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.

Example: Process of absorption and release of infrared radiation by carbon dioxide (CO₂)



As carbon dioxide (CO₂) increases, more infrared rays reach the Earth's surface.

Contribution of Greenhouse Gases to Global Warming



(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 2024, with others

Changes in CO₂ Emissions from Fossil Fuels and Atmospheric CO₂ Concentration in Japan



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

Historical Trends in the World's CO₂ Emissions

(100million t-CO₂)



Until 1990, Russia's CO₂ emissions are included in "Other countries".

Changes in Average Temperatures

Deviation in the Annual Average Temperature Worldwide (1891 to 2024)



Thin line (black): Deviation from the reference value each year (difference from the 1991 to 2020 average)
(Deviation in 2024 was +0.62°C)Thick line (blue): Deviation in the 5-year moving averageSolid line (red): Long-term trends
(Rising at a rate of 0.77°C/100 years)

Deviation in the Annual Average Temperature in Japan (1898 to 2024)



- Thin line (black)
 Deviation from the reference value at the 15 observation sites* in Japan (Average deviation in 2024 was +1.48°C)
 Thick line (blue)
 Deviation in the 5-year moving average
 Solid line (red)
 Long-term trends (Rising at a rate of 1.40°C/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 CO2 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°C by 2100*2 ORCP 2.6 scenario (lower stabilization scenario: assuming that the temperature rise is kept below 2 °C): 0.5 to 1.7 °C rise ORCP 8.5 scenario (high-level reference scenario: assuming no policy mitigation measures): 3.4 to 5.4 °C 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)		
Historical Temperatures	World	Rising at a rate of about 0.77°C/100 years* ³		
	Japan	Rising at a rate of about 1.40°C/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. 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
NovDec. 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)
OctNov. 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.
NovDec. 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.

(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 Parities CMP: Meeting of the Parities (to the Kyoto Protocol) CDM: Clean Development Mechanism CMA: Meeting of the Parities to the Parities Agreement

Japan's Greenhouse Gas Emissions and Removals Itemized

Emissions and Removals



Emissions and removals by measures for forest and other carbon sinks

(Mt CO₂ eq.)

	2023			
Total				
Measures for forest carbon sinks				
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				
Cropland management				
Grazing Land management	-1.2			
Promotion of urban greening				
Urban greening				
Blue carbon and other removals				
Coastal wetlands Other	-03			
	Total asures for forest carbon sinks Afforestation, reforestation Deforestation Deforestation Forest management Forest Harvested wood products res to increase removals in agricultural soils Cropland management Grazing Land management Promotion of urban greening Urban greening urban greening			

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.

Lifecycle-Assessed CO₂ Emissions Intensity of Japan's Energy Sources

[g-CO2/kWh (sending end)]



Various Power Sources in Terms of CO₂ 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 CO₂ Emissions by Sectors and Categories (Allocated emissions)

(100 million t-CO₂)



Changes in GHGs Emissions in Japan



Changes in Percent Increase/Decrease CO₂ Emissions by Sectors and Categories in Japan (Allocated emissions)



Changes in CO2 Emissions by Energy Source

(100 million t-CO₂)



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

Measures by Japan's Electric Power Industry to Reduce CO₂ Emissions

	Target Standards	 From the perspective of simultaneously achieving S+3Ethe prerequisite of ensuring Safety (S), along with the (3 Es) of Energy security, Economic via 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 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 plan to achieve a potential reduction that is forecast to be up to 7 million tons of CO₂. *1, *2 	
1. 2020 Targets for Reducing Domestic Emissions from Business Activities	Foundations for Establishing Targets	 Each participating company shall put together initiatives according to their business structure and strive to realize a low-carbon society. O 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. O 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. O 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 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. 	
2.Strengthen C between Enti	cooperation ties	 Recognize that in order to reduce electricity-related CO₂ 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 CO₂ reductions by spreading the use of highly efficient electrical devices and through energy and CO₂ 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 CO₂ 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 CO₂ 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 CO₂ 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. O Develop technologies for the use of nuclear power O Thermal technologies that reduce environmental impact (A-USC, IGCC, CCS etc.) O 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.) O 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.

Historical Trends in CO₂ Emissions from Electricity Generation in Japan



Thermal Efficiency and T&D Loss Factor in Japan



Comparison of CO2 Emissions Coefficient by Country

(kg-CO₂/kWh) (2022)1.2 CO² emissions coefficient (+ 1) 1.0 0.8 0.73 0.65 0.6 0.42 0.35 0.4 0.35 0.31 0.17 0.2 0.11 0.06 0 U.K. U.S.A. India (%) Canada Italy China France Germany Japan Breakdown of Non-fossil-fuel Generation (st 2) 0 5 6 6 10 3~ 3 13 15 10 18 8 15 2 13 20 6 27 18 15 42 16 63 42 40 61 60 10 **Nuclear** 8 **Hydroelectric** 80 15 **Renewables, Others** 100

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

Countries and Regions That Have Pledged Carbon Neutrality (CN) by a Deadline Year / Total 145 Countries

As of February 2025



Mechanisms in the Development of Acid Rain



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



^{%10} electric power companies and Electric Power Development Co. Ltd.