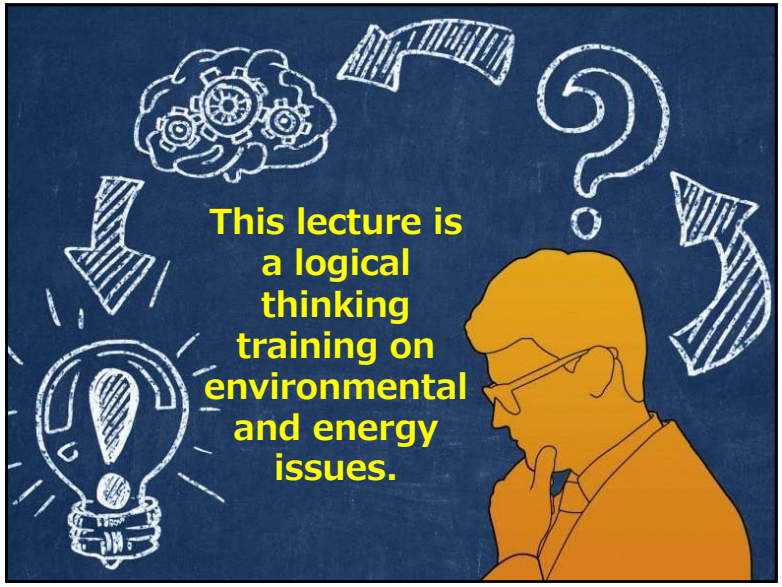
Global Environmental and Energy Policy

環境・エネルギー技術政策

Nov. 24 and Dec. 1, 2020

Jun TAKAHASHI

- ✓ Global energy balance
- ✓ How to read statistics data ?
  - ✓ Long-term viewpoint
  - ✓ Suspect an interpretation and the data itself !
- ✓ How to make a policy ?
- ✓ Quiz



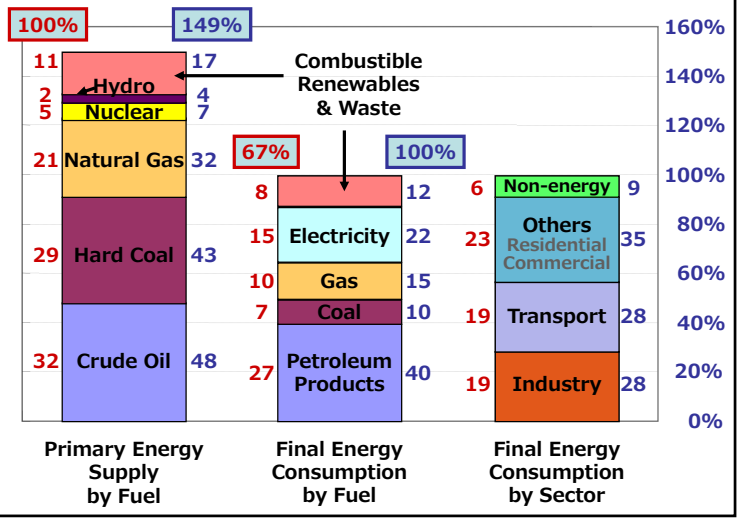
Guidance

1. Lecture website
2. Please submit the google form questionnaire at the end of the lecture as an evidence of your attendance.
3. The google form and lecture slides will be shared via chat between today's first and second half lectures.
4. In the second half of the lecture, we will decide the topics for next week's group presentation and divide everyone into groups, so please start thinking about the topics after the first half of the lecture.

For example...

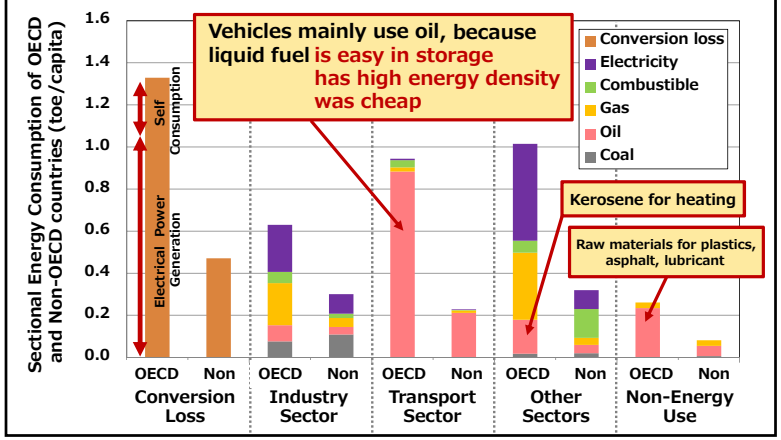
- ➢ How much can autonomous driving reduce energy consumption in the transport sector?
- ➢ Can solar power save the world?
- ➢ Is artificial intelligence good for the environment?

World Energy Balance (Source IEA statistics)

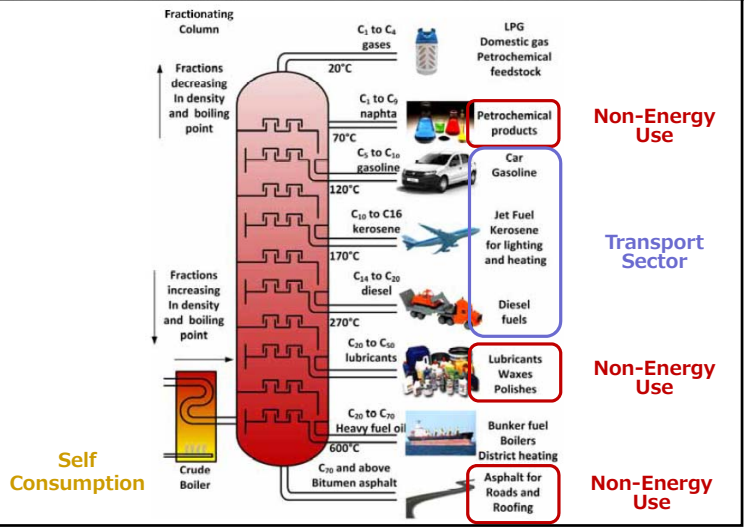


Sectional Energy Consumption of OECD and Non-OECD countries

2012	Population	Total Primary Energy Supply	Total Final Energy Consumption
OECD	1254 million	4.19 toe/capita	2.86 toe/capita
Non-OECD	5783 million	1.40 toe/capita	0.93 toe/capita



Oil Refinery



International Energy Agency

World energy balance, 2018

(Mtoe)

SUPPLY AND CONSUMPTION	Coal[1]	Crude oil	Oil products	Natural gas	Nuclear	Hydro	Biofuels and waste[2]	Other[3]	Total
Production	3 893.68	4 552.55	-	3 293.12	706.81	362.33	1 324.21	288.44	14 421.15
Imports	829.29	2 479.49	1 396.84	985.02	-	-	29.26	62.63	5 782.52
Exports	-879.69	-2 440.07	-1 488.67	-1 019.82	-	-	-25.25	-62.37	-5 915.88
Stock changes	-4.95	-6.45	3.32	3.28	-	-	-1.10	-	-5.91
TES	3 838.33	4 585.52	-88.52	3 261.59	706.81	362.33	1 327.13	288.70	14 281.89
Transfers	-1.16	-230.55	261.07	-	-	-	-0.00	-	29.36
Statistical diff.	-27.37	4.87	9.54	-3.13	-	-	-0.12	-1.22	-17.42
Electricity plants	-1 758.79	-30.84	-146.14	-910.91	-703.39	-362.33	-135.89	1 697.38	-2 350.91
CHP plants	-676.20	-0.02	-15.48	-333.42	-3.42	-	-64.69	609.25	-483.99
Heat plants	-24.10	-0.47	-9.86	-59.92	-	-	-12.43	99.33	-7.45
Blast furnaces	-180.55	-	-0.04	-0.04	-	-	-0.05	-	-180.69
Gas works	-9.66	-	-2.82	5.14	-	-	-0.67	-	-8.01
Coke ovens[4]	-66.28	-	-2.49	-0.01	-	-	-0.11	-	-68.89
Oil refineries	-	-4 361.96	4 269.23	-	-	-	-	-	-92.72
Petchem. plants	-	35.94	-36.00	-	-	-	-	-	-0.06
Liquefaction plants	-17.17	15.46	-	-11.30	-	-	-	-	-13.02
Other transf.	-0.28	12.61	-0.63	-14.74	-	-	-85.12	-0.54	-88.70
Energy ind. own use	-79.96	-9.87	-199.04	-302.71	-	-	-15.47	-232.13	-839.19
Losses	-2.31	-8.10	-0.31	-19.20	-	-	-0.19	-192.38	-222.50
TFC	994.50	12.59	4 038.50	1 611.35	-	-	1 012.37	2 268.40	9 937.70
Industry	796.76	2.50	290.44	597.86	-	-	204.05	947.68	2 839.31
Transport[5]	0.05	0.01	2 650.43	117.17	-	-	89.64	33.53	2 890.90
Other	146.15	0.00	436.00	702.70	-	-	718.68	1 287.20	3 290.73
Non-energy use	51.50	10.01	661.63	193.61	-	-	-	-	916.76

Total Primary Energy Supply

Total Final Energy Consumption

World population 7594M@2018

TPES 1.88 toe per capita

↓

Conversion loss 0.57 (30% of TPES)

↓

TFC 1.31 toe per capita

Fossil Resource and Material Production

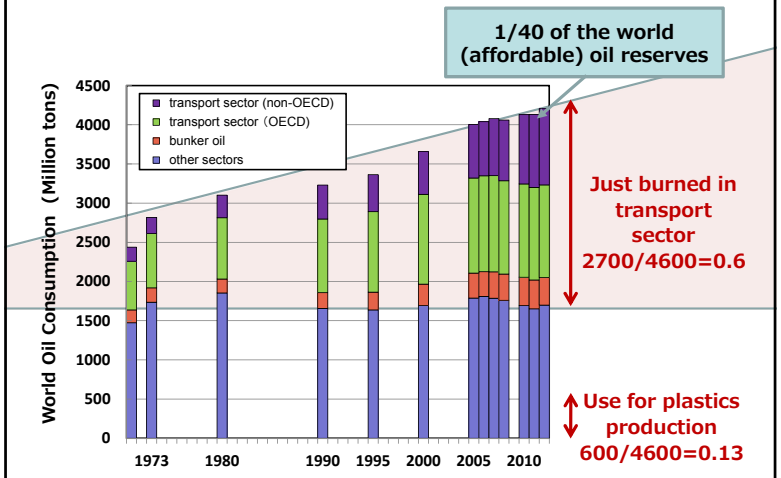
World coal production: 3.8 billion tons

- 2.8 billion tons (74%) is used as fuel
  - 1.8 billion tons (46%) is used for electricity
- 0.8 billion tons (21%) is used to product steel
  - Crude steel production: 1.8 billion tons

World oil production: 4.6 billion tons

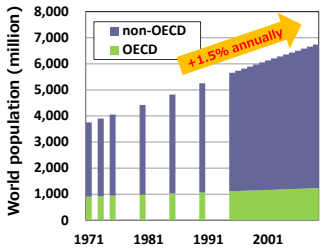
- 2.7 billion tons (58%) is used for transportation
- 0.2 billion tons (4%) is used for electricity
- 0.6 billion tons (13%) is used to product plastics
  - Plastics production: 0.29 billion tons

Oil consumption of the world and transport sector

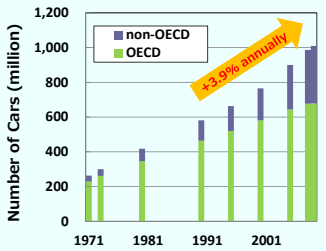


Source: EDMC, Energy & Economic Statistics 2015

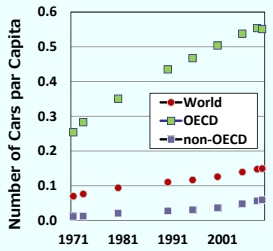
Growing World Population and Number of Cars



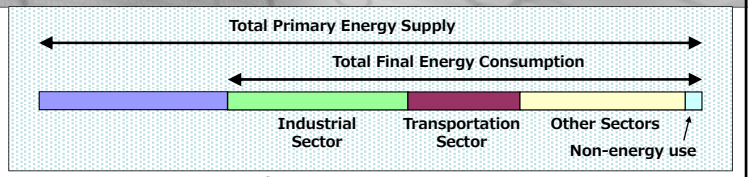
- Number of automobile in OECD countries are about an half of the population, and it will not increase.
- Number of world automobile will increase due to the moralization of non-OECD countries.

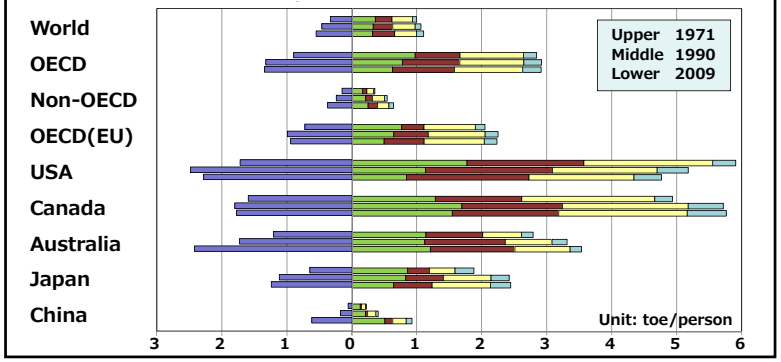


non-OECD	
Population	5508
Total	331
Passenger	205
Track	126
OECD	
Population	1229
Total	678
Passenger	480
Track	198

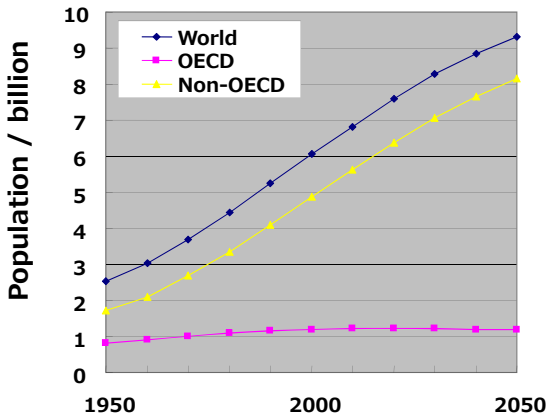


Total final energy consumption per capita





Transition of the world population



Source: UN

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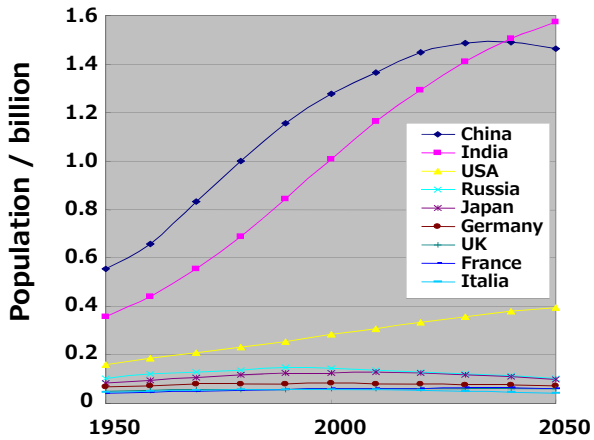

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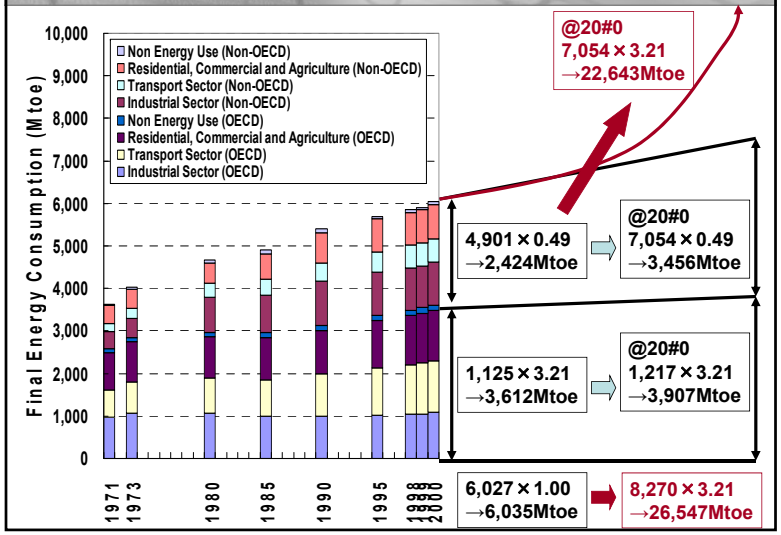
World Final Energy Consumption



Calculation of the amount of solar energy

Reference

- World primary energy supply is about 1.5 toe/year par capita
  - 1.5 [toe/ year par capita] = 40000 [kcal/day par capita]
- Human need energy of 2000 [kcal/day par capita] to live.

Solar energy flowing into the earth

$0.7 \times \pi R^2\ [m^2] \times 1367\ [J/m^2s]$

$= 0.7 \times 1.286 \times 10^{14}\ [m^2] \times 1367\ [J/m^2s]$

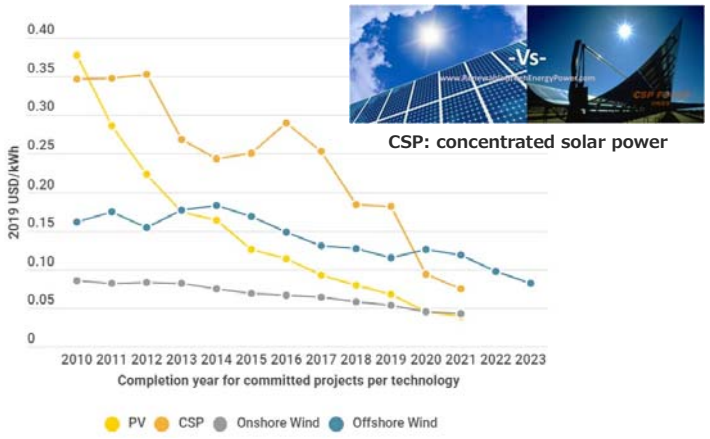
$= 1.23 \times 10^{17}\ [J/s]$

$= 2.94 \times 10^{13}\ [kcal/s]$ $(= 40000 \times 10^4\ [kcal/day\ par\ capita])$

$= 2.94\ [Mtoe/s]$ $(= 1.5 \times 10^4\ [toe/year\ par\ capita])$

We have not used it since fossil fuels were cheap!

Renewable energy costs



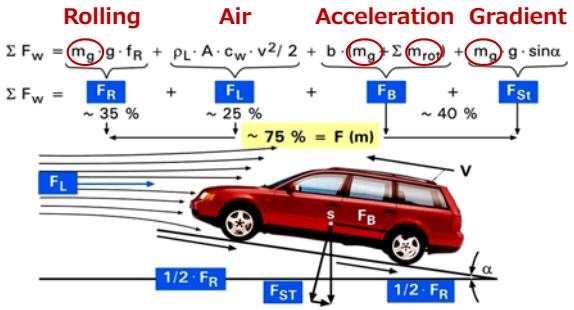
CSP: concentrated solar power

Source: IRENA – International Renewable Energy Agency

Next week's student's presentation

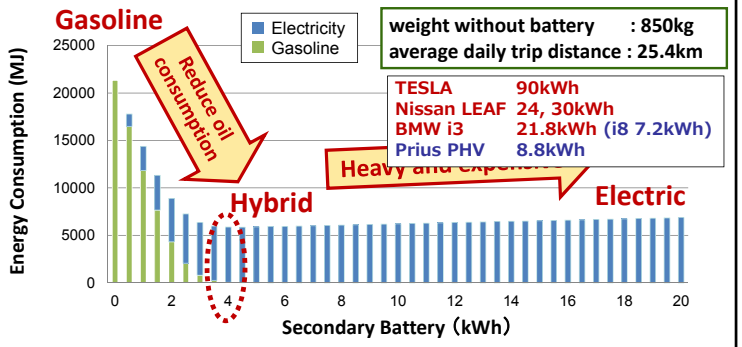
- ✓ Consider effective policy to reduce world's fossil fuel consumption by using statistics like today's lecture or following website first.
  - ✓ http://www.iea.org/
- ✓ Then, show your assumption about technological development such as ICT and AI, and introducing schedule of the technologies to our society.
- ✓ Evaluate the long term effect of the technologies on the reduction of fossil fuel consumption till 2050 quantitatively based on your assumption.

Running Resistance of the Automobile



- About 75% of the running resistance is proportional to vehicle weight
  - 30% improvement in fuel efficiency is expected by 40% weight reduction
- In the case of electric vehicles, the heavy and expensive battery can be reduced in proportion to the weight reduction of vehicle body

EV reduces oil consumption drastically, but …

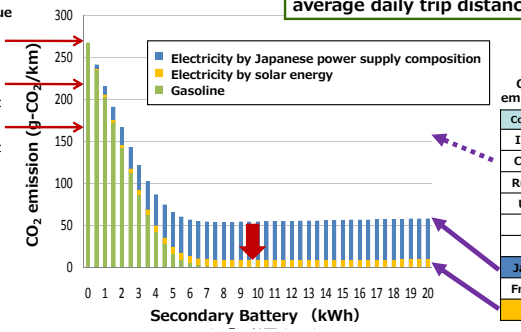


- There is an optimal amount of secondary battery depends on the weight of vehicle and average daily trip distance.
- Hence, weight lightening of HEV (Hybrid-EV) is effective to reduce cost of the optimal HEV, accordingly, its early spread.
- In addition, the daily demand of 4kWh, which is generated by 6m² of photovoltaic, can also be reduced by vehicle's weight reduction.

CO_2 Emission Structure of Japanese PHEV

weight without battery : 1380 kg
average daily trip distance : 30 km

Converted value
160g-CO_2/km current
130g-CO_2/km EU2015 target
95g-CO_2/km EU2020 target



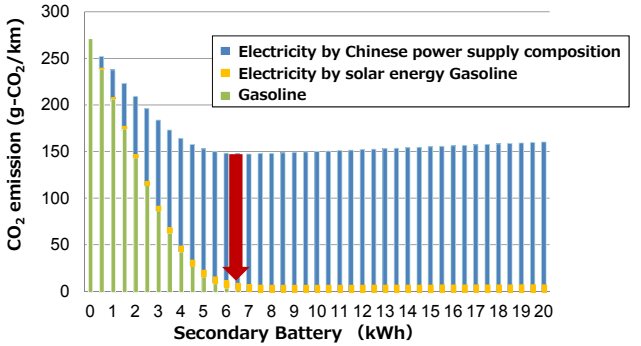
Coefficient of CO_2 emission by electricity

Country	kg-CO_2/kWh
India	1.490
China	1.034
Russia	0.927
USA	0.712
UK	0.564
EU	0.420
Japan	0.375
France	0.069
PV	0.053

■ Combination of solar and PHEV shows a significant effect !!!
- 3m² of PV generates 2kWh daily, hence PV-PHEV is possible.
- The amount of secondary battery is more important from a viewpoint of CO_2 emission.

CO_2 Emission Structure of PHEV in China

weight without battery : 1380 kg
average daily trip distance : 30 km



Vehicle's Weight Lightening Technology will Save the World !

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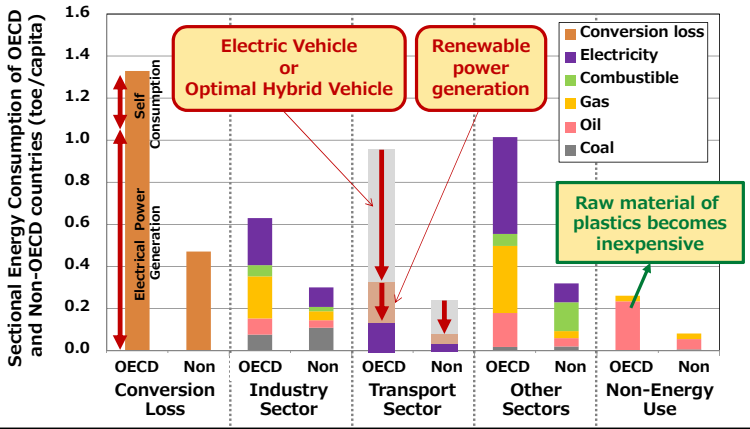

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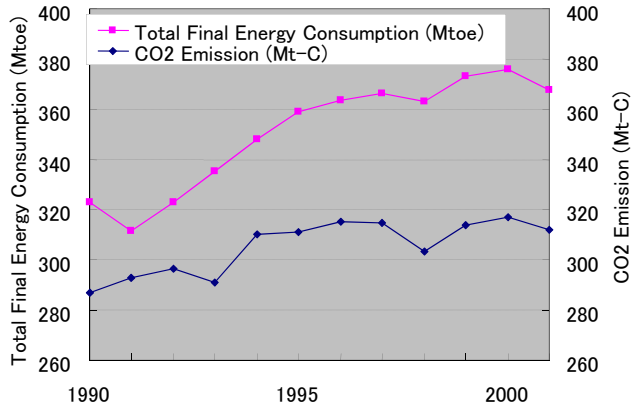
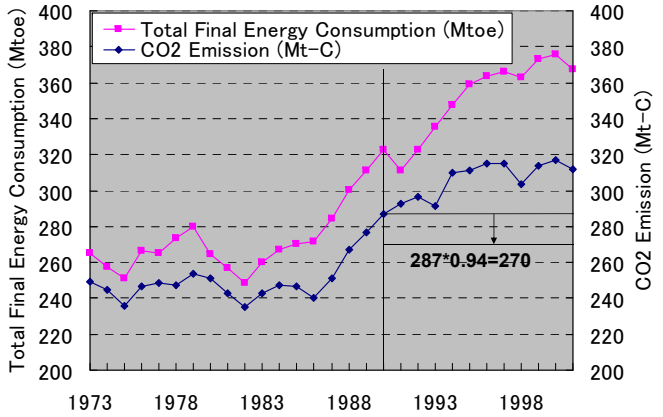
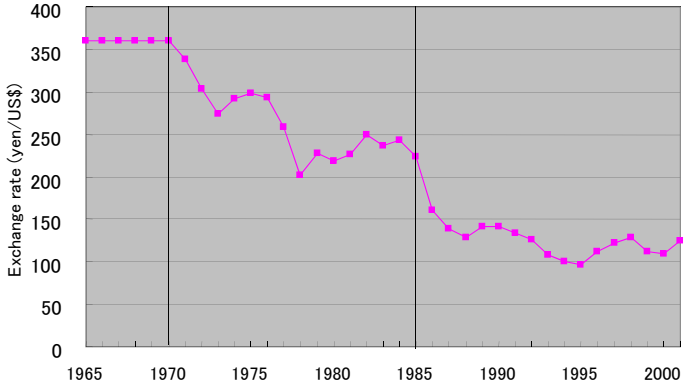
Japanese TFC and CO2 Emission (1990-2001)



Japanese TFC and CO2 Emission (1973-2001)

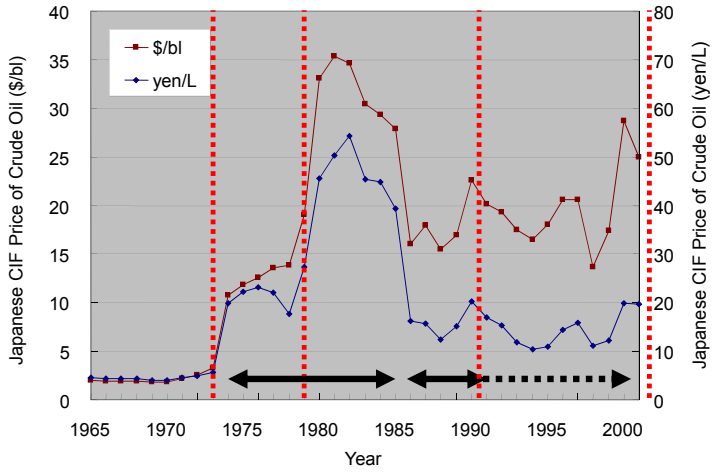


Exchange Rate (yen/US$)

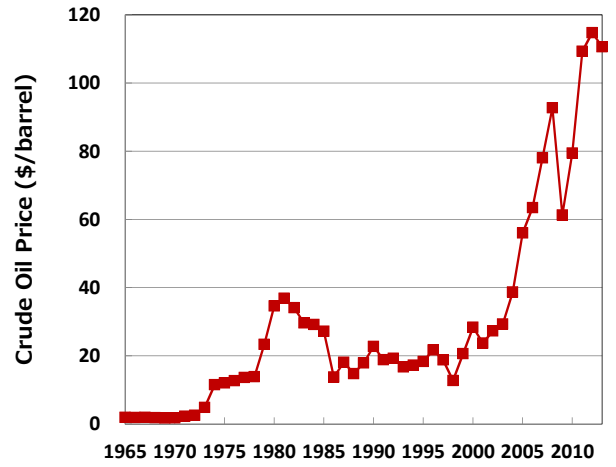


Japanese CIF Price of Crude Oil

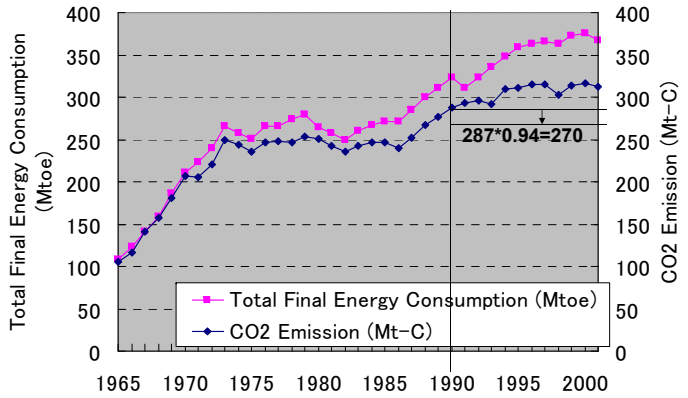
CIF: Cost + Insurance + Freight



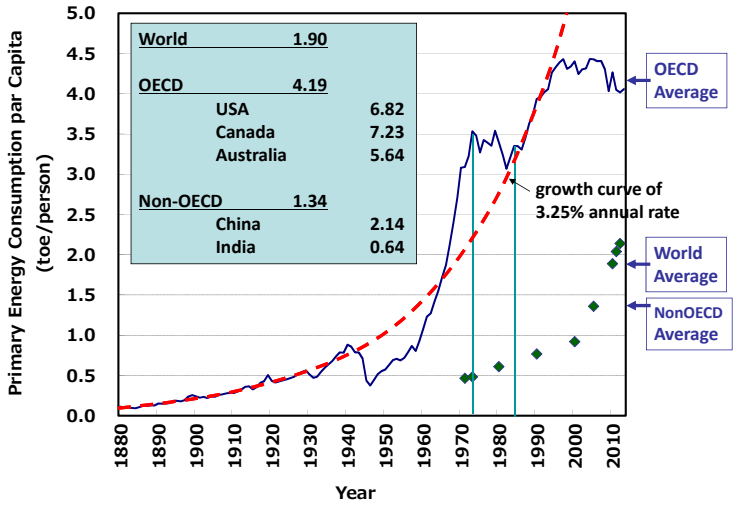
Long Term Trend in Crude Oil Price



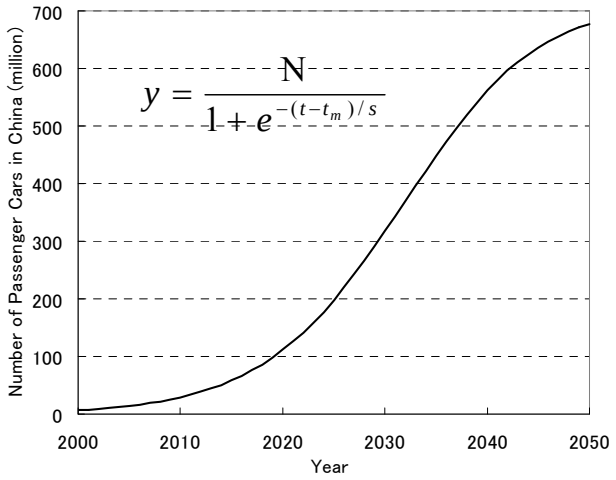
Japanese TFC and CO2 Emission (1965-2001)



Japanese Primary Energy Consumption per Capita (toe/person)



Logistic Function



The Items of Final Energy Consumption

Industrial Sector

- Manufacturing
  - Material
    - Steel
    - Chemicals
    - Cement
    - Paper and Pulp
  - Processing/assembly
    - Foods
    - Textile
    - Nonferrous metal
    - Machines
    - Others
- Non-manufacturing
  - Agriculture, Forestry & Fishery
  - Mining
  - Construction

Residential Sector

- Heating
- Cooling
- Hot Water Supply
- Cooking
- Power & etc.

Commercial Sector

Transport Sector

- Passenger
  - Car (Private)
  - Car (Commercial)
  - Bus
  - Airplane
  - Ship
  - Railway
- Freight
  - Truck
  - Airplane
  - Ship
  - Railway

Non Energy Use

- Asphalt, grease, paraffin, lubricating oil, etc.

最終エネルギー消費部門の分類

産業部門

- 製造業
  - 素材系
    - 鉄鋼
    - 化学
    - 窯業土石
    - 紙・パルプ
  - 非素材系
    - 食品煙草
    - 繊維
    - 非鉄金属
    - 金属機械
    - その他
- 非製造業
  - 農林水産業
  - 鉱業
  - 建設業

家庭部門

- 暖房
- 冷房
- 給湯
- 厨房
- 動力・照明他

業務部門

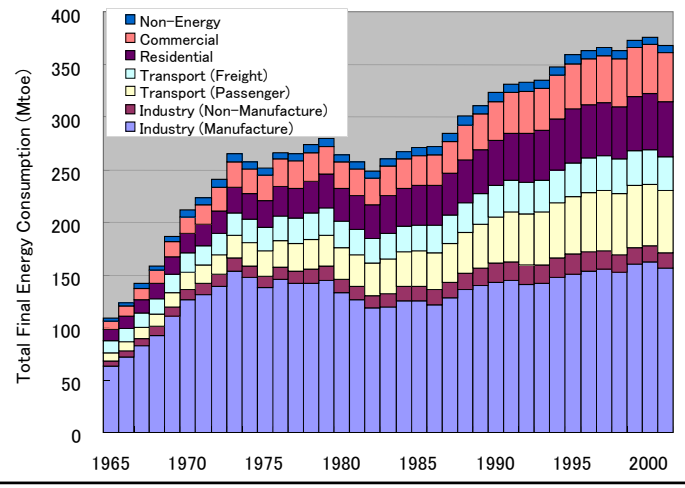
運輸部門

- 旅客
  - 自家用乗用車
  - 営業用乗用車
  - バス
  - 旅客航空
  - 旅客海運
  - 旅客鉄道
- 貨物
  - 貨物自動車
  - 貨物航空
  - 貨物海運
  - 貨物鉄道

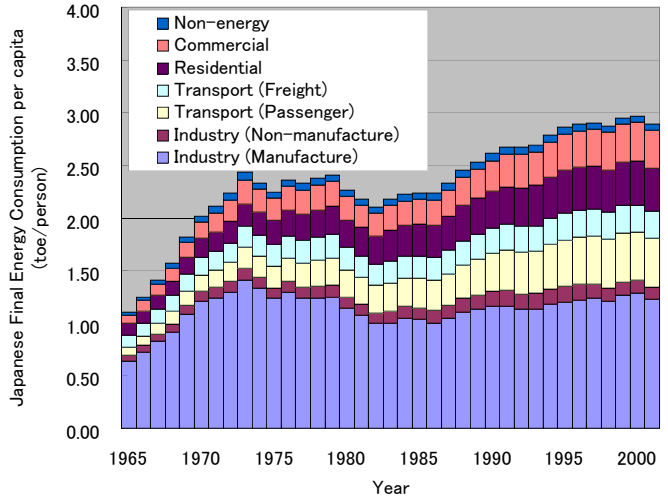
非エネルギー

アスファルト、グリース、パラフィン、潤滑油等

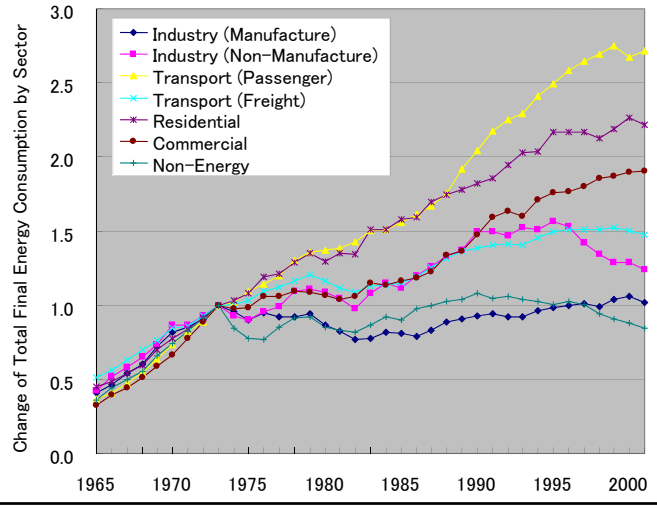
Japanese TFC by Sector (Mtoe)



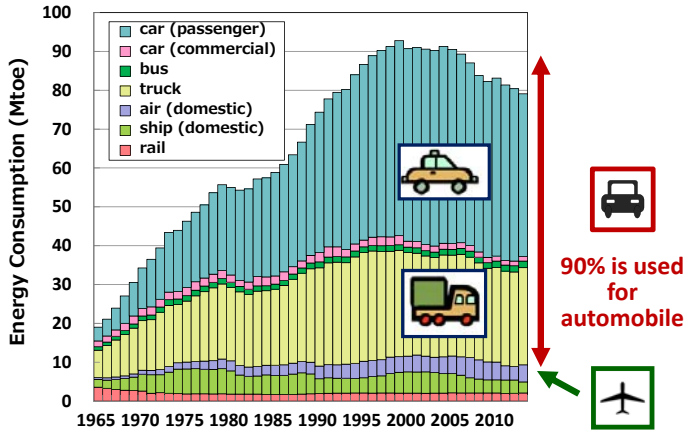
Japanese Final Energy Consumption per capita



Change of TFC by Sector (in comparison with 1973)

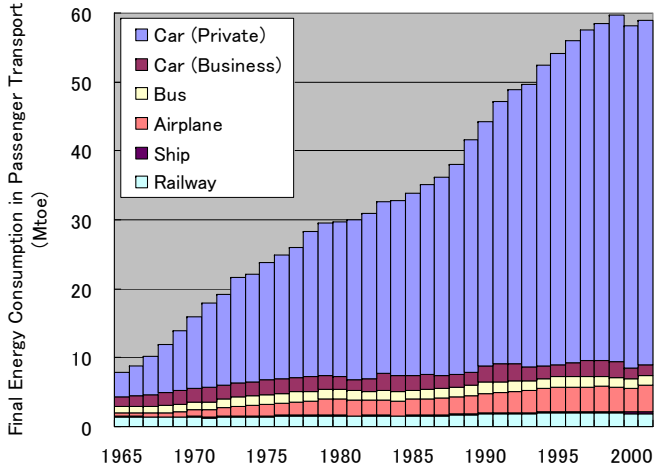


Energy Consumption Structure of Japanese Transport Sector

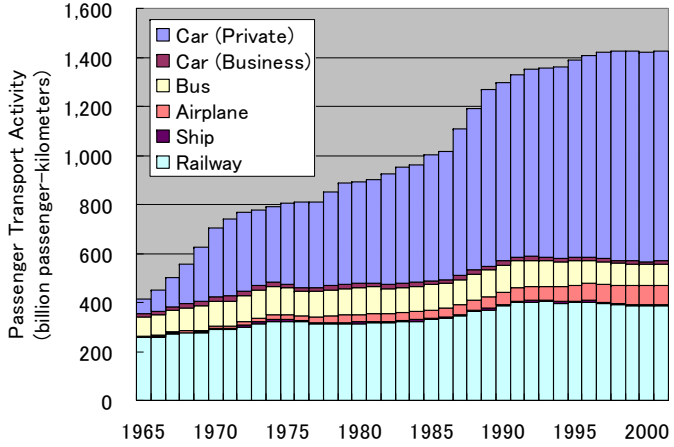


Source: EDMC, Energy & Economic Statistics 2015

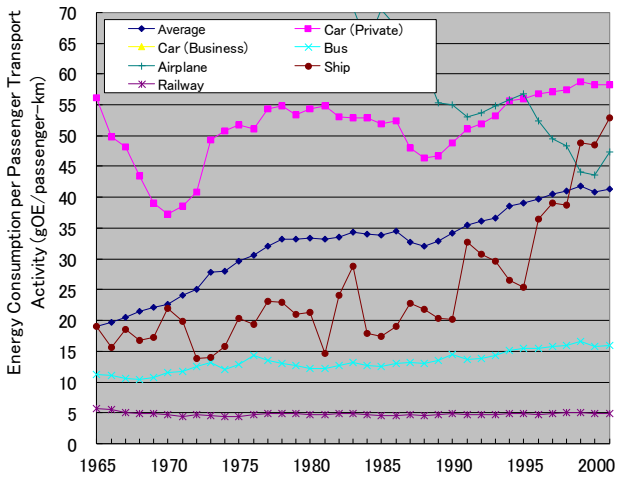
Energy Consumption in Passenger Transport (Mtoe)



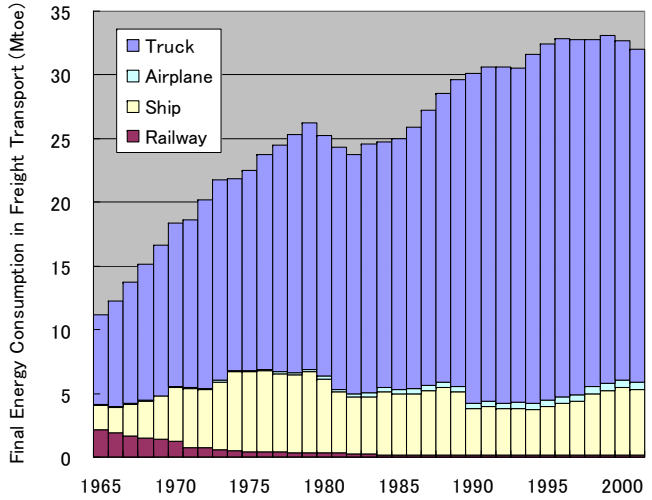
Passenger Transport Activity (passenger-kilometers)



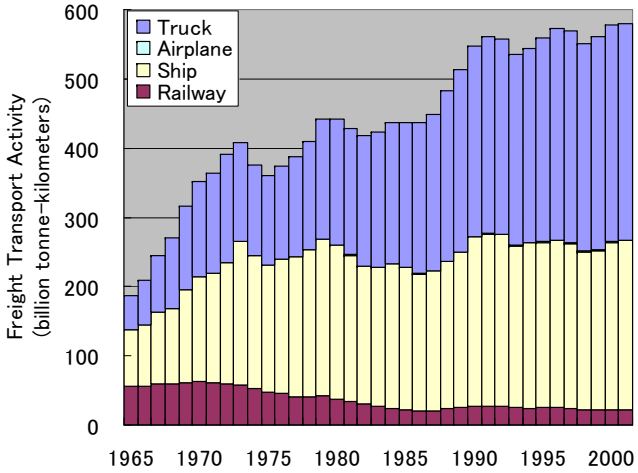
Energy Consumption per Passenger Transport Activity



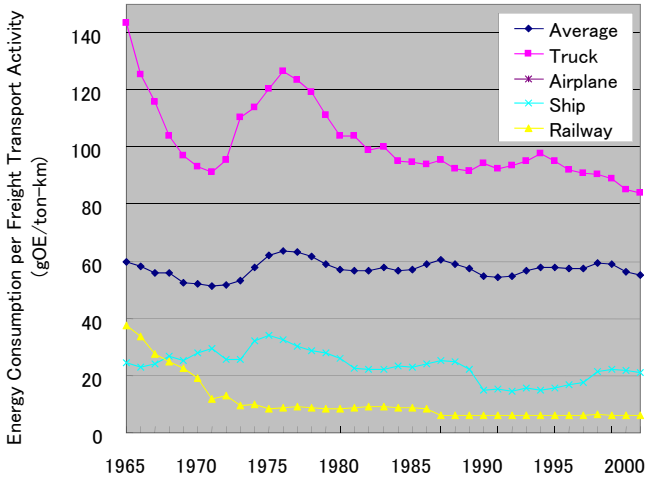
Energy Consumption in Freight Transport (Mtoe)



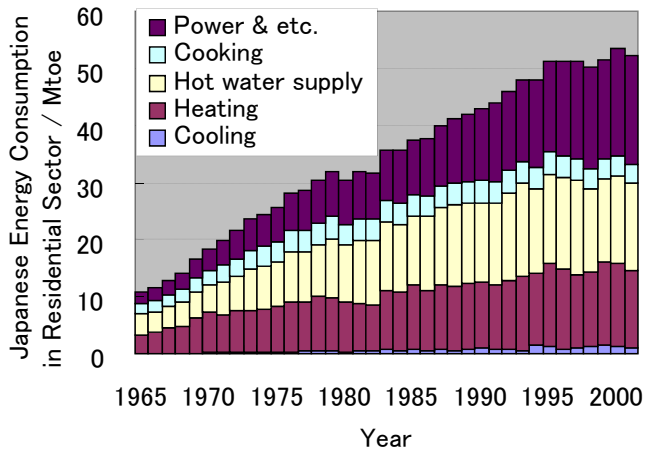
Freight Transport Activity (tones-kilometers)



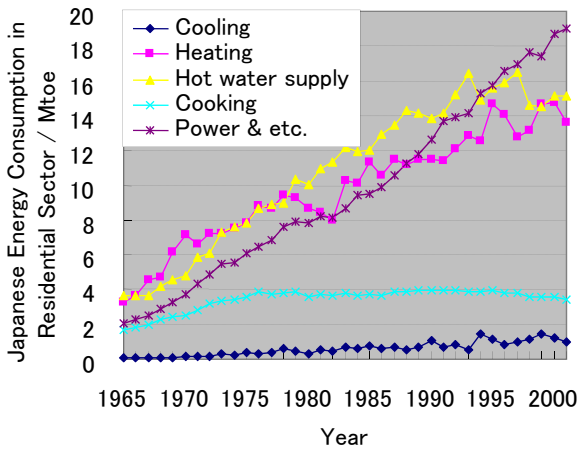
Energy Consumption per Freight Transport Activity



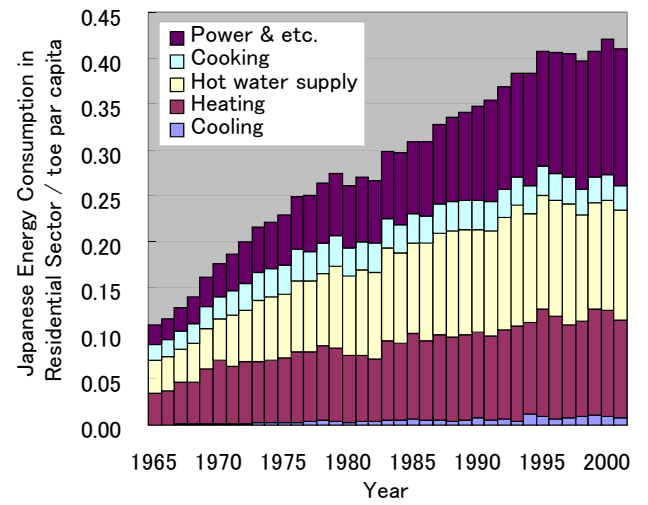
Japanese Energy Consumption in Residential Sector



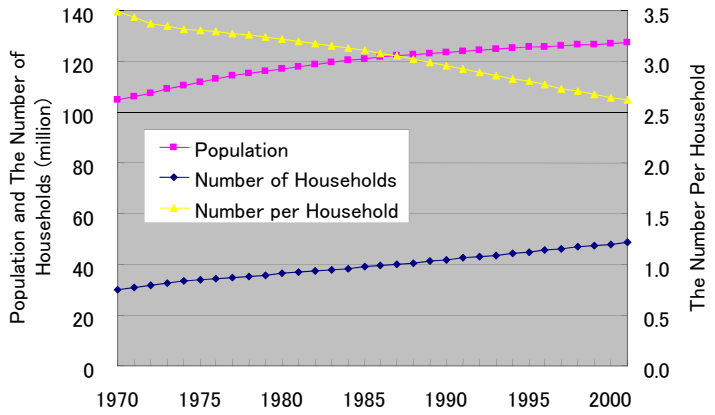
Japanese Energy Consumption in Residential Sector



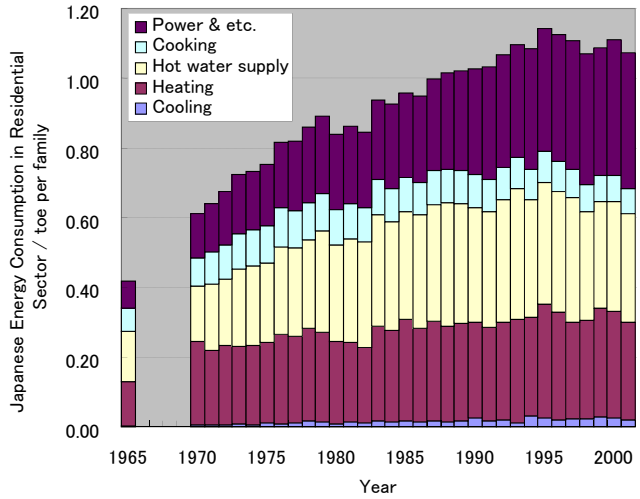
Japanese Energy Consumption in Residential Sector



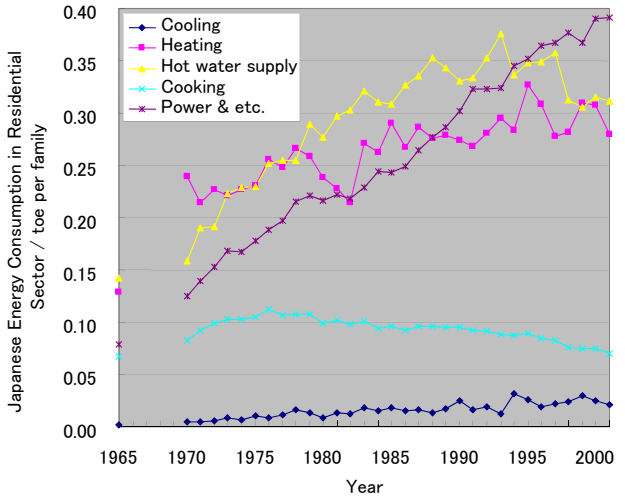
Japanese Population and The Number of Households



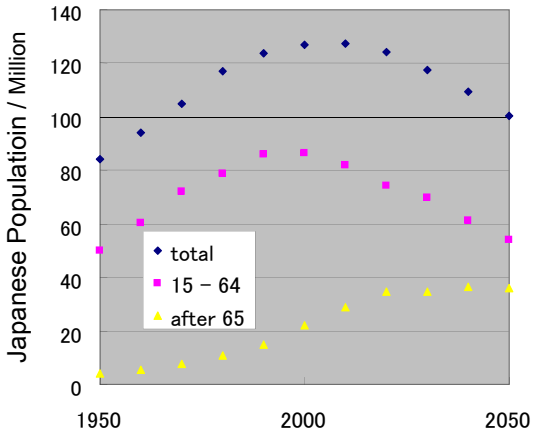
Japanese Energy Consumption in Residential Sector



Japanese Energy Consumption in Residential Sector



Transition of population composition of Japan



% of after 65

year	%
1970	7
1980	9
1990	12
2000	17
2010	23
2020	28
2030	30
2040	33
2050	36

Next week's student's presentation

- ✓ **Theme**
  - ✓ Consider effective policy to reduce world's fossil fuel consumption by using statistics shown in today's lecture or following website first.
    - ✓ http://www.iea.org/
  - ✓ Then, show your assumption about technological development, i.e. ICT and AI, and introducing schedule of the technologies to our society.
  - ✓ Evaluate the long term effect of the technologies on the reduction of fossil fuel consumption till 2050 quantitatively based on your assumption.

- ✓ **Presentation and Submission at Dec. 1**
  - ✓ You have to make a group which consists of 3 to 5 students.
  - ✓ Discuss well about your presentation in your group.
    - ✓ Presentation will start from 15:00
  - ✓ Every group have to make a 15 to 20 minutes on line (Zoom) presentation by using Microsoft powerpoint.
  - ✓ After the class, the slide (if necessary modified) which includes names of the group member have to submit by google form.