

Examples of Toyota's approach on CO₂ reduction

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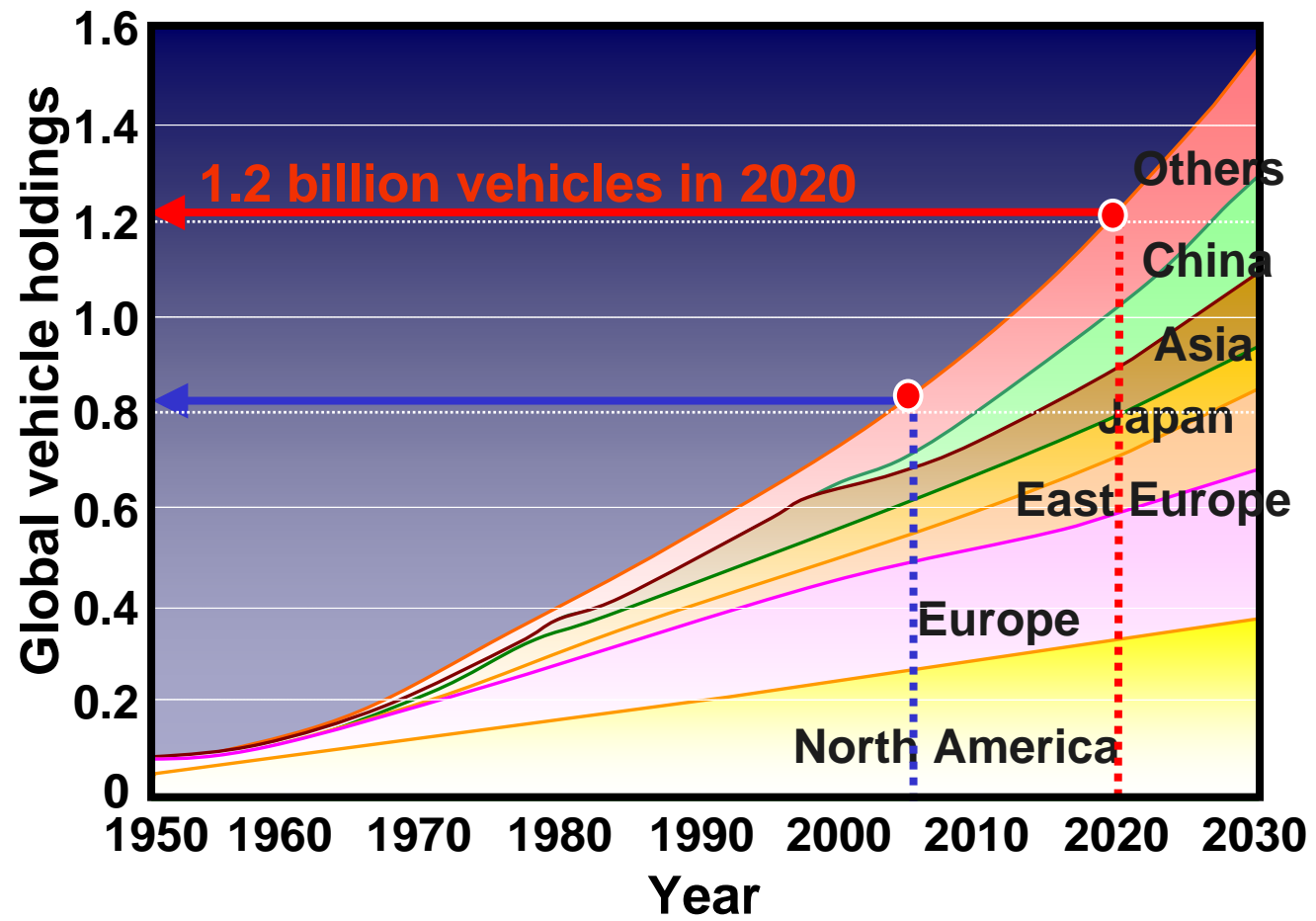
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Vehicle population increase

(billion vehicles)

Source: Handbook of automotive industry 2001



Automobile and Environment

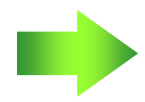
Urban environment



Global environment

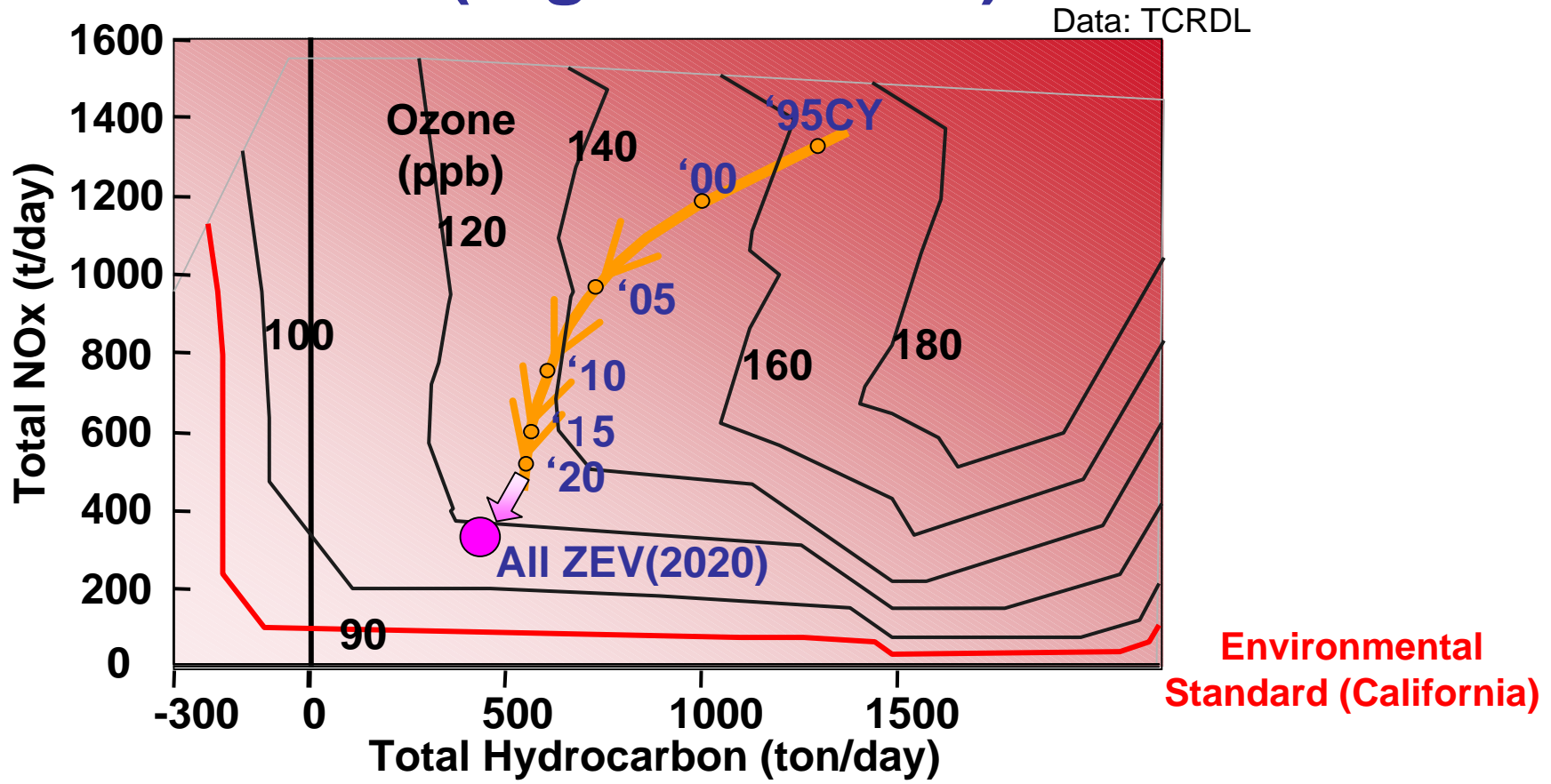


Exhaust emission
Recycling



CO₂
Supply and Demand of Energy

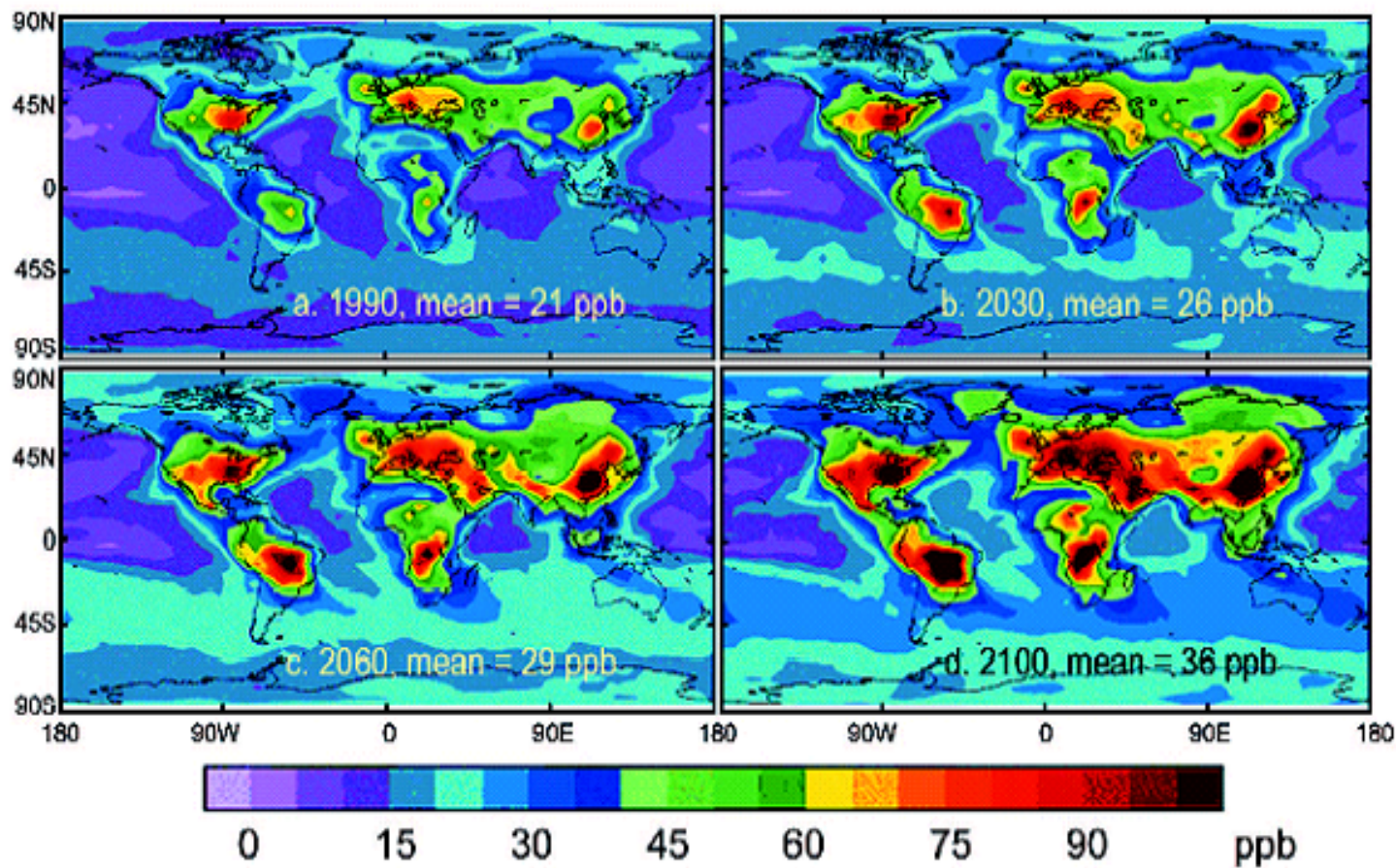
Ozone pollution in urban environment (E.g. California)



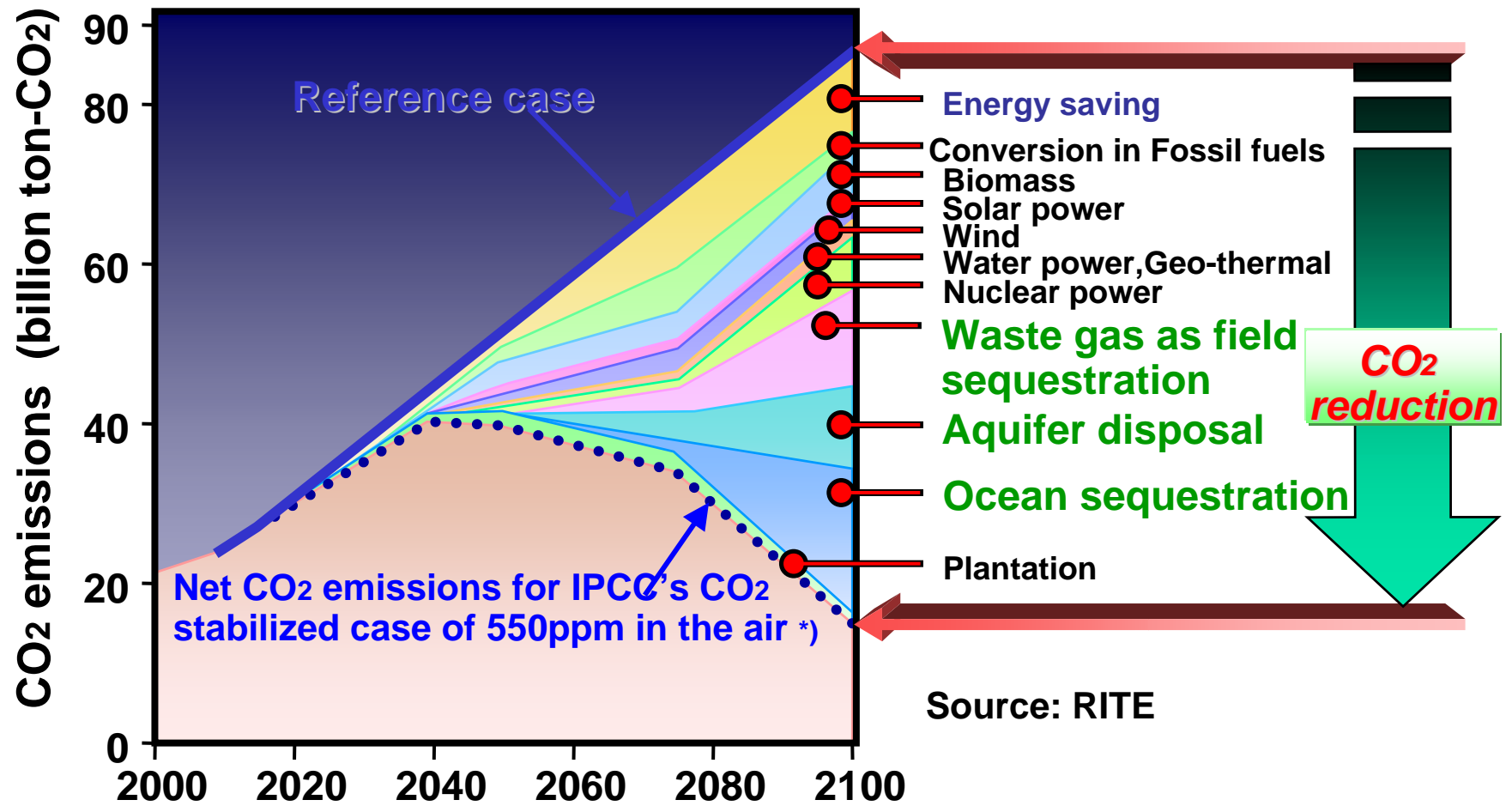
Cf. Excluding emission from biological sources: 300 ton/day

Ozone pollution in global scale

Global surface ozone concentration during the period 1990 – 2100 (Stevenson et al, 1998)

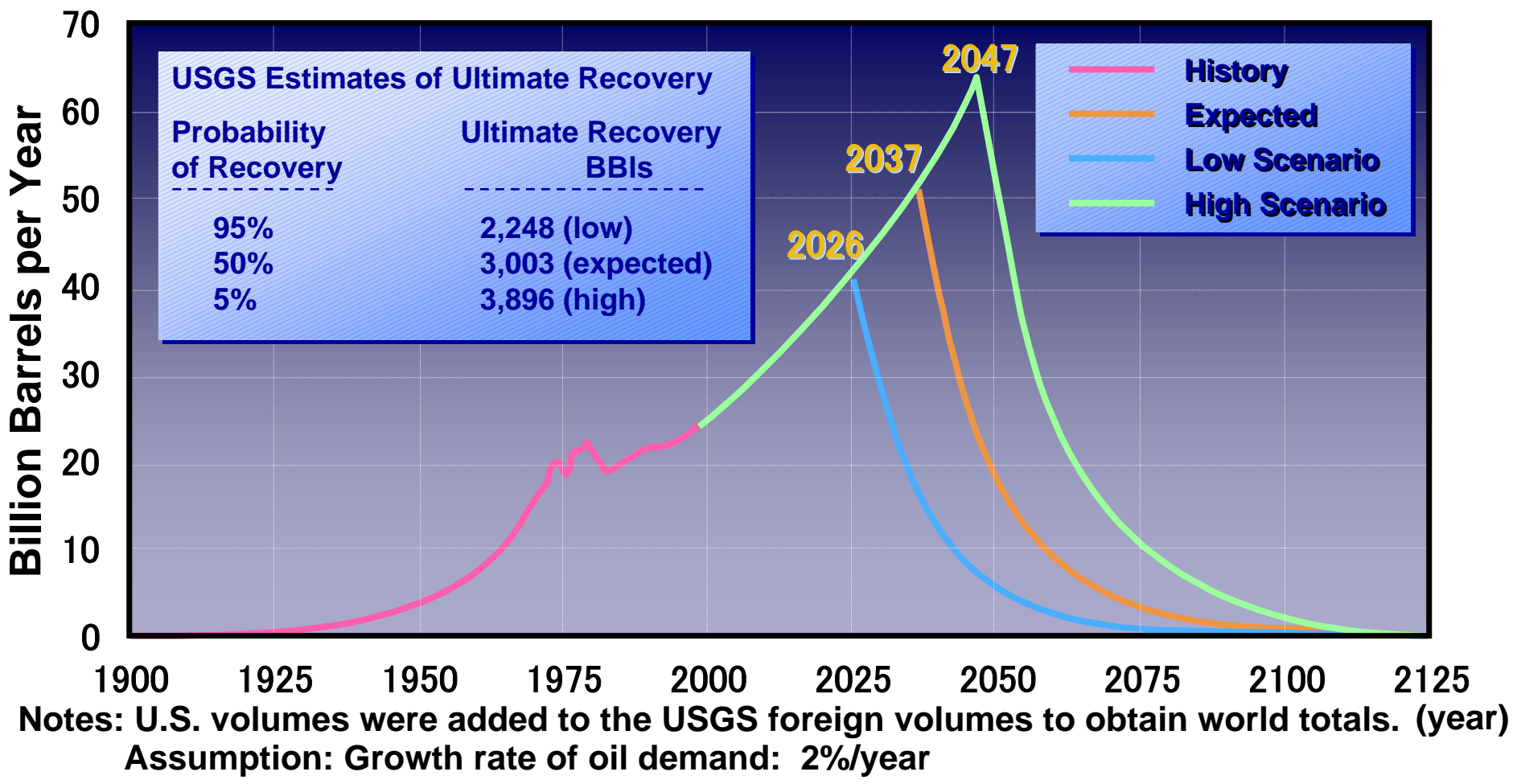


CO₂ scenario

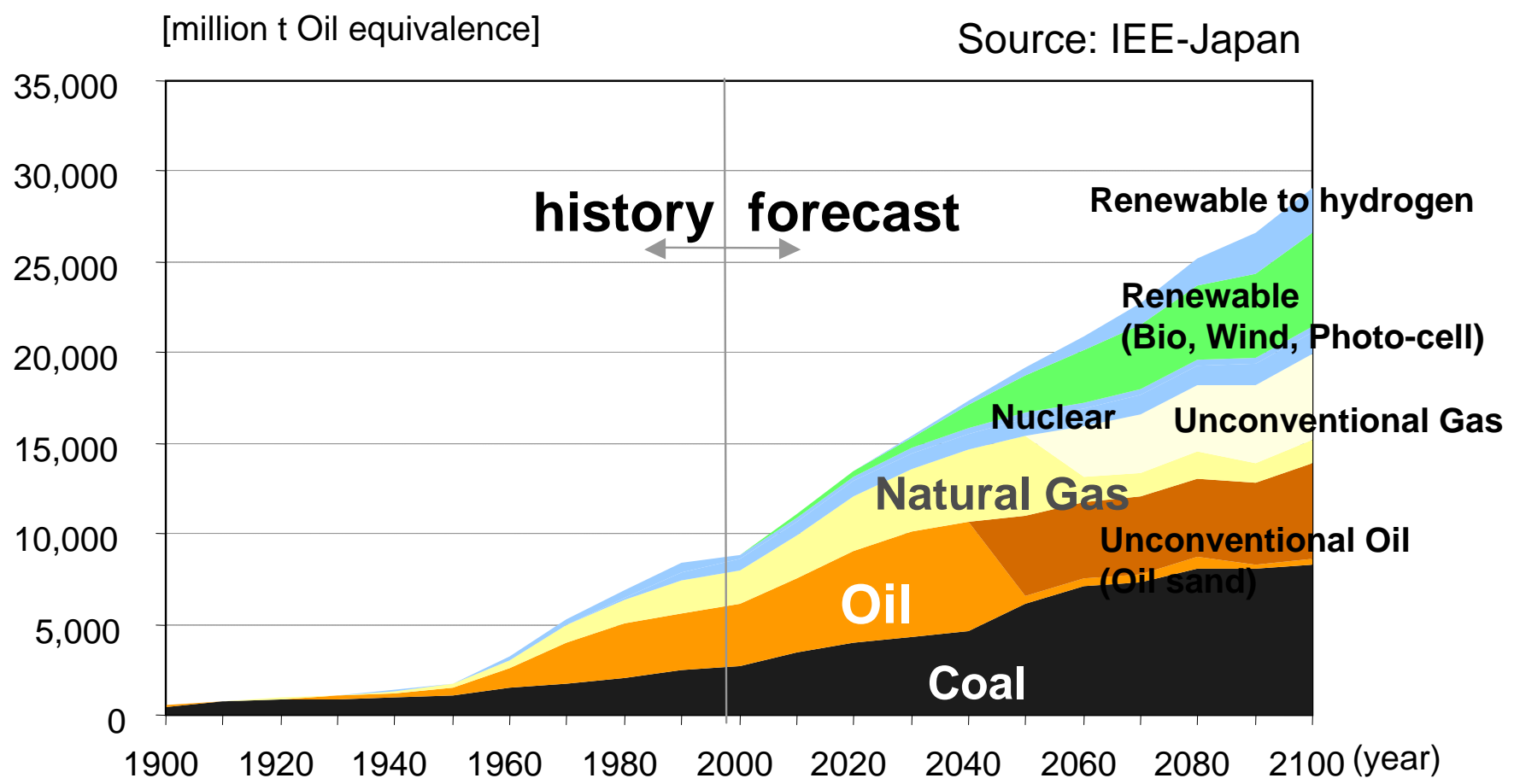


*) IPCC: Intergovernmental Panel for Climate Change

Oil Production Scenario



Primary energy forecast



How the powertrain should look like?

- Drastic CO₂ reduction is needed
- Energy security becomes major concern
- Ambient air quality is still the issue



- Clean emission and low CO₂
- Lowering energy consumption drastically
- Applicable to diversified energy sources








Hybrid Technology

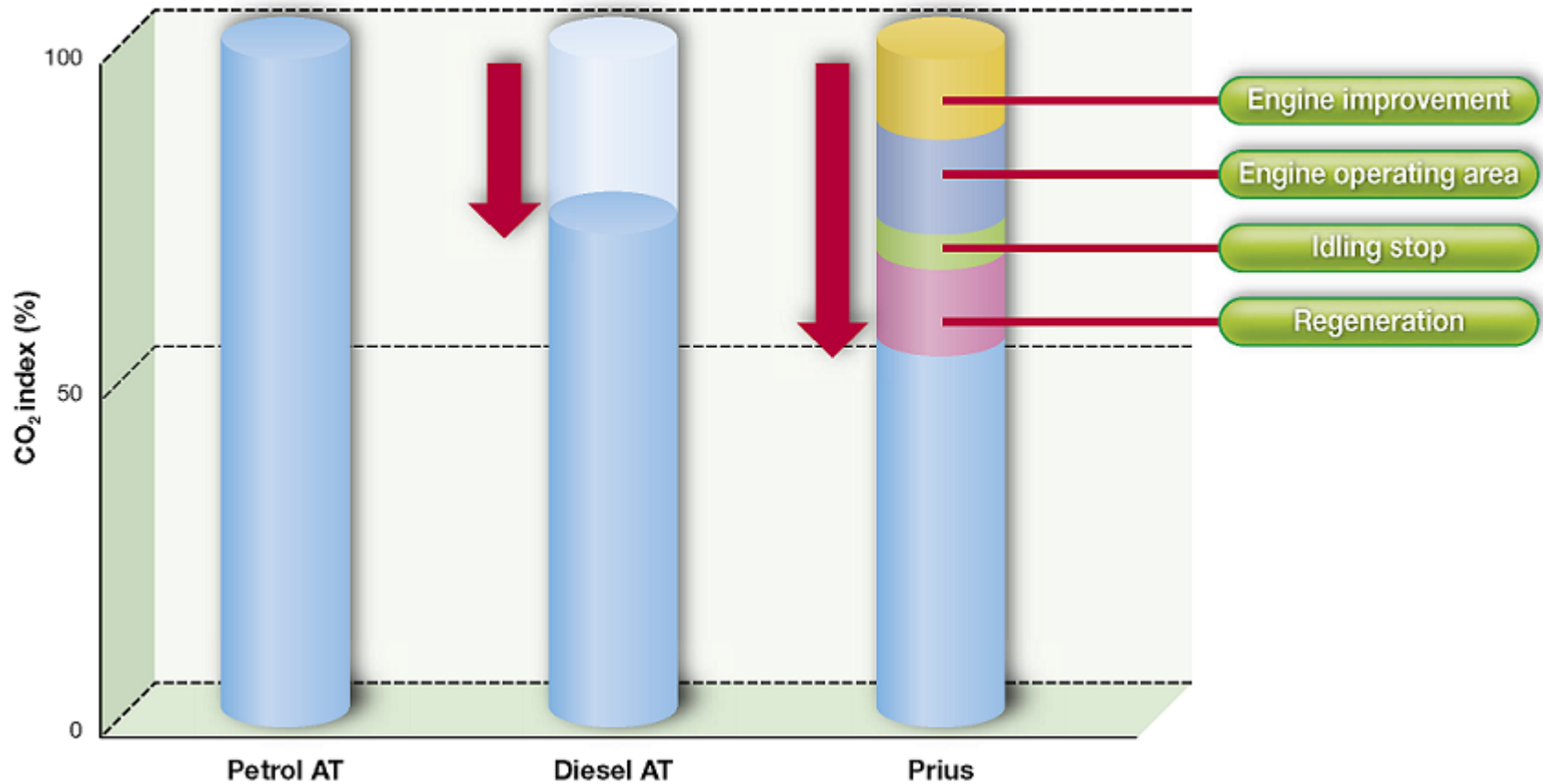
Hybrid Technology

With more than 2 power sources, to enhance fuel economy and environment performance by energy recovery and reuse.

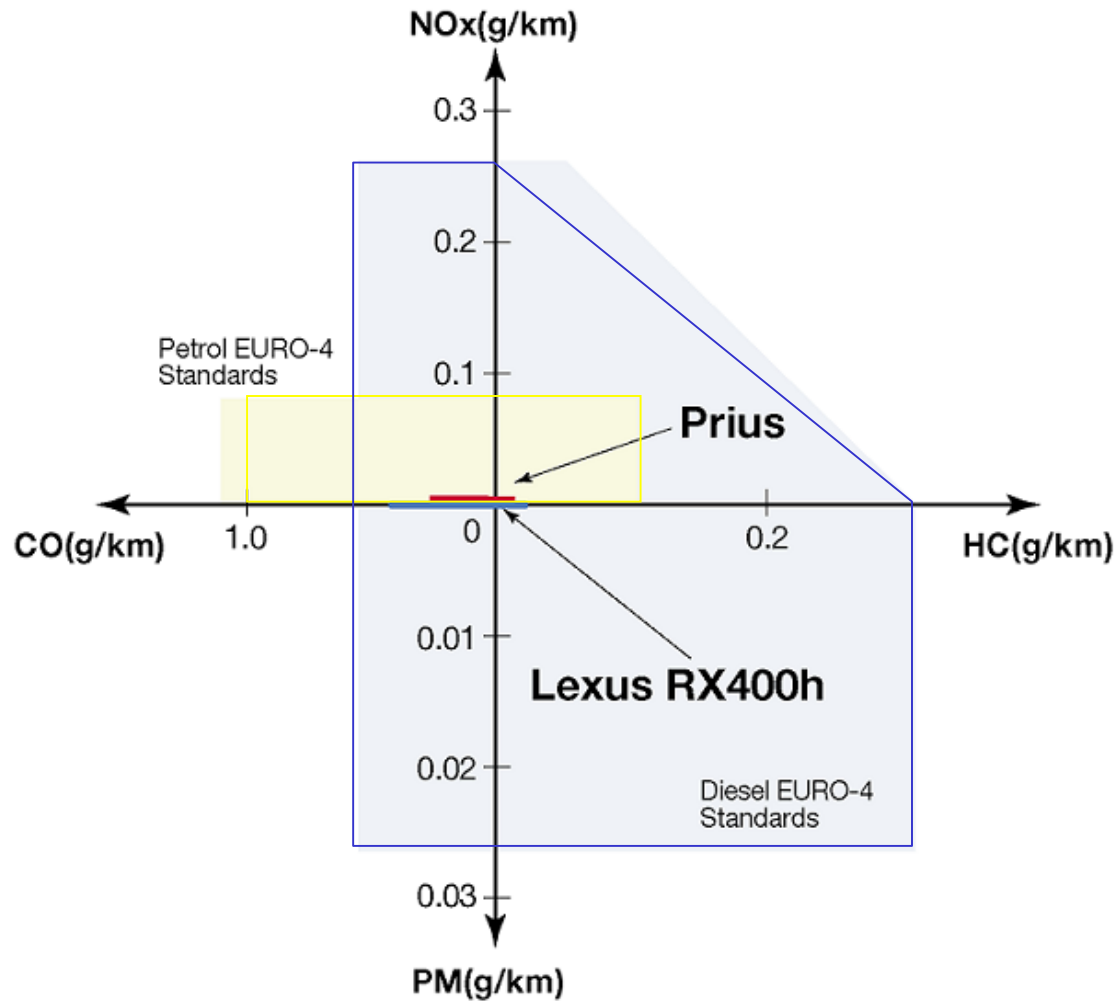
Example in Toyota Prius

				
Start	Driving	Overtaking	Braking	Stop
Engine cut off EV drive	Engine or EV drive or Engine + Motor	Engine + Motor	Engine cut off + Regenerative brake	Engine cut off
Zero fuel consumption	Better thermal efficiency of engine		Energy recovery	Zero fuel consumption

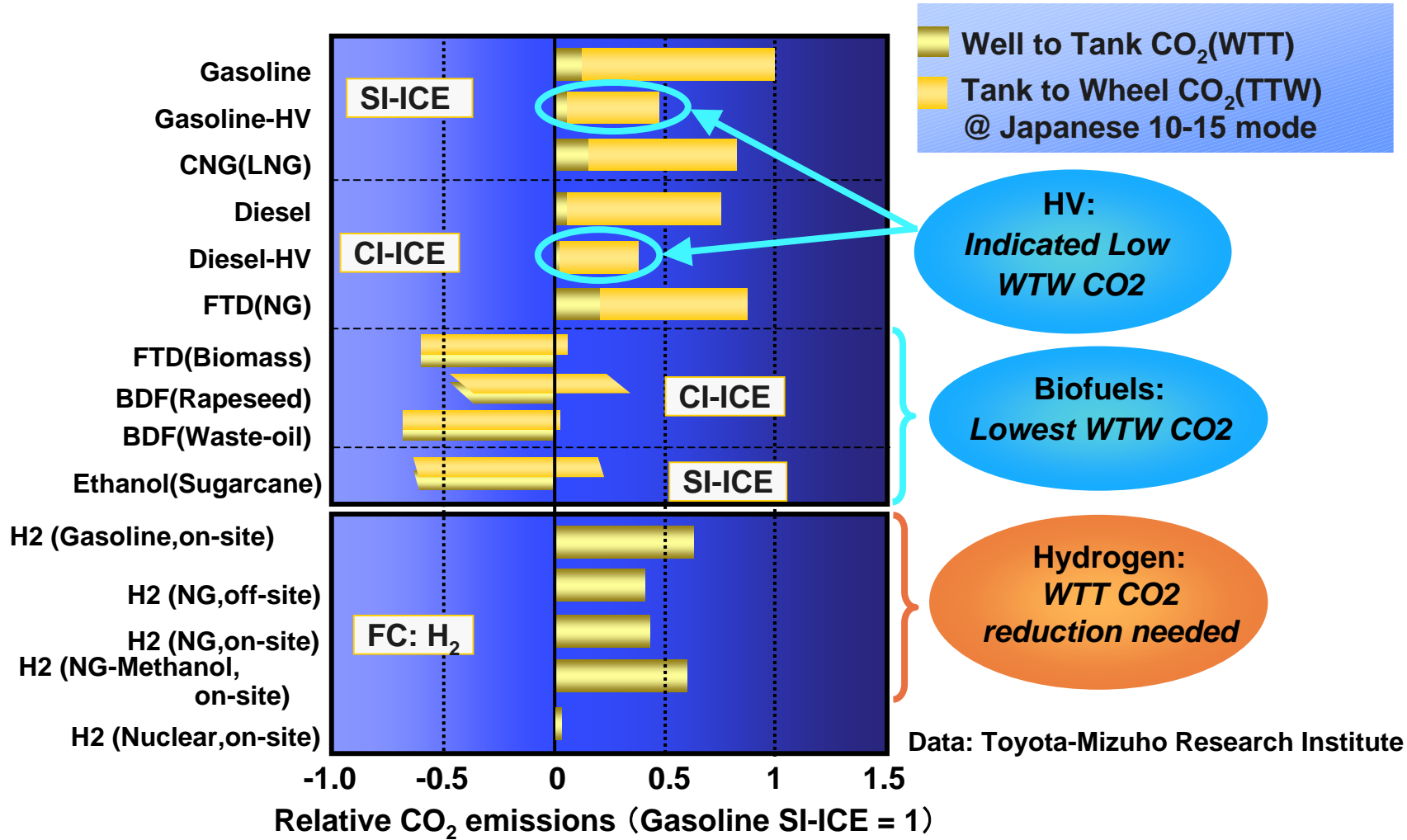
Potential of CO₂ reduction performance



Potential of emission reduction performance



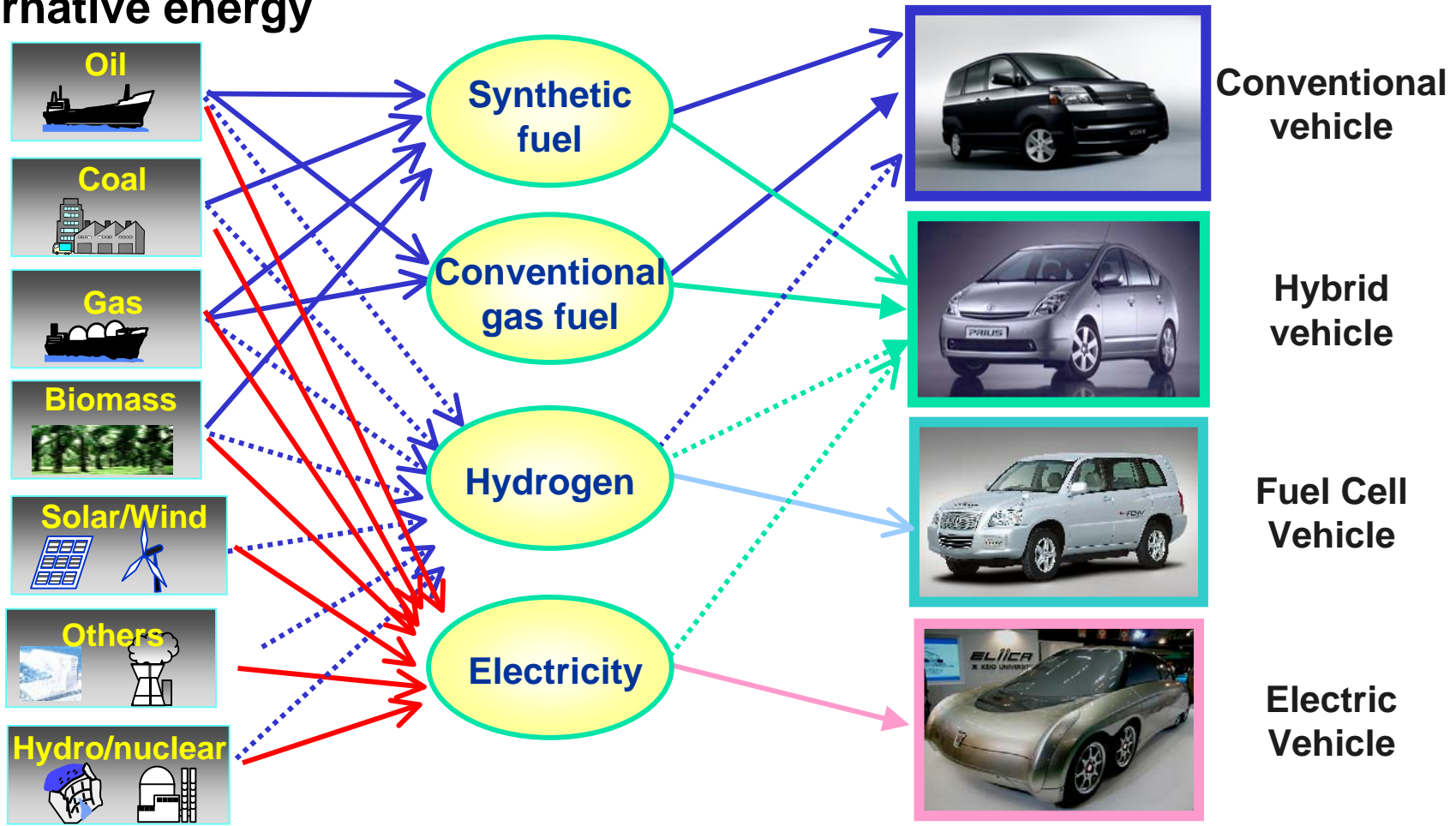
Potential of low 'Well-to-Wheel' CO₂



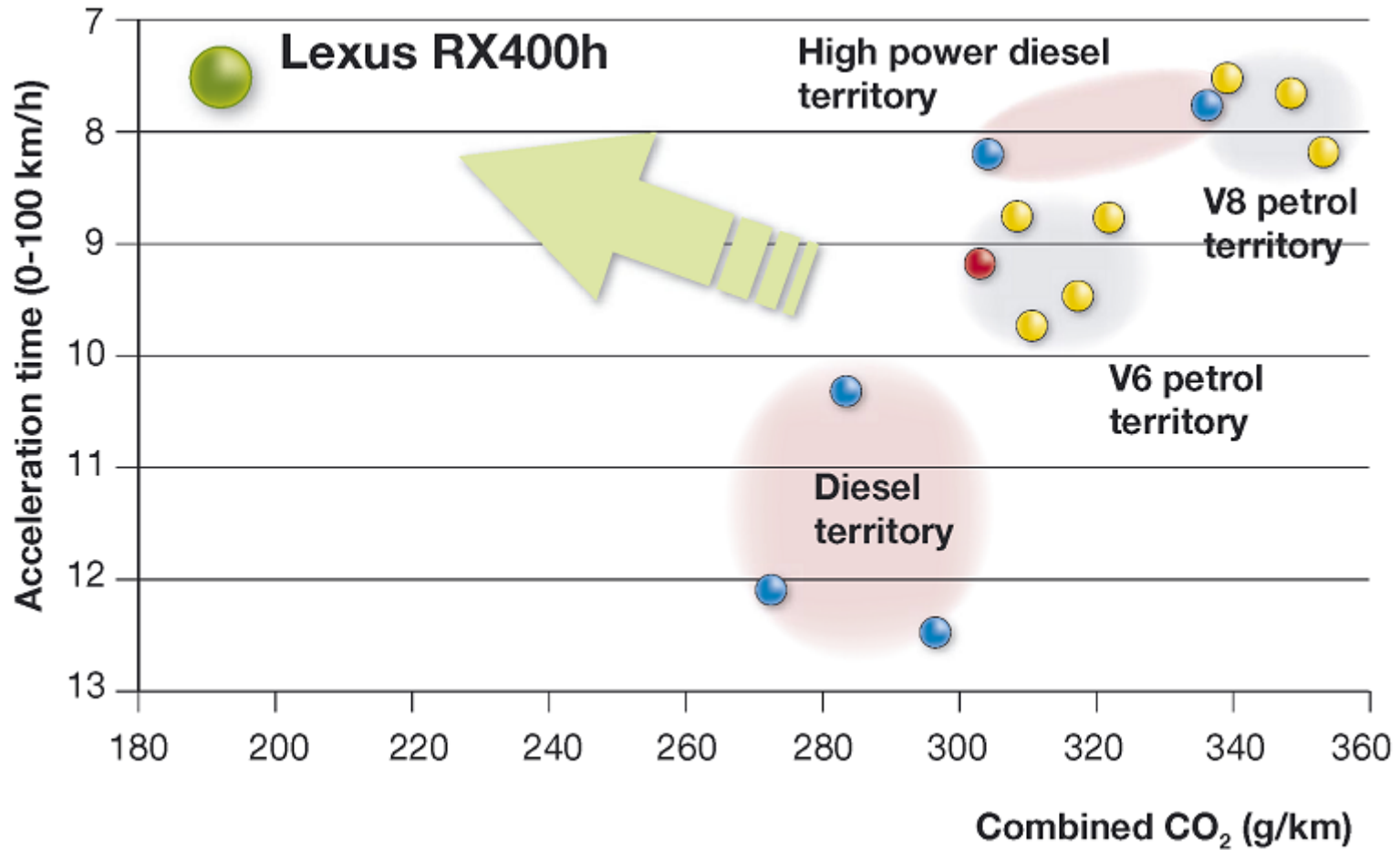
Data: Toyota-Mizuho Research Institute

Applicable to different power sources

Alternative energy



Outstanding in driving performance



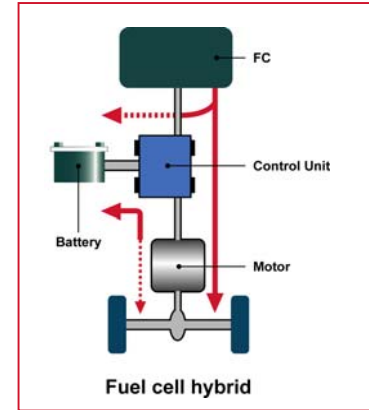
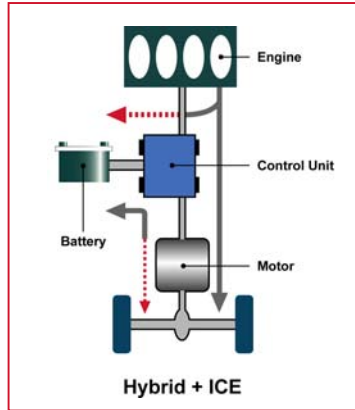
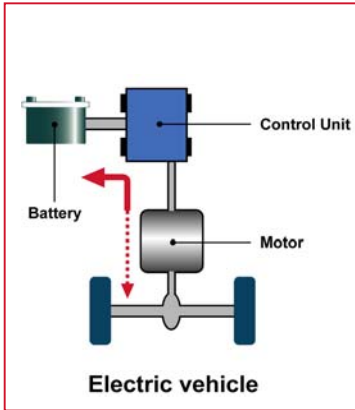
Attractive features: EV mode



Attractive features: Power Generator



Pathway towards Fuel Cell Hybrid



Regenerative brake

Electric Motor control

High output density electric motor

High output density battery

+

Hybrid system control

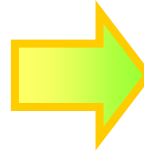
+

Fuel Cell Stack

In-house developments

Issues on Hybrid

Cost



Less than 'Clean Diesel'

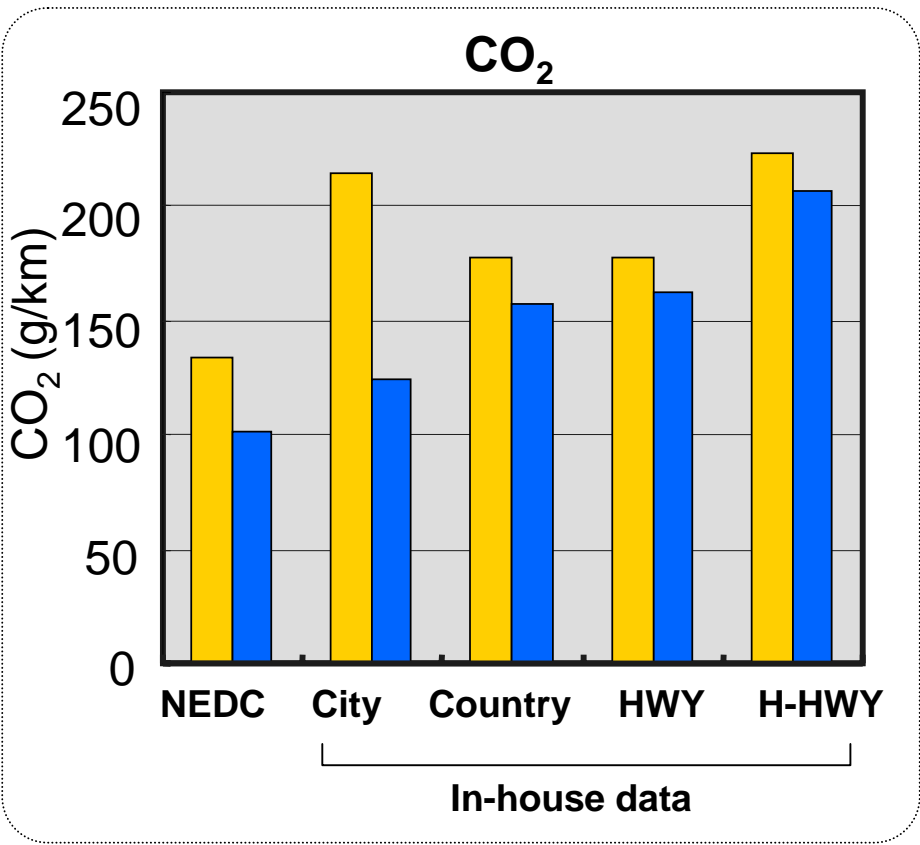
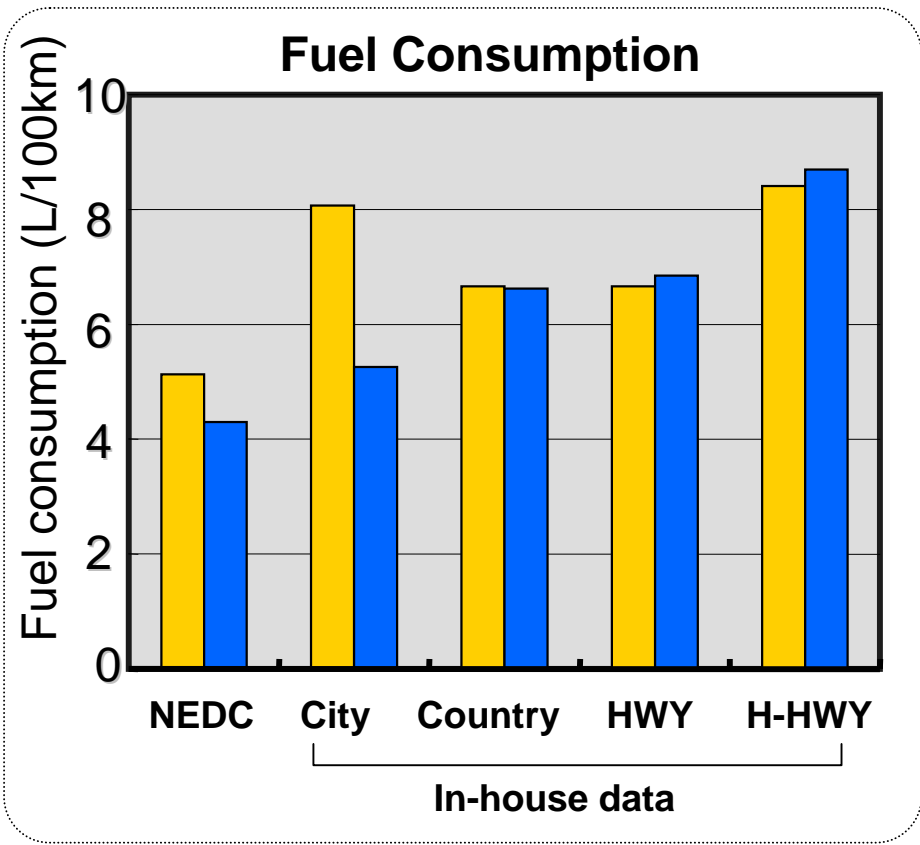
**Fuel Consumption on
highway**



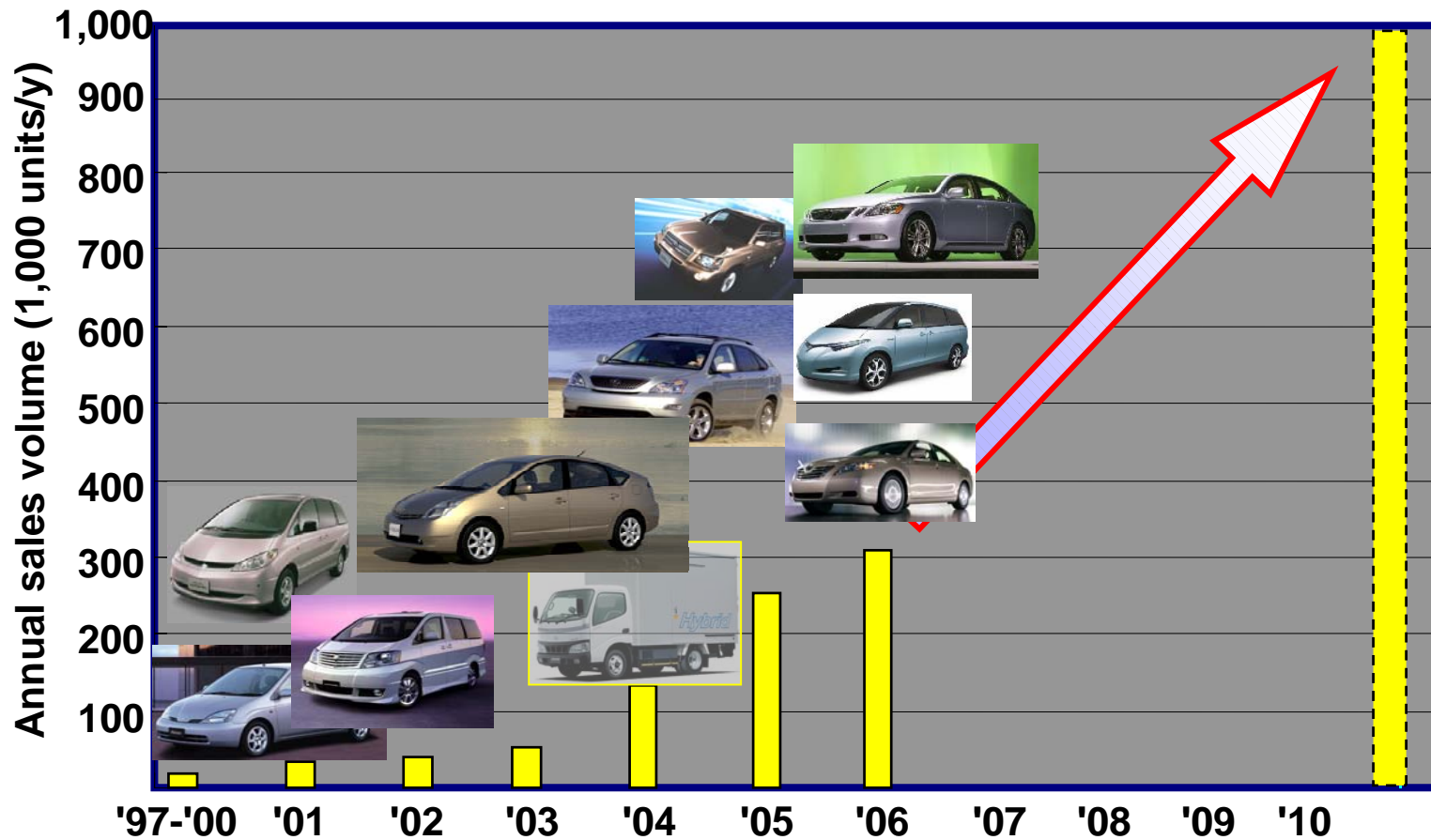
Less than 'Clean Diesel'

Fuel Consumption and CO₂

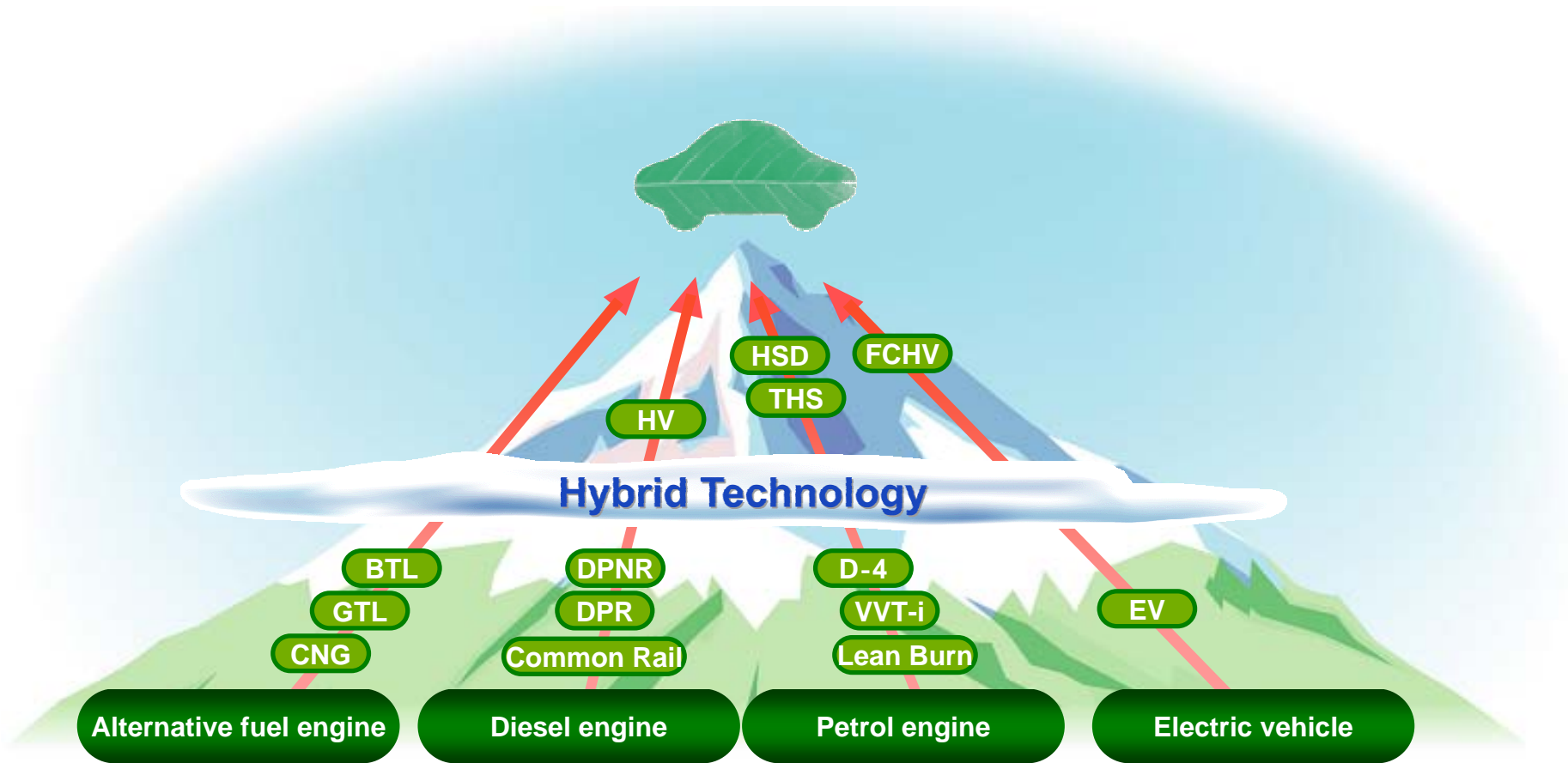
■ Diesel MT (Euro-3)
■ Prius



History of sales volume (Toyota Hybrids)



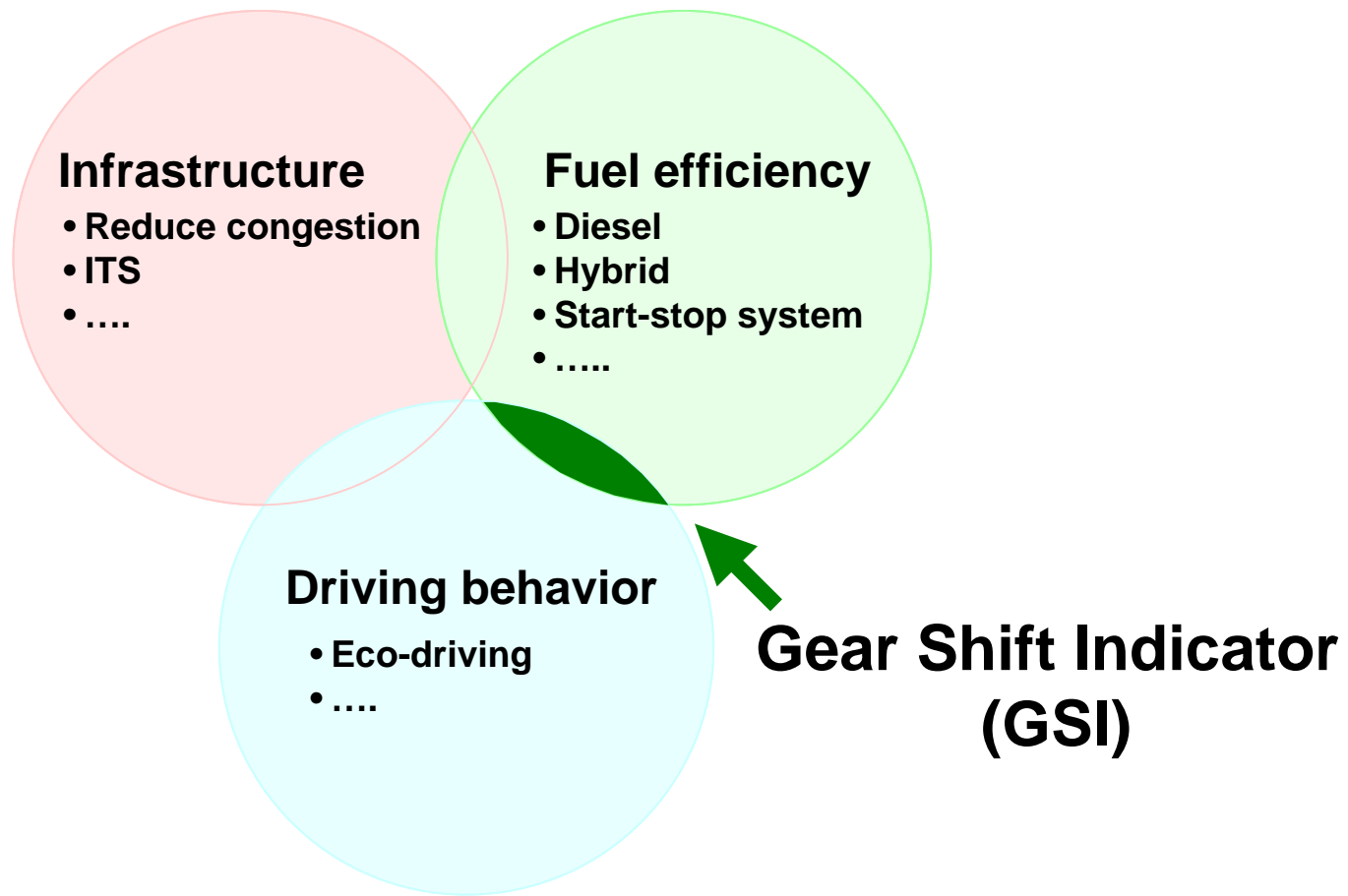
Toyota's multi-path approach



Anything else we can do?



Key factors for 'tank-to-wheel' efficiency



Gear Shift Indicators (GSI)

- Are designed to improve fuel economy by encouraging drivers to shift at the appropriate and practical engine speed for each gear.
- Are an effective way of improving fuel economy and CO₂ reduction in real world driving
- Are technically controlled by vehicle + engine parameters during driving
- Raise awareness on efficient driving and are a permanent education tool

Photo: Honda



3rd Party results on CO₂ benefit (TNO, 2005)

- TNO 'Eco Study Results' (28 vehicles)
- Financed by Dutch government

	<i>NEDC</i>	<i>ARTEMIS</i>
Petrol Euro 3	4 %	7 – 11 %
Petrol Euro 4	4 %	7 – 11 %
Diesel Euro 3	3 %	4 – 5 %
Diesel Euro 4	5 %	3 – 6 %

Benefit in real world

1. Voluntary survey result (Toyota, 2005)

(16 persons, 7 nationalities, driving 15 km route twice)

- **Average fuel consumption benefit:**
→ Greater than 5 %
- **People are surprised the engine can run at so low rpm**
- **No negative impact on driveability**



2. Large-scale survey (FIA) : in preparation

- **European FIA study, managed by German ADAC**
- **Testing in 4 EU countries (North, West, Central, South)**
- **Start in spring 2006**

Conclusions

- Toyota takes 'multi-path' towards ultimate 'Eco-car'
- Hybrid is a core technology for emission/CO₂ reduction and applicable to diversified primary energy
- Gear Shift Indicator is a technology to consider for raising awareness for eco-driving, which is the one key factor for better 'tank-to-wheel' efficiency