Imperial College London

東京大学 THE UNIVERSITY OF TOKYO

Energy and Green House Gas Mitigation Technologies

Japan Society for the Promotion of Science-Imperial College London-University of Tokyo Symposium on Climate Change

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energy futures lab

Imperial College London, South Kensington Campus, London SW7 2AZ

JAPAN SOCIETY FOR THE PROMOTION OF SCIENCE · FOUNDED 1932 ·

JSPS-Imperial College-UT Symsium
06/9/29 10:40-11:15 Imperial College London

Long term technology options for sustainable road transportation systems

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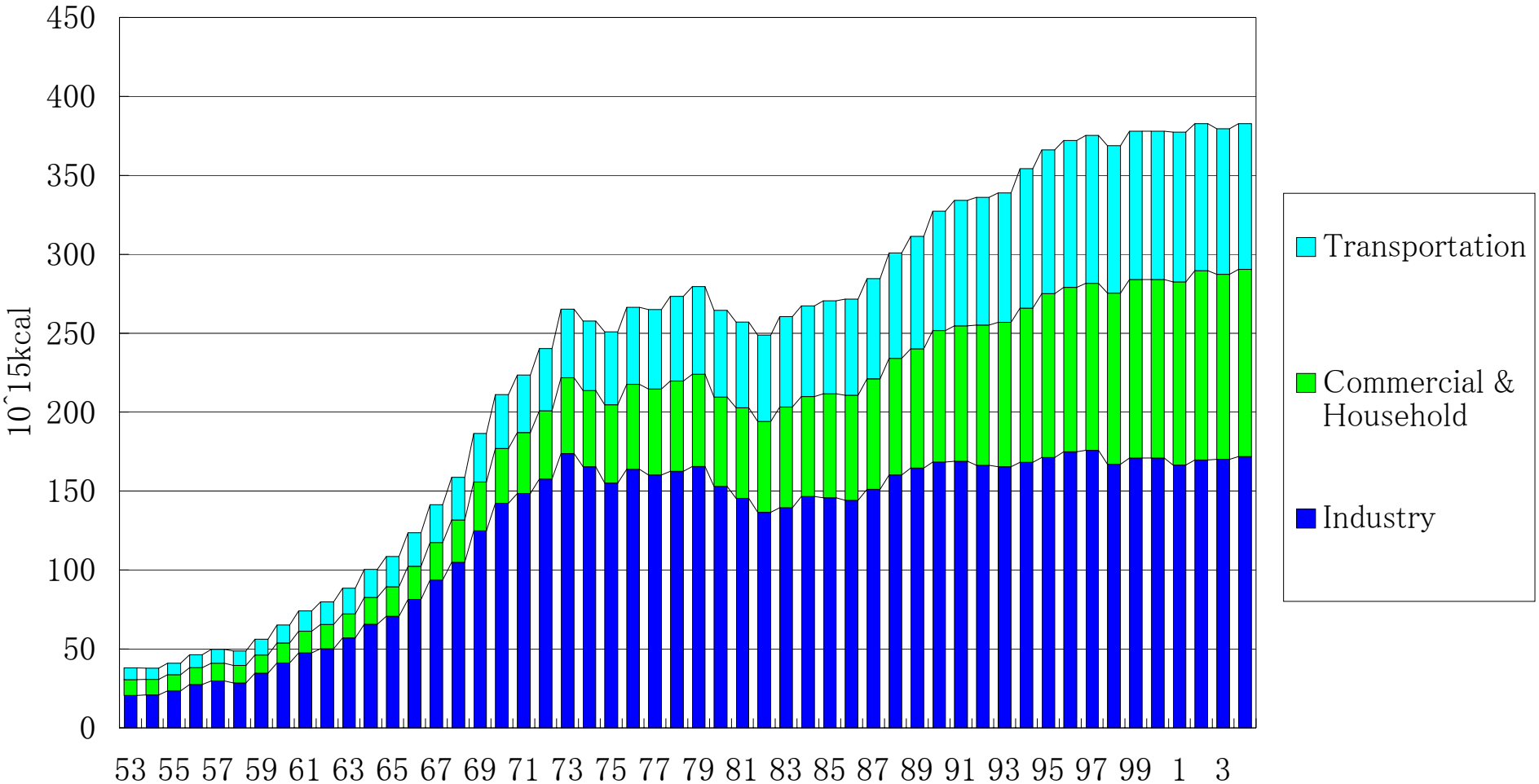
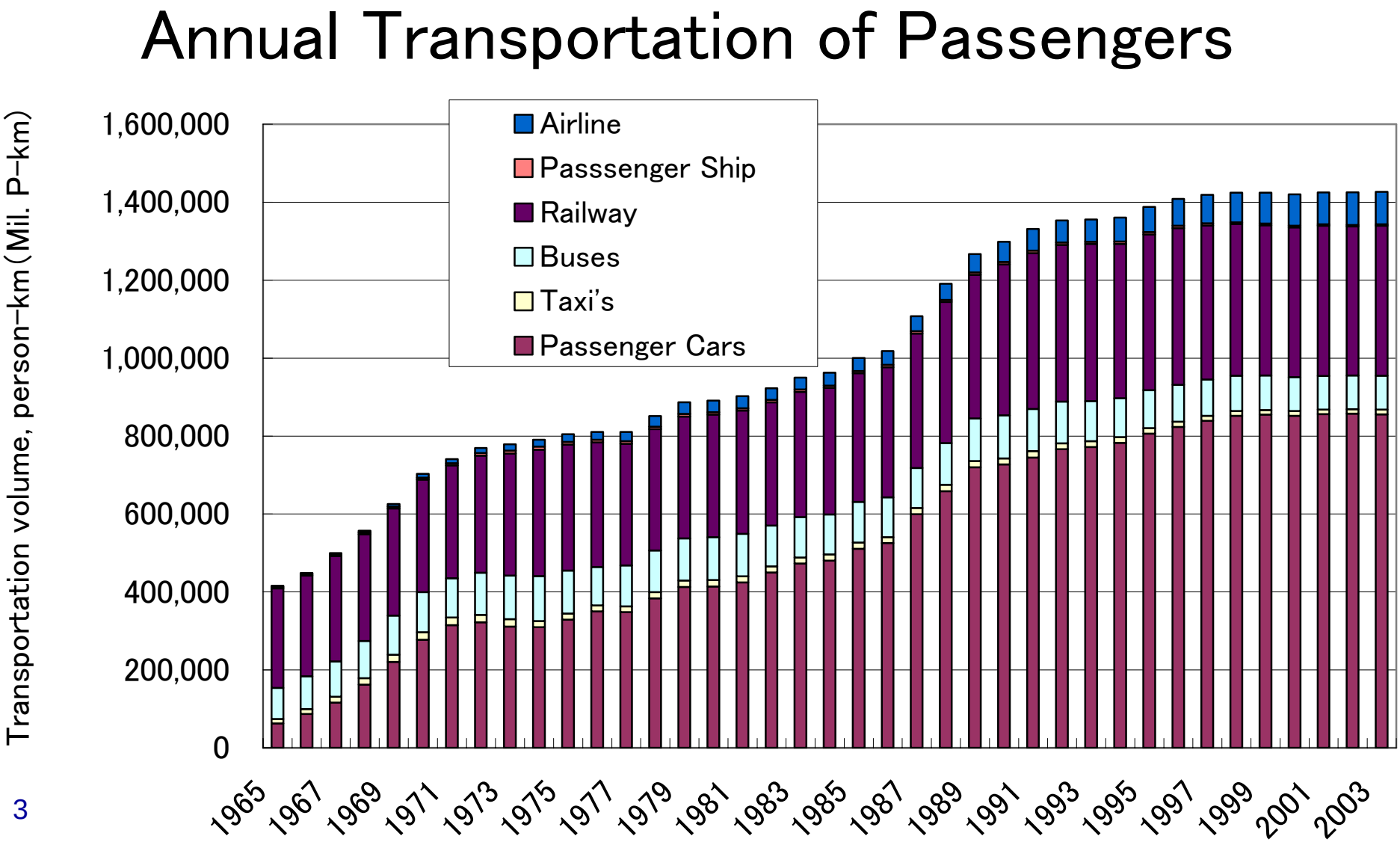
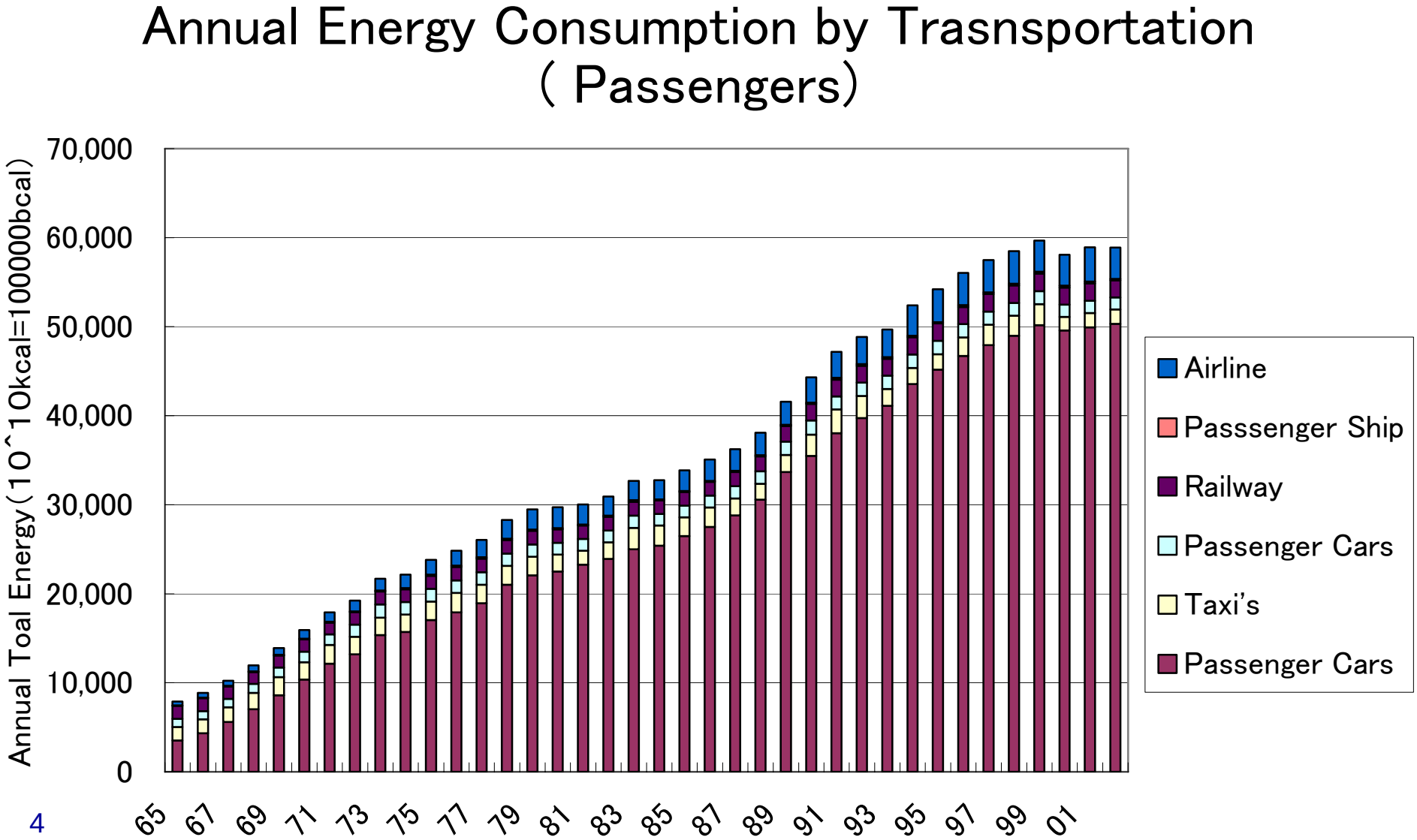
Energy Consumption by sector in Japan



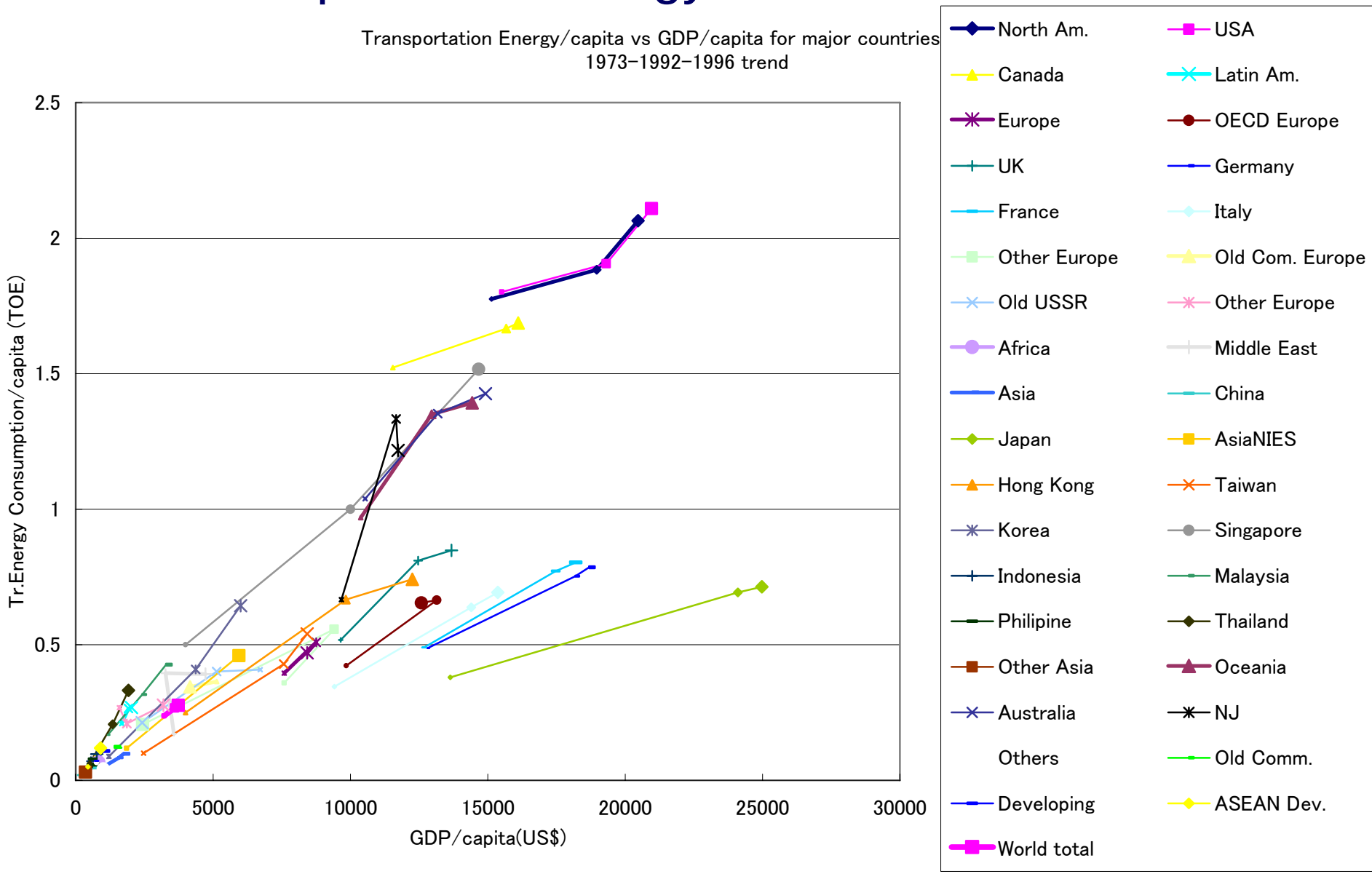
Annual Transportation in Japan (Passengers)



Annual Energy Consumption by Passenger Transportation in Japan



Transportation energy level vs. GDP level



Summary

- Recent trend in Japan
  - Comparatively Transportation Energy consumption level is low, but Steadily Increasing
  - Public transportation share is large, but most energy is consumed by Passenger cars
  - After oil crisis, energy source shifted to other resources, and dependence on oil of transportation increased
- Worldwide situation
  - Big gap remains between developed and developing countries
  - Increase of transportation energy in developing countries seems to follow US trajectory
  - Concern of road transportation energy source (Oil) in near future

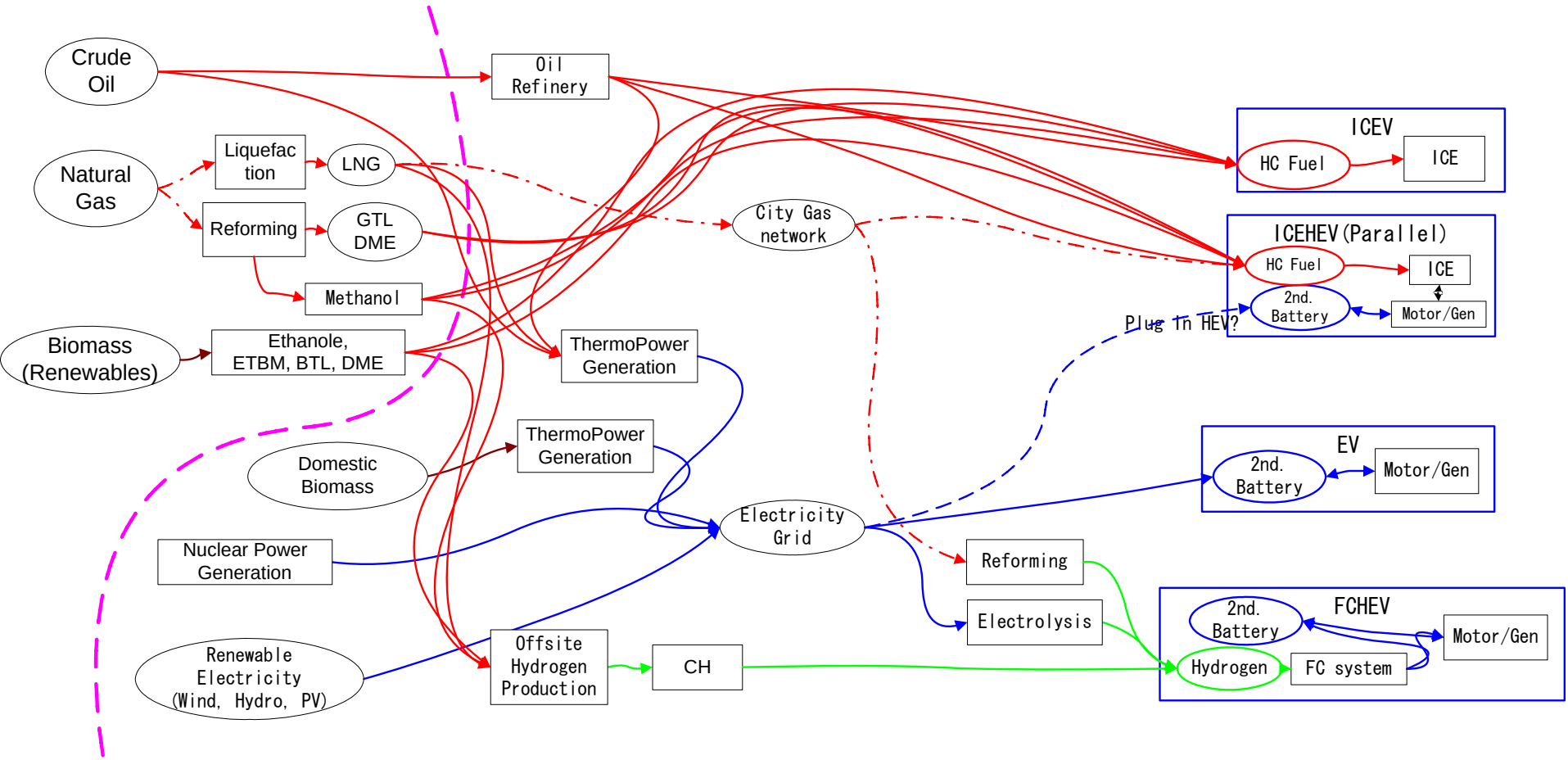
Issues in road transportation

- ***Classic environmental issues***
  - Noise, Vibration, abnormal oder(HC emission)
  - Road congestion, road safety
- ***Emission (Air quality):***
  - CO, SOx, NOx, HC, PM
- ***Energy Issues***
  - Dependence on Liquid HC fuels from Oil
  - Rapid demand increase in Developing countries e.g. China
  - Political Instability of oil producing countries=>Energy security issue
  - Energy conservation
- ***CO2 Emission***
  - Increase of energy consumption or trans. demand
  - Difficulty in fuel switching, technically & economically

Positions of three developed areas for these issues

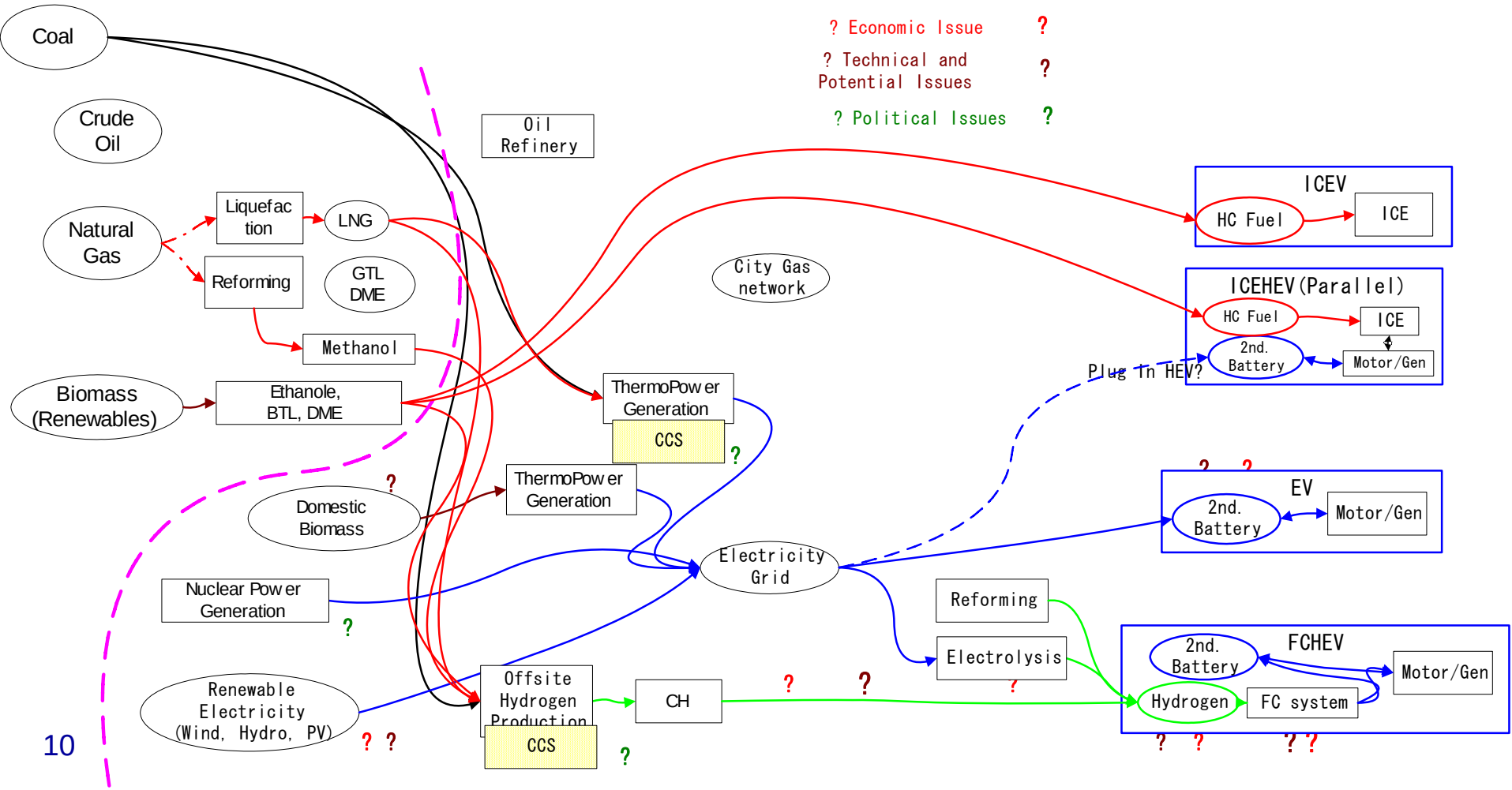
- **USA**
  - After 9/11, try to decrease dependence of foreign oil=> Swithing to alternative fuel/ energy conservation
  - Recent gasoline price increase=> interests for energy conservation
- **EU**
  - CO2 emission reduction=>Energy efficiency and fuel switching, especially Diesel cars and bio fuel
- **Japan**
  - Oil consumption reduction: energy efficiency especially after oil crisis => Energy conservation law (top runner standard), promotion policy for low emission high efficiency vehicles, e.g. subsidies or tax reduction
  - For Kyoto protocol: further energy efficiency increase, HEV, fuel switching, RD&D of FCV
  - Promotion of FCV R&D as an industrial policy

Transportation Energy Options



Options under CO2 emission and Oil Supply constraints

Major Options under Oil Supply and CO2 emission restriction



Future possibilities and challenge

- Short term efficient ICEV: HEV or Diesel ICEV
- Bio Fuel + ICEV:
  - technically easiest
  - regional potential, competition with agriculture
  - low efficiency of bio-fuel from cellulose
- FCV
  - Complicated energy paths, losing energy, but vast possibility for primary energy source
  - Technical challenge: hydrogen storage and FC stack
  - Long term energy sources: CCS?
- BEV
  - Technical challenge: low cost reliable battery, with sufficient energy density
  - Probably, limited to short range use or public transportation

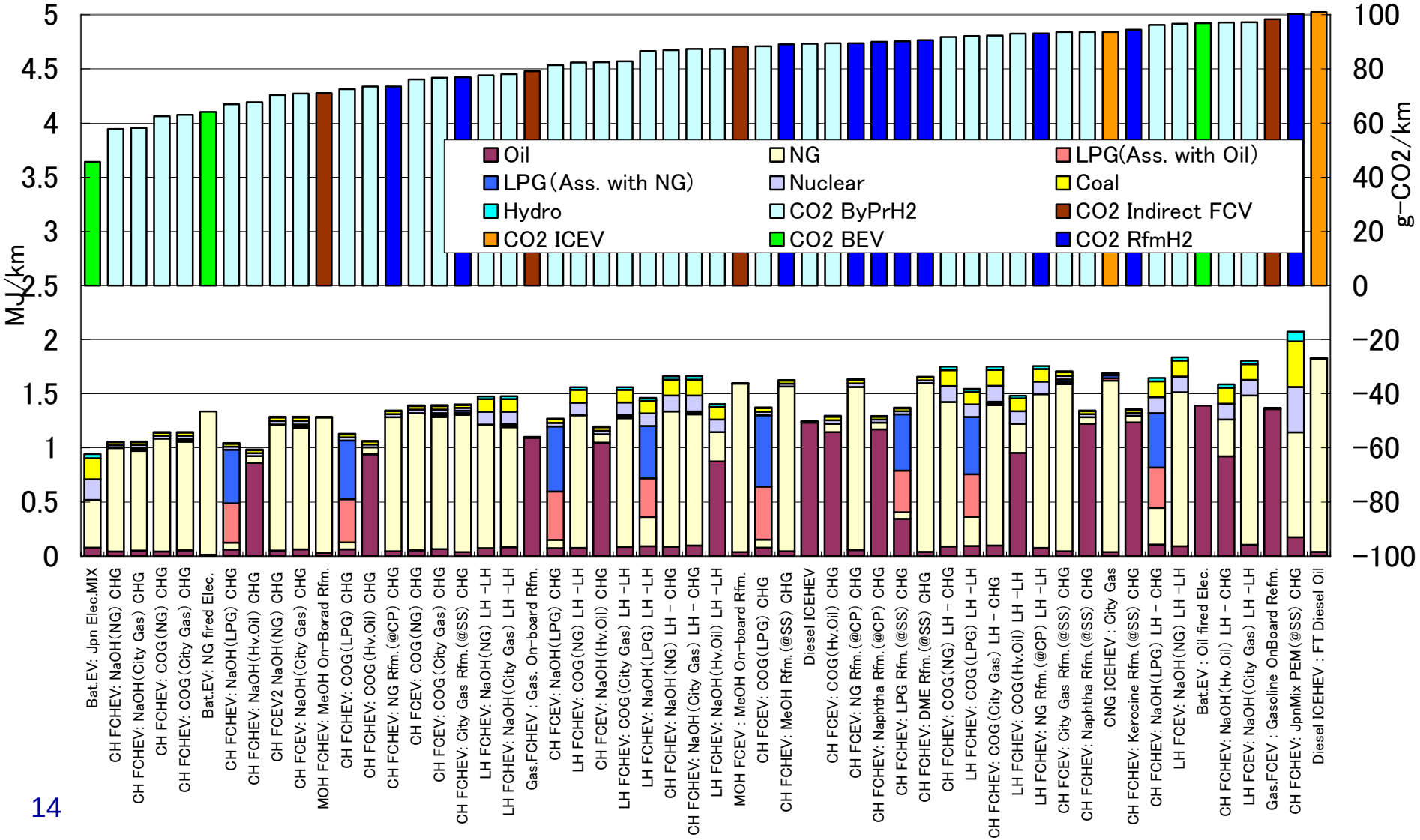
Summary of optional fuel and drive trains

Pathway							Technical Evaluation		
original resources	major conversion	Vehicle type	Energy diversity: security	efficiency	CO2 emission	Local Potential	Infrastructure	Vehicle tech.	Cost
Coal with	Elect. Pwr	BEV	○	◎	◎			Battery	×
	Reforming	FCV		○	◎		×	FCV & H2 Storage	×
	CTL	ICEV		×	×		◎	◎	○
Oil with CCS	Elect. Pwr	BEV		◎	◎			Battery	×
	Reforming	FCV		○	◎		×	FCV & H2 Storage	×
	conventional	ICEV		×	×		◎	◎	◎
Natural Gas with	Elect. Pwr	BEV	○	◎	◎			Battery	×
	Reforming	FCV		○	◎		×	FCV & H2 Storage	×
	GTL	ICEV		×	×		◎	◎	○
Nuclear Power		BEV		◎	◎			Battery	×
	Electrolysis	FCV		△	◎		×	FCV & H2 Storage	×
Hydro & Wind		BEV	◎	◎	◎	depend		Battery	×
	Electrolysis	FCV		△			×	FCV & H2 Storage	×
PV	Elect. Pwr	BEV	◎◎	◎	◎	◎		Battery	×
	Electrolysis	FCV		△			×	FCV & H2 Storage	× ×
Biomass	Power Gen.	BEV	◎	◎	◎	depend		Battery	×
	Ethanol	ICEV		?			○	◎	○
	BTG	ICEV		×			◎	◎	○

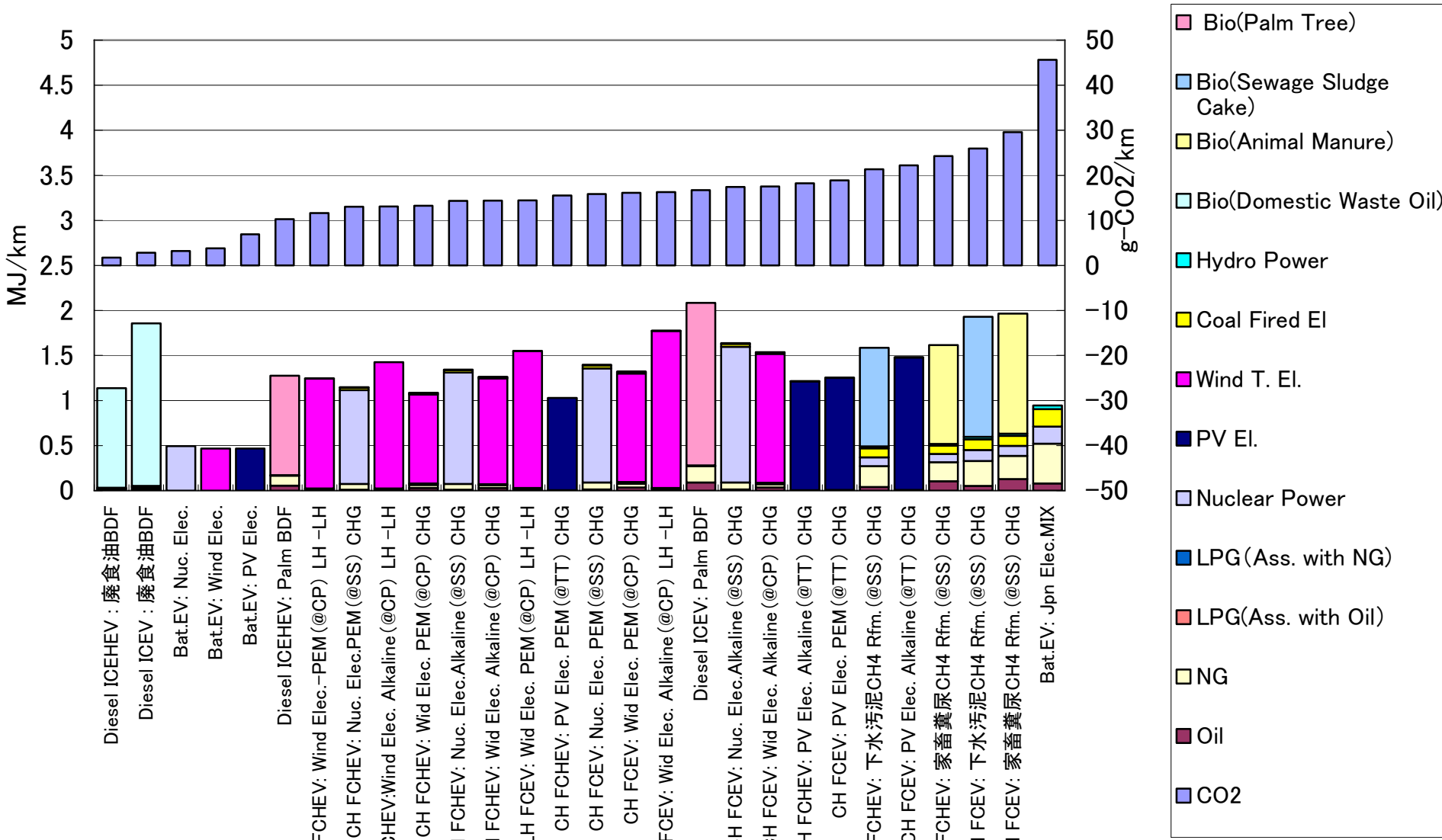
Transportation Energy Options questions?

- Technical Issues
  - FC stacks + Hydrogen Storage on board, and Hydrogen storage, transport at low cost
  - 2ndary battery (Li ion?) cost and durability
- Physical constraints
  - Potential of renewable energy, biomass, winds etc.
- Political Issues
  - Nuclear safety and proliferation
  - CCS potential and Ocean disposal

An example of WtW analysis in Japanese Condition energy source: NG and Oil base



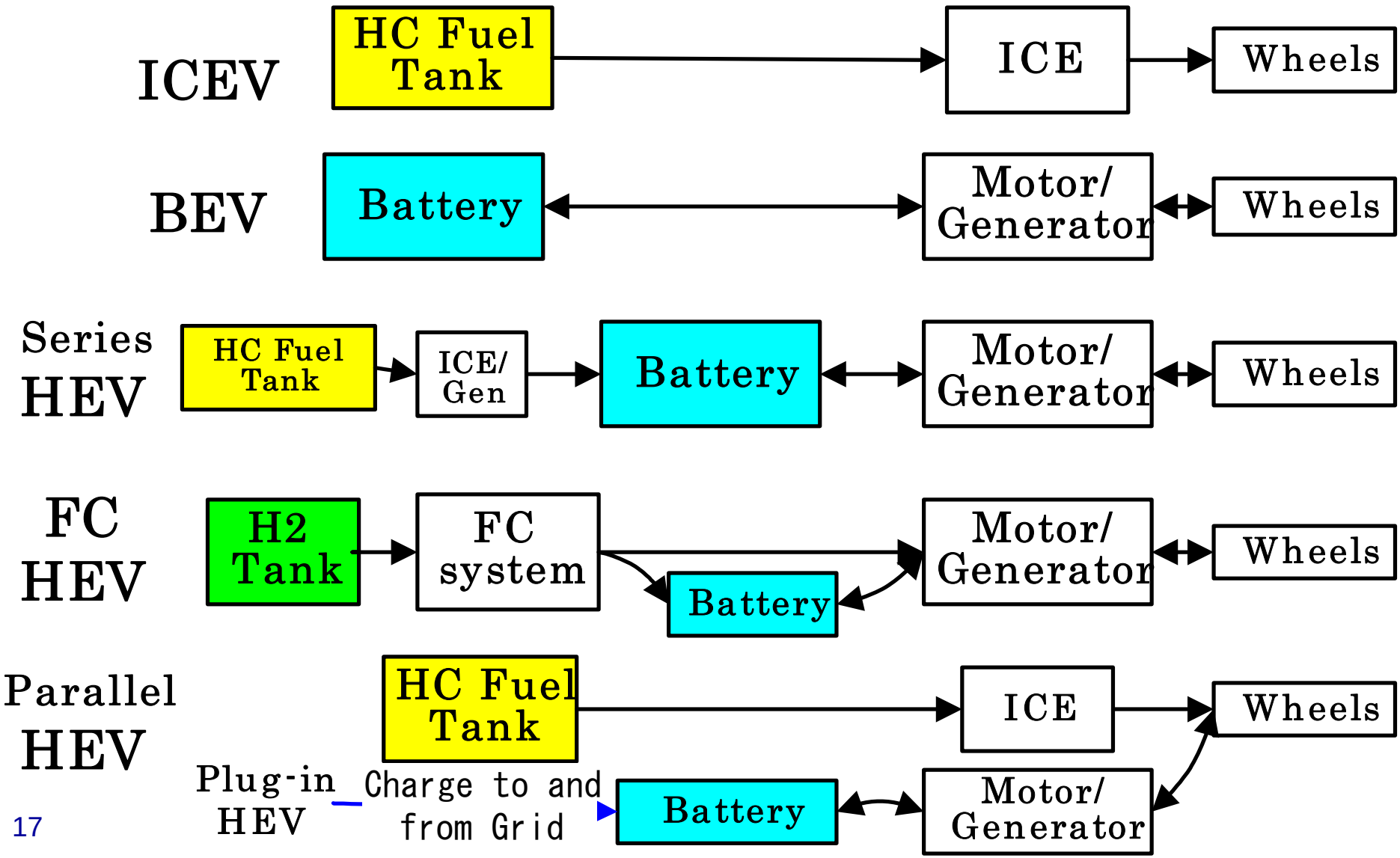
An example of WtW analysis in Japanese Condition energy source: Nuclear and Renewables



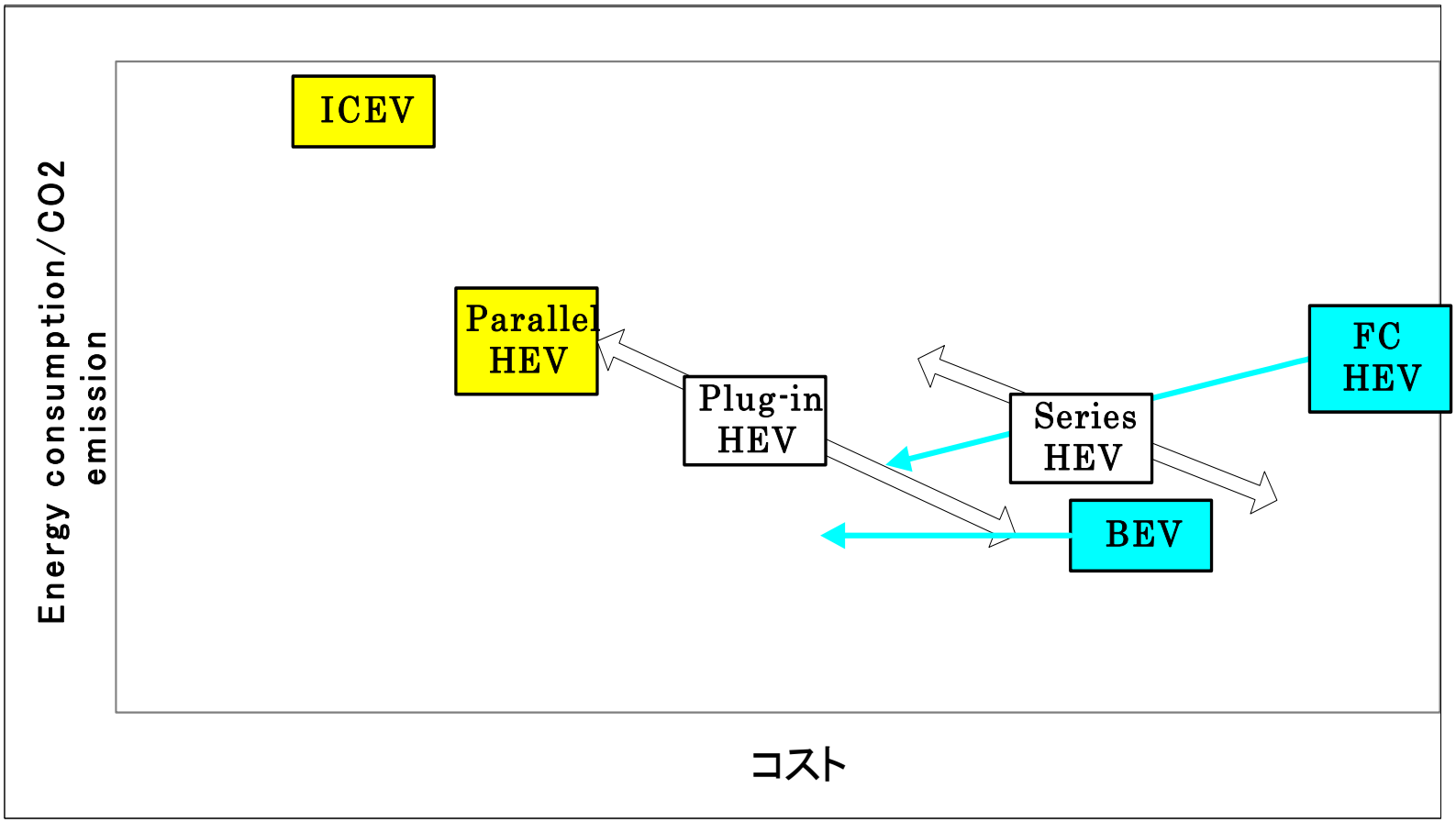
Recent topics and positions of stakeholders in JAPAN

- Car makers
  - For short term, sensitive to Californian movement. HEV, FCV, or Biofuel Diesel?
  - Long term, eager to R&D of Electric drive vehicles, especially, FCV and BEV
- Government
  - For short term, Kyoto Protocol, Revision of top runner standard, introduction of E3 fuel and diesel vehicles
  - Efficiency improvement of fleet service
  - For long term, promotion of R&D of fuel cell, hydrogen storage and infrastructure, and Li-ion Batteries, and demonstration/promotion of BEV and FCV
  - Importance of R&D of those technologies are stressed by identifying them as Strategic Strengthened R&D areas in “the Important R&D Fields and Development Policy” by the council of Science and Technology

Discussion on PHEV.
What is it?



Relative Position in the EV family
- BEV, HEV and FCV-



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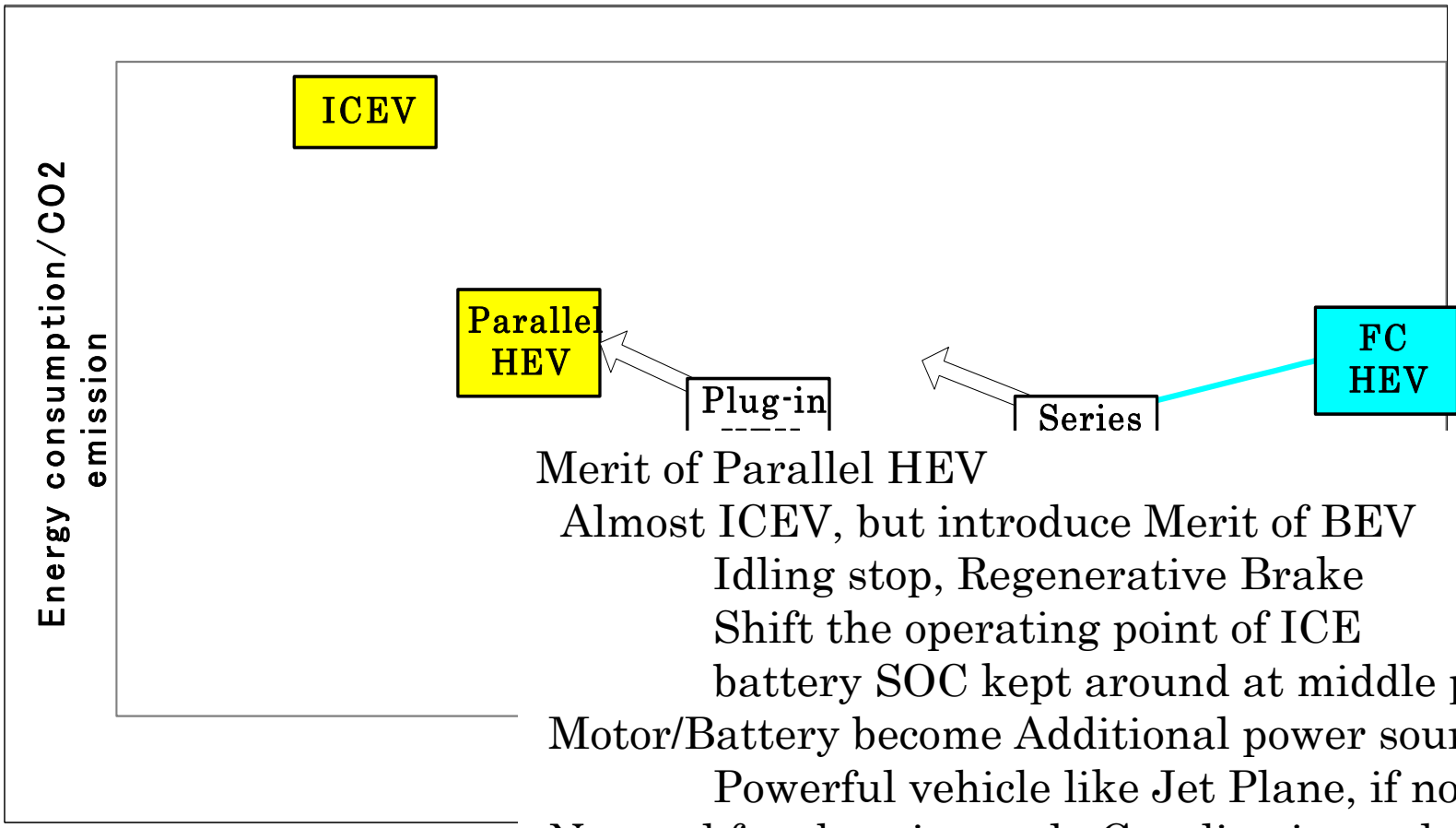

Merit of Parallel HEV

Almost ICEV, but introduce Merit of BEV

Idling stop, Regenerative Brake

Shift the operating point of ICE

battery SOC kept around at middle point

Motor/Battery become Additional power source

Powerful vehicle like Jet Plane, if not efficier

No need for charging, only Gasoline is needed

Why is it Useful?

- Better Well to Wheel Energy Efficiency
- Long term prospects:
  - only Biofuel, BEV, or FCV, from Non-oil CO2-less Energy sources can survive as sustainable Mobility
- Bridge to BEV through Battery tech. Improvements
  - Technically established except for Battery
  - HEV(Parallel type) is only vehicle with Electric drive and battery in the market
  - Almost no additional infrastructure is required for nighttime home charging
  - For short range, can enjoy electric drive in city area, and no range limitation (longer than HEV!)

What are critical issues?

- What are societal merits
  - How much CO2 can be reduced
  - How much Oil consumption can be reduced
- What are merits for customers?
  - Is it possible to Payback for extra cost
  - Comfortable and silent electric drive
- Technical Issues different from HEV
  - Emission control
  - Battery issues other than cost
    - Deep charge and discharge cycle: reliability, output energy density, lifetime
- Additional charging facilities
- Codes and standard settlement

Technical Challenge

- **Coming back to battery issues what HEV avoided.**
- **Battery related technical issues**
  - **Energy density and cost**
  - **Reliability, safety and lifetime**
  - **Low temperature start**
- **System issues as a vehicle**
  - **Weight increase**
  - **Battery space limitation**
  - **User's incentive**
- **System evaluation**
  - **Evaluation of Use patterns and market**
  - **Evaluation of energy consumption**
  - **Code and Standard for complicated vehicles**