SUSTAINABLE TECHNOLOGIES –
THE CHANGING FACE OF MOBILITY.

PHILIP KOEHN
VICE PRESIDENT VEHICLE ARCHITECTURES AND CONCEPTS

BMW GROUP
CHANGING ENVIRONMENT FOR INDIVIDUAL MOBILITY. THE KEY DRIVERS.

Environment
- 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 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.
- Electric water pump
- Decoupled A/C compressor.
- Low rolling resistance tyres.
- Brake Energy Regeneration.
- Highly efficient 8-speed automatic transmission.
BMW EFFICIENTDYNAMICS – BMW GROUP FLEET CO₂ EMISSIONS SO FAR HAVE BEEN REDUCED BY MORE THAN 30% (1997-2010) IN EUROPE.

* EU fleet emissions (g CO₂/km)*

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.

### TwinPower
- Variability
  - Vanos (variable valve timing)
  - Valvetronic (variable valve lift)
  - Variable Turbine Geometry
- Direct injection
  - High precision injection
  - Next generation common rail

### Turbo
- Turbo charging
  - Single turbo
  - Twinscroll turbo
  - Twin turbo
THE NEW BMW TWIN POWER TURBO 4 CYLINDER PETROL ENGINE – POWER AND TORQUE.

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Unit</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Power</td>
<td>kW</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>
</tr>
<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.

<table>
<thead>
<tr>
<th></th>
<th>BMW X1 xDrive28i (four-cylinder)</th>
<th>BMW X1 xDrive28i (six-cylinder)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Output (kW/hp)</td>
<td>180 / 245 (-5%)</td>
<td>190 / 258</td>
</tr>
<tr>
<td>Torque (Nm)</td>
<td>350 (13%)</td>
<td>310</td>
</tr>
<tr>
<td>Acceleration 0-100 km/h (s)</td>
<td>6.1</td>
<td>6.8 (-0.7 seconds)</td>
</tr>
<tr>
<td>Top speed (km/h)</td>
<td>240 (4%)</td>
<td>230</td>
</tr>
<tr>
<td>Fuel consumption* (l/100 km)</td>
<td>7.9</td>
<td>9.4 (-16%)</td>
</tr>
<tr>
<td>CO₂ emissions (g/km)</td>
<td>183 (-16%)</td>
<td>219</td>
</tr>
<tr>
<td>Emission Control Level</td>
<td>EU5</td>
<td>EU5</td>
</tr>
</tbody>
</table>

* Average fuel consumption in the EU test cycle.

- BMWX1 xDrive28i (four-cylinder), BMW TwinPower Turbo technology, Petrol direct injection (High Precision Injection) VALVETRONIC, Double-VANOS
- BMWX1 xDrive28i (six-cylinder), VALVETRONIC, Double-VANOS
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.
CHANGE OF VALUES. CUSTOMER PREFERENCES ARE CHANGING.

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)
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

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MINI E AND BMW ActiveE SERVE AS KEY LEARNING PROJECTS OF OUR MEGACITY VEHICLE.


MINI E 2010

BMW ActiveE 2011

Megacity Vehicle – BMW i3 2013

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THANK YOU.