories
- Modern CAE & Simulation tools
- 500 m² technical center / production technologies
  - Injection molding/compound laboratory
  - Gasket production site
  - Mechanical workshop

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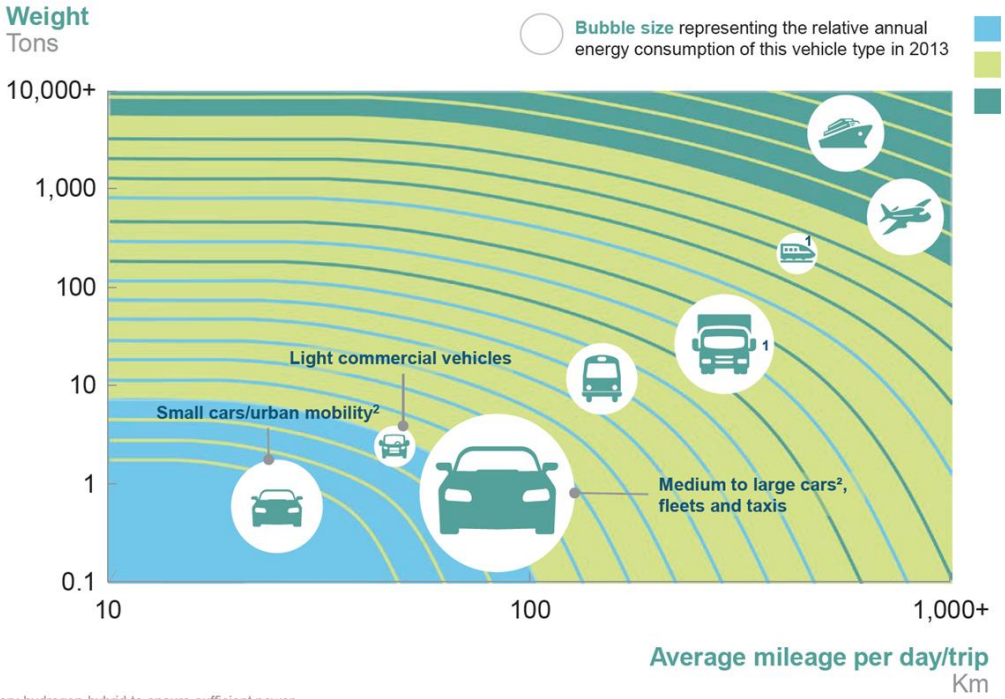
Fuel cells in automotive applications: Powertrain technology options for different transport modes





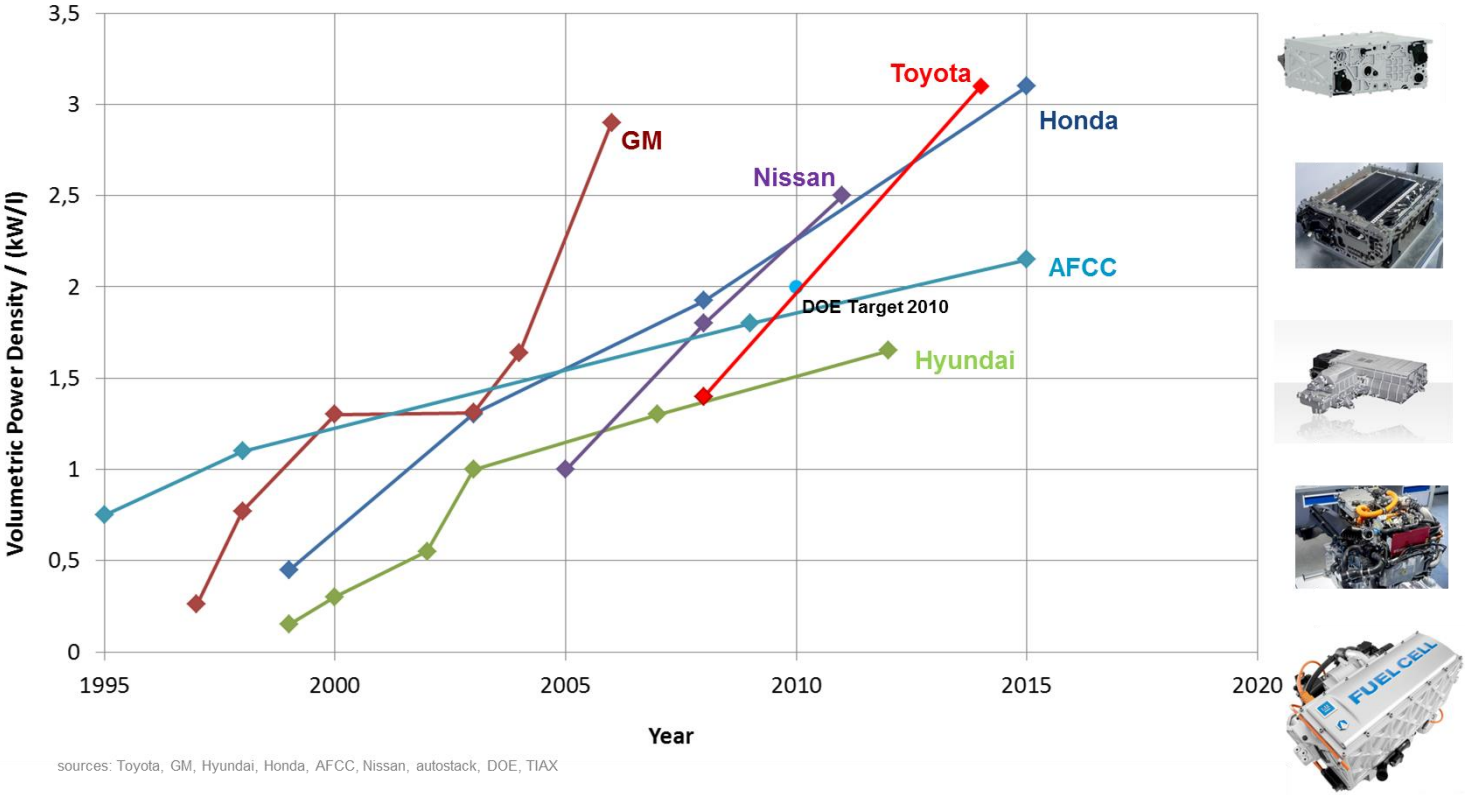




1 Battery-hydrogen hybrid to ensure sufficient power
2 Split in A- and B-segment LDVs (small cars) and C+-segment LDVs (medium to large cars) based on a 30% market share of A/B-segment cars and a 50% less energy demand

Source: Daimler, Honda, Hyundai, Toyota, BMW, Kawasaki, Alstom, Shell, Total, Linde, Air Liquide, Anglo American, Engie, Hydrogen Council 2017
Pictures: Toyota, Alstom, e4ships, ecowatch.com, DLR, Airbus

Fuel cells in automotive applications:
Package / weight: Fuel cell stack volumetric power density



Fuel cells in automotive applications: Platinum is no longer a show stopper for FCEVs

- Platinum loading of automotive fuel cell stacks could be reduced by more than 90% in the latest fuel cell vehicles compared to 2010 technology status

- Current fuel cells require not much more platinum than catalytic converters of a conventional car
  - Daimler GLC: 20g Pt/vehicle
  - GM lab system: 12g Pt/vehicle
  - Catalytic converter diesel: 6-8g Pt/vehicle

- Development continues to further reduce platinum demand

- Platinum is no longer a show-stopper for FCEVs

2010: Underfloor package
206 g Platinum
4 kW / m² active area
Screw compressor

2017: Compartment package
20 g Platinum
9 kW / m² active area
Electric turbo charger with turbine

Source: Daimler

Fuel cells in automotive applications: Technology status and future development

- Stack power output: 115 kW
- Power density: 3.1 kW/l
- Platinum loading: 10-20 g Pt/vehicle
- Cold start: - 40 °C
- Fuel cell vehicle range: 700 km
- Refuelling time: approx. 3 min.
- Durability: 300.000 km

→ Fuel cell vehicle performance meets customer expectations

→ But: Cost targets for series production not yet reached

source: BMW, NuCellSys/Daimler, VW, Toyota

Fuel cell plug-in hybrids:
Long-distance emobility with batteries and fuel cells

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Development of a fuel cell plug-in hybrid: The case for fuel cell plug-in hybrids

- Optimal degree of hybridization of fuel cell vehicles depends on cost development of battery and fuel cell
- Fuel cell plug-in hybrid focuses on downsized, low-cost fuel cell system
- Fuel cell system must provide average vehicle power demand to ensure unlimited long-distance emobility
- Battery electric operation covers short-distance driving w/ highest efficiencies, lowest operating cost
- High value fuel hydrogen is used for long-distance emission free mobility

source: FEV

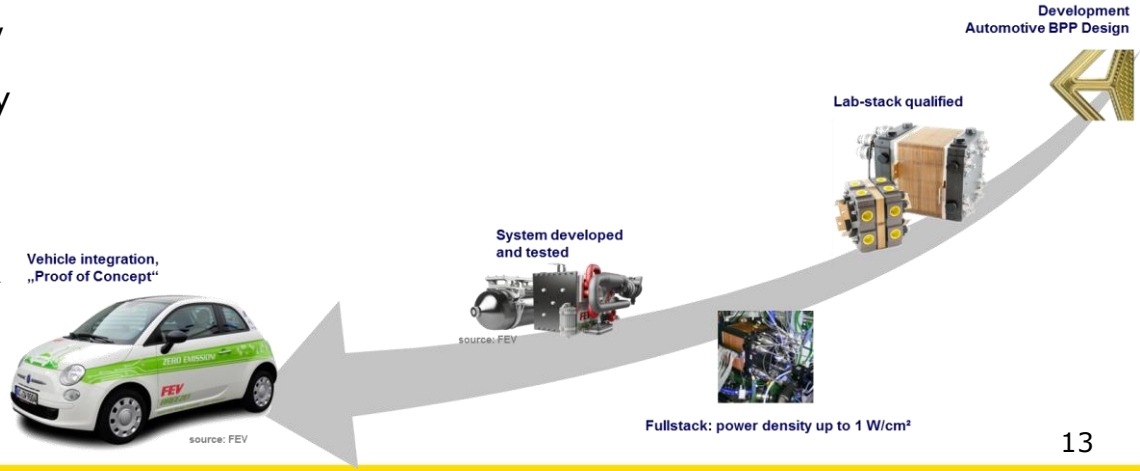
EFRE.NRW 2014-2020
Investitionen in Wachstum und Beschäftigung
Ministerium für Wirtschaft, Energie, Industrie, Mittelstand und Handwerk des Landes Nordrhein-Westfalen
EUROPÄISCHE UNION
Investition in unsere Zukunft
Europäischer Fonds für regionale Entwicklung

BREEZE: Development of a fuel cell plug-in hybrid

- Battery electric operation for short distances
- 30 kW fuel cell system enables emission free long-distance emobility and short refuelling times

- Automotive stack development by ZBT and Gräbener Maschinentechnik
  - Component benchmarking
  - Flowfielddesign/CFD simulation/
  - Development sealing technology
  - Testing and qualification

- System development by FEV and VKA



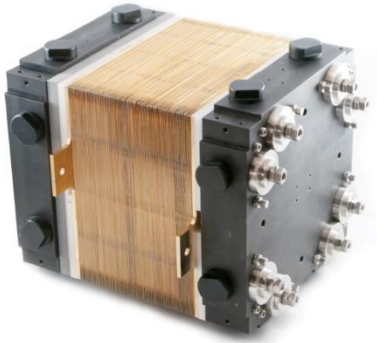
Development of a fuel cell plug-in hybrid: System specification

System:

- Dimensions: 750x520x400 mm
- Weight: 100 kg
- Fuel: Hydrogen 350 bar (opt. 700 bar)
- Refuelling time: 3 min.

Stack:

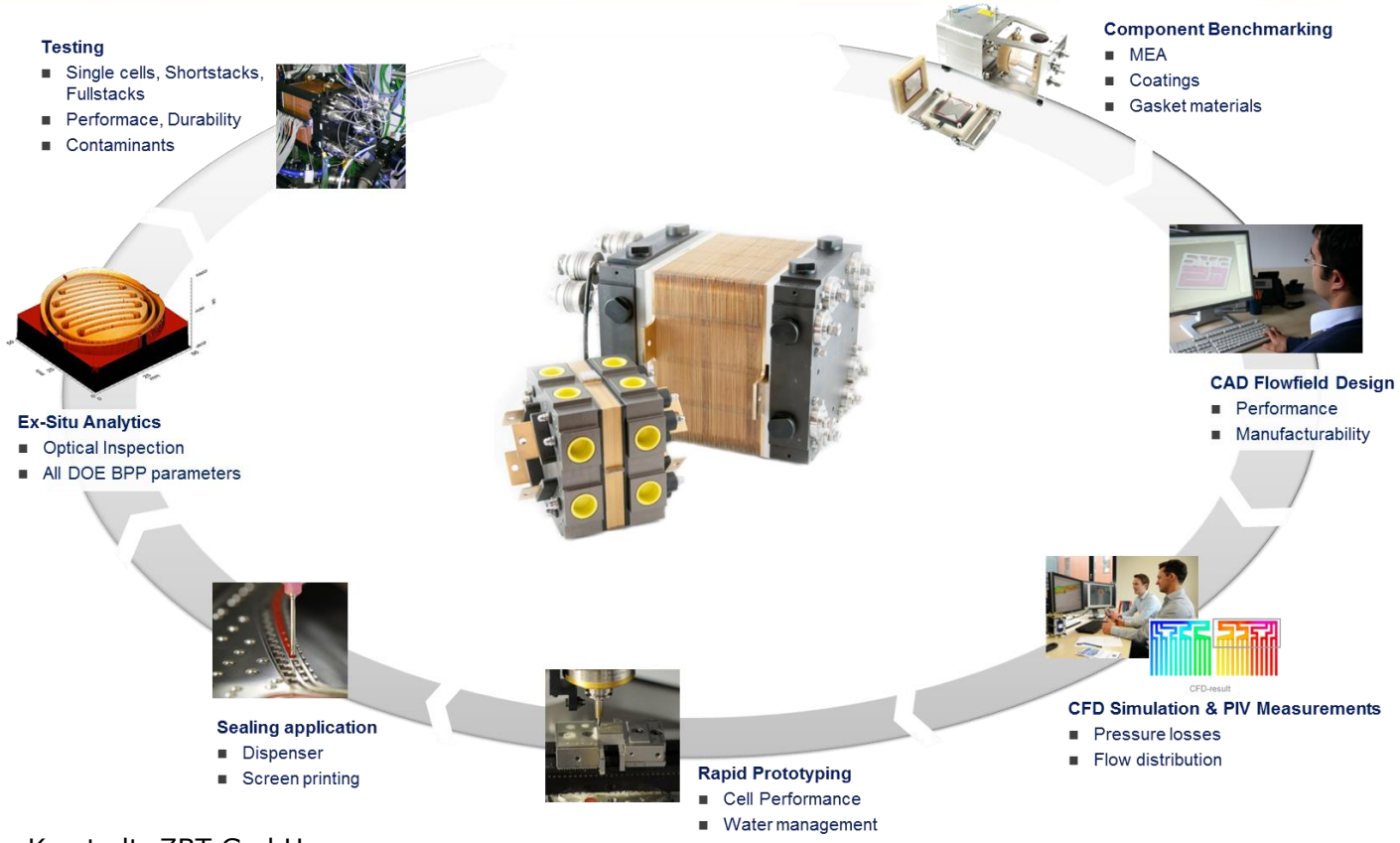
- Stack power output: 33 kW, 325 A at nom. Load
- Operating temperature: 80 °C
- Operating pressure: 2 bar(a)
- Cell pitch: 1,2 mm
  - Metallic Bipolar Plates
  - No cathode humidification
  - Cast aluminum endplate with integrated balance of plant components



Development of a fuel cell plug-in hybrid: Vehicle integration

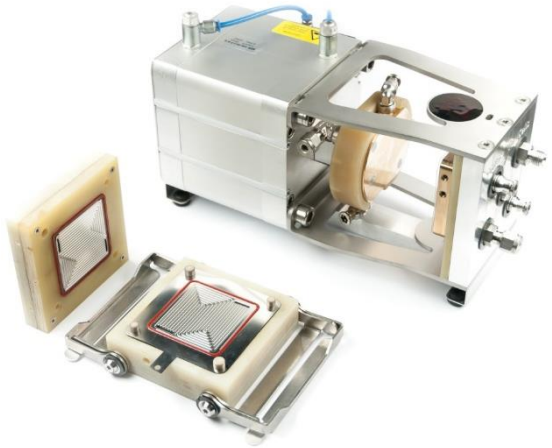
source: FEV

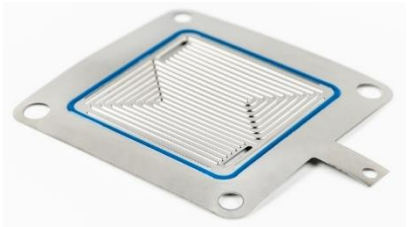
Development of a fuel cell plug-in hybrid: Stack development at ZBT

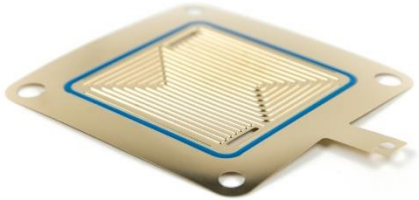


Development of a fuel cell plug-in hybrid: In-situ testing under automotive conditions

- Metallic sheet metal bipolar plates
- Active area: 25 cm^2
- Power density > 1,2 W/cm^2
- Compaction: max. 2.5 MPa on active area
- Sealable by o-rings or FIP gaskets
- Inserted in commercial available test hardware Baltic qCF
- Temperature range: RT…180 °C
- Voltage monitoring directly contacted to the bipolar plates



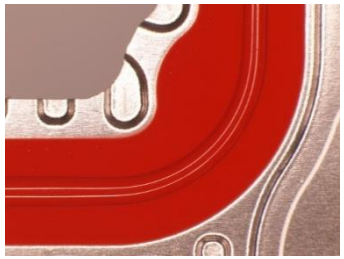




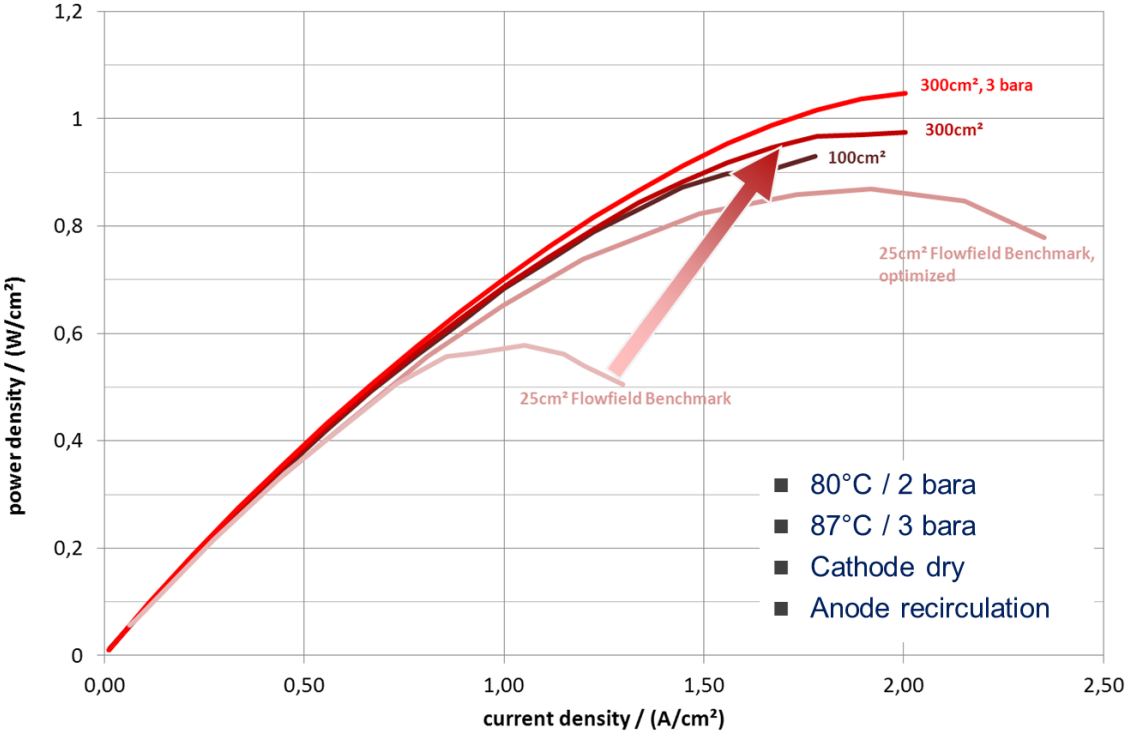
Development of a fuel cell plug-in hybrid: ZBT‘s sealing solutions for fuel cells

Advantages:

- Fast development process
- No tooling cost
- High design flexibility/easy adaptation to different heights
- Materials: Silicone based, FKM and customer specific
- Homogenous sealing height also for complex geometries
- Low sealing loads (~10-15% of stack compression force)
- Fast application process
- High yield
- No gas bubbles in sealing
- Profiled sealing contours possible
- Reworking of existing sealing designs feasible



Development of a fuel cell plug-in hybrid: Performance testing of 300cm² stack



Fuel cell plug-in hybrids: Conclusion

- Fuel cell plug-in hybrids enable long distance emission free electric mobiliy
- Degree of hybridization between battery and fuel cell can be optimized to reduce overall cost
- Development is currently focusing on low-cost, high volume manufacturing technologies
- ZBT supports the industry in the development of fuel cell stacks and systems, manufactures low cost sealing solutions for fuel cells and provides independent testing and qualification services

Thank you for your attention!

Interested?

Vist us in hall 1 booth 1A33!

Contact:
Dr. Jörg Karstedt
+49 (0)203/7598-1178
j.karstedt@zbt-duisburg.de
www.zbt-duisburg.de