Strategies for Future Powertrains

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Top 3 Mobility Issues

Exhaust Emissions CO, NO\textsubscript{X}, HC, PM

Greenhouse Gases CO\textsubscript{2}

Energy
Volkswagen’s Fuel- and Powertrain Strategy
Future Challenges for the Diesel Emissions

- Exhaust Gas Aftertreatment
- Turbocharging
- Injection / Combustion

- High Pressure Turbocharging
- NO$_x$-Storage-Catalyst/SCR
- Injection System
- Homogeneous Combustion
- increased EGR-Rates
- DPF

2004 - Today
BlueMotion
Fuel Consumption Diesel Engine A00-/A0-Class

- Lupo 3L TDI®
- Polo BlueMotion
- Competitors
TSI®-TC – Fuel Consumption Reduction

Comparison V5 vs. TSI - TC (125kW)

Fuel Consumption [l/100 km] NEDC

- 9.0
- 8.0
- 7.0

- 1.8l 110kW

V5

5. gear

TSI - TC

5. gear

Saving by Charging appx. 18%

6. gear

Elasticity 80 - 120 km/h [s]
Gasoline Cars Benchmark

Power Range 90 to 150kW

- Golf 1.4l 103kW TSI
- Golf GT 1.4l 125kW TSI
- Golf 1.4l 90kW TSI
- 1.XI TSI
- Golf GTI 2.0l 147kW

Engine Power [kW] vs. NEDC [l/100km] chart with competitors and maximun power and minimum consumption.
DSG dual-clutch gearbox

- 6 / 7-speed direct shift gearbox
- Consumption lower than manual gearbox
- Shorter shift times without interruption in power flow
- Maximum shifting comfort

![Image of DSG dual-clutch gearbox]

Rel. Fuel Consumption [%]

- Automatic (4-speed)
- DSG (6-speed)
- Manual
- DSG (7-speed)

Consumption lower than manual gearbox
Shorter shift times without interruption in power flow
Maximum shifting comfort
## Sustainability criteria for biofuels

<table>
<thead>
<tr>
<th>GHG performance</th>
<th>Certification for production sites and raw material</th>
</tr>
</thead>
<tbody>
<tr>
<td>Land use &amp; biodiversity</td>
<td>Land efficiency - risk of mono cultures - use of pesticides and fertilizers</td>
</tr>
<tr>
<td>Raw material</td>
<td>Social impacts – usage of food materials – influence on food prizes</td>
</tr>
<tr>
<td>Substitution Potential</td>
<td>Is a Substitution of Existing Fuels Possible by More than 10 %?</td>
</tr>
</tbody>
</table>

...
## Alternative Fuels – Overview

### Alternatives Fuels

<table>
<thead>
<tr>
<th>Oil</th>
<th>Gas</th>
<th>Ethanol</th>
</tr>
</thead>
<tbody>
<tr>
<td>Rape seed Methyl Ester</td>
<td>Compressed Natural Gas</td>
<td>Sugar Beet</td>
</tr>
<tr>
<td>Soya-Methyl-Ester</td>
<td>Liquid Petroleum Gas</td>
<td>Wheat</td>
</tr>
<tr>
<td>Frit Oil</td>
<td>Biogas</td>
<td>Sugar Cane</td>
</tr>
<tr>
<td>Hydrated Vegetable Oil</td>
<td>Hydrogen H$_2$</td>
<td>Celluloses</td>
</tr>
</tbody>
</table>

### Synthetic Fuels

<table>
<thead>
<tr>
<th>Gas to Liquid</th>
<th>Coal to Liquid</th>
<th>Biomass to Liquid</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coal to Liquid</td>
<td>SunDiesel</td>
<td></td>
</tr>
</tbody>
</table>

- **Bio Fuel**
- **Volkswagen Focus**
Characterization of Various Bio Fuels

1st Generation
- Biodiesel (Rapeseed)
- Ethanol (Wheat, Sugar Beet)

2nd Generation (SunFuel®)
- Biomass to Liquid (Choren)
- Cellulose Ethanol (Iogen)

- High CO₂ Avoidance Potential
- No Interference in the Food Chain
- High Hectare Yields
Improvements by Synthetic Fuels

• Direct Improvement of Local Air Quality by Usage of Synthetic Fuels in Existing Vehicles Based on the Outstanding Purity of the Fuels

• Reduction of Global CO2-Emissions if Biomass is Used as Primary Energy for Synthetic Fuels

• Possibility to Develop New Combustion Systems with Widely Improved Characteristics Based on the Designability of Synthetic Fuels
Energy Pathways

Source
- Fossil
  - Crude Oil
  - Coal
  - Uranium
  - Natural Gas
- Renewable
  - Wind
  - Water
  - Solar
  - Geothermal
  - Biomass

Energy Carrier
- Electric Power
- Fuels
  - Gasoline/Diesel
  - CtL
  - GtL
  - BtL
- Biogas
- H₂

Powertrain
- Fuel Cell E-Drive
- Battery E-Drive
- Conventional Powertrain (ICE)
Hybrid Powertrain 1,4l T-FSI with DQ200

Combustion Engine
1,4l 110kW T-FSI

Transmission DQ200-7

E-Motor (20kW) + Clutch (Impulse Start Module)

Graph showing:
- Drehmoment [Nm]
- Drehzahl [1/min]
- Leistung [kW]

Drehmomentgrenze DQ200 (verstärkt)
1,4l T-FSI (statische Kurve)
1,4l T-FSI + E-Maschine (max. 30sec.)
Roadmap “Universal Powertrain”

- **Zero Impact Powertrain**
  - Topics
  - Single Cylinder Displacement > 400 ccm
  - Optimized Combustion (CCS®/GCI)
  - Optimized Fuels XTL
  - Total Emission Reduction
  - High Charging, Friction Reduction
  - Fully Variability (Air/Fuel)
  - E-Technology-Integration in Powertrain
  - High Power Battery

- **Integrated Hybrid**
  - Topics
  - Single Cylinder Displacement < 250 ccm
  - Combustion Optimization for high Load (no HCCI)
  - Emission Reduction at Full load
  - High Charging, Friction Reduction
  - High Power Electric Motor
  - High Energy Battery
  - 40-50 kW – FC-Stack

- **Full-Hybrid**
- **Plug-In-Hybrid**
- **Mild-Hybrid**
- **Combustion Engine**

- **Electrical Powertrain with Range Extender**

- **Electrical Powertrain with FC-Range Extender**

- **Long Distance Electrical Powertrain**

- **Research, Production**

- **Focus: Combustion Power**

- **Focus: Electric Power**
Space up! Blue - Zero Emission Van

Electric Drive
with
Lithium-Ion Battery
and
HT-PEM Fuel Cell
as
Range-Extender

<table>
<thead>
<tr>
<th>Size</th>
<th>3680x1630x1570 mm</th>
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<tbody>
<tr>
<td>Seats</td>
<td>4</td>
</tr>
<tr>
<td>V_{max.}</td>
<td>120 km/h</td>
</tr>
<tr>
<td>0-100 km/h</td>
<td>13.7 sec.</td>
</tr>
<tr>
<td>Zero Emission</td>
<td>350 km</td>
</tr>
<tr>
<td>Mileage</td>
<td></td>
</tr>
<tr>
<td>Electric Drive</td>
<td></td>
</tr>
<tr>
<td>Battery</td>
<td></td>
</tr>
<tr>
<td>Fuel Cell</td>
<td></td>
</tr>
<tr>
<td>Hydrogen</td>
<td></td>
</tr>
<tr>
<td>Mileage Battery</td>
<td></td>
</tr>
<tr>
<td>Mileage H2</td>
<td></td>
</tr>
<tr>
<td>Electric Drive</td>
<td>45 kW 120 Nm</td>
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<tr>
<td>Battery</td>
<td>Li-Ion 12 kWh</td>
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<tr>
<td>Fuel Cell</td>
<td>High Temperature</td>
</tr>
<tr>
<td>Hydrogen</td>
<td>700 bar 3.3 kg</td>
</tr>
<tr>
<td>Mileage Battery</td>
<td>100 km</td>
</tr>
<tr>
<td>Mileage H2</td>
<td>250 km</td>
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Future Electrical Energy Storages Requirements

<table>
<thead>
<tr>
<th>Today</th>
<th>2008</th>
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<tbody>
<tr>
<td>Realizable with today’s Technology</td>
<td>7</td>
</tr>
<tr>
<td>Potential of today’s Technology</td>
<td>21</td>
</tr>
<tr>
<td>Research target</td>
<td></td>
</tr>
<tr>
<td>Theor. bounds of Electrochemistry</td>
<td>500</td>
</tr>
</tbody>
</table>

Mileage [km/100kg]
Thank you for Your Attention