

**Toyota Media Tour 2015 Tokyo Motor Show**

# **Toyota's More Efficient Powertrain**

Toyota Motor Corporation  
Tetsu Yamada

- 1** Toyota's Powertrain Approach
- 2** High Thermal Efficiency Gasoline Engine
- 3** Turbo Gasoline Engine
- 4** Global Diesel Engine
- 5** Market Introduction
- 6** New CVT

### **1** Toyota's Powertrain Approach

### **2** High Thermal Efficiency Gasoline Engine

### **3** Turbo Gasoline Engine





### **4** Global Diesel Engine

### **5** Market Introduction

### **6** New CVT

# 1. Toyota's Powertrain Approach

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Region	Japan				
	North America				
	Europe				
	China Emerging Markets				
Road condition					

Supply powertrains in a timely manner based on regional needs and intended purpose

## 1. Toyota's Powertrain Approach

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HV



Conventional Engine



EV



PHV



FCV



### The New Engine Series

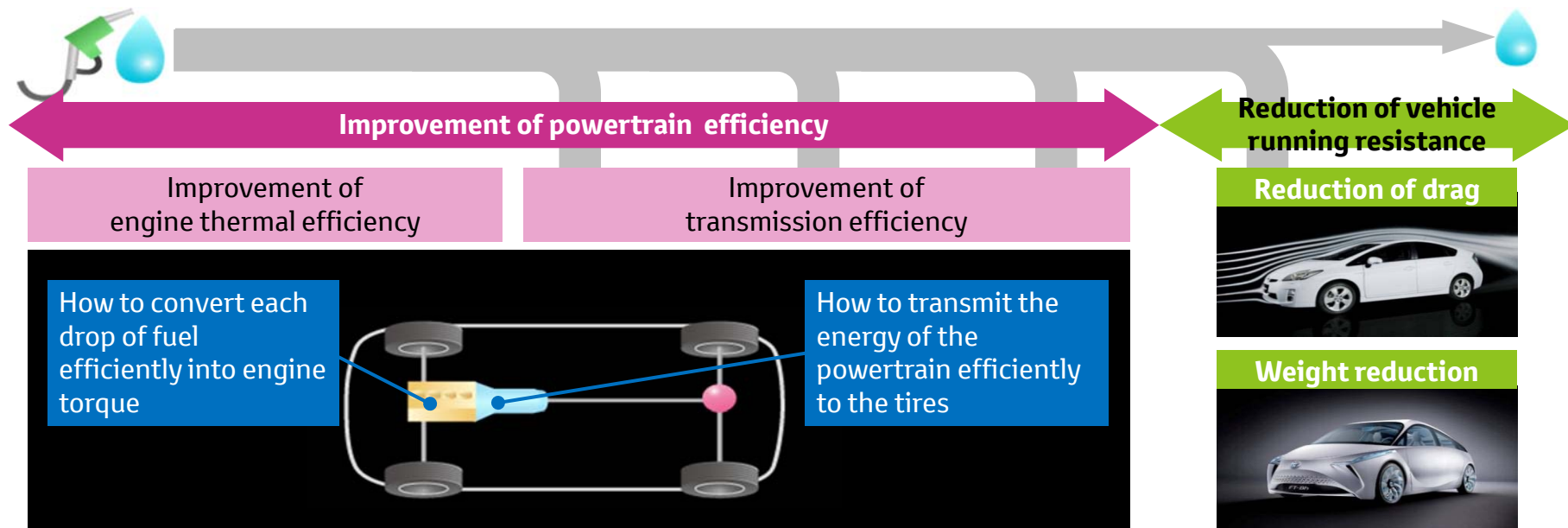
**Fuel economy improvement of 10 percent or higher compared to existing engines**

**World-class maximum thermal efficiency**

# 1. Toyota's Powertrain Approach

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How to convert each drop of fuel efficiently into energy and maximize work



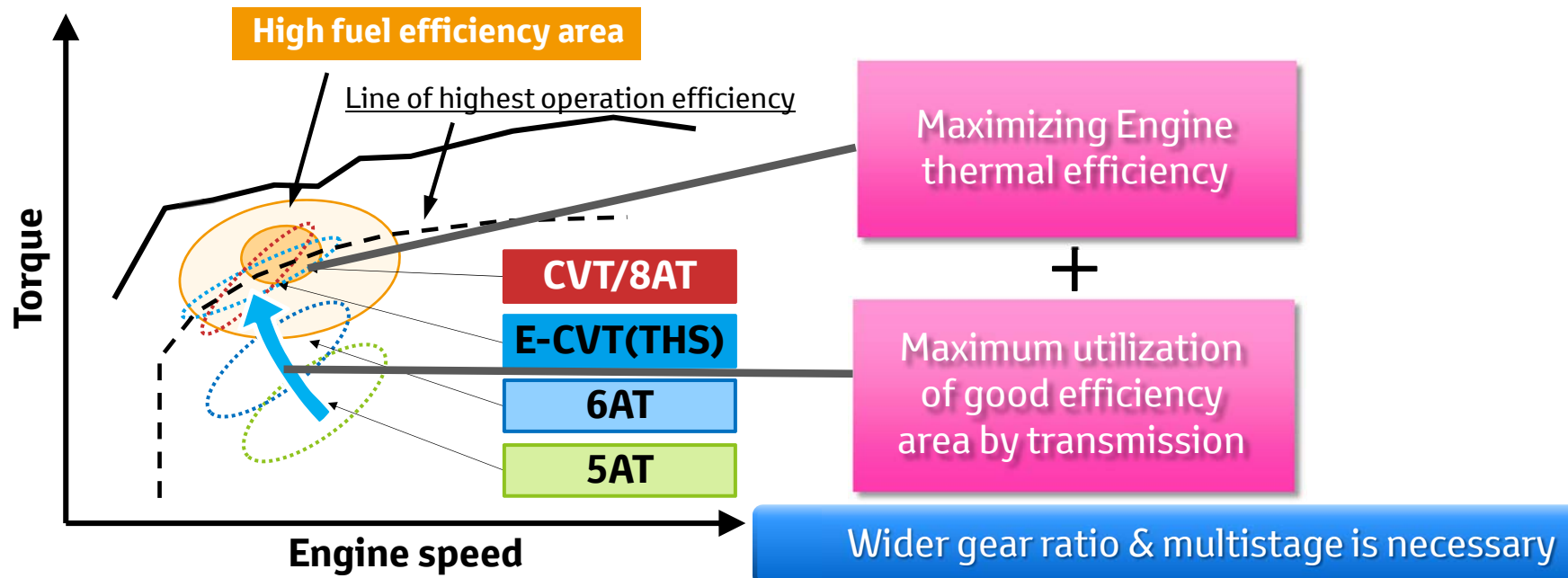
A fundamental way of improving the powertrain efficiency is to develop more efficient components and to minimize the combined losses

## 1. Toyota's Powertrain Approach

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For Maximization of powertrain system, Fully utilizing Engine thermal efficiency areas by transmission operation

### Engine and Transmission Combinations (image)












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## 2. High Thermal Efficiency Gasoline Engine

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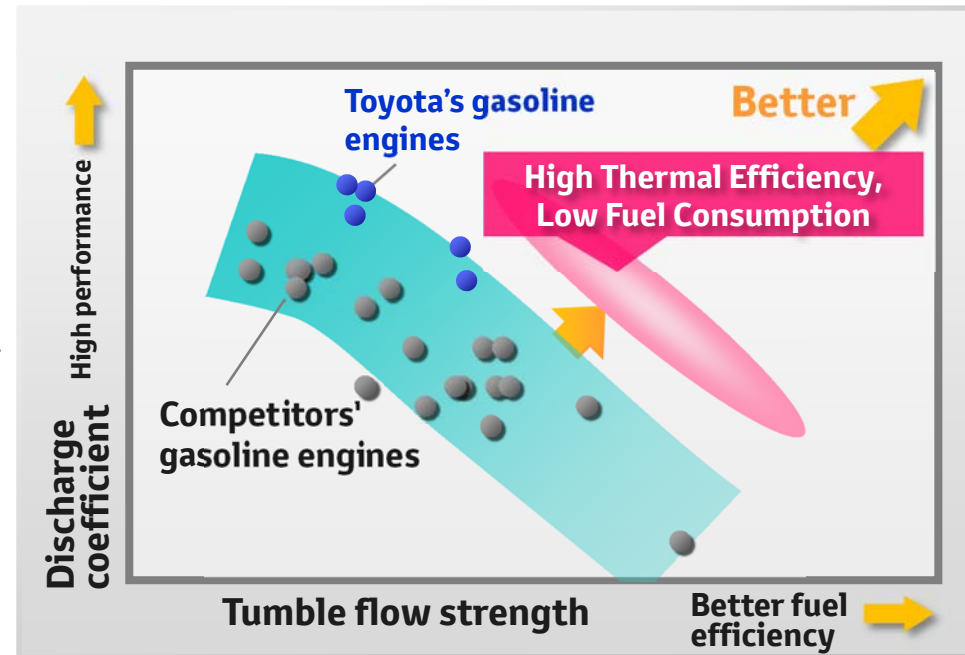
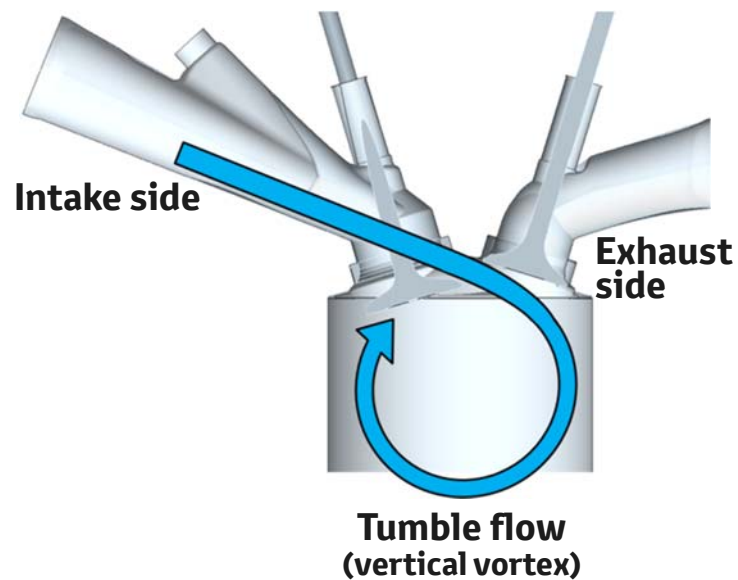
		HVs	Vehicles with conventional gasoline engines
Improved combustion	1 Rapid combustion		
	2 Higher compression ratio		
Loss reduction	3 Reduced pumping loss		
	1 Atkinson cycle		
	2 Large-volume cooled EGR		
	4 Low friction		

 : Technology used/refined

## 2. High Thermal Efficiency Gasoline Engine

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### Rapid Combustion



**Achieve unprecedented efficiency and tumble**

## 2. High Thermal Efficiency Gasoline Engine

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### Rapid Combustion



**Rapid combustion through higher tumble flow**

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### 3. Turbo Gasoline Engine

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#### Turbo engines

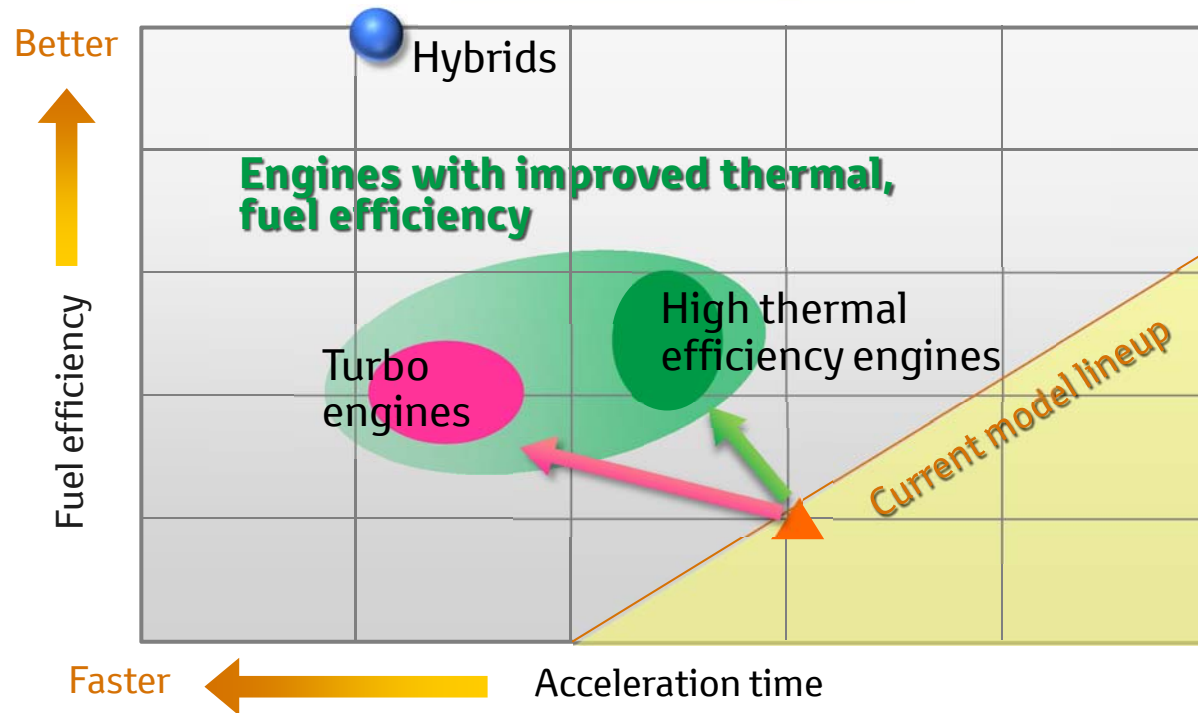


**Numerous improvements developed in a variety of powertrains combine to improve combustion in turbo engines**

### 3. Turbo Gasoline Engine

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#### Gasoline Engine

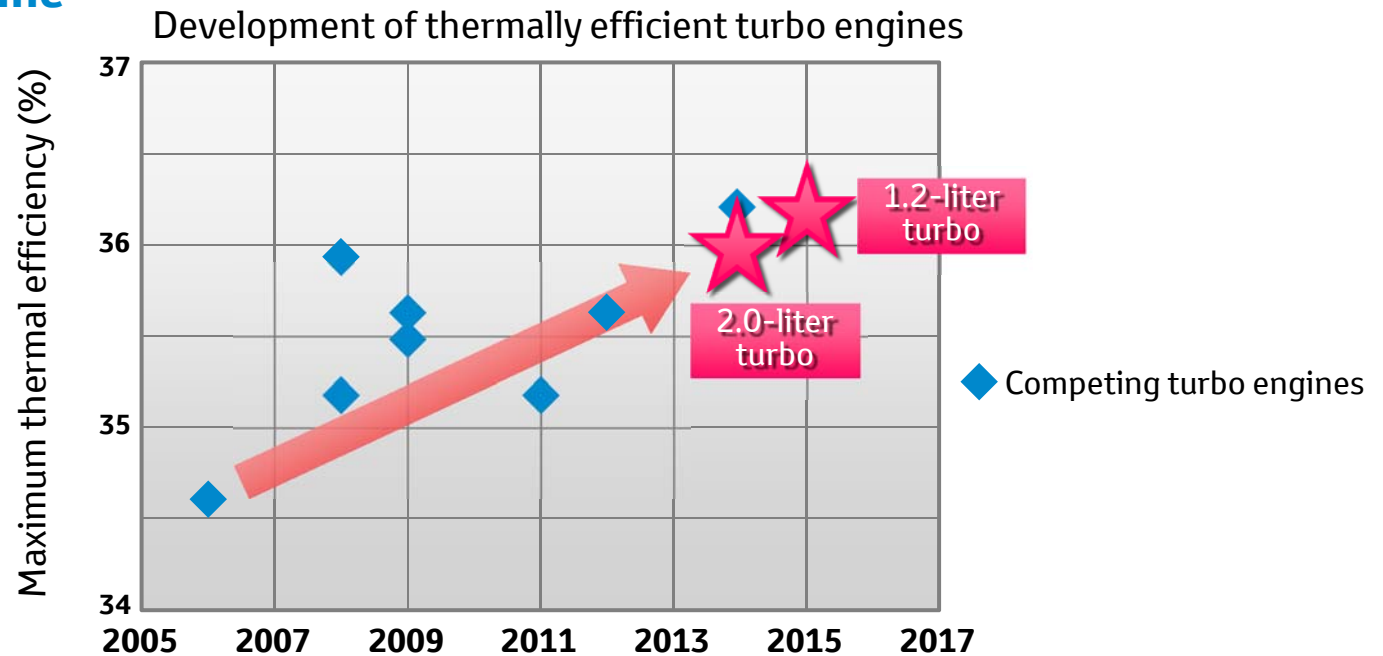


Improving thermal efficiency and the driving experience with turbo engines

### 3. Turbo Gasoline Engine

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#### Turbo gasoline engine

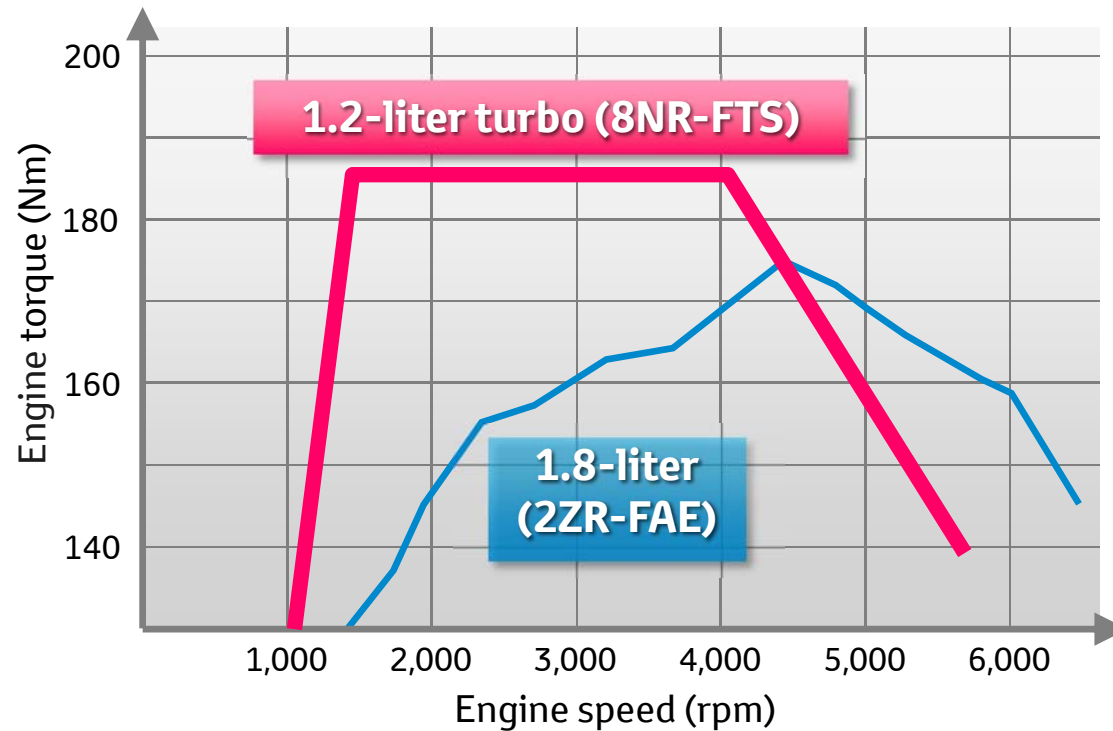


Top class thermal efficiency



### 3. Turbo Gasoline Engine

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**Turbo engine delivers high torque at low engine speeds**

### 3. Turbo Gasoline Engine

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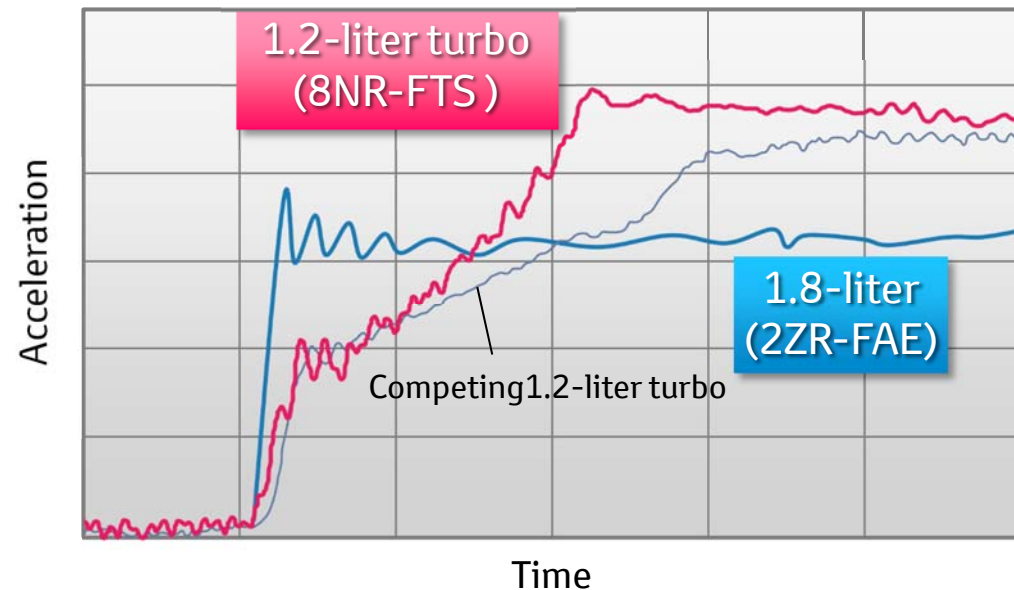
Low fuel consumption=  
excellent environmental  
performance

Easy/fun to drive

➔ Responsiveness  
High torque

Extremely quiet

Acceleration from 30 km/h (third gear)



**Low fuel consumption and an exciting driving experience**

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## 4. Global Diesel Engine

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**Toyota's diesel engine used for daily life all over the world**

**Brazil**



**Venezuela**



## 4. Global Diesel Engine

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### Diesel Engine

**Easier to drive**

Improved torque  
from start

+

Improved low-  
speed torque

**Quieter**

Achieve quiet combustion under all  
driving conditions.

**Cleaner**

Development of low emission systems  
that respond rapidly to ever-changing  
global environmental requirements.

## 4. Global Diesel Engine

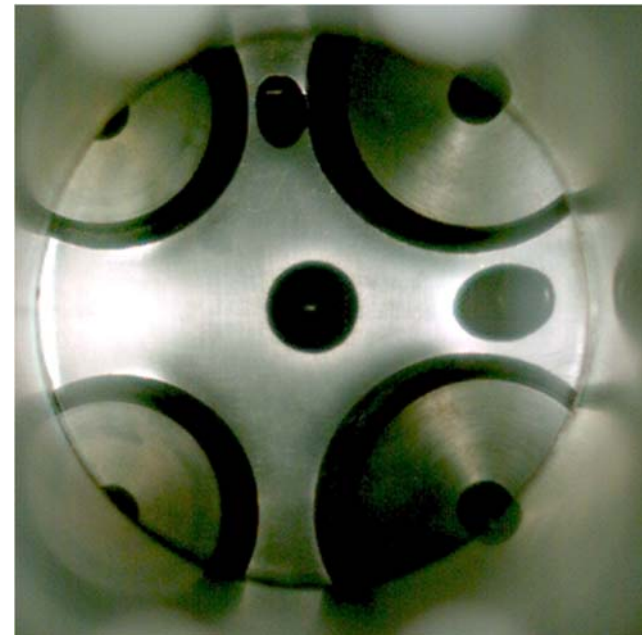
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▶ Next-generation advanced thermal insulation diesel combustion **Ideal combustion state**

Standard combustion



Next-generation advanced thermal insulation diesel combustion



Minutely-controlled combustion rather than combustion from mixing fuel and air.

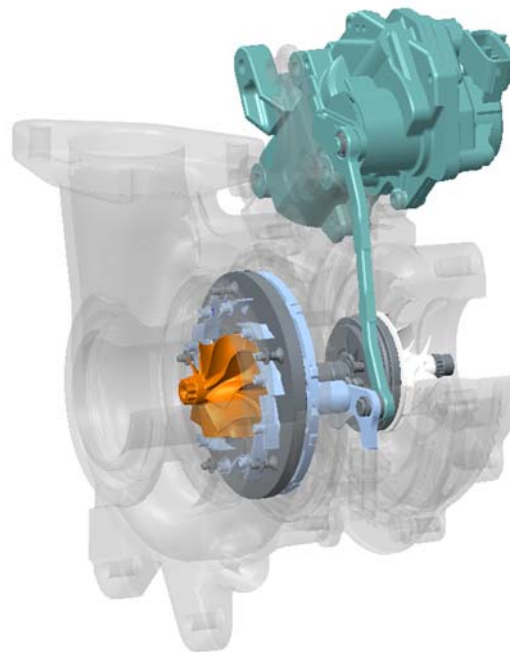
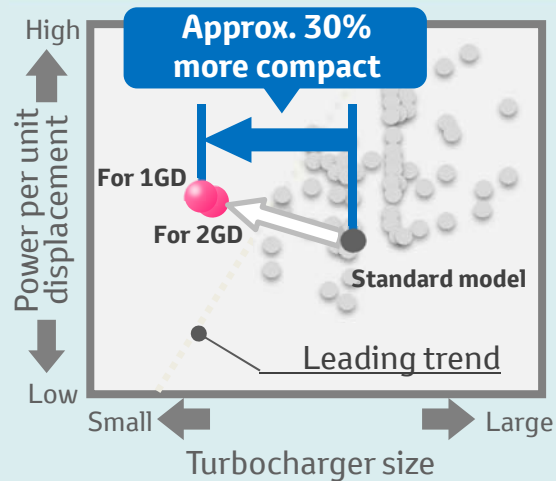
## 4. Global Diesel Engine

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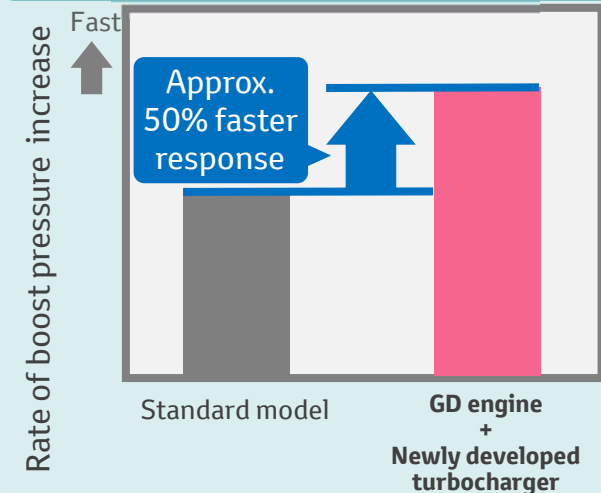
Technology to expand the potential of combustion: **Newly developed turbocharger**

In-house development

Dramatic size reduction and efficiency increase to achieve extensive response



Effect on response by reducing size and increasing efficiency



This turbocharger—which responds at all engine speed ranges was developed as an integral part of engine development—helps to maximize the potential of combustion.



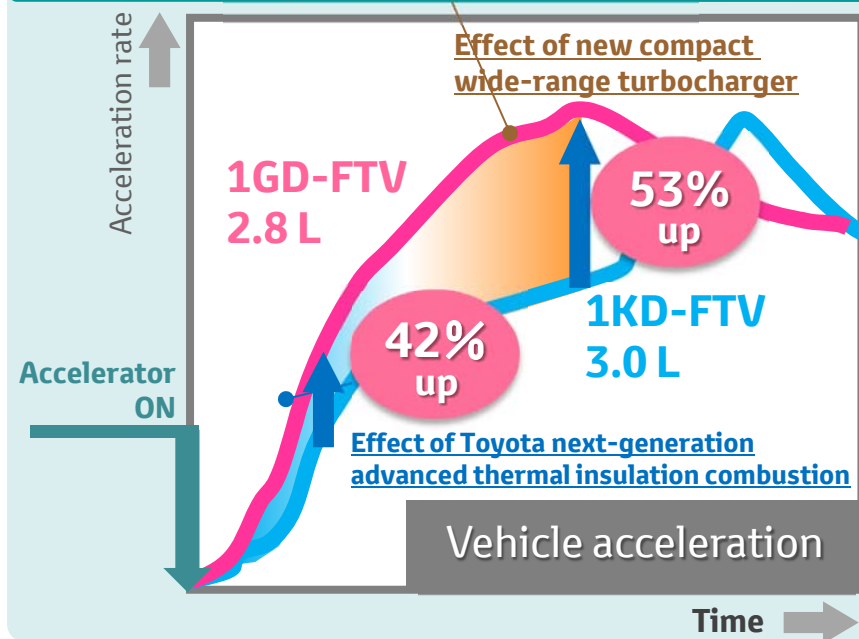
## 4. Global Diesel Engine

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### Global Diesel Engine: Maximum Thermal Efficiency of 44% (Prado)

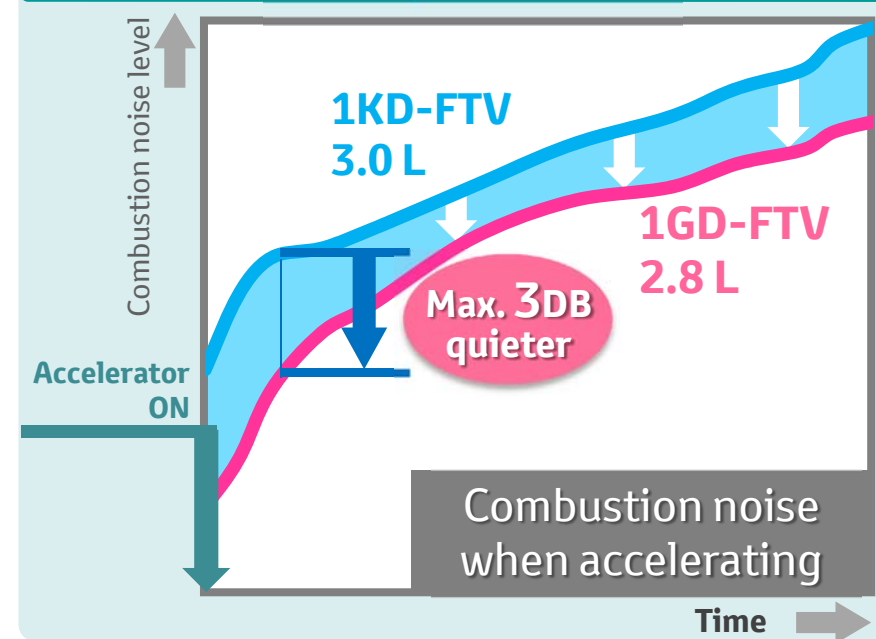
World-leading  
for passenger  
vehicle

#### Dynamic performance



Impressive acceleration right from start

#### Noise performance



Quieter performance right from start

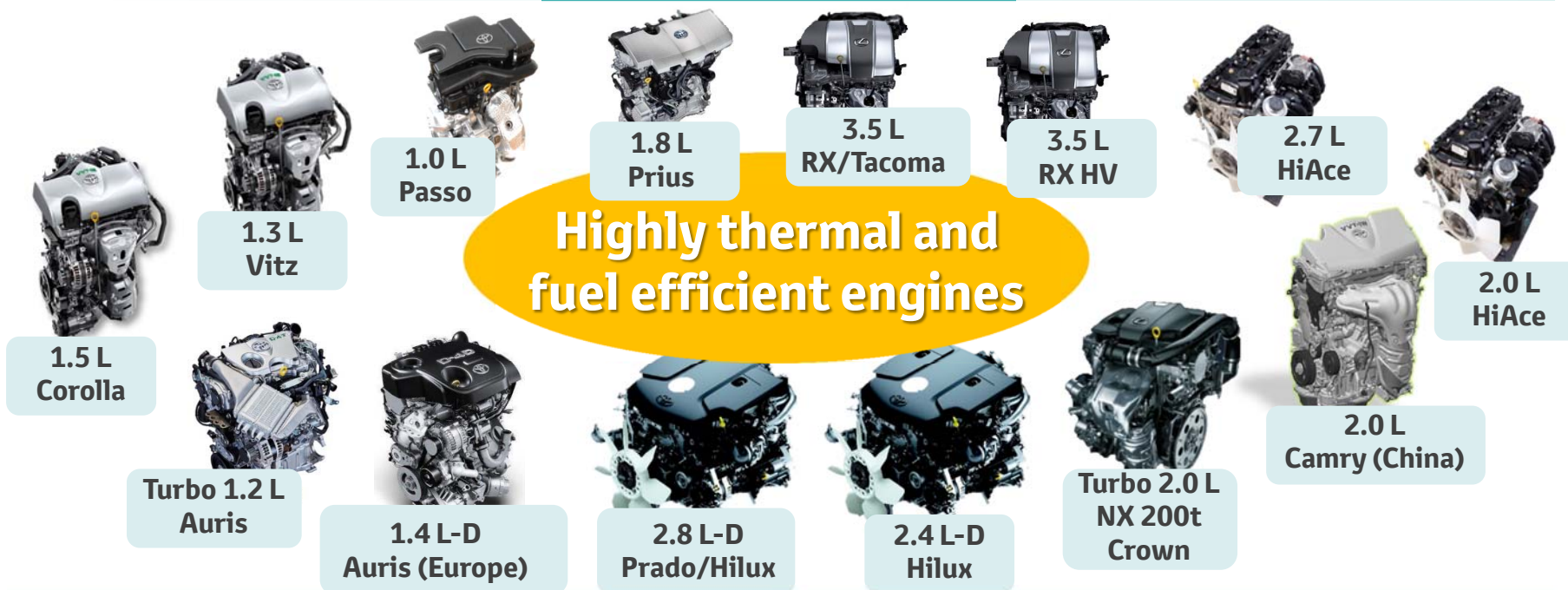


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## 5. Market Introduction

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### Engine deployment



As planned, Toyota has launched all of the 14 highly thermal and fuel efficient engines.

## 5. Market Introduction (1.8-liter engine)

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### Improved combustion

- Rapid combustion
  - High tumble port
  - High volume cooled EGR
  - Optimized Piston top surface
- Improved Knocking
  - High energy Ignition Coil
  - Optimized the alignment of the spark plug grounding electrodes
  - Branch pipes in the EGR passage built into the intake manifold

### Heat Management

- Dual passage cooling system
- Water jacket spacer with rubber form

### Friction reduction

- Crank bearings with fine grooves
- Oil pump with new rotor profile
- Piston with a smoothing surface treatment

Maximum thermal efficiency: **40%**

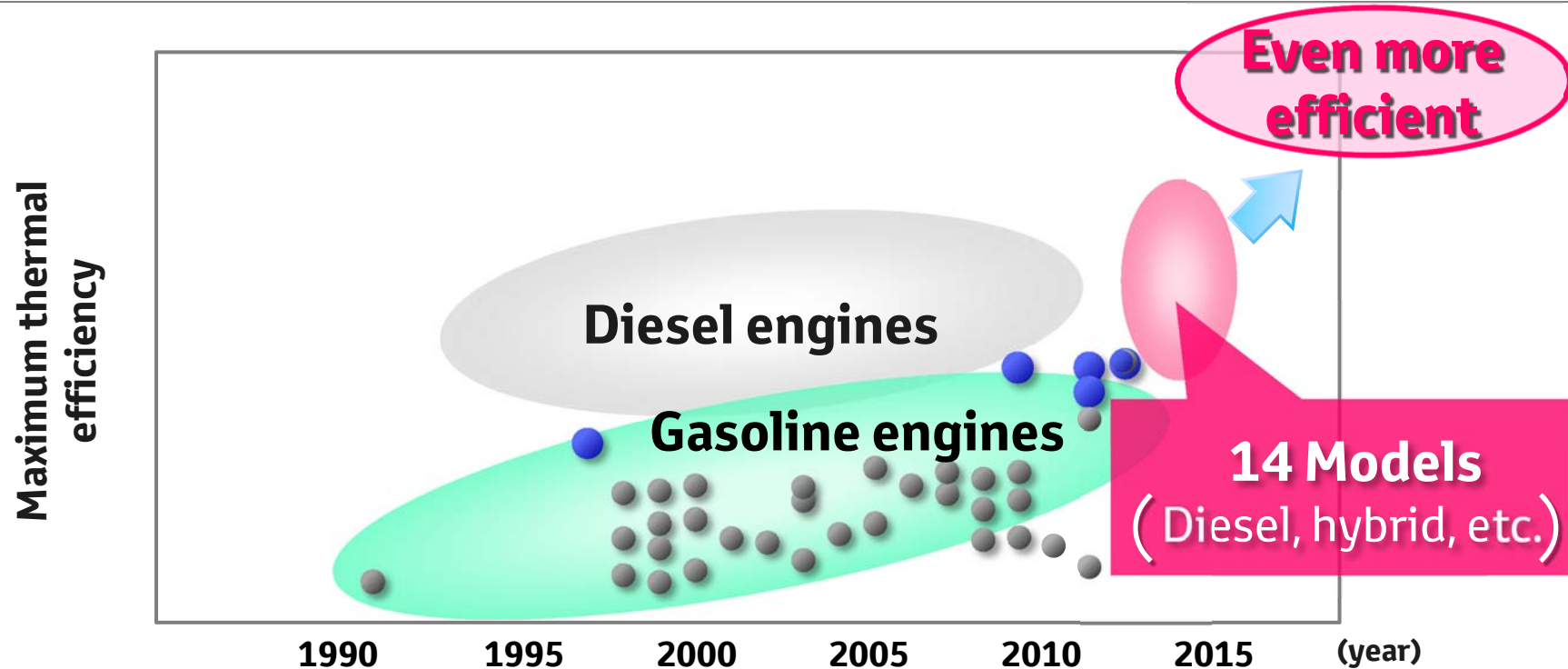


**Installed in New Prius**

**TOYOTA**

## 5. Market Introduction

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**Aim for further improvements in the future**

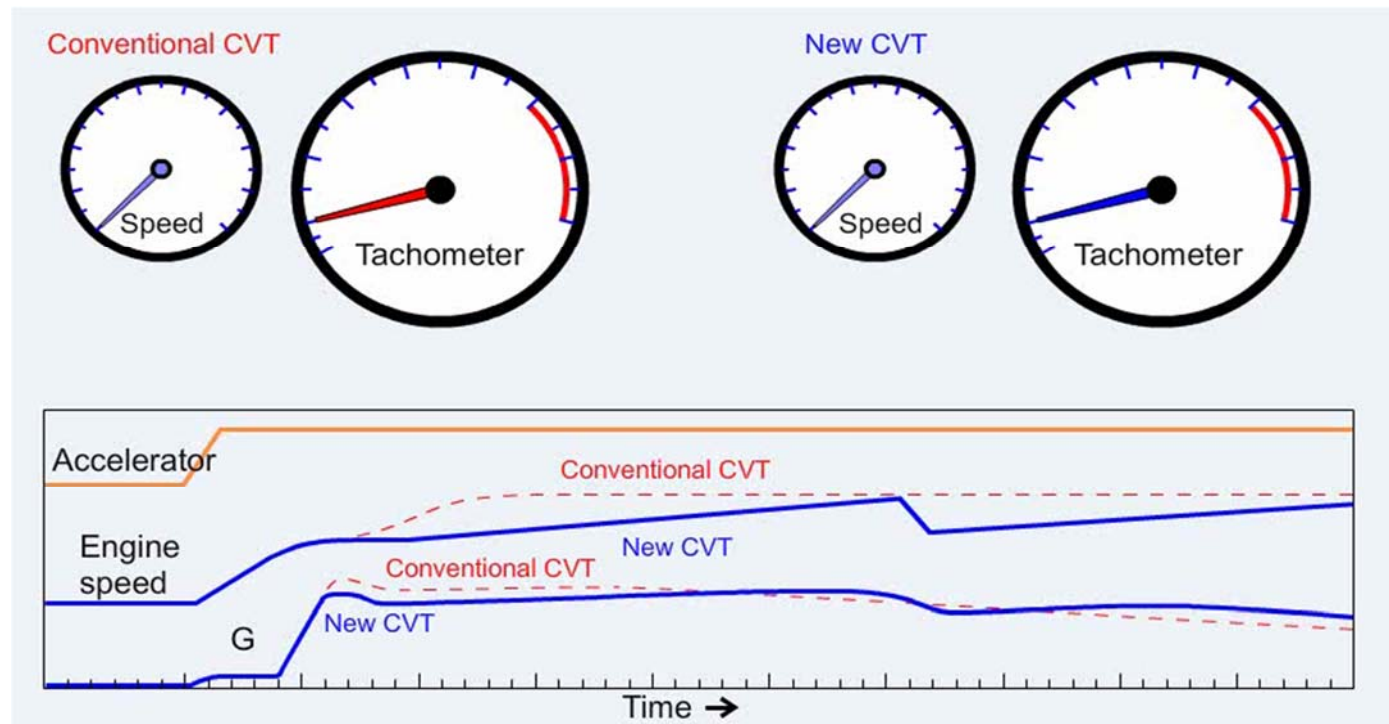
TOYOTA

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## 6. New CVT

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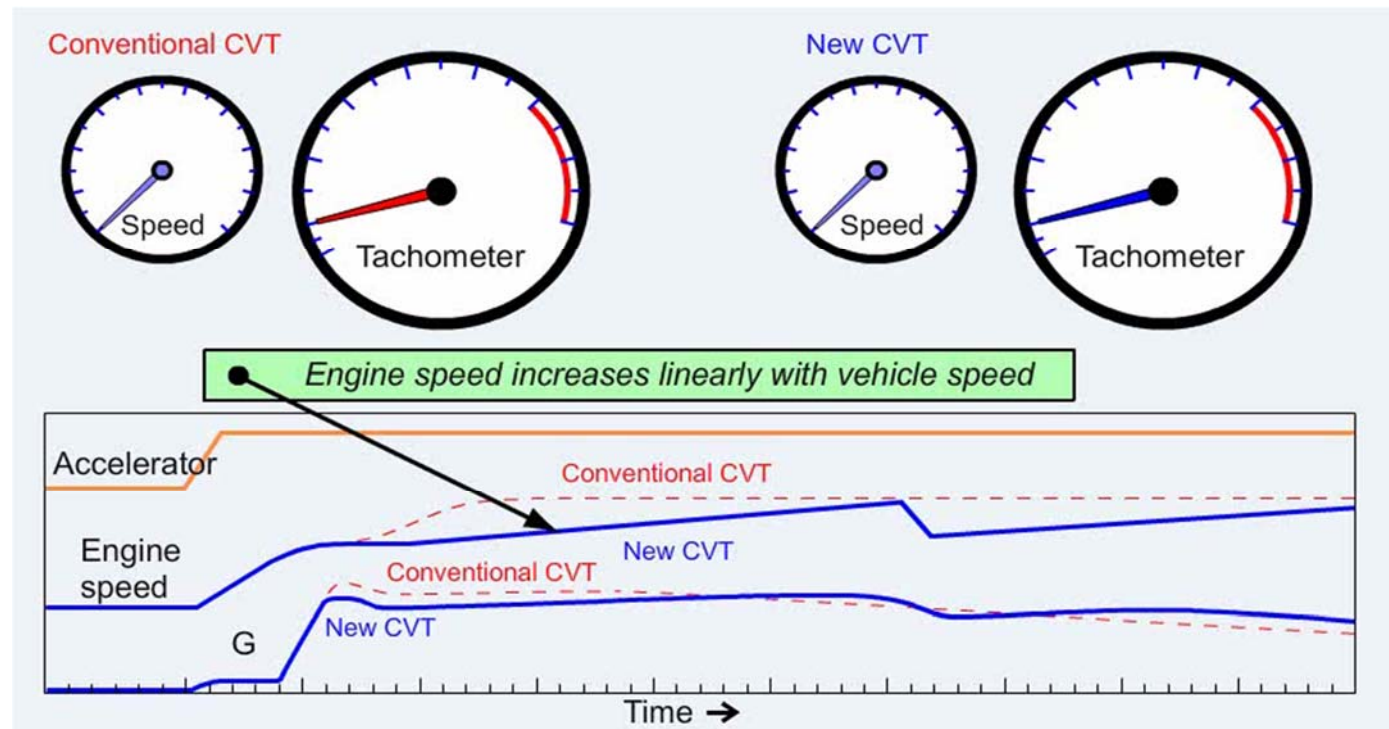
### Improving Fun-to-Drive Performance of CVT



## 6. New CVT

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### Improving Fun-to-Drive Performance of CVT



**Adoption of linear up-shift control to achieve smooth and continuous acceleration**

# Appendix



## Improved combustion

- Rapid combustion
  - High performance, high tumble port
- High compression ratio (10.0)
  - D-4T
  - Water-cooled intercooler
  - Water jacket spacer
  - Cylinder head with water-cooled exhaust manifold

## Loss reduction

- Pumping and cooling loss reduction
  - Atkinson cycle
  - Single scroll turbo
  - VVT-iW (variable valve timing)
- Low friction
  - Modified piston skirt surface
  - Low friction chain
  - Water jacket spacer
  - Cylinder bore quick-warming system
  - Plastic-coated bearing
  - Piston jet control system

Maximum thermal  
efficiency: **36%**



**Installed in Auris**

## Improved combustion

- Rapid combustion
  - High performance, high tumble port
- High compression ratio (10.0)
  - D-4ST
  - Water-cooled intercooler
  - Water jacket spacer
  - 4-in-2 exhaust manifold integrated cylinder head

## Loss reduction

- Reduced pumping loss/coolness loss
  - Atkinson cycle
  - Twin scroll turbo
  - VVT-iW (variable valve timing)
- Low friction
  - Modified piston skirt surface
  - Low friction chain
  - Water jacket spacer
  - Cylinder bore quick-warming system
  - Resin-coated bearings
  - Piston jet control system

Maximum thermal  
efficiency: **36%**



**Installed in Crown**

## Combustion technology

- **Advanced thermal insulation diesel combustion**
  - Low-flow, high-efficiency intake ports
  - Taper lip combustion chamber
  - Fuel injection strategy (robust combustion)
  - Thermo Swing Wall Insulation Technology

## Structural technology / highly functional devices

- **Adoption of appropriate displacements (right-sizing)**
  - Uniform structure: 2.4 & 2.8 L
- **Various loss reduction**
  - Adoption of low-friction technologies from gasoline engines and low thermal capacity structure
- **Compact and highly efficient wide-range turbocharger**

## Clean catalyst technology

- **High-performance urea SCR & compact catalyst**
  - High-performance and compact urea SCR system (Toyota-first)
  - Compact DOC & DPF with low use of precious metals

DOC : Diesel Oxidation Catalyst

DPF : Diesel Particulate Filter

SCR: Selective Catalytic Reduction

**Maximum thermal  
efficiency: 44%**

World-leading  
for passenger  
vehicle



**Installed in Prado**