

# Recent Developments in BMW's Diesel Technology

DEER Conference 2003 – Newport, USA

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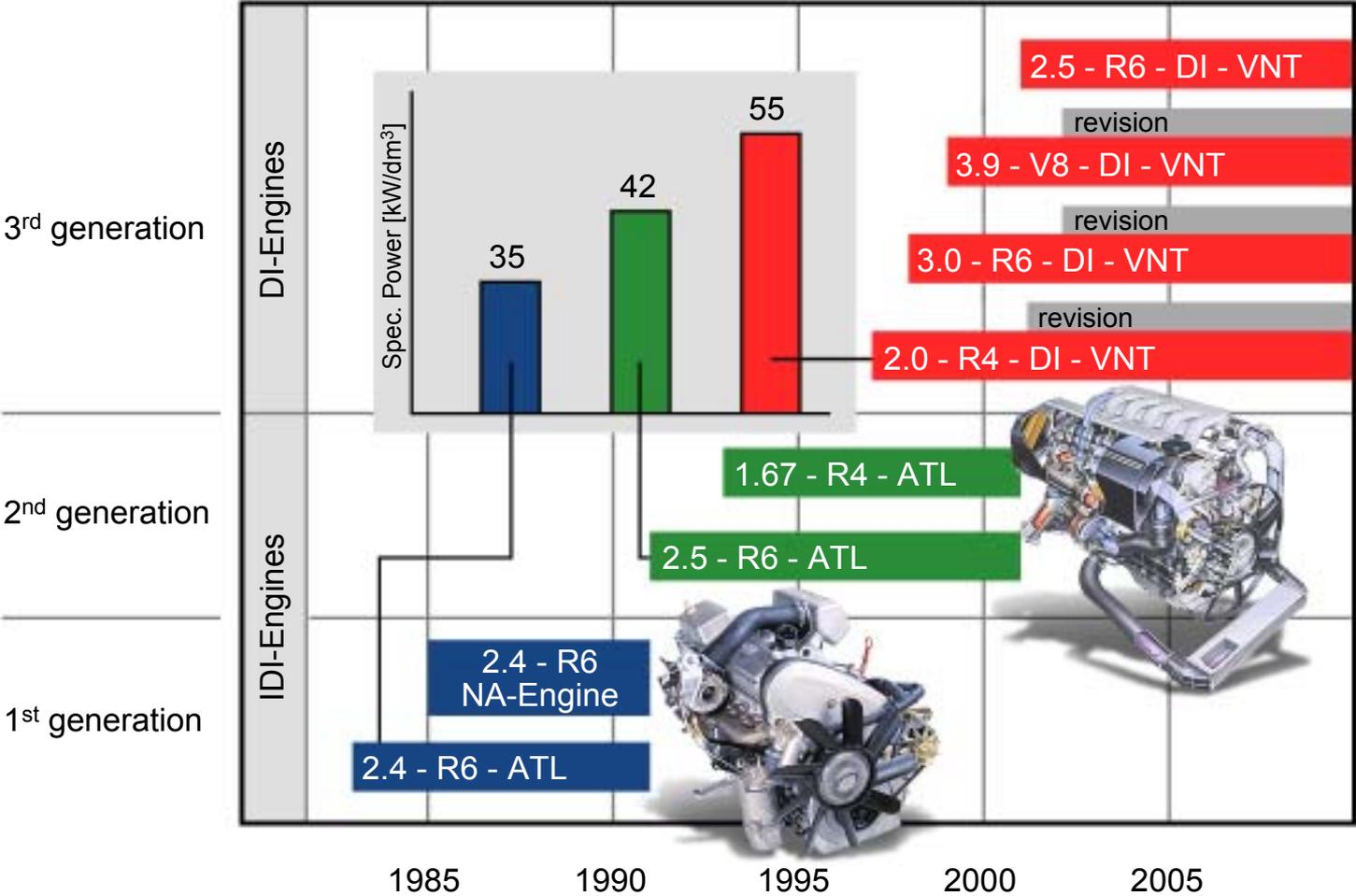


**BMW Group**



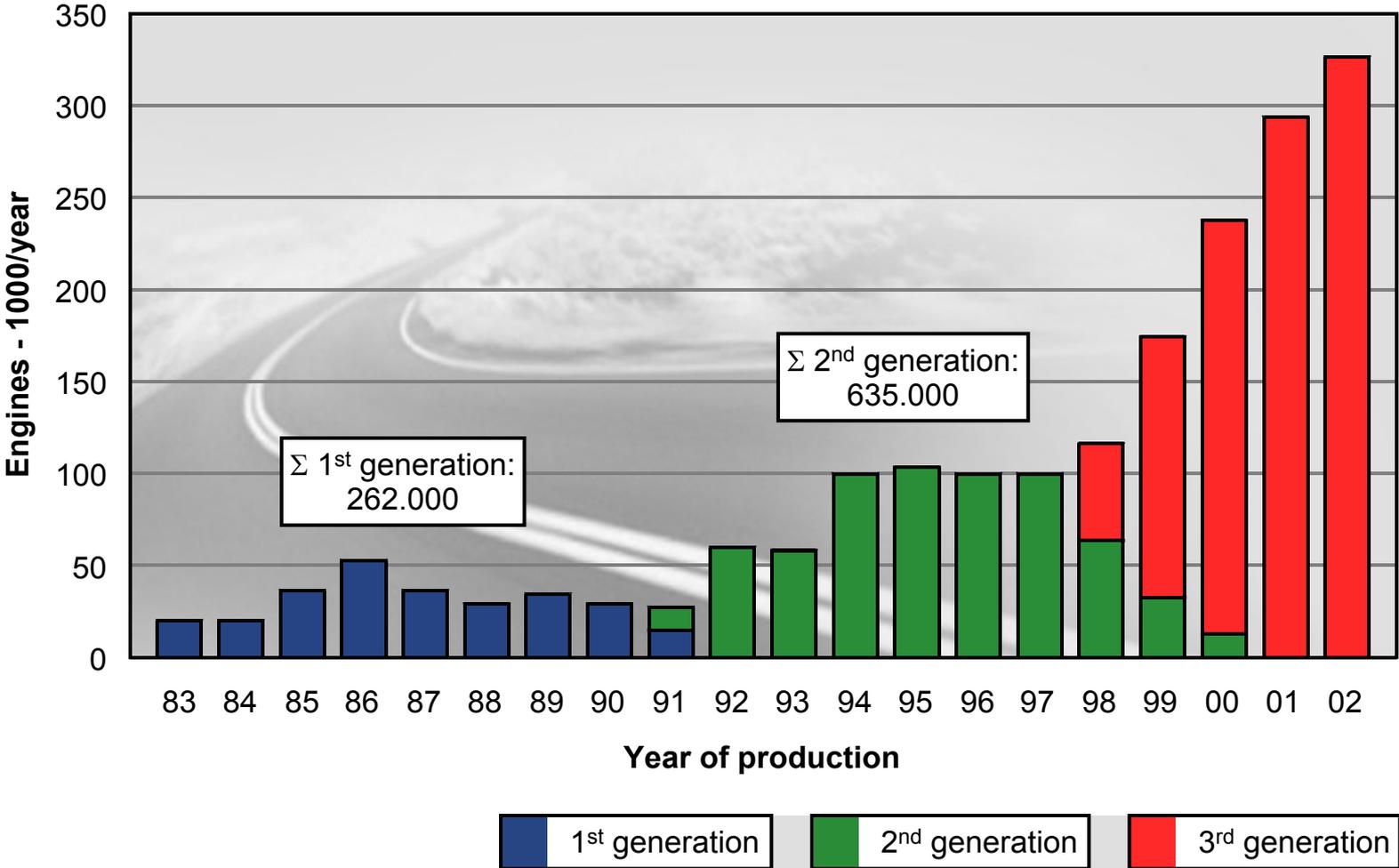
# Recent Developments in BMW's Diesel Technology

## BMW Diesel History



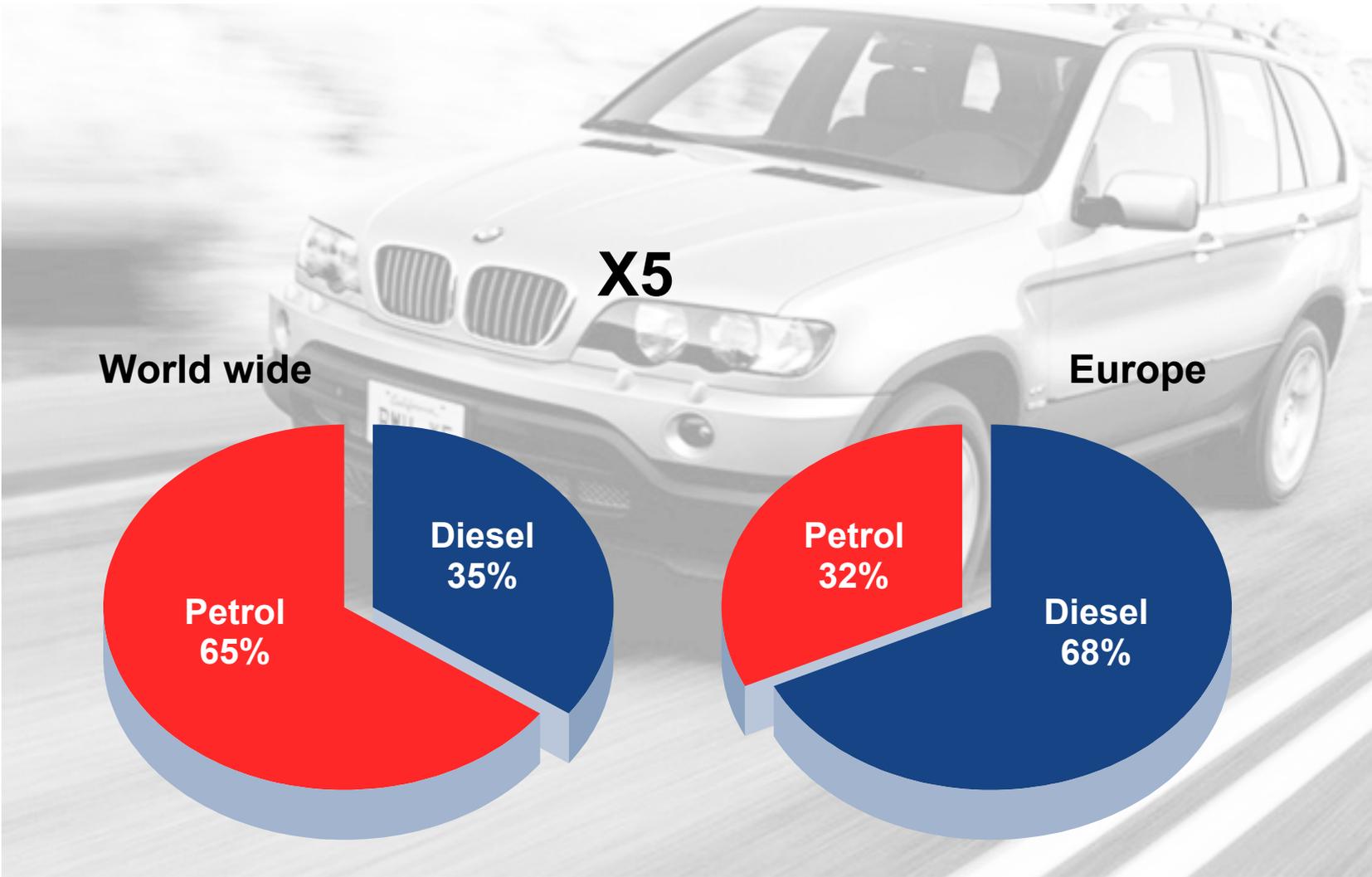
# Recent Developments in BMW's Diesel Technology

## BMW Diesel Production



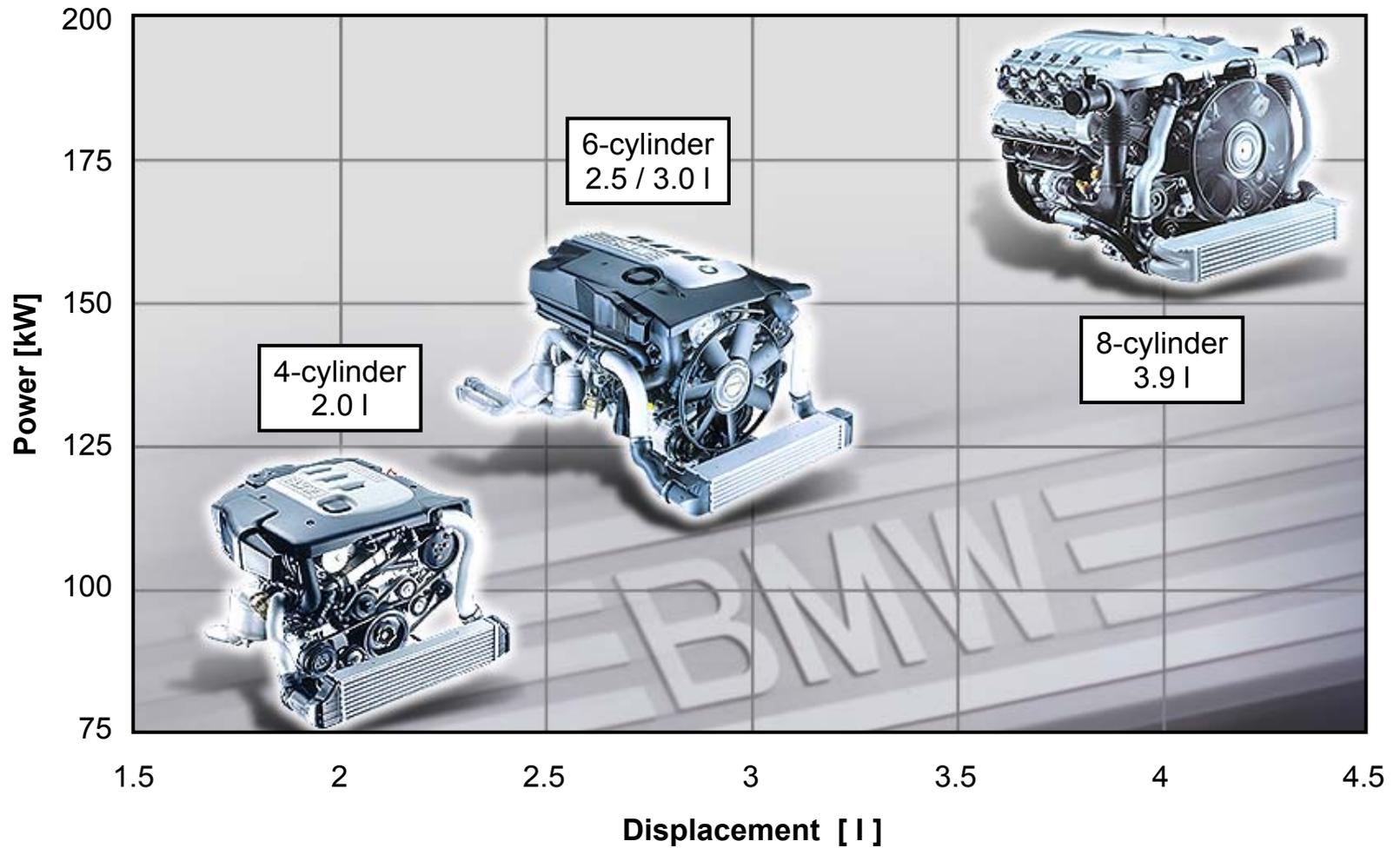
# Recent Developments in BMW's Diesel Technology

BMW Market Share 04/2003



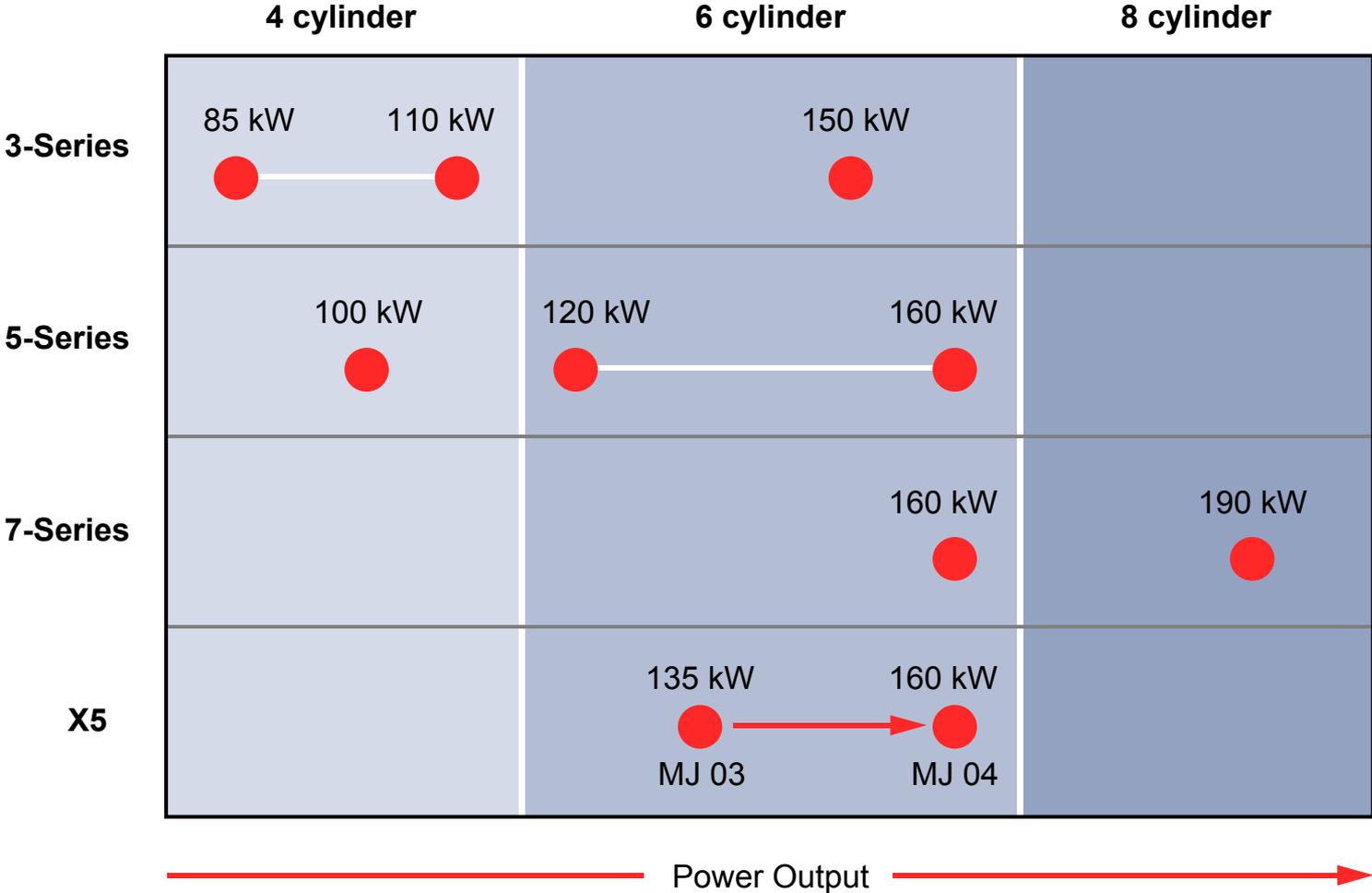
# Recent Developments in BMW's Diesel Technology

## BMW Diesel Engine Family



# Recent Developments in BMW's Diesel Technology

## BMW Diesel Product Range



# Recent Developments in BMW's Diesel Technology

## Key Technologies

### Core engine

- Durability for cylinder pressures up to 180 bar
- High thermal resistance
- Low friction

### Injection system

- High hydraulic performance
- Sophisticated application strategy

### Combustion concept

- Combustion chamber layout
- Port design for efficient swirl generation

### Air management

- VNT-Turbochargers
- Optimised intake / exhaust system with intercooling

**BMW Diesel-Development**

**Outstanding performance  
Low consumption and emissions**

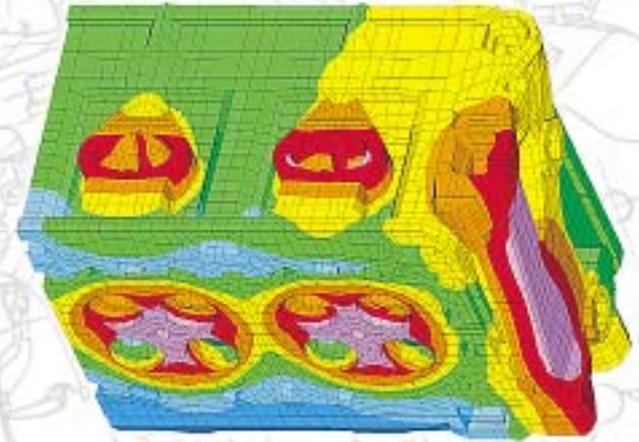


# Recent Developments in BMW's Diesel Technology

## Core Engine Design

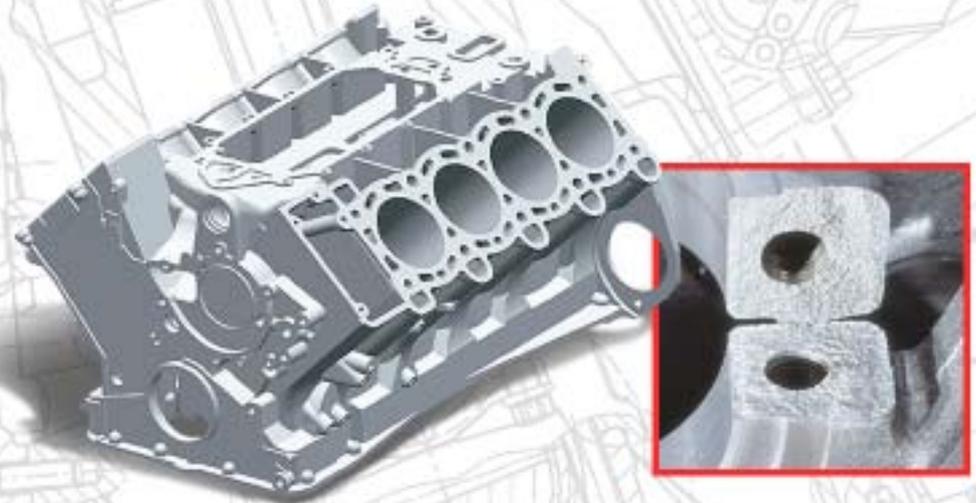
### Cylinder head

- Aluminium alloy with specific thermal treatment
- Design based on sophisticated simulation methods
  - Mould filling
  - Residual stress simulation
  - Strength and fatigue analysis



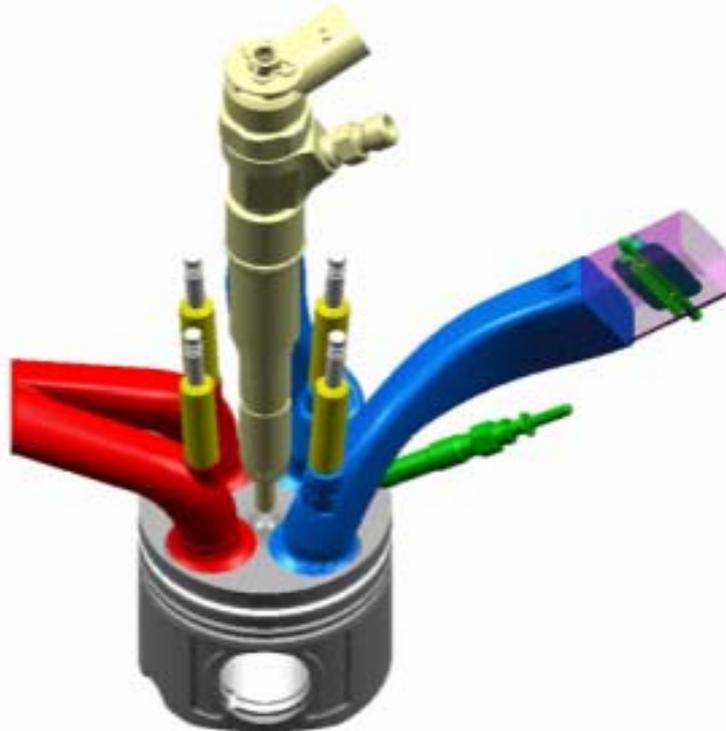
### Crank case

- Material GGV-500
- Cracked main bearing walls
- Two main bearing bolts



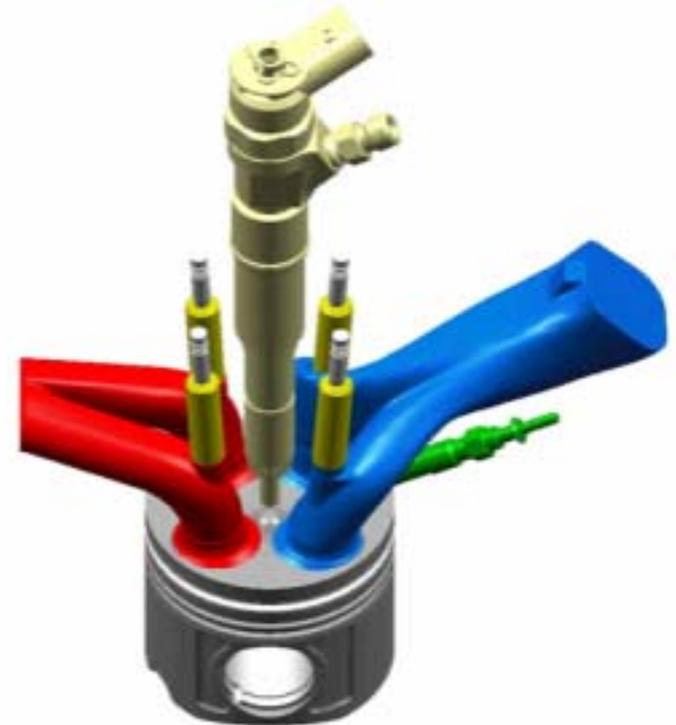
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## Combustion Chamber and Port Design



### 6-Cylinder Engine

- Swirl port from the top
- Tangential port with swirl flap from the side

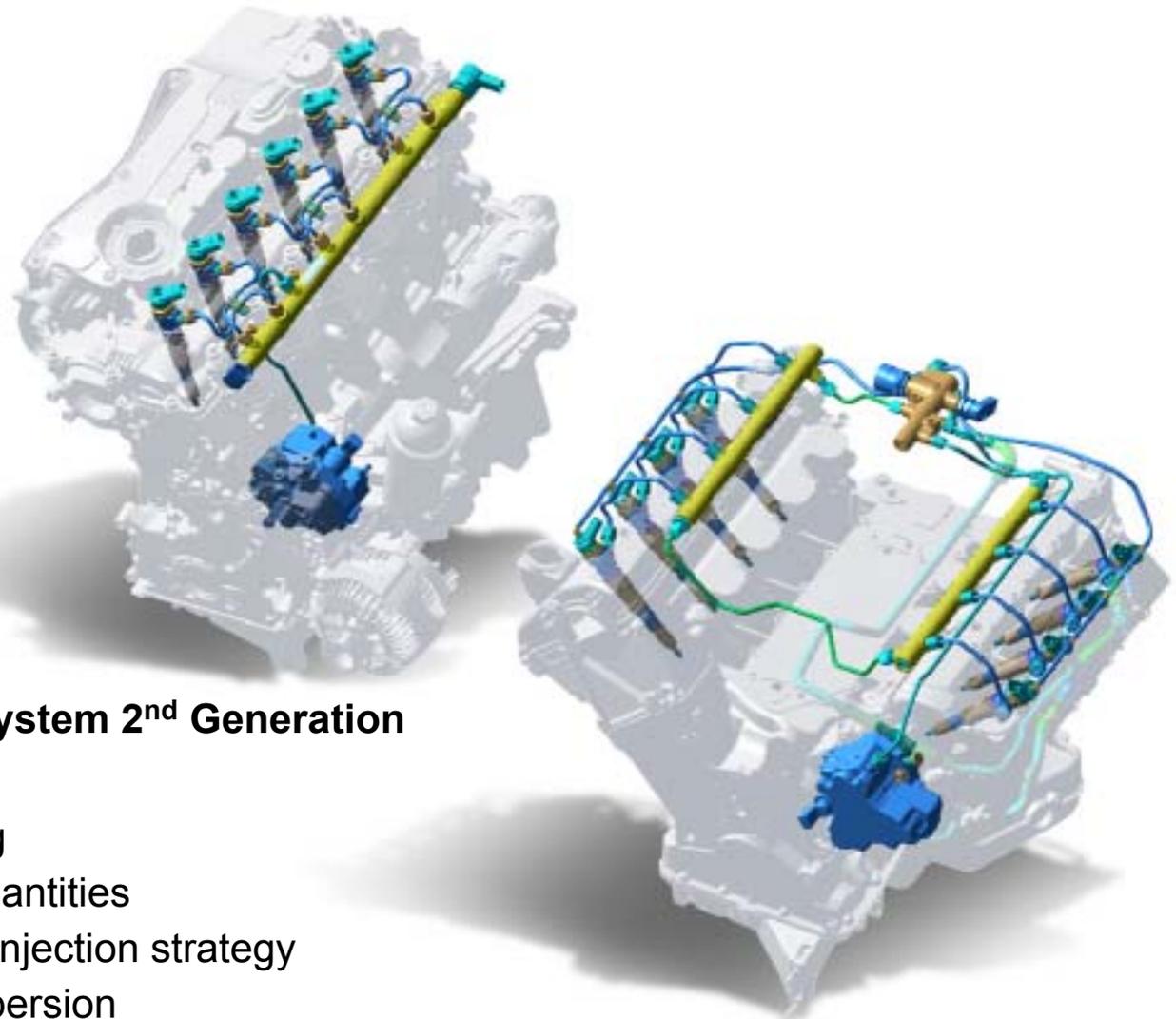


### 8-Cylinder Engine

- Inlet ports coming from one side

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## Fuel Injection System

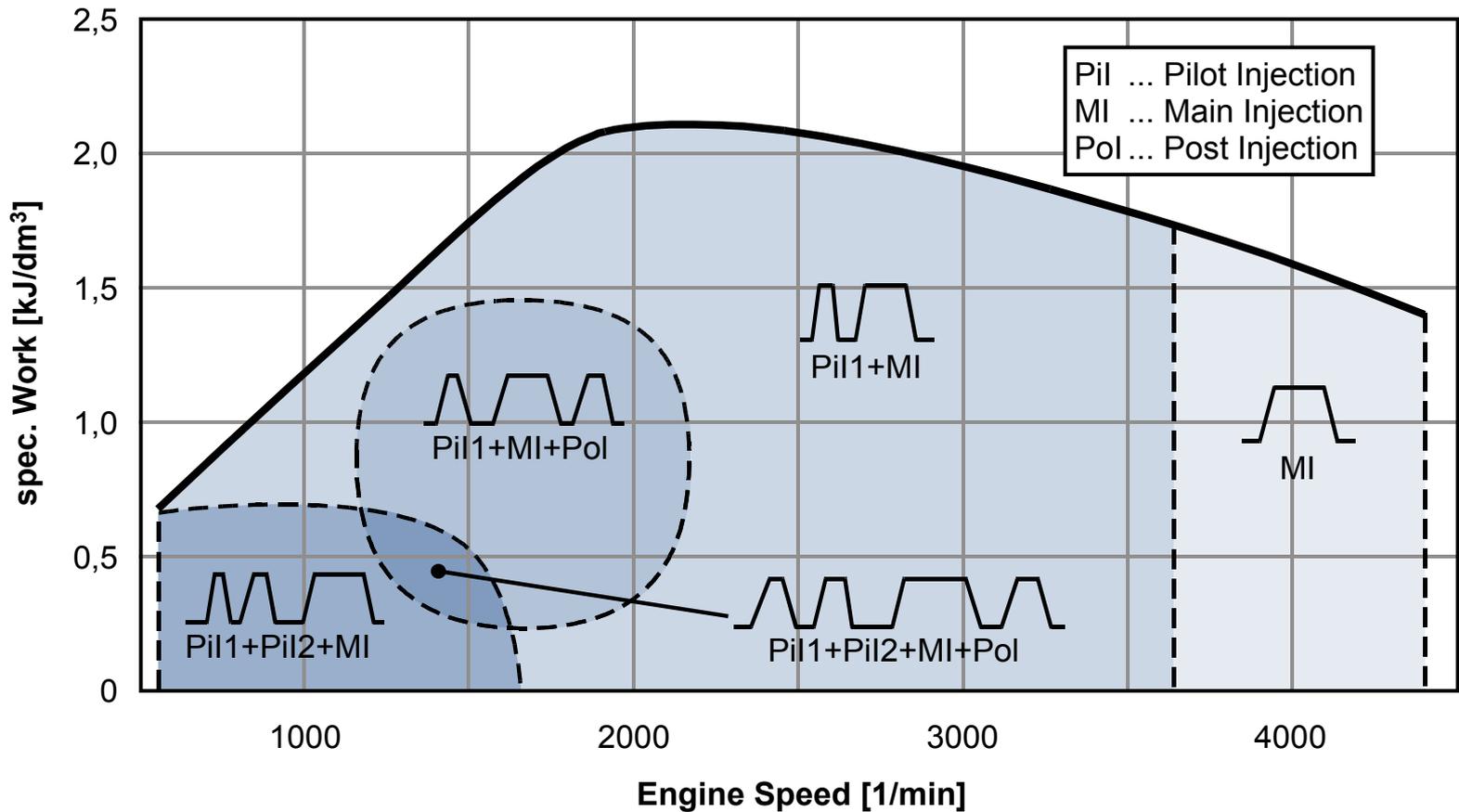


### Common rail system 2<sup>nd</sup> Generation

- 1600 bar
- Fuel metering
- Small pilot quantities
- High flexible injection strategy
- Reduced dispersion

# Recent Developments in BMW's Diesel Technology

## Injection Strategy



# Recent Developments in BMW's Diesel Technology

## Characteristics Diesel Electronic Control Units

				<b>730d 740d</b>	
<b>Start of Production</b>		<b>1989</b>	<b>1993</b>	<b>1998</b>	<b>2002</b>
ECU-Type		DDE1	DDE2	DDE4	DDE5
Data Length	bit	8	16	16	32
Computer Performance	MIPS	<1	1	4	40
Number of Transistors	Mio	<1	<1	<1	7
Memory	kByte	33	64	256	1000
Number Labels for Calibration		500	1500	4500	7800*
Number of ECU - Pins		55	55	121	154

\* With Master / Slave ECU's: 15600 Labels for Calibration

# Recent Developments in BMW's Diesel Technology

## Spontaneous Glow System



- Pre Glow Phase < 3 sec
- Reduction Power Consumption
- ECU Mounted to the Engine

Previous Engine  
12V Glow Plug

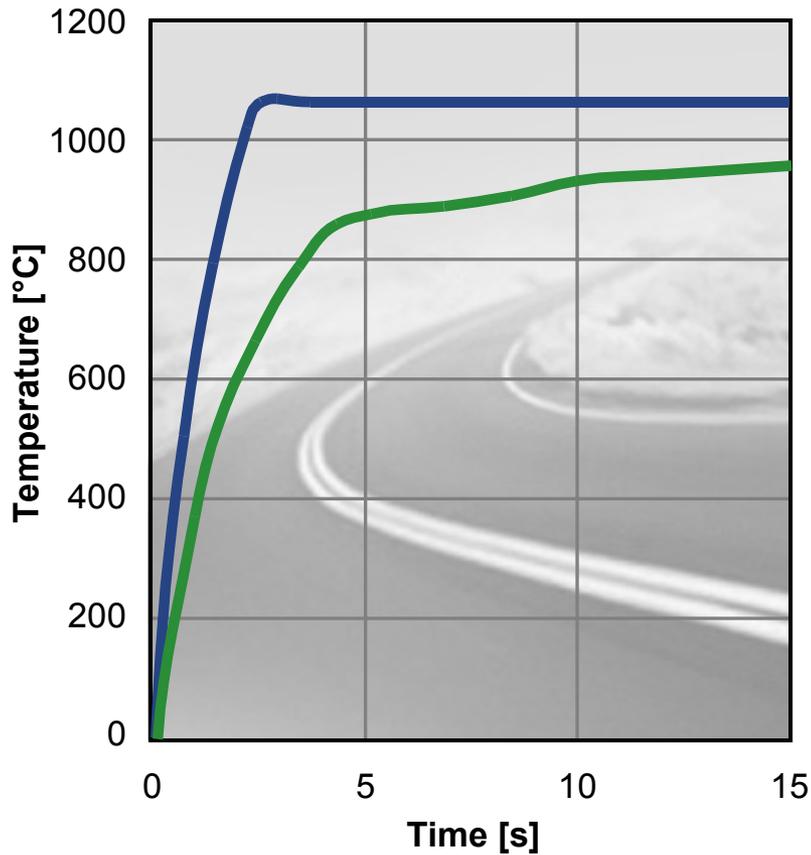


New Engine  
6V Glow Plug

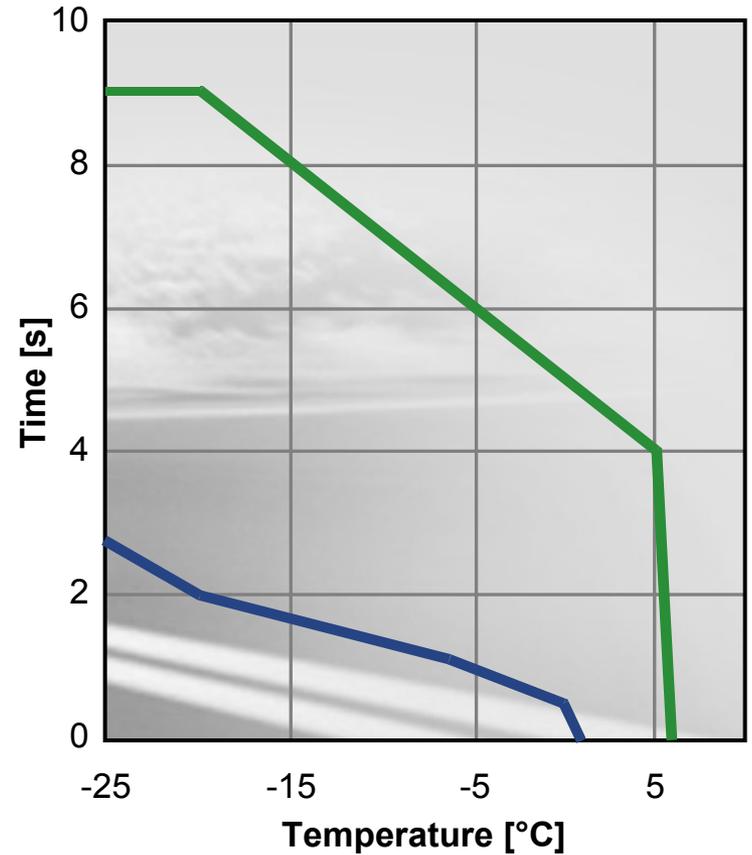
# Recent Developments in BMW's Diesel Technology

## Spontaneous Glow System

### Temperature Glow Plugs



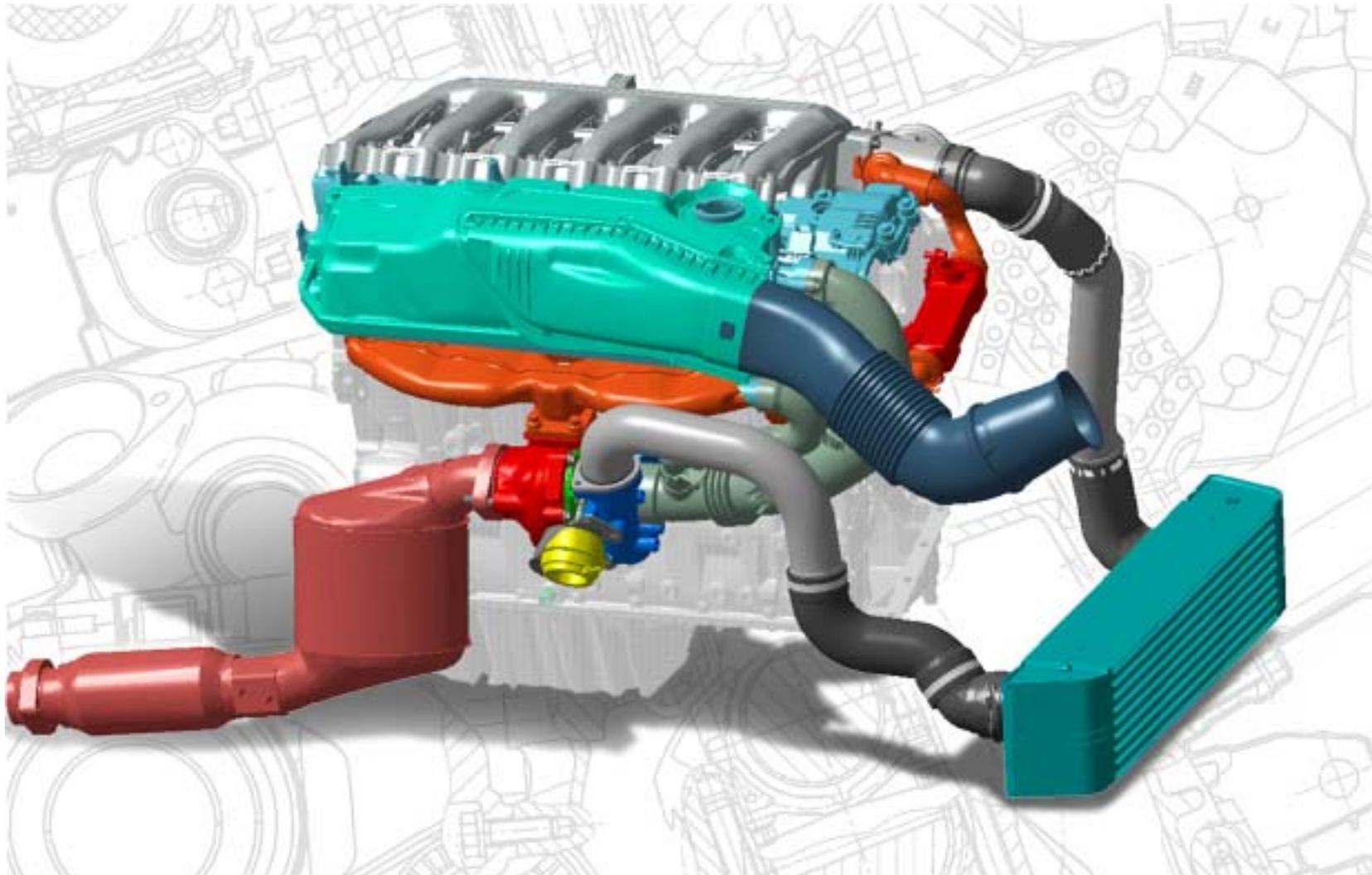
### Pre Glow Time



**New Engine**      **Previous Engine**

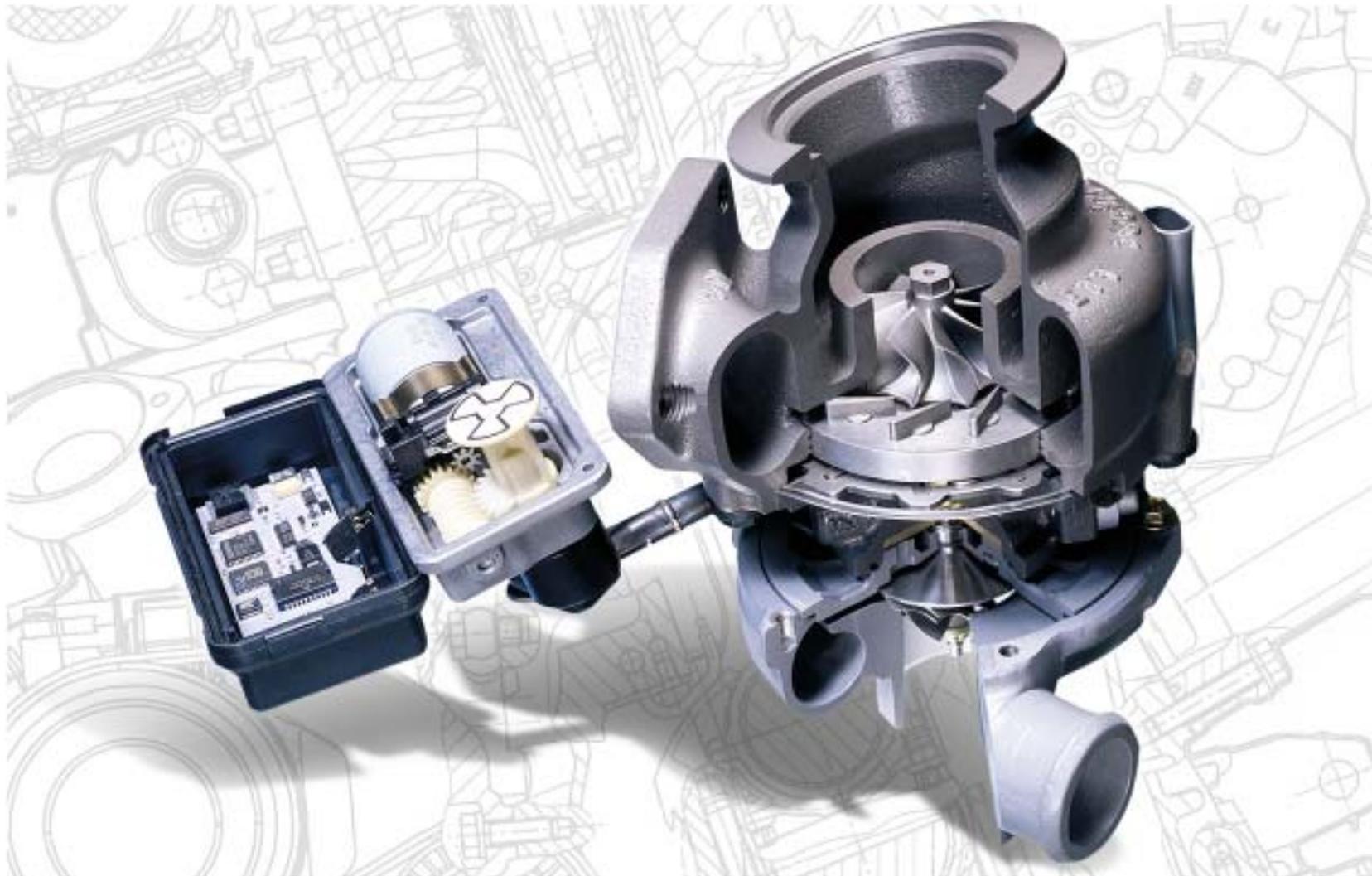
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## Air Management



# Recent Developments in BMW's Diesel Technology

## Air Management



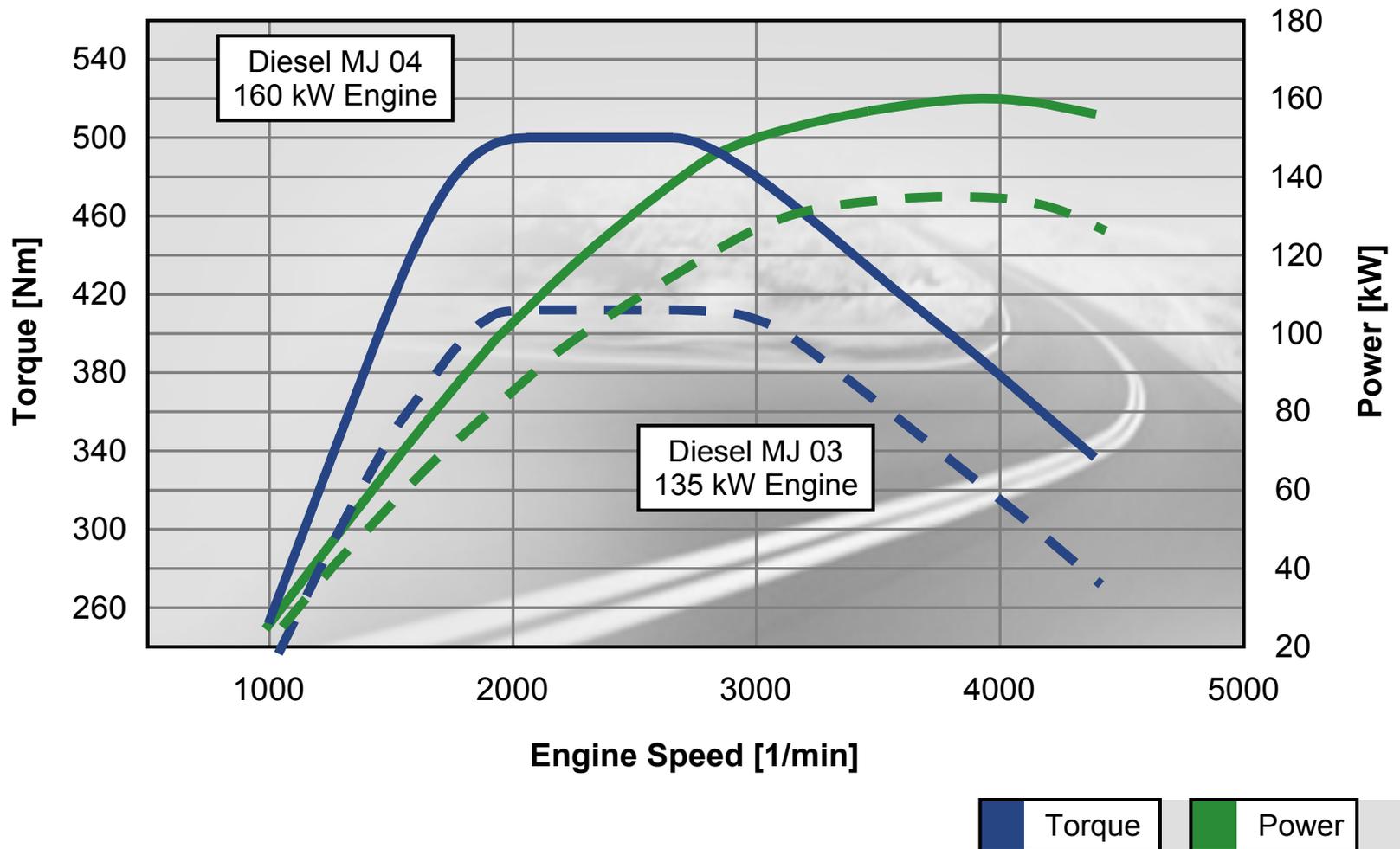
# Recent Developments in BMW's Diesel Technology

## Improvements DI 1<sup>st</sup> to 2<sup>nd</sup> Generation

		1 <sup>st</sup> gen.	2 <sup>nd</sup> gen.
<b>Base Engine:</b>	Cylinder pressure                      bar	160	180
	Compression Ratio	18:1	17:1
<b>Injection System:</b>	Rail pressure                              bar	1350	1600
	Number of Injection	3	4
	Min. Pilot quantity                      mm <sup>3</sup> /cyc	1.6	1.0
	Fuel metering	without	with
<b>Turbocharging:</b>	Max. Boost pressure                      bar	2.1	2.3
	Pressure ratio	2.48	2.72
	Max. Turbine Eff.                              %	64	70
	Max. Compressor Eff.                      %	59	63

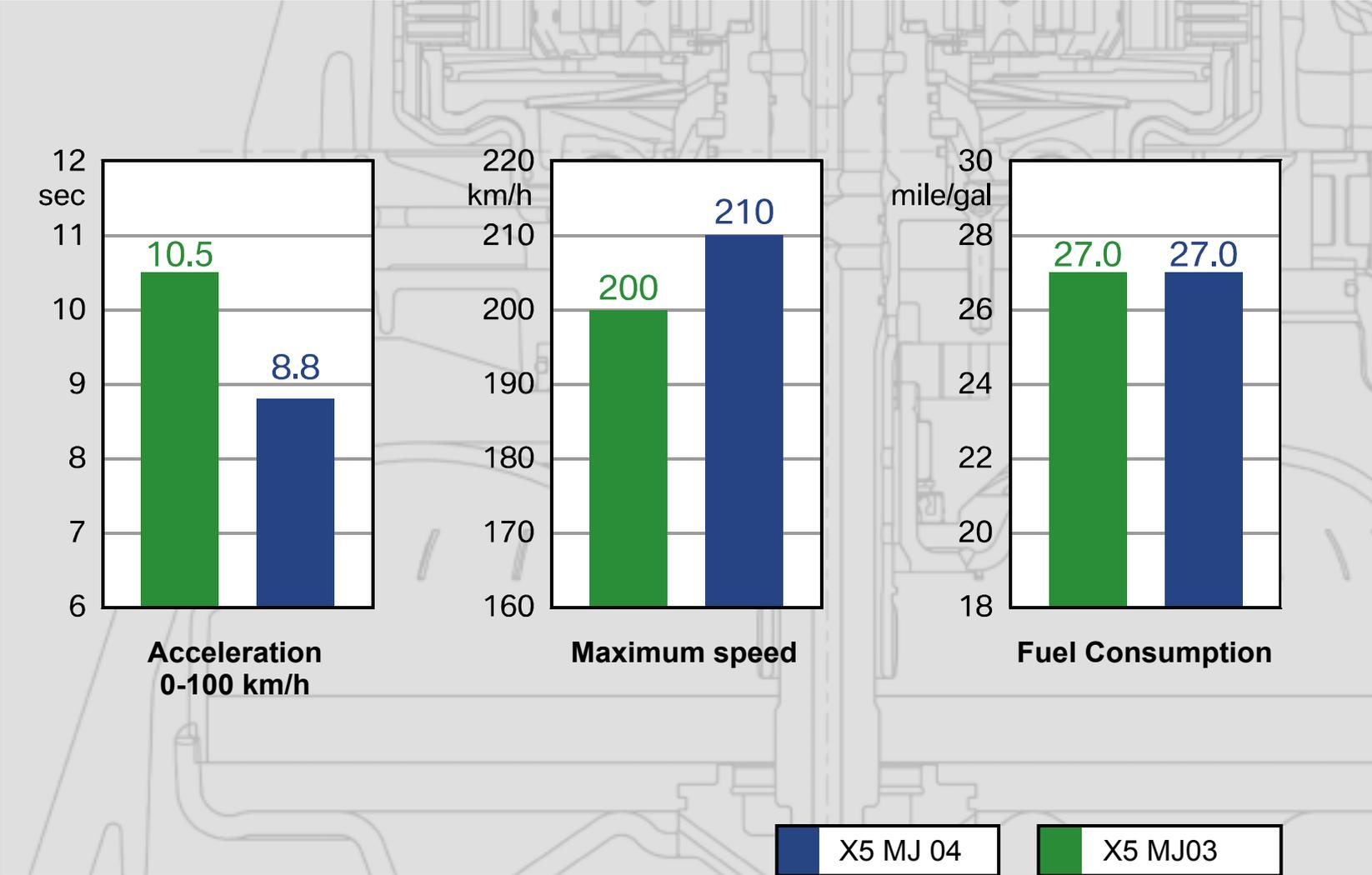
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## Engine Performance 6-Cylinder in X5



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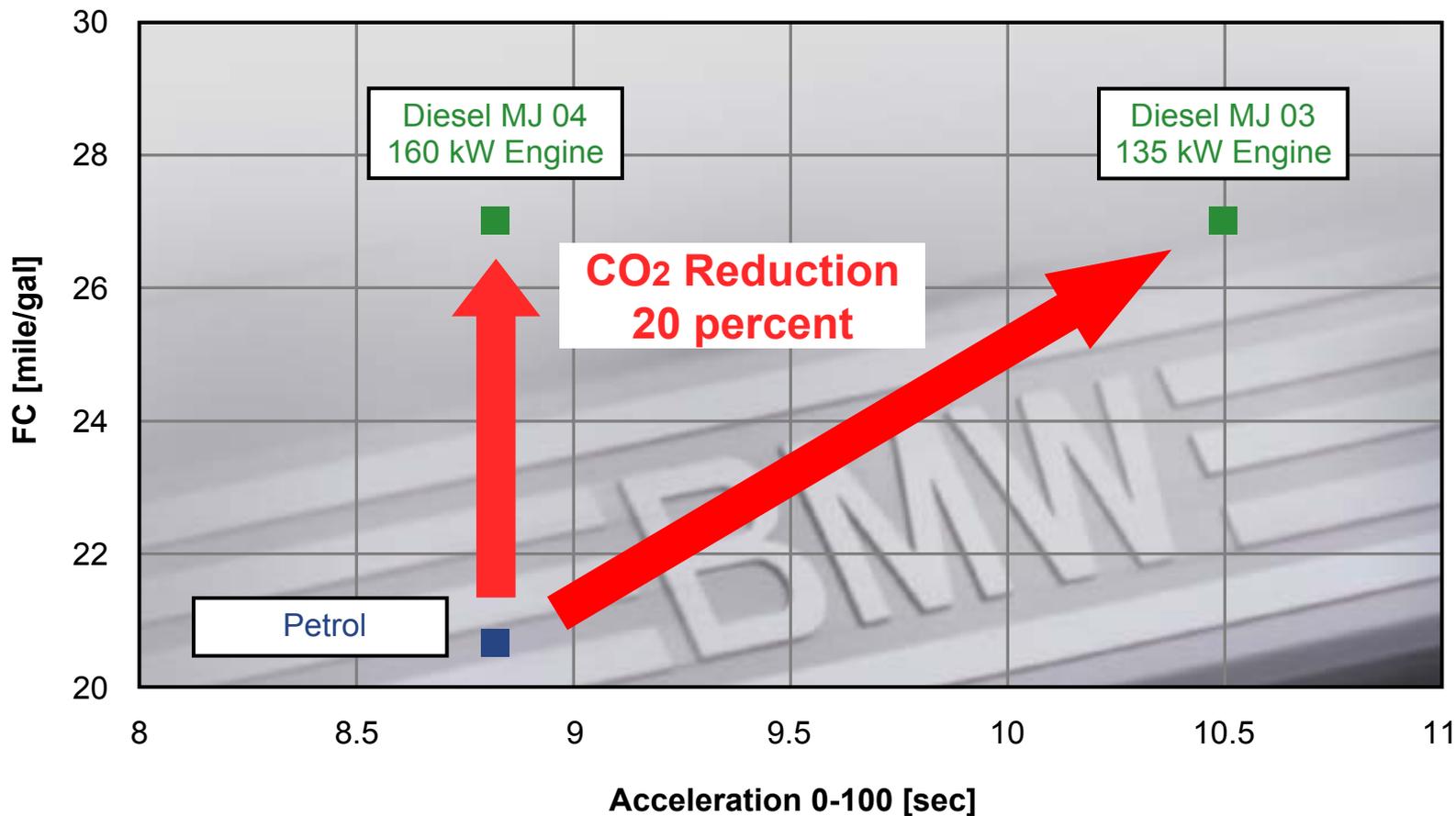
## Performance / Fuel Consumption - X5 AT



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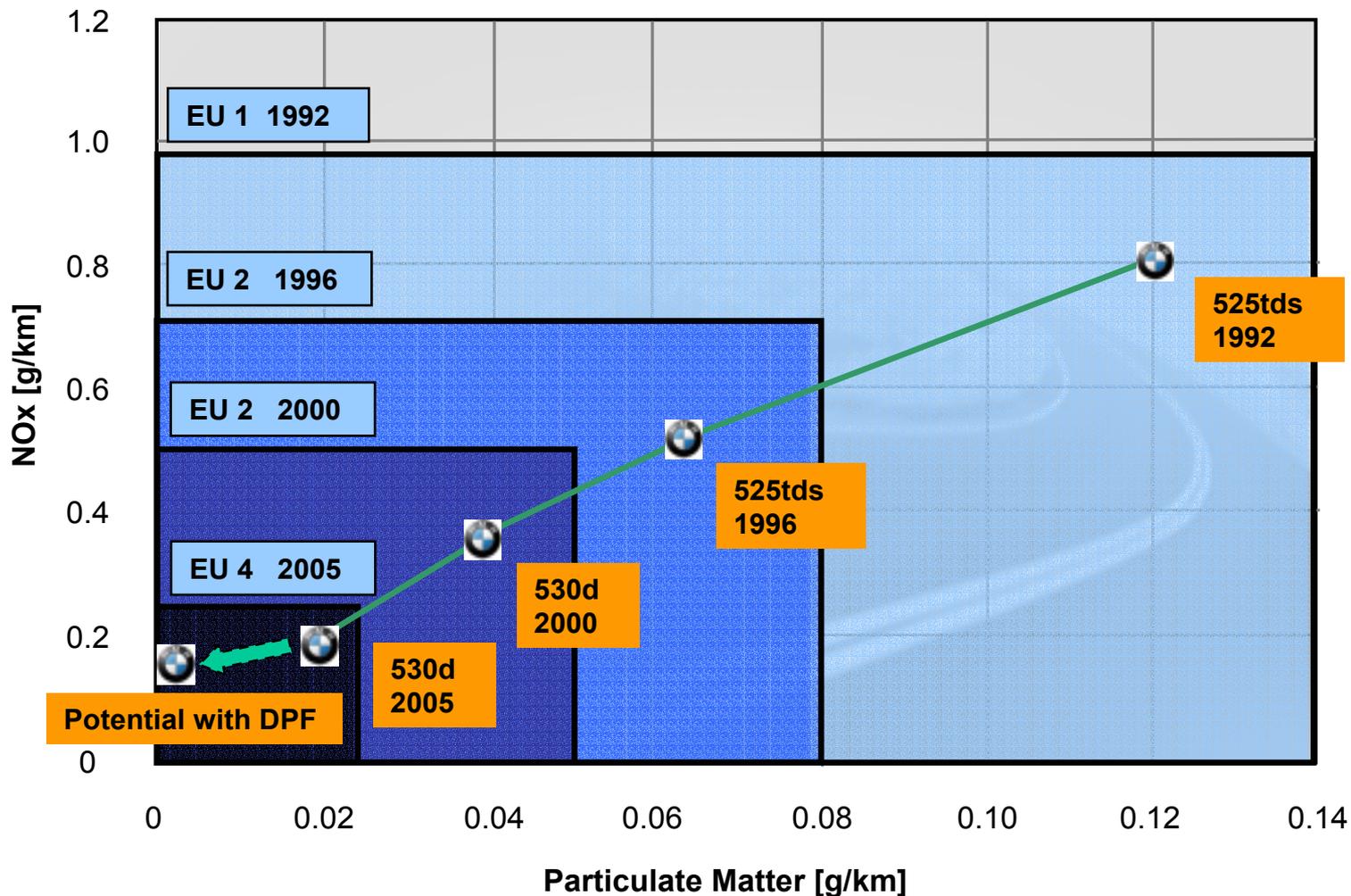
## Fuel Consumption in X5 AT – Comparison Diesel / Petrol

### X5 with 3.0 6-cylinder engines



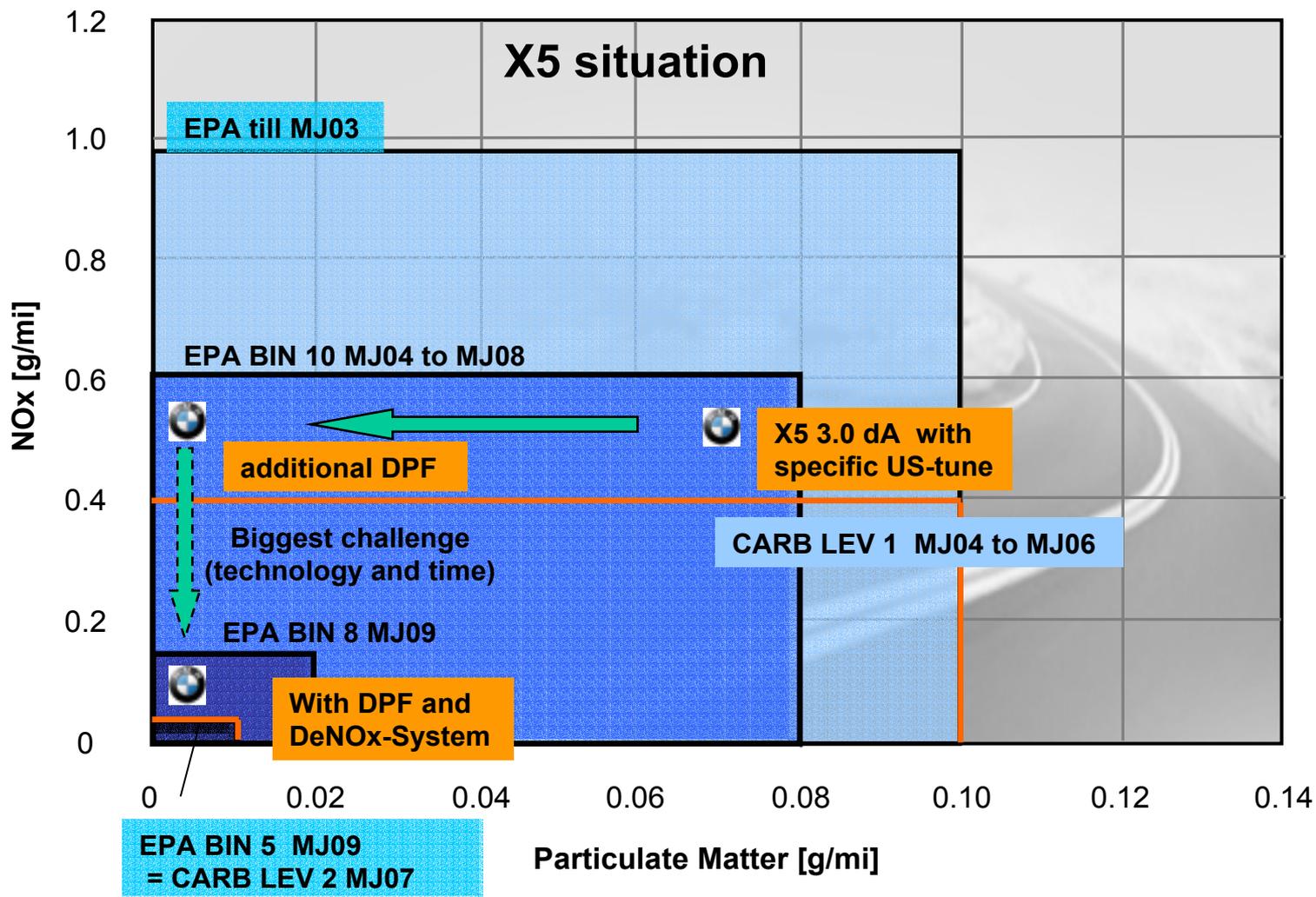
# Recent Developments in BMW's Diesel Technology

## NOx- and PM-Reduction for BMW 5 Series Diesel cars



# Recent Developments in BMW's Diesel Technology

## Emission Legislation in USA



# Recent Developments in BMW's Diesel Technology

## Conclusion

**Diesel engines could play a major role in saving crude oil and reducing CO<sub>2</sub>-emissions in USA too**

- **Modern BMW Diesel technology offers powerful, clean and economic engines for the new decade**
- **Improved combustion systems combined with filter technologies can virtually remove PM-emissions**
- **The 2007 US NO<sub>x</sub>-limits are the biggest challenge**
  - Technology for highly efficient NO<sub>x</sub>-aftertreatment
  - Time scale for 2007 very demanding
- **The introduction of diesels with durable and enabling emission control technologies should be supported by:**
  - Better fuel quality similar to ECE 2005+
  - Slightly legislation adaptations to take account of the specific diesel advantages (long term emission stability, CO<sub>2</sub>)

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