

The Past – Present – Future of Clean Diesel



Association of Diesel Specialists

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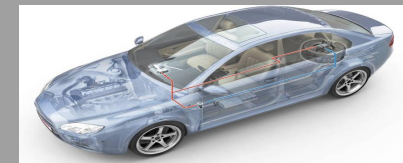
Clean Diesel in North America

The PAST

The PRESENT



The FUTURE



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The PAST-PRESENT-FUTURE of Clean Diesel

The first Diesel Engine, Paris World Exhibit
 Rudolf Diesel: "The use of vegetable oils for engine fuels might seem insignificant today, but such oils may become, in course of time, as important as the petroleum and coal tar products of the present"

First Trip in the US by a diesel-powered car (Packard Sedan with Cummins Engine) Indianapolis to New York 800 miles for a total cost of \$ 1.38

Oil Crisis 1970's

GM introduces as first North American OEM Diesel to the market accounting in 1981 for 10% of GM's overall vehicle sales
 By mid 1980's more than 100 different diesel models to choose from. For OEM's like Mercedes and Peugeot the sales of diesels accounted for up to 85% and Bosch introduced electronics to the fuel system

Bosch revolutionizes the diesel industry by introducing a Common Rail System from 1997 to 2007 for diesels - accelerated 50%, resulting in more than 50 million Systems sold by January 2009
 Mandated Ultra Low Sulfur Diesel in CA and phase in on National Level in 2006

The New CLEAN Diesel in CA - DIESEL no longer a dirty Word -
 Green Car of the Year 2 years in a row

Timeline of milestones:

- 1897**: The first Diesel Engine, Paris World Exhibit
- 1912**: Rudolf Diesel: "The use of vegetable oils for engine fuels might seem insignificant today, but such oils may become, in course of time, as important as the petroleum and coal tar products of the present"
- 1930**: First Trip in the US by a diesel-powered car (Packard Sedan with Cummins Engine) Indianapolis to New York 800 miles for a total cost of \$ 1.38
- 1970**: Oil Crisis 1970's
- 1980**: GM introduces as first North American OEM Diesel to the market accounting in 1981 for 10% of GM's overall vehicle sales
- 1990**: By mid 1980's more than 100 different diesel models to choose from. For OEM's like Mercedes and Peugeot the sales of diesels accounted for up to 85% and Bosch introduced electronics to the fuel system
- 2000**: Bosch revolutionizes the diesel industry by introducing a Common Rail System from 1997 to 2007 for diesels - accelerated 50%, resulting in more than 50 million Systems sold by January 2009
- 2006**: Mandated Ultra Low Sulfur Diesel in CA and phase in on National Level in 2006
- 2008**: The New CLEAN Diesel in CA - DIESEL no longer a dirty Word -
- 2009/10**: Green Car of the Year 2 years in a row

Milestones of Diesels in the US – LD/PC market

1977



Mercedes-Benz first turbocharged Diesel passenger car. In the late 70's nearly 80% of Mercedes sold in the US were diesels.

1978



GM introduces diesel engines into the market- a 5.7L V8 or 4.3L V6 made their way into many GM passenger cars.

1985



After ~1.0 million passenger car sales, numerous engine failures, and a class action lawsuit, the Diesel option for passenger cars is abandoned.

1989



The Dodge Ram with a 5.9L Cummins turbocharged engine increases diesel performance and leads the way to today's Diesel dominance in this market segment.

2004 - 2007



In 2008 the first Diesel vehicles were certified as EPA Tier 2 Bin 5, also meeting the world's most stringent LEV2 California emission regulation.

Recent Diesel Technology achievements

1998



For the first time a diesel car wins the 24-hour race at the Nürburgring. It is a BMW 320d with the distributor pump from Bosch.

2006



The diesel era at the Le Mans 24hrs race begins. The Audi R10 TDI with a V12 diesel engine and Bosch injection technology wins the race. Further victories follow in 2007, 2008 and 2010.

2011



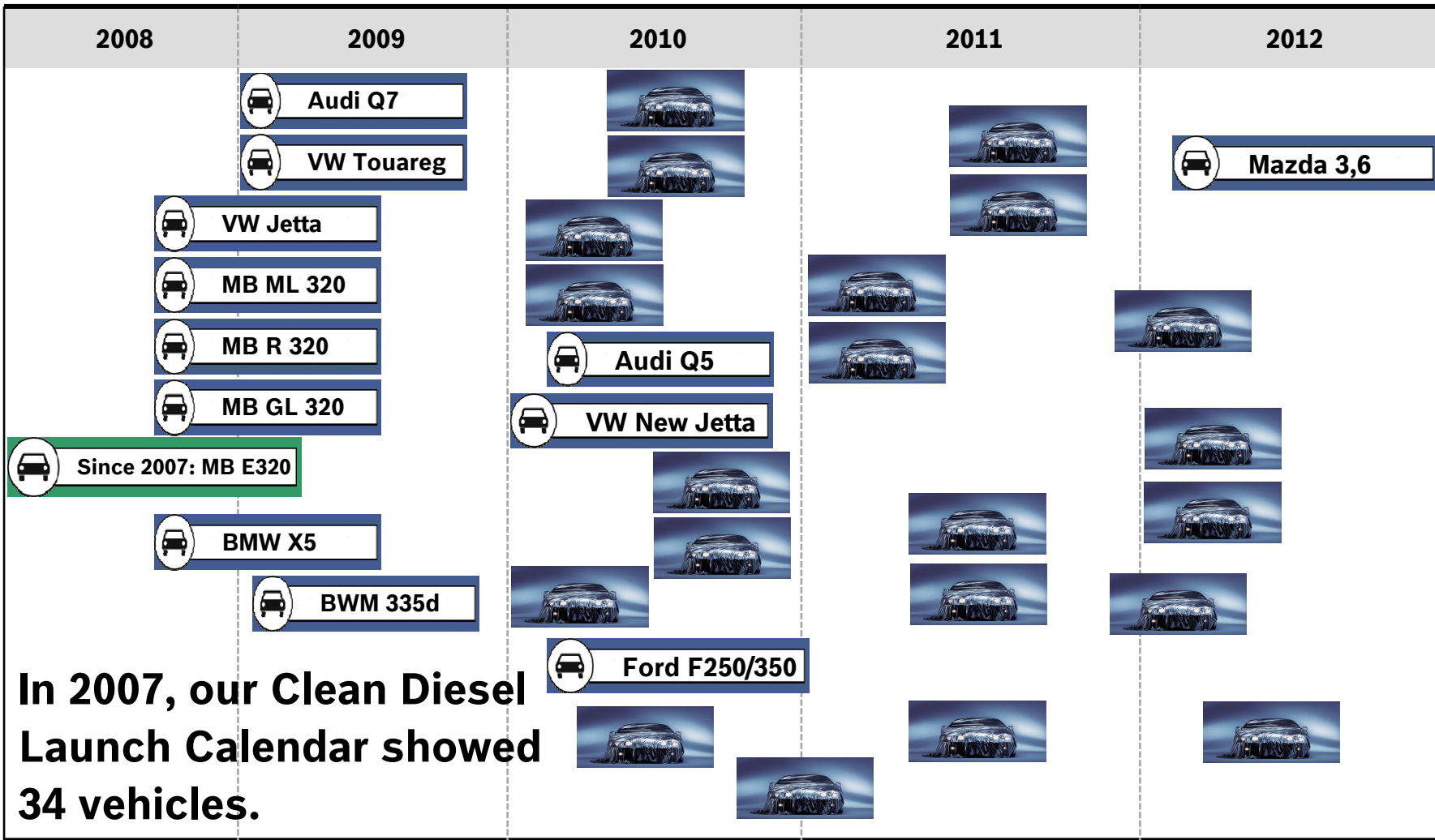
In collaboration with Bosch, Peugeot introduces the first diesel hybrid. The 3008 Hybrid4 has a 163 hp 2.0L Diesel engine driving the front wheels and a 37 hp electric motor powering the rear wheels. Average fuel consumption is est. over 60 mpg.

July 16th, 2011



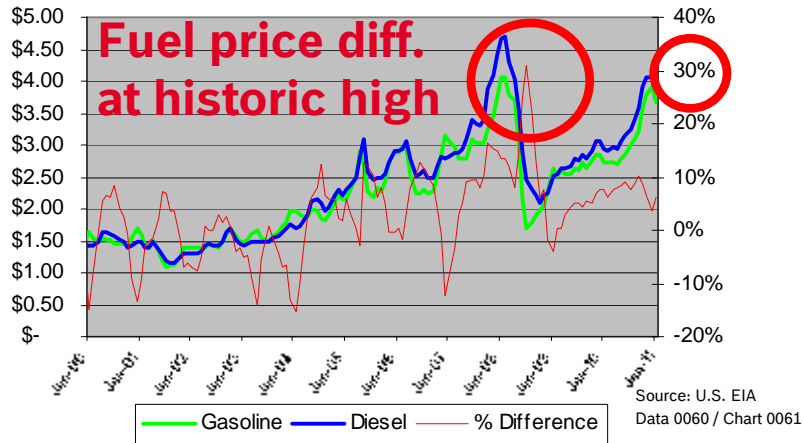
TDI Panamericana to commemorate the 75th anniversary of the Pan-American Highway the VW Touareg TDI Clean Diesel set a new world record time of 11d-17h-22m from Argentina to Alaska.

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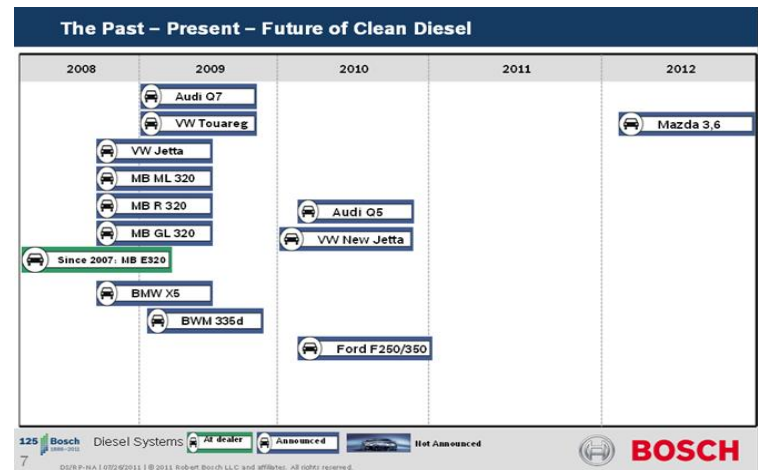
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What Happened in 2008?



Uncertainty regarding future California emission legislation LEV3 (avoid distraction from electrification).

➔ Financial crisis forced OEMs to cancel many development projects.



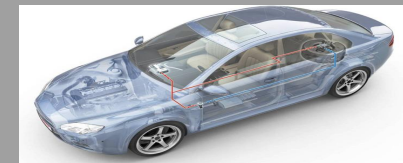
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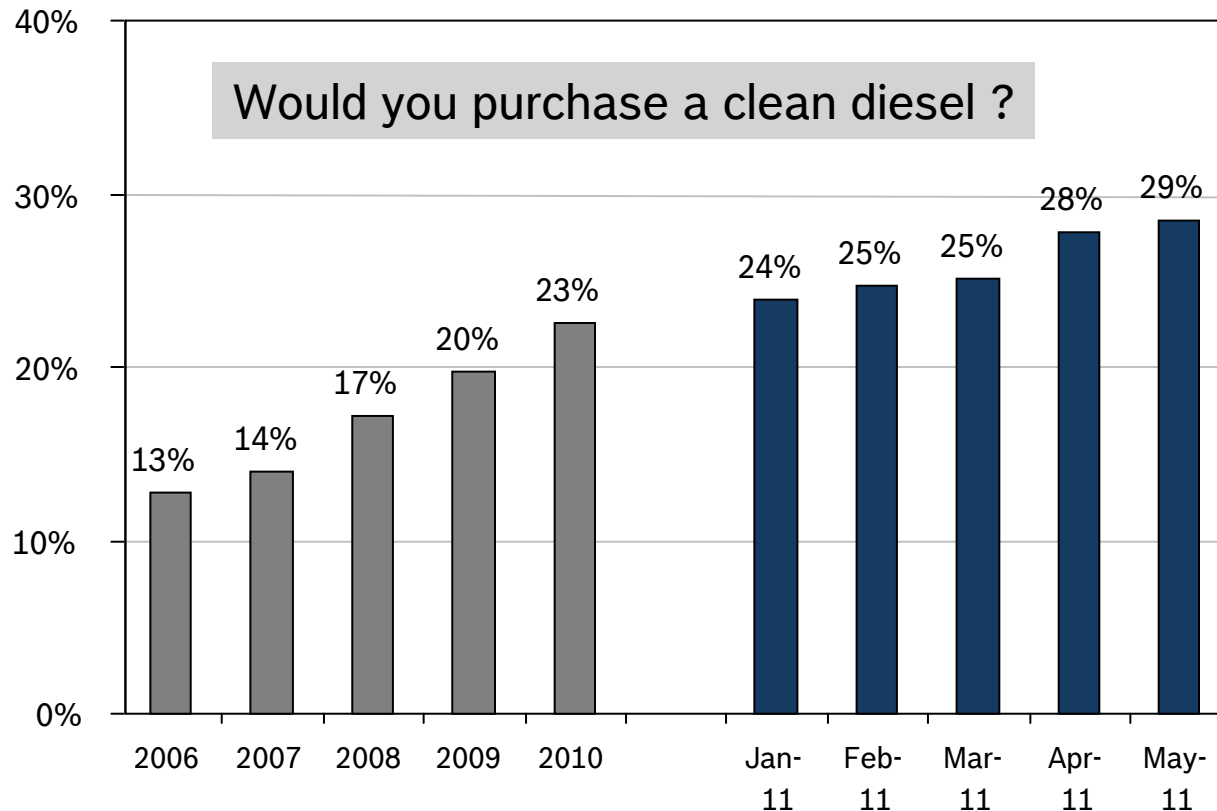
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Consumer Consideration Index



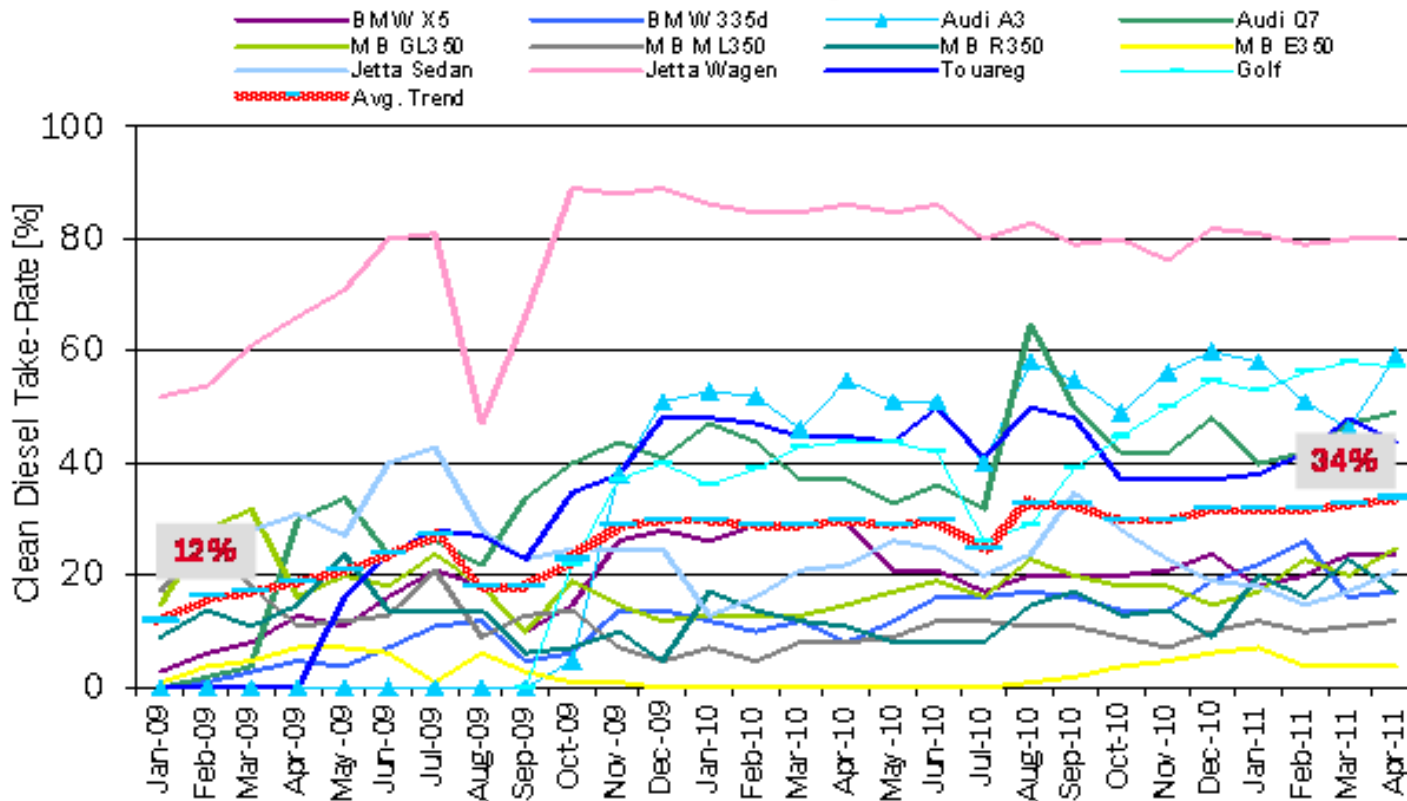
Source: CNW Research

Steady Increase in Consumer Consideration of Clean Diesel Technology



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Clean Diesel Take-Rate PC/LD

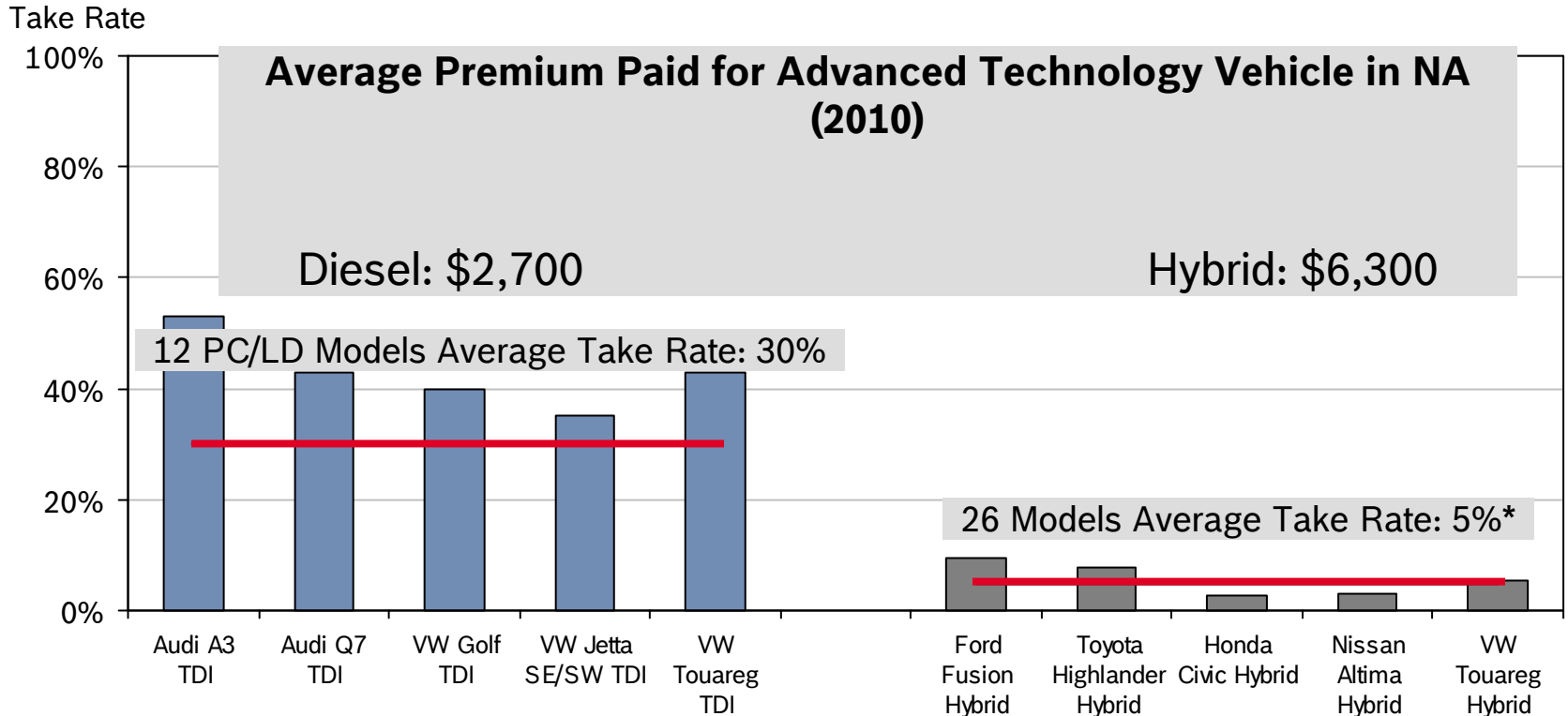


Source: Polk

Clean Diesel Technology achieved Take Rate of > 30% in less than 2 years



Alternative Powertrain Comparison



*Not incl. hybrid/electric only vehicles e.g. Toyota Prius, Chevy Volt, etc.

Source: Polk / Edmunds

Clean Diesel Technology on par with other alternative powertrains



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Washington D.C. Panel Discussion



Gas - Diesel comparison:



Tepper School of Business • William Larimer Mellon, Founder



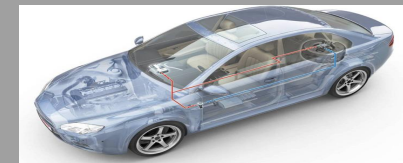
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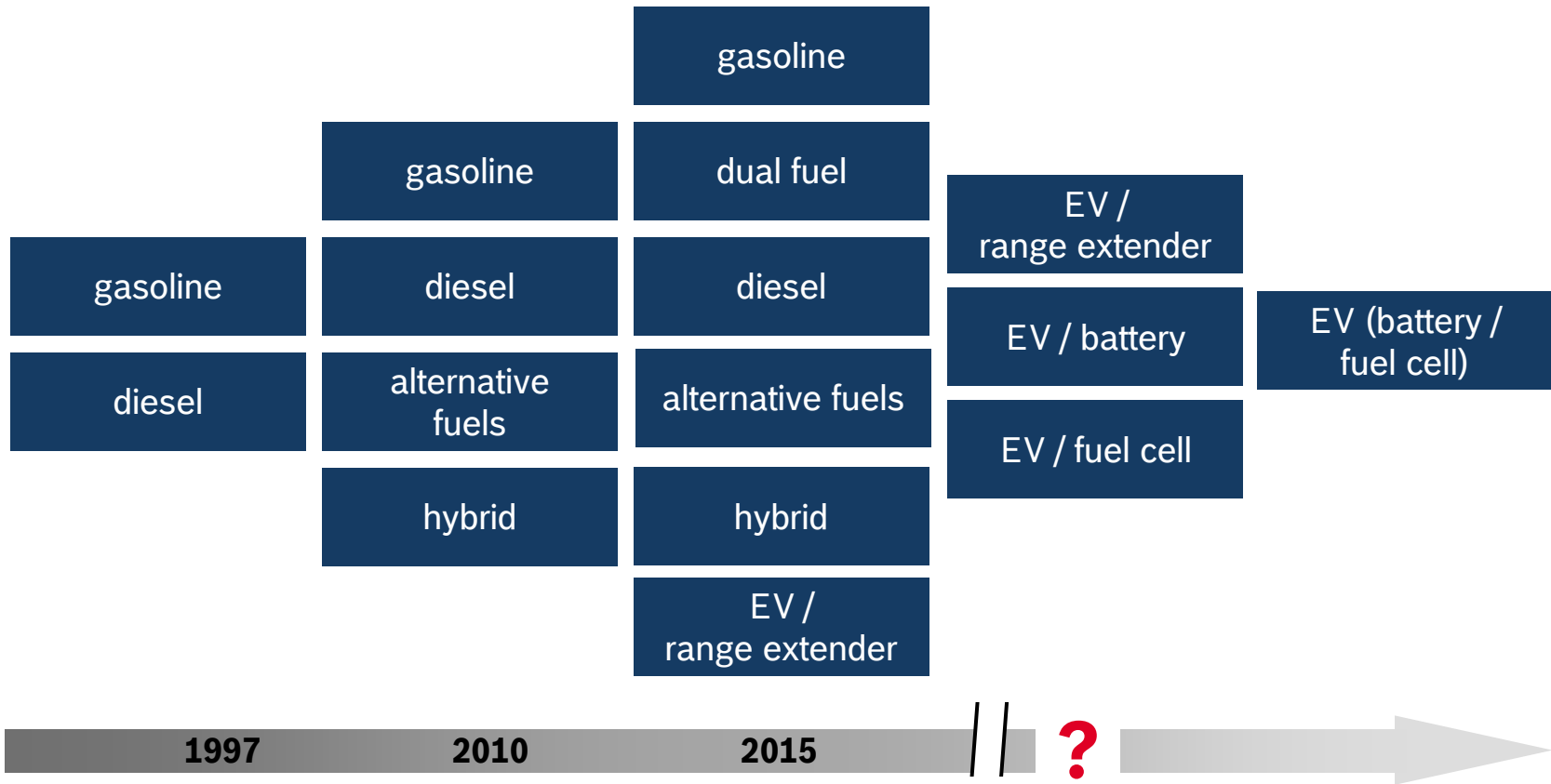
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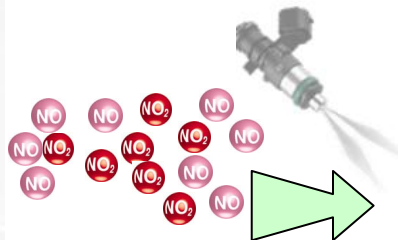


Powertrain diversification for Today and the Future



Variety of technical solutions needed to address energy reduction

Optimizing the Diesel System



Combustion Process

- Reduction of compression ratio
- Partly homogenous combustion

Air Management

- Swirl/Throttle Valve
- Turbo Charger/VGT*

Exhaust gas management

- Fast Catalyst Light-Off (reduce thermal losses)
- Diesel Particulate Filter
- NOx storage catalyst
- Catalystst temp control



Fuel Injection System

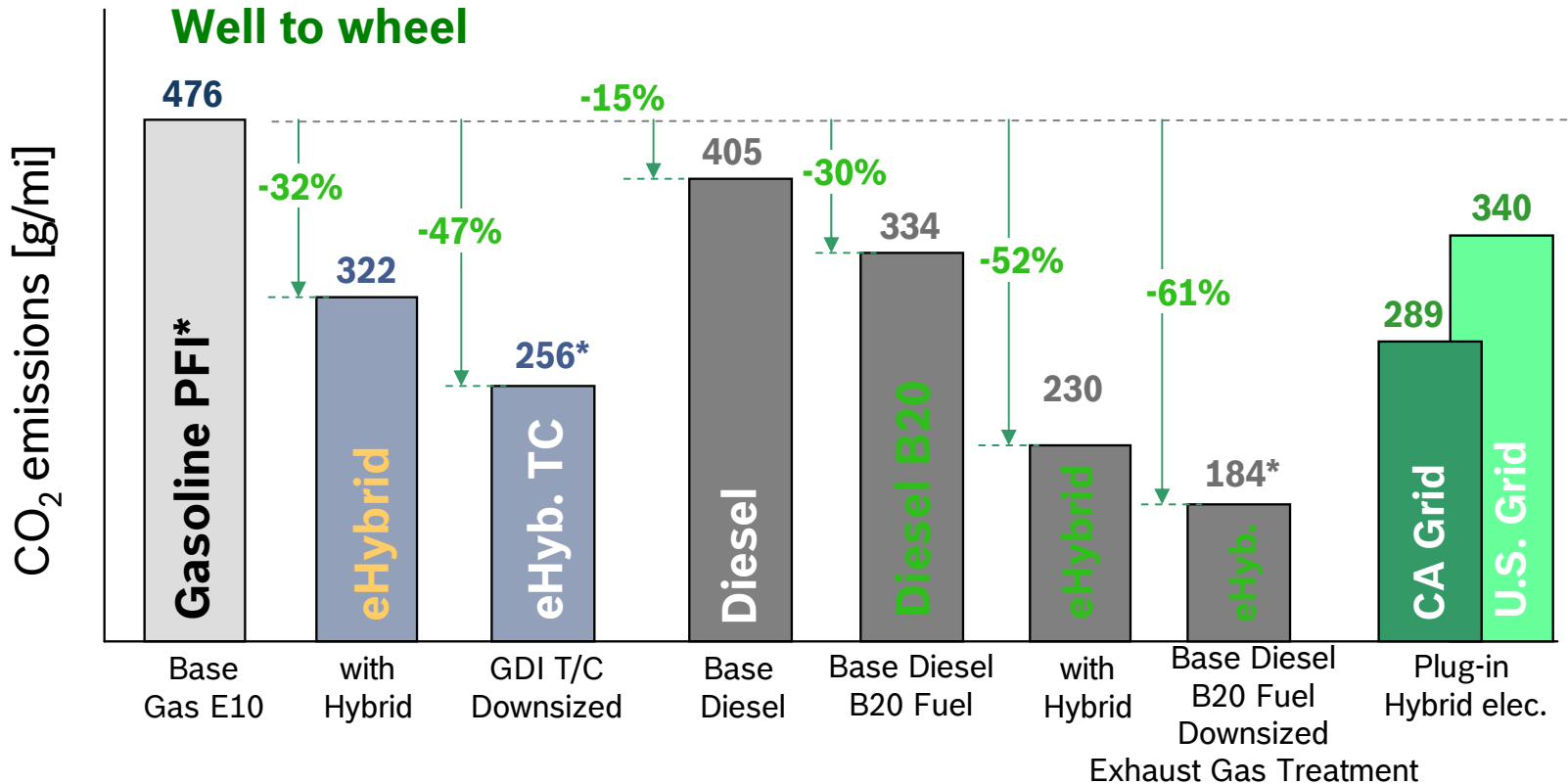
- New Generations
- Multiple Injections
- Reduced Tolerance
- Optimized Nozzle

Tolerance Reduction

- Zero Fuel Calibration
- Fuel Balancing Control
- Individual Cylinder Control



Greenhouse Gas Reduction Simulation



Source: EIA report based on GREET model

Significant Potential in Greenhouse Gas reduction expected from Clean Diesel



Summary Clean Diesel Technology

Well accepted by consumers and fun to drive

Payback in less than 3 years due to fuel savings and greater residual value

Significant potential to further reduce fuel consumption and GHG emissions



The Past – Present – Future of Clean Diesel

Clean. Efficient. **Diesel!**

We shape the future of diesel.

By

Driving Diesel System Success in NA

Thank You !

