NISSAN
MOTOR COMPANY

NGP2010
Diesel Engine Briefing
Sept. 18, 2007

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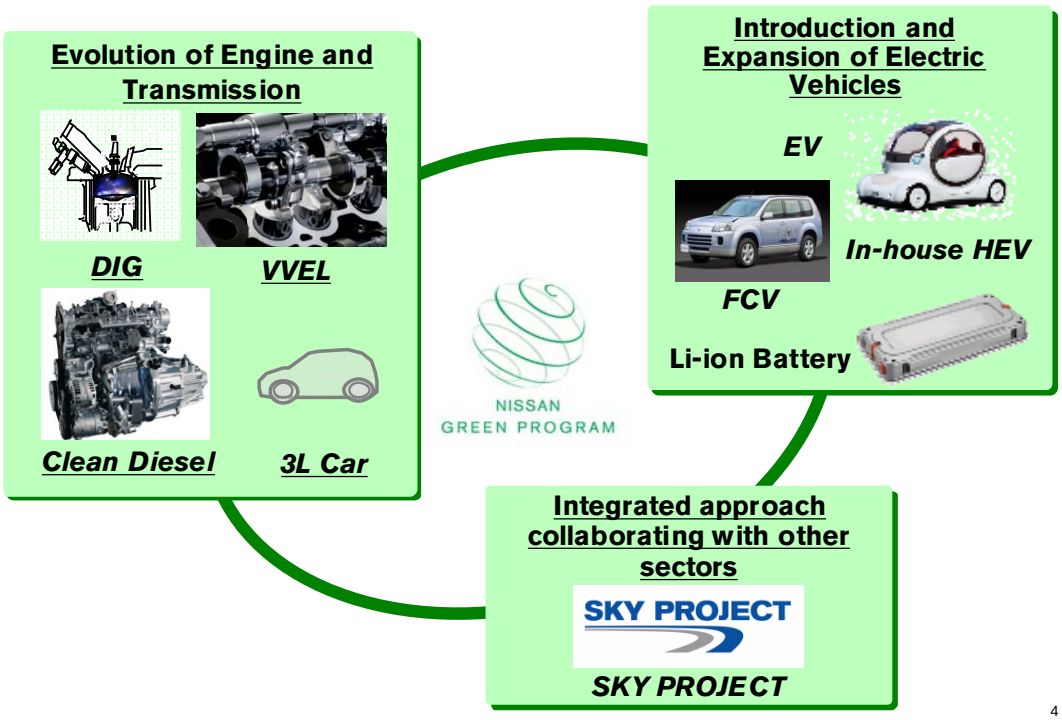
Agenda

1. Environmental Technology Activities
2. Potential of Diesel Engines
3. Clean Diesels
4. Future Diesel Emissions Regulations
5. Japan's Efforts to Reduce Emissions
6. Future Clean Diesels

1. Environmental Technology Activities

Nissan Green Program 2010

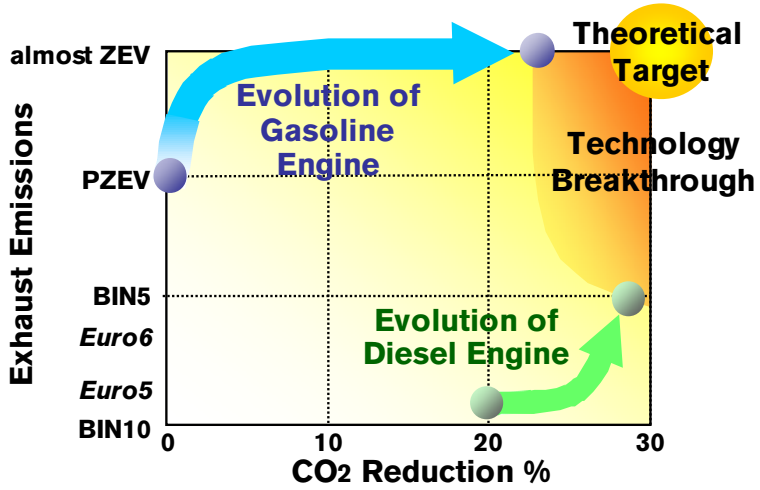


Engine Technology Roadmap

NISSAN GREEN PROGRAM

- Technical challenges and long-term targets

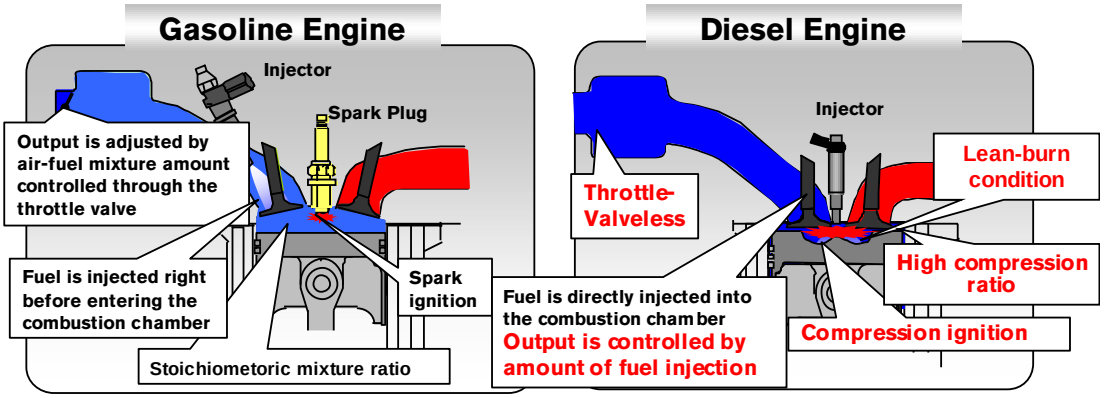
Gasoline engine : CO_2 emission reduction (-30%)
Diesel engine : Exhaust emissions reduction (-90%)



2. Potential of Diesel Engines

Comparison: Gasoline Engine and Diesel Engine

■ Although they are both internal combustion engines, they differ in output control and ignition method

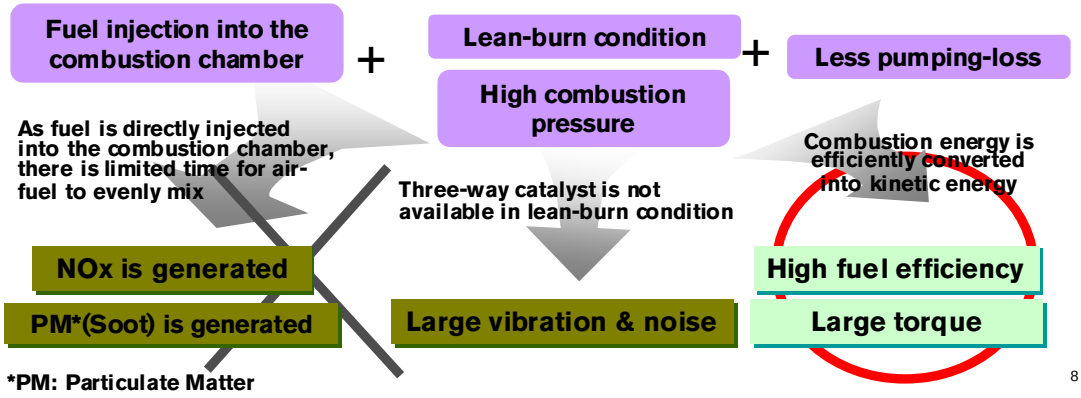


Mixture flow through throttle valve	Output control	Fuel injection amount (throttle valveless)
Intake port	Position of fuel injection	Combustion chamber
Spark ignition	Ignition method	Compression ignition
8-11	Compression ratio	16-22
Stoichiometric	Air and fuel ratio	Lean

Comparison: Gasoline Engine and Diesel Engine

■ Conventional diesel engines had high fuel efficiency and large torques, however emissions and vibration needed improvement

Gasoline Engine		Diesel Engine
Intake port	Position of fuel injection	Combustion chamber
Spark ignition	Injection method	Compression ignition
8-11	Compression ratio	16-22
Stoichiometric	Air and fuel ratio	Lean
Mixture flow through throttle valve	Output control	Fuel injection amount (throttle valveless)



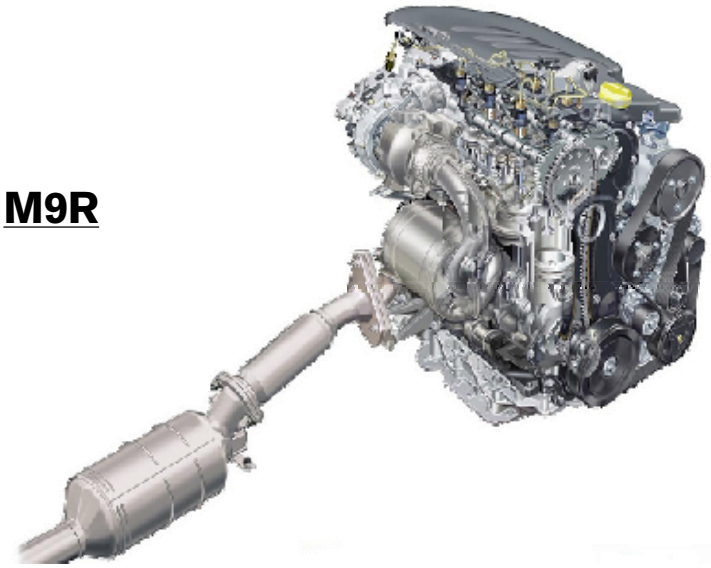
*PM: Particulate Matter

3. Clean Diesels

Clean Diesel: M9R

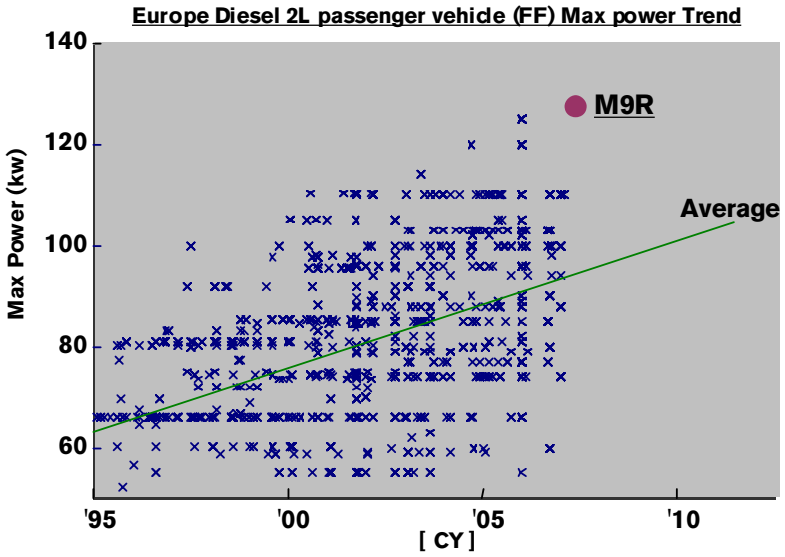
- **The M9R engine developed as part of the Renault-Nissan Alliance, achieves high efficiency, clean exhaust emissions, high power and low-noise.**

M9R



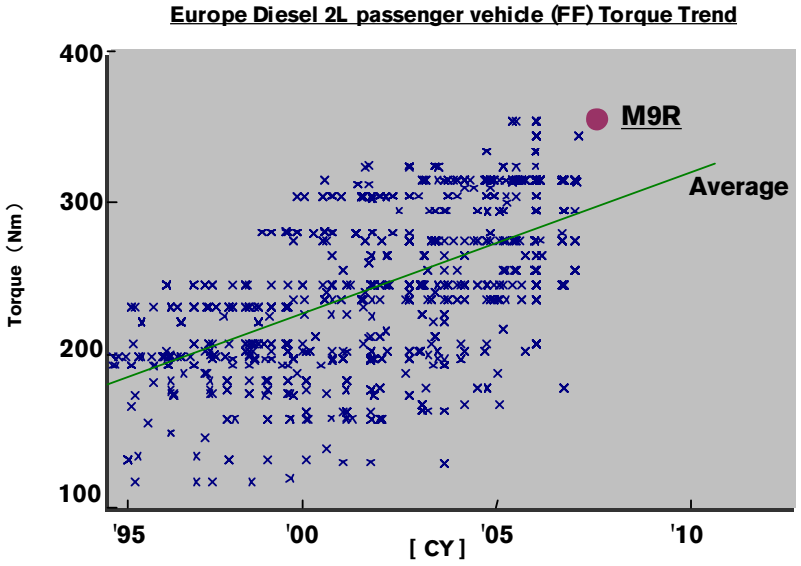
Clean Diesel: M9R

- The M9R cuts the 2 main complaints of the conventional diesel engines; noise and vibration. It also reduces regulated substances, meeting the Euro4 standard, while achieving top-level max power for a two-liter diesel engine.



Clean Diesel: M9R

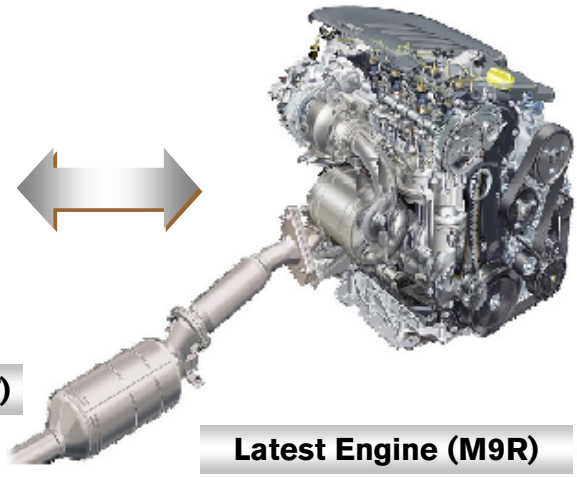
- The M9R achieves top-level torque for a two-liter diesel engine as well, providing max torque of 360Nm from 1750rpm engine speeds.



Comparison:
Conventional Engine & Latest (M9R) Clean Engine

- The level of technology applied in Nissan's M9R clean diesel engine is comparable to that in the CD20T, used in the first Serena in the 1990s.

Conventional Engine (CD20T)

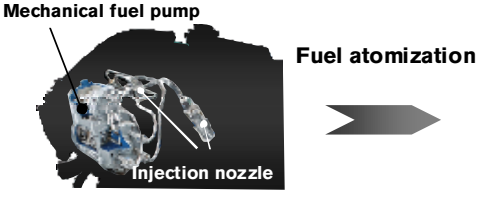


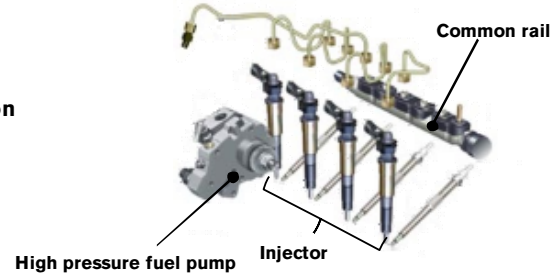
Latest Engine (M9R)

Comparison:
Conventional Engine & Latest (M9R) Clean Engine

Restrains the generation of NOx and soot (PM)

- **Fuel-supply system: A common-rail system replaces the regular mechanical fuel pump**
  - Fuel is under high pressure to ensure it injects as a fine mist and mixes more evenly with the air
  - The system precisely controls fuel for optimal injection timing





Conventional Engine (CD20T)

- A mechanical pump injects fuel directly into each cylinder.

Fuel pressure: 200 - 300bar

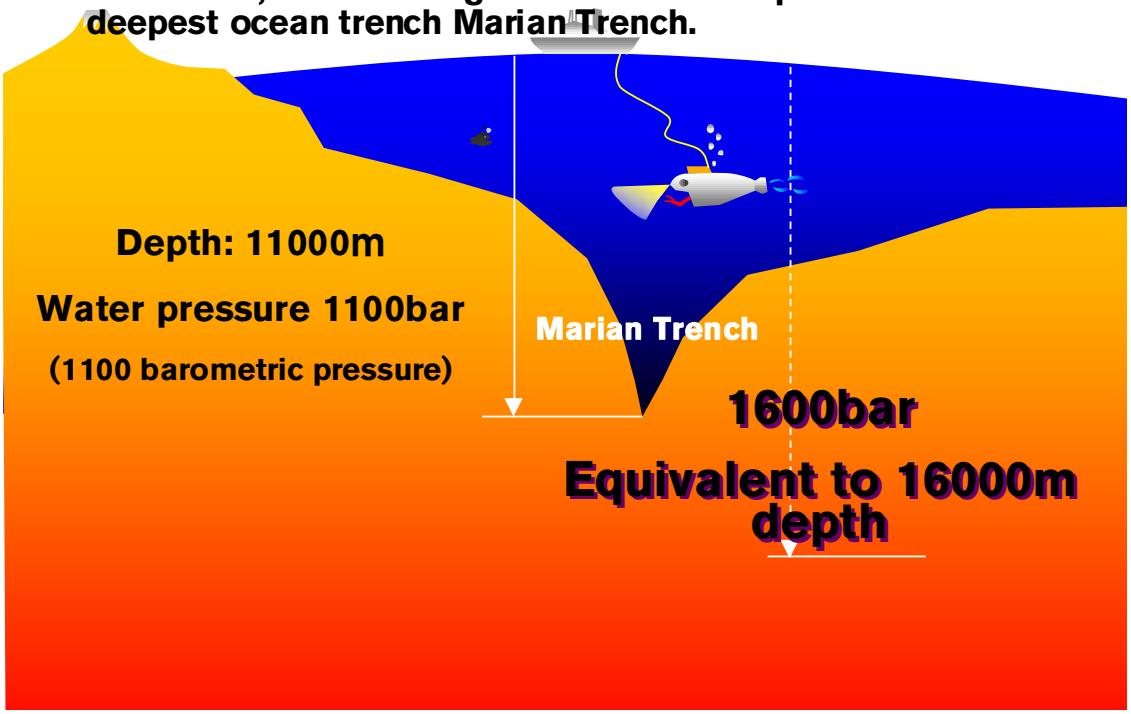
Latest Engine (M9R)

- Fuel pressure is kept even, optimizing injection to each cylinder by electronic control.

Fuel pressure: 1,600bar

What is 1600bar?

- 1600bar is equivalent to water pressure at the ocean depth of 16000m, which is larger than the water pressure at the deepest ocean trench Marian Trench.

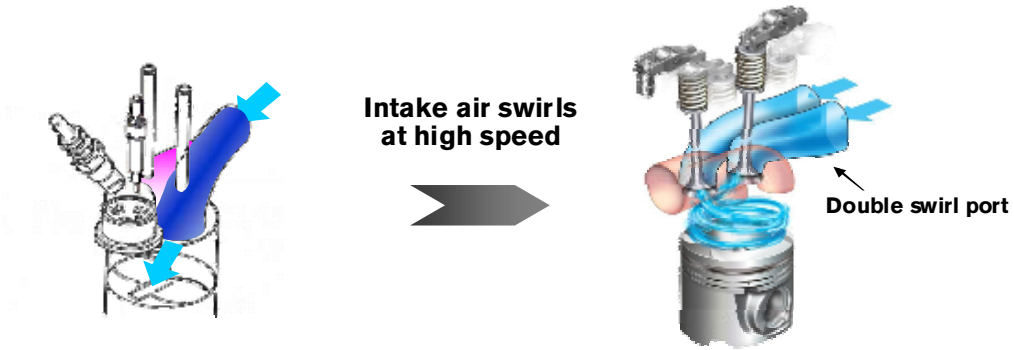


Comparison:
Conventional Engine & Latest (M9R) Clean Engine

Restrains the generation of soot (PM)

- Air-intake port: The double swirl port guides air into the combustion chamber in high-speed swirls

•Air and fuel mix evenly



Conventional Engine (CD20T) | **Latest Engine (M9R)**

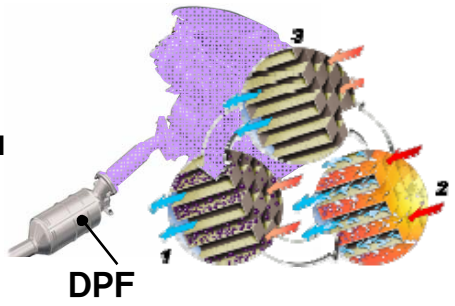
Comparison:
Conventional Engine & Latest (M9R) Clean Engine

Prevents most emissions of soot (PM)

- The DPF disposes up to 99% of soot (PM)

No Aftertreatment Device

Trapping and disposing of PM



Conventional Engine (CD20T)

Latest Engine (M9R)

1. It absorbs and deposits particulates generated by combustion.
2. It oxidizes particulates by keeping the temperature of the DPF body at 600 degrees C.
3. The DPF is self-cleaning and the cycle continues.

* DPF: Diesel Particulate Filter

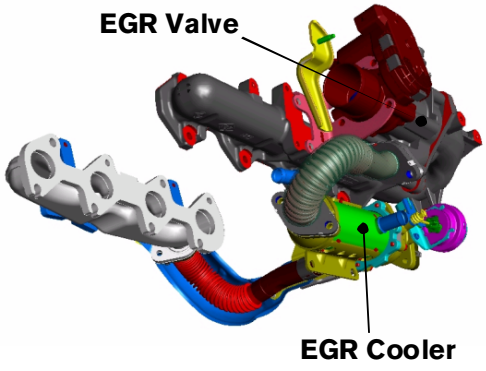
Comparison:
Conventional Engine & Latest (M9R) Clean Engine

Restrains the generation of NOx

- Added to reduce combustion temperature, the EGR cooler prevents the generation of NOx.

• EGR System

Further lowering combustion temperature



Conventional Engine (CD20T)

• Blowing inert exhaust gas into the combustion chamber lowers combustion temperature.

Latest Engine (M9R)

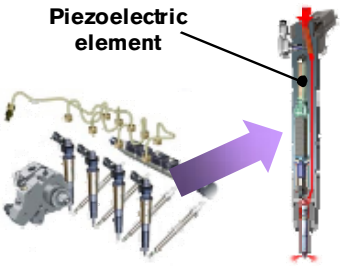
• To lower combustion temperature, the EGR cooler cools the exhaust gas guided into the combustion chamber.

Comparison:
Conventional Engine & Latest (M9R) Clean Engine

Noise restraint

■ Highly responsive piezoelectric-controlled injectors allow multiple fuel streams of high accuracy. Dispersed combustion pressure under optimum control reduces combustion noise.

Each injection is divided into several times streams



• A mechanical fuel pump injects only one stream.

•Common rail system (1600 bars)
•Piezoelectric-controlled injectors

Conventional Engine (CD20T)

Latest Engine (M9R)

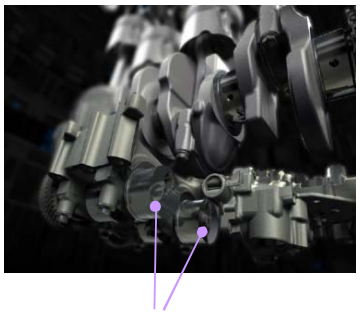
Comparison:
Conventional Engine & Latest (M9R) Clean Engine

Noise and vibration restraint

■ Vibration is reduced by balance the moving parts of the engine

Without Balancer

Reducing elements causing unbalance



•Balancer Shaft

Conventional Engine (CD20T)

Latest Engine (M9R)

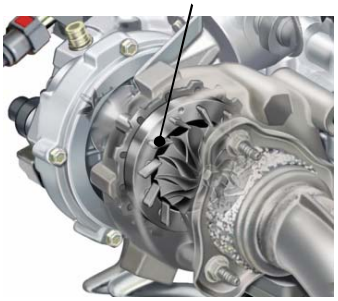
Comparison:
Conventional Engine & Latest (M9R) Clean Engine

Higher torque

■ **A variable plate inside the turbocharger, controlled according to the speed of the exhaust stream, helps the turbo make big torque in the low-rpm range.**

Turbocharger

A variable nozzle increases turbocharger operating range



•Variable nozzle turbocharger

Conventional Engine (CD20T)

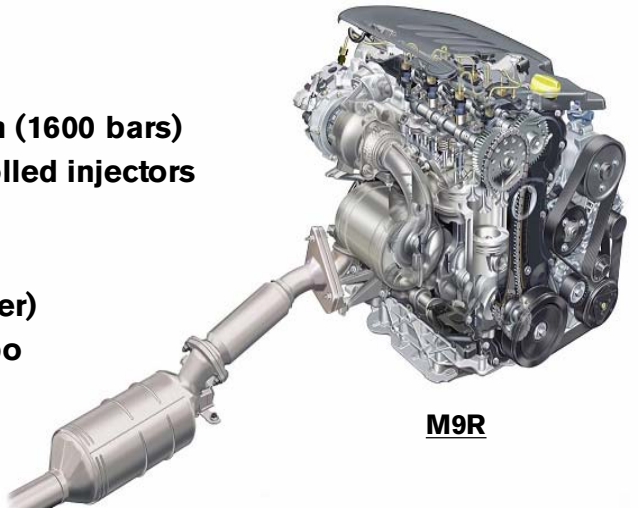
Latest Engine (M9R)

Clean Diesel (M9R)

■ **The M9R cuts the 2 main complaints of the conventional diesel engines, noise and vibration. It also reduces regulated substances, meeting the Euro4 standard, while achieving top-level output for a two-liter diesel engine.**

Technology Items

- **Common rail system (1600 bars)**
- **Piezoelectric-controlled injectors**
- **Double swirl port**
- **DPF***
- **EGR (with EGR cooler)**
- **Variable nozzle turbo**
- **Balance shaft**



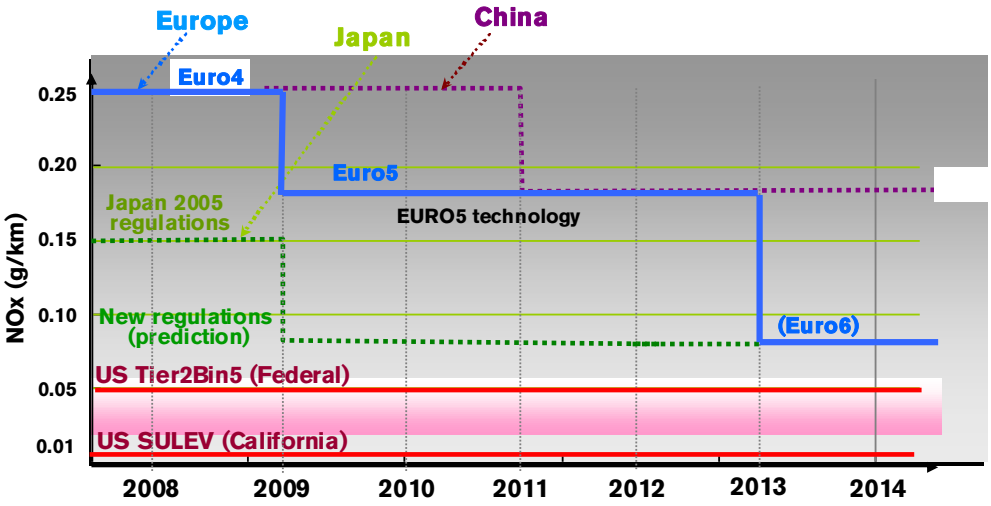
M9R

***DPF: Diesel Particulate Filter**

4. Future Diesel Emissions Regulations

Trend of Exhaust Emissions Regulations

- Restrictions on diesel emissions are tightest in the U.S, but target figures alone cannot illustrate how tight the restrictions are because testing modes differ from region to region



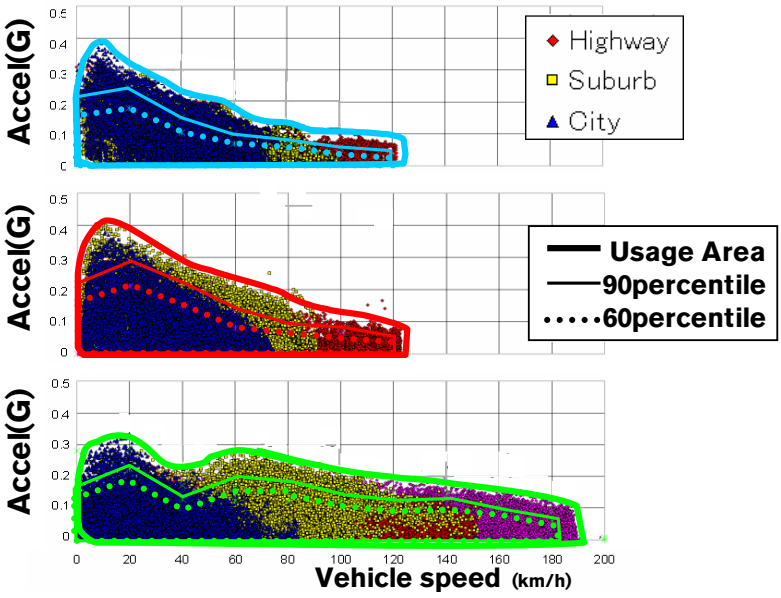
Differences in Driving Patterns (JPN, U.S, Europe)

■ **Acceleration is high on the list in Japan and U.S, while high-speed driving is a more common need in Europe.**

Japan

U.S.

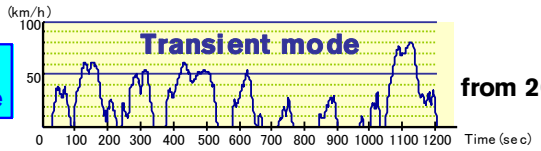
Europe



Differences in Exhaust-Testing Mode (JPN, U.S, Europe)

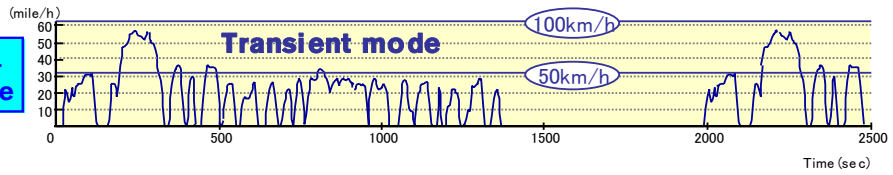
■ **Testing modes and restrictions differ depending on region**

【JPN】 **JC08 Mode**

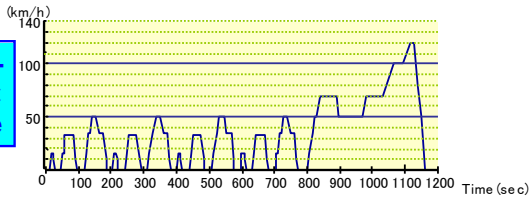


from 2008 year

【U.S.】 **LA4 Mode**



【Europe】 **ECE + EUDC Mode**

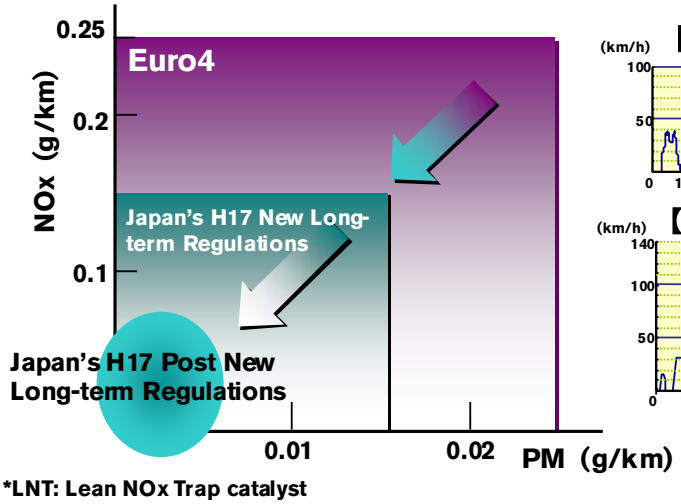


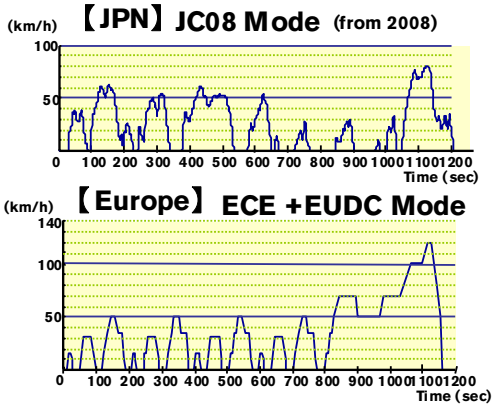
5. Japan's Efforts to Reduce Emissions

Clean Diesel (M9R) JPN model (Fall 2008)

■ Japan's New Long-term Regulations are more stringent, requiring PM reduction by 45% and NOx reduction by 40% against Europe's Euro4 Regulations. Therefore, Nissan has added technology to enhance NOx removal performance.

- NOx-trap catalyst (LNT*) added
- As there are more transient driving patterns compared to Europe, advanced engine combustion control technology has been added



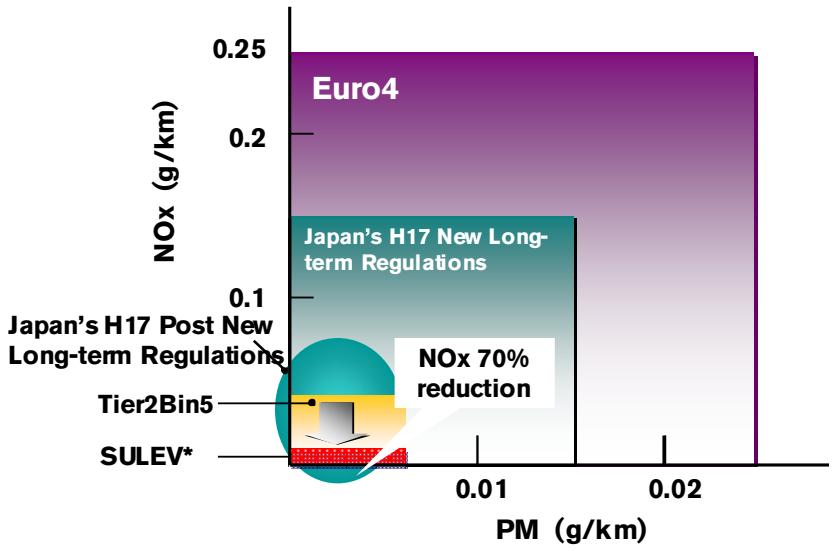


*LNT: Lean NOx Trap catalyst

6. Future Clean Diesels

Development of Future Clean Diesels: SULEV*

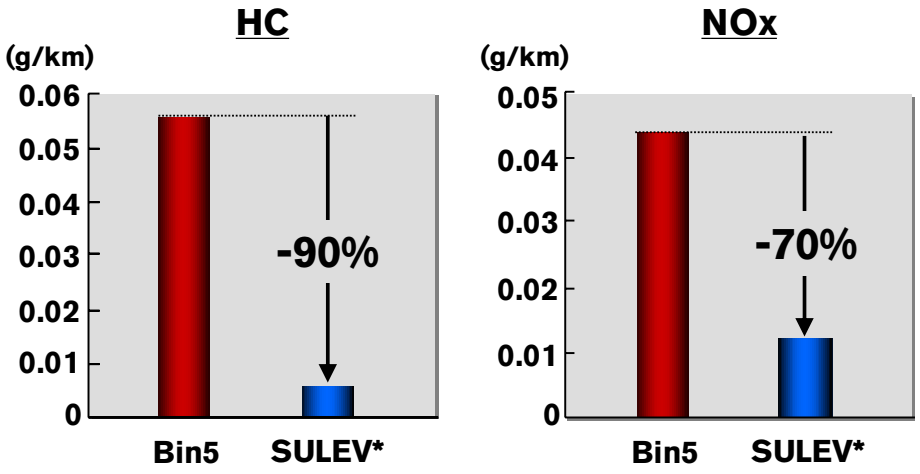
- Developing technology aiming at the ultimate goal of cleaning exhaust emissions to meet SULEV requirements



*The State of California Emission Standards

Development of Future Clean Diesels: SULEV*

- Presently, HC is reduced by 90% and NOx is reduced by 70% against Tier2Bin5 standards.



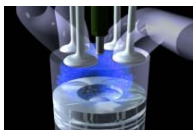
*The State of California Emission Standards

Development of Future Clean Diesels: SULEV*

- 3 technologies that support SULEV*

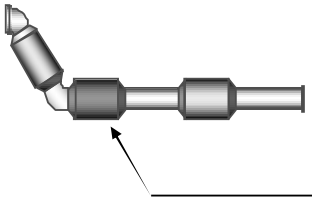
① Improvement in combustion technology

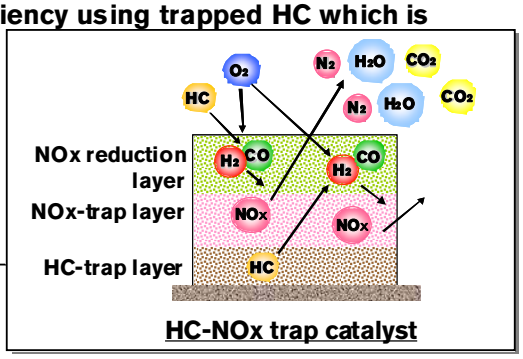
MK combustion curbs regulated substances at its origin-phase



② Newly developed HC-NOx trap catalyst

Improves NOx conversion efficiency using trapped HC which is regulated substances



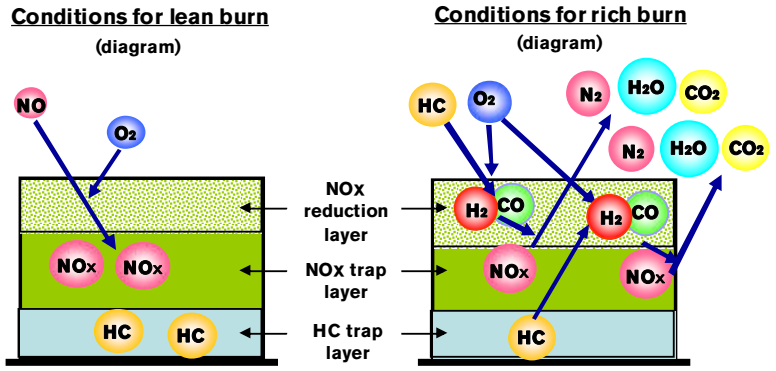


③ Advanced engine control realizes a highly efficient catalyst as well as combustion improvement

*The State of California Emission Standards

HC-NOx Trap Catalyst

- While conventional NOx-trap catalysts reduced only NOx, the new catalyst has an additional HC-trap layer to efficiently use HC, a regulated substance, for generating a chemical reaction to reduce NOx. This realizes highly efficient removal of both HC and NOx.

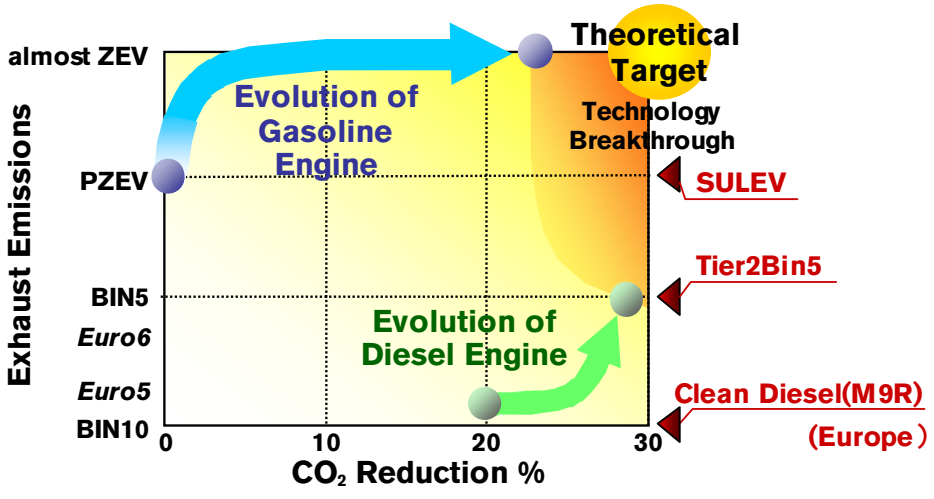


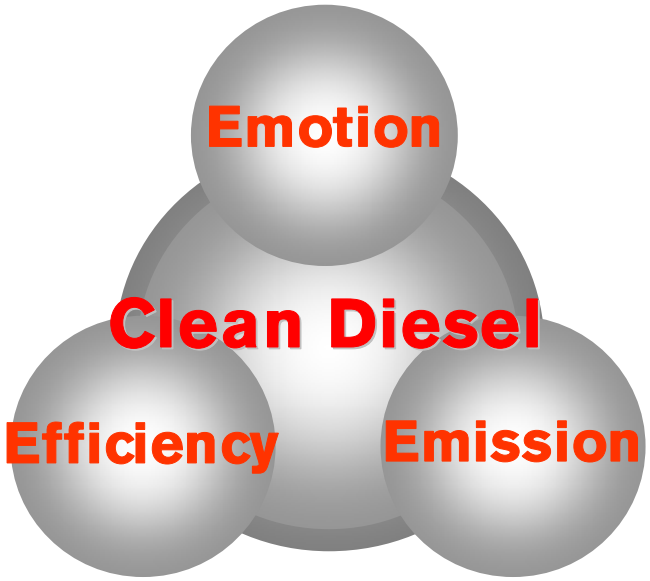
1. NO is oxidized and NOx is absorbed by the trap layer

2. The system uses a small controlled amount of O_2 with HC to generate H_2 and Co, which together perform a highly efficient NO_x chemical reaction.

Development of Future Clean Diesels

- Aiming at the technology goal of cleaning engine emissions to the atmospheric level, Nissan will further technology development for CO_2 reduction





Thank you