



# History of Sustainable Energy Policies and Development of Green Energy Technologies in Japan



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# Outline

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- ▶ Brief history of sustainable energy policies
  - ▶ Especially, after the oil crises and Kyoto protocol
- ▶ Development of green energy technologies under the sustainable energy policies
- ▶ Science and technology policies, ecological tax reforms, bounty systems for saving energy and developing renewable energy



# Brief history of sustainable energy policies

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# Brief history of sustainable energy policies

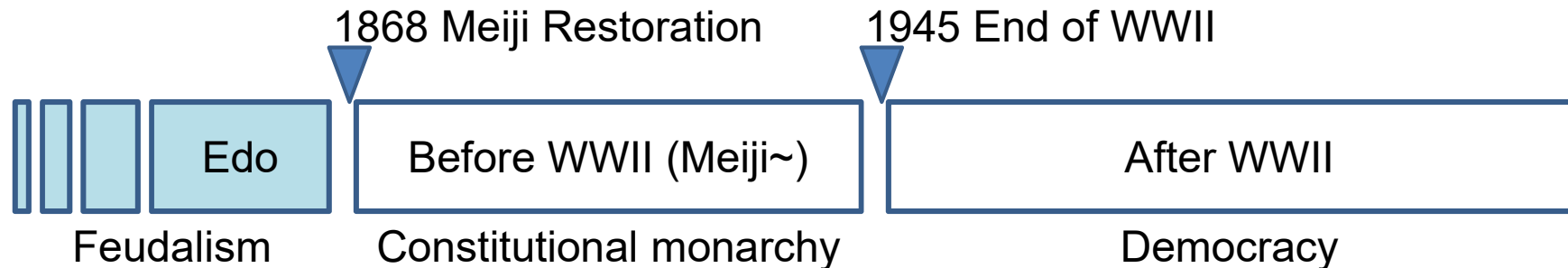
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- ▶ Brief history of modern Japan
- ▶ Brief history of Japanese industry after WWII
- ▶ Changes of Japanese energy policy
  - ▶ Oil crises
  - ▶ Global warming
  - ▶ Fukushima Daiichi nuclear disaster



# Brief history of Modern Japan (1)

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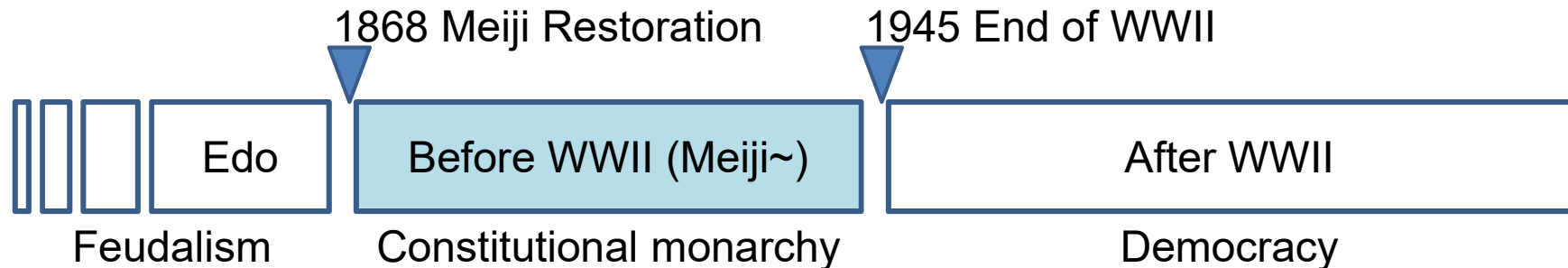


- Edo Period (1603 - 1868)
    - Tokugawa family ruled Japan as shoguns (generalissimos / tycoons)
    - Foreign affair and trade were limited: “national isolation policy” or “seclusion policy”
    - Absence of warfare
    - High Literacy rate
      - 30 – 50% of men and 20% of women could read and write in early 1800s
  - Fall of Tokugawa government
    - In 1854, under the pressure of USA, Tokugawa government agreed to open the border
    - Economic and social chaos broke out
- 



# Brief history of Modern Japan (2)

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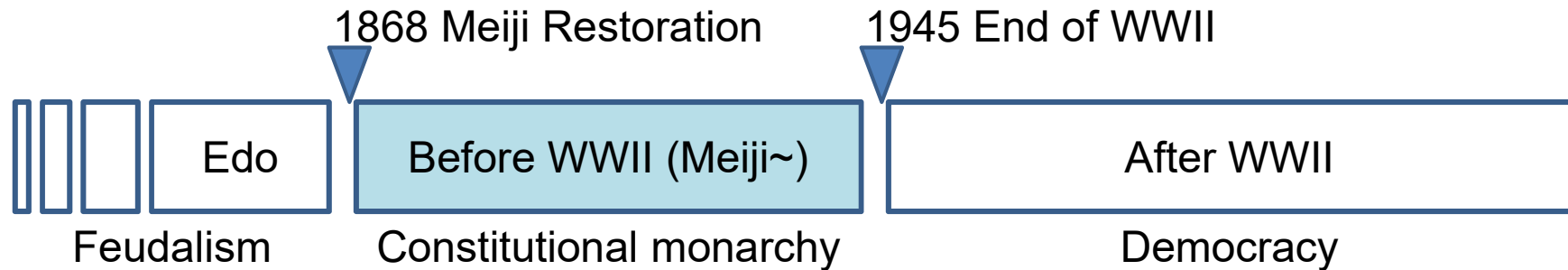


- Meiji Restoration (1868)
  - After a short-term civil war, the new government was established
  - Political, social, economical, educational, and military modernization began
- New education system
  - One of the leaders of the new government, Kido Koin thought that the mass schooling was a fundamental source of the economic and military power [1]
  - In 1872, the four-years elementary education became to be compulsory for all children
  - By the beginning of the 20th century, 98% of boys and 93% of girls were educated in the elementary school



# Brief history of Modern Japan (3)

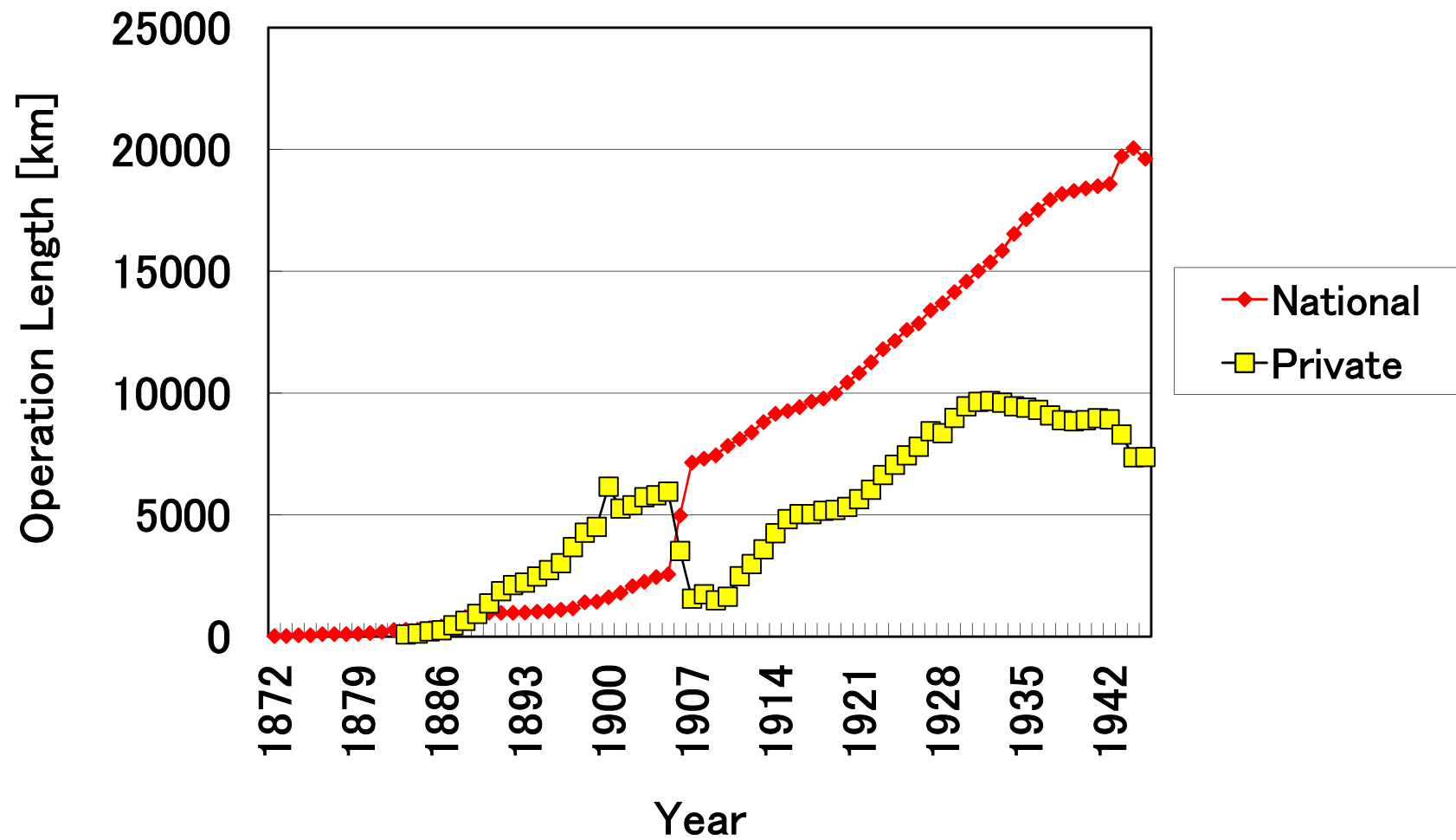
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- Industrial Revolution
  - From 1880 to 1900, The Meiji government built the economic infrastructure:
    - Railway
    - Commercial law
    - Specialized banks to provide long-term credit to industry
- Manufacturing output increased more quickly than the Western countries
  - From 1895 to 1915, the American manufacturing output doubled
  - In the same period, the Japanese manufacturing output increased 2.5 times



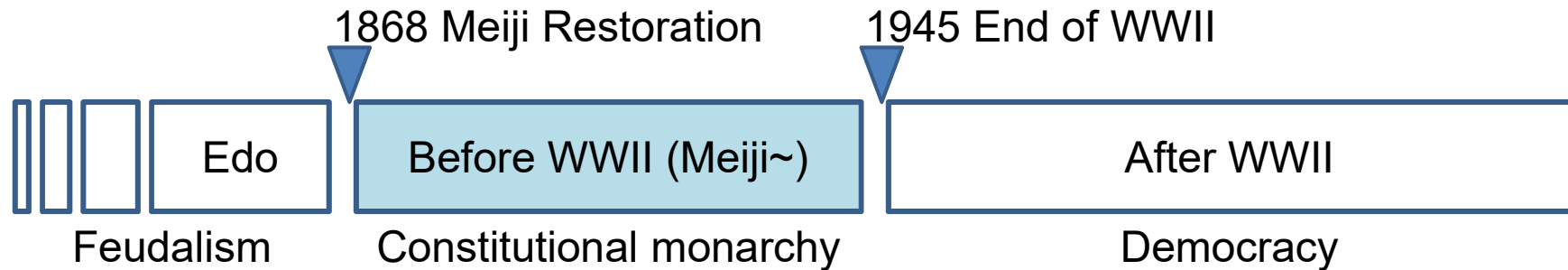
# Expansion of Railroads (1872 - 1944) [2]





# Brief history of Modern Japan (4)

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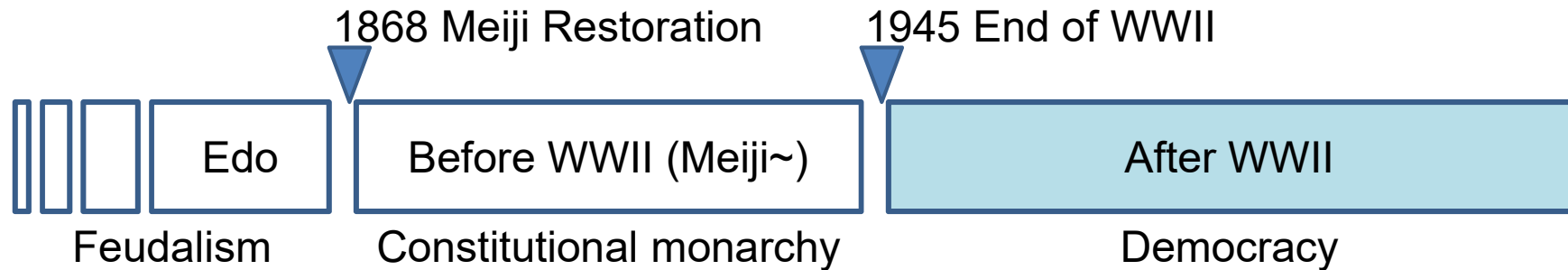


- Problematic point of Japanese modernization
  - Imperialism and military-first policy
  - Poor living standard
- Fall of Japanese Empire
  - In 1941, Japan attacked the USA fleet at Pearl Harbor and invaded the Philippines, Malaysia, and Thailand
  - The social and economical infrastructure of Japan was destroyed by the US bombardments
  - In 1945, Japan surrendered after the USA dropped two atomic bombs on Hiroshima and Nagasaki



# Brief history of Modern Japan (5)

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- Recovery and development of Japan
    - In the WWII, the social and economical infrastructure of Japan was destroyed by the US bombardments
    - However, the Japanese economy was recovered from such situation
    - “From 1950 to 1973, Japan’s gross national product (GNP) expanded by an average annual rate of more than 10%”
  - Reasons of quick recovery of Japanese economy
    - Entrepreneurship
    - Highly educated labor force
    - Exports
    - Domestic demands
    - Long-term and stable price of oil
- 



# Entrepreneurship

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- One of the reasons of the economic growth is thought to be the “Entrepreneurship”
- “A new generation of daring younger managers took charge of established companies and founded new ones”
  - “Many top managers of the wartime economy” were forced to retire by order of GHQ (occupation army)



# Entrepreneurship: Honda

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- **Establishment**
  - In 1948, Soichiro Honda established the Honda Technical Research Institute to develop and produce small 2-cycle motorbike engines
- **Motorcycle**
  - His company grew quickly and became the world's largest motorcycle manufacturer by 1964
- **Automobile**
  - The company entered the automobile market in 1963 and now becomes the sixth largest automobile manufacturer in the world



# Entrepreneurship: Sony

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**SONY**

- **Establishment**
  - At first, it was called Tokyo Telecommunications Engineering Corporation and was established in 1948 by two young entrepreneurs, Akio Morita and Masaru Ibuka
- **Transistor**
  - In the early 1950s, in his business trip in the US, Ibuka heard that Bell labs' invention of the transistor
  - Morita and Ibuka thought that transistors could be used to make radios
  - They won the permission to purchase a license to make transistors
- **Growth**
  - After the success of the transistor radios, Sony produced TVs, video tape recorders, compact discs, personal computers, video game consoles



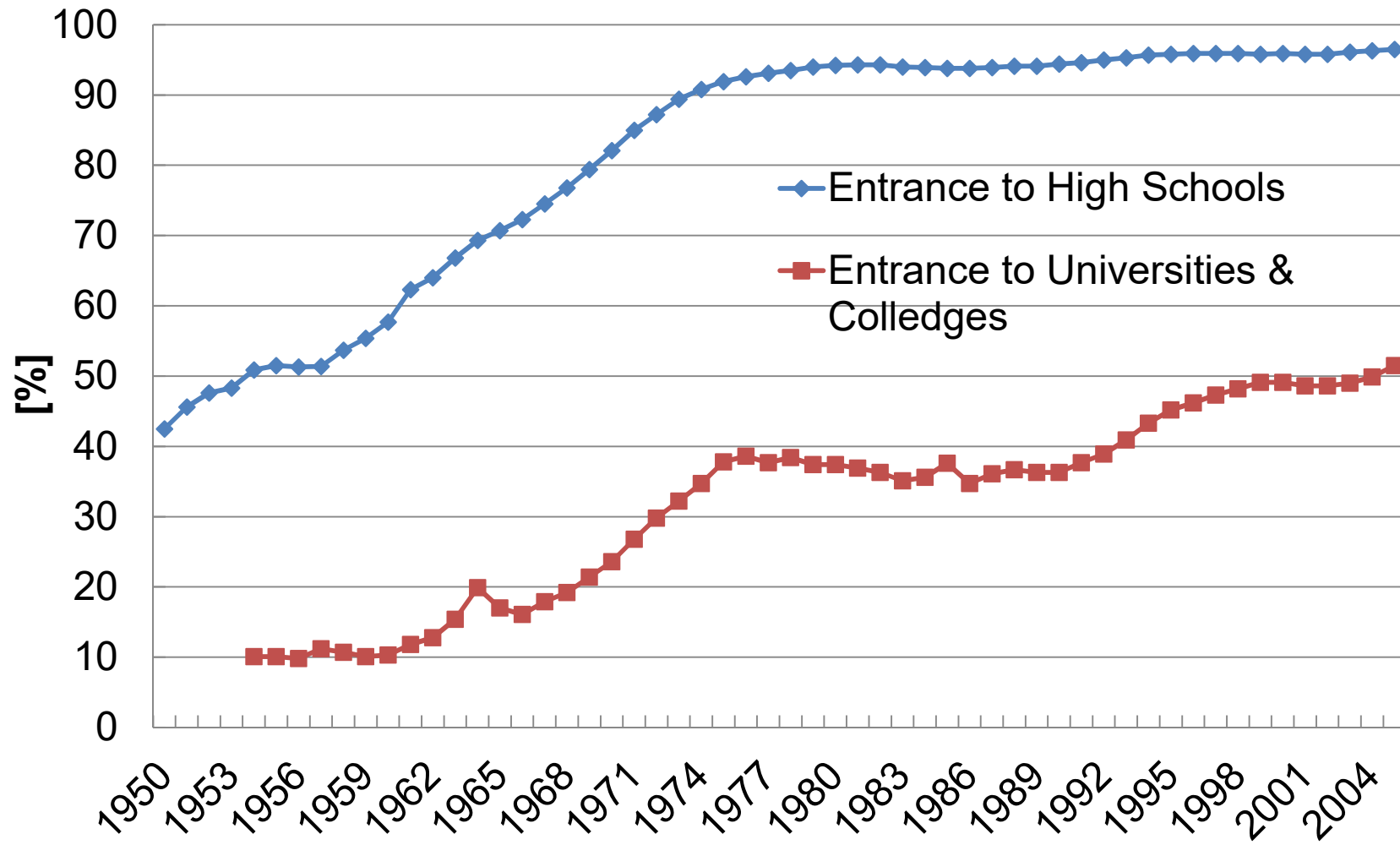
## High quality of human resources

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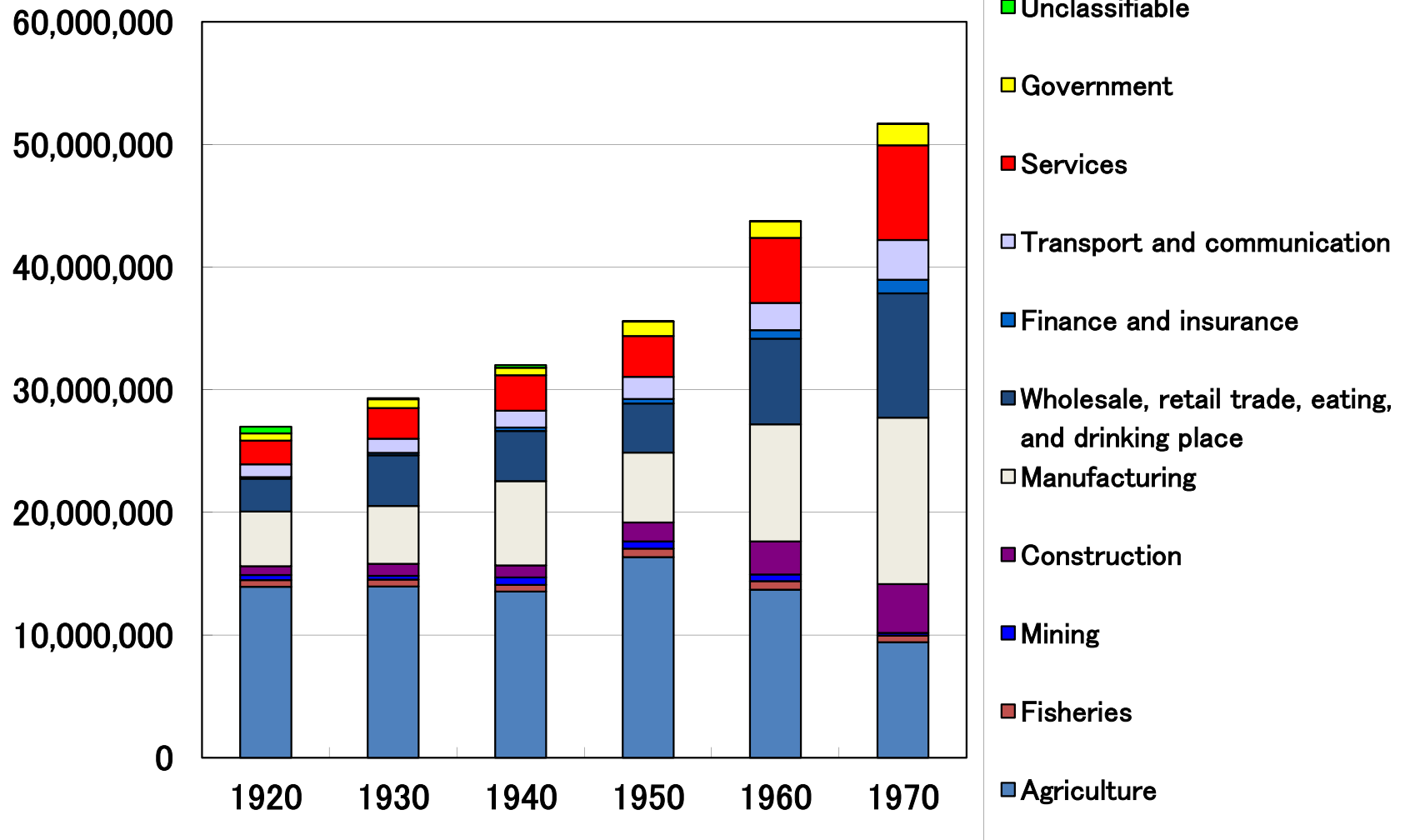
- Compulsory education was extended to middle school by order of the GHQ (occupation army)
- Young people were well educated and became good workers
- “Labor productivity in manufacturing rose 88 percent in the decade from 1955 through 1964” [1]



# Enrollment Rate of Higher Education [2]



# Employed persons [2]





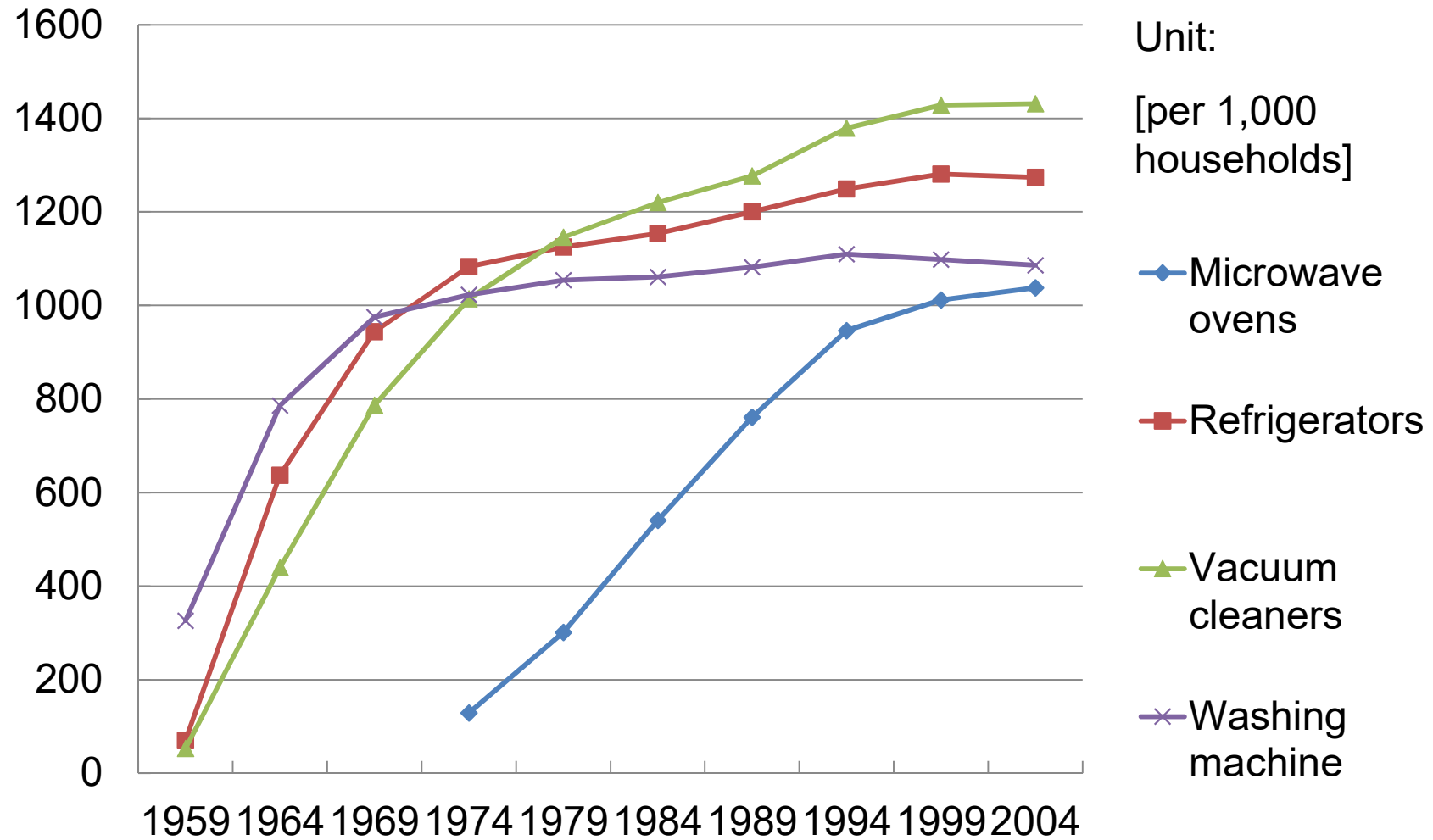
# A main engine of economic growth

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- Exports contributed to the Japanese economy
- However, domestic demand was the main engine of economic growth
  - “From the 1950s through the early 1970s, exports accounted for just 11 percent of GNP” [1]
  - “Over the same time span, the capitalist economies of Western European nations exported an average of 21 percent of their GNP” [1]
- Japanese citizens worked hard and spent on a expensive consumer goods
  - Refrigerators, washing machines, cars, TV, etc.

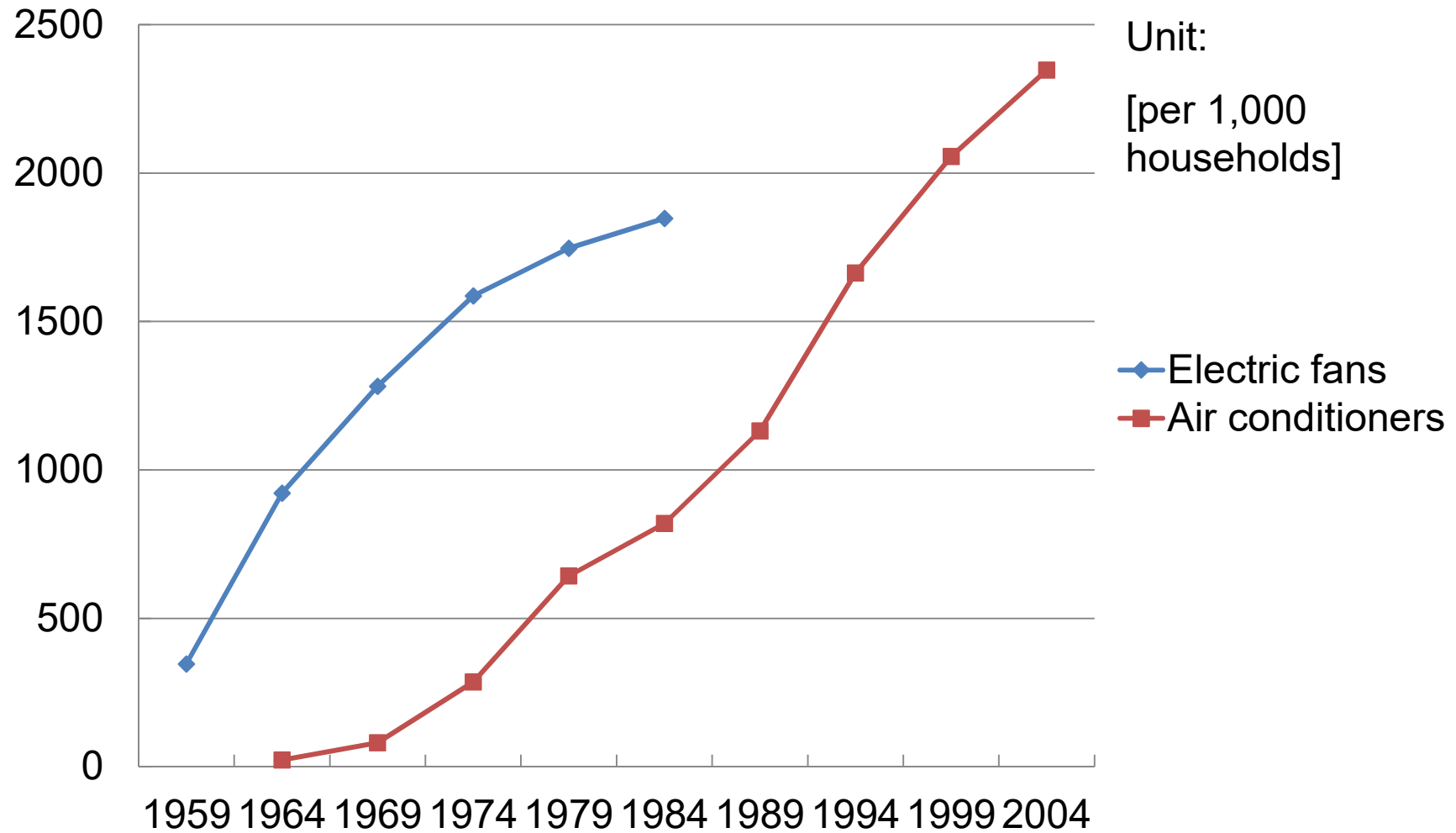


# Quantity of household durables [2]

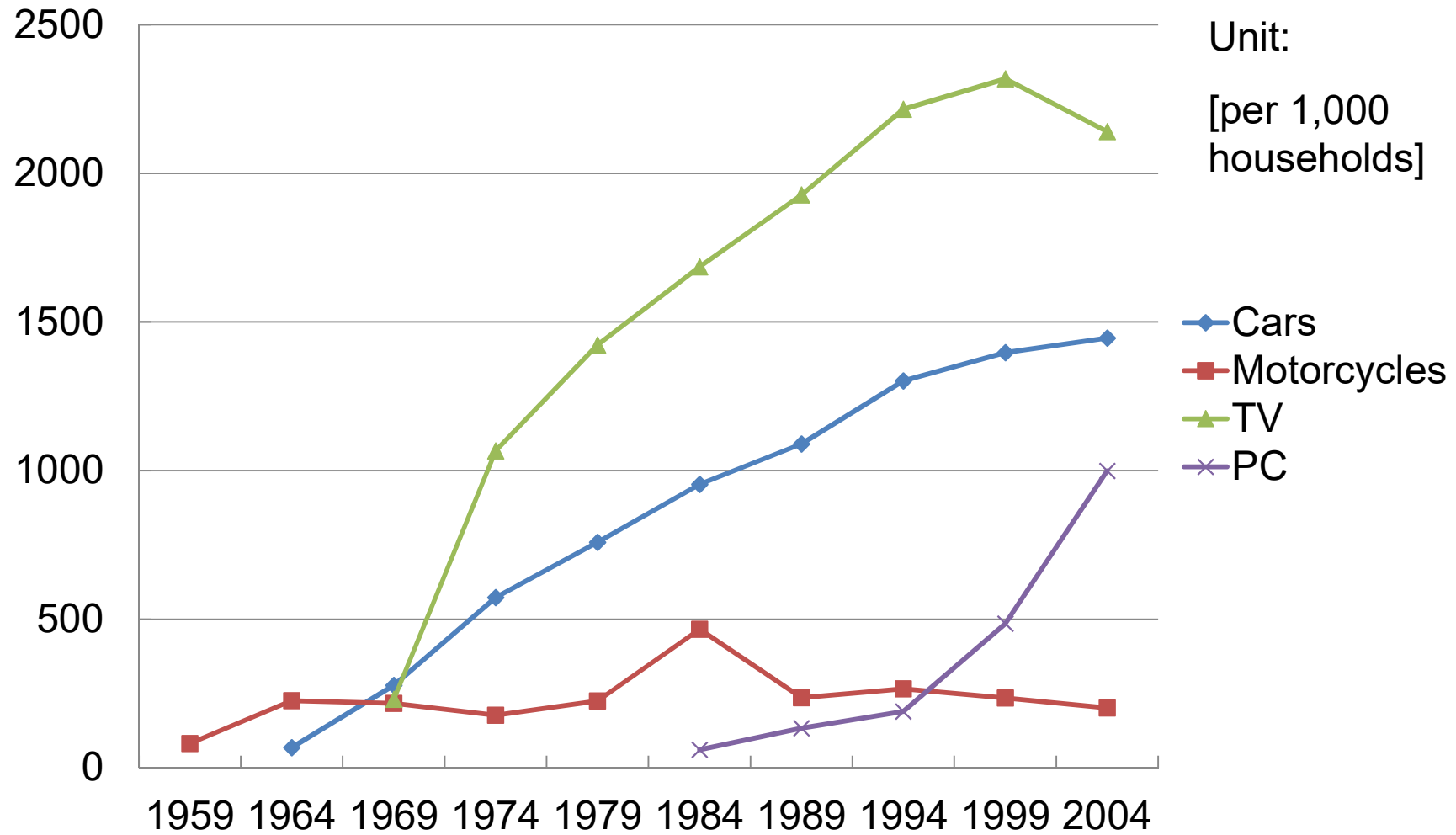


## Quantity of cooling appliances [2]

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# Transportation and communication tools [2]



# Existence of guiding agencies

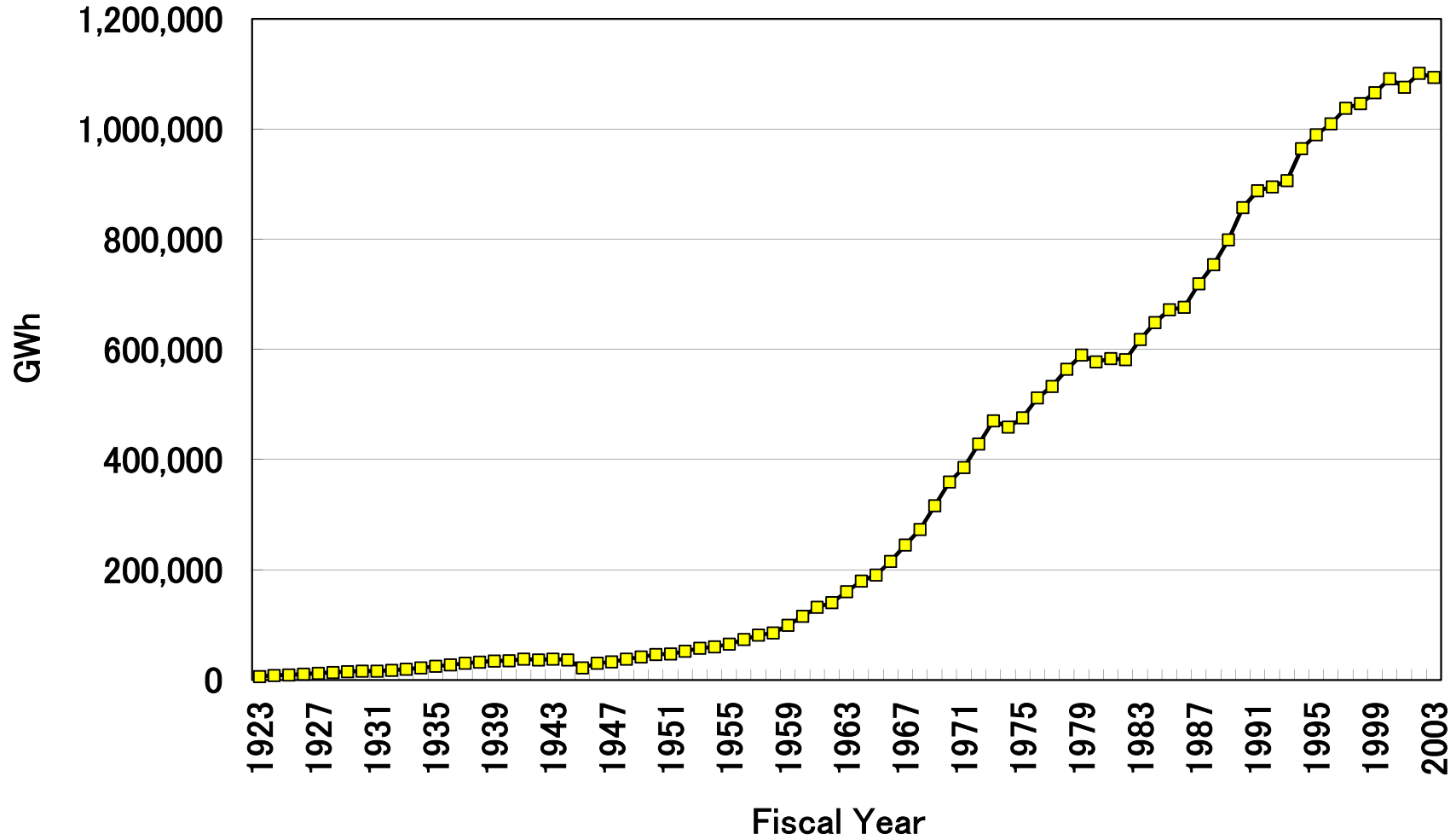
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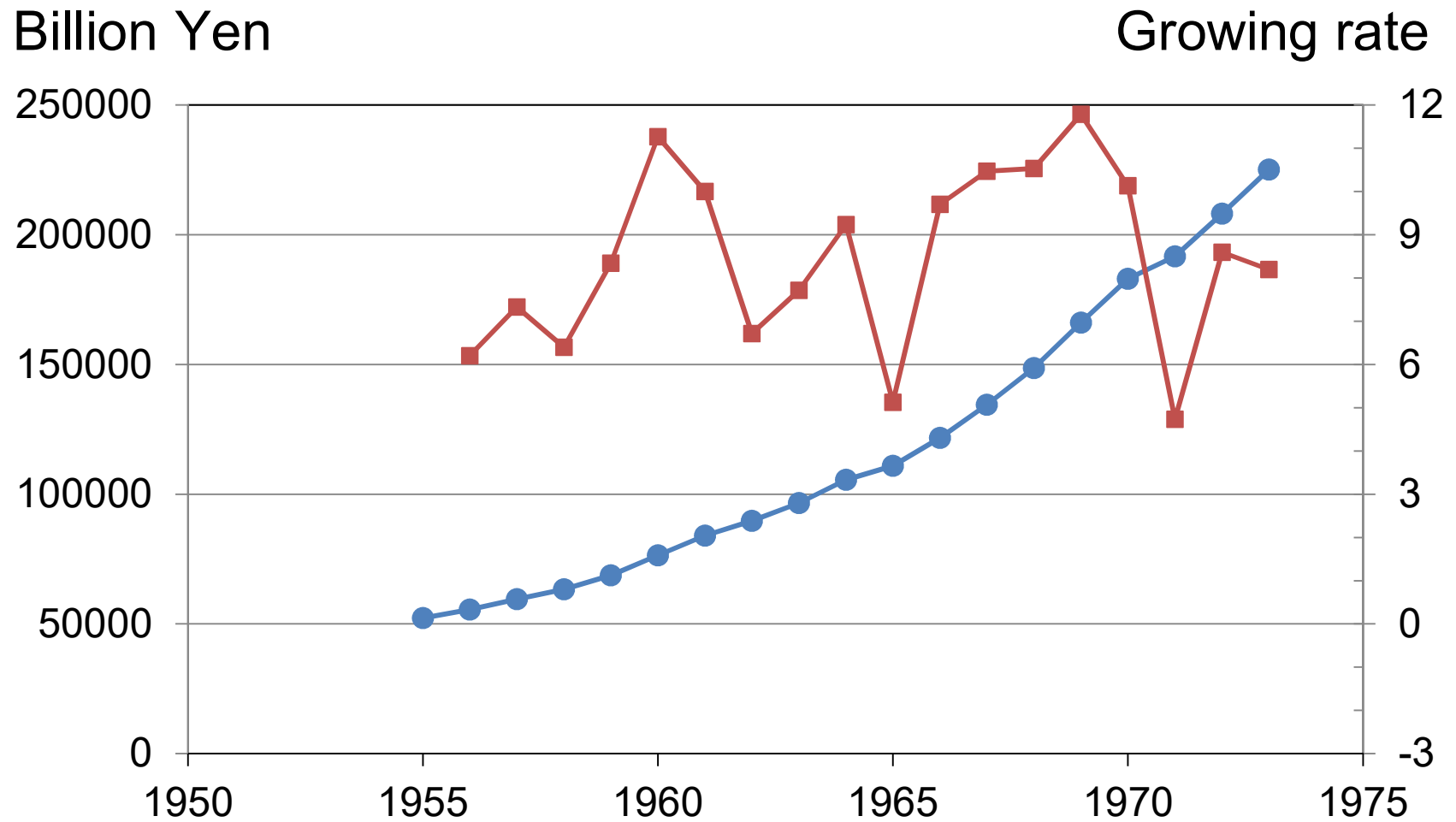
- MITI (Ministry of International Trade and Industry)
    - It was founded in 1949 to strengthen the country's industrial base
    - It ran much of Japanese industrial policy, funding research and directing investment to new plants and equipment
    - It merged with the Economic Planning Agency and became METI
  - Japan Development Bank [4]
    - Established in 1952
    - Offered Loans for the rationalization, modernization and cultivation of such important industries as coal and steel
    - Helped the development of power supply, which forms the basis for the economy and industry
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# Electric Power Generated (1923 – 2003)



# Real GNP and growing rate



# Oil crises

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## End of high economic growth period

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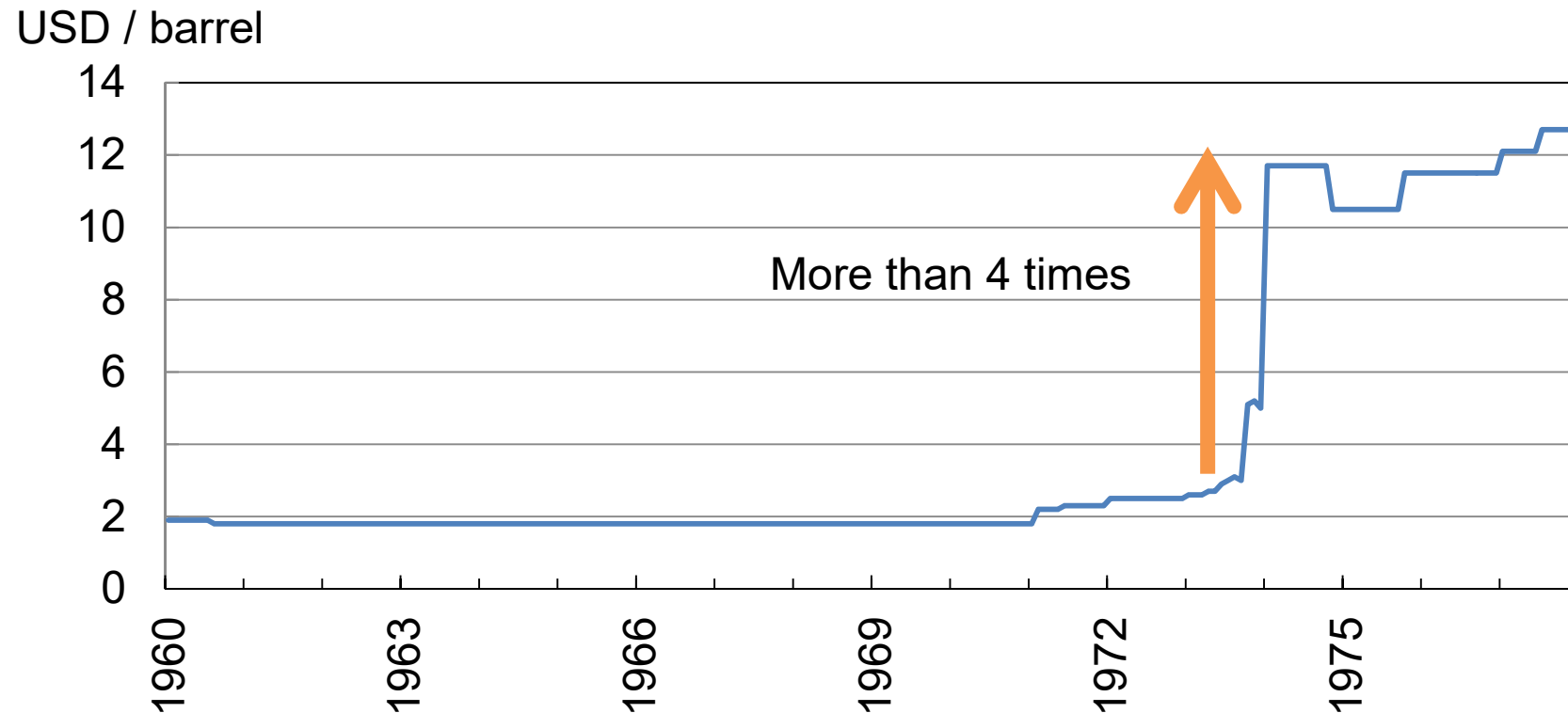
- ▶ Japan's "high economic growth period" suddenly ended in 1973
- ▶ Fourth Middle East War broke out
- ▶ Arab countries limited oil exports to the pro-Israel countries
- ▶ "First oil crisis / shock"



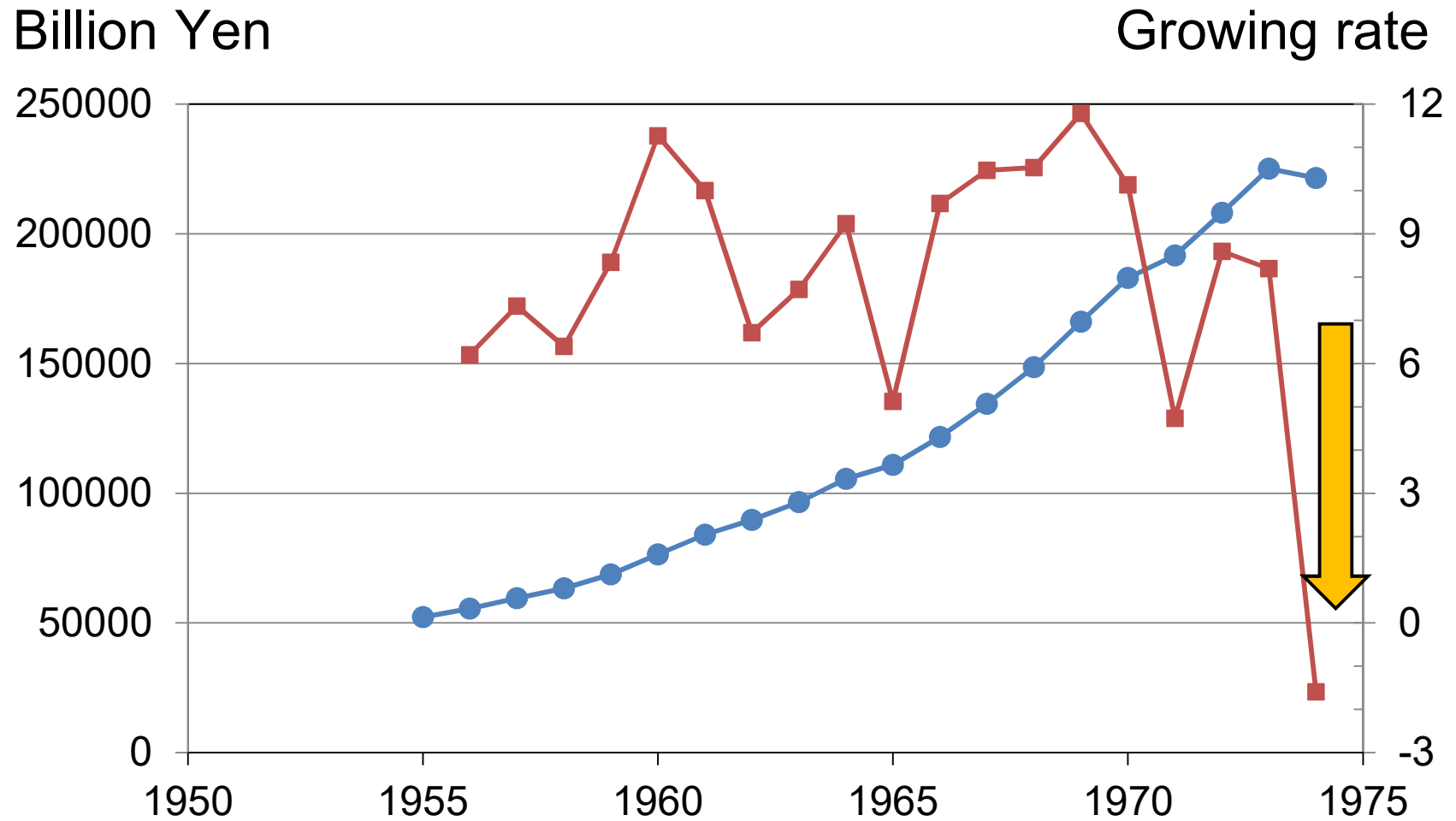
# Sudden rise in oil price

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- ▶ International crude oil price (Arabian light, Nominal \$ per barrel, 1 barrel = 159 liters) jumped by over four times (\$11.7)



# Sudden drop in Real GNP



# Social disruption and change in energy policy

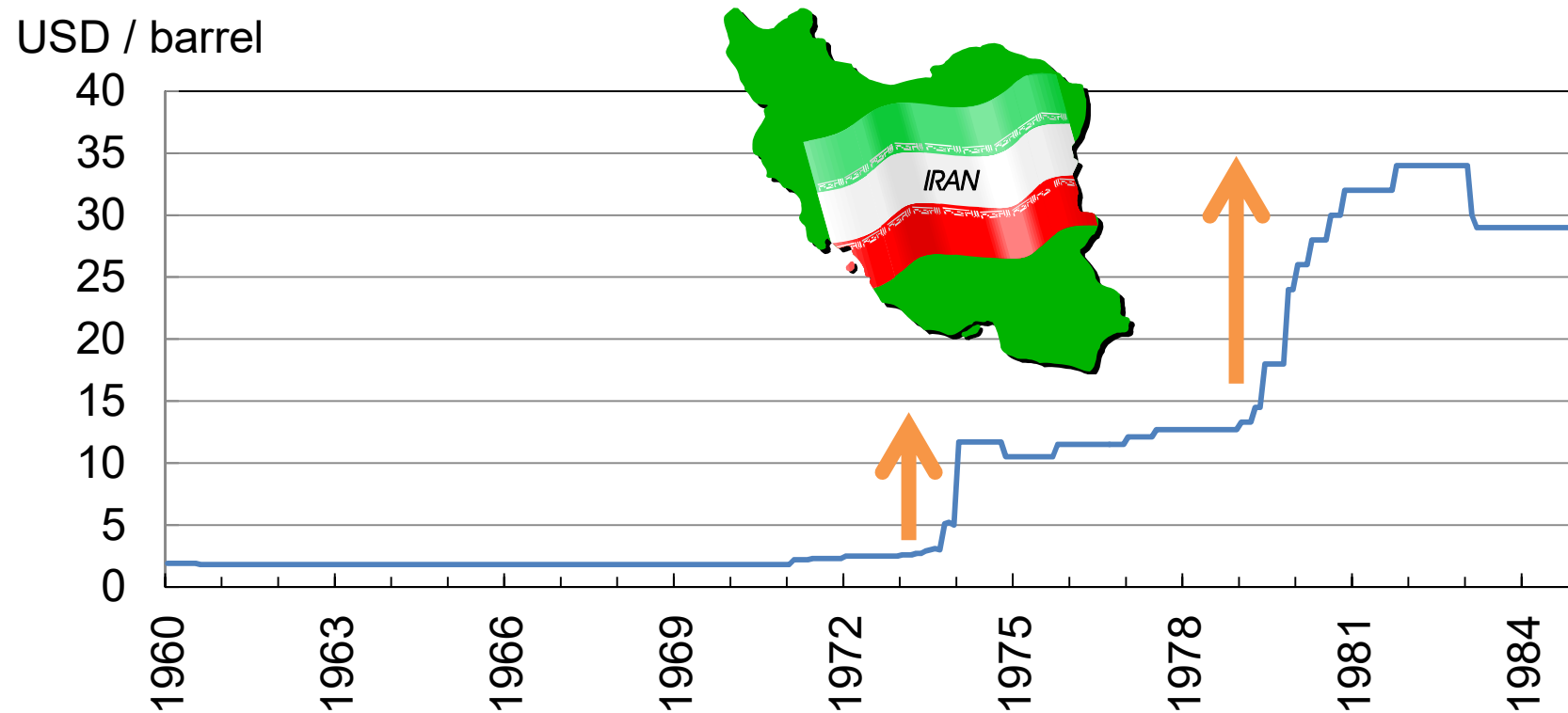
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- ▶ Social disruption
  - ▶ People recognized Japan as a resource-poor country
  - ▶ Consumers hoarded housewares
- ▶ Change in energy policy
  - ▶ The government developed “a long-range plan to reduce Japan’s dependence on oil in general, and Middle East sources in particular” [1]
  - ▶ “MITI ministers turned down their heaters in winter and their air conditioners in summer” [1]
  - ▶ “They required schools and government buildings to do likewise, and they urged all others to comply” [1]



# Second oil shock

- ▶ Islamic revolution (Iranian revolution, 1979) caused second oil shock
- ▶ Oil price rose from \$12 to \$34 / barrel



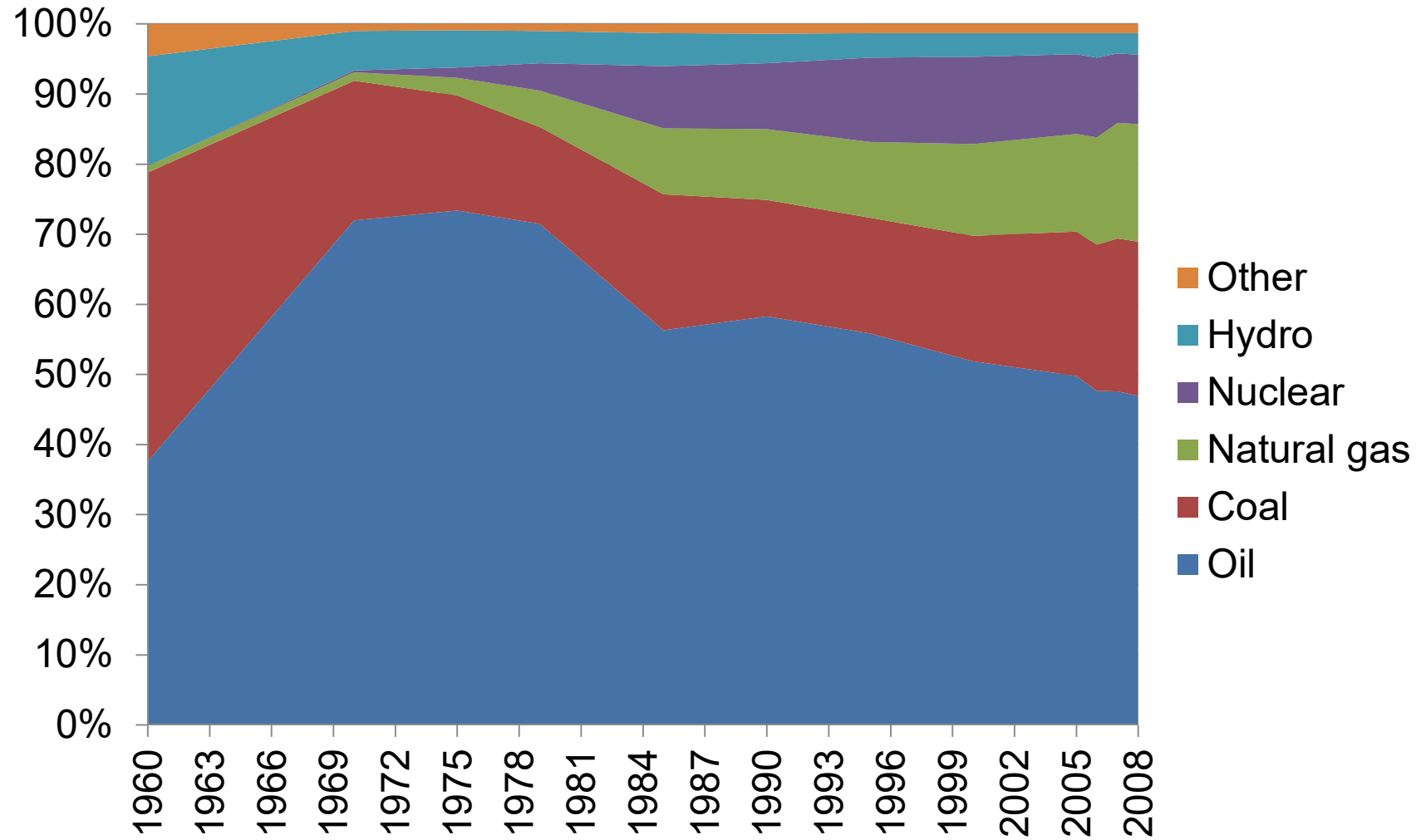
# Radical change in energy policy

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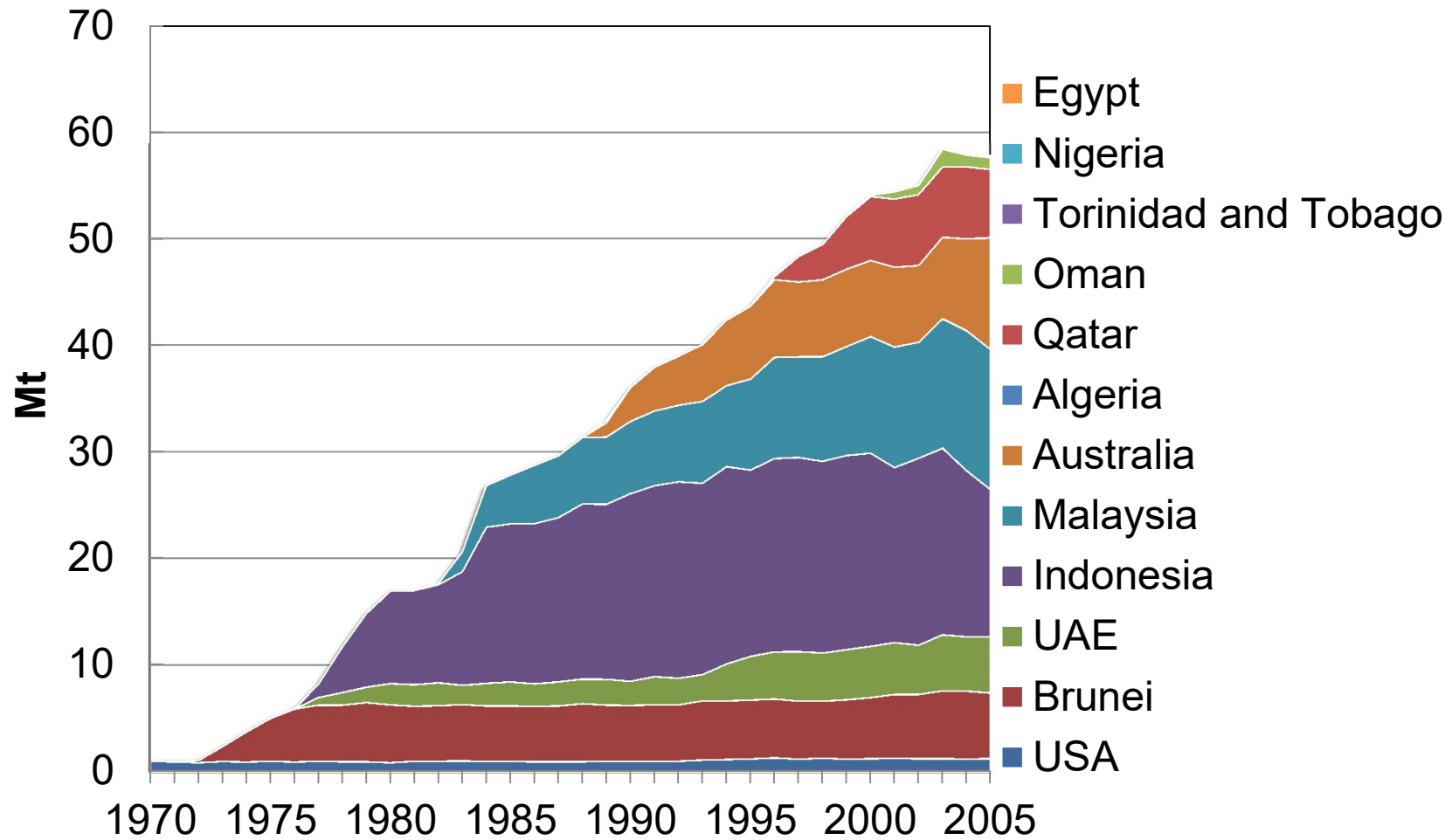
- ▶ “Energy Security” became the core of the energy policies
  - ▶ Energy security means security of energy supply
- ▶ Actions
  - ▶ Departure from dependence on oil
    - ▶ Energy sources shifted from oil to nuclear power and natural gas
  - ▶ Enhancement of energy conservation
    - ▶ Conservation or saving of fossil energy sources, especially oil
    - ▶ “Act on the Rational Use of Energy (Energy Saving Act)” become effective in 1979



# Primary energy supply [6]



# Import volume of LNG by exporting country



Source: 2006 Annual report on energy



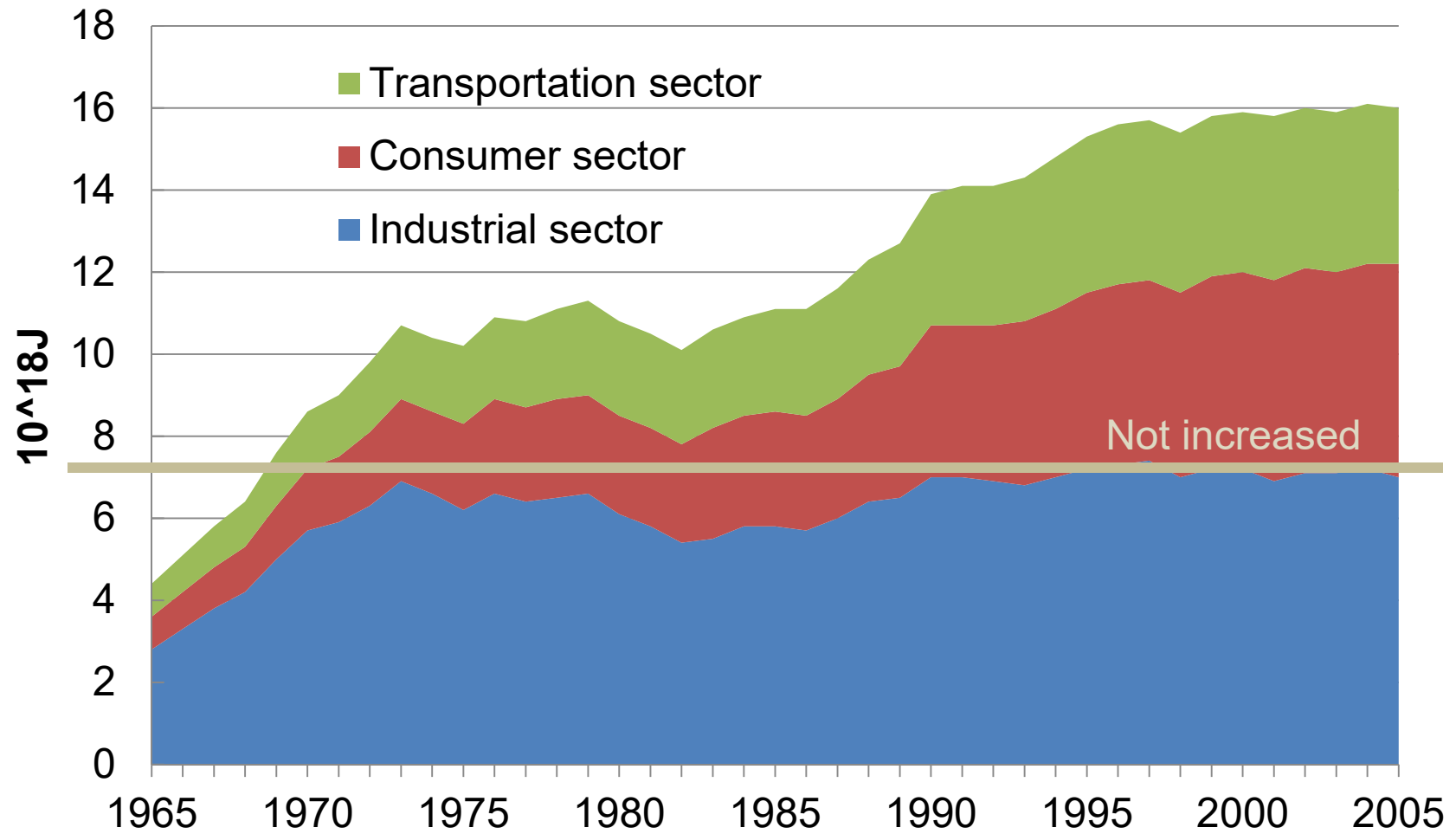
## Energy saving act (1979)

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- ▶ “Energy saving act” ordered large-scale factories to save energy by the following activities:
  - ▶ Rationalization of burning of fuel
  - ▶ Rationalization of heating, cooling, and heat transfer
  - ▶ Recovering exhaust heat
  - ▶ Increase in energy conversion efficiency
  - ▶ Reducing energy losses by radiation, conduction, etc.
- ▶ Large-scale factories were ordered to have “energy managers”
  - ▶ Energy managers monitor, control and make improvements in energy use



# Energy consumption by sector

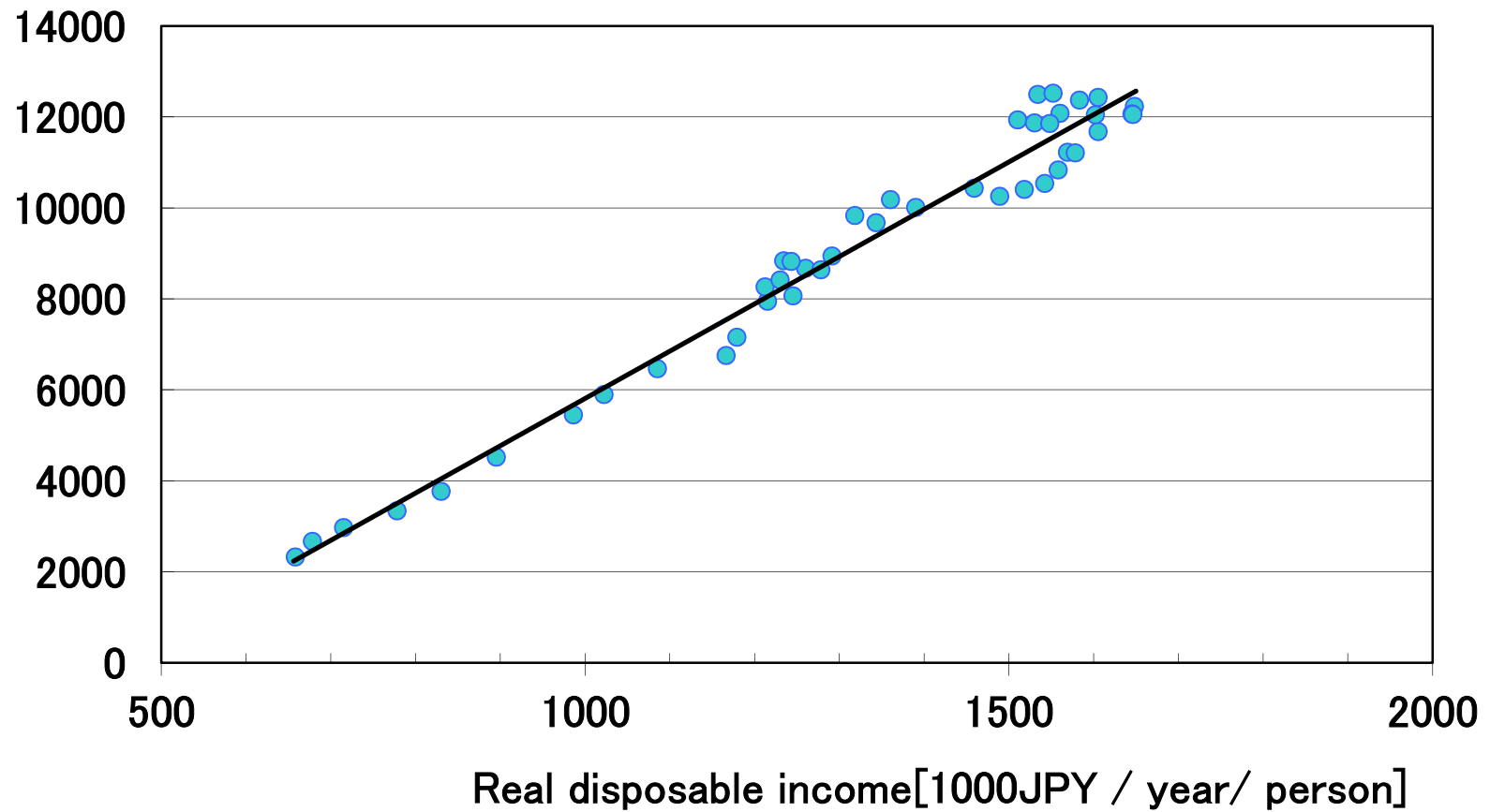


Source: 2006 Annual report on energy

# Disposable income and energy consumption

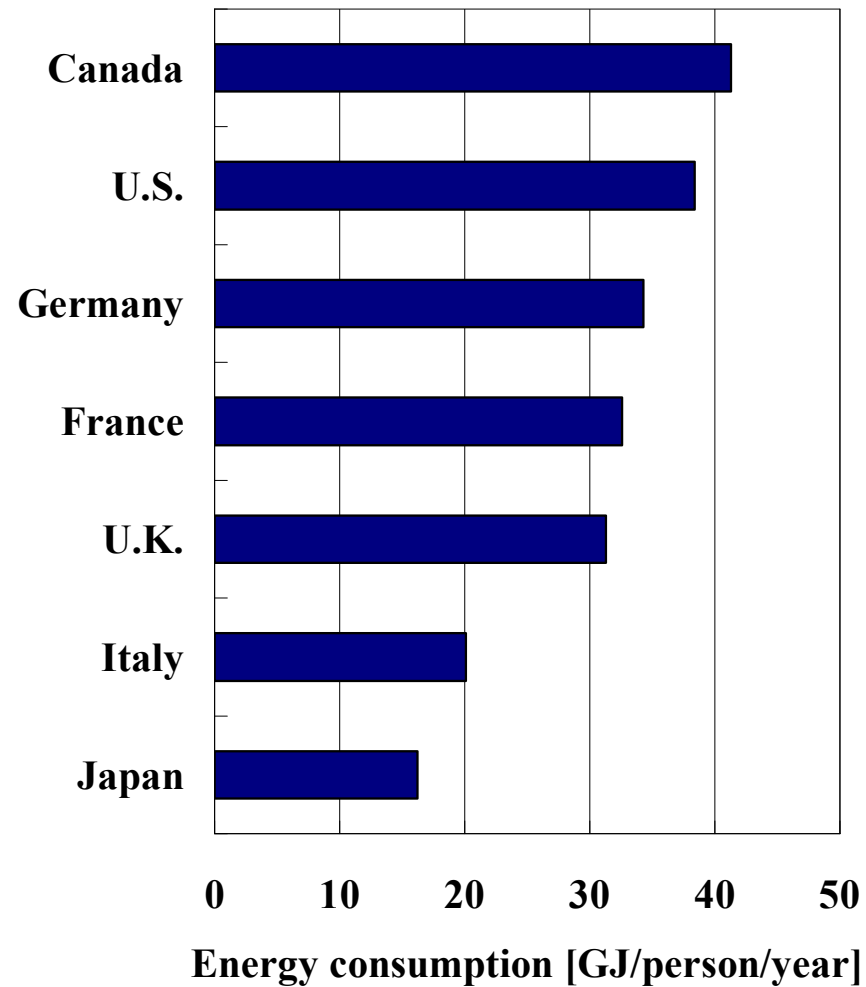
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Energy consumption [MJ / year / person]



# Comparison of household energy consumption

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■ The energy consumption per capita in Japan is the lowest among the G7 countries.



# Global warming problem

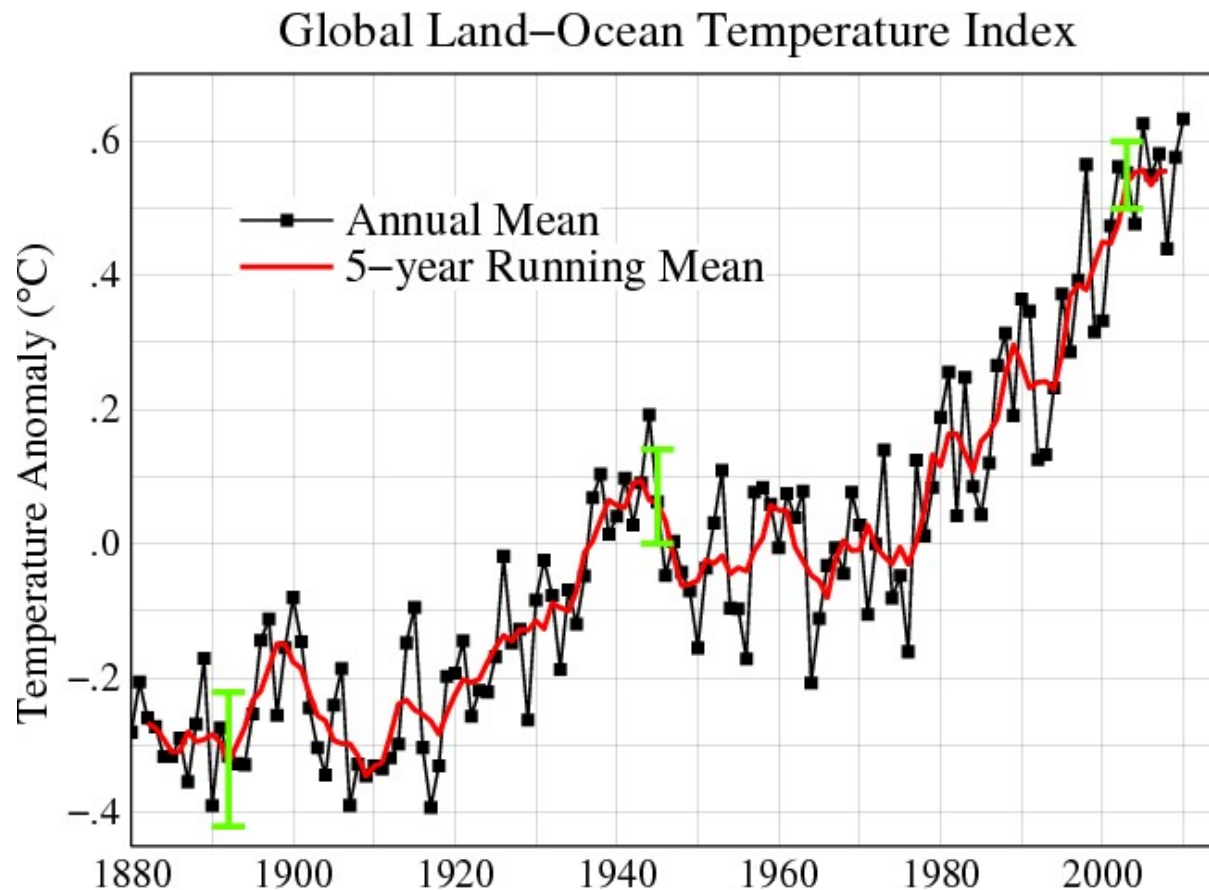
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# Global warming problem

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- ▶ Global warming emerged as political and social issues in 1990s



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▶ From Wikipedia, the free encyclopedia

# Causes and influences of global warming

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## ▶ Causes

- ▶ Scientists say global warming is caused by increasing concentrations of greenhouse gases (GHG)
- ▶ GHG are CO<sub>2</sub>, methane, nitrous oxides, ozone, etc.
- ▶ GHG are produced by human activities such as burning fossil fuels (that is energy consumption) and deforestation (destruction of forests)

## ▶ Influences

### ▶ Global warming will cause

- ▶ Sea level rise (lost of the land areas)
- ▶ Expansion of deserts (lost of agricultural lands)



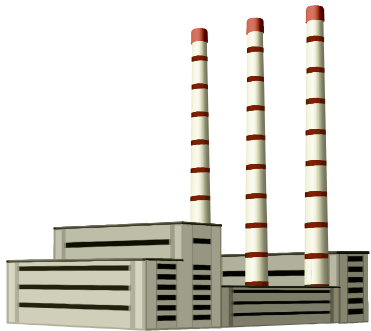
# Energy consumption and Environment

Environment

Global warming  
Ozone layer destruction  
Air and water pollution

CO<sub>2</sub>, NO<sub>x</sub>, SO<sub>x</sub>, etc.

Energy consumption



Industry



Transportation



Consumers

Natural resources

Exhaustion of oil, coal, gas, and other resources



# Action against the global warming

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- ▶ To fight global warming, the Kyoto Protocol was adapted in 1997 and became effective 2005
- ▶ Under the Kyoto Protocol, "Annex I countries" commit to reduce GHG produced by themselves
  - ▶ Annex I consists of the developed countries such as the USA, Canada, Australia, EU countries, Russia, and Japan
  - ▶ However, the USA denied to ratify
  - ▶ Canada withdrew from the Protocol in Dec. 2011
- ▶ Japan's target is to reduce GHG emissions to a level 6% below 1990 levels until 2012



## Top ten emitters of GHG for 2005

Country	GHG share [%]	Per-capita emissions [ton / person]
China	17	5.8
USA	16	24.1
EU	11	10.6
Indonesia	6	12.9
India	5	2.1
Russia	5	14.9
Brazil	4	10.0
Japan	3	10.6
Canada	2	23.2
Mexico	2	6.4

Source: MNP(2007)



## Energy saving act was changed

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- ▶ Main purpose of “Energy saving act” is changed into reduction of GHG
- ▶ Not only large-scale factories, but also small-scale factories are ordered to reduce energy consumption
- ▶ Not only factories, but also large buildings are ordered likewise
- ▶ “Top runner approach” is applied to home appliances such as air conditioners, refrigerators, TVs, etc.



## Top runner approach

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- ▶ The Japanese Ministry of Economy, Trade and Industry (METI) created the “Top Runner program” in 1998 as part of the revised “Energy saving act” for improving energy efficiency in cars and appliances
- ▶ Instead of setting a minimum energy performance standard (MEPS), the current highest energy efficiency rate of the products in each sub-group is taken as a standard (the “Top Runner”)
- ▶ The standard can be set even higher than the highest energy efficiency currently achieved and performance targets are continuously updated



# Example of top runner approach

This year

	Company A	Company B	Company C
Fuel consumption	15km/liter	14km/liter	9km/liter

Top runner / standard of the next year

Next year

Fuel consumption	16km/liter	18km/liter	15km/liter
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Top runner



# Fukushima Daiichi nuclear disaster

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## 3.11, Fukushima Daiichi nuclear disaster

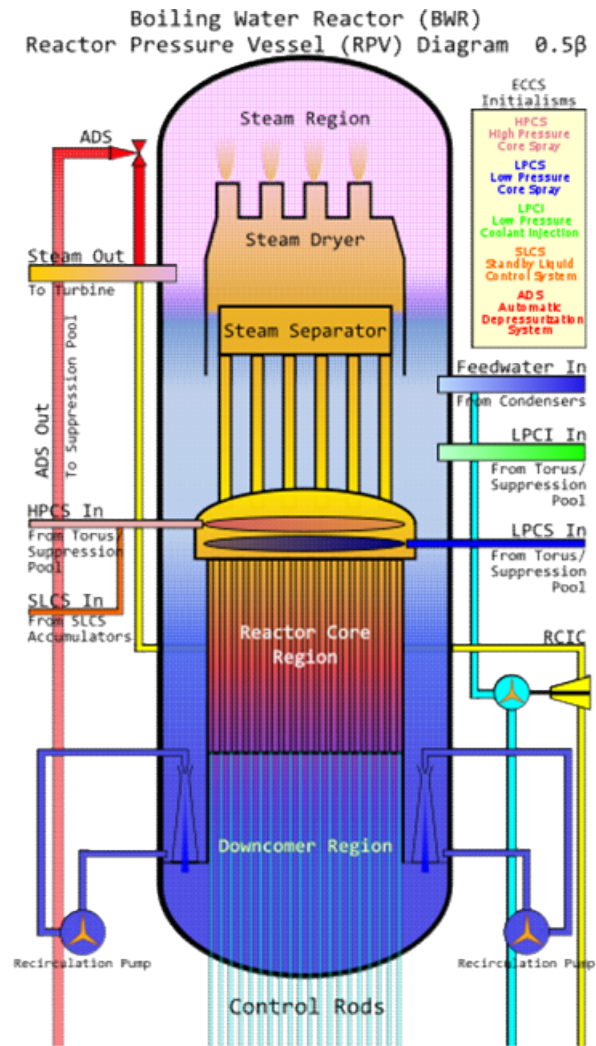
- ▶ At 14:46 JST on Friday, 11 March 2011, the Great East Japan Earthquake occurred
- ▶ The earthquake and tsunami caused equipment failures, nuclear meltdowns, and release of radioactive materials at Fukushima 1st nuclear power plant.
- ▶ It is the largest nuclear disaster since the Chernobyl disaster of 1986



Source: Wikipedia

# Nuclear meltdown

- ▶ “Nuclear meltdown” is a nuclear reactor accident that results in core damage from overheating
- ▶ If the cooling water cannot be supplied, the core begins to melt
- ▶ Overheated core will destroy the reactor and release radioactive materials to the environment

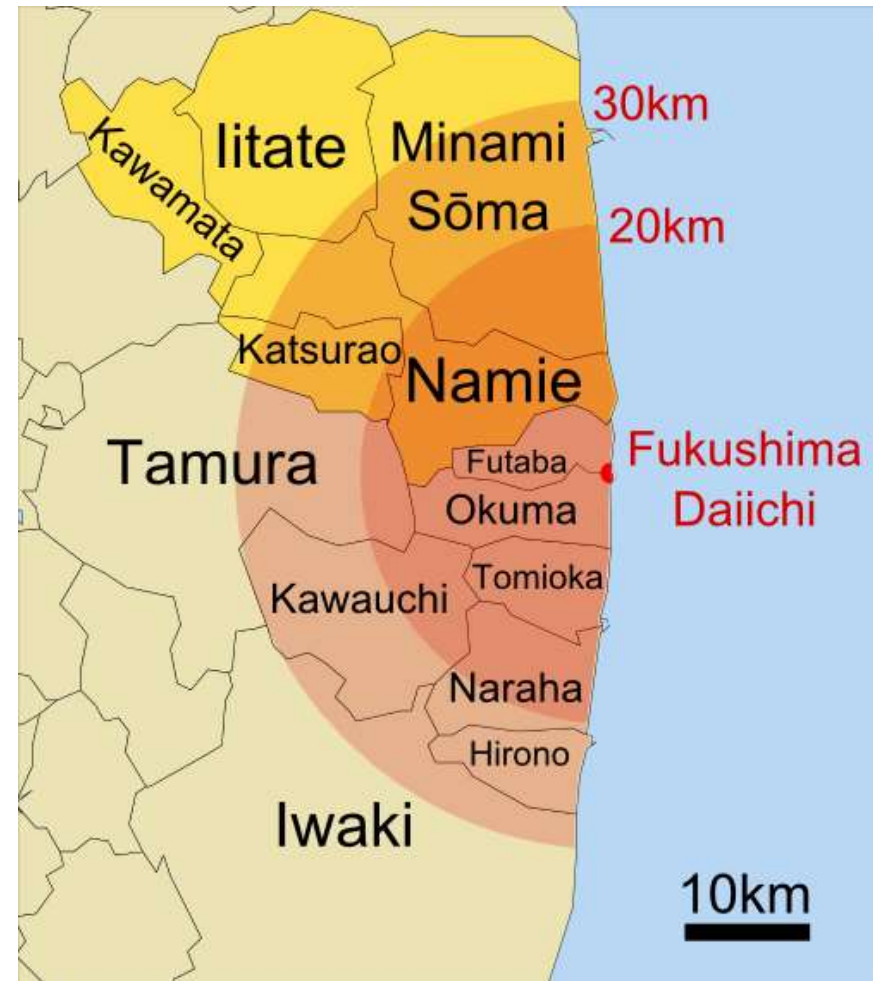


Source: Wikipedia



# Nuclear pollution and evacuation

- ▶ Although the worst of the crisis was avoided, radioactive materials were released into ground and ocean waters
- ▶ First day of the disaster about 134,000 people were evacuated to avoid the nuclear pollution
- ▶ Four days later, additionally 354,000 people were evacuated



Source: Wikipedia

## As of 2012...

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- ▶ As of August 2012, there were 160,000 people evacuated from their homes
- ▶ Japanese government is continuing to remove the nuclear pollutions
- ▶ It requires 30 or 40 years to decommission the nuclear reactors at Fukushima Daiichi



# Division in public opinion

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- ▶ After the disaster, public opinion is divided
  - ▶ Antinuclear power
  - ▶ Pro-nuclear power



# Changes of Japanese energy policy

Period	Matter	Policies	Remarks
1945 – 1955	Postwar reconstruction	Priority production system	
1956 – 1965	High economic growth period	From coal to oil	OPEC formed in 1960
1966 – 1975	First oil shock	Stable supply of oil	Dependency rate on oil: 77%
1976 – 1984	Second oil shock	Alternative energy to oil Energy conservation	
1985 ~	Economic globalization	Introduction of market mechanisms	Dependency rate on oil: 52%
1990 ~	Global warming	Reduction of greenhouse gases	
2011~	Fukushima Daiichi nuclear disaster	?	?



# Development of green technologies

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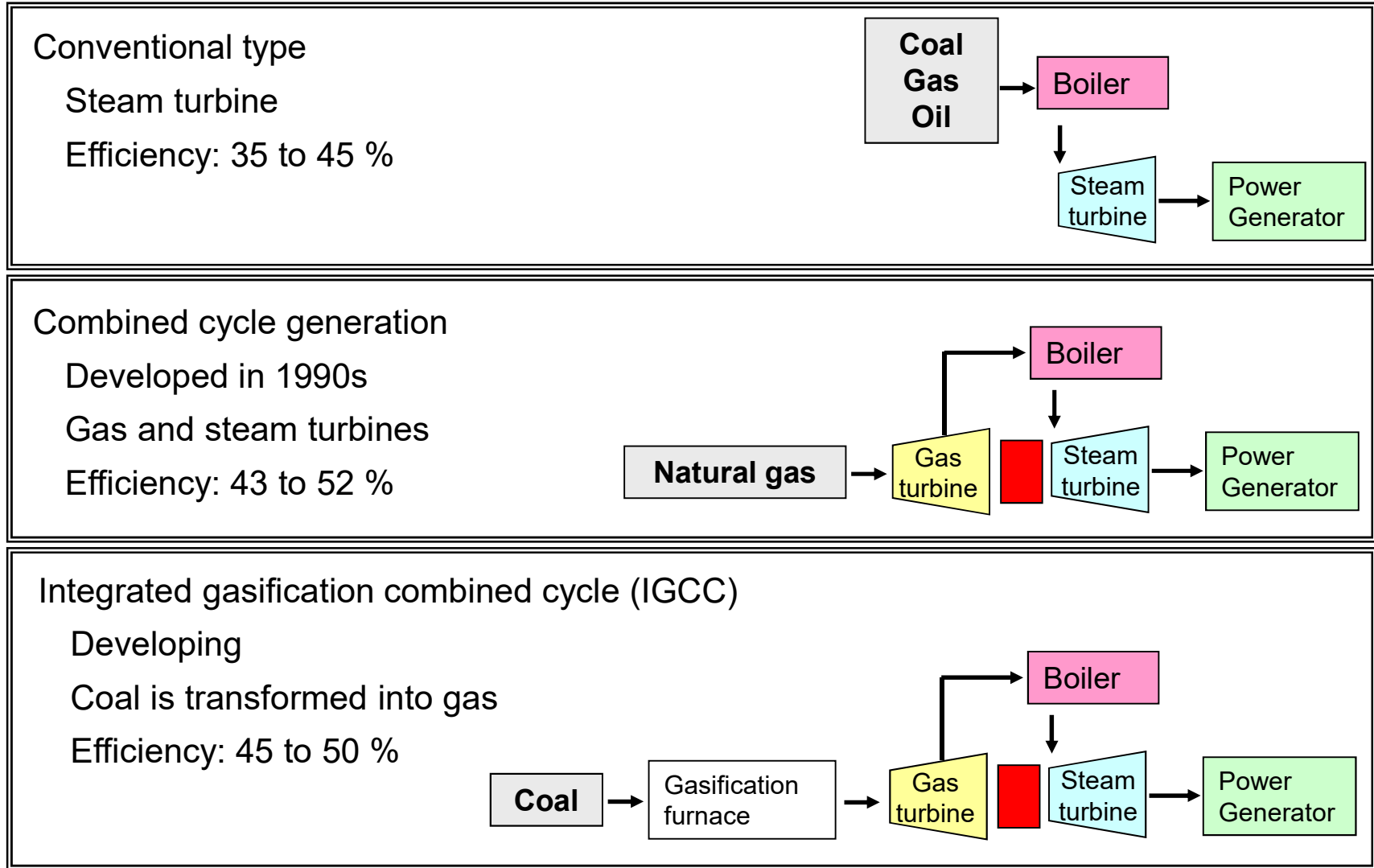
# Green technologies

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- ▶ Green technologies are developing in two sides
- ▶ Supply side
  - ▶ High-efficiency power generation
  - ▶ Wind power generation
  - ▶ Photovoltaic (PV) generation (solar power)
- ▶ Demand side
  - ▶ High-efficiency cars and home appliances
  - ▶ Home energy management system



# Development of high-efficiency thermal power plants



# Wind turbine

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- ▶ Wind turbines generate electricity by wind power

Source: Fuji heavy industry ,  
[http://www.fhi.co.jp/news/00\\_10\\_12/11\\_1.htm](http://www.fhi.co.jp/news/00_10_12/11_1.htm)

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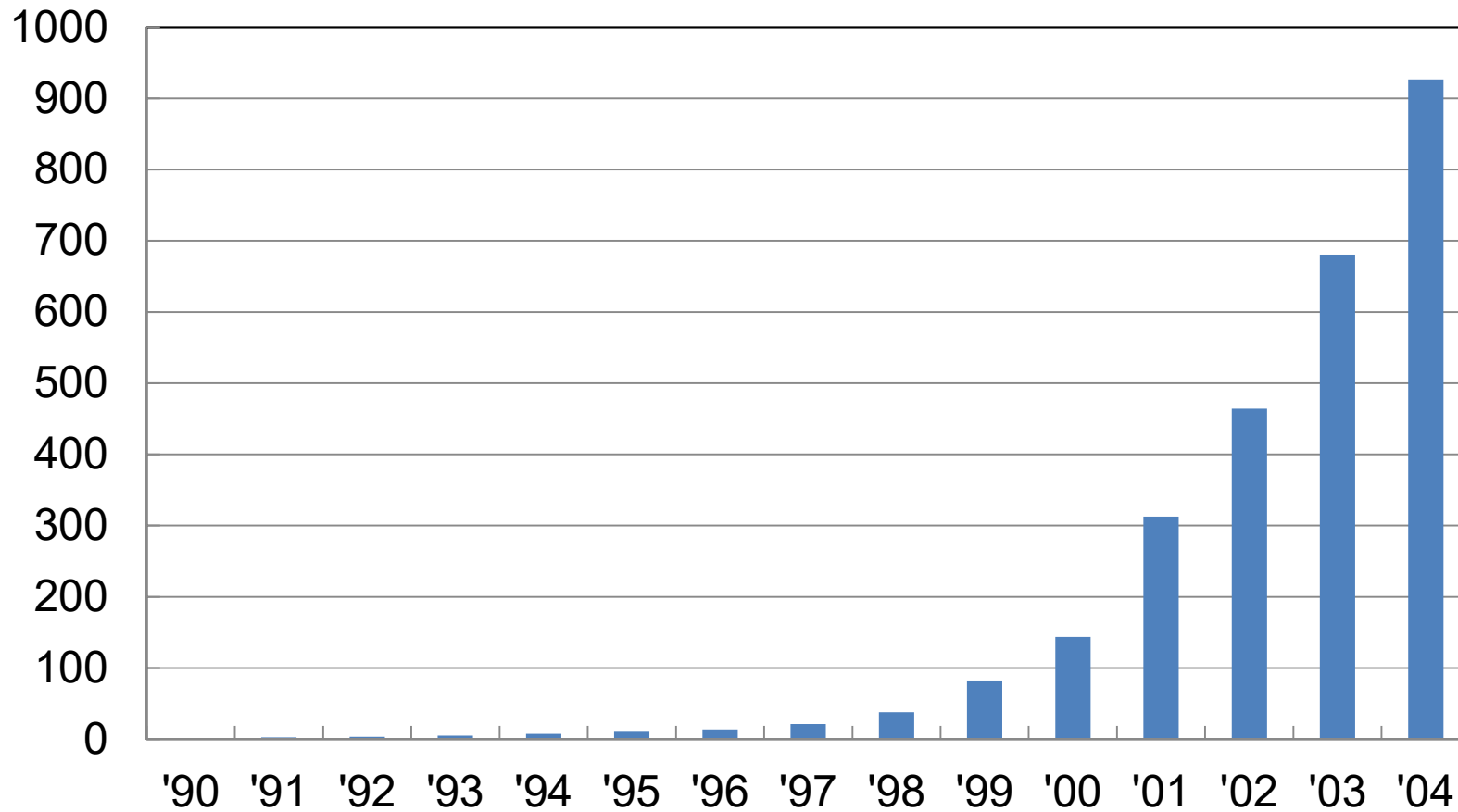




# Installation of wind turbines in Japan

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Total installed capacity [MW]



# Problem that remains to be solved

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- ▶ Typhoons hit Japanese islands every year
- ▶ Example
  - ▶ On Sep. 11, 2003, Typhoon No.14 broke six wind turbines in Miyako island



Wind turbine No. 3



Wind turbine No. 5



Wind turbine No. 6

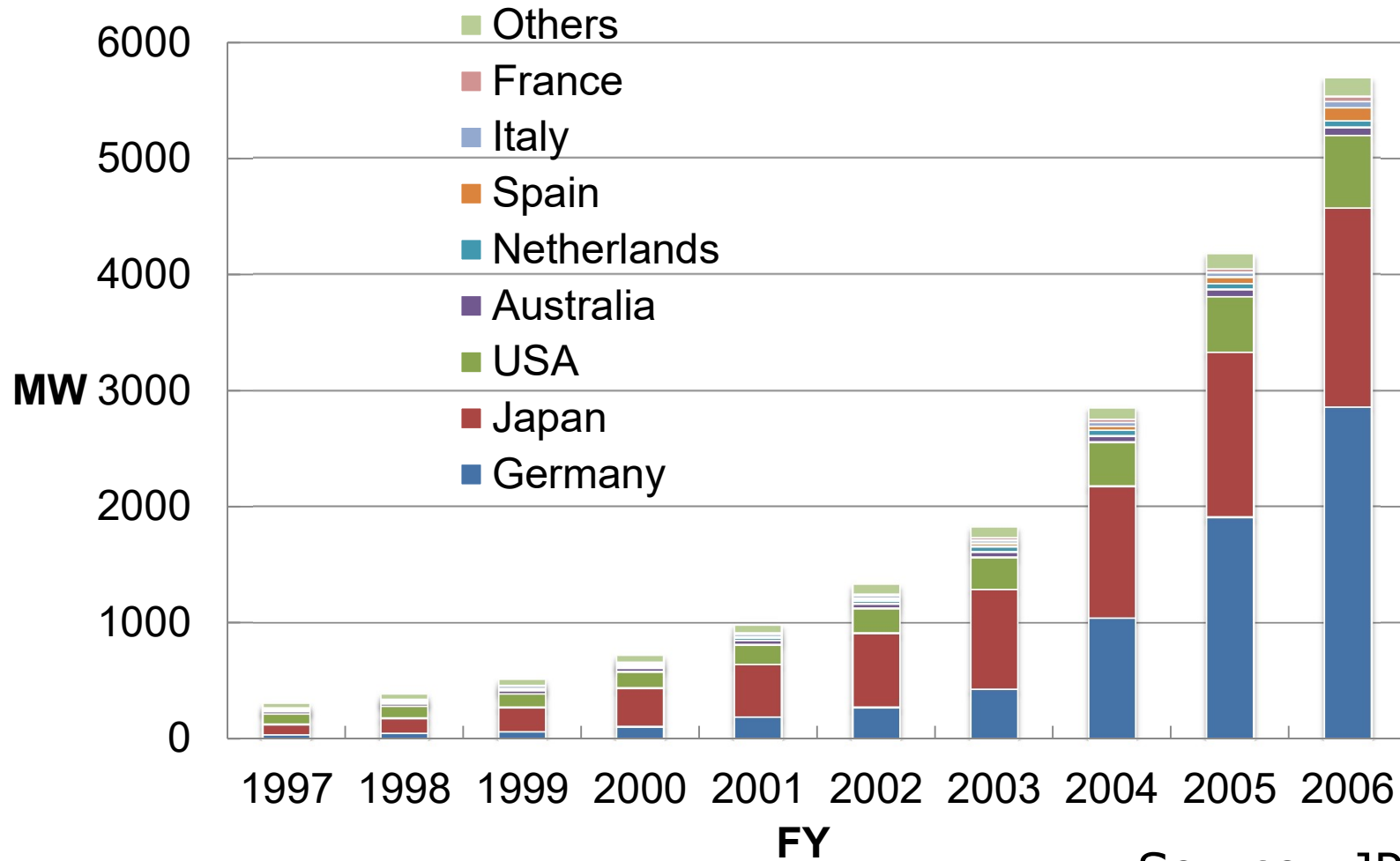
Karimata wind farms (Miyako island)

Source: Okinawa Electric Company

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# Global spread of photovoltaic cells

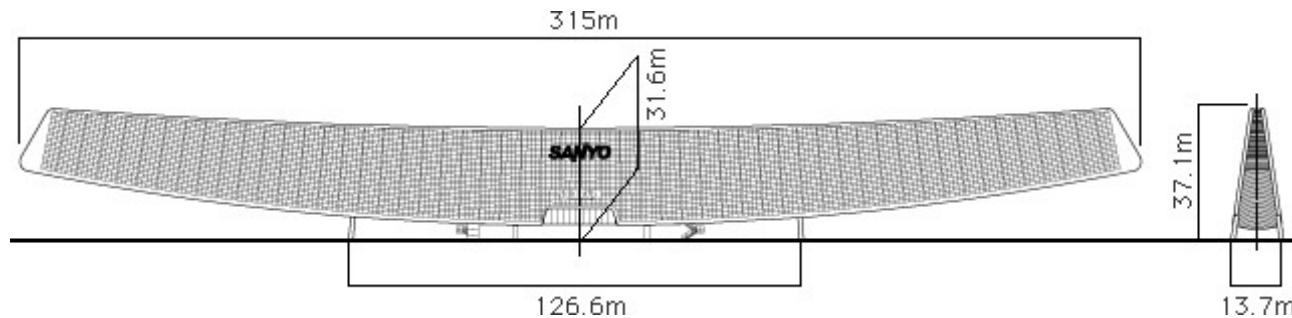


Source: JPEA



**SANYO**

**SOLAR ARK**



Photovoltaic cells: 5046 cells, Max output: 630kW

Location: Gifu-Hashima, Gifu Prefecture, Japan

Source: <http://www.solar-ark.com/>

# One of the world largest solar power plant

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US army is constructing a 500MW (500,000kW) class solar power plant in Fort Irwin, California

It is scheduled for completion in 2022

Overall construction costs 1.5 billion USD

Source: Wired vision, 2009

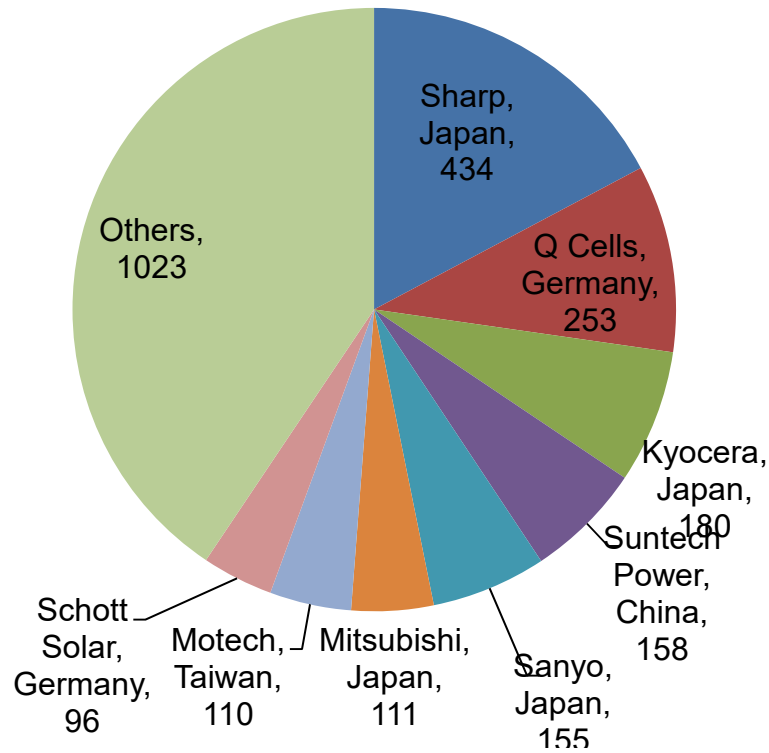
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# Share of the world's PV cell production

## 2006 [Unit, MW]

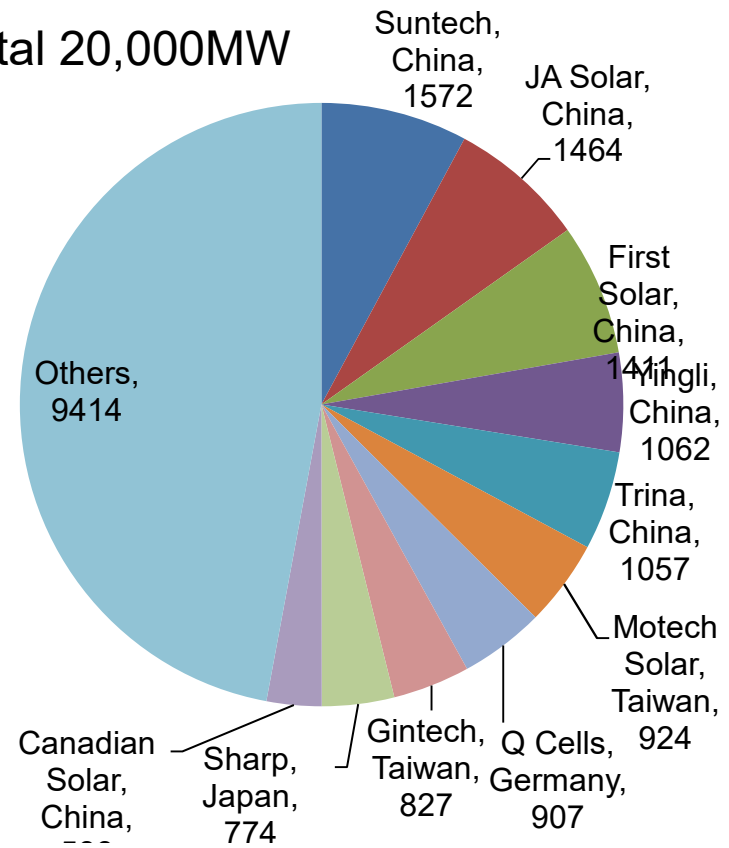
Total 2,520MW



Source: PVNews

## 2011 [Unit, MW]

Total 20,000MW



Source: PVInsights

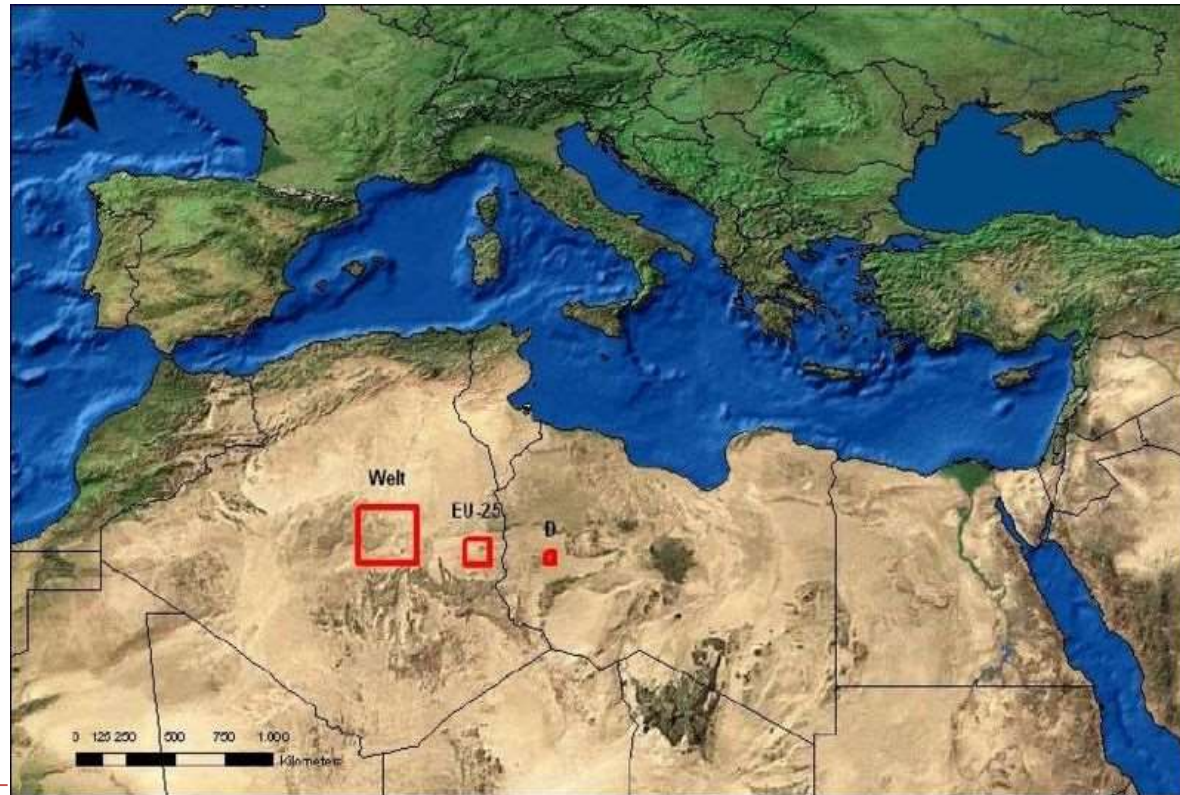
# Demerits of PV cells

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- ▶ In order to generate large amount of electricity, extremely large area for PV cells are required
- ▶ Generation of electricity depends on weather

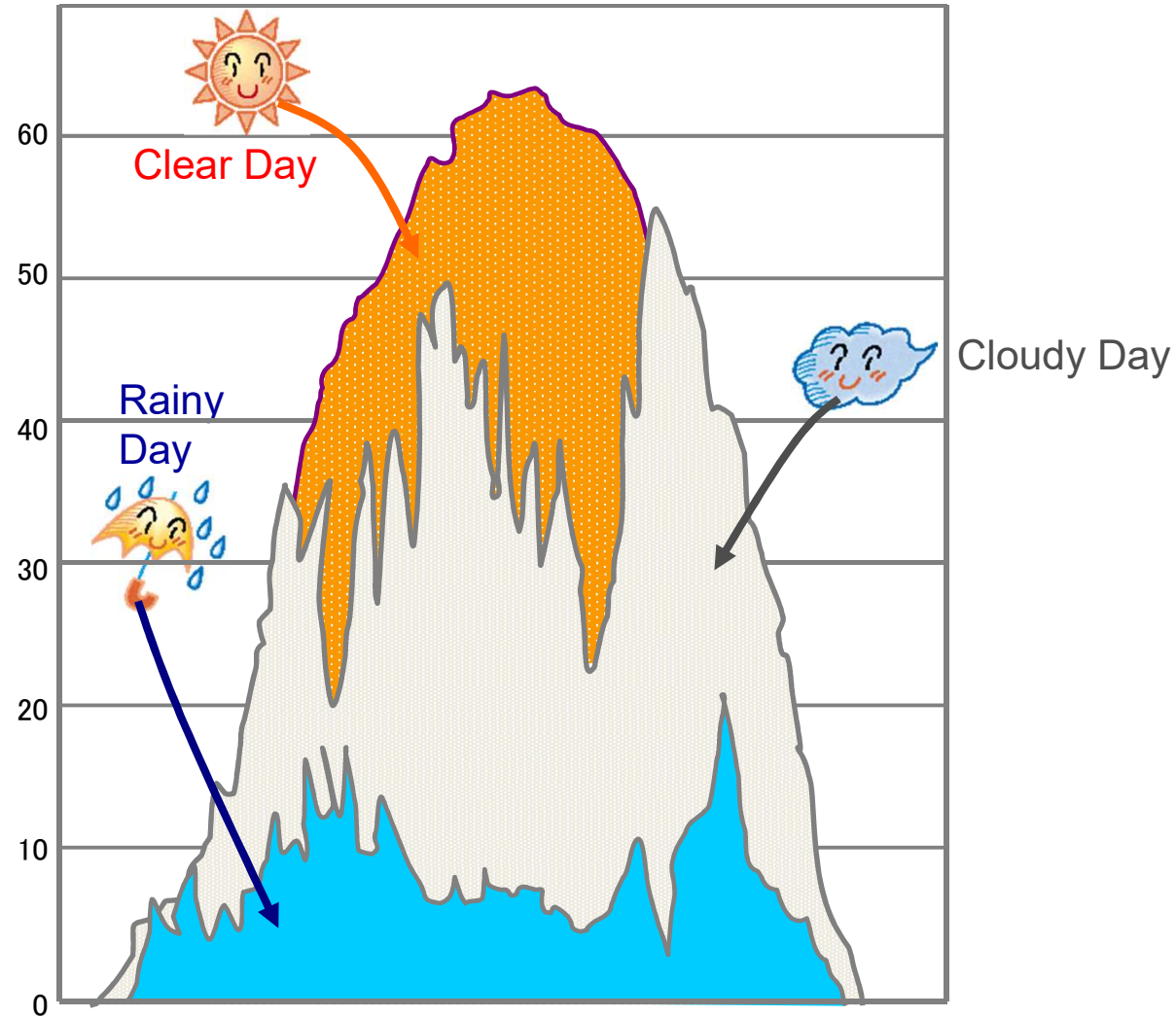
The areas required for generating electricity to meet the demands of Germany, EU, and the world

Source: Nadine May, Eco-balance of a Solar Electricity Transmission from North Africa to Europe



# Weather influence on power generation

Power generation efficiency



Source: Japan's Energy 2003 (METI)



# Hybrid car

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- ▶ A hybrid car integrates a gasoline engine and electric motor
- ▶ It keeps better fuel efficiency and lower gas emissions compared to conventional gasoline engine cars
- ▶ Example: Toyota's "Prius" and Honda's "Insight"



Source: Toyota



Source: Wikipedia



# High energy efficiency of air conditioners

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- ▶ Under the “Energy saving act”, “Top runner approach” is applied to develop the performance of air conditioners
- ▶ Coefficient of performance (that is energy efficiency) of an average air conditioner has increased from 3.0 to 6.0 about ten years



External Unit



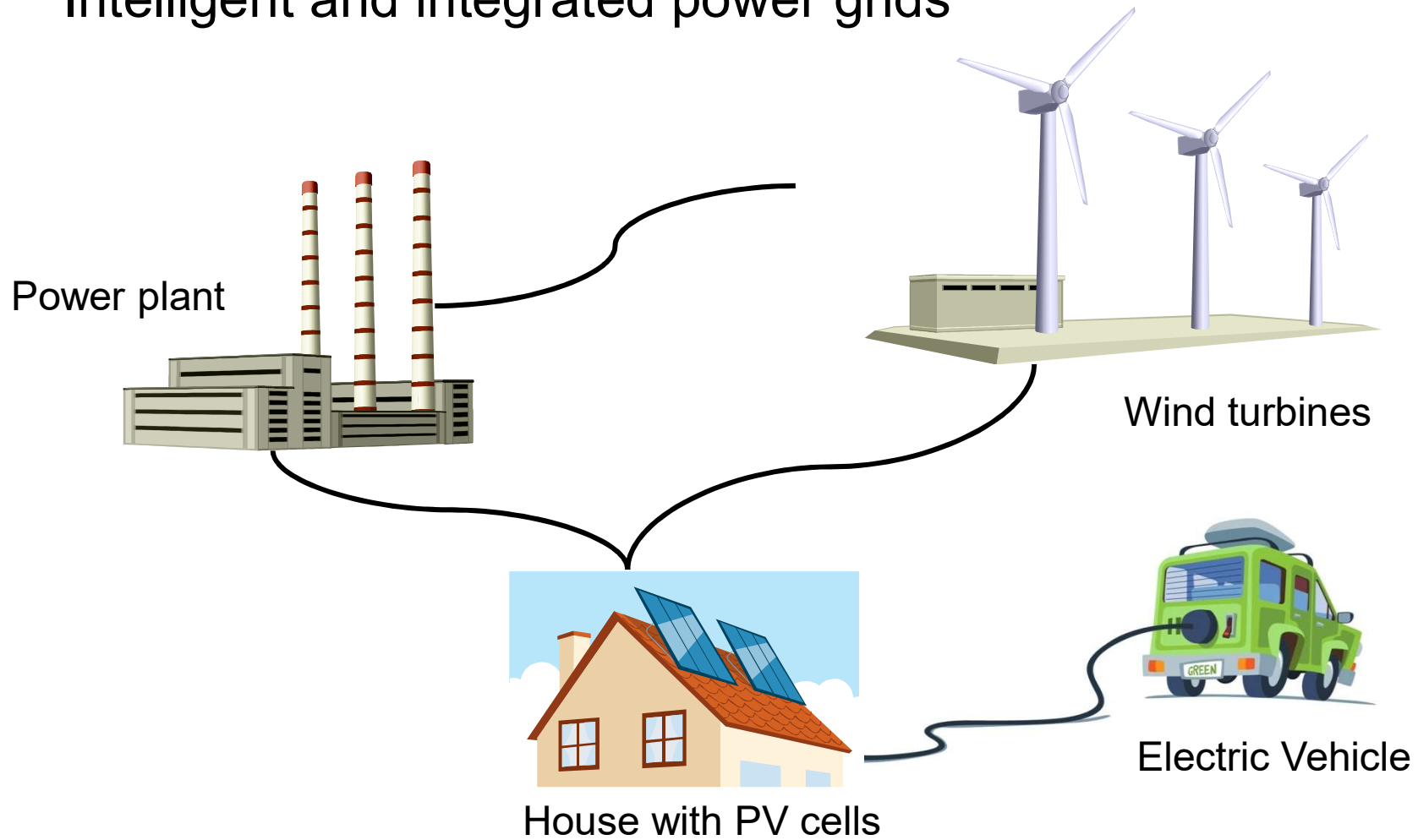
Internal Unit



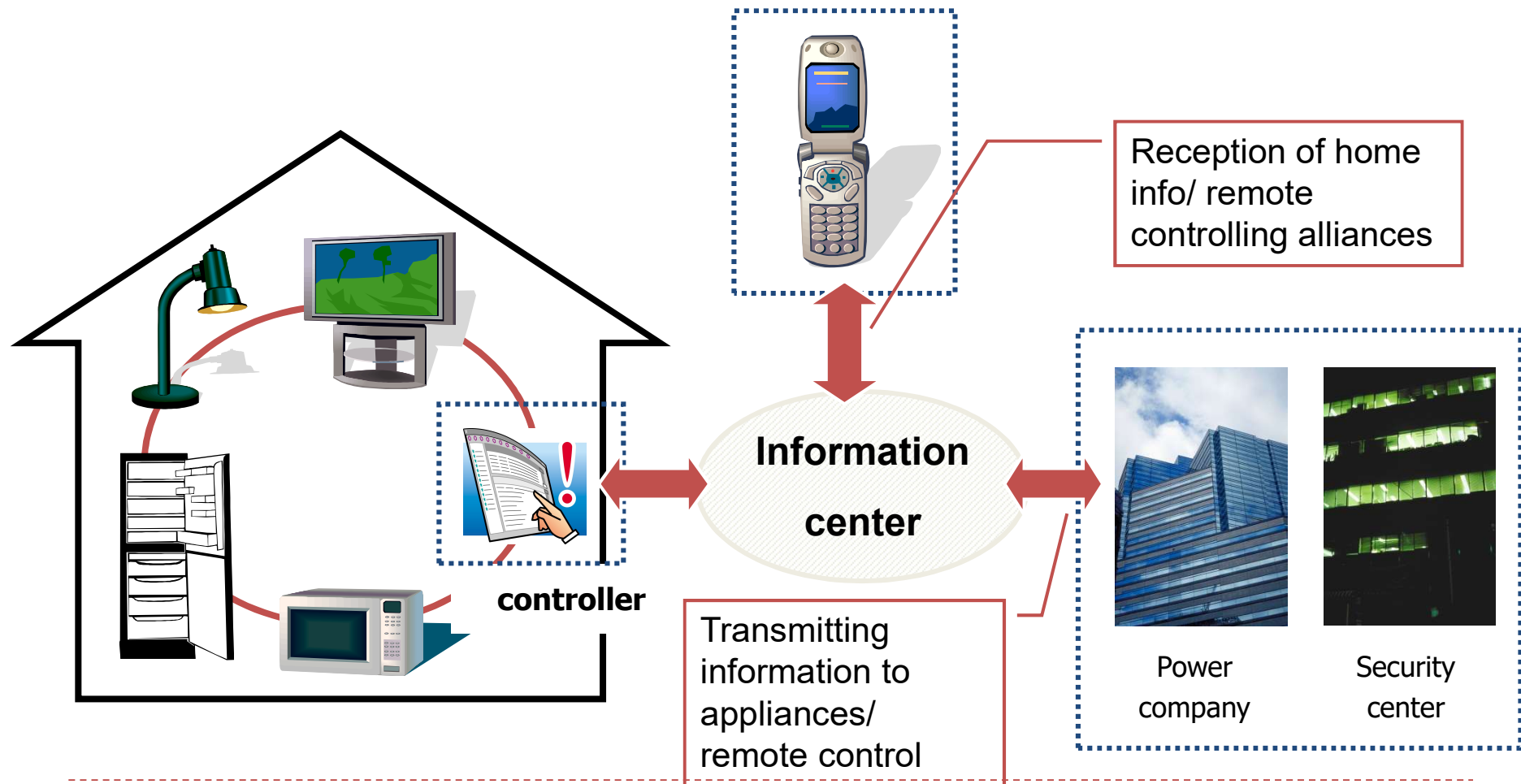
# Smart Grid

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Intelligent and integrated power grids



# Home energy management system



Science and technology policies,  
ecological tax reforms, bounty systems

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# Ecological organization and systems

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- ▶ Leading organization for developing green technologies
  - ▶ NEDO
- ▶ Systems for helping the spread of green technologies
  - ▶ Top runner approach (already explained)
  - ▶ Bounty systems
  - ▶ Feed-in tariff
- ▶ Other measures
  - ▶ 3R movement



# NEDO

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- ▶ New Energy and Industrial Technology Development Organization
  - ▶ NEDO promotes research and development of energy, environmental and industrial technologies
  - ▶ NEDO invests about 150 billion JPY / year to make universities and industries research and develop green technologies



# Bounty systems

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- ▶ Japanese government and local governments provides subsidies for installation of PV cells on houses
  - ▶ Japanese government offers 48,000 JPY / kW





## Feed-in tariff

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- ▶ Feed-in tariff is a policy mechanism to accelerate investment in renewable energy technologies such as solar, wind, biomass geothermal, etc.
- ▶ To spread this green technologies, the government offers long-term (10 – 20 years) contracts to renewable energy producers based on the cost of generation of each technology
- ▶ In many cases, power from renewable sources is bought at above-market rates
- ▶ This mechanism was authorized by the Diet (Japanese parliament) in Aug., 2011



# 3R movement

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- ▶ Reduce
  - ▶ Buy less and use less
- ▶ Reuse
  - ▶ Use elements of the discarded item again
  - ▶ Repair goods
- ▶ Recycle
  - ▶ Discards are separated into materials that may be incorporated into new products



## Literature

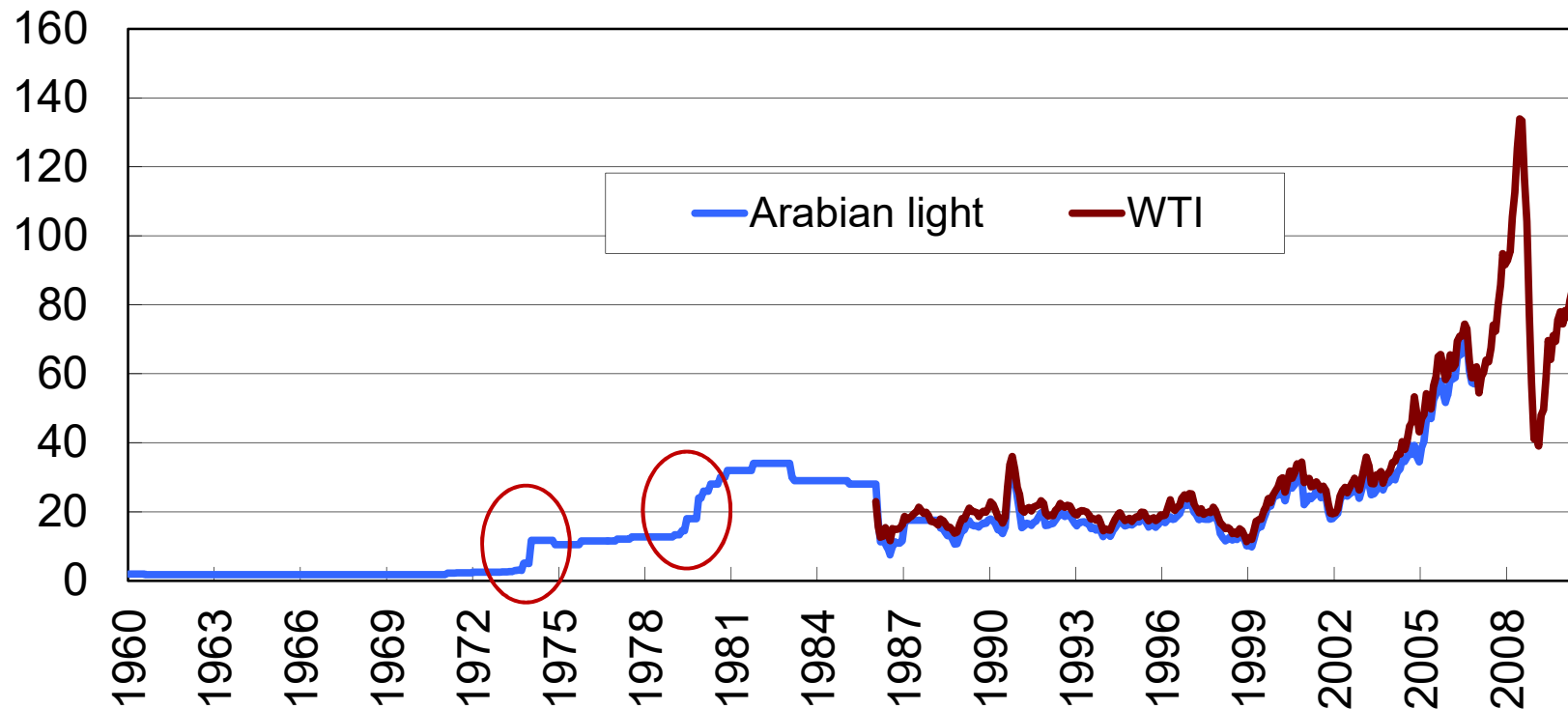
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- ▶ [1] Andrew Gordon “A modern history of Japan, from Tokugawa times to the present”, 2003, Oxford University Press
- ▶ [2] Statistics Bureau, Ministry of International Affairs and Communications of Japan
- ▶ [3] Bureau of Economic Analysis, U.S. Department of Commerce
- ▶ [4] Development Bank of Japan, <http://www.dbj.jp/en/>
- ▶ [5] Kazuya Fujime “Energy Policy of Japan – Basic Targets and Subjects”, IEEJ:November 2000
- ▶ [6] The energy data and modeling center 2010



# Reference material: Changes in oil price

- ▶ International crude oil price (Arabian light {undisclosed from 1986} and WTI {West Texas Intermediate}, Nominal \$ per barrel, 1 barrel = 159 liters)
- ▶ Rise of oil prices: First oil shock: \$11.7, Second: \$34



# Reference material: Real GNP

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