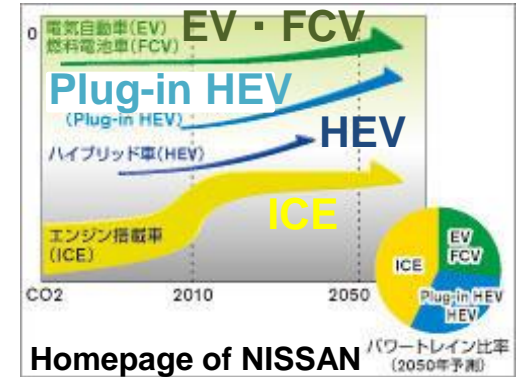


Necessity of Novel Engine Sensor in Automobile

More than 40% gasoline automobile is expected to be used widely in 2050. (NISSAN green program)

To achieve the goal of CO₂ reduction, rapid-acting CO₂ reduction technology is needed as intermediate technology.

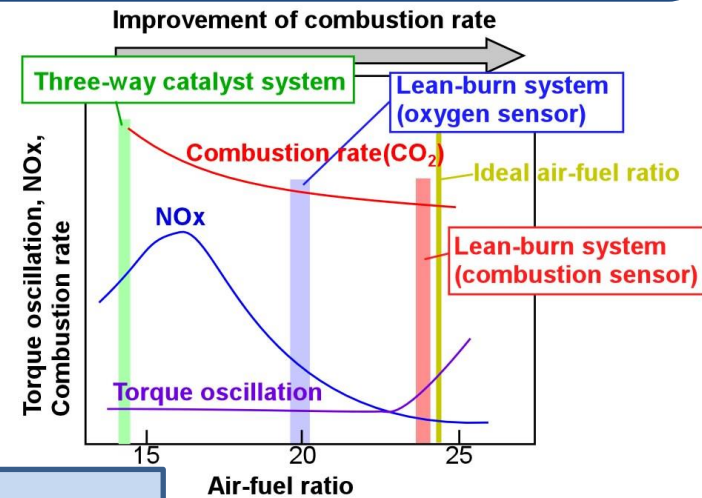


In the lean-burn system using the oxygen sensors, combustion rate is insufficient.

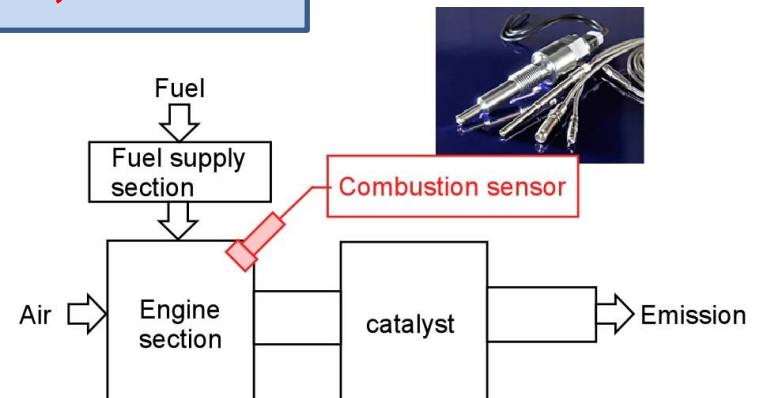
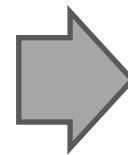
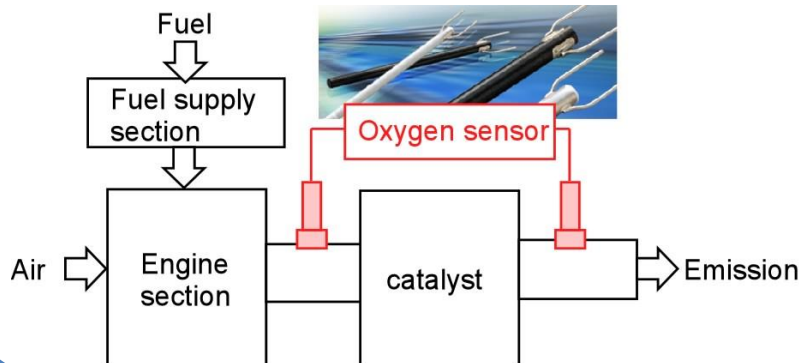


Direct sensing of the torque oscillation in the engine section using **the combustion sensor.**

- Improvement of combustion rate
- Reduction of emission amount of NO_x



Improvement of fuel efficiency : M/T ~10%, A/T ~4%



Estimation of CO₂ reduction by combustion sensor

- By combustion sensor, combustion rate is expected to be improved **~4% in the case of AT car** and **~10% in MT car.** (average : 7%)

Estimation by Toyota

- In 2020, **80% automobile is expected to be still the gasoline car.**

Report by AIM Project Team(2012)

- Amount of CO₂ emission by automobile for transportation is **20 million tons / year (2008)**

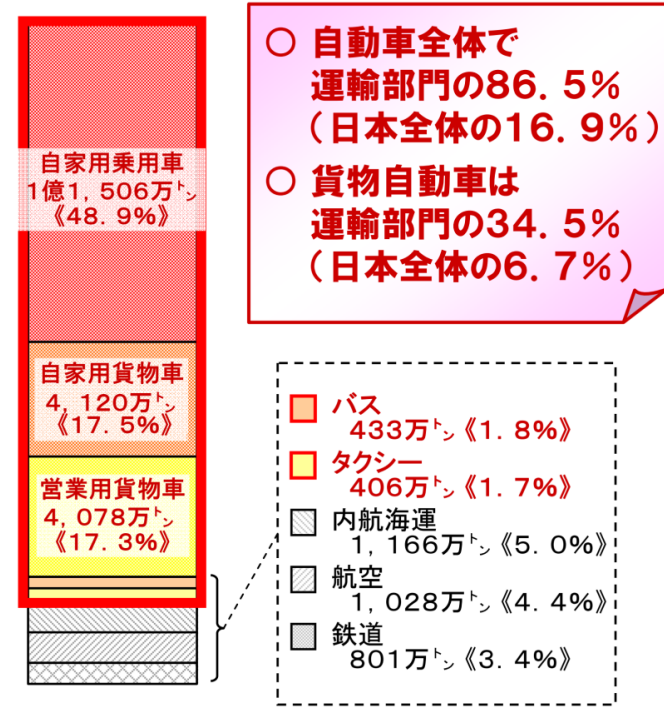
Report by MLIT

If 20% automobile in Japan will equip the combustion sensor,

20 million t x 7% x 20% x 80%
= **2.3 million tons**

Amount of CO₂ reduction by combustion sensor
2.3 million t-CO₂ / year

CO₂ emission by transportation



- 自動車全体で 運輸部門の86.5% (日本全体の16.9%)
- 貨物自動車は 運輸部門の34.5% (日本全体の6.7%)

- バス 433万ト 《1.8%》
- タクシー 406万ト 《1.7%》
- 内航海運 1,166万ト 《5.0%》
- 航空 1,028万ト 《4.4%》
- 鉄道 801万ト 《3.4%》

Report by MLIT

Measures for achievement of 2020 medium target

Section	Measure	Reduction
Transportation	Next-generation Vehicle	2.1 million t
	Traffic stream	1.6 million t

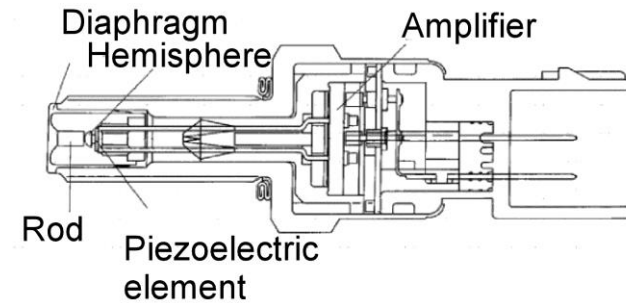
Report by METI

Piezoelectric material in the combustion sensor

The piezoelectric materials in the combustion sensor are located in the cylinder.

Operating temperature limit more than 400°C is required.

Schematic of the combustion sensor



The Quartz and PZT cannot be used for the combustion sensor without the water cooling.

Langasite-type piezoelectric crystals

- More than twice the piezoelectric constant of quartz
- High operating temperature limit ($T_c > 1300\text{ }^\circ\text{C}$)
- However, the production cost of langasite-type crystals is much higher than that of quartz.

	Quartz	PZT	Langasite-type
Curie Temp. ($^\circ\text{C}$)	573	~300	>1300
Piezoelectric constant (pC/N)	2.0	~300	4 - 7
Electro-mechanical coupling factor(%)	10	30 - 70	~ 15
Mechanical quality factor	$> 10^5$	100 - 900	$10^3 - 10^5$