The Possibilities of E-Mobility for the Future

Volkswagen Group’s Solutions for Sustainable Mobility

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Group External Relations
Future Technologies

2013-10-17
E-mobility event
Swedish Car Industry Association
Stockholm, Sweden
Why do we need sustainable mobility?

Climate change – emissions

Smog and noise in megacities

The finite nature of fossil fuels
Volkswagen XL1

<table>
<thead>
<tr>
<th>Specification</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aerodynamics</td>
<td>$cd = 0.189$</td>
</tr>
<tr>
<td>Curb weight</td>
<td>795 kg</td>
</tr>
<tr>
<td>Top speed</td>
<td>160 km/h</td>
</tr>
<tr>
<td>Fuel consumption (NEDC)</td>
<td>0.83 l/100 km</td>
</tr>
<tr>
<td>CO2 emissions (NEDC)</td>
<td>21 g/km</td>
</tr>
<tr>
<td>All-electric range</td>
<td>50 km</td>
</tr>
<tr>
<td>Total range</td>
<td>approx. 500 km</td>
</tr>
</tbody>
</table>
Carbon dioxide: Conventional drive technologies are not enough

Technologies to increase CO₂ efficiency

- Optimizing conventional drive trains
- CO₂ efficiency measures in the vehicle
- Using alternative drive technologies

Fleet CO₂ emissions

- EU27 Fleet value in 2006: 166 g CO₂/km
- EU27 Fleet value in 2012: 134 g CO₂/km
- EU27 Fleet value in 2020: 95 g CO₂/km

Technologies and energy sources

EU27 Fleet value in 2006
EU27 Fleet value in 2012
EU27 Fleet value in 2020

PHEV
Volkswagen Group: Technologies to suit every need
What Volkswagen customers in Germany use their cars for most of the time (i.e., >75% of the time)
Golf TDI BlueMotion
3,2 l/100km, 85gCO₂/km
Measures to improve CO₂ efficiency

Engine

Combustion system
- High-performance combustion system
- Combined turbo- and supercharging
- Ignition systems
- Variable valve train
- Variable compression ratio

Lightweight design
- Alternative materials
- Lightweight design through optimized structures

Operational strategy
- Active Cylinder Management
- Optimizing engine mapping
- Engine off while coasting
- Downspeeding
- NVH at low rpm

Friction
- Surface coating
- Thermal management
- Utilizing exhaust heat

Gearbox

Dual-clutch gearbox
- Gear-ratio spread
- Efficiency
- Performance when pulling away
- Low-rpm solution
Evolution of renewable energy pathways

Source/Feedstock
- Vegetable oil
- Glucose
- Syngas
- “green” electricity
- CO₂ + sunlight

Intermediate energy carrier
- Vegetable oil
- Glucose
- Syngas
- “green” electricity
- CO₂ + sunlight

Energy carrier for mobility
- Gasoline and Diesel
- Gas
- Battery and fuel cell
The new CNG-powered vehicles: Advantages of CNG in terms of CO₂ emissions

**Gasoline C₈H₁₈**  
(ISO-Oktan)

\[2 \text{C}_8\text{H}_{18} + 25 \text{O}_2 \rightarrow 16 \text{CO}_2 + 18 \text{H}_2\text{O}\]

1 kg of gasoline generates 3.1 kg of CO₂  
(Heating value 41.0 MJ/kg)

**CNG CH₄**  
(Methan)

\[\text{CH}_4 + 2 \text{O}_2 \rightarrow \text{CO}_2 + 2 \text{H}_2\text{O}\]

1 kg of methane generates 2.75 kg of CO₂  
(Heating value 47.7 MJ/kg)

**Potential reduction in CO₂ emissions in consideration of the heating value**

-25%

Methane
Volkswagen eco up!, Volkswagen Golf TGI & Audi A3 g-tron
Electrifying the Drive systems at Volkswagen

- Micro hybrid/start-stop
- Mild hybrid
- Full hybrid (HEV)
- Plug-in hybrid (PHEV)
- Range extender (RE BEV)
- Battery vehicle (BEV)
- Fuel cell (FCEV) ¹)

**Electric range**
- 2 km
- 20–80 km
- 50–120 km
- 80–200 km
- 400–600 km

**Electric motor**

**Internal combustion engine** + power generator

¹) > 2020

2013-10-17 BIL Stockholm BW Steiger.pptx
Volkswagen Group: Technologies to suit every need
What Volkswagen customers in Germany use their cars for most of the time (i.e., >75% of the time)
Volkswagen e-up!
The electric drive system of the e-Golf

**Electric machine**
Permanent magnet synchronous motor

<table>
<thead>
<tr>
<th>Feature</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Max. power output</td>
<td>85 kW</td>
</tr>
<tr>
<td>Constant power output</td>
<td>50 kW</td>
</tr>
<tr>
<td>Max. torque</td>
<td>270 Nm</td>
</tr>
<tr>
<td>Constant torque</td>
<td>160 Nm</td>
</tr>
<tr>
<td>Range</td>
<td>175 km</td>
</tr>
</tbody>
</table>
Combined Charging System – One System for All

Easy Handling and Widely Spread User Acceptance
Uniform, open and standardised solution as future-proof investment

Simple – Safe – Flexible
No need for variants

Charging Time

- **High Power DC**
  - Ultra Fast: 15 min
  - Speed of Charging: 1 h
  - Basic: 8 h

- **Type 2 Core**
Volkswagen Group: Technologies to suit every need
What Volkswagen customers in Germany use their cars for most of the time (i.e., >75% of the time)
Audi A3 e-tron

1.4-l 110-kW TSI engine with aluminum cylinder block and crankcase

Dual clutch gearbox DQ400E with integrated electric machine (80 kW)

Lithium-ion battery
96 cells, 352 V, 8.8 kWh

Power electronics including DC-DC converter
## Assembly kit for hybrid drive systems

<table>
<thead>
<tr>
<th>Engine</th>
<th>Electric machine</th>
<th>Gearbox</th>
<th>Battery</th>
<th>Power electronics</th>
</tr>
</thead>
<tbody>
<tr>
<td>2-cylinder in-line TDI</td>
<td>HEM 20</td>
<td>DQ200E</td>
<td>HEV</td>
<td>Power electronics</td>
</tr>
<tr>
<td>3-cylinder in-line TSI/TDI</td>
<td>HEM 60</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4-cylinder in-line TSI/TDI</td>
<td>HEM 80</td>
<td>DQ400E</td>
<td>PHEV</td>
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</tr>
</tbody>
</table>
Volkswagen is electrifying all vehicle classes

<table>
<thead>
<tr>
<th>Year</th>
<th>HEV</th>
<th>PHEV</th>
<th>HEV</th>
<th>PHEV</th>
<th>HEV</th>
<th>PHEV</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>VW Touareg</td>
<td></td>
<td>Porsche Cayenne S</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>Audi Q5</td>
<td></td>
<td>Audi Q7</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2012</td>
<td>VW Jetta</td>
<td></td>
<td>Porsche Cayenne</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2013</td>
<td>VW e-Golf</td>
<td></td>
<td>Audi A6</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2014</td>
<td>VW e-up!</td>
<td></td>
<td>Audi A8</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Audi A3</td>
<td></td>
<td>Porsche Panamera</td>
<td></td>
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<td></td>
</tr>
<tr>
<td></td>
<td>Audi A6</td>
<td></td>
<td>VW Passat</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>Audi A8</td>
<td></td>
<td>Porsche Panamera</td>
<td></td>
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<tr>
<td></td>
<td>Volkswagen</td>
<td></td>
<td>Audi Q7</td>
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<tr>
<td></td>
<td>Porsche Panamera</td>
<td></td>
<td>Derivatives of other Group brands</td>
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</tbody>
</table>
E-Mobility is more than just the development of E-Cars
Megatrends Urbanization, Technological und Societal Change result in needs, often only partly addressed in urban environment.

<table>
<thead>
<tr>
<th>Societal needs are changing continously</th>
<th>Adressing actual insufficient</th>
</tr>
</thead>
<tbody>
<tr>
<td>increasing Urbanisation</td>
<td></td>
</tr>
<tr>
<td>Technology-change</td>
<td></td>
</tr>
<tr>
<td>Society change</td>
<td></td>
</tr>
</tbody>
</table>

- Search for **modern center of living**
- **Places to Recover** from fast city live
- optional, connected **Mobility system**
- **Communication** every time, every place
- **Sustainability** for daily live
- **Support** and Integration of the **society**
To address the needs we must tackle three main challenges:

**Ensuring city mobility**

...despite reductions in innercity road traffic

**Connecting and interactive communication**

Creation of seamless transport modes

Integration of modern Technology and Communication

**Creation of live worth city environment**

Recapture public space

Support Community and Co-creation

...despite noise- and exhaust emissions
Solution: VW MicroCity as innovative answer to future challenges

- The VW MicroCity serves as modern Mobility center...
- ...connecting various Mobility offers with complementary services
- The VW MicroCity is creating an emotional connection to customers...
- ...through Integration of the society, support of sustainability and creation of a modern center of living

Seamless Connection of cross sectorial services concentrated in a MicroCity
The Concept enables reduced inner city traffic by guiding customer streams

Define Customer streams...

...examples of MicroCitys

MicroCity in suburban environment
- platform to change to alternative Mobility offers as well as shopping place for commuters and residents

MicroCity in outer ring areas
- Central docking station / traffic center for commuters from suburbs

MicroCity in City center
- Near to city center to switch to last mile mobility
Customer function Vehicle to Home / Vehicle to Grid

Charge with locally produced Emergency supply Household

Smart charging at low prize Sell energy into grid

Development of an customer oriented energy management considering the car needs

Electro mobility can failsave a continuous Increase of fluctuating energy supply
Electric Vehicle Grid Integration
Role model – BEV/PHEV Grid Integration
Electro mobility – a systems approach

Source: Nationale Plattform Elektromobilität (NPE)
Thank you for your Attention!