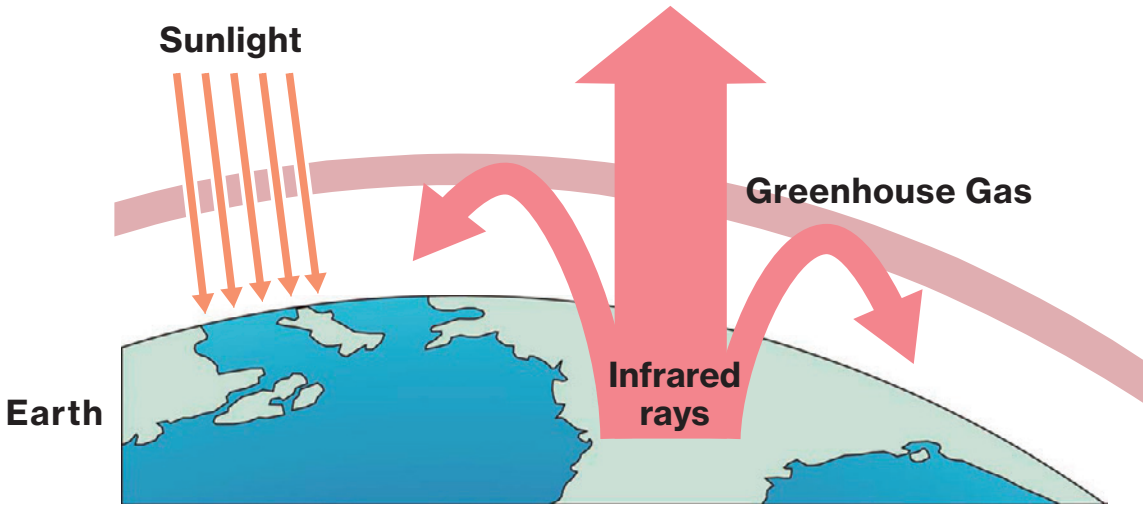
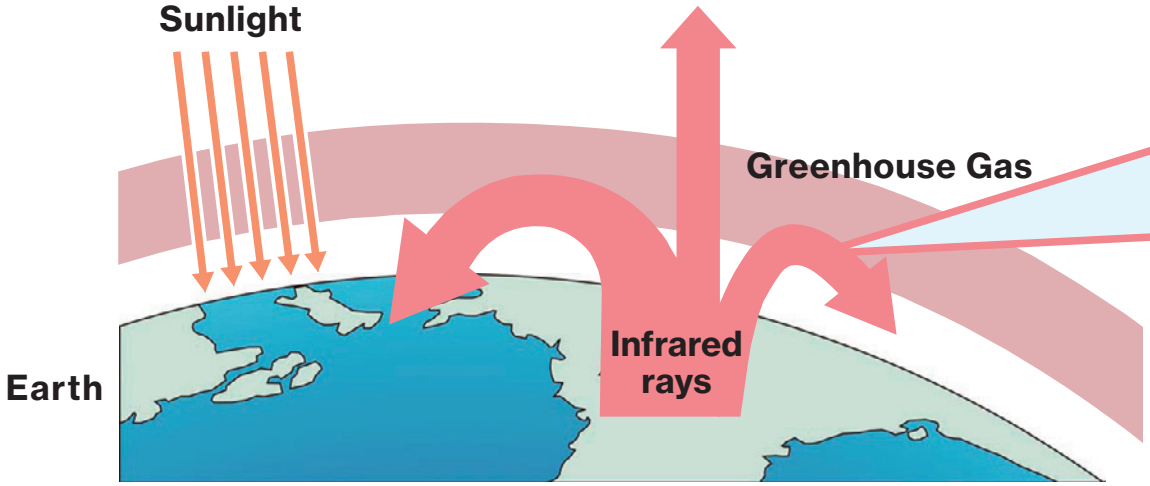
Mechanism of Greenhouse Effect

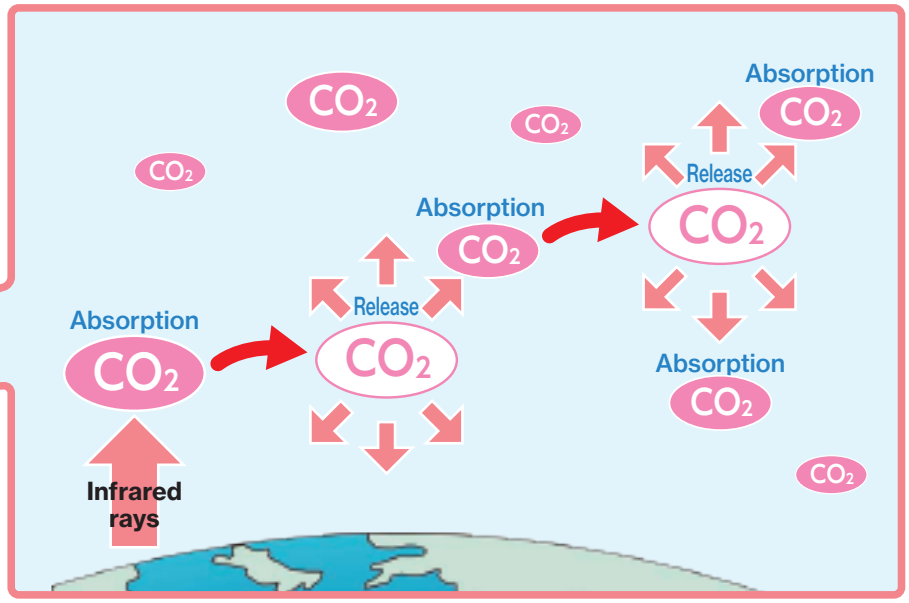


The Earth's atmosphere contains small amounts of "greenhouse gases" such as carbon dioxide, which have a property of absorbing infrared radiation and then releasing it again.
Because of this property, when light from the sun heats up the Earth's surface, infrared radiation travels up and away from the surface and may be absorbed and released by greenhouse gases. A portion of this infrared radiation returns to the surface and heats it up again. As the greenhouse gases in the atmosphere increase, they absorb and release more infrared radiation and make the "greenhouse effect" more severe, raising the air temperature at the Earth's surface.

Further increase in greenhouse gas causes:



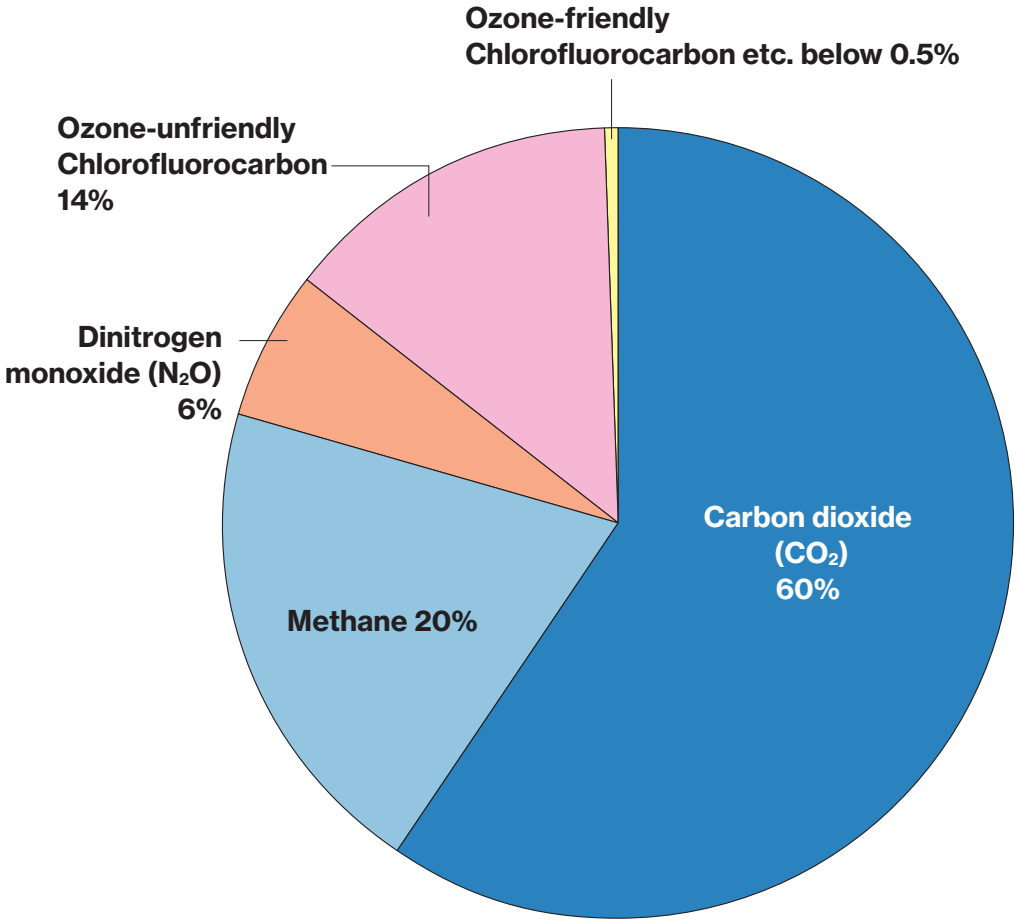
Example: Process of absorption and release of infrared radiation by carbon dioxide (CO_2)



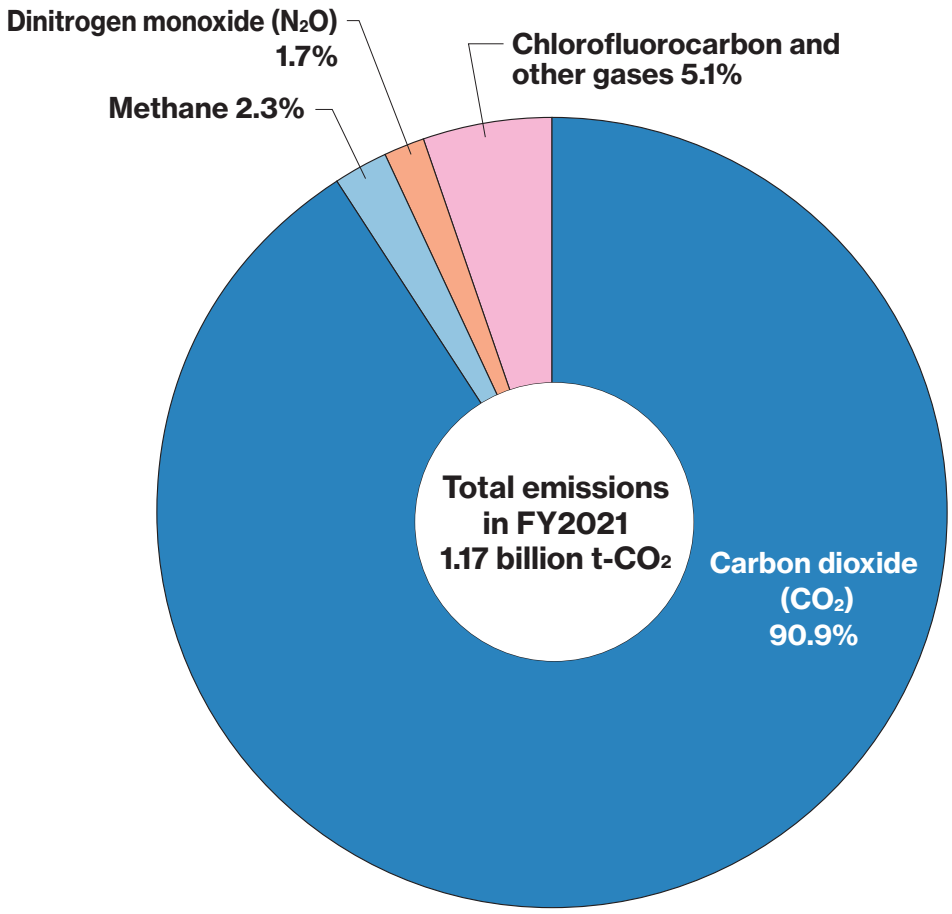
As carbon dioxide (CO_2) increases, more infrared rays reach the Earth's surface.

Contribution of Greenhouse Gases to Global Warming

Direct contribution to global warming of GHGs emitted by human activities after the Industrial Revolution



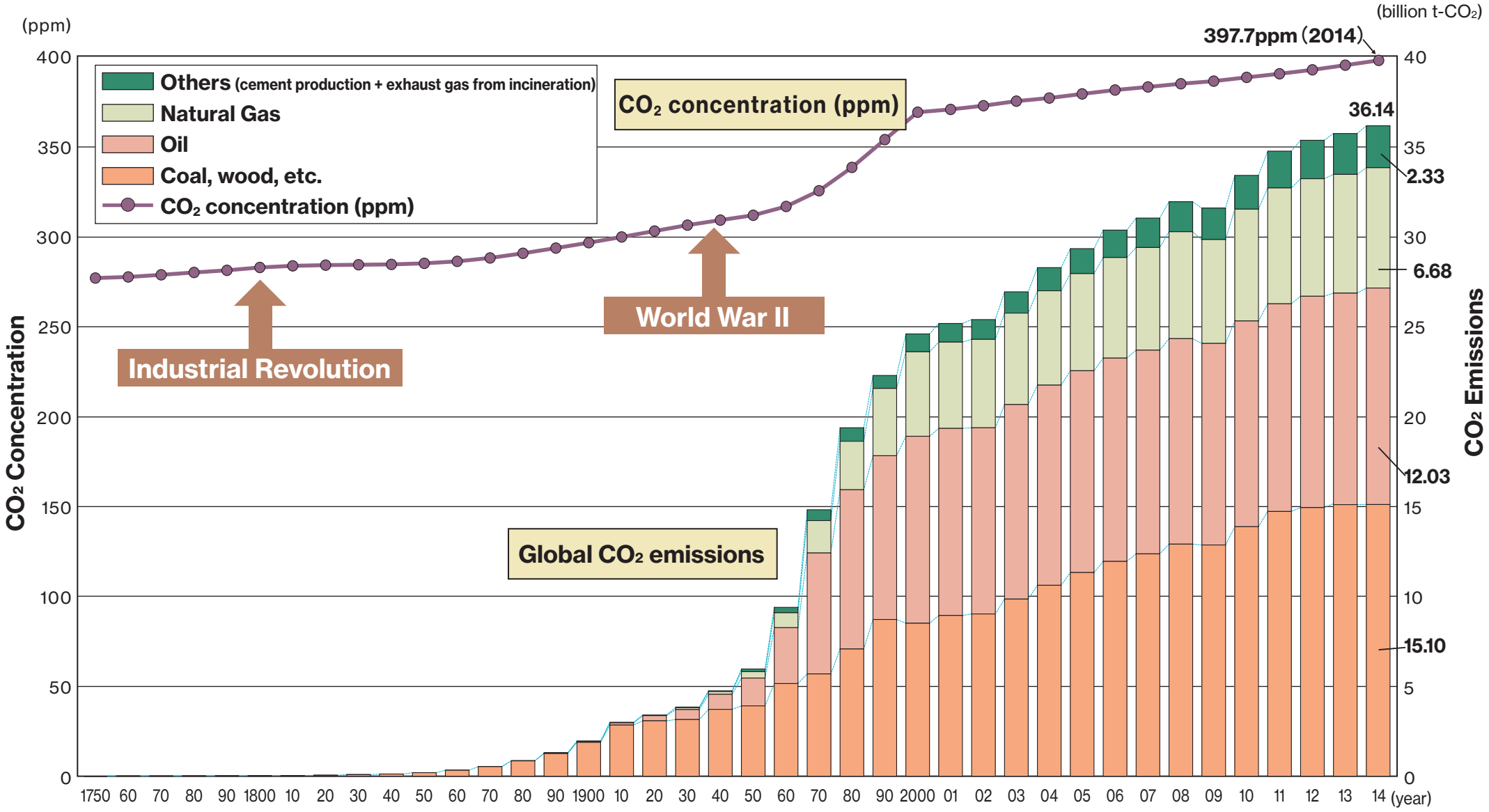
Direct contribution to global warming of GHGs emitted by Japan (for the single year of fiscal 2021)



(Note) Figures may not add up to the totals due to rounding.
GHGs: Greenhouse Gases

Source: Ministry of the Environment, Annual Report on the Environment, the Sound Material-Cycle Society and Biodiversity in Japan 2023, with others

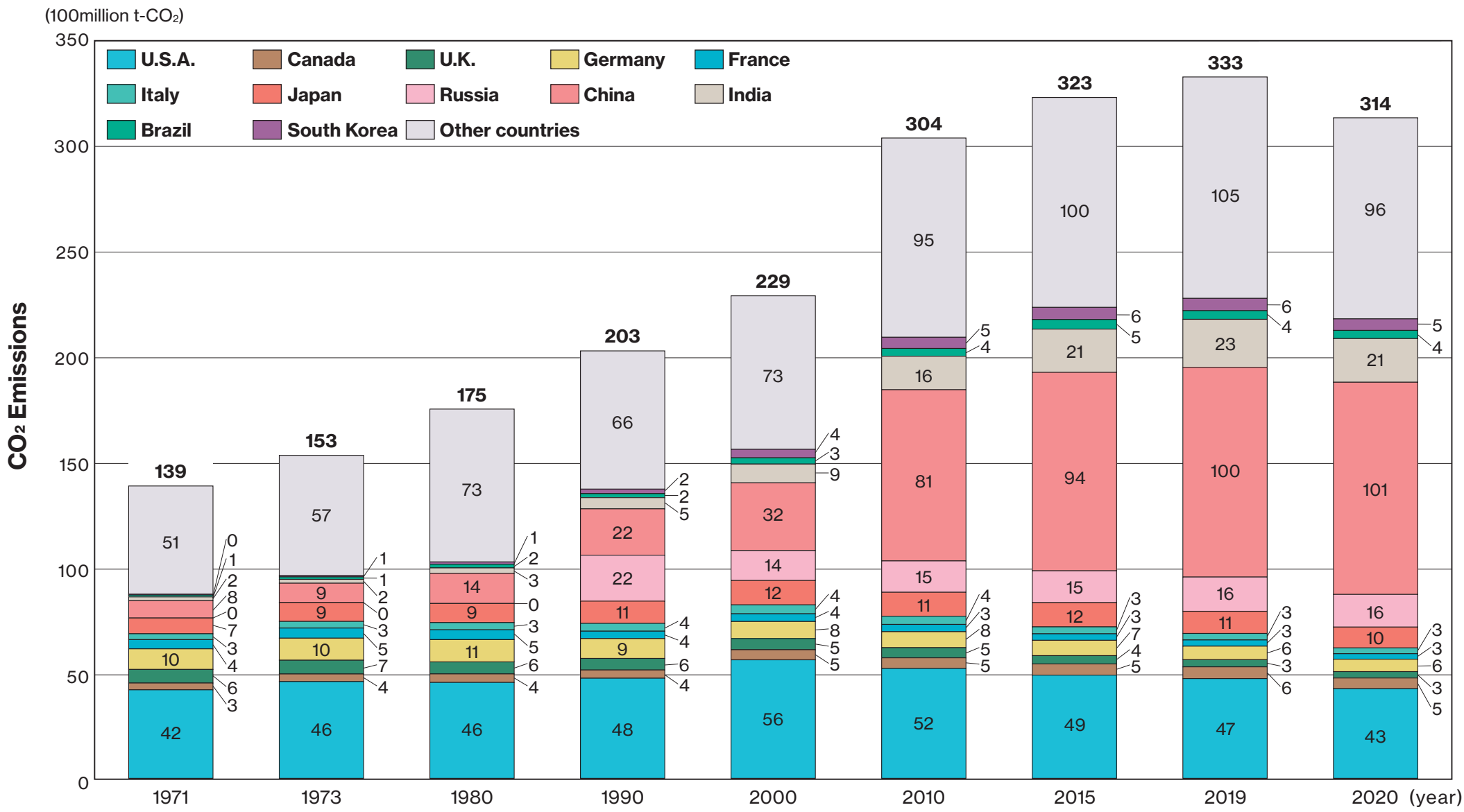
Changes in CO_2 Emissions from Fossil Fuels and Atmospheric CO_2 Concentration in Japan



(Note) Figures may not add up to the totals due to rounding.

Source: CDIAC, Global Fossil-Fuel Carbon Emissions, with others

Historical Trends in the World's CO_2 Emissions

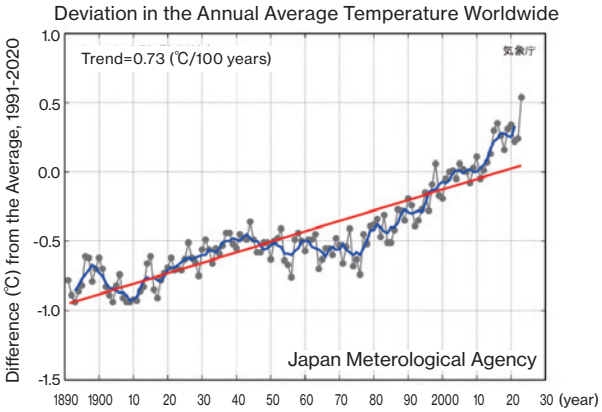


(Note) Figures may not add up to the totals due to rounding.
Until 1990, Russia's CO_2 emissions are included in "Other countries".

Source: The Institute of Energy Economics, Japan, FY2023 Handbook of Energy & Economic Statistics in Japan

Changes in Average Temperatures

Deviation in the Annual Average Temperature Worldwide (1891 to 2023)

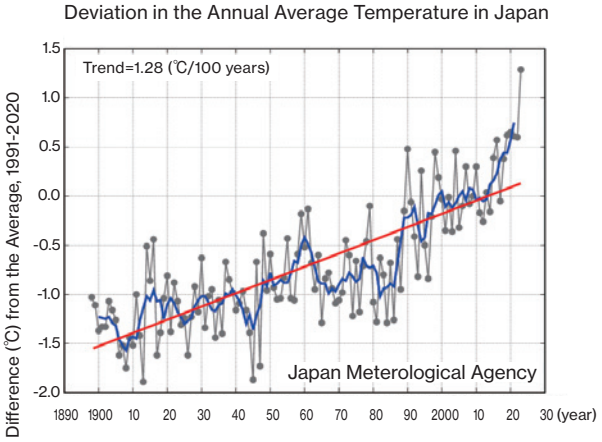


Thin line (black) : Deviation from the reference value each year (difference from the 1991 to 2020 average)
(Deviation in 2023 was +0.54℃)

Thick line (blue) : Deviation in the 5-year moving average

Solid line (red) : Long-term trends
(Rising at a rate of about 0.76℃/100 years)

Deviation in the Annual Average Temperature in Japan (1898 to 2023)



Thin line (black) : Deviation from the reference value at the 15 observation sites* in Japan
(Average deviation in 2023 was +1.29℃)

Thick line (blue) : Deviation in the 5-year moving average

Solid line (red) : Long-term trends
(Rising at a rate of about 1.35℃/100 years)

*The 15 observation sites are in Abashiri, Nemuro, Suttsu, Yamagata, Ishinomaki, Fushiki, Iida, Choshi, Sakai, Hamada, Hikone, Miyazaki, Tadotsu, Naze, Ishigaki.

Source: Japan Meteorological Agency website

Historical Temperatures and Predictions of Warming due to Increasing CO_2

Historical Temperatures	World	Rising at a rate of about 0.74℃/100 years*1
	Japan	Rising at a rate of about 1.30℃/100 years*2
Predicted Temperatures	World	Global warming of 1.5°C and 2°C will be exceeded during the 21st century unless deep reductions in CO_2 and other greenhouse gas emissions occur in the coming decades*3
	Japan	Rising 0.5 to 5.4℃ by 2100*4 ○RCP 2.6 scenario (lower stabilization scenario: assuming that the temperature rise is kept below 2 ℃): 0.5 to 1.7 ℃ rise ○RCP 8.5 scenario (high-level reference scenario: assuming no policy mitigation measures): 3.4 to 5.4 ℃ rise (RCP scenario is a scenario calculated from the idea of the concentration of greenhouse gases to be stabilized in the future, assuming policy mitigation measures)

Source: (*1,*2) Japan Meteorological Agency website, (*3) Intergovernmental Panel on Climate Change (IPCC), 6th Assessment Report - Climate Change 2021, and Ministry of the Environment
(*4)Ministry of the Environment, MEXT, MLIT, MAFF, Japan Meteorological Agency ; Climate Change Observation, Forecasting and Impact Assessment Integrated Report 2018

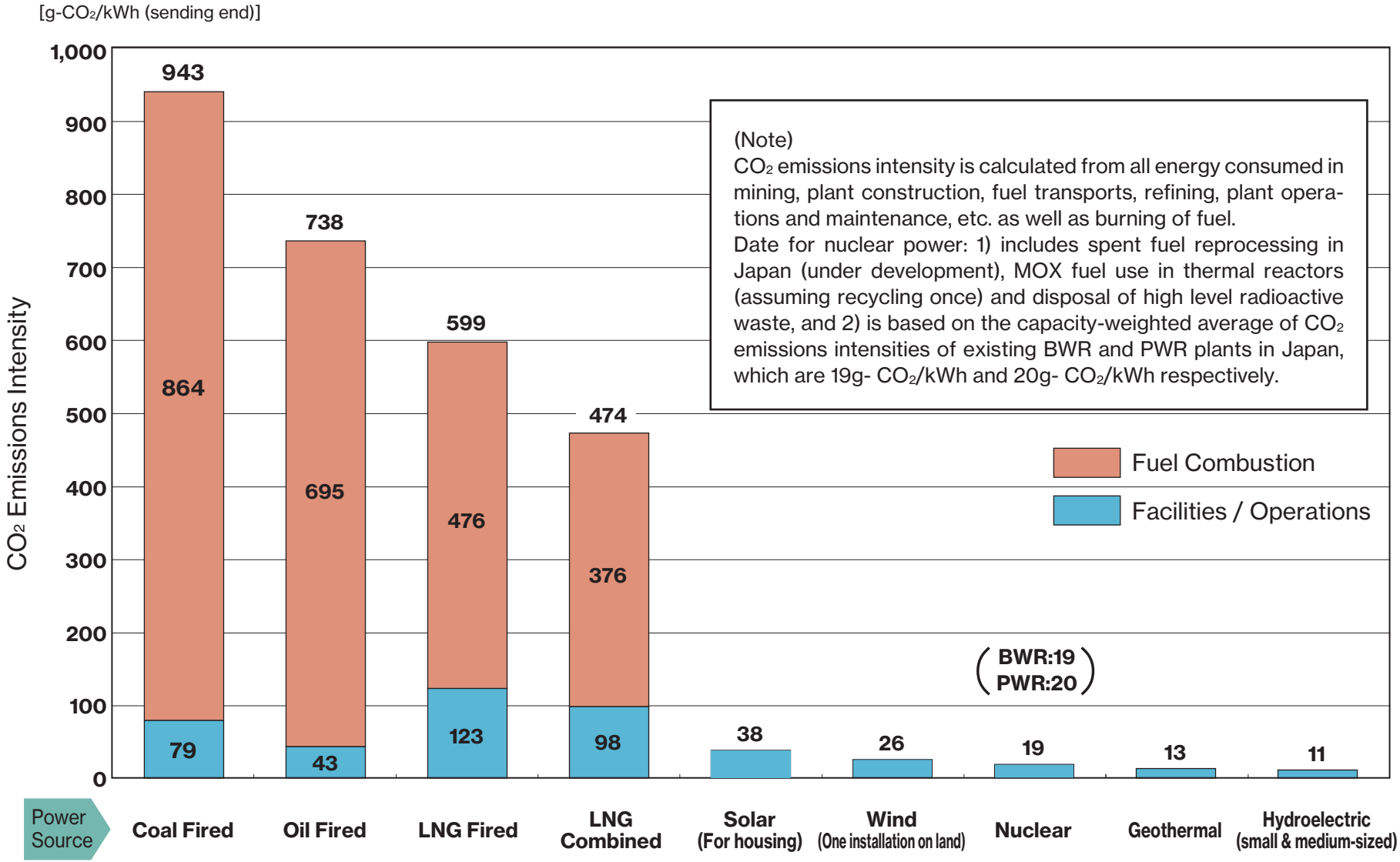
Efforts Toward Solving the Problem of Global Warming

Month/Year	Location	Organization	Description
Nov. 1988	Geneva, Switzerland	IPCC established	Established the first venue for discussions between governments on global warming
Mar. 1995	Berlin, Germany	COP1	Decided to discuss international agreements on numerical targets for greenhouse gas emission reductions
Dec. 1997	Kyoto, Japan	COP3	Set numerical targets for greenhouse gas emission reductions during the 1st greenhouse gas emission reductions agreement period (adopted the Kyoto Protocol)
Oct.–Nov. 1999	Bonn, Germany	COP5	Many countries recognized the importance of bringing the Kyoto Protocol into effect by 2002
Oct.–Nov. 2001	Marrakesh, Morocco	COP7	Final agreement on the operational rules for the Kyoto Protocol
Dec. 2003	Milan, Italy	COP9	Discussed detailed rules for implementing the Kyoto Protocol
Nov.–Dec. 2005	Montreal, Canada	COP11 & CMP1	Made improvements, such as full establishment of operational rules for the Kyoto Protocol (effect Feb. 2005) and the CDM
Nov. 2006	Nairobi, Kenya	COP12 &CMP2	Made improvements, including a framework for the future after the Kyoto Protocol (from 2013 on), for supporting developing countries and changes to the CDM
Dec. 2007	Bali, Indonesia	COP13 & CMP3	Discussed the framework for after 2013 and support for developing countries (adopted the Bali Roadmap)
Dec. 2008	Poznan, Poland	COP14 & CMP4	Discussions held with the aim of reaching agreement on the framework after 2013 by the end of 2009
Dec. 2009	Copenhagen, Denmark	COP15 & CMP5	Decided to keep the Copenhagen Accord on the table
Nov.–Dec. 2010	Cancun, Mexico	COP16 & CMP6	Formally determined the content of the Copenhagen Accord
Nov.–Dec. 2011	Durban, South Africa	COP17 & CMP7	Extended the Kyoto Protocol and adopted the Durban Platform for bringing a new legal framework into place in 2020
Nov.–Dec. 2012	Doha, Qatar	COP18 & CMP8	Adopted the Doha Climate Gateway, incorporating elements such as an action plan for creating a new framework in force to 2020, as well as an 8-year extension of the Kyoto Protocol
Nov. 2013	Warsaw, Poland	COP19 & CMP9	Laid the groundwork for agreement on the framework after 2020
Dec. 2014	Lima, Peru	COP20 & CMP10	Adopted the Lima Statement for Climate Action
Dec. 2015	Paris, France	COP21 & CMP11	Adopted the Paris Agreement
Nov. 2016	Makelash, Morocco	COP22, CMP12 & CMA1	Discussion over the implementation guidelines of the Paris Agreement
Nov. 2017	Bonn, Germany	COP23, CMP13 & CMA1-2	Implementation guideline of Paris Agreement negotiation, basic design of promotional dialogue, promotion of global climate action
Dec. 2018	Katowice, Poland	COP24, CMP14 & CMA1-3	Adopted implementation guidelines for the Paris Agreement for full operation of the Paris Agreement after 2020
Dec. 2019	Madrid, Spain	COP25, CMP15 & CMA2	Discussion over the implementation guidelines in the Paris Agreement Article 6 (Market Mechanism)
Oct.–Nov. 2021	Glasgow, United Kingdom	COP26, CMP16 & CMA3	The agreement calls for net zero greenhouse gas emissions by the midpoint of this century as well as ambitious mitigation and adaptation measures to be implemented by 2030, while relying on the latest scientific knowledge. Finalization of the Paris Rulebook.
Nov. 2022	Sharm el-Sheikh, Egypt	COP27, CMP17 & CMA4	Adopted the Sharm el-Sheikh Implementation Plan , which calls for increased efforts to combat climate change in various fields, and the Mitigation Work Programme which aims to improve ambition for and implementation of mitigation by 2030. Decided to establish measures and funds for assistance with loss and damage accompanying the adverse effects of climate change.
Nov.–Dec. 2023	Dubai, United Arab Emirates	COP28, CMP18 & CMA5	Adopted a decision on the GST to assess global progress, decision on operationalization of the new funding arrangements, including a fund, for responding to loss and damage, and decisions on mitigation, adaptation, finance and a just transition was adopted.

(Note) 1st greenhouse gas emission reductions agreement period: 2008 to 2012 GST (Global Stocktake):Efforts to review the implementation status of the Paris Agreement and evaluate progress towards achieving long-term goals
IPCC: Intergovernmental Panel on Climate Change COP: Conference of the Parties CMP: Meeting of the Parties (to the Kyoto Protocol) CDM: Clean Development Mechanism CMA: Meeting of the Parties to the Paris Agreement

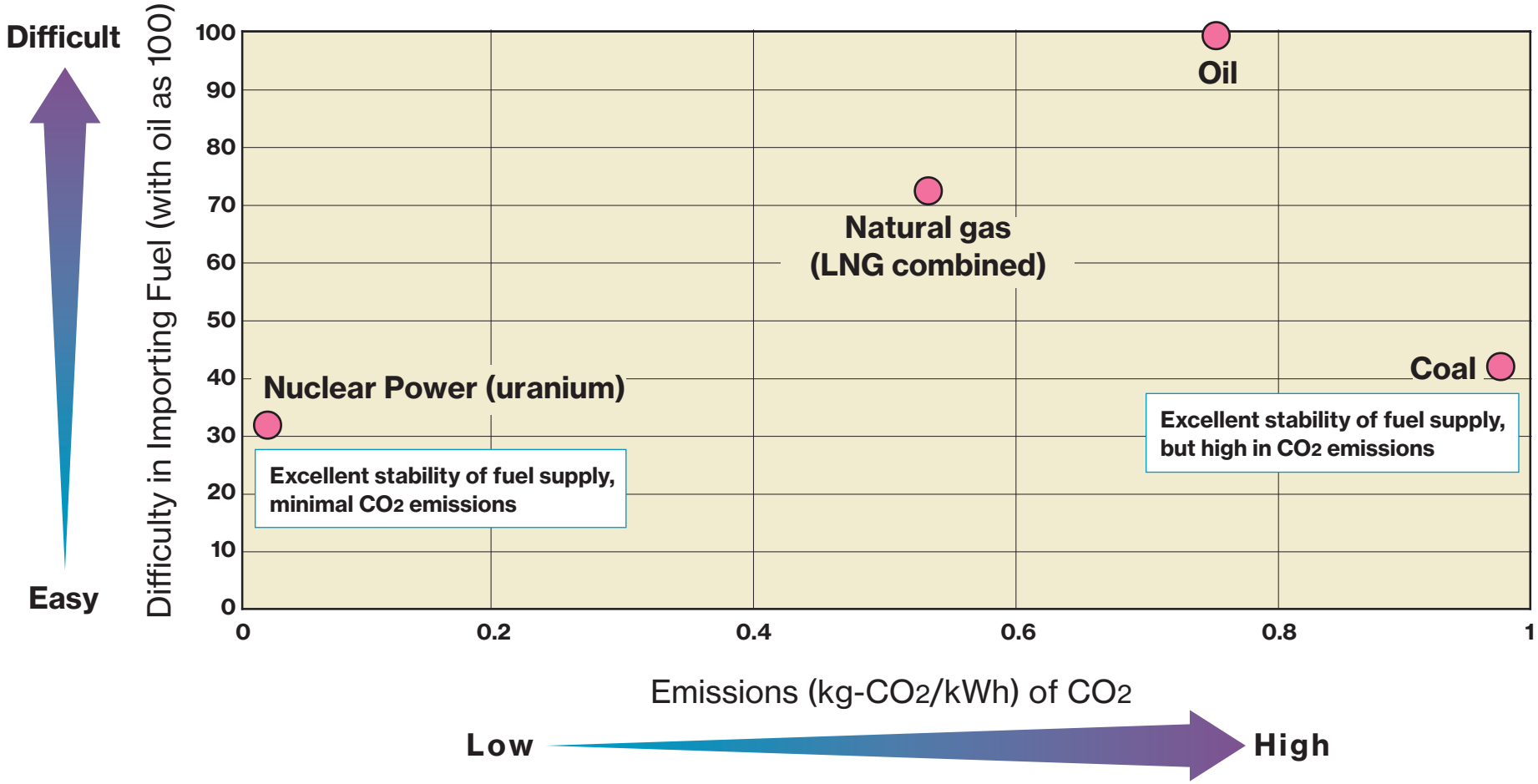
Source: Press Releases Material of the Ministry of the Environment

Lifecycle-Assessed CO_2 Emissions Intensity of Japan's Energy Sources



Source: Central Research Institute of Electric Power Industry, Comprehensive Assessment of Life Cycle CO_2 Emissions from Power Generation Technologies in Japan (July 2016)

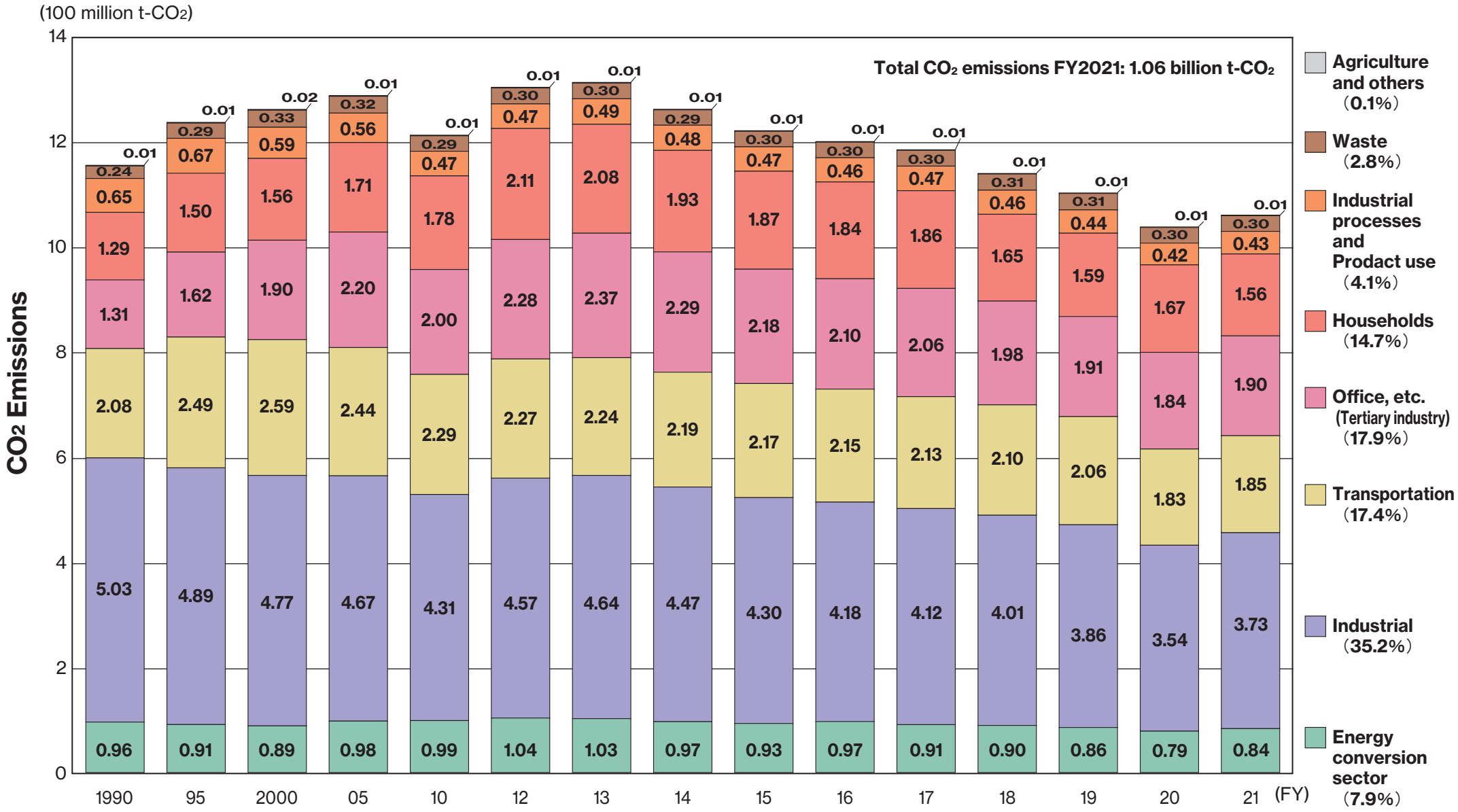
Various Power Sources in Terms of CO_2 Emissions and Stability of Energy Resource Procurement



(Note) Degree of difficulty of importing fuel = (difficulty of ensuring world energy resources) + (difficulty of ensuring resources from supplier to Japan)
= (Imbalance in location of resource reserve + imbalance in volume exported) x (political & economic stability of each country)
+ (imbalance in suppliers to Japan) x (political & economic stability of each country)
Countries are rated on their political and economic stability on a 10 step scale of 0.1 to 1.0 by Nippon Export and Investment Insurance; for example, Australia is rated a 0.1, while Afghanistan is a 1.0.

Source: Central Research Institute of Electric Power Industry, A Quantitative Evaluation of the Fuel Supply Stability of Nuclear Power (April 2008), and others

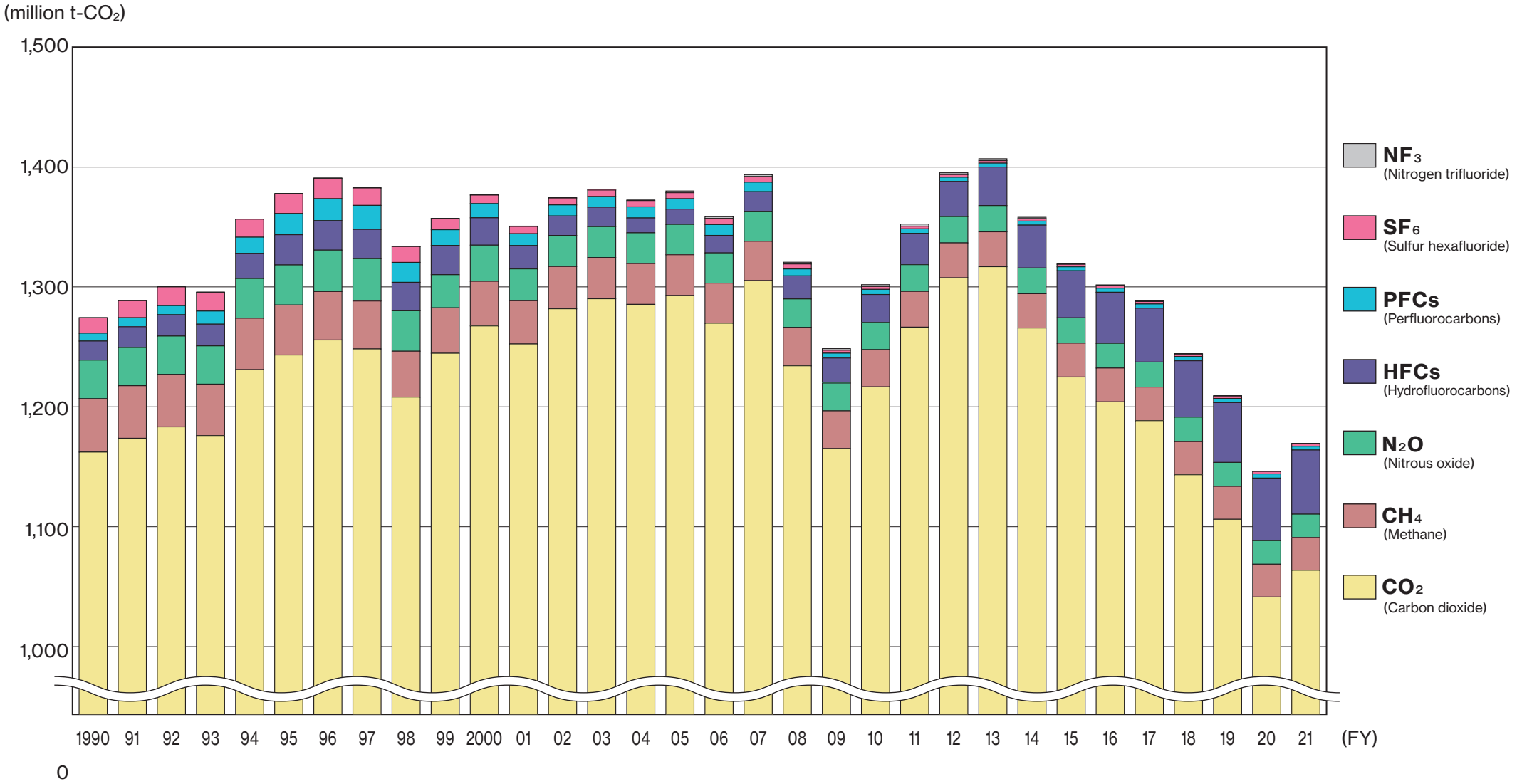
Japan's Changes in CO_2 Emissions by Sector



(Note) The numerical values show the indirect emissions (CO_2 emissions associated with power generation or heat generation are allocated to individual end demand sectors according to the electricity and heat consumption).

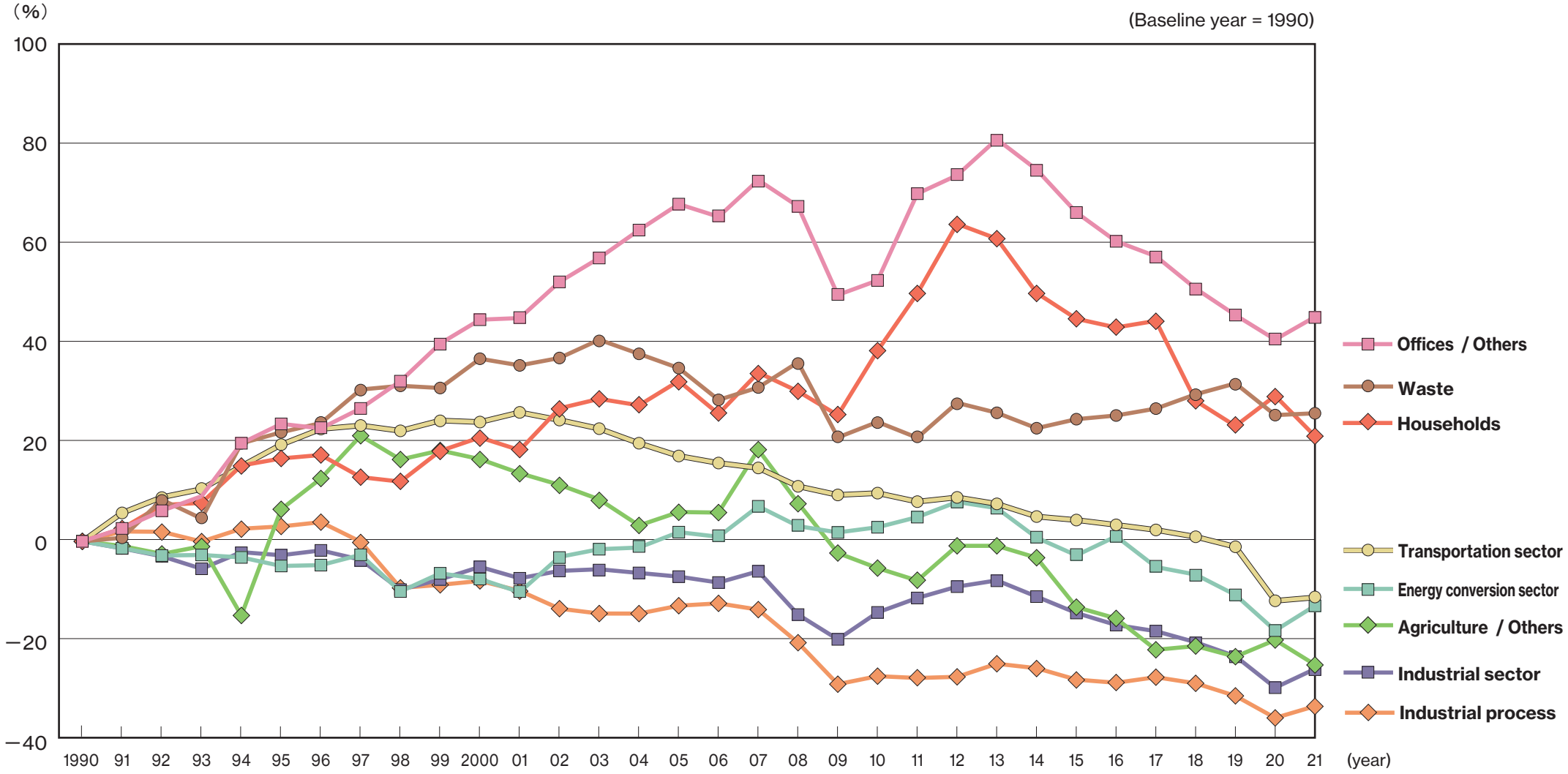
Source: Greenhouse Gas Inventory Office of Japan

Changes in GHGs Emissions in Japan



Source: Greenhouse Gas Inventory Office of Japan

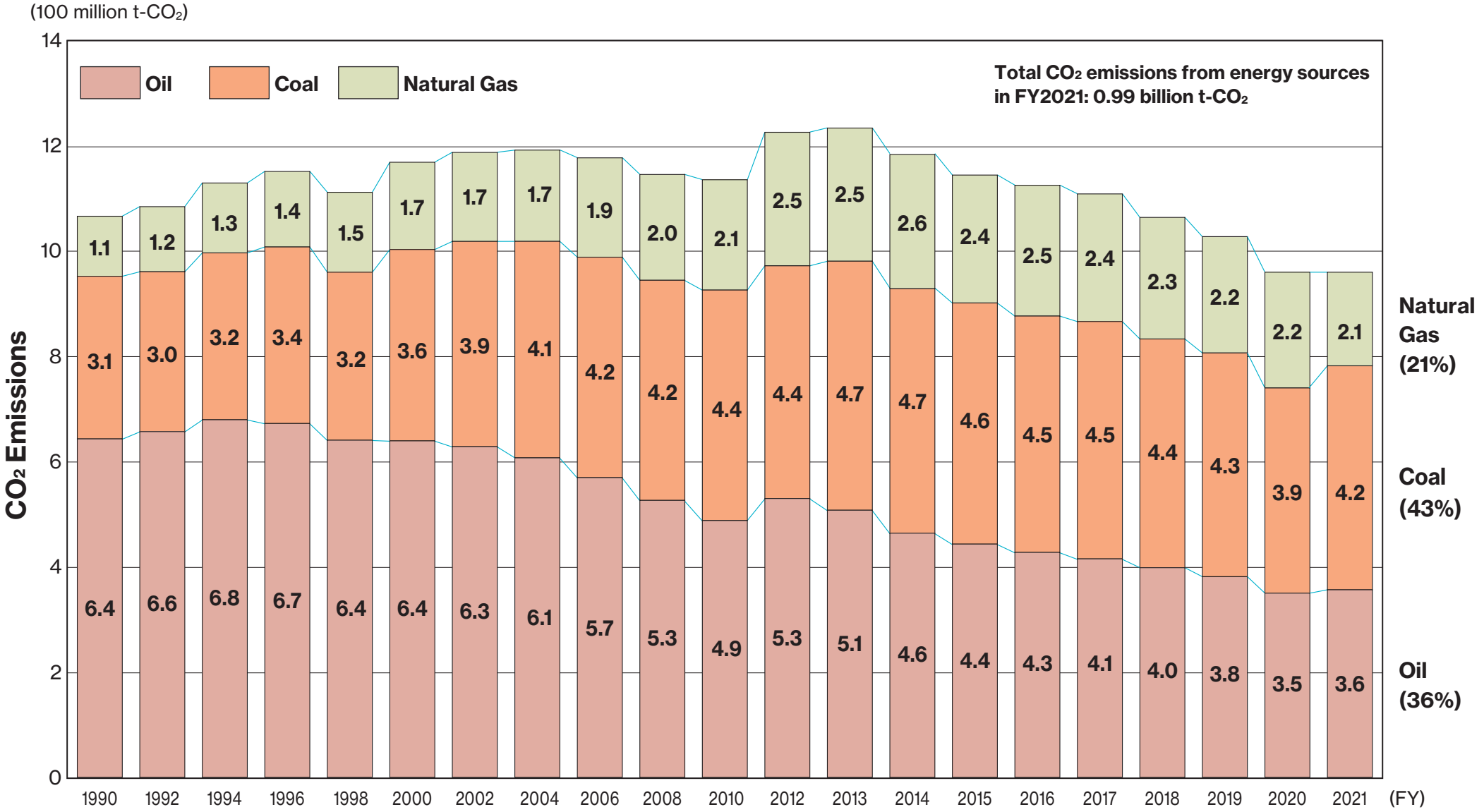
Changes in Percent Increase/Decrease CO_2 Emissions by Sector in Japan



(Note) The numerical values show the increase and decrease of the indirect emissions (CO_2 emissions associated with power generation or heat generation are allocated to individual end demand sectors according to the electricity and heat consumption).

Source: Greenhouse Gas Inventory Office of Japan

Changes in CO_2 Emissions by Energy Source



(Note) Figures may not add up to the totals due to rounding.

Source: Greenhouse Gas Inventory Office of Japan

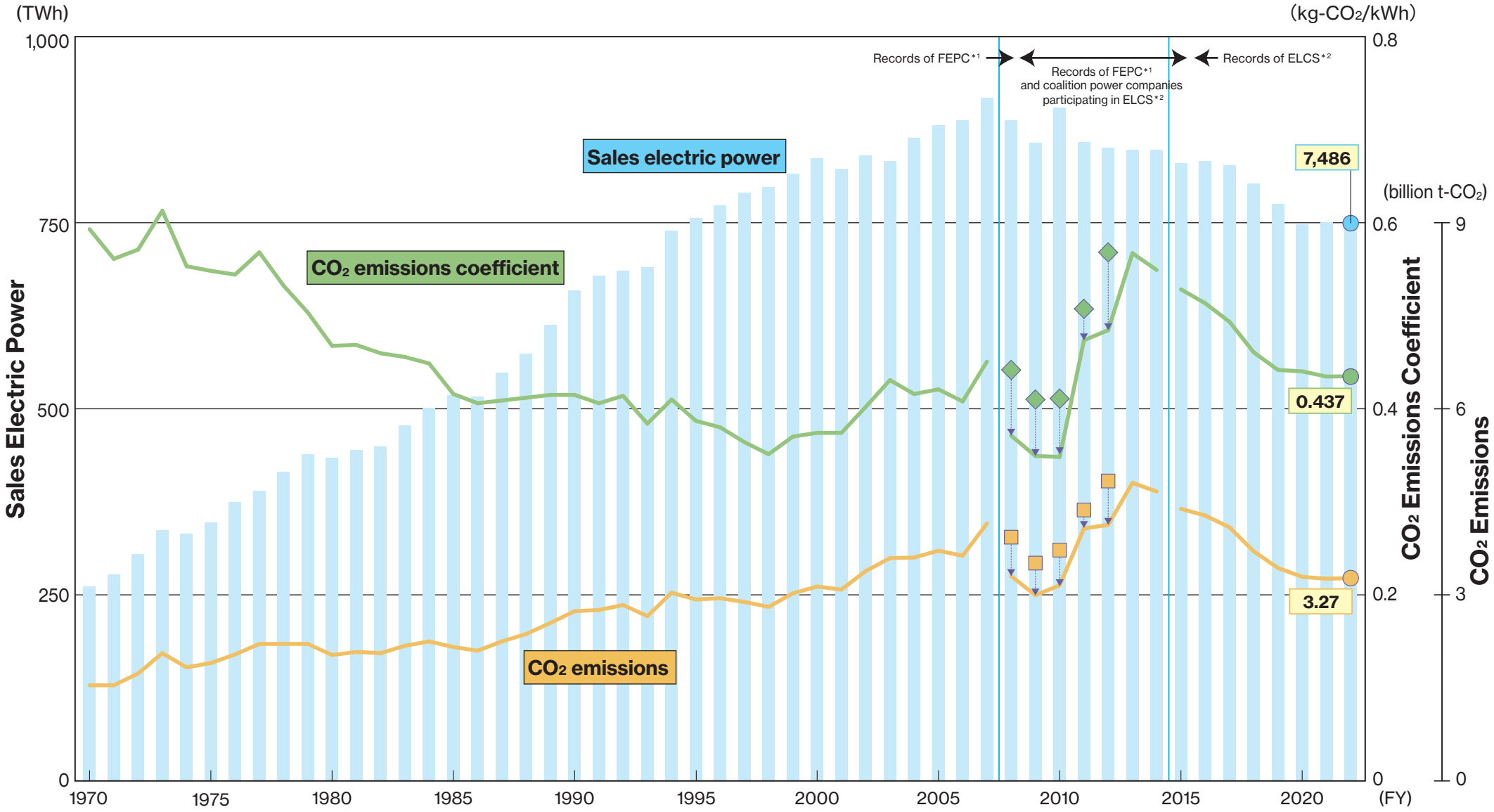
Measures by Japan's Electric Power Industry to Reduce CO_2 Emissions

1. 2020 Targets for Reducing Domestic Emissions from Business Activities	**Target Standards**	○ From the perspective of simultaneously achieving S+3E--the prerequisite of ensuring Safety (S), along with the (3 Es) of Energy security, Economic viability and Environmental conservation, and under the premise of pursuing an ideal mix of energy sources, take steps on both the electricity demand and supply side and continue to strive to realize a low-carbon society. ○ When newly installing thermal generation, use the highest standard of technology that can be applied economically (BAT), according to the scale of the plant, in order to achieve a potential reduction that is forecast to be up to 7 million tons of CO_2. *1, *2
	Foundations for Establishing Targets	Each participating company shall put together initiatives according to their business structure and strive to realize a low-carbon society. ○ Promote the use of nuclear energy under the prerequisite of ensuring safety. ・In addition to implementing thorough safety measures at nuclear power plants, based on the lessons learned and knowledge gained from the Fukushima nuclear power plant accident, take independent, continuous steps to improve safety, not restricted to regulatory standards. ・In order to gain the broad understanding of everybody in society, including residents living near plants, in addition to providing careful explanations, strive to safely and stably operate plants whose safe operation has been confirmed. ○ Promote the use of renewable energies ・Utilize hydro, geothermal, solar, wind and bio-mass energy sources. ・Promote technological R&D etc. for dealing with fluctuations in output of renewable energy sources. Investigate measures for dealing with fluctuations in the output of solar power. Investigate introducing and expanding wind power generation, utilizing tie lines between regions. ○ Strive to improve the efficiency of thermal plants, etc. ・When developing thermal generation, use the highest standard of technology that can be applied economically (BAT), according to the scale of the plant. ・Strive to maintain the appropriate thermal efficiency of existing plants. ○ Strive to provide customer energy efficiency and low carbon services that contribute to a low carbon society. ・Strive to provide energy efficiency and low carbon services based on customer needs for a low carbon society in the field of electricity retailing.
2.Strengthen Cooperation between Entities		Recognize that in order to reduce electricity-related CO_2 emissions and improve the emissions factor, cooperation is essential between the government, which makes energy policies including those for nuclear power and renewable energy, and customers who use electricity via generation, transmission and distribution, and retailing. In addition to company's own efforts, linkages between the main players should be strengthened. ○ From the perspective of getting customers to use electricity more efficiently, we will help them achieve CO_2 reductions by spreading the use of highly efficient electrical devices and through energy and CO_2 conserving initiatives. ○ Work to introduce smart meters, as a green technology to help customers achieve more efficient use of electricity.
3.Promote International Contributions		Contribute to reducing CO_2 in various countries by spreading overseas the technology and know-how gained by electricity companies in Japan. ○ Support shifting to low carbon output in developing countries and transfer or supply Japanese power generation technologies via international partnership (GSEP) activities for energy efficiency, such as assessing coal-fired equipment and CO_2 reduction initiatives. ○ Aim for a global shift to low carbon through the development and introduction of advanced and feasible electric power technologies based on trends in international schemes including Joint Crediting Mechanism (JCM). (Note) There is potential for a reduction of up to 500 million tons/year of CO_2 from coal fired power plants in the OECD and Asian developing countries in 2020 if high-efficiency plants are introduced and operations are improved.
4.Development of Innovative Technologies		Continue to work to develop technologies that contribute to environmental protection on both the electricity demand and supply sides. ○ Develop technologies for the use of nuclear power ○ Thermal technologies that reduce environmental impact (A-USC, IGCC, CCS etc.) ○ Manage the large-scale introduction of renewable energy (improvement of thermal plant load following, stabilization of transmission and distribution networks, increased adoption of biomass and geothermal generation, etc.) ○ Develop technologies for the efficient use of energy

*1: Review these targets and action plans as necessary based on trends in energy and environmental policies, technology development in Japan and overseas, and changes in the business environment, etc., while promoting the PDCA cycle.
*2: Maximum reduction potential based on a comparison of the effect of adopting the BAT for the development of the main electricity sources from FY2013 onward instead of conventional technologies.

Source: The Federation of Electric Power Companies, Environmental Action Plan by the Japanese Electric Utility Industry (September 2015)

Historical Trends in CO_2 Emissions from Electricity Generation in Japan

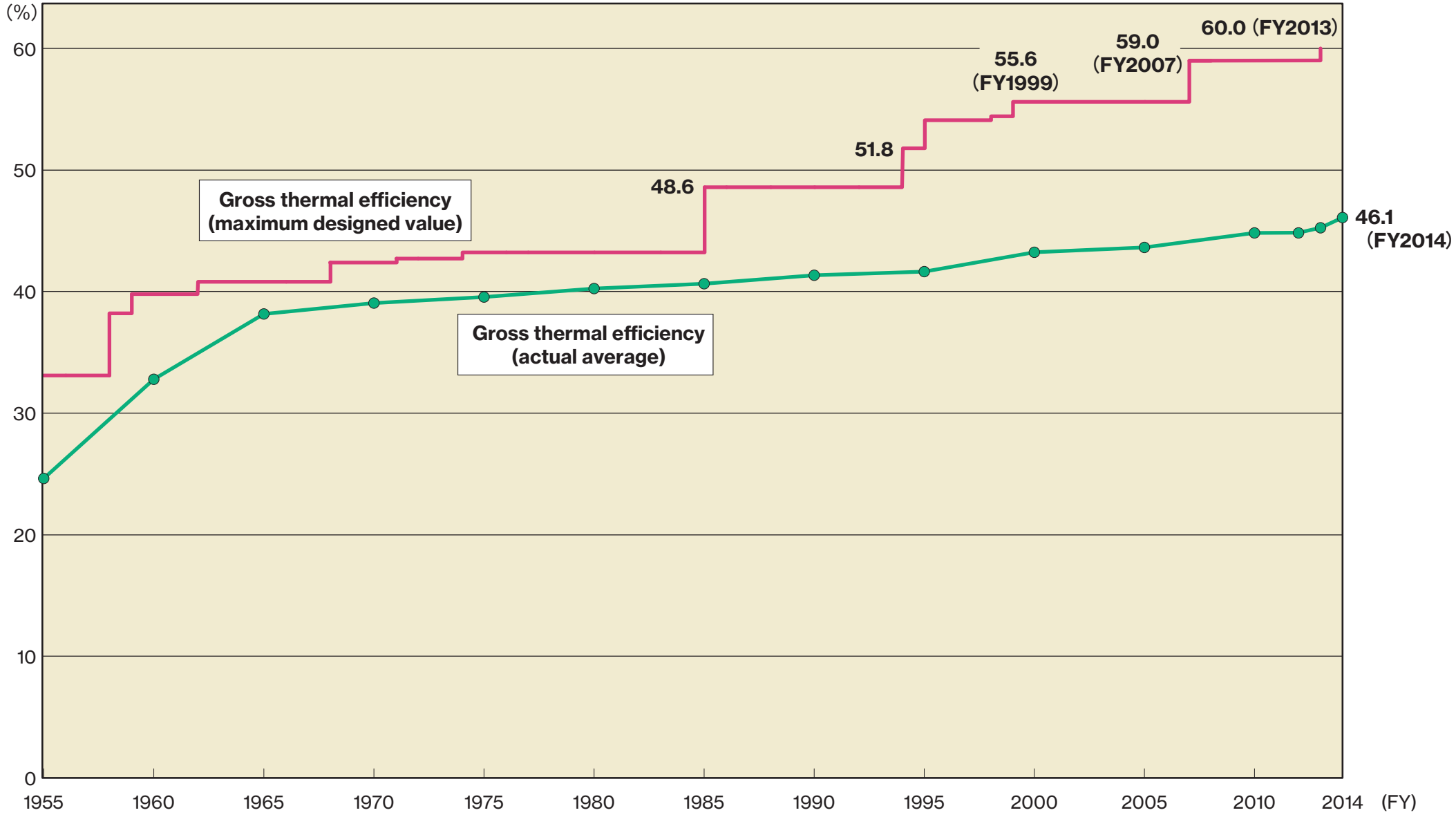


Note: For CO_2 emission amounts and emission coefficients, values shown for fiscal 2008–2019 records are after adjustment for FIT credit, etc., and values shown for fiscal 2008–2012 markers (◆ and ■) are base emissions.

＊1 FEPC：Federation of Electric Power Companies ＊2 ELCS：Electric Power Council for a Low Carbon Society

Source:The Electric Power Council for a Low Carbon Society, Follow-up Results of Initiatives Towards a Low-carbon Society

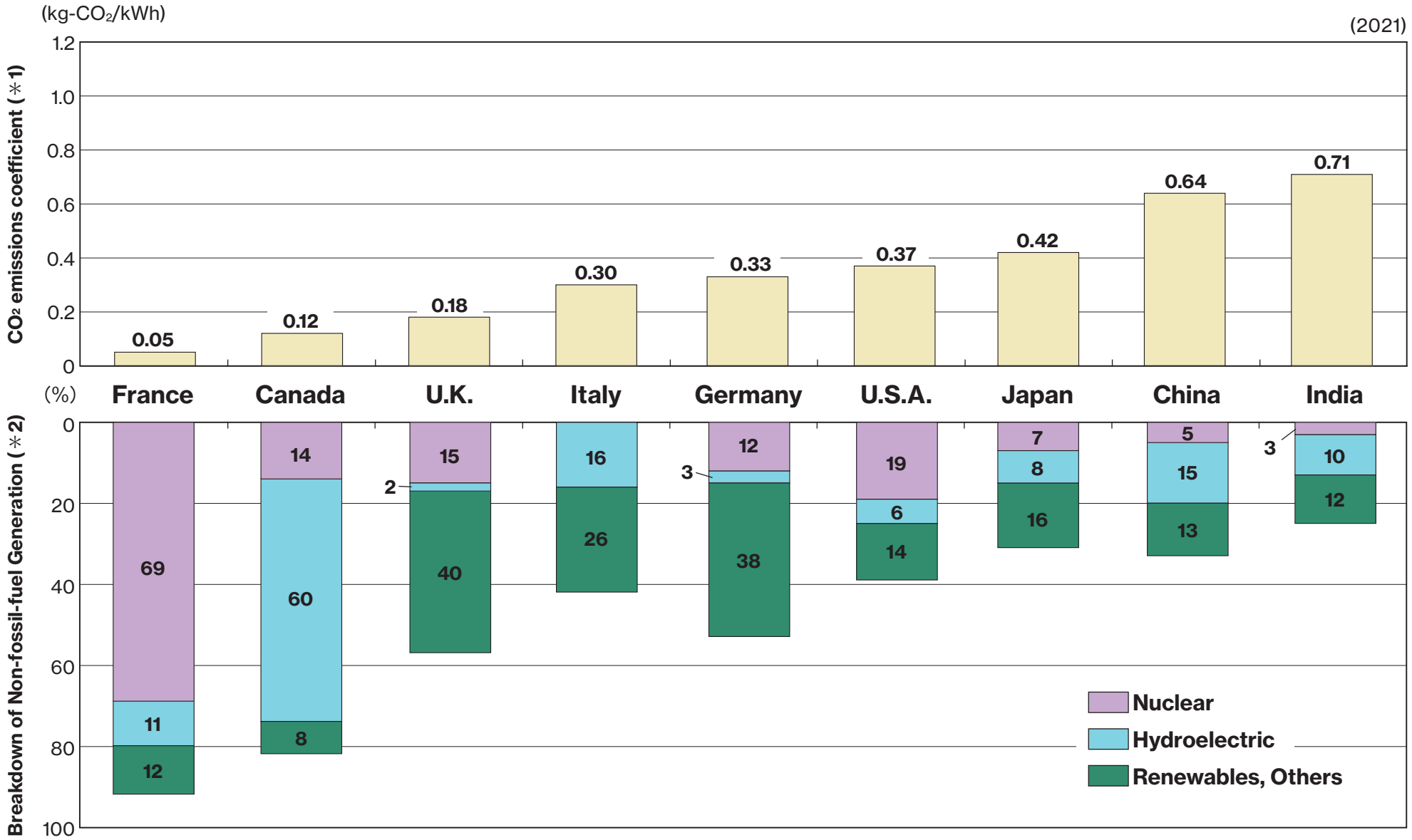
Thermal Efficiency and T&D Loss Factor in Japan



(Note) Lower Heating Value: Estimated from the higher heating value standard based on the conversion factor from the Comprehensive Energy Statistics (FY2010).

Source: Agency for Natural Resources and Energy, Japan Electric Utilities Handbook, with others

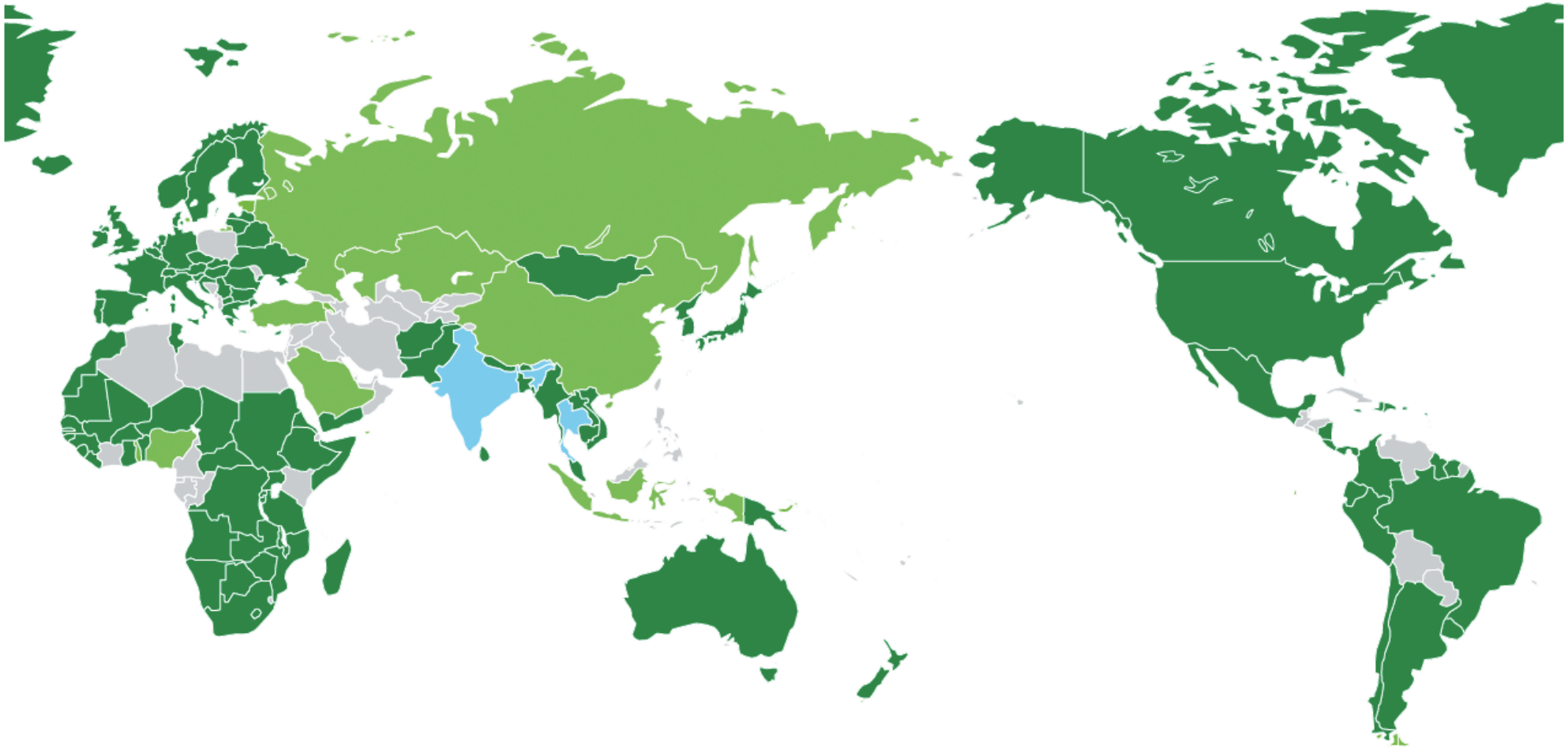
Comparison of CO_2 Emissions Coefficient by Country



(Note) The figures contain Combined Heat and Power (CHP) plants. The figures of Japan contain non-utility generation facilities.

Source: ＊1 The Electric Power Council for a Low Carbon Society, Efforts against Global Warming in the Electricity Business ＊2 IEA, World Energy Balances

Countries/Regions That Have Agreed With the Principle of Achieving Carbon Neutrality*



Countries that have agreed with the principle of achieving carbon neutrality by 2050 (144 countries including Japan)

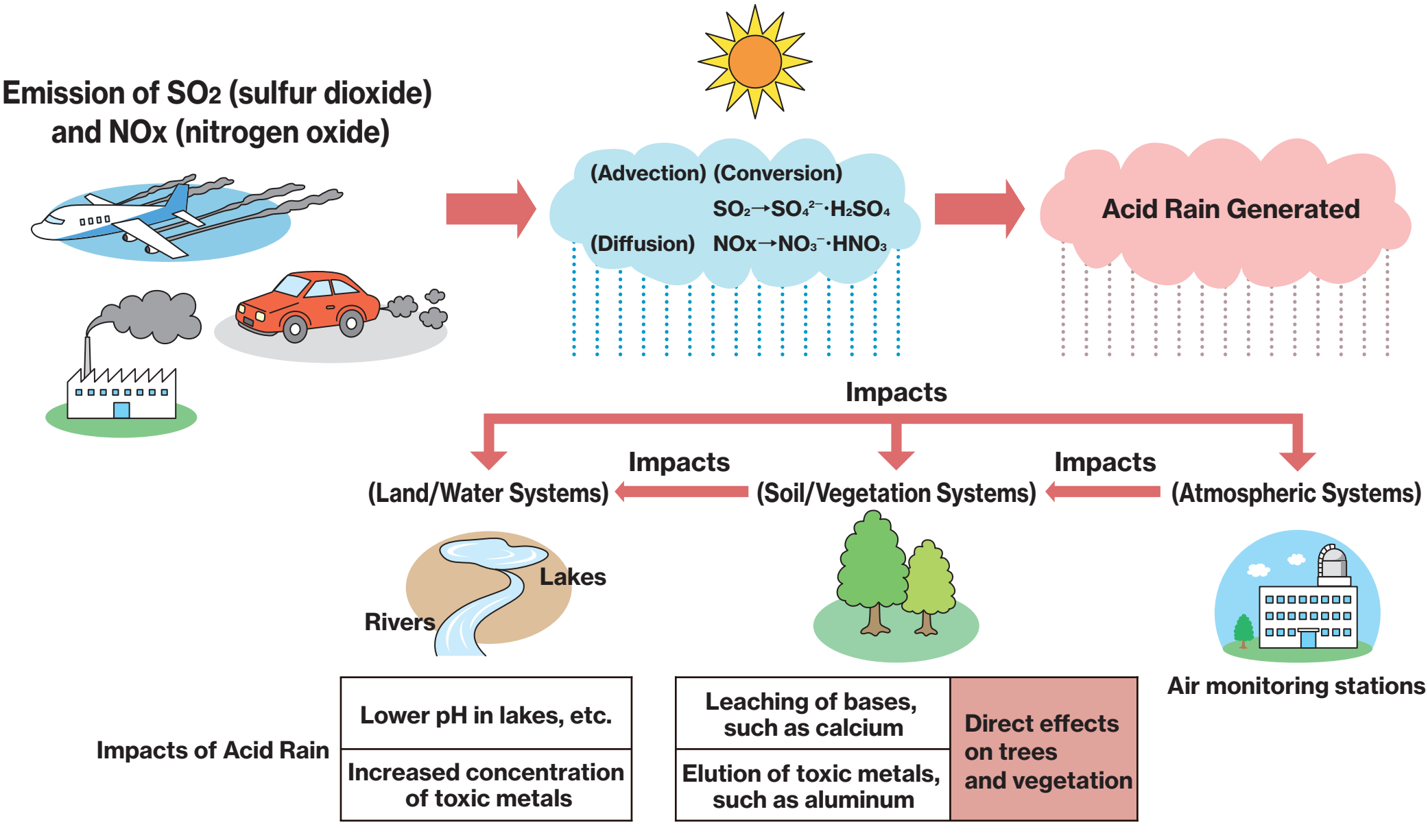
Countries that have agreed with the principle of achieving carbon neutrality by 2060

Countries that have agreed with the principle of achieving carbon neutrality by 2070

* (1) Countries participating in the Climate Ambition Alliance ; (2) Countries that have submitted a long-term strategy to the United Nations and announced CN by 2050, and countries that announced CN by 2050 at the Leaders Summit on Climate in April 2021, COP26 , etc. Created by METI by counting those countries (as of November 9, 2021)

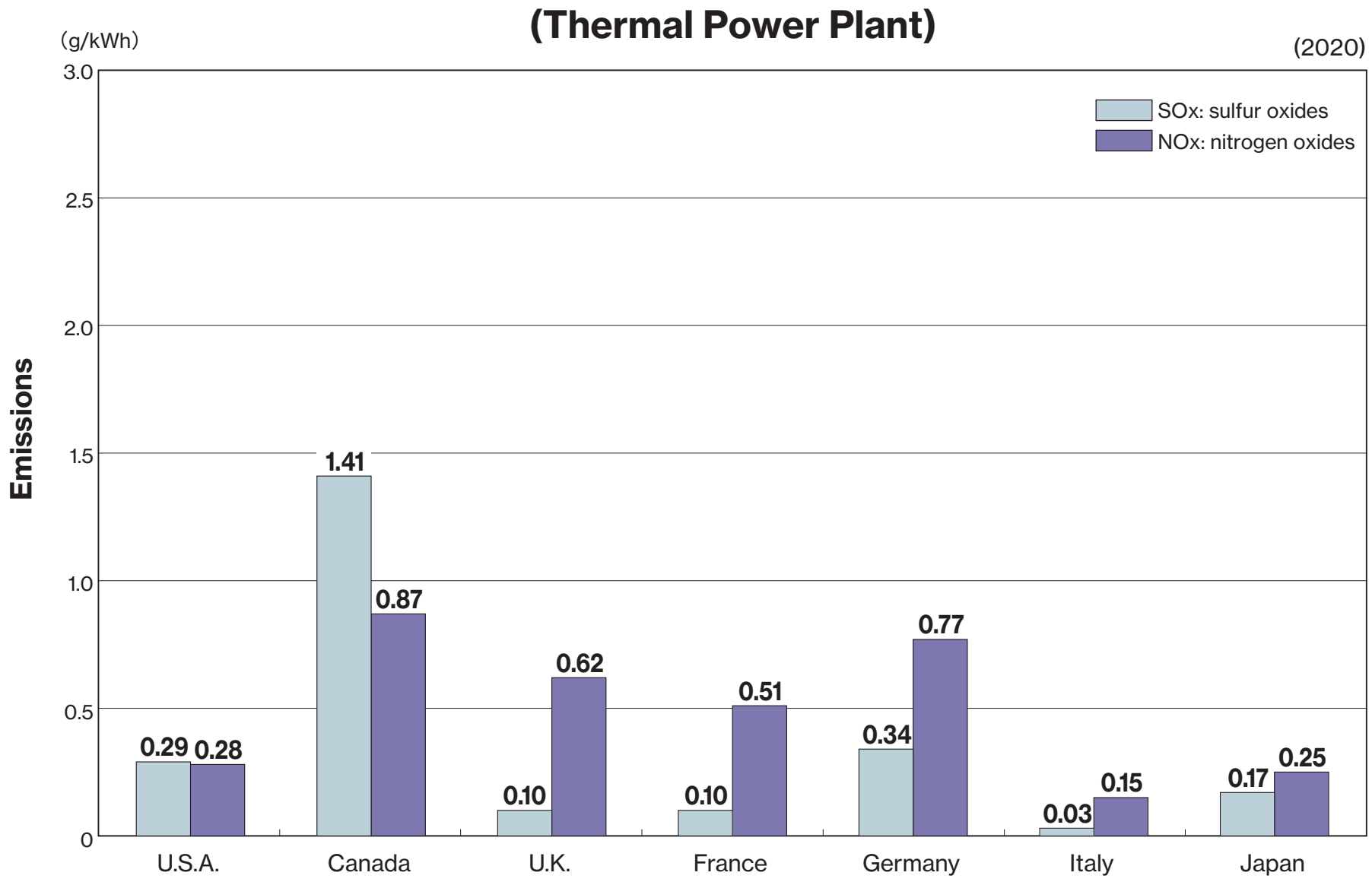
Source: Created from Japan's ENERGY (2021 EDITION)

Mechanisms in the Development of Acid Rain



Impacts of Acid Rain			
	Lower pH in lakes, etc.	Leaching of bases, such as calcium	Direct effects on trees and vegetation
	Increased concentration of toxic metals	Elution of toxic metals, such as aluminum	

SOx and NOx Emissions per Unit of Electricity Generated in Major Countries



※10 electric power companies and Electric Power Development Co. Ltd.

Source: The Federation of Electric Power Companies