TOYOTA's Environmental Technology

TOYOTA

Vehicles that are compatible with the Environment

* **High Energy Efficiency**
  (Reducing CO2 Emission)
* **Low Exhaust Emissions**
  (PM, NOx => ozone)

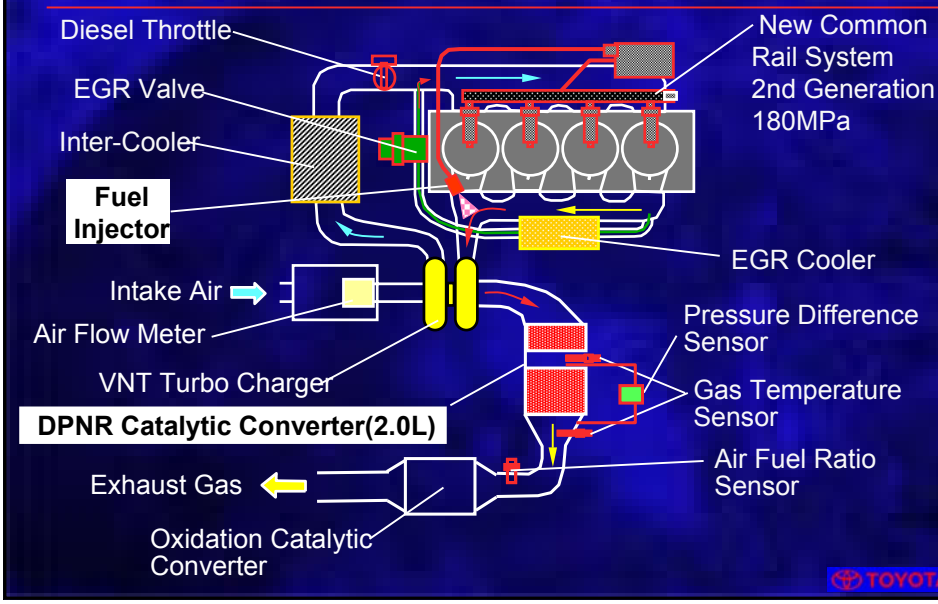
Diesel ⇩ **TOYOTA D-CAT**

Petrol ⇩ **TOYOTA Hybrid System**

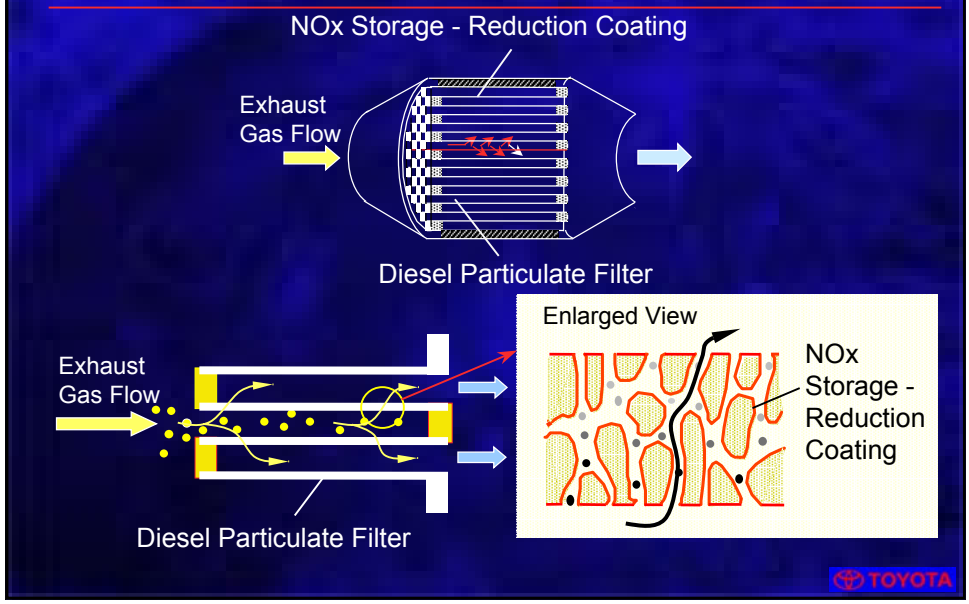
TOYOTA

TOYOTA D-CAT

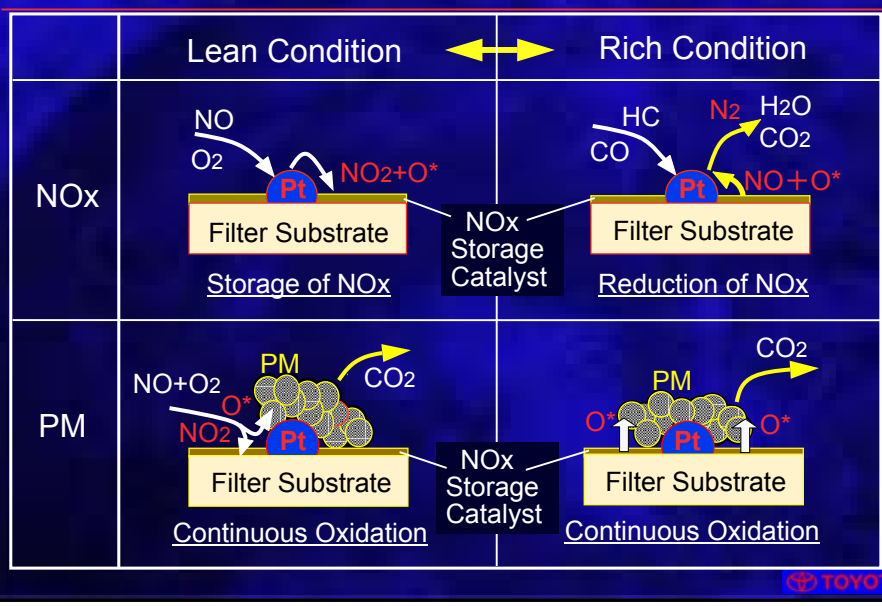
System configuration



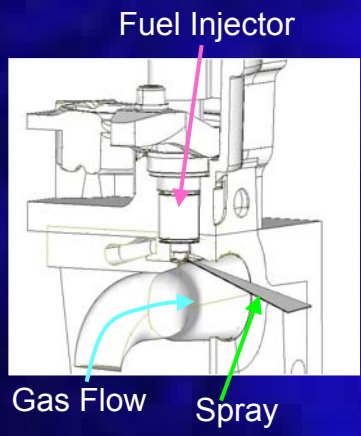
DPNR catalyst cross-section



DPNR system purification mechanism



Additional Fuel Injector

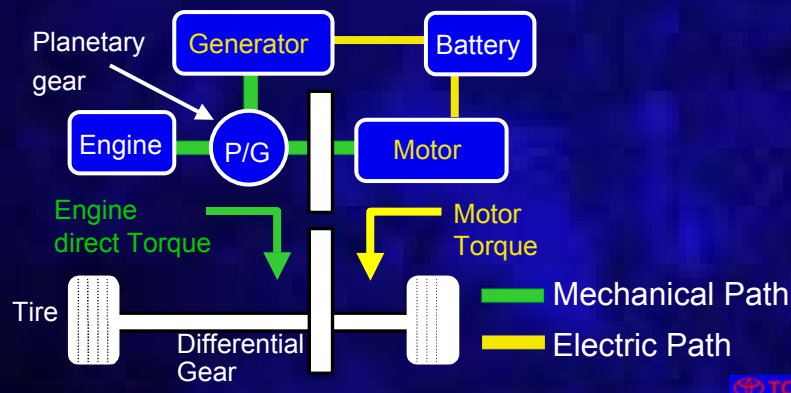


TOYOTA Hybrid System

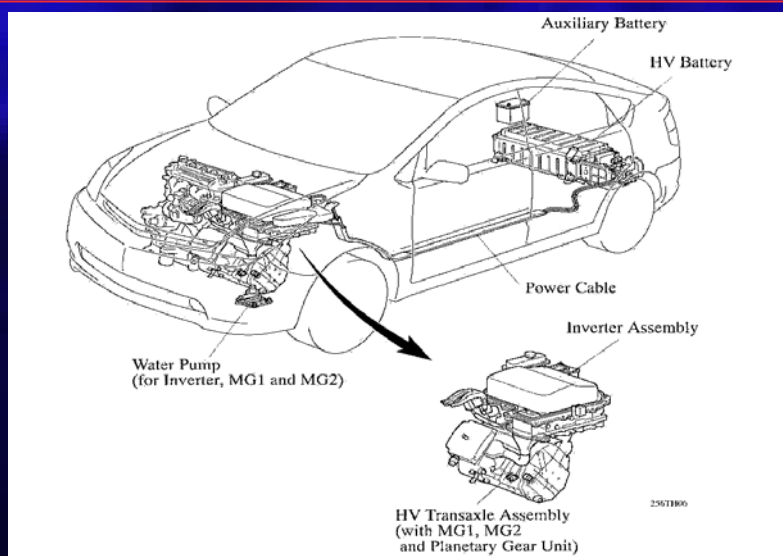
HYBRID SYNERGY DRIVE

Toyota Hybrid System (THS)

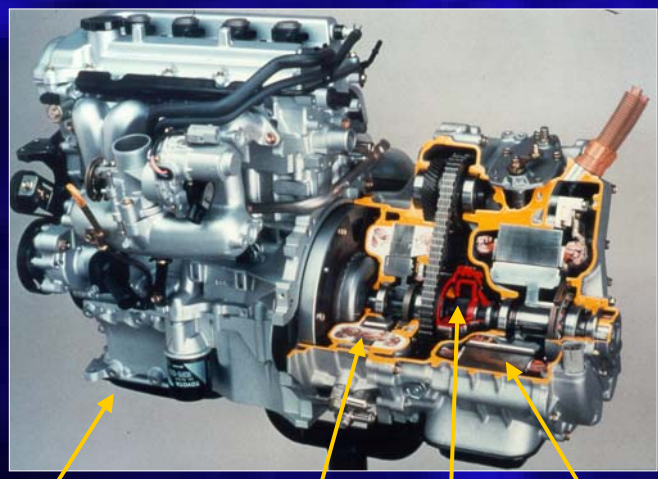
- Vehicle is propelled by engine and/or motor
- Strong hybrid with high power NiMH battery (EV driving)
- Engine, motor, generator are connected by planetary gear
- No clutch, no torque converter



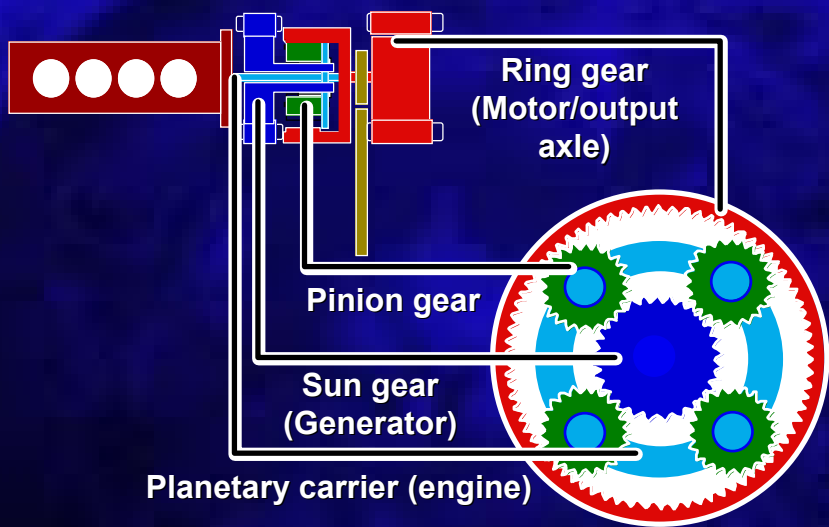
Hybrid Component Location



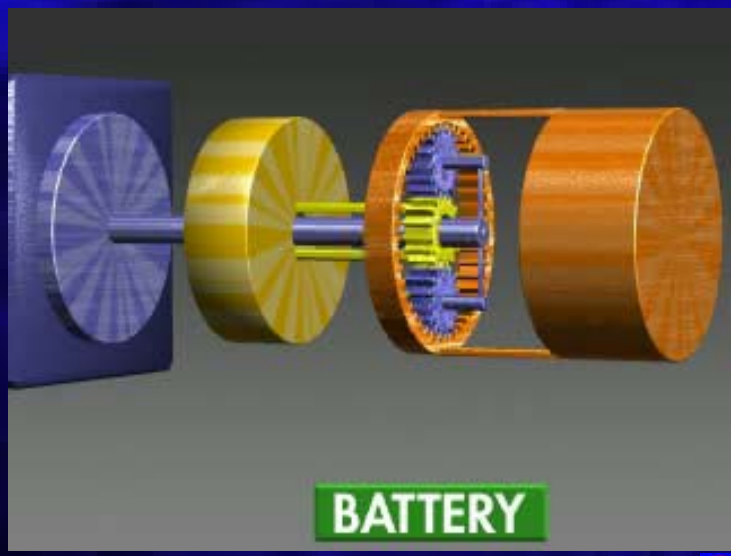
THS Hardware



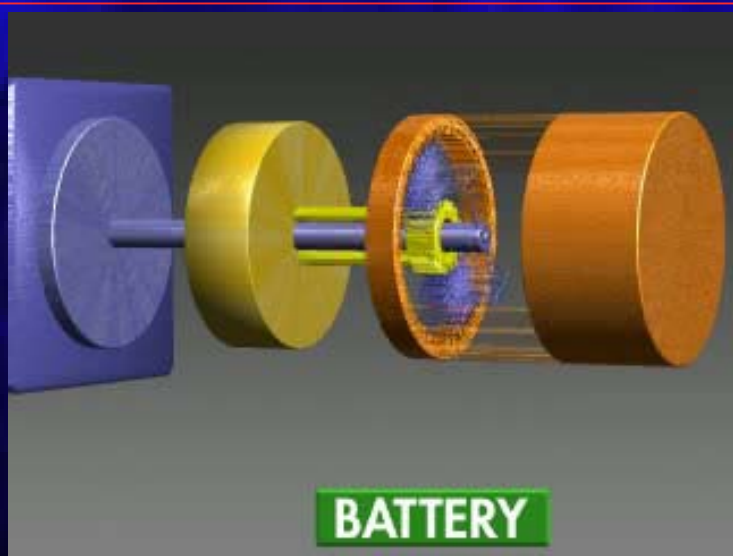
Power Split Device



Take off from 0km/h



Deceleration



Vehicles that are compatible with the Environment

* **High Energy Efficiency**
(Reducing CO2 Emission)

- **Highly efficient engine**
- **Optimised vehicle / system efficiency**
- **Regenerative Braking**

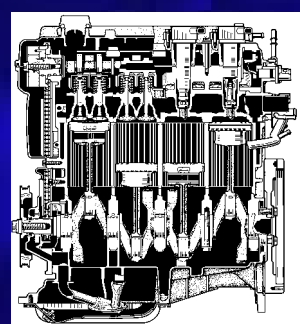
Highly efficient Engine

Specifications ('03 model)

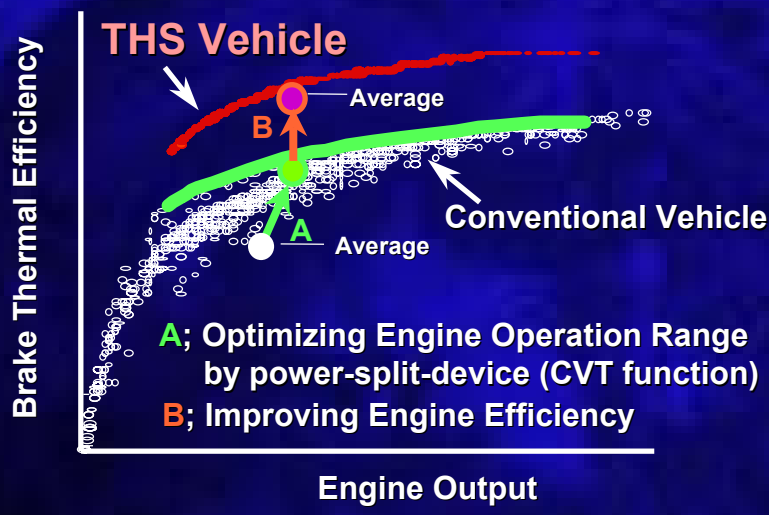
Displacement	1497
Bore x Stroke	φ75 × 84.7
Power	57kW/5000rpm
Mechanical Compression ratio	13.0
Compression actual	4.8～9.3
Intake valve close	70～115° ABDC
Exhaust valve open	32° BBDC

Minimum SFC 225g/kWh

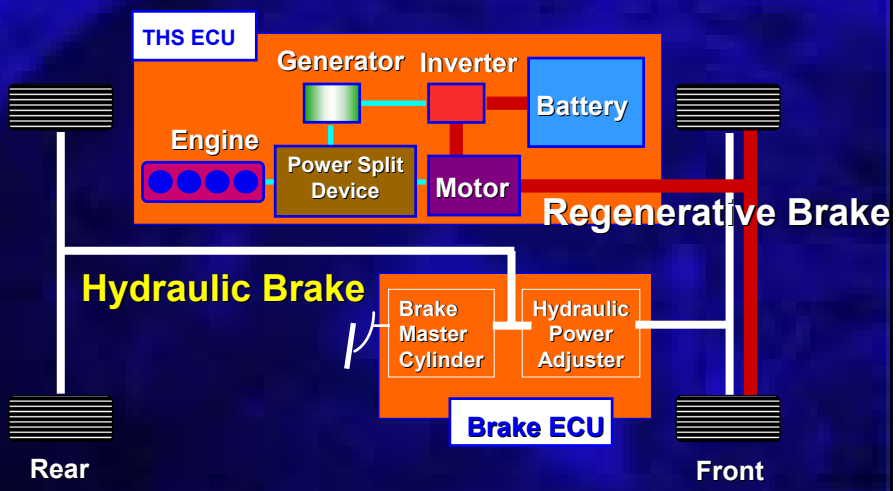
(1) Atkinson cycle
(2) VVT- i
(3) Low friction design
(4) All range λ=1



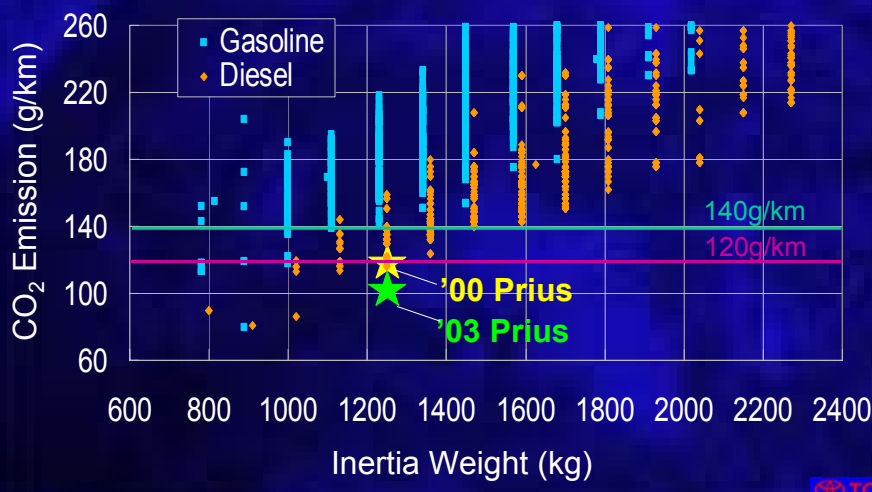
High Vehicle Efficiency => low CO2



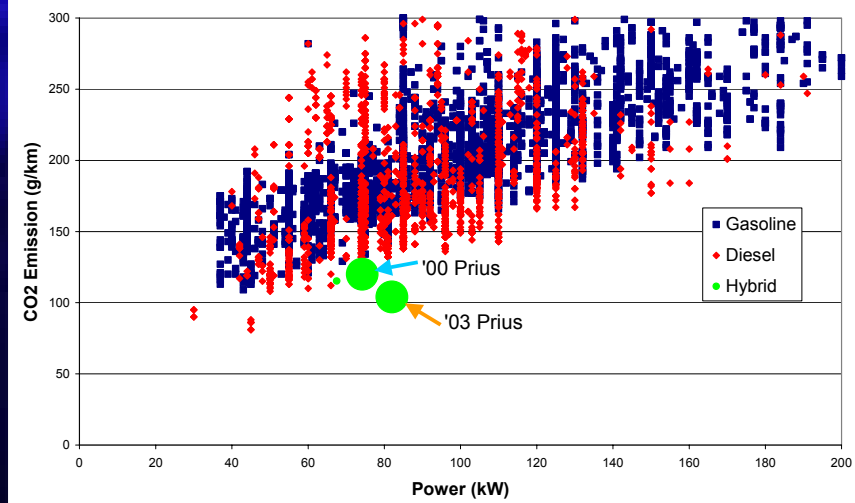
Regenerative Braking System



CO2 Potential

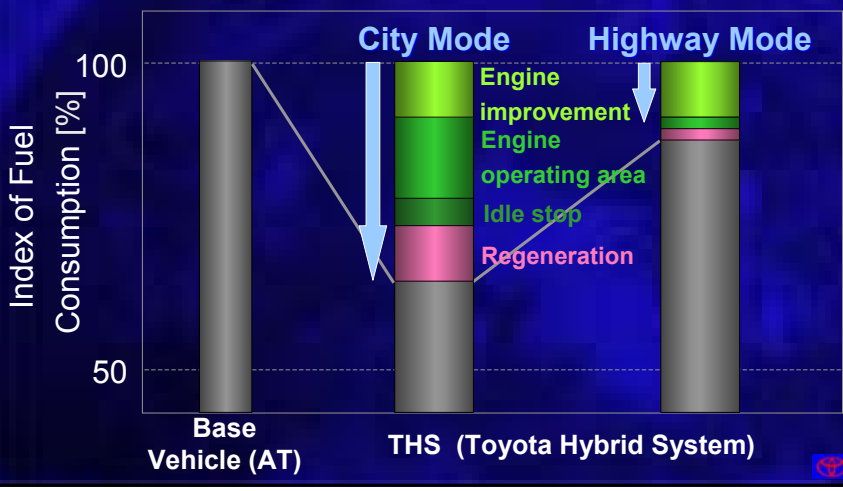


CO2 versus Power



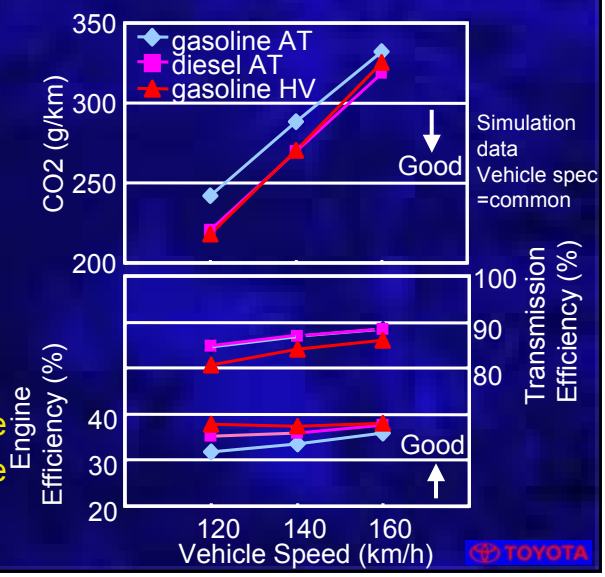
Fuel Consumption Improvement

Engine technologies play a key role
for reduction of fuel consumption



CO2 Potential in Highway cruising

- Cruising mode => reduced HV function
- Gasoline HV: equal CO2 as diesel even in highway driving.
- 1L Diesel = 15% more CO2 than 1L gasoline



Vehicles that are compatible with the Environment

* **High Energy Efficiency**

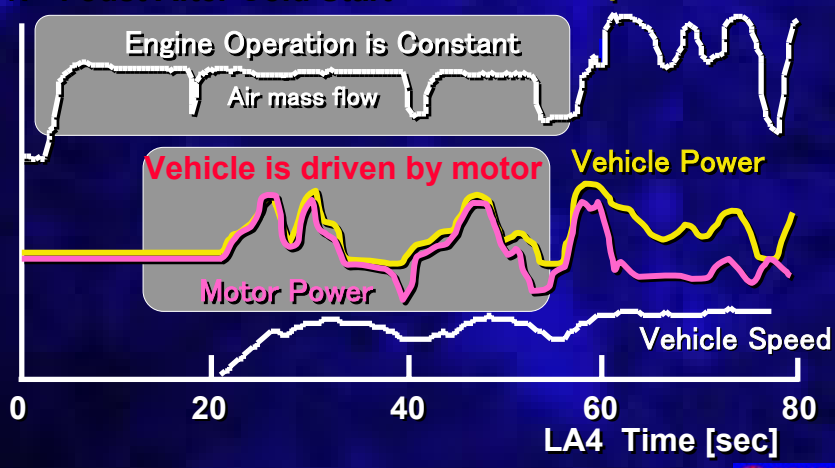
* **Low Exhaust Emissions**
(PM, NOx => ozone)

- Driving by motor (Zero-emission)
- Power assisted by motor at acceleration (all λ=1)
- Engine start/stop by high power MG

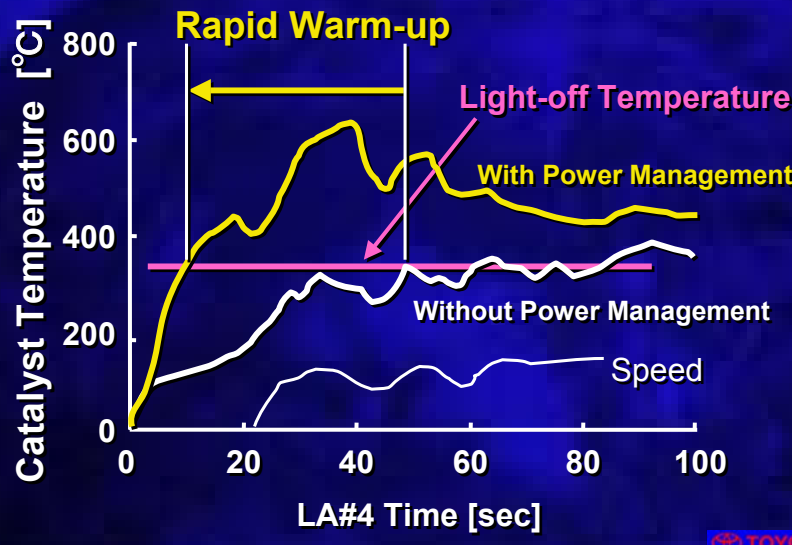
Rapid Catalyst Warm up Using Motor Drive

- **Retard Control**
- **λ =1 Just After Cold Start**

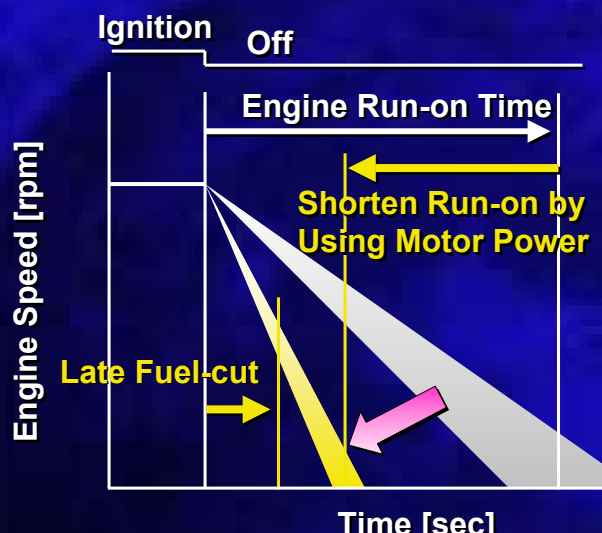
Rapid Catalyst Warm-up

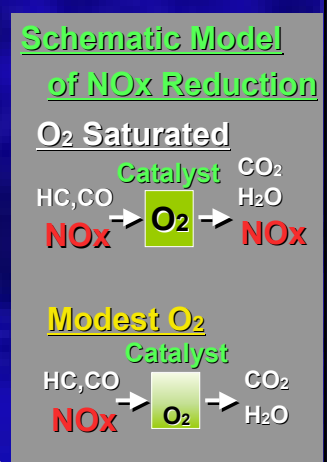


Effect of Rapid Catalyst Warm up Control

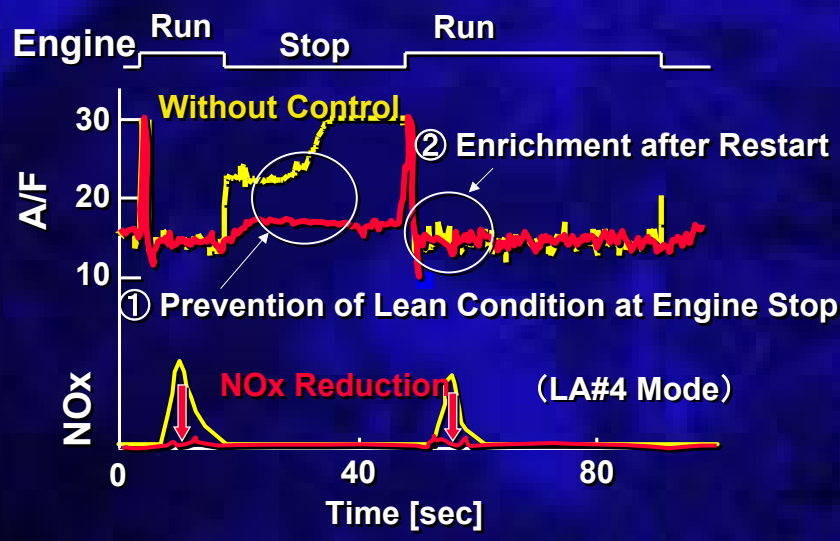


Engine Stop Control for lowest NOx



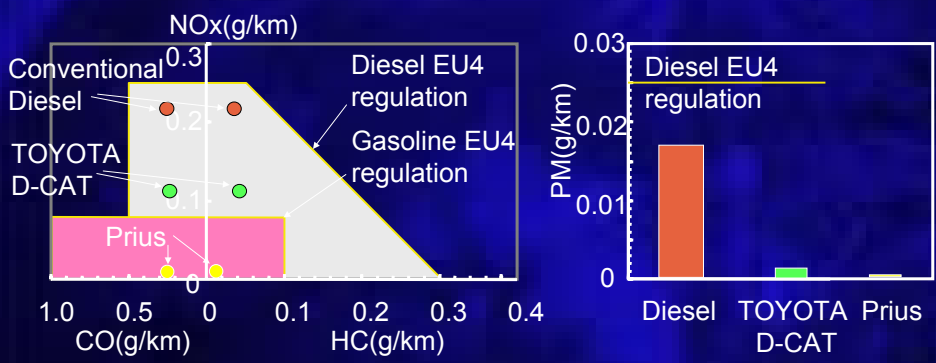


NOx emission effect at Stop&Go



Emission Potential of TOYOTA's environmental technologies

- Prius: NOx and PM: Lowest in city and highway driving



In house data

Environmental summary

- Prius: Most environmental friendly car

	CO2	NOx + PM emissions
City	Prius	Prius
Highway (120~140km/h)	Prius = Diesel	Prius
Highspeed (160km/h)	Diesel	Prius

Toyota D-Cat: Clean Diesel with low NOx + PM

FIA / ADAC Ecotest

FIA / ADAC Ecotest

- **Toyota Prius : most eco-friendly car out of 113 tested vehicles**

Untere Mittelklasse							
Toyota Prius 1.5 Hybrid	1497/57	Euro4	5,0 S	50	39	89	★★★★
Honda Civic 1.3 DSi IMA Hybrid	1339/61	Euro4	5,6 S	48	35	83	★★★★
Peugeot 307 HDi FAP 135 [1]	1997/100	Euro4	5,5 D	44	30	74	★★★★
Mercedes A140	1397/60	Euro4	7,2 S	48	22	70	★★★★

- **Toyota Avensis D-4D D-CAT best in D-segment, first diesel to reach "green" emission**

Mittelklasse							
Toyota Avensis 2.0 D-CAT [2]	1995/85	Euro4	6,0 D	45	34	79	★★★★
Opel Vectra 1.8 16V	1796/90	Euro4	7,3 S	46	31	77	★★★★
Ford Mondeo 1.8 SCi [3]	1798/96	Euro4	7,7 S	49	28	77	★★★★
Hyundai Elantra 2.0	1975/105	Euro4	7,8 N	48	27	75	★★★★
BMW 318i	1995/105	Euro4	8,0 SP	49	25	74	★★★★
Mazda 6 1.8	1798/88	Euro4	7,8 S	47	27	74	★★★★
Skoda Octavia Combi 1.8 Turbo	1781/110	Euro4	8,1 S	46	25	71	★★★★
Honda Accord Tourer 2.2 i-CTDi	2204/103	Euro4	6,3 D	39	32	71	★★★★
Toyota Celica 1.8 TS	1796/141	Euro3	8,5 S	49	22	71	★★★★
Toyota Avensis 2.0 [3]	1998/108	Euro4	8,0 S	44	26	70	★★★★

TOYOTA

Vehicles that are compatible with the Environment

* **High Energy Efficiency**
  (Reducing CO2 Emission)
* **Low Exhaust Emissions**

… and

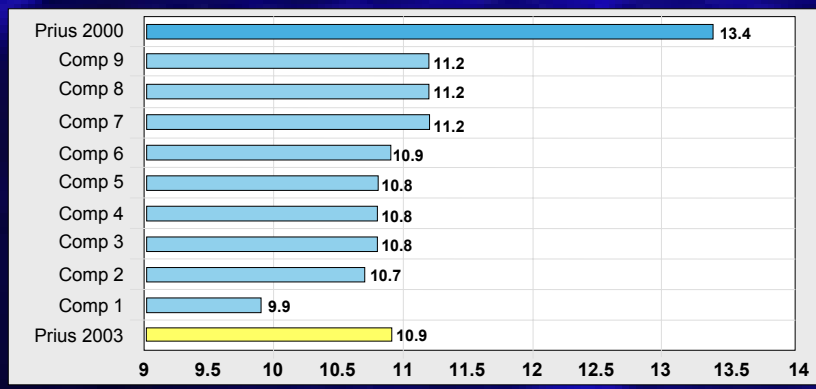
* **attractive for the customer**

Acceleration performance
"TOYOTA" reliability & durability
High comfort

TOYOTA

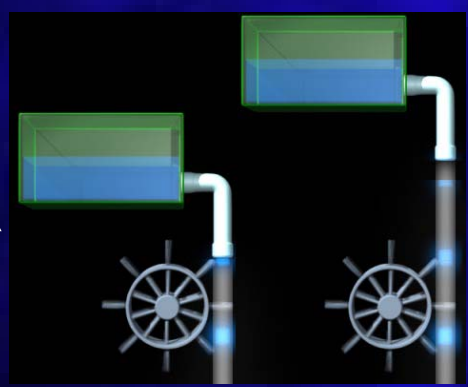
Competitive Performance

0-100km/h: '03 Prius in comparison to '00 Prius and Diesel market



Hybrid Synergy Drive

Power (W) = Current (I) x Voltage (V)



Prius'2000

274V

New Prius:

Higher level

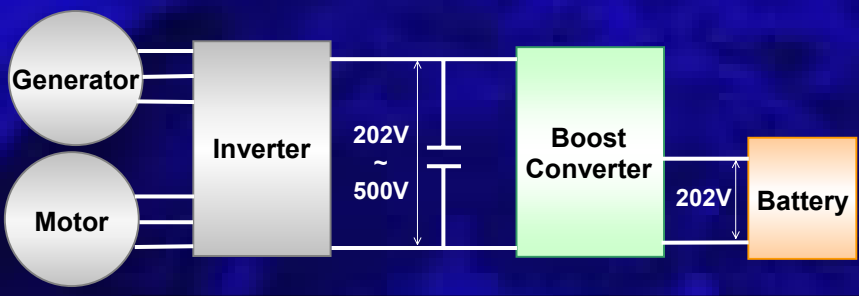
= Higher voltage

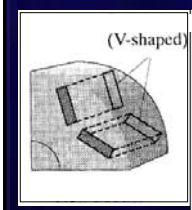
=> Lower losses

500V

High power by high voltage

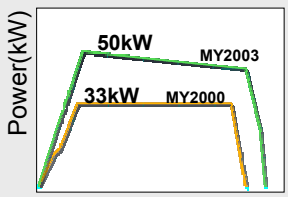
Hybrid Synergy Drive



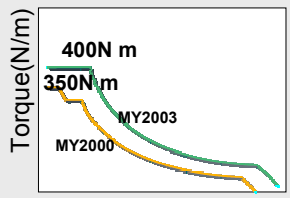


+ cost optimisation

Motor power

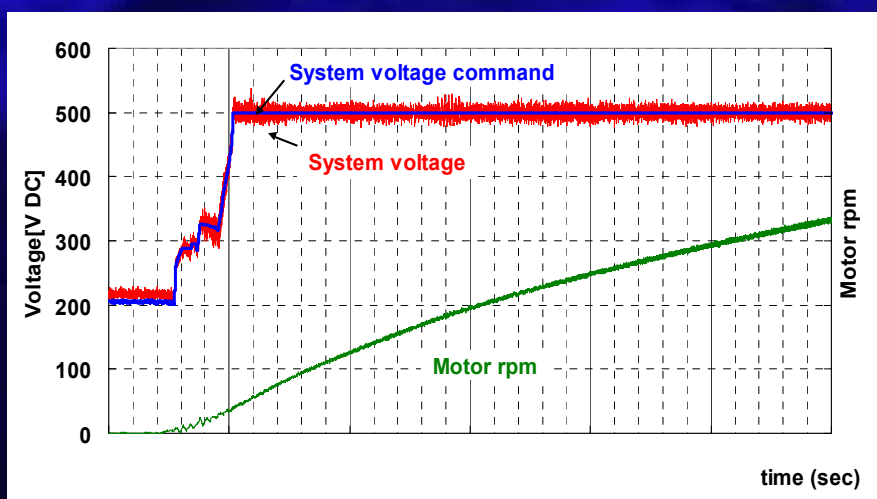


Motor torque

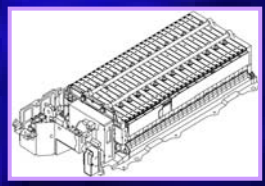


Hybrid Synergy Drive

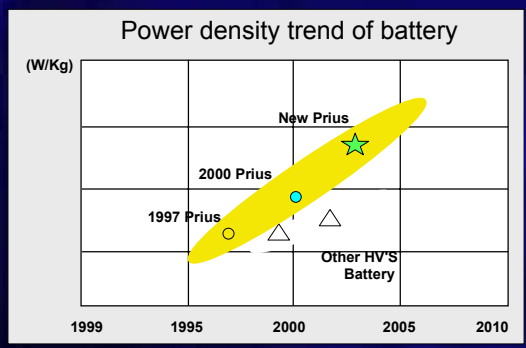
Full acceleration

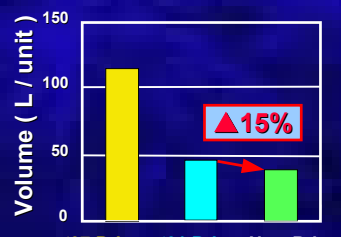


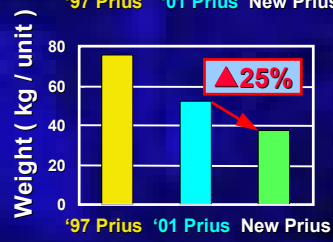
NiMH Battery



- Air-cooled (3 sensors)
- integrated Battery-CU
- 28modules x 7.2V
  => 201.6V

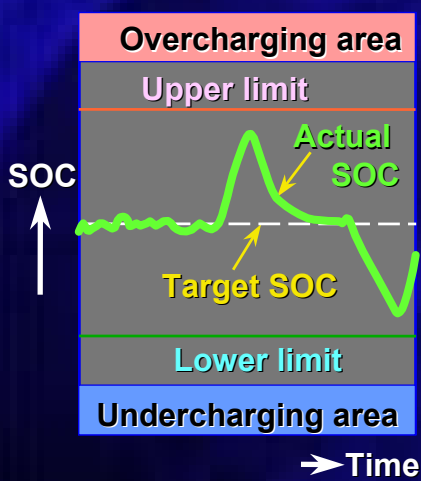


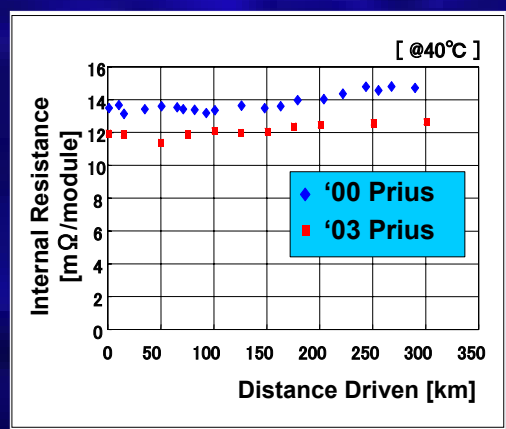




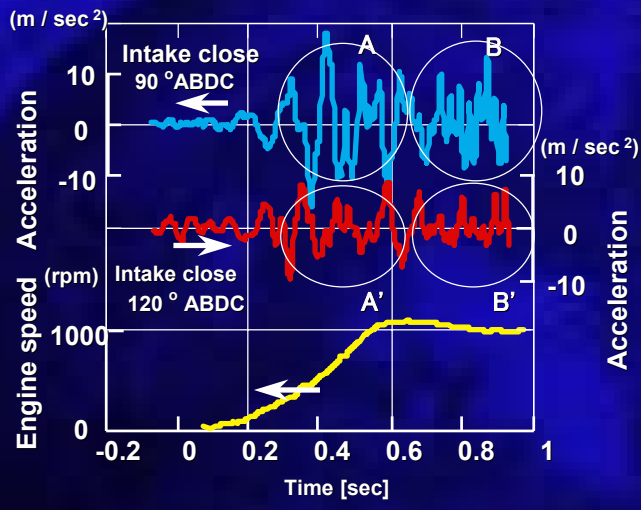
State of Charge Control

- Key for highest durability





Engine start/stop by generator



- Low noise by engine stop
- Low vibrations by low compr. ratio at engine start

Diesel Hybrid

Toyota Dyna Hybrid (2003)
Hino Dutro Hybrid (2003)

Hino Ranger Hybrid (4'2004)

Vehicles that are compatible with the Environment

* **High Energy Efficiency**

* **Low Exhaust Emissions**

… and

* **attractive for the customer**

What's the benchmark for the future ?

Comparison with Fuel Cell in Well to Wheel Efficiency

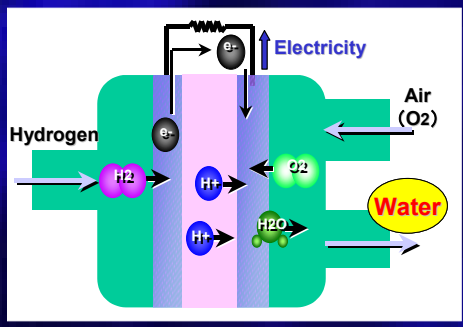
'03 THS exceed '02FCHV efficiency in well to wheel

	Well to Tank (%)	Tank to Wheel (%)	Total Efficiency(%) 0 10 20 30 40
Current Gasoline AT	88	16	14%
'97 THS	88	28	22% (Ref. THS with conventional engine) 25%
'00 THS	88	32	28%
'03 THS	88	37	32%
'02 FCHV	58*1	50	29%
FCHV (Target)	70	60	42%

Toyota Data: Japanese 10-15 mode

*1 Natural gas to hydrogen

Low Temperature Startability



The generated water freezes

Low temperature starting is a major issue

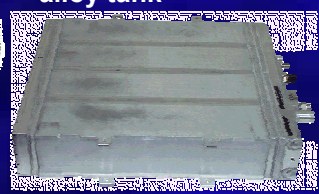
TOYOTA

Hydrogen Storage Technology

High pressure hydrogen tank

Issue: Volume

Hydrogen-absorbing alloy tank



Weight

Liquid hydrogen tank

Boil-off gas

and: Hydrogen Infrastructure ?

TOYOTA

Fuel-Cell Research

- Exciting prototype cars for an exciting technology

Evolution of Hybrid Technology

- HV and FC are based on common technologies
- Easy to transfer the technologies

ICE Hybrid Vehicle

Fuel Cell Vehicle

Engine ⟷ Fuel Cell

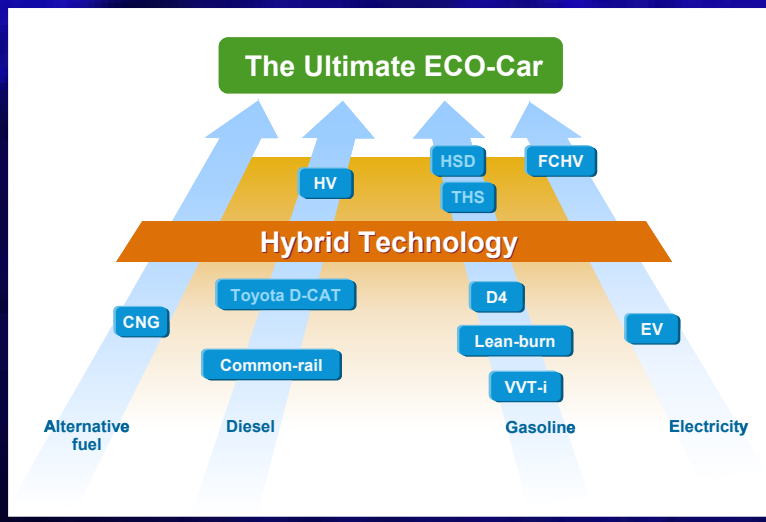
Common Tech.

>Motor
>Inverter
>Battery

>Vehicle power management

>Regenerative braking

Conclusion



Thank you

for your attention