BMW Diesel - Engine Concepts for Efficient Dynamics

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BMW Group
BMW Diesel.

Contents.

- Evolution of Diesel Performance
- Diesel Motivation
- Efficient Dynamics
- US Market Introduction
- Future Trends
- Summary
BMW Diesel.
Evolution of Diesel Performance.

- **1983**: 1st BMW 6Cyl. Inline Diesel - 524td fastest diesel vehicle in its segment
- **1987**: First Digital Diesel Electronics (DDE)
- **1990**: First BMW Diesel with Oxy-Cat.
- **1998**: Introduction of DI Technology at BMW Diesels - BMW 320d wins “24 Hours of Nürburgring”
- **1999**: First V8 Diesel Sedan in Premium Segment offered by BMW
- **2001**: 2nd Gen. Common Rail (1600 bar)
- **2004**: Variable Twin Turbo - Diesel Particulate Filter of 2nd Gen.
- **2007**: 3rd generation Common Rail (2000 bar) - Piezo injectors

**BMW 535d**

- Torque: + 170%
- Power: + 147%
- Consumption: - 20%
- Emissions: - 99%
BMW Diesel.

Evolution of Diesel Performance.

Year of Production

- **1st Generation**: 262,000
- **2nd Generation**: 635,000
- **3rd Generation until End 2006**: 2,821,000

BMW Market Share Europe

- **5 Series**: 80%
- **7 Series**: 73%
- **X5**: 93%
- **Mini**: 67%
BMW Diesel.

Diesel Motivation.

- Souvereign Performance
- Pleasant Acoustics
- Low Fuel Consumption
- High Range
**BMW Diesel.**

**Diesel Motivation.**

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**Diagram Description:**

- **Diesel vs. comparable Gasoline Vehicle:** "Acceleration at 4th Gear"
- **Max. Load Diesel Engine**
- **Max. Load Gasoline Engine**
- **Available Power for acceleration Gasoline Vehicle**
- **Available Power for Acceleration Diesel Vehicle**
- **Power for const. Speed**

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**Graph Axes:**

- **Vehicle Speed [mph]**
  - 35, 60, 85, 110
- **Engine Power**

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**Key Points:**

- **Available Power for Diesel Vehicle**
  - Increases with speed up to 85 mph
- **Available Power for Gasoline Vehicle**
  - Peaks at 4th gear and decreases

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**Caption:**

The graph illustrates the comparison between Diesel and Gasoline vehicles in terms of available power for acceleration. The Diesel vehicle shows a higher power output compared to the Gasoline counterpart, especially at lower speeds. The chart highlights the optimal power delivery for both types of engines, specifically focusing on acceleration at 4th gear.
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Diesel Motivation.

- **5series Sedan 3.0l Diesel**
- **Comparable Gasoline Vehicle**
  (Automatic Transmissions)

<table>
<thead>
<tr>
<th></th>
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<th></th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Fuel Consumption</strong></td>
<td>20%</td>
<td>26%</td>
<td>32%</td>
<td>35%</td>
</tr>
</tbody>
</table>

Source: Test Reports

"Vehicle Dynamic"
Average noise inside vehicle at 30 mph - BMW 5series

- Diesel: -7.5 dB
- Petrol: -5 dB

2 dB variation

BMW Diesel engines.

Diesel Motivation.
BMW Diesel.

Efficient Dynamics.

- Increased Power
- Efficient Dynamics
- Reduced Weight
- Low Fuel Consumption and Emissions
BMW Diesel.

Efficient Dynamics.

- Increased Power
- Reduced Weight
- Low Fuel Consumption and Emissions

Efficient Dynamics
BMW Diesel.
Variable Twin Turbo.
BMW Diesel.
Variable Twin Turbo.
### BMW Diesel.

#### Variable Twin Turbo.

<table>
<thead>
<tr>
<th>Engine Speed [rpm]</th>
<th>Effective Mean Pressure [bar]</th>
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<tbody>
<tr>
<td>1000</td>
<td>10</td>
</tr>
<tr>
<td>2000</td>
<td>14</td>
</tr>
<tr>
<td>3000</td>
<td>22</td>
</tr>
<tr>
<td>4000</td>
<td>26</td>
</tr>
</tbody>
</table>

- **VNT + Mech. Compressor**
- **Variable Twin Turbo**
- **VNT**
- **EAT / E-Boost**
BMW Diesel.
Variable Twin Turbo.

- Large T/C → pre-charging
- Small T/C → post-charging
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Variable Twin Turbo.
BMW Diesel.
Variable Twin Turbo.

Large T/C
→ main charger

Small T/C
→ standby
BMW Diesel.
Variable Twin Turbo.
BMW Diesel.

Variable Twin Turbo.

- **Variable Twin Turbo 3.0l**
  - 280 hp at 4200 rpm
  - 430 ft lbf at 1750 rpm

- **Single Turbo Engine 3.0l**
  - 230 hp at 4000 rpm
  - 380 ft lbf at 2000 rpm
Cylinder Displacement: 499 cm³
Bore / Stroke: 84 / 90 mm
Max. Combustion Pressure: 180 bar
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Piezo Common-Rail System.

- Very quick Needle Opening and Closing for Effective Combustion
- Up to 5 Shots per Combustion Stroke
- Very low Tolerances for Injection Quantities
- Long term Learn Algorithm for Injection Control
- High Pressure Pump with Feed Volume Control
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Efficient Dynamics.

Increased Power
Efficient Dynamics
Reduced Weight
Low Fuel Consumption and Emissions
BMW Diesel.
Aluminium Crankcase.

<table>
<thead>
<tr>
<th>Engine Power [ hp ]</th>
<th>Aluminium</th>
<th>3.0l 6-Cylinder</th>
</tr>
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<tbody>
<tr>
<td>175</td>
<td>300</td>
<td>80</td>
</tr>
<tr>
<td>200</td>
<td>250</td>
<td>70</td>
</tr>
<tr>
<td>225</td>
<td>225</td>
<td>60</td>
</tr>
<tr>
<td>250</td>
<td>225</td>
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<tr>
<td>275</td>
<td>225</td>
<td>40</td>
</tr>
<tr>
<td>300</td>
<td>225</td>
<td>30</td>
</tr>
</tbody>
</table>

Weight [ kg ]

- Aluminium: 175 kg
- Cast Iron: 200 kg
- Cast Iron "optimized": 225 kg
- Aluminium: 250 kg
- Cast Iron: 275 kg
- Aluminium: 300 kg

3.0l 6-Cylinder
BMW Diesel.
Aluminium Crankcase.

- Vertical armed „Deep Skirt“
- Formed Threads
- Deep Screw Linking
- Diagonal Crankcase Stiffening
- Cooling Duct between Cylinder Walls
- Thermal fitted Cast Iron (GG) Liners
- Embossed and shape-forced Bearing Caps („Sintermaterial“)
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Specific Engine Weight.
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Efficient Dynamics.

Increased Power

Reduced Weight

Low Fuel Consumption and Emissions
BMW Diesel.
Engine Efficiency.
BMW Diesel.

CO₂ Emissions.

Diesel

Gasoline

Vehicle Curb Weight

Source: VDA

-25%
BMW Diesel.

Fuel Consumption.

Available 8-Cyl. Concept

“Downsizing“

+40%

6 Cyl. VTT (535d)
BMW Diesel.
Exceeding even today’s Hybrid Concepts.

* Source: An increasing number of press test reports
BMW Diesel.

Emissions.

- Tier 1 LDT3
- Tier 2 Bin 10 (till MY 08)
- Tier 2 Bin 5 (MY 09)

**Emission Standards:**
- Tier 1 LDT3: 0.60 g/mi
- Tier 2 Bin 10: 0.08 g/mi
- Tier 2 Bin 5: 0.05 g/mi

**Species:**
- PM (Particulate Matter)
- NMHC (Non-Methane Hydrocarbons)
- NOx
- CO

**Catalytic Systems:**
- DPF (Diesel Particulate Filter)
- DOC (Diesel Oxidation Catalyst)
- SCR (Selective Catalytic Reduction)
BMW Diesel.
Exhaust System Bin 5.
BMW Diesel.
Particulate Filter.

- Particulates are being filtered and frequently burned
- Permanent Reduction of Particulates
- Additional positive Effect on HC-/CO-Emissions
- No Loss in Engine Power
- No Increase in Fuel Consumption
- No Maintenance necessary
BMW Diesel.

SCR System.

- High Efficiency
- Good Long Term Stability
- No Increase in Fuel Consumption
- Maintenance (Urea Refill) together with Oil Service

Source: Bosch
BMW Diesel.

EGR System.

- Further NOx Reduction 30%
- Reduced Charge Air Temperature
- Higher Boost Pressure and better Turbocharger Efficiency
- Improved Fuel Economy

Low pressure EGR

High pressure EGR

EGR...Exhaust Gas Recirculation System
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US Market Introduction.

**X5 xDrive 35d**
- 265 hp, 425 ft lbf
- Emission Standard LEVII / Bin5
- 0-60 mph = 6.9 s
- Fuel Efficiency
  - City ≥ 25 mpg (Test Figures)
  - Hwy ≥ 36 mpg
  - USC ≥ 29 mpg

**335d**
- 265 hp, 425 ft lbf
- Emission Standard LEVII / Bin5
- 0-60 mph = 6.0 s
- Fuel Efficiency
  - City ≥ 30 mpg (Test Figures)
  - Hwy ≥ 48 mpg
  - USC ≥ 36 mpg
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US Market Introduction.

6 Cyl. Inline 3.0l Diesel Engine

SCR System

Close Coupled Catalyst and Particulate Filter

2-Stage-Turbo-System („Variable Twin Turbo“)

Piezo Common Rail System

Aluminium Crankcase
Increased specific Power and Torque (>100 hp/dm³)
- 2-stage Turbocharging: NG Variable Twin Turbo – Technology
- Common-Rail Injection System: Pressure >2000 bar
- Improved Combustion

Further improved Fuel Consumption (>15%)
- Reduced Engine Friction
- Optimized Combustion
- Downsizing
- Advanced Energy Management: „Hybrid Functions“
- Optimized Powertrain: Transmission

Reduced Engine Weight (>5 %)
- Downsizing
- Compact Design with high Integration Level
- Light Weight Materials
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Summary.

- Evolution of Diesel Performance is impressive
- Good Reasons for a high Diesel Motivation exist
- “Efficient Dynamics”-Philosophy is fundamental for all our Engine Concepts
- BMW’s US Market Introduction starts with X5 xDrive 35d and 335d, both featuring a 6 Cyl. 3.0l Variable Twin Turbo Engine
- Modern Diesel Technology can contribute a lot to guarantee Future Mobility
- Medium- and long-term Potentials to further increase Power and in parallel reduce Emissions und Fuel Consumption exist
BMW Diesel.
Thank you for your Attention.