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Analysis of CO2 Emissions to Consider Future Technologies and Integrated Approaches in the Road Transport Sector

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※CEAMAT：Energy Analysis model for the long term in road the transport sector

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Introduction

Background

- Increasing concerns about energy security and global climate change
- Necessity of energy saving, fuel diversification and reduction of greenhouse gas
- Not enough evaluation of long term technical scenarios in the road transport sector
  - Not considering cost-effectiveness and realizing fuel economy improvement technologies
  - Restriction of analysis vehicle target (e.g. only Passenger cars)

Purpose

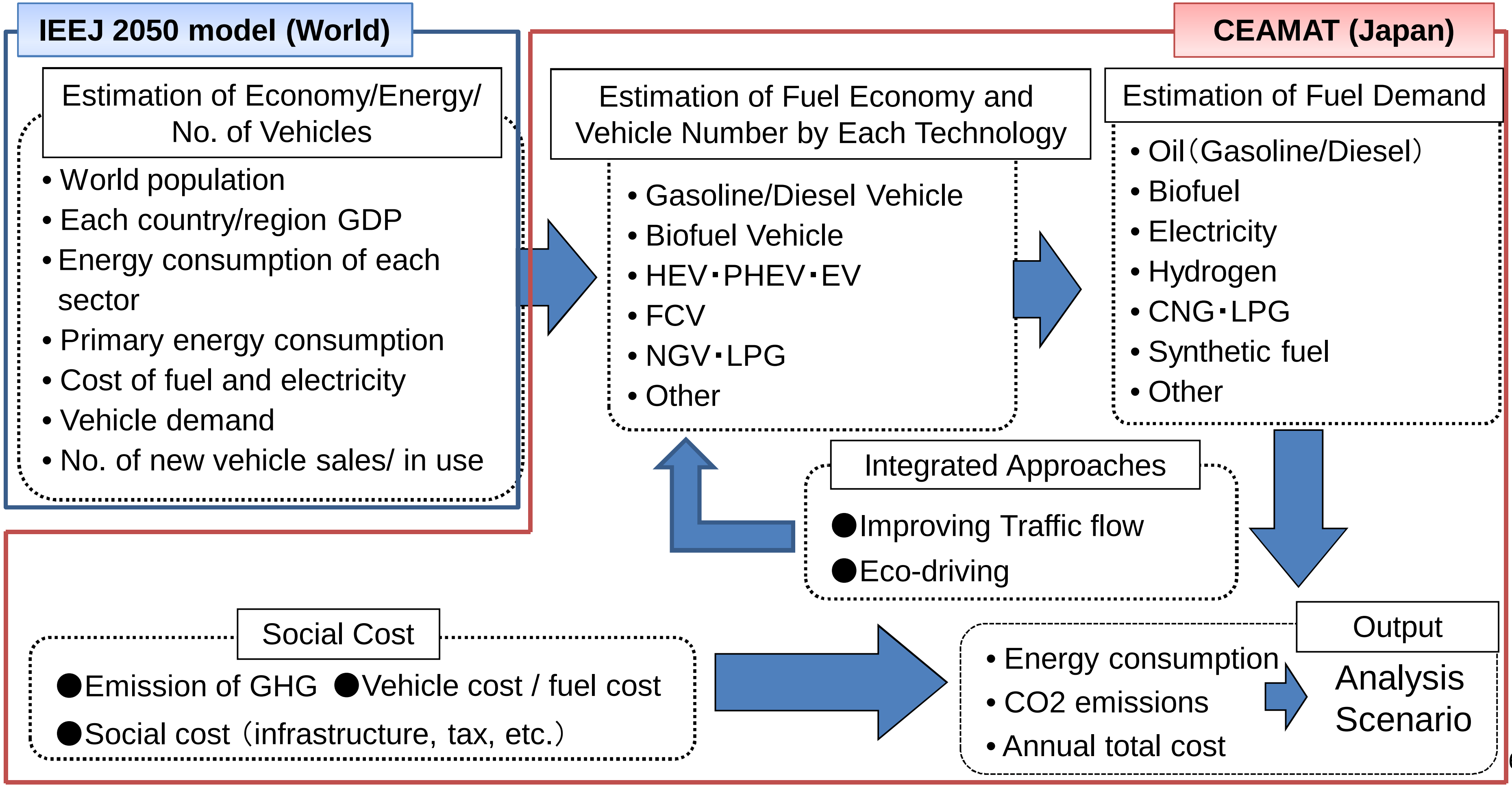
Development of long term CO2 reduction scenarios to consider future automotive technologies and integrated approaches in the Japanese automotive sector.

1. Construction of a database with demand of the road transport sector and future automotive technologies
2. Development of cost-effectiveness tools for future automotive technologies
3. Scenario analysis
4. Analysis of CO2 reduction with integrated approaches

Contents

What is CEAMAT?

- CEAMAT is an analysis energy model for the road transport sector for the long-term (–2050)
  - The IEEJ 2050 model is an energy analysis model for all sectors worldwide, developed by The Institute of Energy Economics, JAPAN
  - CEAMAT links with the IEEJ2050 model



Target Vehicle Type and Class

➢ Vehicle section, focus on the Japanese automotive market

Passenger car	Truck	Bus
Middle (＞ 2000cc)	Large (GVW ＞ 8t)	Large (GVW ＞ 8t)
Small (≦ 2000cc)	Middle (3.5t＜GVW ≦ 8t)	Small (GVW ≦ 8t)
Mini (≦ 660cc)	Small (GVW ≦3.5t)	
	Mini (≦ 660cc)	

Passenger car

Truck

Bus

Target Automotive Technologies

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Technology		Fuel path
GICEV	Gasoline Internal Combustion Engine Vehicle	Gasoline/Ethanol
GICEHEV	Gasoline Internal Combustion Engine Hybrid Vehicle	
DICEV	Diesel Internal Combustion Engine Vehicle	Diesel oil/BDF
DICEHEV	Diesel Internal Combustion Engine Hybrid Vehicle	
HICEV	Hydrogen Internal Combustion Engine Vehicle	Hydrogen/Gasoline
HICEHEV	Hydrogen Internal Combustion Engine Hybrid Vehicle	
CNGV	Compressed Natural Gas Vehicle	CNG
DMEV	Dimethylether Vehicle	DME
LPGV	Liquefied Petroleum Gas Vehicle	LPG
EV	Electric Vehicle	Electricity
HFCV	Hydrogen Fuel Cell Vehicle	Hydrogen
GICEPHEV	Gasoline Internal Combustion Engine Plug-in Hybrid Vehicle	Gasoline/Electricity
DICEPHEV	Diesel Internal Combustion Engine Plug-in Hybrid Vehicle	Diesel oil/Electricity
HFCPHEV	Hydrogen Fuel Cell Plug-in Hybrid Vehicle	Hydrogen/Electricity

CNGV

GICEV(mixed Bio-ethanol)

GICEHEV

EV

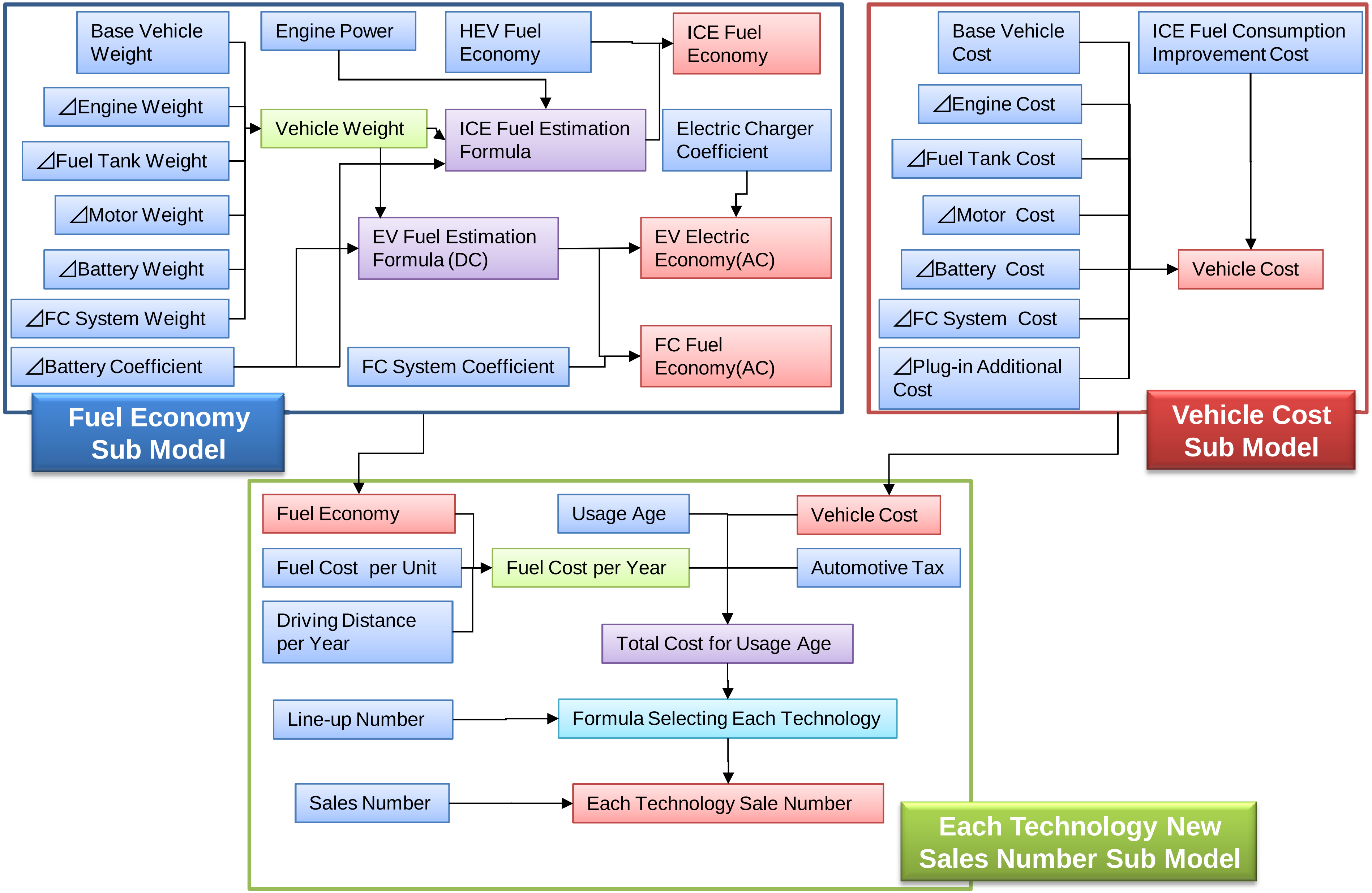
DICEV(mixed Bio-diesel)

HICEV

GICEPHEV

HFCV

Model Structure for New Vehicles

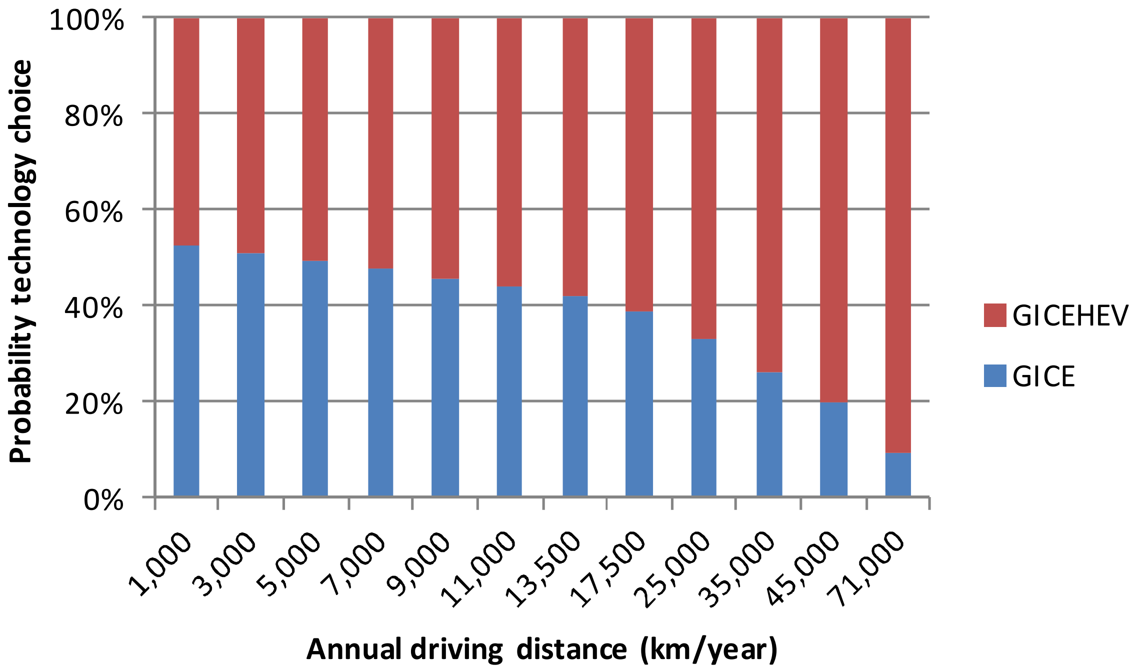


Related Probability of Technology Choice and Driving Distance (e.g. GICEV vs. GHEV)

➢Probability of technology choice (Pr) is estimated by total cost in the depreciation period and Line-up number for each distance.

$$\Pr_k = \frac{M_k^{\theta 1} \cdot \exp(\theta_0 \cdot C_{Tk})}{\sum_{k' \in K} M_{k'}^{\theta 1} \cdot \exp(\theta_0 \cdot C_{Tk'})}$$

k: Technology section
K: Assembly technology section
C_{Tk}: Total cost in usage period
M_k: Line-up number
θ_0 , θ_1: Parameter (θ_0=-6.46, θ_1=0.94)



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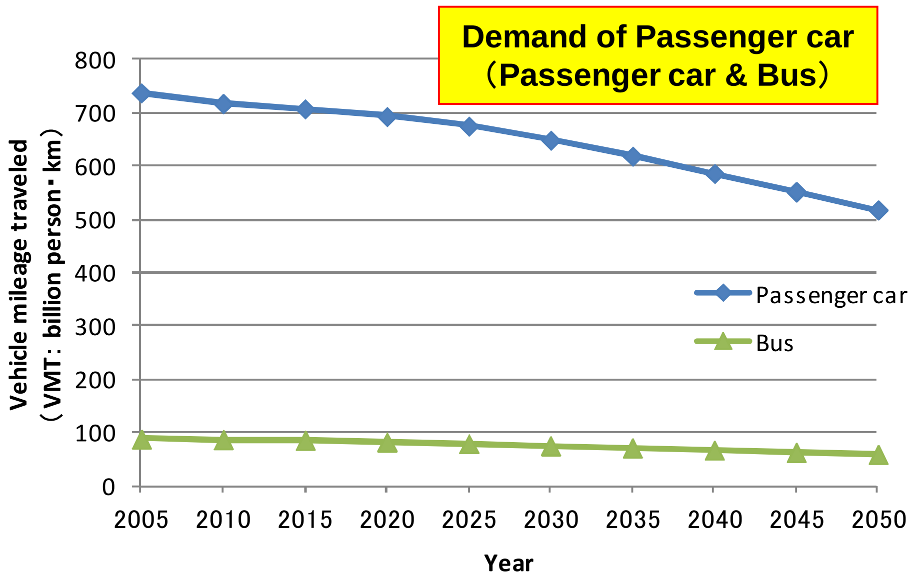
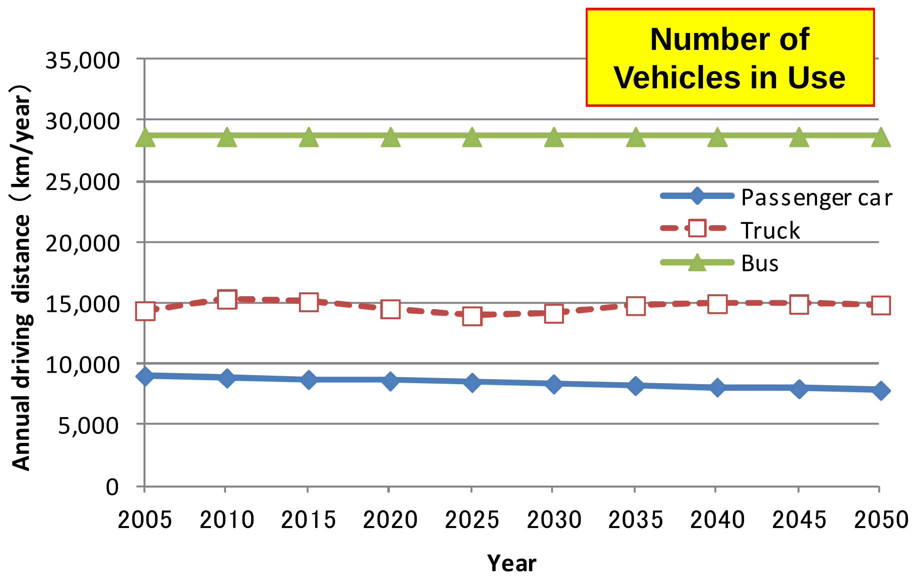
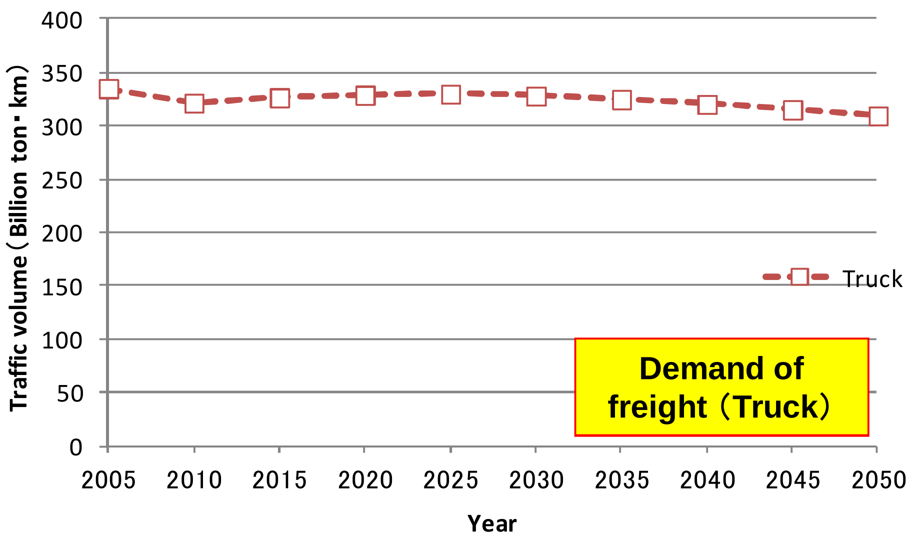
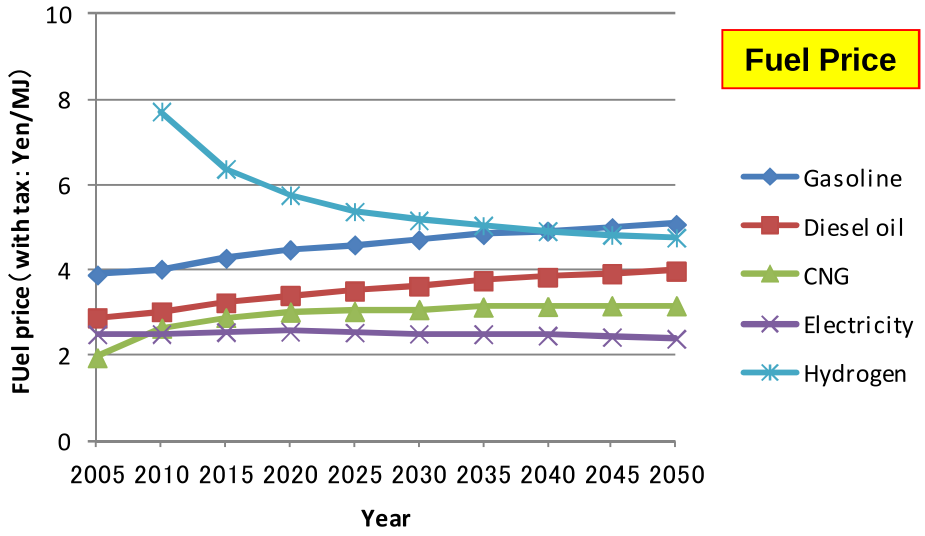
Demand of the Transport Sector and Fuel Price in the IEEJ2050 Model





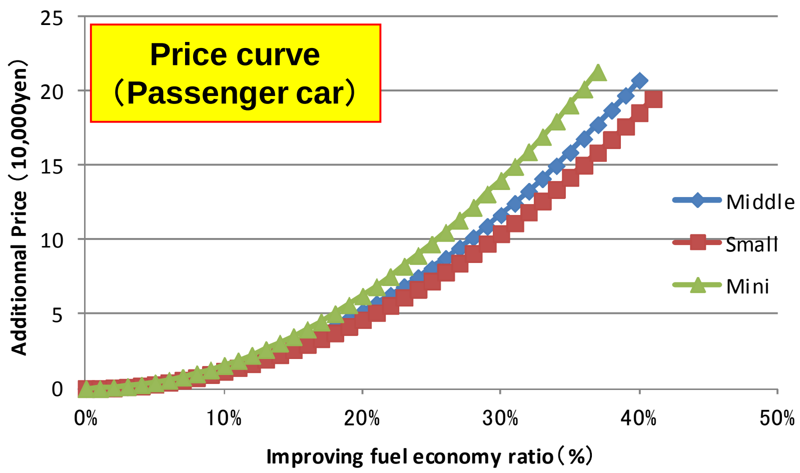


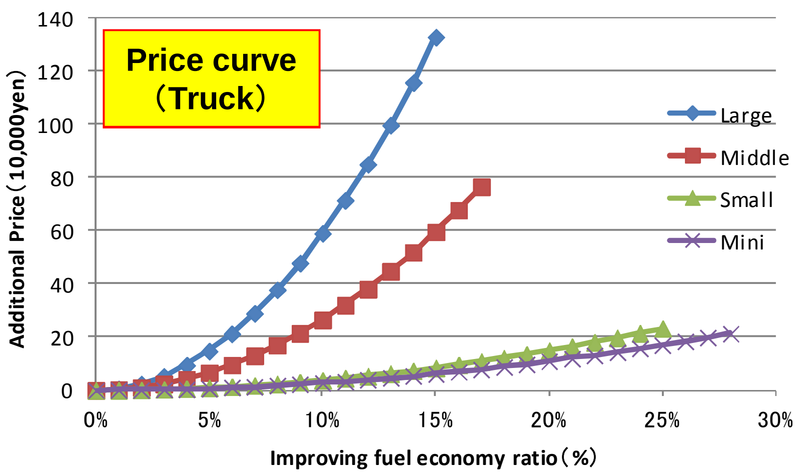


Efficiency and Price of Future Technologies in ICEV

- Base vehicle：Standard vehicles in the year 2000
- Choice of good cost-effectiveness technology combinations
- Determination of approximate curve to use good cost-effectiveness technology combinations

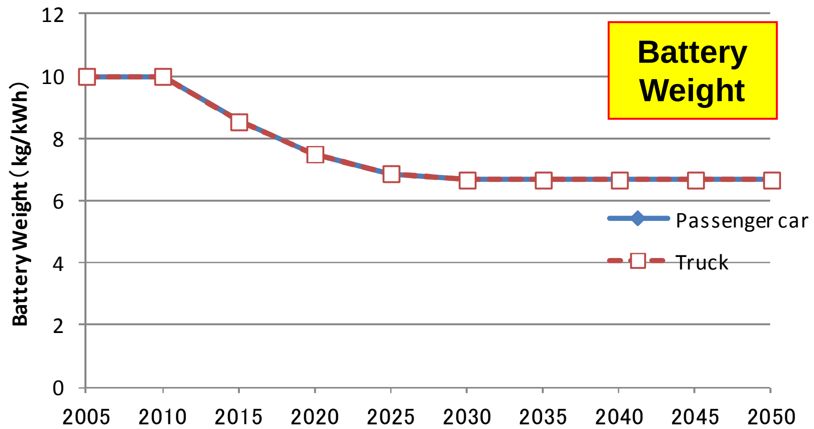
Groping	Improving FE Technology	Passenger car	Truck
Engine	Gasoline Direct Injection (Stoichimetric)	○	
	Gasoline HCCI	○	
	Cam Phasing	○	
	Engine Downsizing	○	○
	EGR	○	○
	Improved Engine Friction	○	○
	Improved firing chamber	○	○
	Other normal advance technologies	○	○
	Turbo Compound		○
	Variable Compression Ratio		○
	Valuable Valve Timing	○	○
	2 stages Turbo		○
	After treatment Device		○
Transmission	CVT	○	
	5AT	○	
	6AT	○	
	Multiple Transmission		○
	High Differential Gears Ratio		○
	Direct-connected maximum gear		○
	Dual Clutch		○
	AMT	○	○
Accessories	Electric Power Steering	○	
	Improved Alternator	○	
	Electric Accessories	○	○

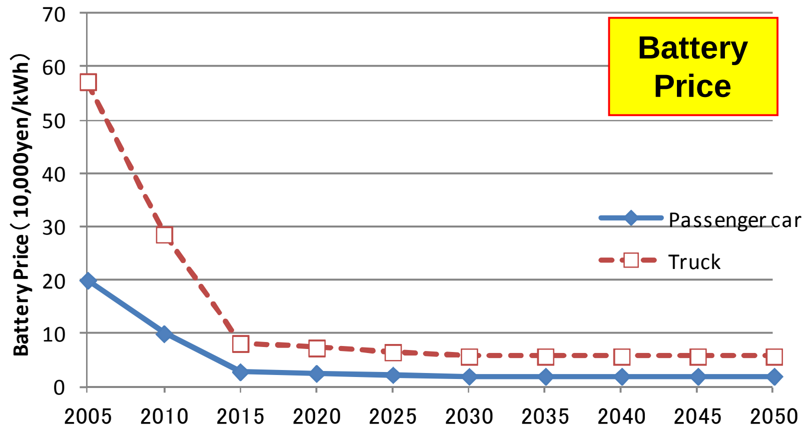


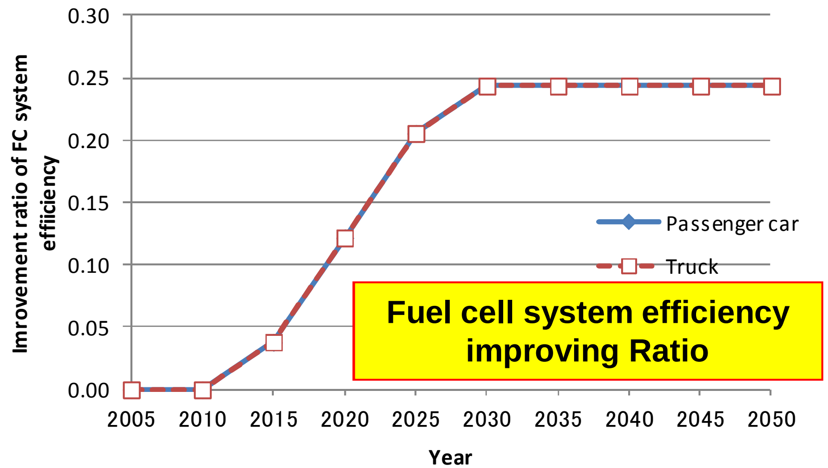


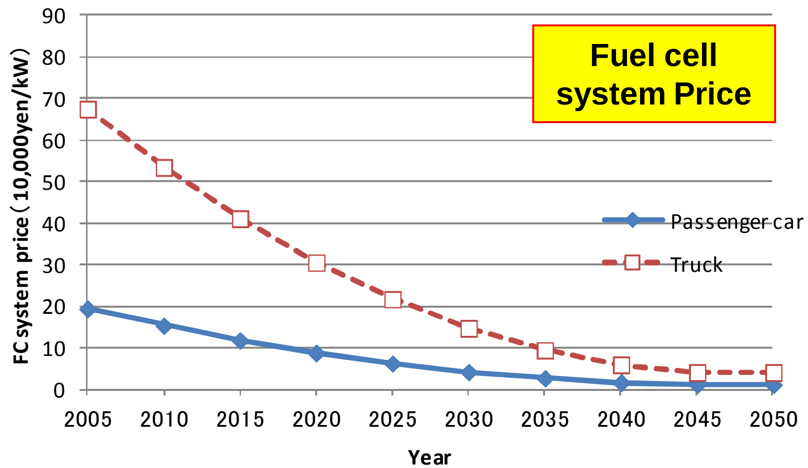
Scenario of Future Technological Factors with EV and HFCV

- Price and efficiency of battery and fuel cell systems in the future are based on government and private sector reports and interviews.
- Future scenarios are efficiency improvement and a lower price, considering advance technologies and mass production.
- Truck's part prices are higher than part of passenger car prices, because system accessories are larger and more expensive.



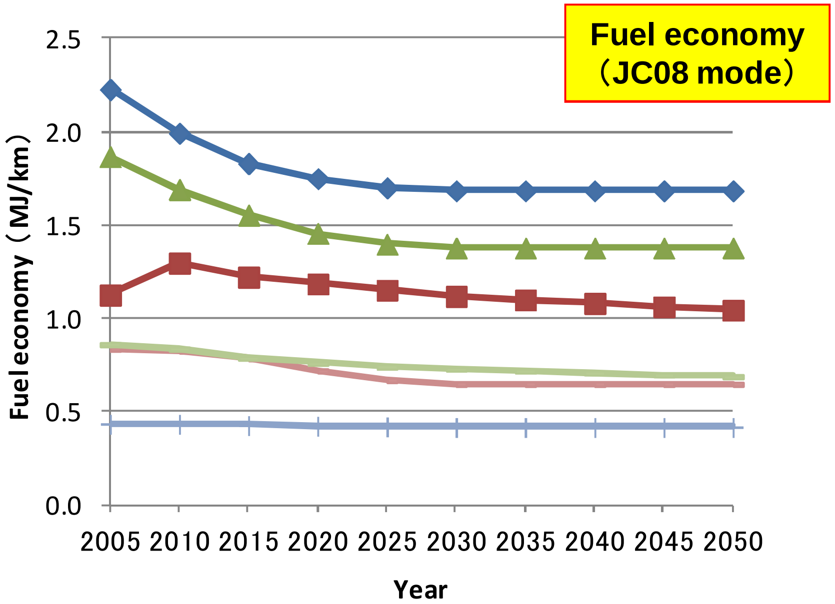


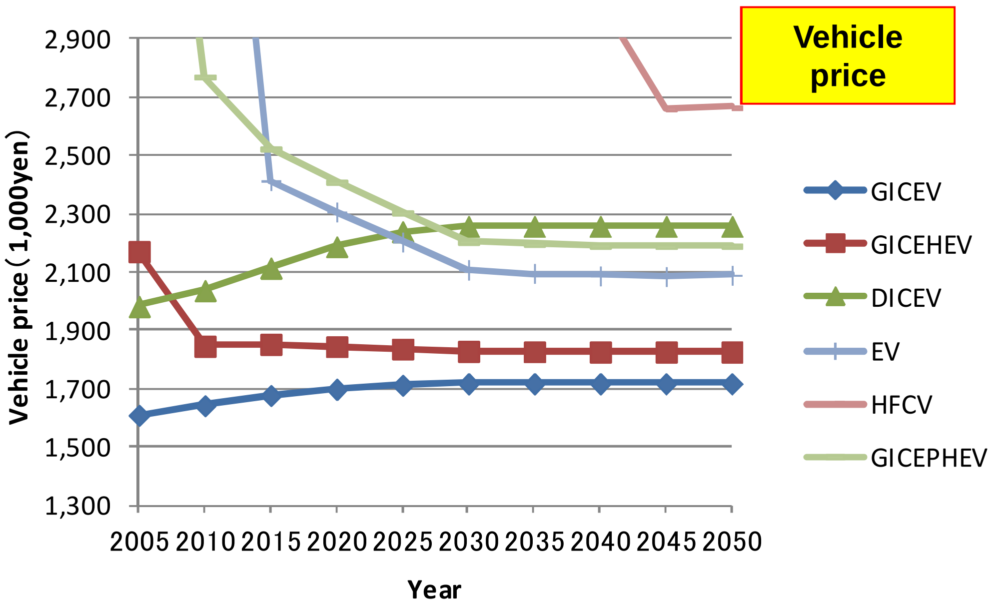




New Vehicle Energy Economy and Price (e.g. Small Passenger car)

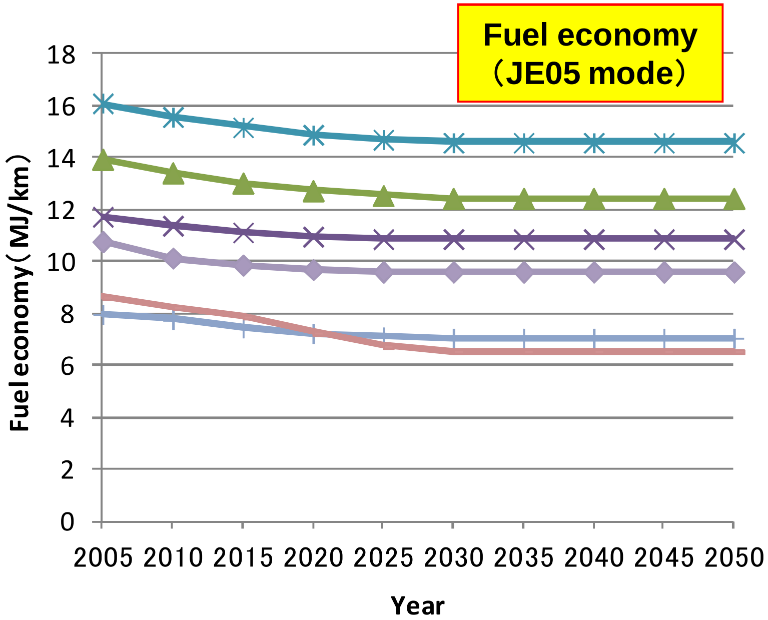
- All technologies improved energy economy, considering advance technology factors such as ICE technologies, battery and fuel cost.
- Improvement technologies price of improving are added to ICEV's vehicle price.
- Other new automobiles come down in price to reflect mass production of technology factors (Battery and fuel cell system, etc.).

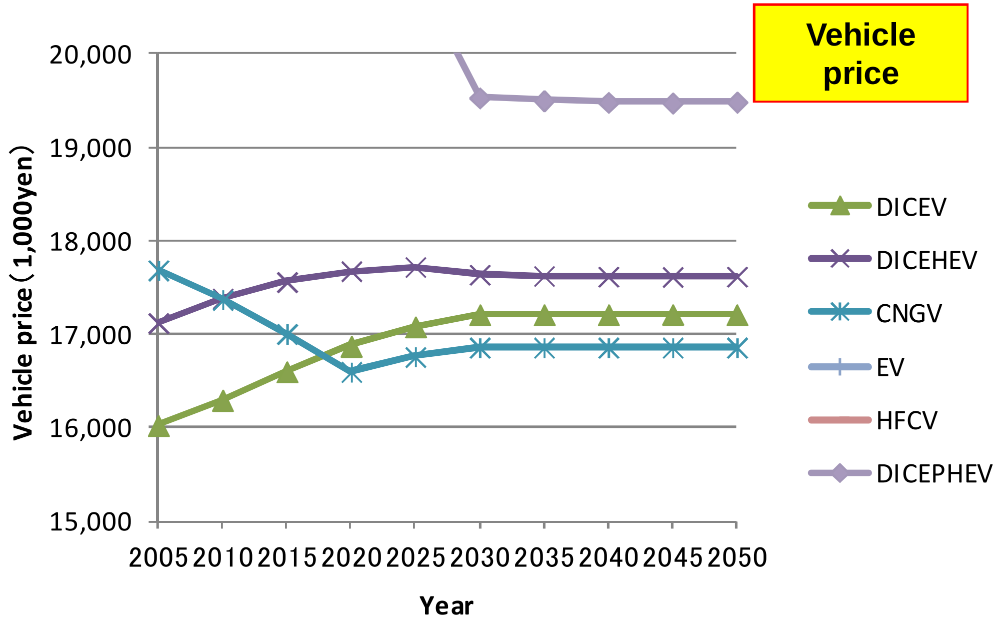




New Vehicle Energy Economy and Price (e.g. Large Truck)

- Trend of fuel economy and vehicle price is shown, same as small passenger cars
- All technologies improved energy economy, considering advance technology factors such as ICE technologies, battery and fuel cost.
- Improvement technologies price of improving are added to ICEV's vehicle price.
- Other new automobiles come down in price to reflect mass production of technology factors (Battery and fuel cell system, etc.).





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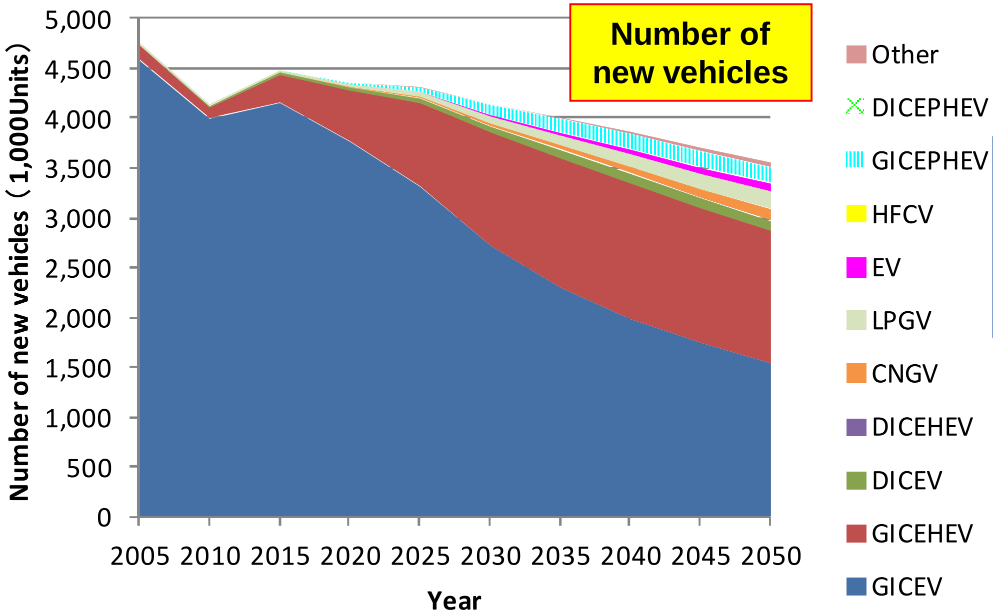
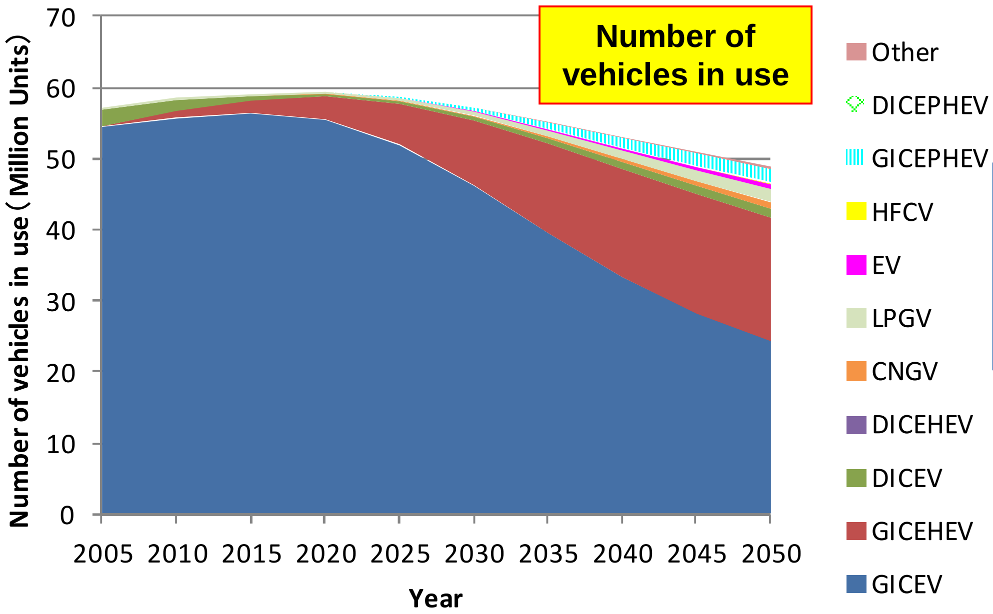
Number of New Vehicles and Vehicles in Use (Passenger Car)



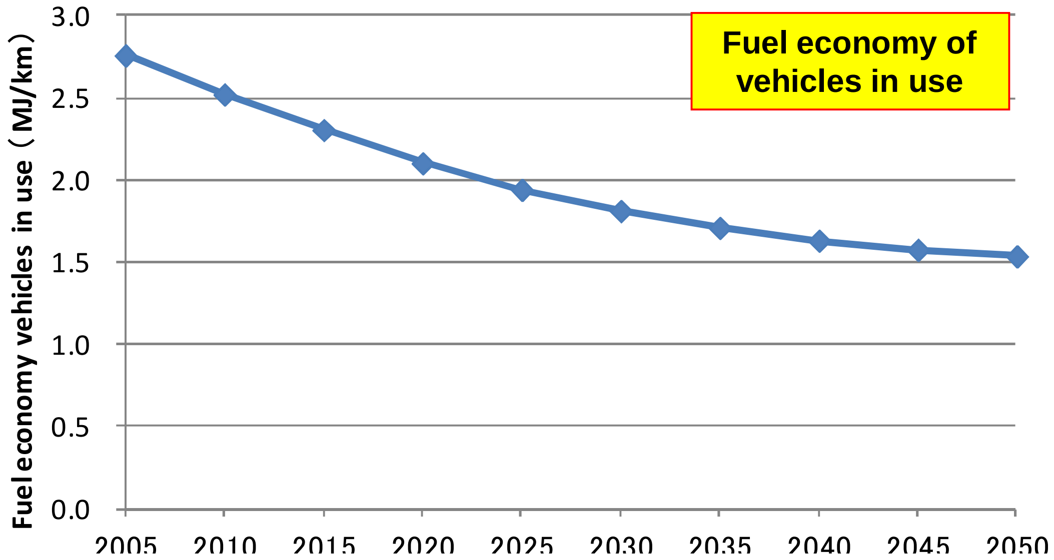
- ➢Number of new vehicles
  - ◆Share of next generation vehicles※: 48% (2050)

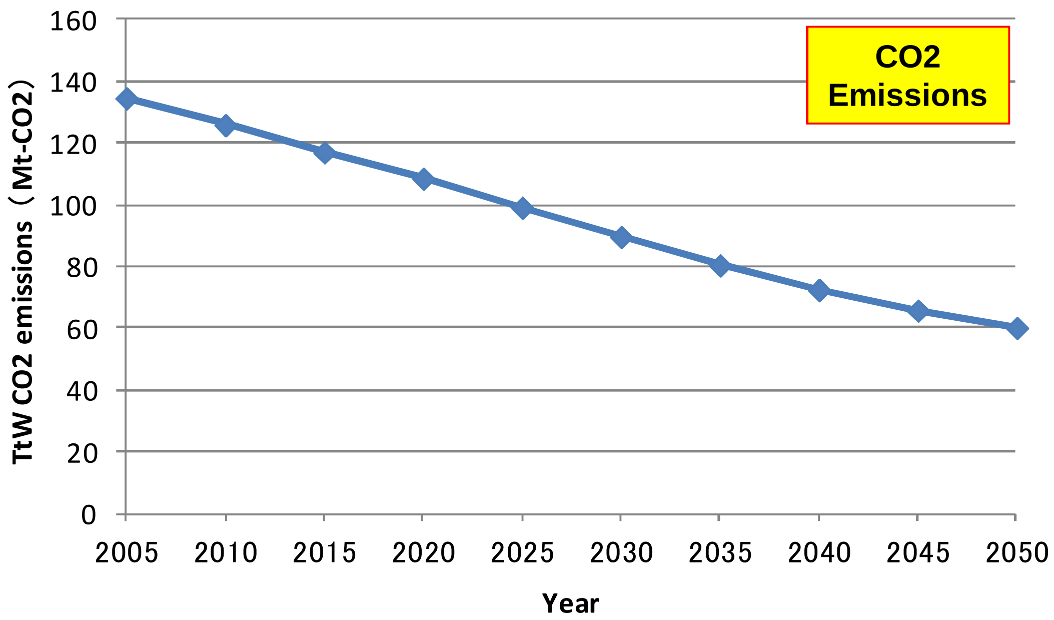


- ➢Number of vehicles in use
  - ◆Share of next generation vehicles : 43% (2050)

※Next generation vehicles are HEV, EV, PHEV, FCV and CNGV. This definition is from a report by METI, "Diffusion report of next generation vehicles 2010" written in Japanese.

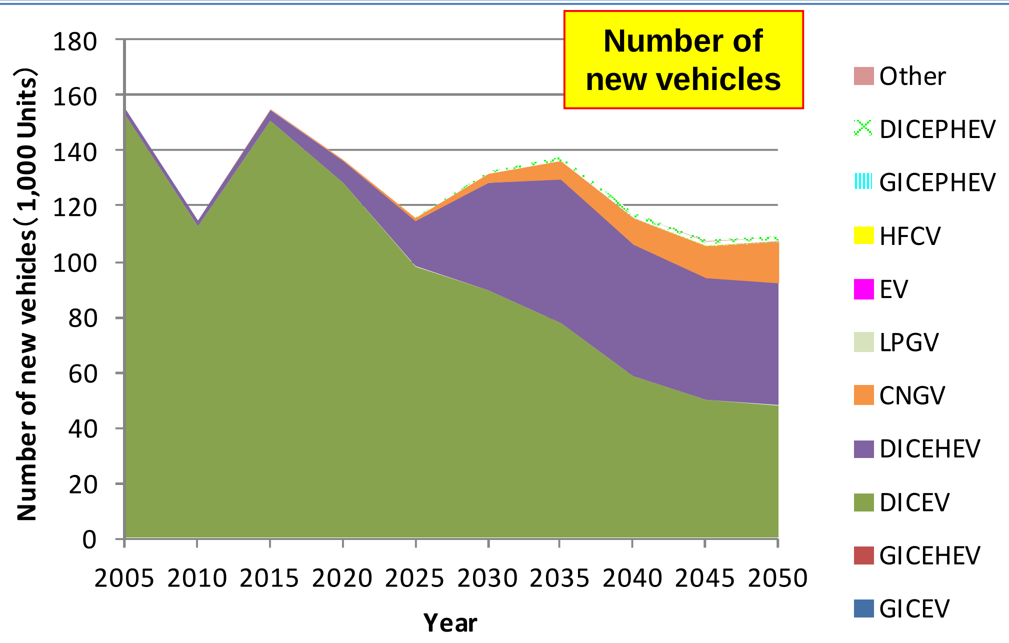
Fuel Economy of Vehicles in Use and TtW CO_2 Emissions in the Passenger Car Sector



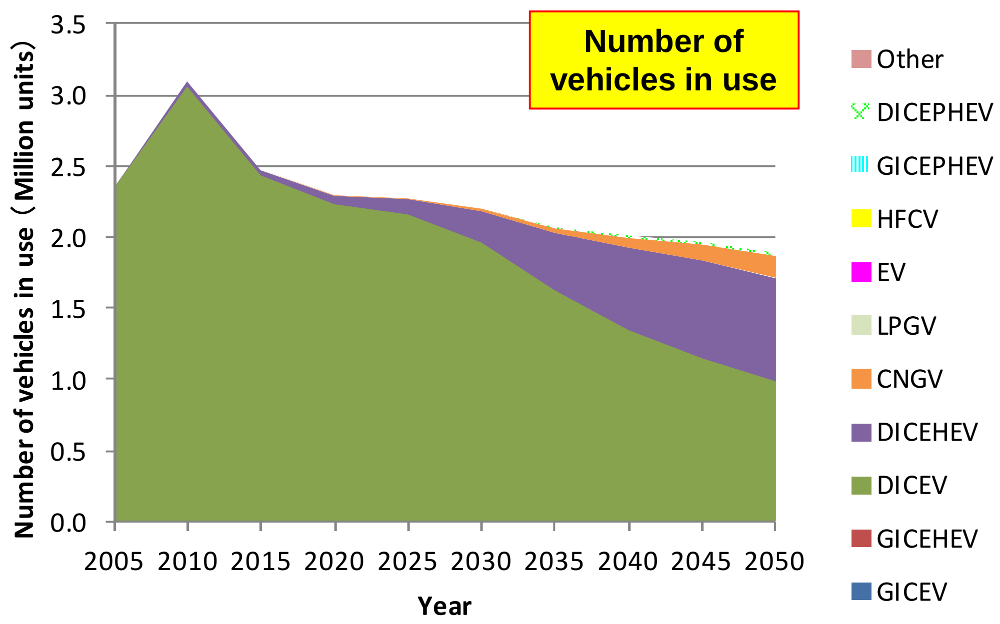


- CO2 emissions in 2050: −55%（Based on 2005）

Number of New Vehicles and Vehicles in Use（Truck）

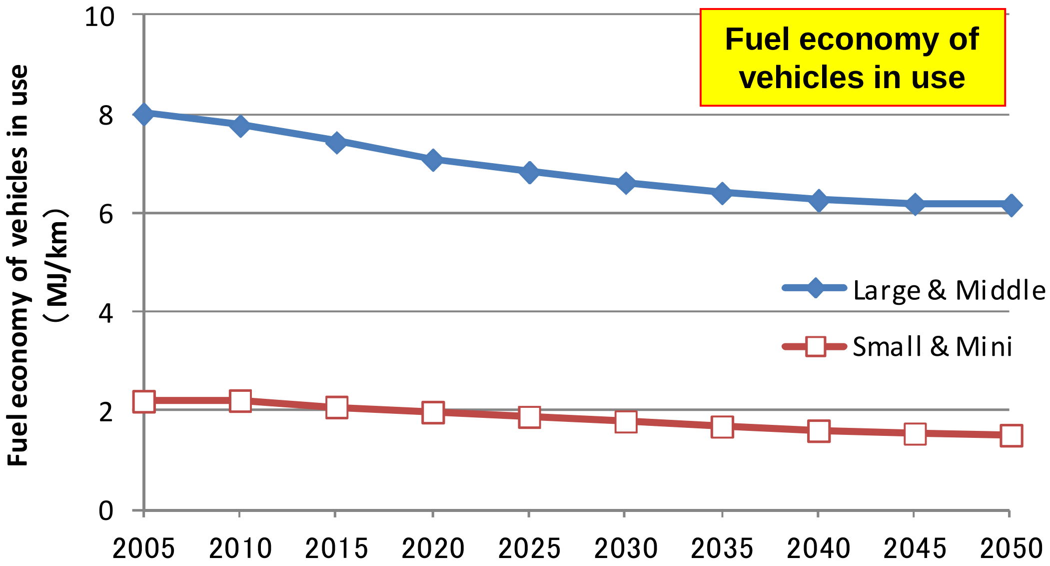


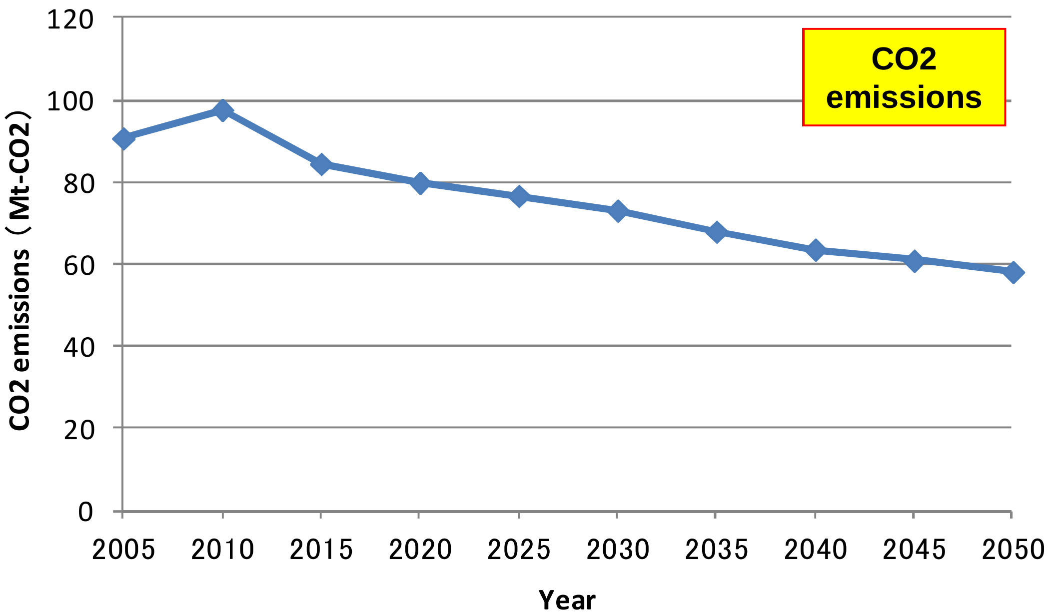
- ➢Number of new vehicles（GVW : 3.5t over)
  - ◆Share of next generation vehicles：56%（2050)
- ➢Small and mini trucks (GVW: 3.5t and under, trucks) have a similar trend to passenger cars.



- ➢Number of vehicles in use (GVW : 3.5t over)
  - ◆Share of next generation vehicles: 48%（2050)
- ➢Small and mini trucks (GVW: 3.5t and under, trucks) have a similar trend to passenger cars.

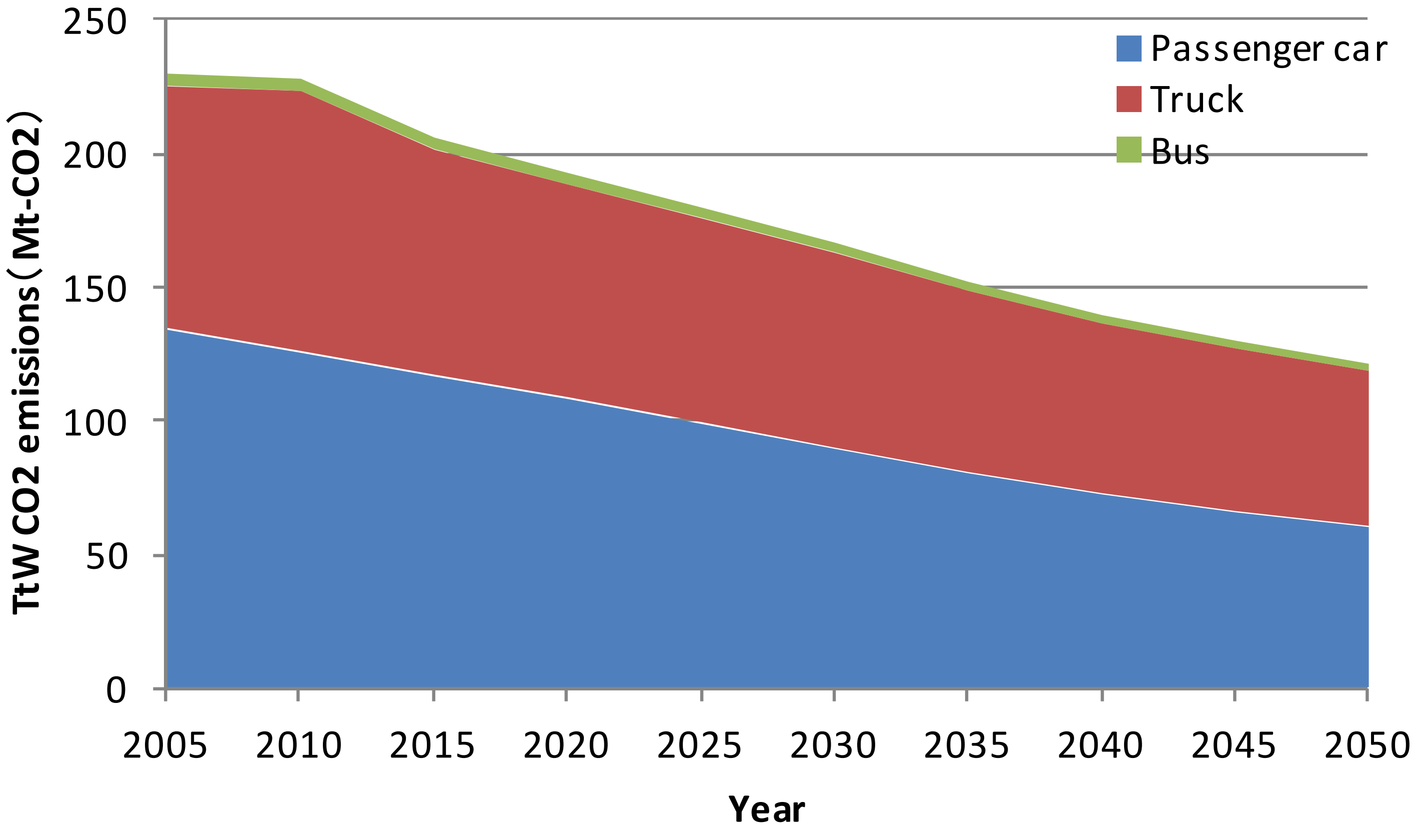
Fuel Economy of Vehicles in Use and TtW CO2 Emissions （Truck Sector）





- CO2 emissions in 2050 −36%（Based on 2005）

CO2 Emissions（Road Transport Sector）



➢CO2 emissions in 2050：
−47%（Based on 2005）

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Analysis Process of CO2 Reduction for Eco-driving

CO2 reduction of eco-driving per unit
- Passenger car: 13%
- Truck: 9%

(Average of 9 organizations※)

Popularization ratio of eco-driving in 2050
- Passenger car & Truck: 70%

(Energy ITS research meeting report)

(Result of CEAMAT)

CO2 weighting factor in 2050 (Based on vehicle mileage traveled)
- Passenger car: 65%
- Truck: 35%

→ **Each CO2 reduction for eco-driving**
- Passenger car: 9%
- Truck: 6%

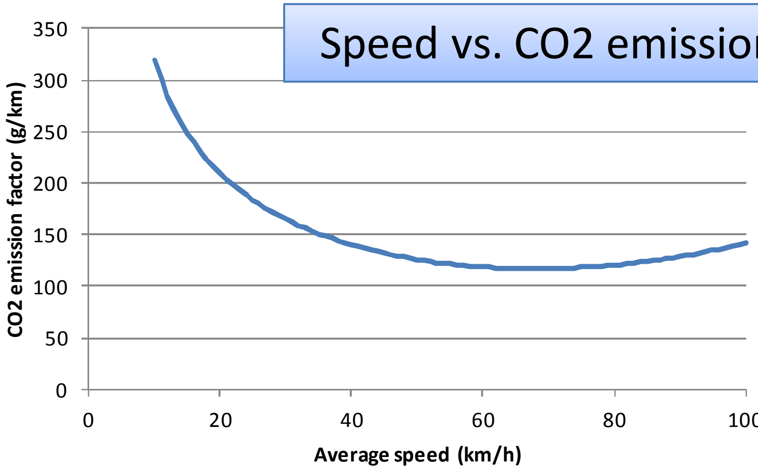
→ **CO2 reduction for eco-driving**
- Total: **8%**

9 organizations of evaluating eco-driving:
NIES, Libertas terra Co.Ltd, HONDA R&D CO.Ltd
IID.Inc. NTSEL, LEVO, etc

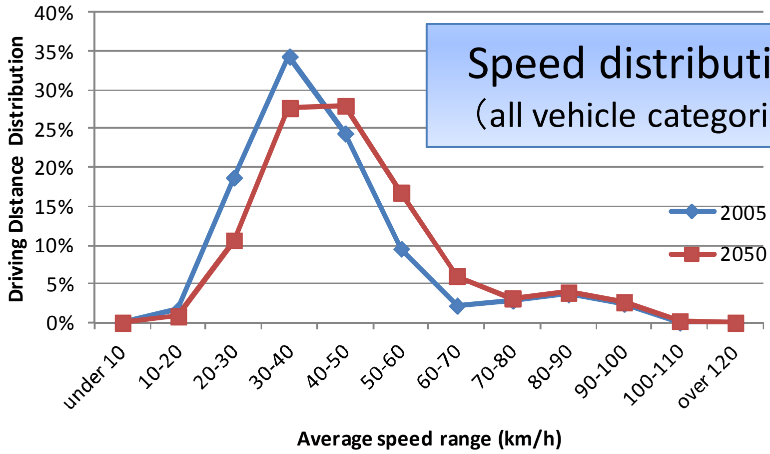
Analysis Process of CO2 Reduction to Improving Traffic Flow

GDP in Japan → Road project cost in Japan → Changing average speed in Japan

Speed vs. CO2 emissions



Speed distribution (all vehicle categories)



CO2 reduction to road improvement
Total : **4%**

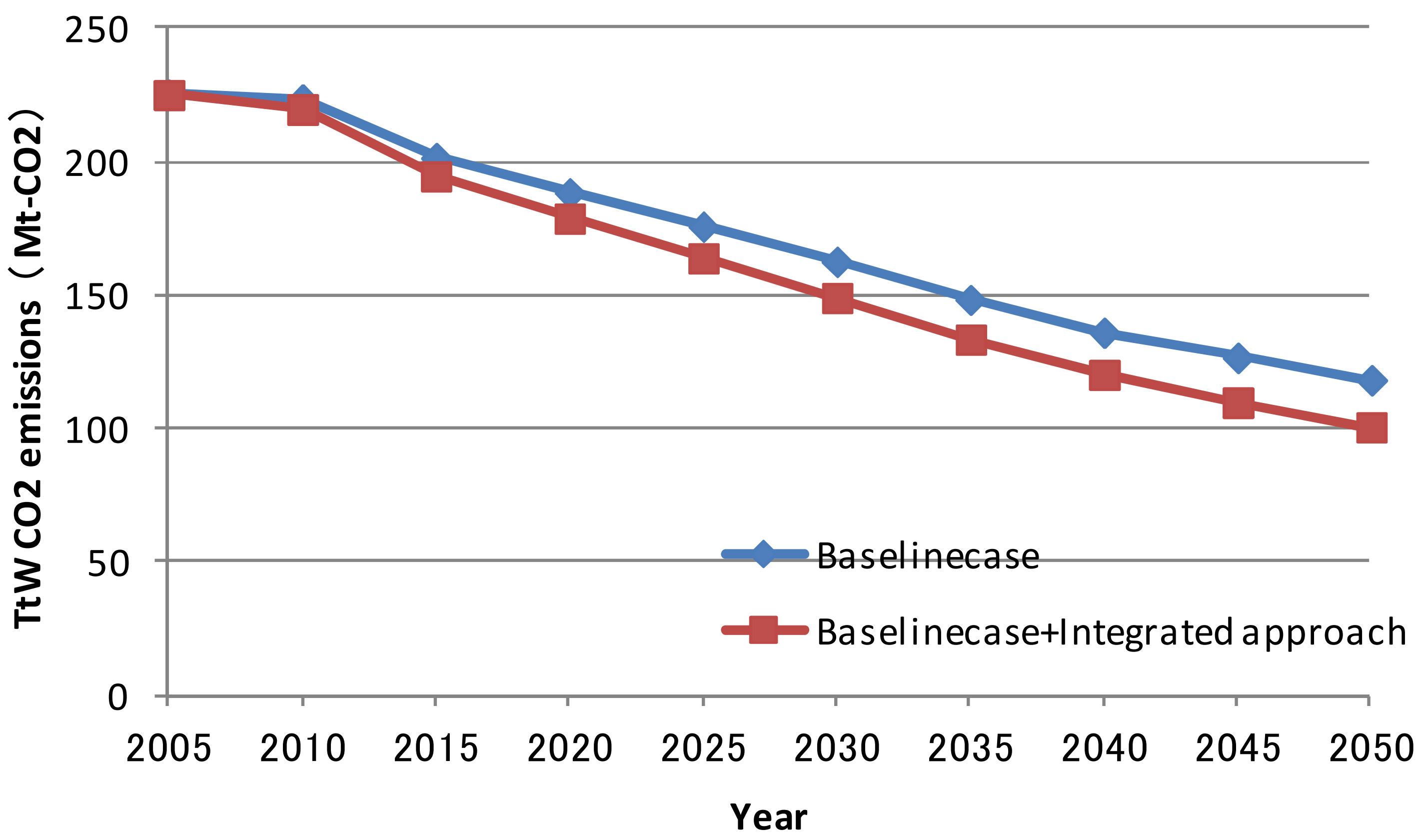
Energy ITS research meeting report

Item	CO2 Reduction
Platooning	0.2%
Traffic light control (Only vehicle)	0.04%
Traffic light control (link up with infrastructure)	2%
Full route information	1.4%
Predicting optimal starting time	0.1%

CO2 reduction to implement technologies
Total : **4%**

CO2 reduction to improving traffic flow
Total : **7%**

CO2 Reduction for Integrated Approaches (Road Transport Sector)



- Technological composition is assumed to be the same as the Baseline case, that is without integrated approach.
- CO2 Reduction in 2050：
  55% based on 2005（Baseline case：47%）

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Conclusion

A cost-effectiveness analysis tool including an automotive database with advanced technologies were developed, and future scenarios were analyzed. In addition, integrated approaches were researched and calculated about reducing CO2 emission potential.

1. From the result of this scenario analysis, CO2 reduction potential of the road transport sector with next generation automobiles is calculated as 47% (based on 2005) in 2050.

2. CO2 reduction potential from next generation automobiles and integrated approaches (Improving traffic flow and Eco-driving) is calculated as 55% (based on 2005) in 2050.

From the result of CO2 potential from improving traffic flow and eco-driving, we've shown it is necessary to popularize next generation automobiles and integrated approaches.

Thank you for your attention!

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