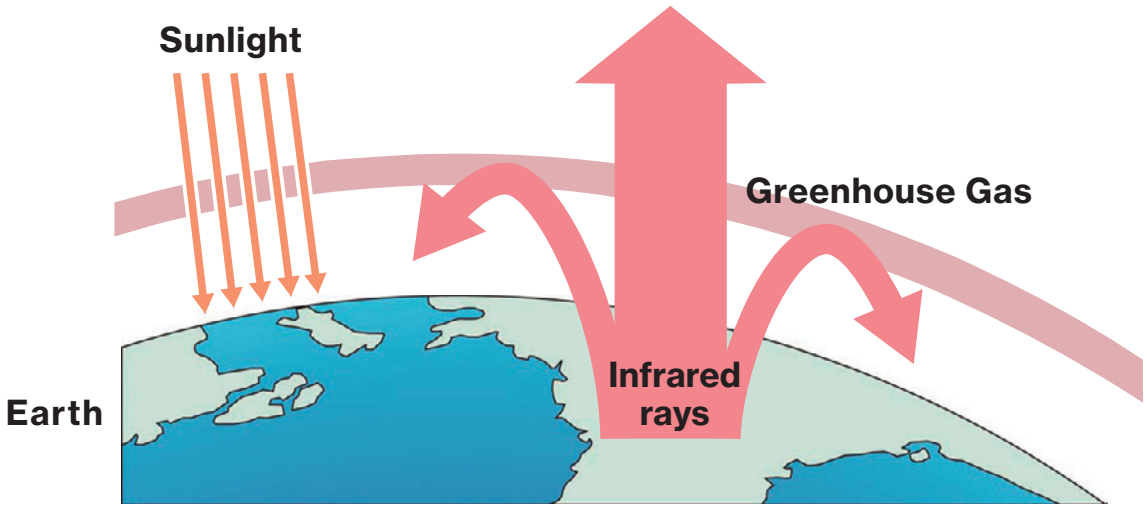
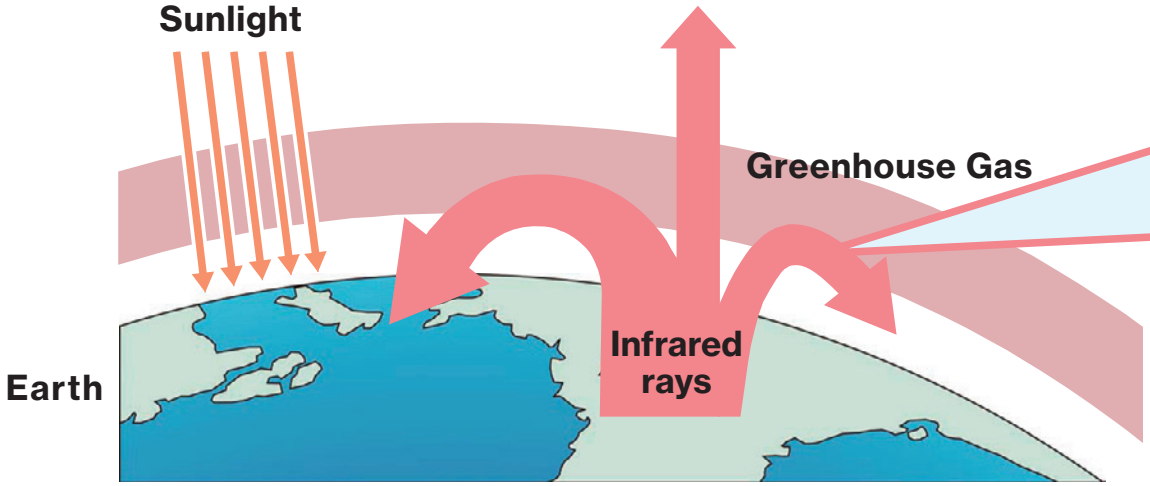
# Mechanism of Greenhouse Effect

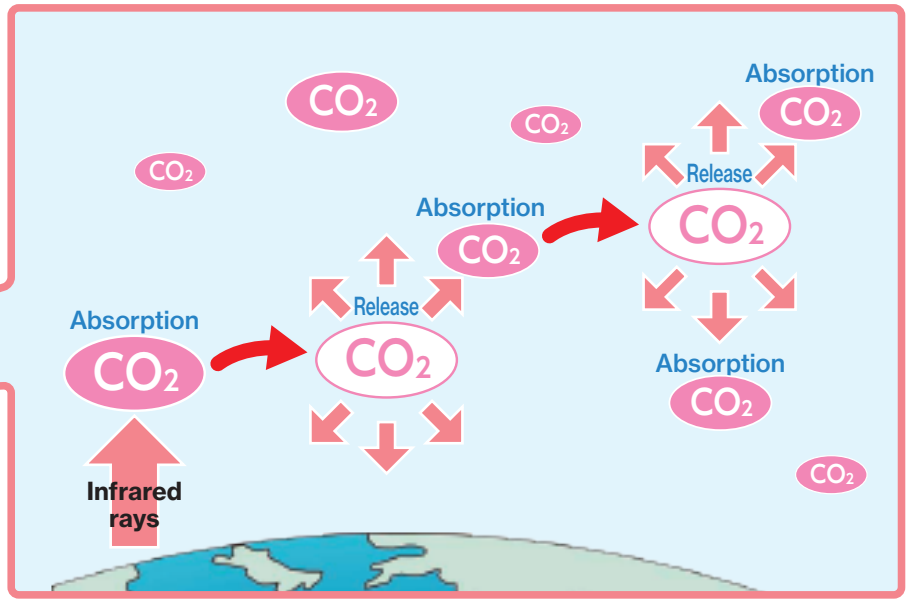



The Earth's atmosphere contains small amounts of "greenhouse gases" such as carbon dioxide, which have a property of absorbing infrared radiation and then releasing it again.
Because of this property, when light from the sun heats up the Earth's surface, infrared radiation travels up and away from the 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:**



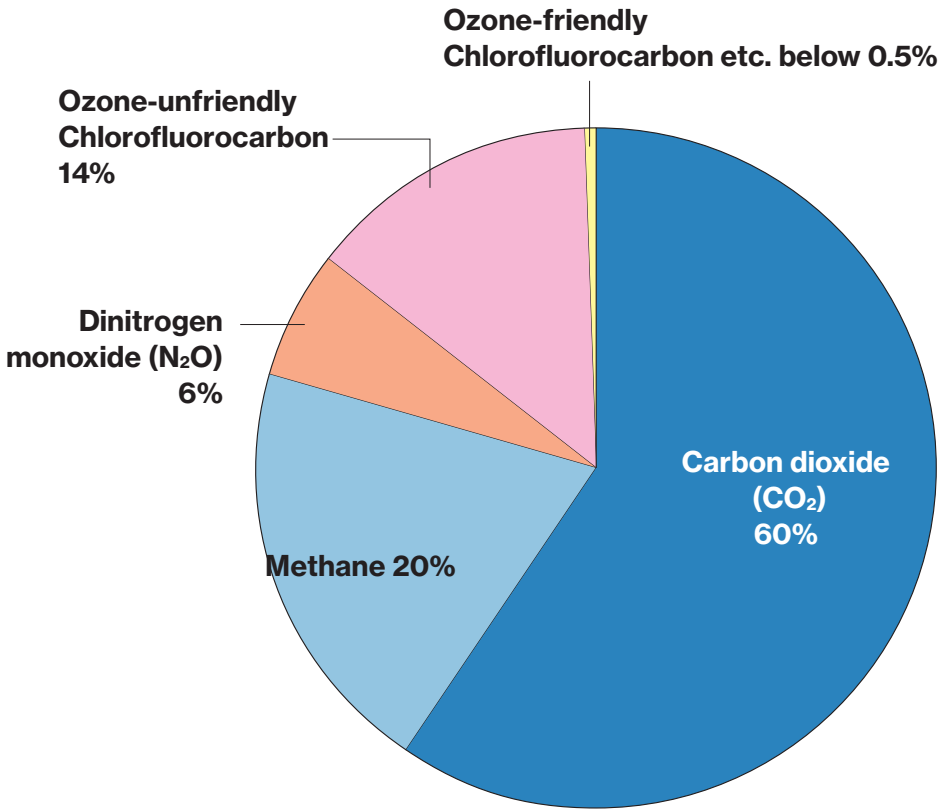

Example: Process of absorption and release of infrared radiation by carbon dioxide ($CO_2$)



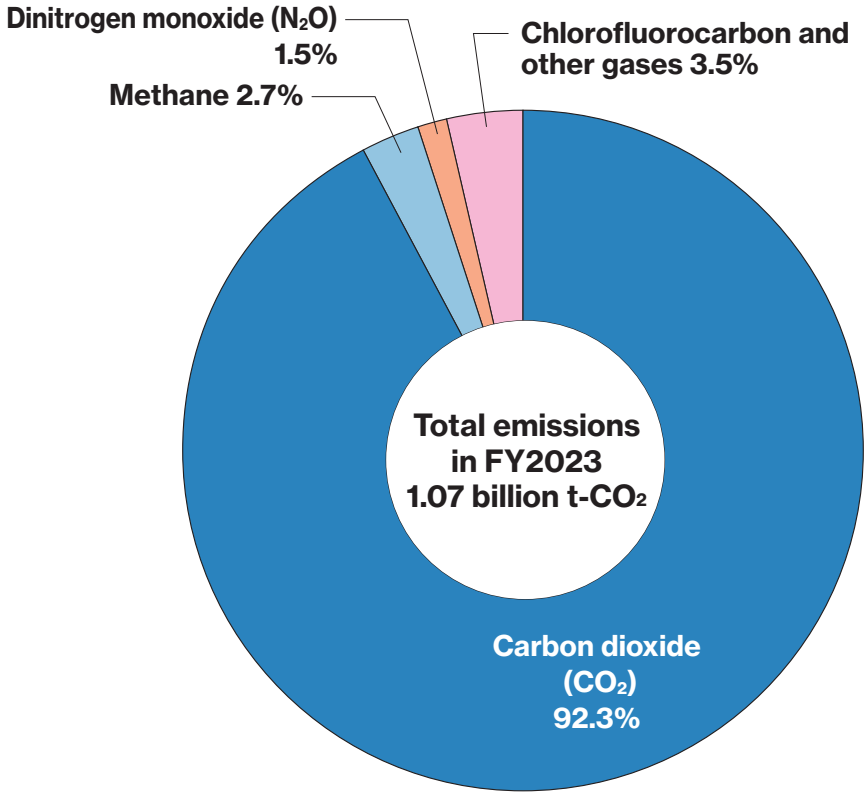

As carbon dioxide ($CO_2$) increases, more infrared rays reach the Earth's surface.

# Contribution of Greenhouse Gases to Global Warming

**Direct contribution to global warming of GHGs emitted by human activities after the Industrial Revolution (FY 2008)**




**Direct contribution to global warming of GHGs emitted by Japan (FY 2023)**

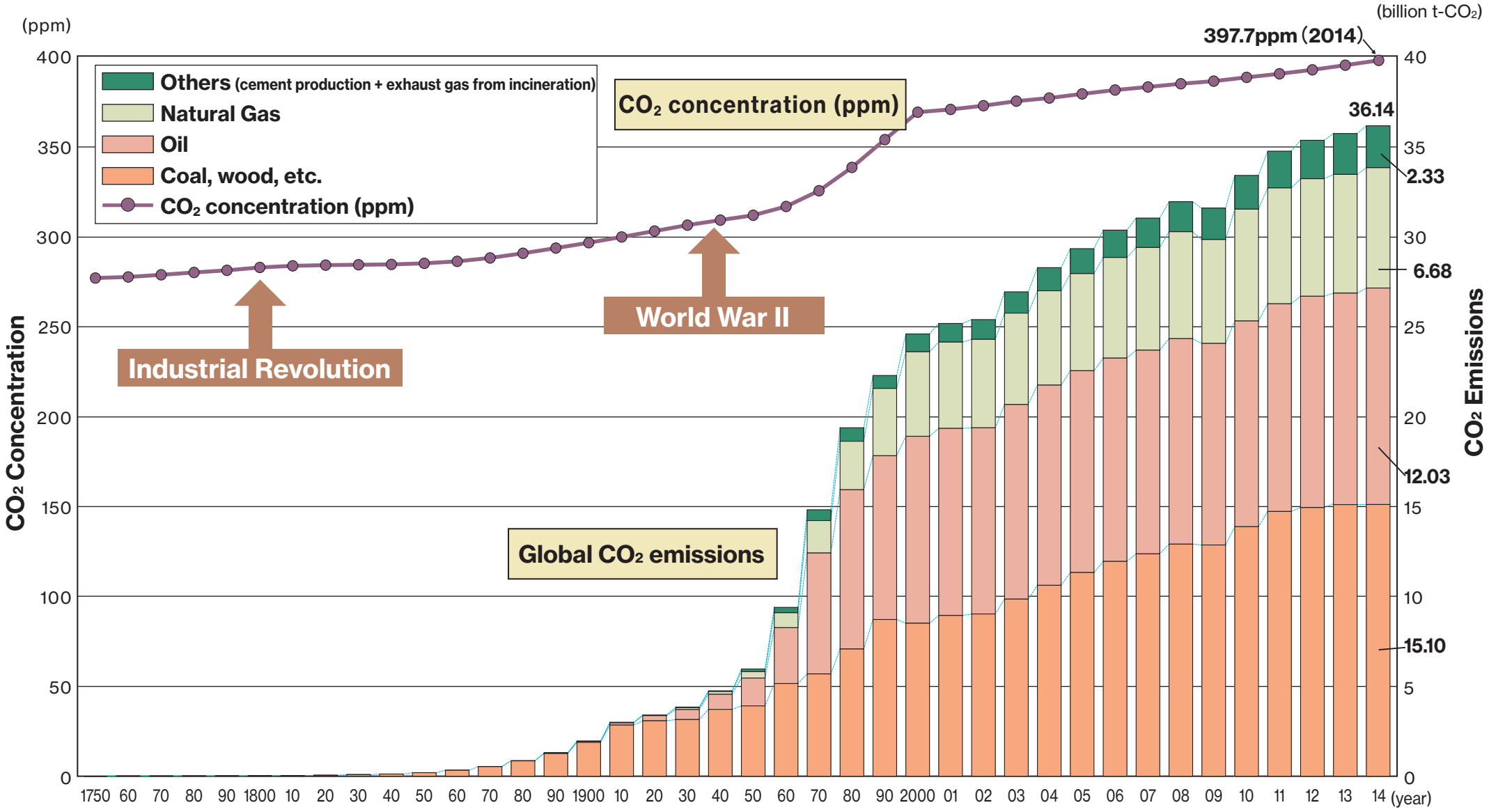



(Note) Figures may not add up to the totals due to rounding.
GHGs: Greenhouse Gases



Source: Ministry of the Environment, Annual Report on the Environment, the Sound Material-Cycle Society and Biodiversity in Japan 2025, with others

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

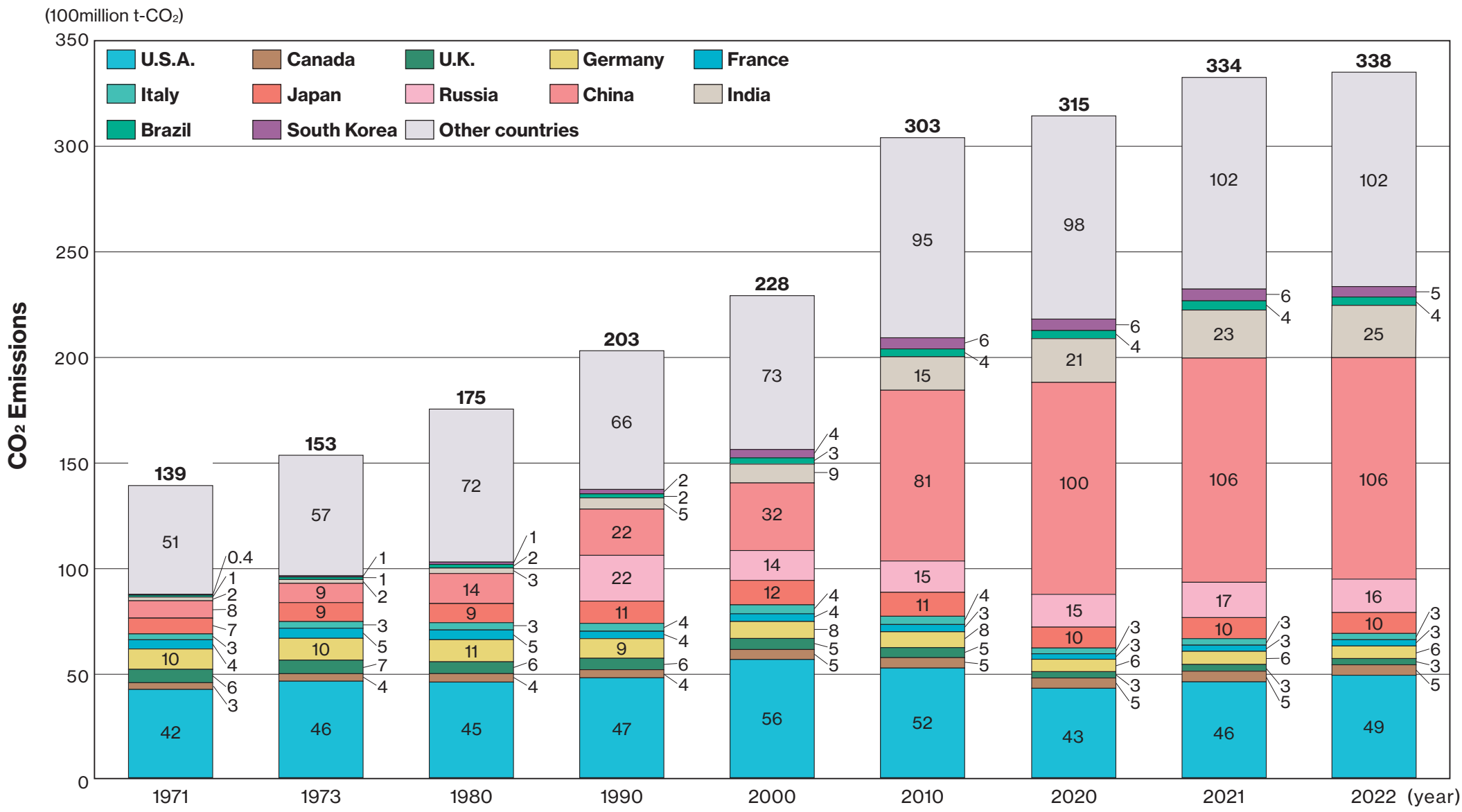



(Note) Figures may not add up to the totals due to rounding.



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

# Historical Trends in the World's $CO_2$ Emissions



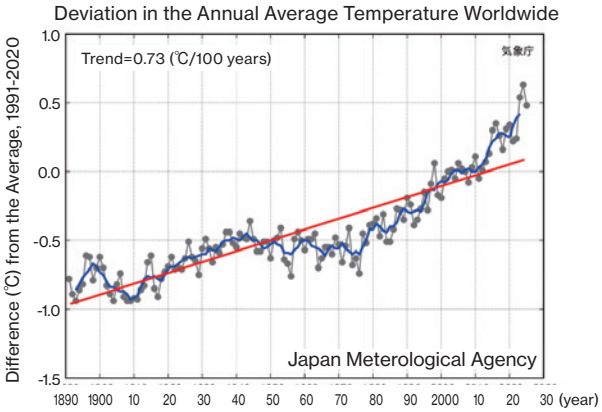

(Note) Figures may not add up to the totals due to rounding.
Until 1990, Russia's $CO_2$ emissions are included in "Other countries".



Source: The Institute of Energy Economics, Japan, FY2025 Handbook of Energy & Economic Statistics in Japan

# Changes in Average Temperatures

## Deviation in the Annual Average Temperature Worldwide (1891 to 2025)

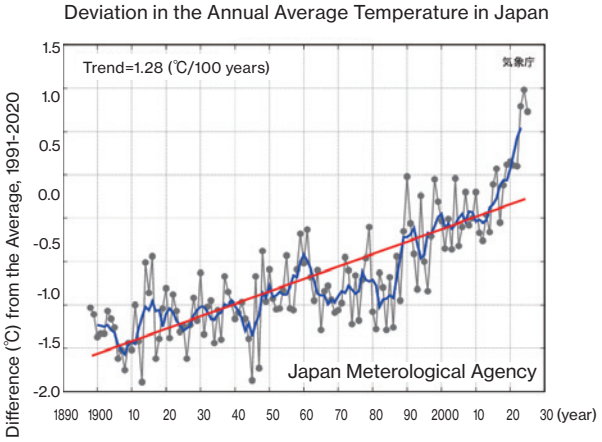



Thin line (black) : Deviation from the reference value each year at approximately 2,300–2,600 locations worldwide (30-year average from 1991 to 2020)
(Deviation in 2025 was +0.48℃)

Thick line (blue) : 5-year moving average of deviations

Solid line (red) : Long-term trends
(Rising at a rate of 0.79℃/100 years)

## Deviation in the Annual Average Temperature in Japan (1898 to 2025)




Thin line (black) : Deviation from the reference value at the 15 observation sites* in Japan (30-year average from 1991 to 2020)
(Average deviation in 2025 was +1.23℃)

Thick line (blue) : 5-year moving average of deviations

Solid line (red) : Long-term trends
(Rising at a rate of 1.44℃/100 years)

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



Source: Japan Meteorological Agency website

# Predictions of Warming due to Increasing $CO_2$ and Historical Temperatures

| | | |
|---|---|---|
| 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**[*1] |
| | Japan | **Rising 0.5 to 5.4℃ by 2100**[*2]<br>◯RCP 2.6 scenario (lower stabilization scenario: assuming that the temperature rise is kept below 2 ℃): 0.5 to 1.7 ℃ rise<br>◯RCP 8.5 scenario (high-level reference scenario: assuming no policy mitigation measures): 3.4 to 5.4 ℃ rise<br>(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) |
| Historical Temperatures | World | **Rising at a rate of about 0.79℃/100 years**[*3] |
| | Japan | **Rising at a rate of about 1.44℃/100 years**[*4] |



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

# Efforts Toward Solving the Problem of Global Warming

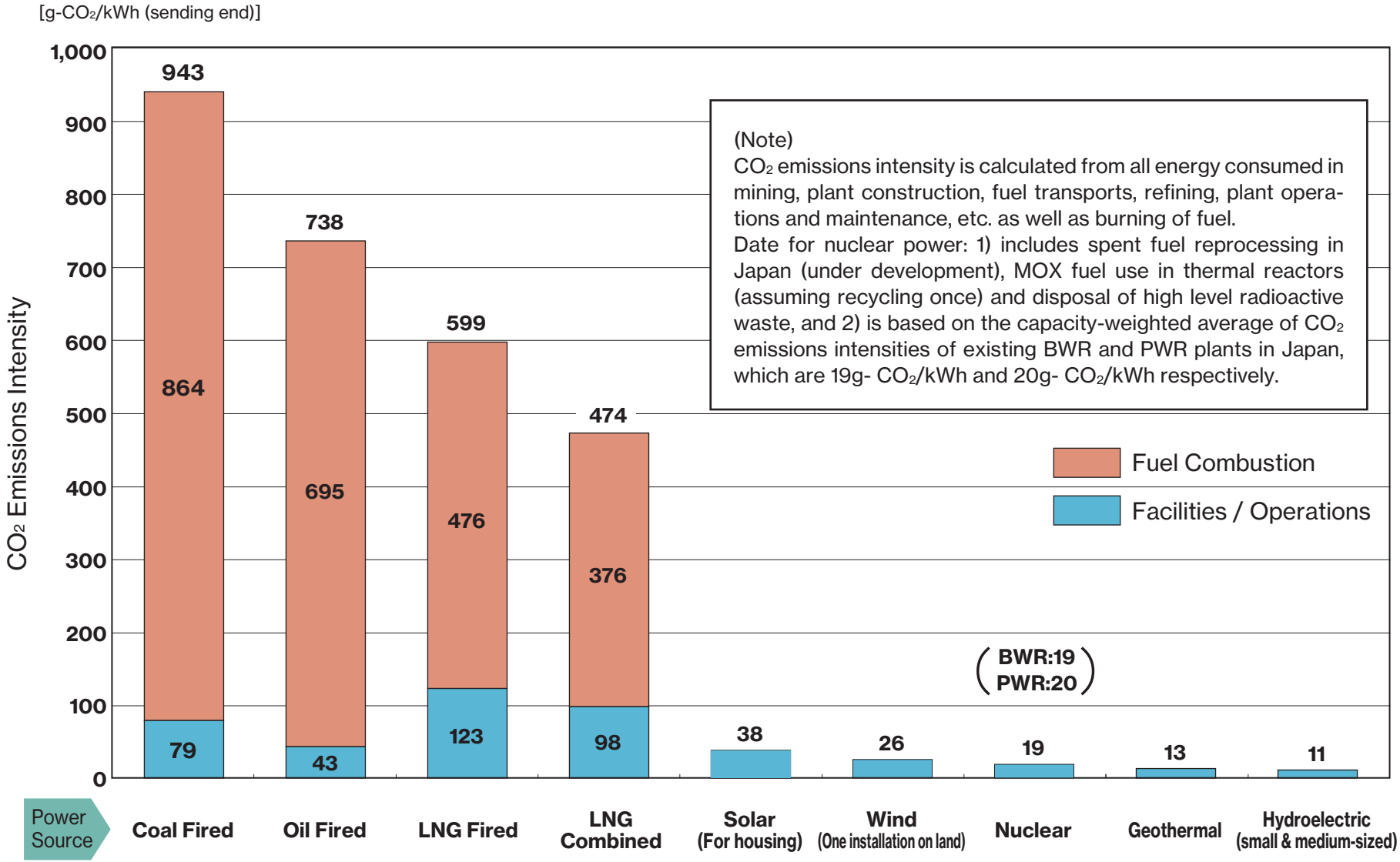
| Month/Year | Location | Organization | Description |
|---|---|---|---|
| Nov. 1988 | Geneva, Switzerland | IPCC established | Established the first venue for discussions between governments on global warming |
| Mar. 1995 | Berlin, Germany | COP1 | Decided to discuss international agreements on numerical 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 |
| 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. The global goal is to keep the temperature rise well below 2 degrees and to make efforts to limit it to 1.5 degrees. |
| 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. |
| Nov. 2022 | Sharm el-Sheikh, Egypt | COP27, CMP17 & CMA4 | Adopted a mitigation work plan up to 2030. Decided on measures and the establishment of a fund for loss and damage assistance associated with 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, achievement Documents that Accelerate the transition away from fossil fuels in this decade. |
| Nov. 2024 | Baku, Azerbaijan | COP29, CMP19 & CMA6 | Regarding new joint numerical targets for climate finance, a target of supporting developing countries of $300 billion per year by 2035 was decided. A decision was made to call on all actors to work together to increase financing for climate action in developing countries to more than $1.3 trillion per year by 2035. |
| Nov. 2025 | Belem, Brazil | COP30, CMP20 & CMA7 | Adopted the Global Mutirão Decision*, which incorporated provisions including efforts to at least triple the adaptation finance by 2035, and a call for countries that have not yet submitted their reduction targets for the Paris Agreement to do so promptly.<br>*Global Mutirão Decision: Based on the spirit of the Portuguese word "mutirão" (meaning collective action, collaboration, or working together), the decision encompassed a wide range of content structured around three pillars: ① the 10th anniversary of the Paris Agreement, ② the transition from negotiations to implementation, and ③ the acceleration of implementation, solidarity, and international cooperation. |

(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



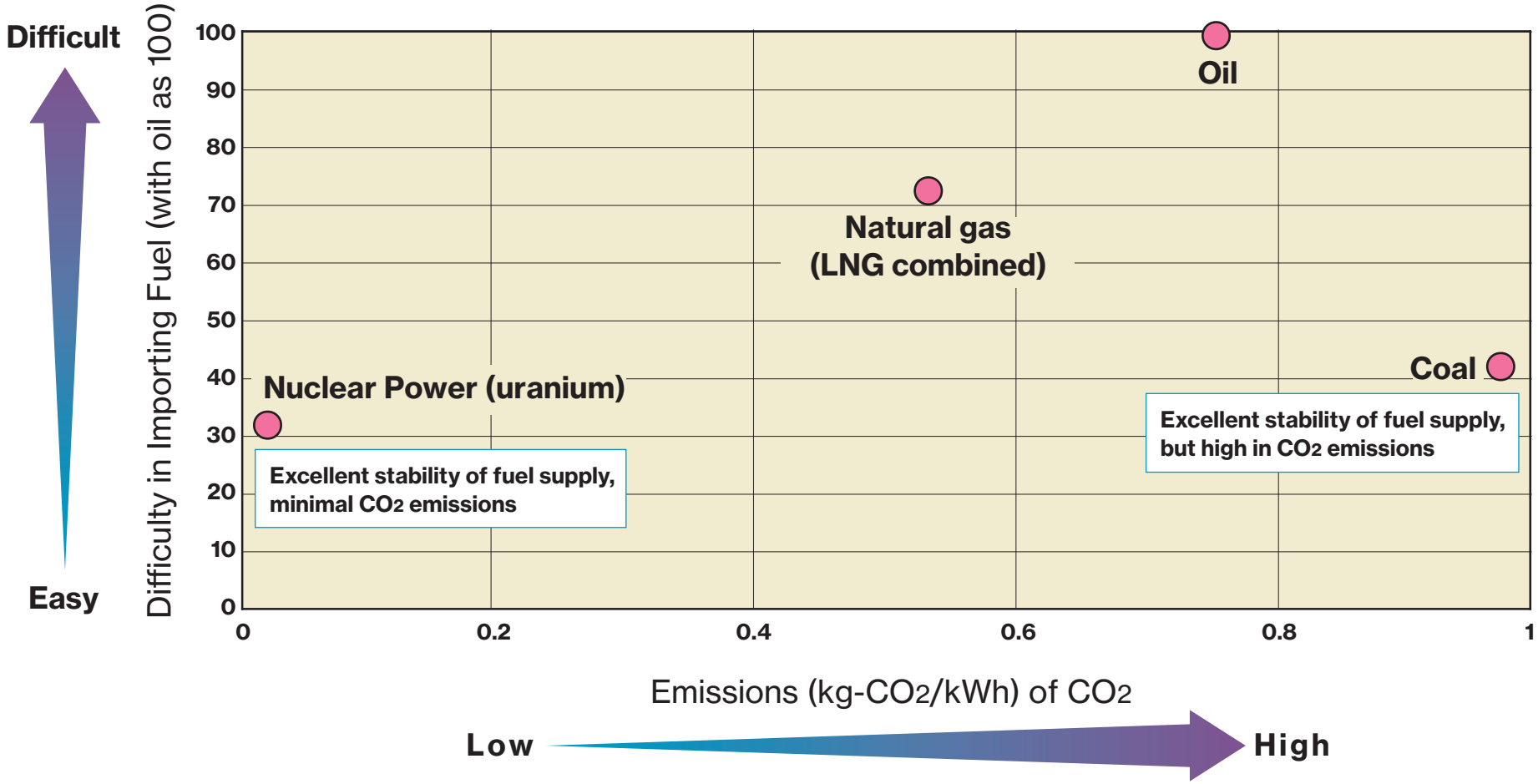
Source: Press Releases Material of the Ministry of the Environment with others

# 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

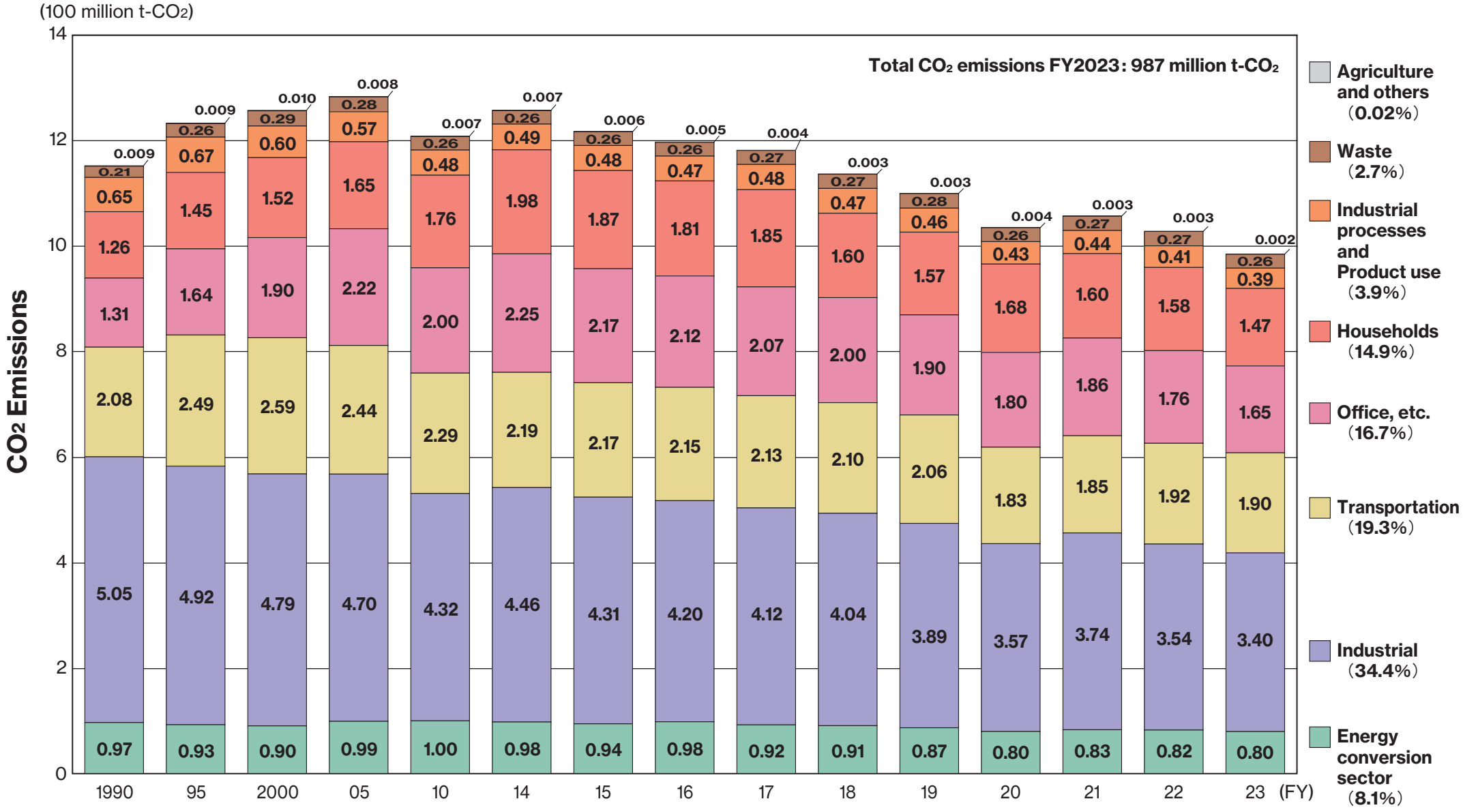



(Note) Degree of difficulty of importing fuel = (difficulty of ensuring world energy resources) + (difficulty of ensuring resources from supplier to Japan)
= (Imbalance in location of resource reserve + imbalance in volume exported) x (political & economic stability of each country)
+ (imbalance in suppliers 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

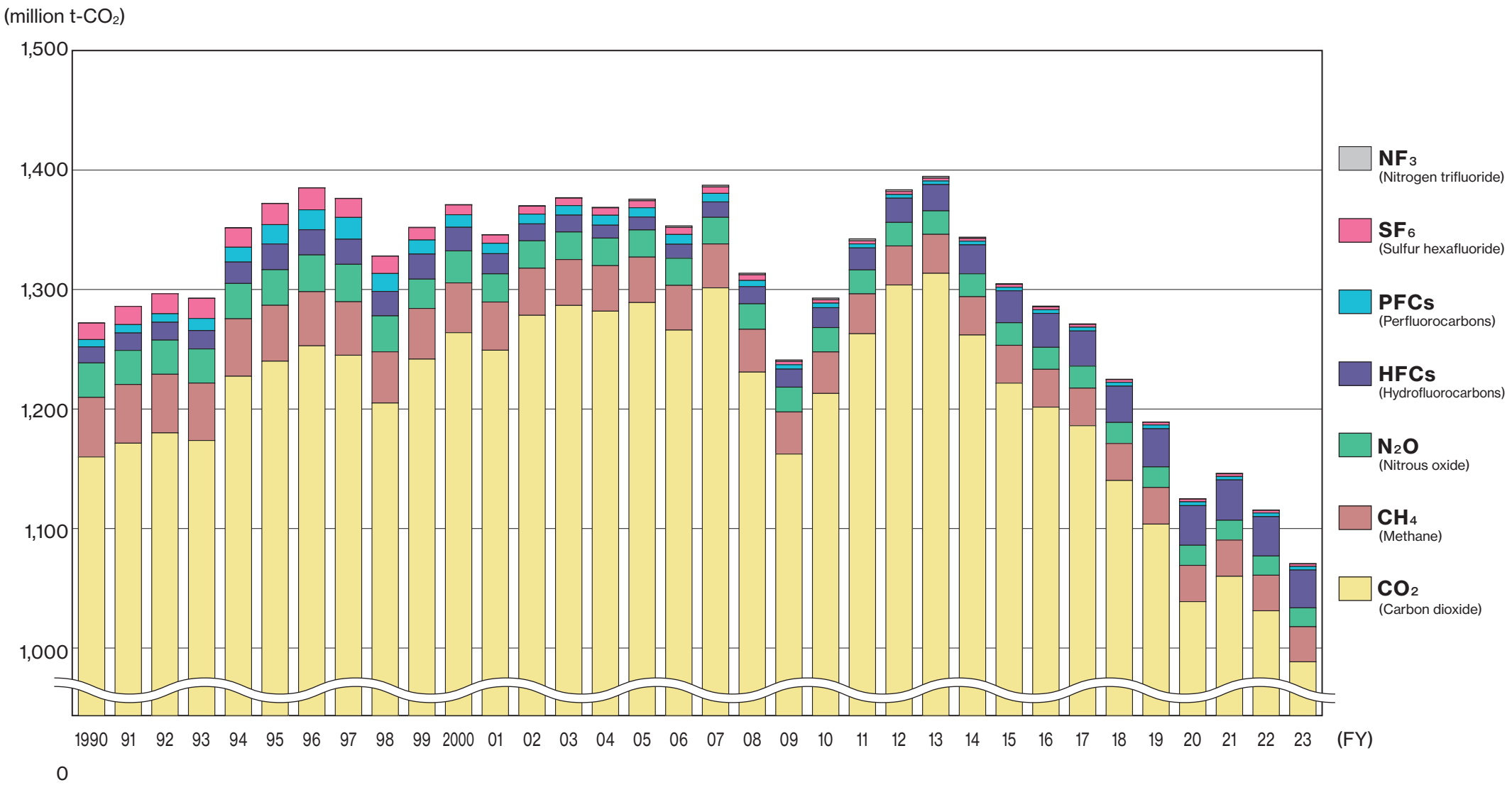
# Japan's Changes in $CO_2$ Emissions by Sectors and Categories (Allocated emissions)






Source: Greenhouse Gas Inventory Office of Japan

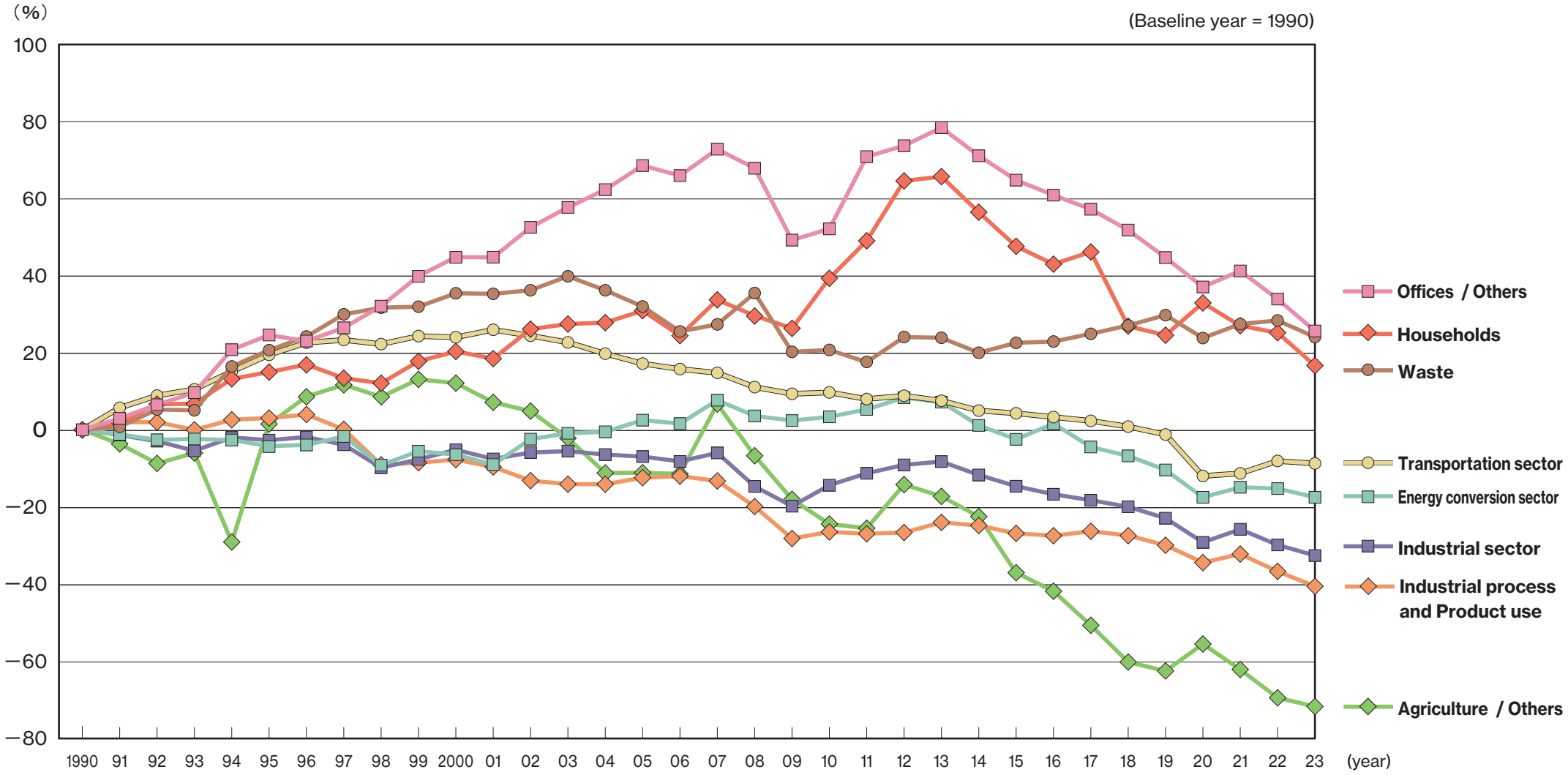
# Changes in GHGs Emissions in Japan






Source: Greenhouse Gas Inventory Office of Japan

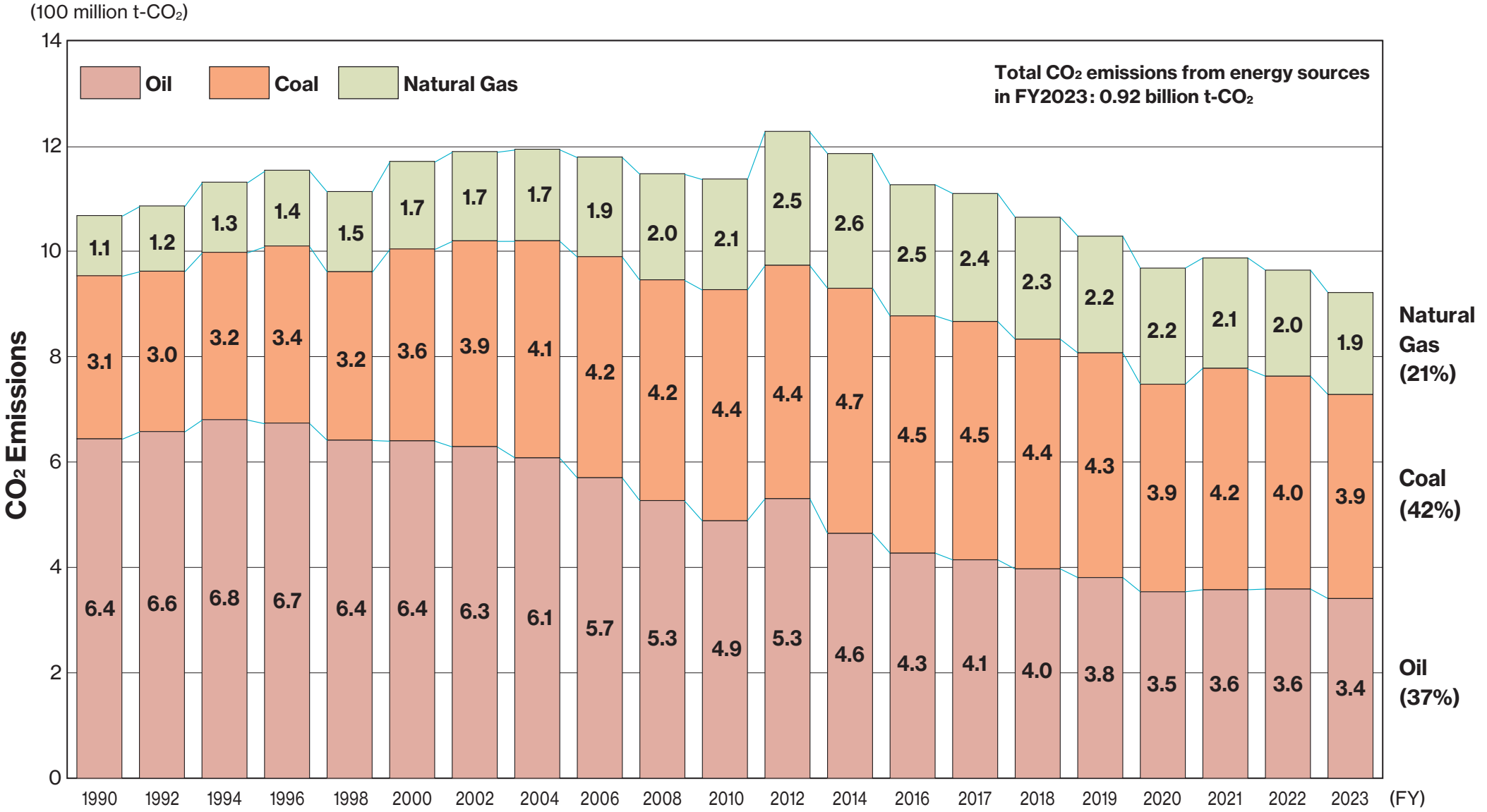
# Changes in Percent Increase/Decrease $CO_2$ Emissions by Sectors and Categories in Japan (Allocated emissions)






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

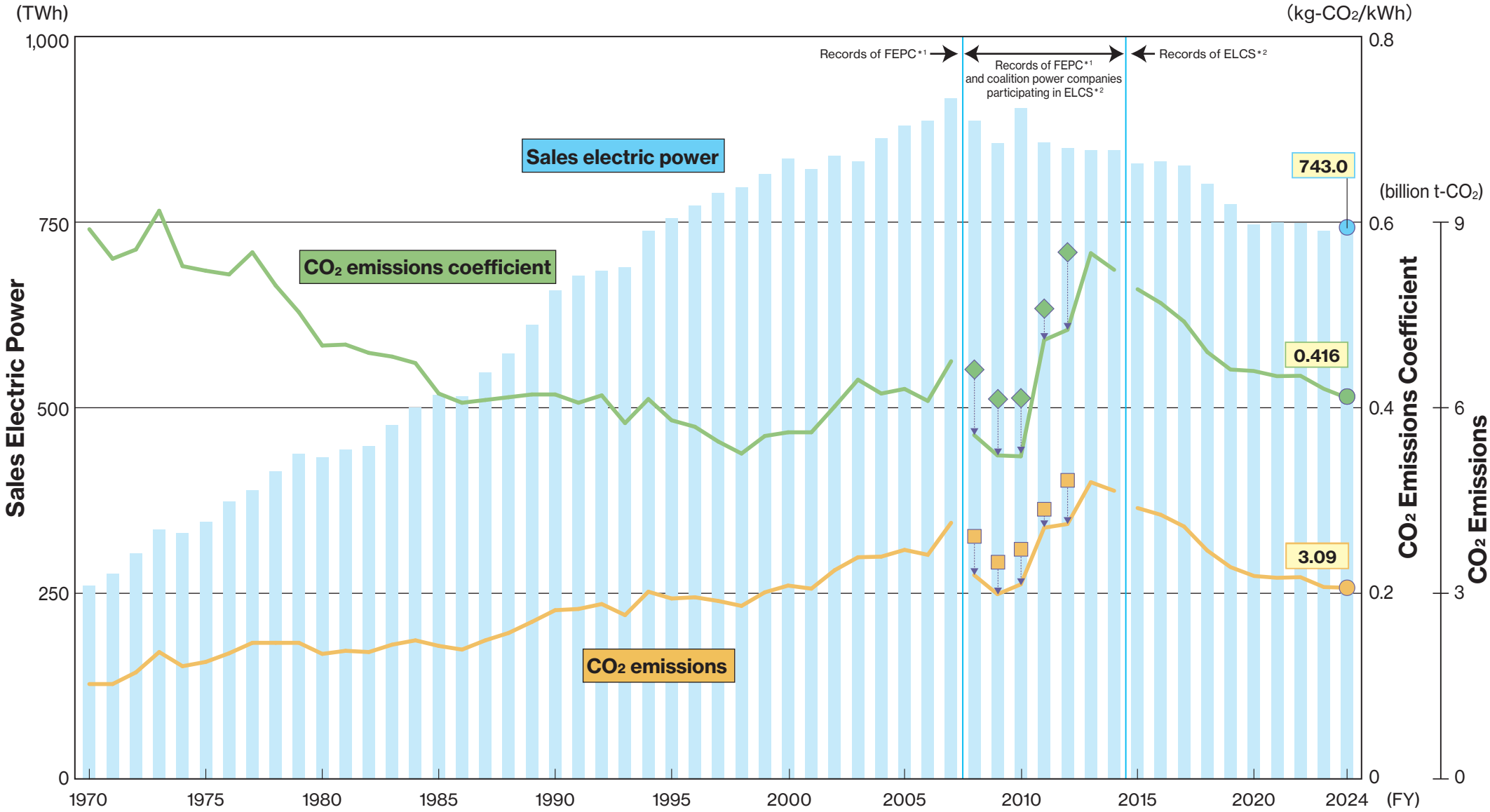
| | | |
|---|---|---|
| **1. 2020 Targets for Reducing Domestic Emissions from Business Activities** | **Target Standards** | ○ From the perspective of simultaneously achieving S+3E--the prerequisite of ensuring Safety (S), along with the (3 Es) of Energy security, Economic viability and Environmental 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.<br>○ 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.<br>○ Promote the use of nuclear energy under the prerequisite of ensuring safety.<br>・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.<br>・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.<br>○ Promote the use of renewable energies<br>・Utilize hydro, geothermal, solar, wind and bio-mass energy sources.<br>・Promote technological R&D etc. for dealing with fluctuations in output of renewable energy sources.<br>Investigate measures for dealing with fluctuations in the output of solar power.<br>Investigate introducing and expanding wind power generation, utilizing tie lines between regions.<br>○ Strive to improve the efficiency of thermal plants, etc.<br>・When developing thermal generation, use the highest standard of technology that can be applied economically (BAT), according to the scale of the plant.<br>・Strive to maintain the appropriate thermal efficiency of existing plants.<br>○ Strive to provide customer energy efficiency and low carbon services that contribute to a low carbon society.<br>・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.<br>○ 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.<br>○ 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.<br>○ 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.<br>○ 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).<br>(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.<br>○ Develop technologies for the use of nuclear power<br>○ Thermal technologies that reduce environmental impact (A-USC, IGCC, CCS etc.)<br>○ 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.)<br>○ 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

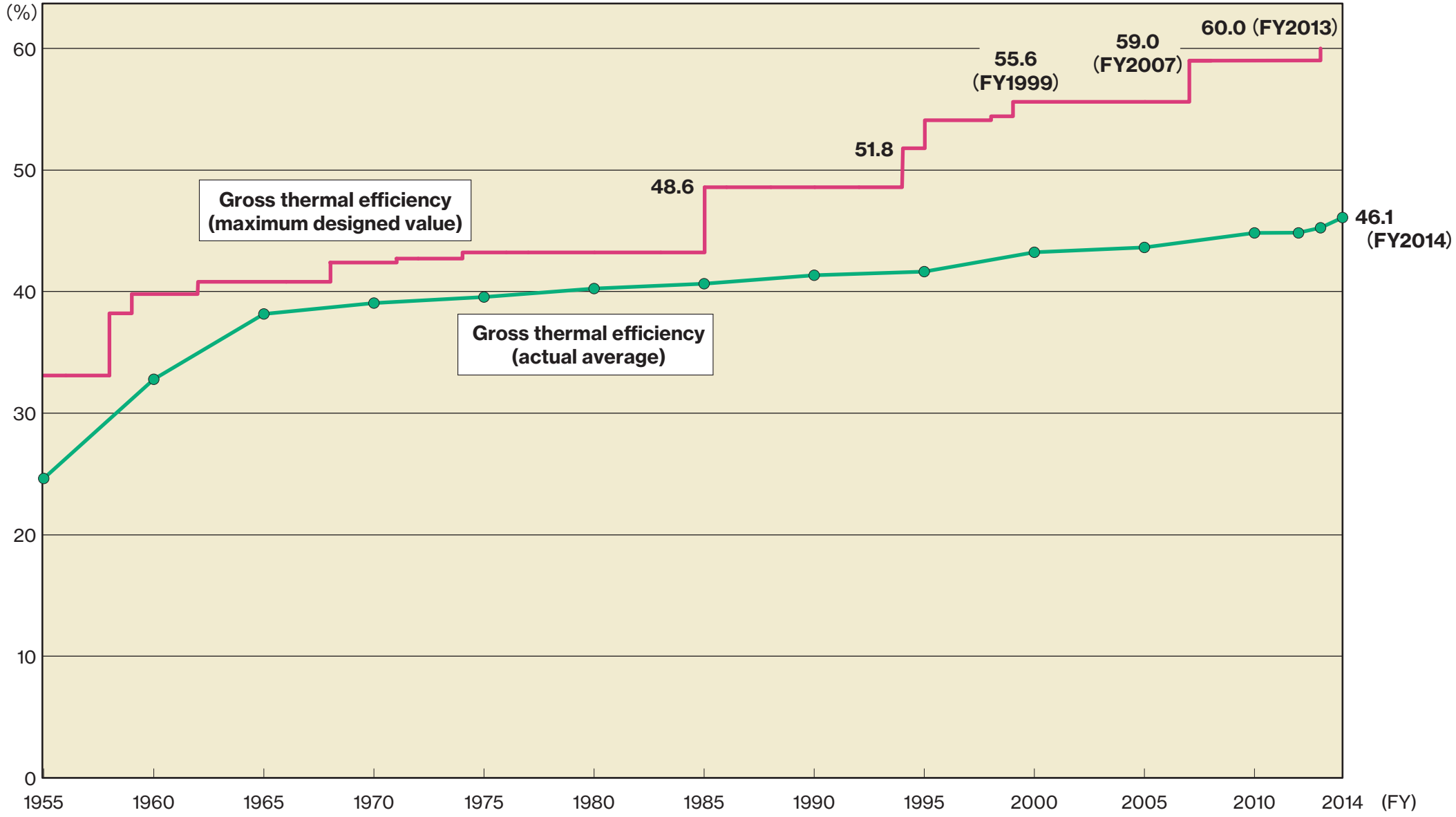



Note: For $CO_2$ emission amounts and emission coefficients, values shown for fiscal 2008–2019 records are after adjustment for FIT credit, etc., and values shown for fiscal 2008–2012 markers (◆ and ■) are base emissions.

＊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

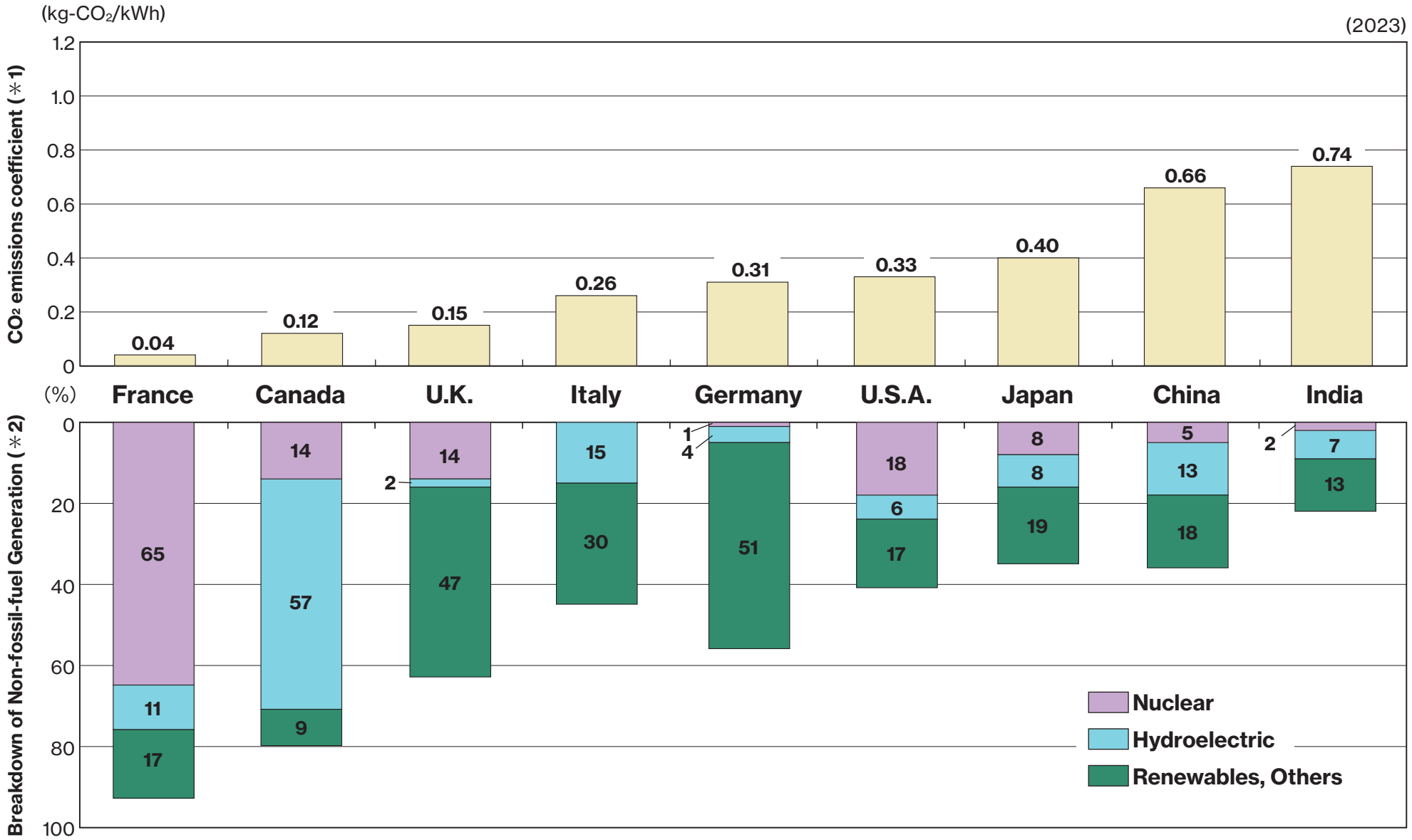
# Thermal Efficiency and T&D Loss Factor in Japan




(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



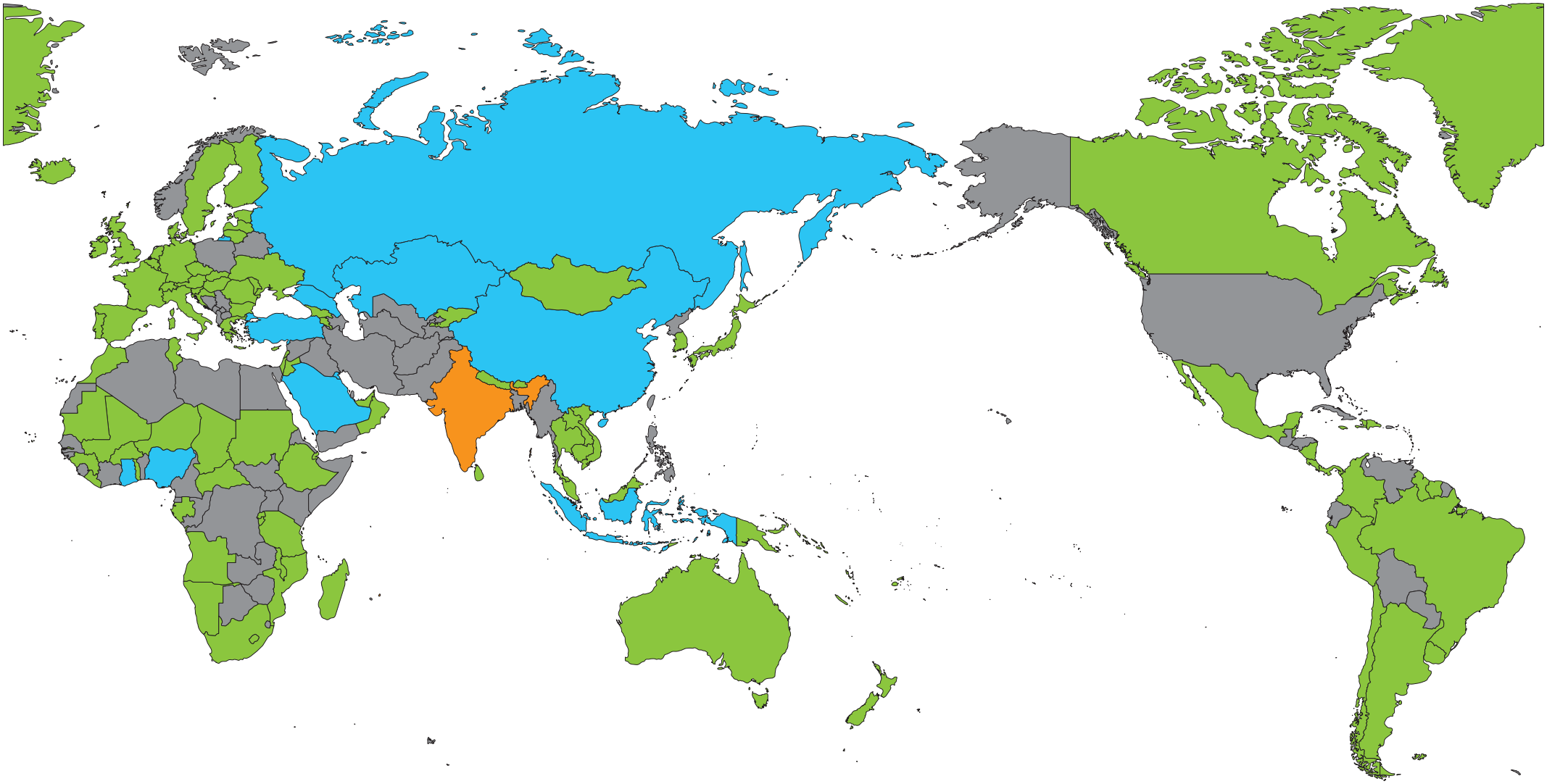

(Note) The figures contain Combined Heat and Power (CHP) plants. The figures of Japan contain non-utility generation facilities.



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 and Regions That Have Pledged Carbon Neutrality (CN) by a Deadline Year / Total 136 Countries

As of January 2026



■ By 2050 : 124 Countries ■ By 2060 : 10 Countries ■ By 2070 : 2 Countries

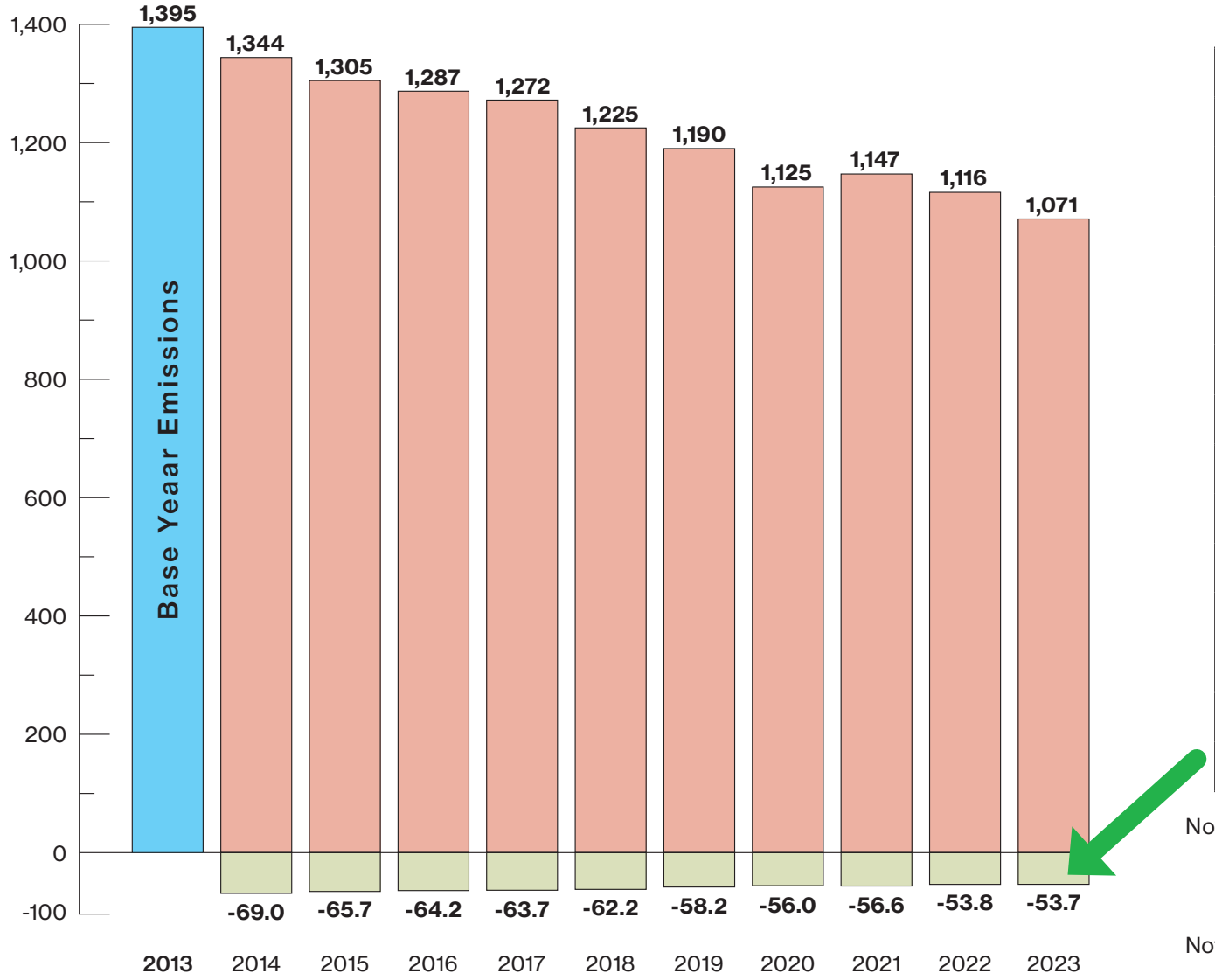
2-1-19

Source: Press Releases Ministry of Economy, Trade and Industry

# Japan's Greenhouse Gas Emissions and Removals Itemized

## Emissions [Removals are represented as minus (-) values]

(Mt $CO_2$ eq.)




## Emissions and removals by measures for forest and other carbon sinks

(Mt $CO_2$ eq.)

| | 2023 |
|---|---|
| **Total** | **−53.7** |
| **Measures for forest carbon sinks** | **−45.2** |
| Afforestation, reforestation | −1.4 |
| Deforestation | +2.8 |
| Forest management | −46.6 |
| Forest | −43.3 |
| Harvested wood products | −3.3 |
| **Measures to increase removals in agricultural soils** | **−6.9** |
| Cropland management | −5.7 |
| Grazing Land management | −1.2 |
| **Promotion of urban greening** | **−1.3** |
| Urban greening | −1.3 |
| **Blue carbon and other removals** | **−0.3** |
| Coastal wetlands, Other | −0.3 |

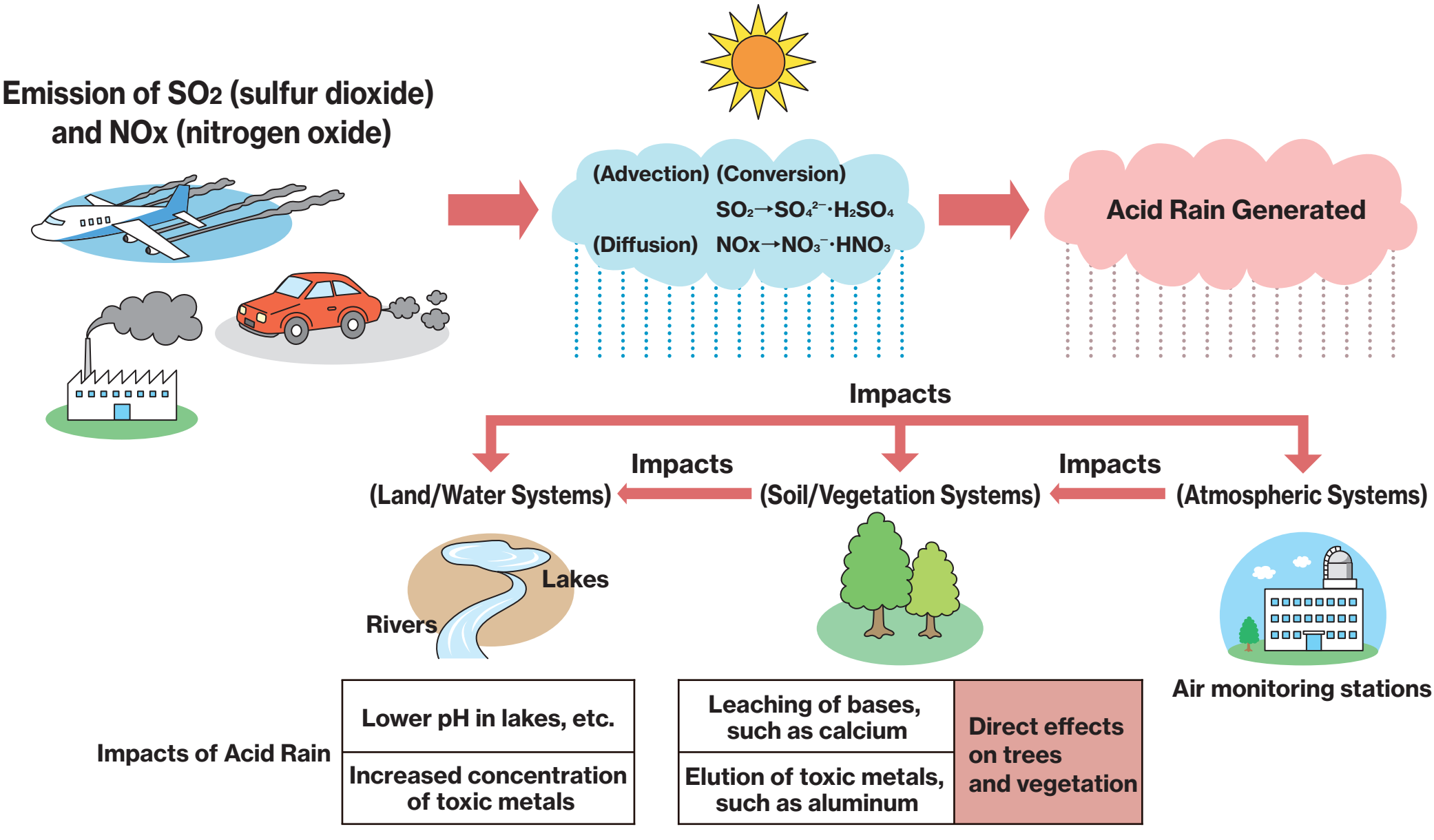
Note:The emissions/removals values are not for each fiscal year but values after applying the reference level method, etc. except for Other.See Annex 9 of the NID for the accounting method for sink activities.

Note:Emissions are represented as plus (+) values, and removals are represented as minus (-) values.



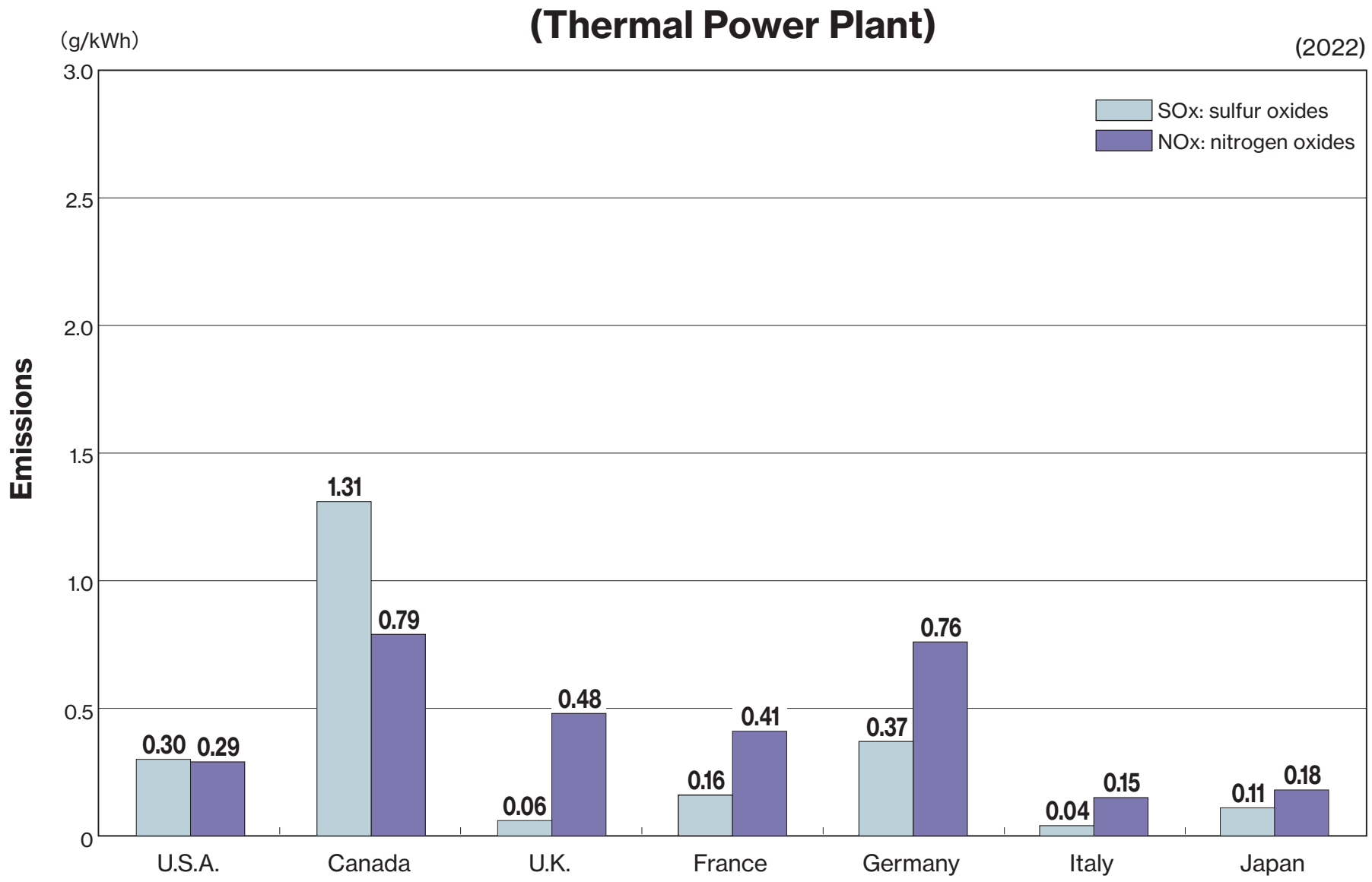
Source: Created from materials by the Greenhouse Gas Inventory Office of the National Institute for Environmental Studies, Japan

# 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