SUSTAINABLE TECHNOLOGIES – THE CHANGING FACE OF MOBILITY.

PHILIP KOEHN
VICE PRESIDENT VEHICLE ARCHITECTURES AND CONCEPTS
Climate change
- Destructive consequences

Urbanisation

Politics
- Fleet regulations
- City driving restrictions
- CO₂ taxation

Drivers for Sustainable Mobility

Economy
- Resource scarcity
- Price increases for fossil fuels

Culture
- Sustainable mobility as an element of urban style
- Growing social responsibility

Changing values

BMW Group, Dr. Ing. Philip Koehn, November 4, 2011, Page 2
GLOBAL CO₂ REGULATION IS BECOMING STRICTER.

- Self-imposed obligation 2008
- 120g CO₂ Legal Limit / 2012
- 95g CO₂ Legal Limit / 2020
- 75g CO₂ Legal Limit / 2025

- Unstable legal situation
- Penalties for individual vehicles
- Increasing share of NEV vehicles expected

Amendment to CAFE 2010
- Penalties
Greenhouse Gas EPA 2010
- No registration
Greenhouse Gas CARB 2010
- No registration

Energy Conservation Law
2010 Stage 1
2015 Stage 2
Public ostracism

BMW Group, Dr. Ing. Philip Koehn, November 4, 2011, Page 3
BMW EFFICIENTDYNAMICS – WE HAVE UNDERSTOOD THE COMPLEXITY OF THE ENERGY FLUXES IN THE VEHICLE AND DERIVED CO₂ MEASURES.
BMW EFFICIENTDYNAMICS – WE APPLY CUSTOMIZED EFFICIENCY PACKAGES FOR OUR PRODUCTS.

- Petrol engines with High Precision Injection and Twin Turbo.
- Diesel engines with 1800 bar High Pressure Injection.
- Efficient route selection.
- Final Drive Aluminum Housing.
- Aluminium bonnet.
- Aluminum roof.
- Aluminum doors.
- Active aerodynamics with flaps.
- Decoupled A/C compressor.
- Electric water pump.
- Low rolling resistance tyres.
- Highly efficient 8-speed automatic transmission.
- Brake Energy Regeneration.
BMW EFFICIENTDYNAMICS – BMW GROUP FLEET CO₂ EMISSIONS SO FAR HAVE BEEN REDUCED BY MORE THAN 30% (1997-2010) IN EUROPE.

BMW EFFICIENTDYNAMICS. SHORT, MID AND LONG TERM SOLUTIONS.

- **Engine technology**
- **Intelligent light weight construction**
- **Aerodynamics**
- **Intelligent energy management systems, Active Hybrid**
- **Alternative energies: Hydrogen, Electricity**

**short-term**

**mid-term**

**long-term**
THE NEW BMW ENGINE PORTFOLIO.
BMW TWIN POWER TURBO.

<table>
<thead>
<tr>
<th>TwinPower</th>
<th>Turbo</th>
</tr>
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<tbody>
<tr>
<td><strong>Variability</strong></td>
<td><strong>Direct injection</strong></td>
</tr>
<tr>
<td>Vanos (variable valve timing)</td>
<td>High precision injection</td>
</tr>
<tr>
<td>Valvetronic (variable valve lift)</td>
<td>Next generation common rail</td>
</tr>
<tr>
<td>Variable Turbine Geometry</td>
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</tbody>
</table>
THE NEW BMW TWIN POWER TURBO 4 CYLINDER PETROL ENGINE – POWER AND TORQUE.

<table>
<thead>
<tr>
<th></th>
<th>kW</th>
<th></th>
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<tbody>
<tr>
<td>Power</td>
<td></td>
<td>180</td>
</tr>
<tr>
<td>@ Speed</td>
<td>rpm</td>
<td>5,000</td>
</tr>
<tr>
<td>Torque</td>
<td>Nm</td>
<td>350</td>
</tr>
<tr>
<td>@ Speed</td>
<td>rpm</td>
<td>1,250-4,800</td>
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<tr>
<td>max. Speed</td>
<td>rpm</td>
<td>7,000</td>
</tr>
<tr>
<td>spec. Power</td>
<td>kW/l</td>
<td>90</td>
</tr>
<tr>
<td>spec. Torque</td>
<td>Nm/l</td>
<td>175</td>
</tr>
</tbody>
</table>
THE NEW FOUR-CYLINDER PETROL ENGINE COMPARED TO THE IN-LINE SIX-CYLINDER PETROL ENGINE.
THE NEW FOUR-CYLINDER PETROL ENGINE COMPARED TO THE IN-LINE SIX-CYLINDER PETROL ENGINE.

| Output (kW/hp) | 180 / 245 | 190 / 258 | ▼ - 5 % |
| Torque (Nm)    | 350       | 310       | ▲ + 13 % |
| Acceleration 0-100 km/h (s) | 6.1       | 6.8       | ▼ - 0.7 seconds |
| Top speed (km/h) | 240       | 230       | ▲ + 4 % |
| Fuel consumption* (l/100 km) | 7.9       | 9.4       | ▼ - 16 % |
| CO₂ emissions (g/km) | 183       | 219       | ▼ - 16 % |
| Emission Control Level | EU5       | EU5       |        |

* Average fuel consumption in the EU test cycle.

BMW X1 xDrive28i (four-cylinder), BMW TwinPower Turbo technology, Petrol direct injection (High Precision Injection) VALVETRONIC, Double-VANOS
BMW X1 xDrive28i (six-cylinder), VALVETRONIC, Double-VANOS

BMW Group, Dr. Ing. Philip Koehn, November 4, 2011, Page 11
THE NEW BMW EFFICIENTDYNAMICS ENGINE FAMILY—INTERFACES BETWEEN THE ENGINE AND THE VEHICLE ARE OPTIMIZED OVER THE WHOLE PRODUCT RANGE.

Common parts shared between gasoline or diesel engines is approx. 60%.

Between the gasoline and diesel engines there is a 40% sharing.
THE NEW BMW EFFICIENTDYNAMICS ENGINE FAMILY - SCALABILITY OF BASIC DESIGN OF ENGINE FAMILY ALLOWS A BROADER APPLICATION ACROSS VEHICLE PROJECTS AND TECHNOLOGIES.
Customers are increasingly sensitive towards:

- climate change
- personal contribution to environmental pollution
- Increasing fuel prices
- emerging energy sources / carriers such as electricity & hydrogen
- sustainability as part of a modern lifestyle
BATTERY ELECTRIC VEHICLES AT THE BMW GROUP – BMW 1602er (1972).

Lead battery:
- weight: ca. 2,100kg
- volume: ca. 1,200l

Fuel:
- weight: ca. 30kg
- volume: ca. 40l
BMW GROUP’S ELECTRIC DRIVE TRAIN PORTFOLIO – INHOUSE DEVELOPMENT OF THE "KEY COMPONENTS".

High voltage battery  |  Power electronics  |  Electric engine
Potential for optimization

- Improvement of efficiency (battery costs, range)
- Wide range behaviour (reduction gearbox)
- Power density (volume)
- Noise (acoustic)
BMW ACTIVE HYBRID VEHICLES.

CURRENT PRODUCT RANGE:

X6 Active Hybrid
- Full (Two-Mode) Hybrid system
- Emission Standard ULEVII / EU5
- System Power: 485 hp, 0-60 mph: 5.6s
- Consumption: 9.9l/100km (28.5mpg) (-20% compared to base X6 xdrive 50i)

7 series Active Hybrid
- Mild Hybrid system
- Emission Standard ULEVII / EU5
- System Power: 465 hp, 0-60 mph: 4.9s
- Consumption 9.4l/100km (29.1mpg) (-15% compared to base 750li)
BMW CONCEPT 5 SERIES ACTIVE HYBRID.

Features:
- Future-oriented full hybrid system
- Battery technology: Li-Ion
- Auto Start Stop
- Brake Energy Regeneration
- Boost function
- All-electric zero-emission driving in city traffic
- Intelligent energy management

1 Electric motor
2 8-speed automatic transmission
3 High voltage electronics
4 High voltage battery
MINI E AND BMW ActiveE SERVE AS KEY LEARNING PROJECTS OF OUR MEGACITY VEHICLE.
THANK YOU.