CHALLENGE 25

Chapter 2 Responsibility of the Present Generation to Quickly Deal with Global Warming —Challenge 25—

Section 1 Increasing Damage from Global Warming

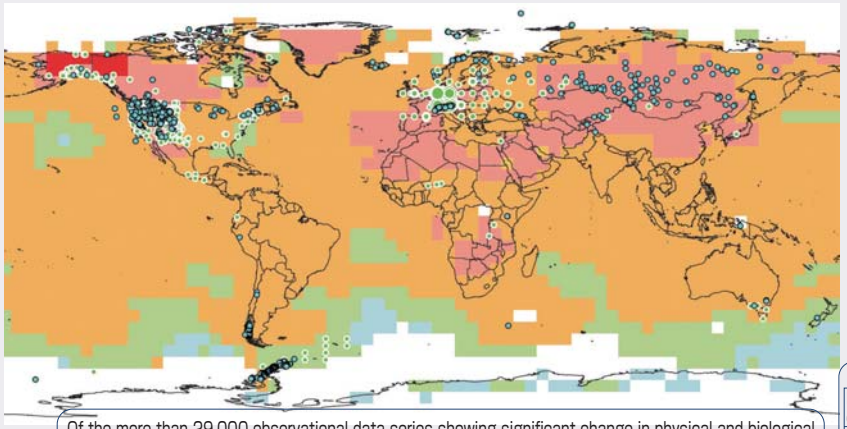
1 The Damage Currently Occurring

Efforts to accumulate scientific knowledge about global warming have been led by the Intergovernmental Panel on Climate Change (IPCC), established in 1988 by the World Meteorological Organization (WMO) and the United Nations Environment Program (UNEP) to make a comprehensive assessment of anthropogenic climate change, its impacts, and adaptation to and mitigation of it from scientific, technical and socio-economic perspective. The Synthesis Report of the IPCC's Fourth Assessment Report: Climate Change 2007, its latest report, states in the Summary for Policymakers: "Warming of the climate system is unequivocal, as is now evident from observations of increases in global average air and ocean temperatures, widespread melting of snow and ice and rising global average sea level" (Figure 2-1-1).

Among events likely to be due to the effects of global warming are reduced snow and ice in polar regions and highlands, increases in wildfires and droughts, and an increase in intense tropical cyclone activity, etc. For example, annual average article sea ice extent has shrunk by 2.7 [2.1-3.3] % per decade, with larger decreases in summer of 7.4 [5.0-9.8] % (Numbers in square brackets indicate a 90% uncertainly interval around a best estimate).

We can observe the diminishing trend of sea ice in Figure 2-1-2. Figure 2-1-4 shows the satellite observation results of sea ice in the Arctic region in September 1979 and September 2007, indicating that the sea ice area dwindled to its smallest size on record in 2007. The IPCC Fourth Assessment Report noted that in some projections, "Arctic late-summer sea ice disappears almost entirely by the latter part of the 21st century."

Figure2-1-1 Correlation between Changes in Physical and Biological Systems*2 Observed Globally*1 and Warming



North America		Latin America		28,115 Europe		Africa		Asia		Australia/ New Zealand		Polar regions		28,586 Terrestrial		Marine and freshwater		28,671 Global	
355	455	53	5	119		5	2	106	8	6	0	120	24	764		1	85	765	
94%	92%	98%	100%	94%	89%	100%	100%	96%	100%	100%	–	91%	100%	94%	90%	100%	99%	94%	90%

"Polar regions" include also observed changes in marine and freshwater biological systems. "Marine and freshwater" includes observed changes at sites and large areas in oceans, small islands and continents. Locations of large-area marine changes are not shown on the map.

*1: Observation results were obtained from a subset of about 29,000 data series (from about 75 studies), selected from about 80,000 data series from 577 studies. These data series were selected by the following criteria: (1) ending in 1990 or later; (2) spanning a period of at least 20 years; and (3) showing a significant change in either direction.

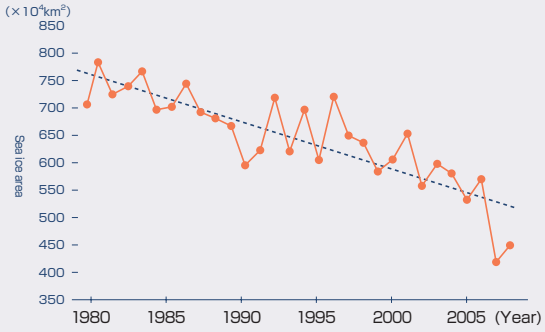
*2: Physical systems mean physical events related to ice, snow, frozen ground, hydrology and coastal areas, while biological systems mean events related to terrestrial, marine and freshwater living matter.

Source: IPCC, Summary for Policymakers, Synthesis Report, Fourth Assessment Report: Climate Change 2007

A study on wildfires by the University of California, et al, and referenced by the IPCC Fourth Assesment Report found that since the 1970s, wildfires in the western United States increased in years when temperatures from spring to summer increased by about 2 degrees Celsius. Thus, large wildfires increased suddenly since the mid-1980s, and it has been reported that the frequency of wildfires is about four times and the forested area burned from 1987 to 2003 is 6.7 times the area from 1970 to 1986.

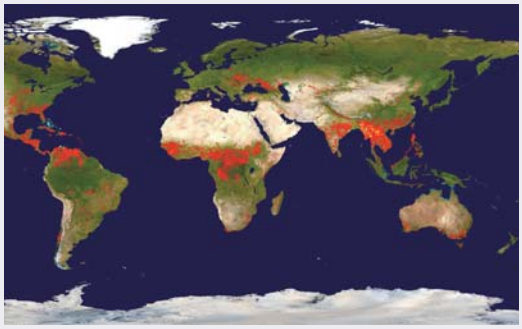
There are various causes of wildfires including temperature rises, which are due in part to global warming, droughts and precipitation patterns. Statistics of the U.S. National Aeronautics and Space Administration (NASA) show that up to about 500,000 square kilometers (=50 million hectares) of forests have been burned a year (Figure 2-1-5). It amounts to seven times the annual net reduction of the forest area of about 7.30 million hectares including increase of area by

Figure2-1-2 Change in Annual Minimum Extent of Arctic Sea Ice Over Time (1979-2008)



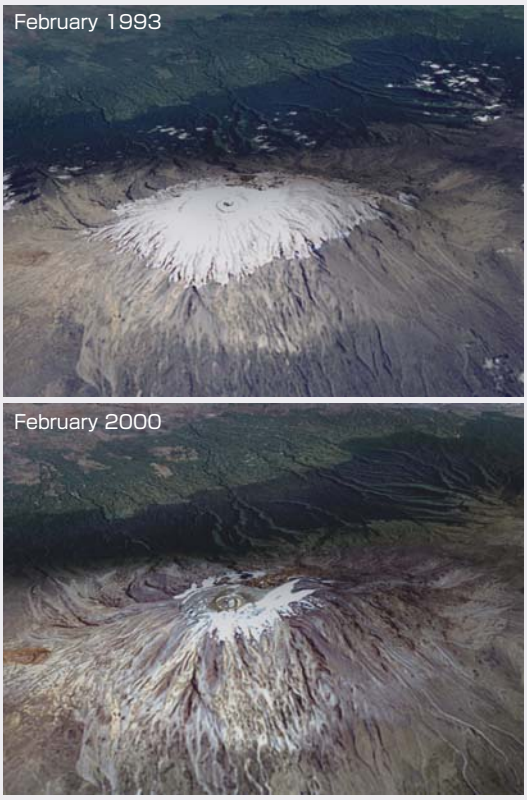
Note: The dotted line indicates the linear trend.
Source: The Japan Meteorological Agency website

Figure2-1-5 Fires in the World Detected by Satellite (MODIS) (March 22-31, 2010)



Source: Moderate Resolution Imaging Spectroradiometer (MODIS) Rapid Response System Global Fire Map (http://rapidfire.sci.gsfc.nasa.gov/firemaps/)

Figure2-1-3 Changes in Glaciers and Snow Cover on Kilimanjaro

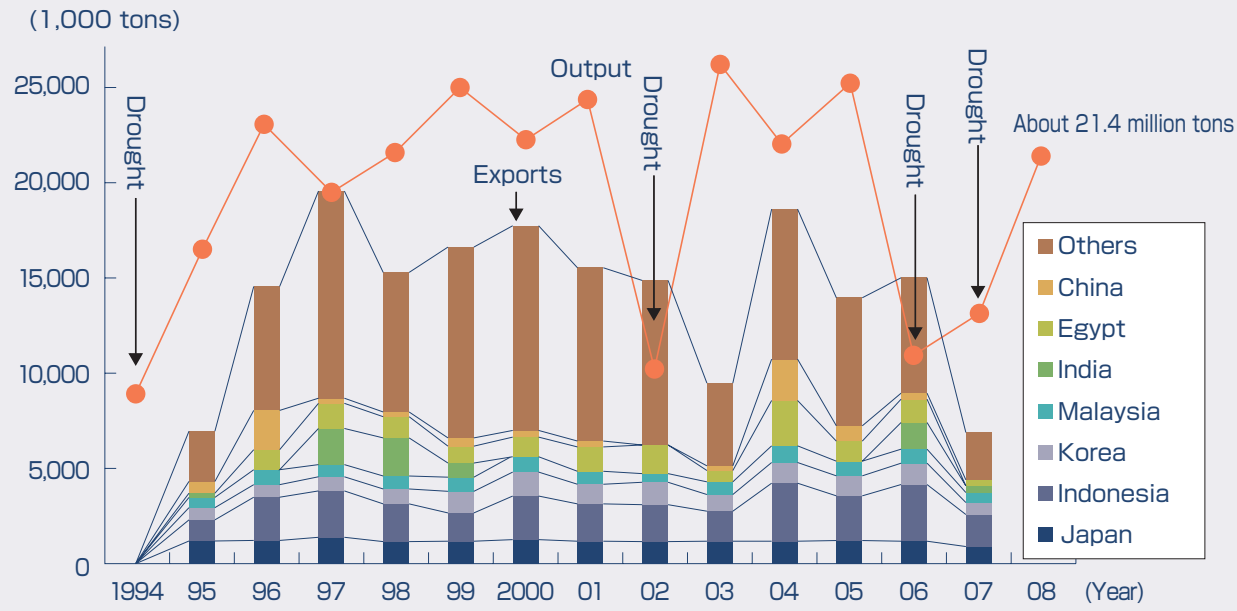


Source: NASA
(http://earthobservatory.nasa.gov/IOTD/view.php?id=3054)

Figure2-1-4 Comparison of Satellite-Observed Arctic Sea Ice between September 1979 and September 2007 Lowest Levels in Satellite Observation Records

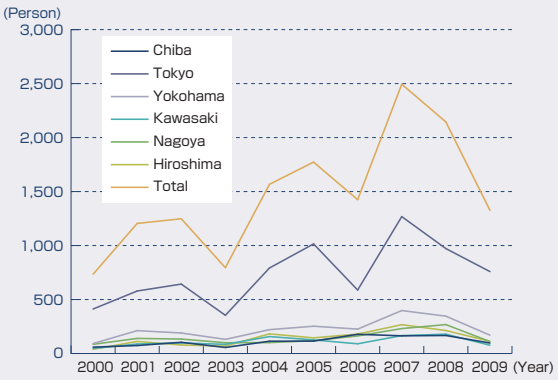
Note: The sea ice distribution was observed in 1979 by NASA's Scanning Multichannel Microwave Radiometer (SMMR) and in 2007 by JAXA's Advanced Microwave Scanning Radiometer for EOS (AMSR-E).
Source: Japan Aerospace Exploration Agency

Figure2-1-6 Wheat Output and Exports of Australia



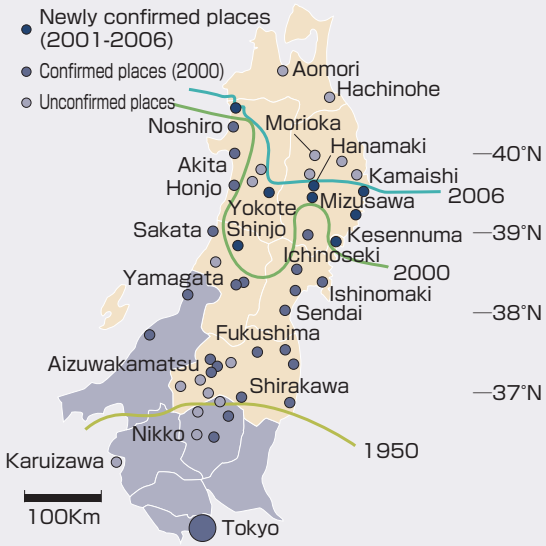
Source: Trade statistics of respective countries, U.S. Department of Agriculture, "Production, Supply and Distribution (PS&D) (2009.08)"

Figure2-1-7 Annual Trends of Heat Stroke Patients by Region



Source: National Institute for Environmental Studies (NIES)

Figure2-1-8 Shift in the Northern Limit of the Distribution of Tiger Mosquitoes



Source: Kobayashi, M., Komagata O., Nihei N., 2008: Global warming and vector-borne infectious diseases, J. Disast. Res, 3(2), 105-112. Fig.2

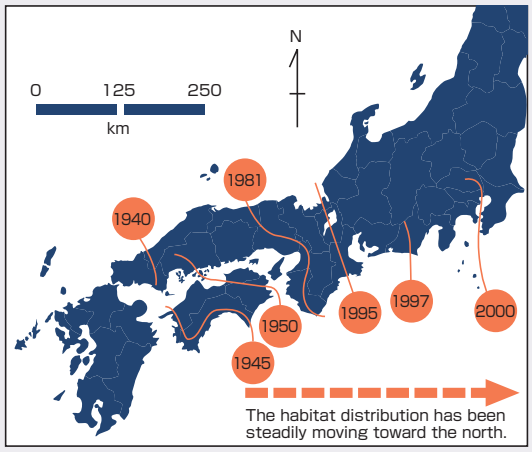
afforestation, restoration of vegitations and natural recovery of forests. Furthermore, the U.S. National Center for Atmospheric Research (NCAR) estimates that forest fires in the mainland United States and Alaska emitted about 290 million tons of carbon dioxide a year. According to the IPCC Fourth Assessment Report, annual global carbon dioxide emissions due to wildfires are estimated at 6.2 billion to 15.0 billion tons. In Australia, droughts have been occurring frequently since the turn of the century, causing large fluctuations in wheat crops (Figure 2-1-6).

In Japan, various events that are potentially attributable in part to the global warming have already been occurring, including an increase in heat stroke patients, expansion of distribution area of the Asian tiger mosquitoes that transmit dengue fever, etc., phenomena in which the distribution of living creatures shifts northward or to higher altitudes, and reduction in quality of rice and fruits.

Regarding heat stroke, there have been reports on increases in the number of patients, with many cities registering record numbers of heat stroke patients in 2007 (the number of people carried to medical institutions by ambulances) (Figure 2-1-7).

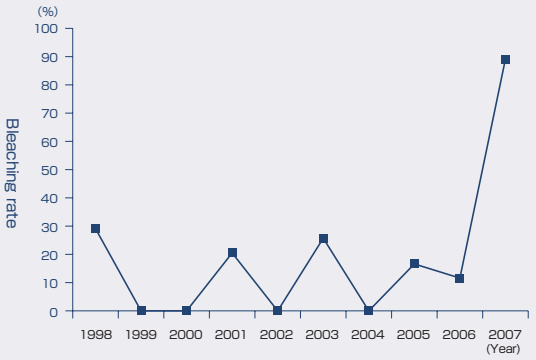
As one development that could affect human health, the expansion of mosquitoes that transmit infectious diseases has also been confirmed. The annual average temperature of about 11 degrees Centigrade is believed to be one of conditions for the habitat of tiger mosquitoes. In the 1950s, Tochigi Prefecture was the northern limit of the habitat distribution of tiger mosquitoes, but in the 2000s, the habitat distribution is confirmed to have expanded to the northern part of the Tohoku region (Figure 2-1-8).

Figure2-1-9 Shift to the North of the Habit Distribution of Great Mormons



Source: Masahiko Kitahara, "Expansion of the Range of Butterflies and Global Warming," 2008, Insects and Nature

Figure2-1-10 Coral Reef Bleaching Rate in Sekisei Lagoon



Note: The average for survey points with continuous data series (26 points)
Source: Ministry of the Environment

Figure2-1-11 Lower Quality of Rice due to Immature White Grains

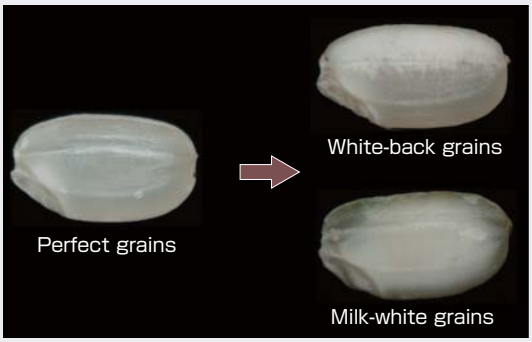


Photo: Satoshi Morita, Senior Researcher, National Agricultural Research Center for Kyushu Okinawa region (KONARC)

Figure2-1-12 Sunburn Mandarin Oranges

Photo: Citrus Breeding and Physiology Research Team, National Institute of Fruit Tree Science, National Agriculture and Food Research Organization (NARO)

As for the impacts on living organisms, there have been reports on the shift of the habitat distribution to the north or to higher altitudes. For example, the habitat distribution of great Mormons, which are said to need the average temperature of around 15 degrees Centigrade at the northern limit of the habitat, has been confirmed to move toward the north from the 1950s to the 2000s (Figure 2-1-9). The decline of alpine plant communities and bleaching of coral reefs have also been confirmed (Figure 2-1-10).

Looking further at the impacts on agricultural products, high temperatures are causing immature white grains (whitened brown rice) and body cracks (cracked brown rice) in rice and sunburned mandarin oranges (Figure 2-1-11, 2-1-12).

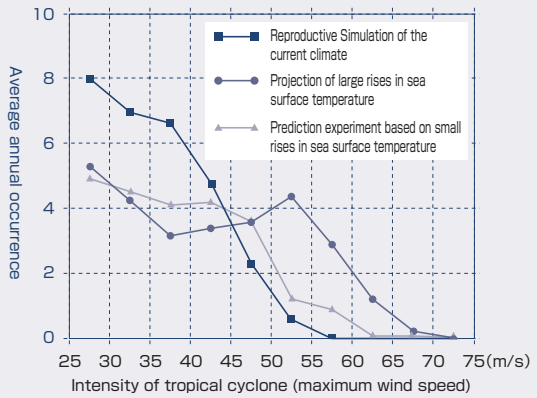
It is difficult to determine whether these events have been caused by global warming or by short-run, sporadic high temperatures. It is because that over the long term, the average temperature across Japan has risen about 1.1 degrees Centigrade in the past century, but in the short run, in 2004, the average temperature increased 1.00 degree Centigrade over the average year. It is believed that even when the above-mentioned events have been caused directly by short-term high temperatures, long-term global warming is also likely to have played a key role.

2 The Damage Expected in the Future

In recent years, studies on future projections of global warming have made strides and we are now able to envision what the earth will be like 50 years or 100 years later, though with a measure of uncertainty. In this subsection, we address the increase in powerful typhoons, the frequency of heavy rains, the rise in sea level and the increase or decrease in sweltering nights and frost days as symptoms of climate change, and the reduction in suitable habitats for beech forests and the expanding areas at risk of pine wilt as examples of the ill effects of global warming.

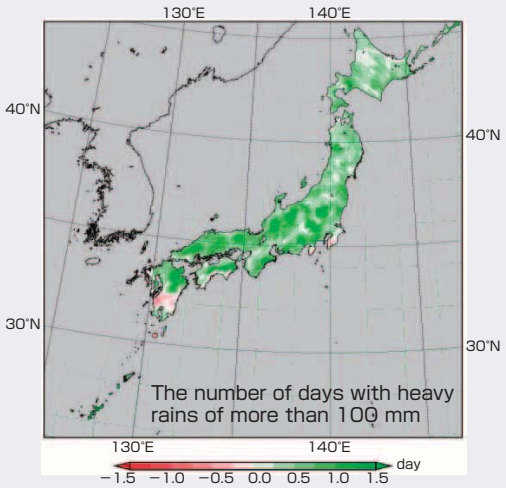
Regarding the future forecast of typhoons, the reproducibility of typhoons has improved with the use of the high-resolution atmospheric global climate model, and the reliability of change forecasts for typhoons has been enhanced. The use of this model indicates that while the total number of tropical cyclones generated in association with global warming will decline, the number of "extremely strong (the maximum wind speed of 44 m/s or more)" tropical cyclones will increase globally, accompanied by heavier rains (Figure 2-1-13). Forecasts of the frequency of heavy rains by the high-resolution regional climate model also show that comparison between two decades of the late 20th century and two decades in the late 21st century indicates that the number of days with heavy rains of more than 100 mm per day

Figure2-1-13 Frequency Distribution of the Average Number of Tropical Cyclones per Year by Intensity of Tropical Cyclones in Global Warming Simulations



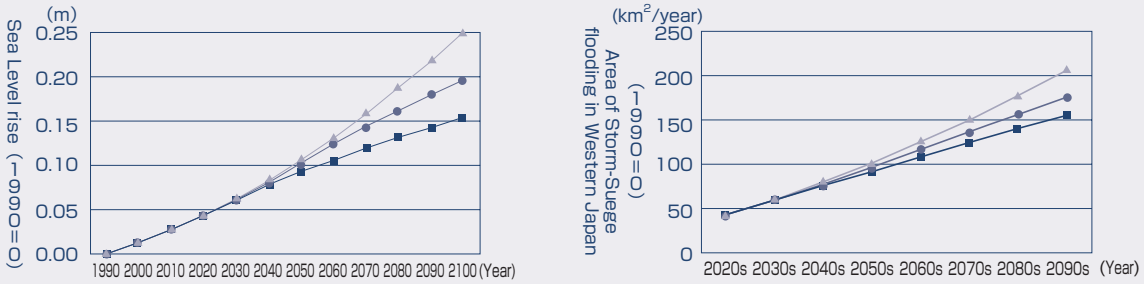
Note: Results of the simulations based on the observed sea surface temperature the simulations based on the projected sea surface temperature with small progress in warming (small increase in sea surface temperature) and the experiment based on the predicted sea surface temperature with greater progress in warming (large increase in sea surface temperature)
Source: Meteorological Research Institute, etc., 2007

Figure2-1-14 Projected Changes in Precipitation across Japan



Source: Ministry of Education, Culture, Sports, Science and Technology, Japan Meteorological Agency, Ministry of the Environment, "Climate Change and Its Impacts in Japan" (October 2009)

Figure2-1-15 Global Sea Level Rise by Scenario and Area of Storm-Surge Flooding in Western Japan



Source: Project Team for Comprehensive Projection of Climate Change Impacts, 2009

will increase in many regions, except for the southern part of the Kyushu region (Figure 2-1-14).

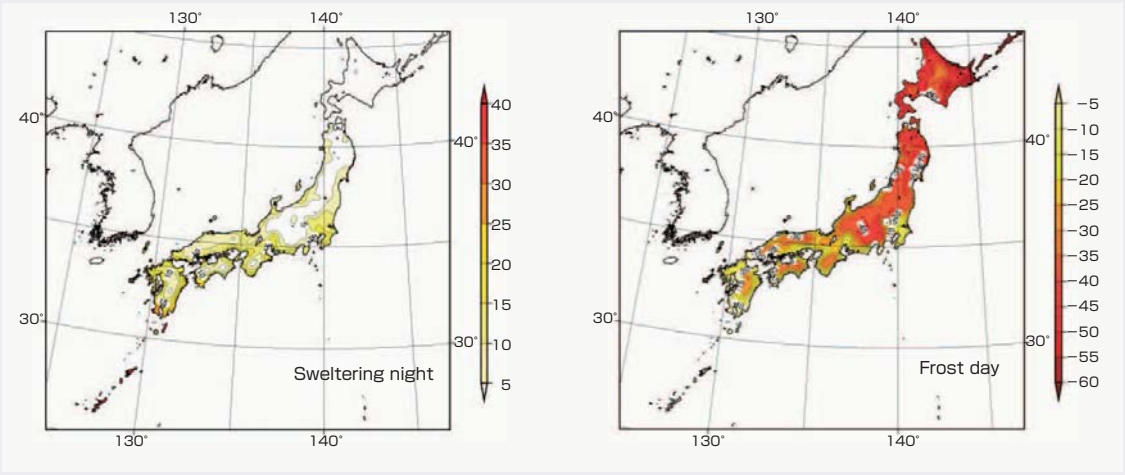
According to "Comprehensive Assessment of Climate Change Impacts to Determine the Dangerous Level of Global Warming and Appropriate Stabilization Target of Atmospheric GHG Concentration" (hereafter referred to as "Project for Comprehensive Projection of Climate Change Impacts"), a strategic research and development area project financed by the Global Environment Research Fund of the Ministry of the Environment, the global average sea level is projected to rise by about 25 cm by 2100 if no action is taken to cope with global warming. Projections of the flooded area caused by storm surges in Western Japan under the same scenario point to an annual increase of about 200 km^2 by the end of the 21st century, indicating that areas with relatively low levels of coastal waterproof barriers are at risk of being flooded (Figure 2-1-15).

We are already beginning to feel in our bones an increase in sweltering nights and a decrease in frost days. According to the Synthesis Report on Observations, Projections, and Impact Assessments of Climate Change, "Climate Change and Its Impacts in Japan" – which was compiled in October 2009 by the Ministry of Education, Culture, Sports, Science and Technology, the Japan Meteorological Agency and the Ministry of the Environment – the number of frost days (with the intraday lowest temperature of less than 0 degree Centigrade) 100 years from now is projected to drop particularly sharply in the mountain areas of Honshu, Tohoku and Hokkaido, while the number of sweltering nights (with the intraday lowest temperature of 25 degrees Centigrade or higher) is expected to sharply increase in the Kanto region and south of the Kinki region (Figure 2-1-16).

These temperature changes have a big impact on vegetation, etc. According to studies under the Project for Comprehensive Projection of Climate Change Impacts, if no action is taken, suitable habitats for beech forest are projected to decline by nearly 70% by the end of the 21st century, and about 50% of the pine distribution areas that were not at risk of pine wilt at the end of the 20th century are expected to newly become areas at risk of pine wilt (Figure 2-1-17).

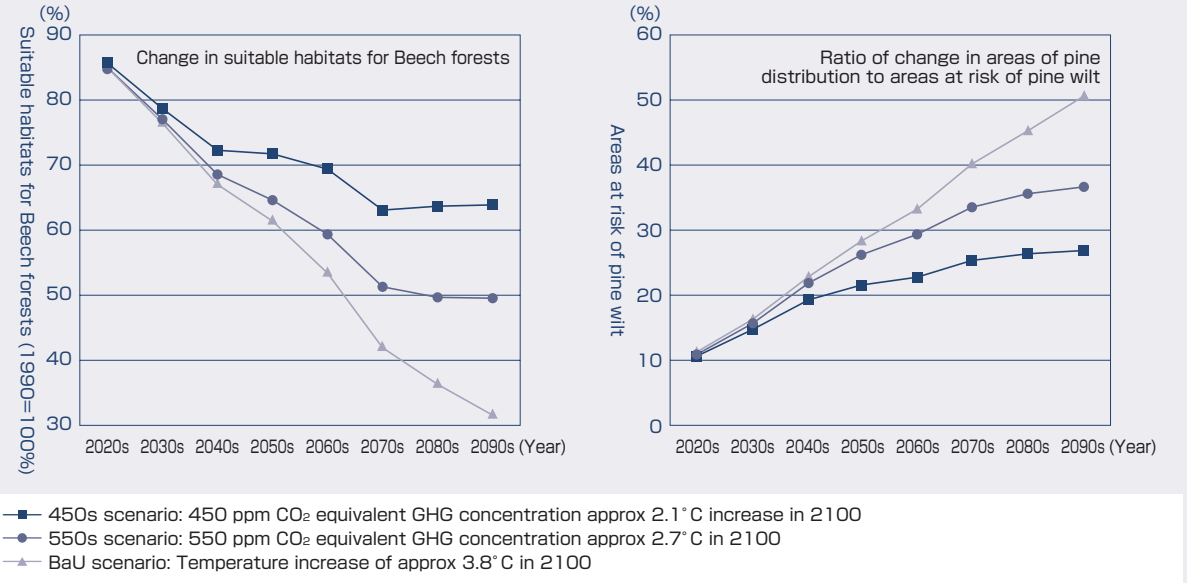
Meanwhile, other countries are also making various projections about future impacts of global warming. Many

Figure2-1-16 Changes in the Annual Number of Days above 25℃ and Frost Days across Japan (Unit: Day)



Note 1: Difference between the 20-year average from 2081-2100 and the 20-year average to the 1981-2000
2: Projection results under the A2 scenario based on a regional model with a holizontal resolution of 20 km (RCM20)
3: Calculation results are based on a single model under a single scenario. Results may vary if a different model or scenario is used.
Source: Ministry of Education, Culture, Sports, Science and Technology, Japan Meteorological Agency, Ministry of the Environment, "Climate Change and Its Impacts in Japan" (October 2009)

Figure2-1-17 Global Warming Impacts on Japan (Change in Suitable Habitats for Beech Forests and Ratio of Change in Areas of Pine Distribution to Areas at Risk of Pine Wilt)



Source: Project Team for Comprehensive Projection of Climate Change Impacts, 2009

of impacts of global warming are related to "water," such as increased risk of flooding and a decline in water supply, and the damage from water-related impacts is likely to increase sharply as global warming progresses. Climate change poses particularly large threats to developing regions. Many developing regions have had warm climates from the beginning, and are vulnerable to major changes in precipitation patterns. Economies of developing countries often depend on agriculture that is particularly vulnerable to climate change, and this presents a major risk factor. Lastly, because of poverty, many developing countries often find it difficult to take measures to cope with climate change on their own.

In Table 2-1-1, we summarize examples of impacts of climate change projected for Africa, Asia, Latin America and small islands in the IPCC Fourth Assessment Report.

3 Necessary Countermeasures

As discussed above, the damage presumably caused by global warming is already beginning to occur as a reality, making it necessary to take adaptation measures (measures to mitigate the adverse impacts by adjusting appropriate responses of nature and the human community to climate change and associated rises in

Table2-1-1 Examples of Projected Impacts by Region

Africa	· By 2020, between 75 and 250 million of people are projected to be exposed to increased water stress due to climate change. · In some countries, yields from rain-fed agriculture could be reduced by up to 50% by 2020. Agricultural production, including access to food, in many African countries is projected to be severely compromised. This would further adversely affect food security and exacerbate malnutrition. · Towards the end of the 21st century, projected sea level rise will affect low-lying coastal areas with large populations. The cost of adaptation could amount to at least 5 to 10% of Gross Domestic Product (GDP). · By 2080, an increase of 5 to 8% of arid and semi-arid land in Africa is projected under a range of climate scenario.
Asia	· By the 2050s, freshwater availability in Central, South, East and South-East Asia, particularly in large river basins, is projected to decrease. · Coastal areas, especially heavily populated megadelta regions in South, East and South-East Asia, will be at greatest risk due to increased flooding from the sea and, in some megadeltas, flooding from the rivers. · Climate change is projected to compound the pressures on natural resources and the environment associated with rapid urbanization, industrialization and economic development. · Endemic morbidity and mortality due to diarrhoeal disease primarily associated with floods and droughts are expected to rise in East, South and South-East Asia due to projected changes in the hydrological cycle.
Latin America	· By mid-century, increases in temperature and associated decreases in soil water are projected to lead to gradual replacement of tropical forest by savanna in eastern Amazonia. Semi-arid vegetation will tend to be replaced by arid-land vegetation. · There is a risk of significant biodiversity loss through species extinction in many areas of tropical Latin America. · Productivity of some important crops is projected to decrease and livestock productivity to decline, with adverse consequences for food security. In temperate zones, soybean yields are projected to increase. Overall, the number of people at risk of hunger is projected to increase. · Changes in precipitation patterns and the disappearance of glaciers are projected to significantly affect water availability for human consumption, agriculture and energy generation.
Small islands	· Sea level rise is expected to exacerbate inundation, storm surge, erosion and other coastal hazards, thus threatening vital infrastructure, settlements and facilities that support the livelihood of island communities. · Deterioration in coastal conditions, for example through erosion of beaches and coral bleaching, is expected to affect local resources. · By mid-century, climate change is expected to reduce water resources in many small islands, e.g. in the Caribbean and Pacific, to the point where they become insufficient to meet demand during low-rainfall periods. · With higher temperatures, increased invasion by non-native species is expected to occur, particularly on mid- and high-latitude islands.

Source: Ministry of Education, Culture, Sports, Science and Technology, Ministry of Economy, Trade and Industry, Japan Meteorological Agency, "Intergovernmental Panel on Climate Change (IPCC) Fourth Assessment Report, Summary for Policymakers" (translated by the Ministry of the Environment)

Table2-1-2 Climate Scenarios and Impacts by Stabilization Level (Nationwide Values)

Climate Scenario/Impact Field		Unit	2030s			2050s			2090s		
			450s	550s	BaU	450s	550s	BaU	450s	550s	BaU
	Change in average temperature (1990=0℃)	℃	0.9	0.9	1.0	1.3	1.6	1.7	1.6	2.3	3.2
	Change in annual mean precipitation (1990=100%)	%	100	101	101	105	106	107	107	110	113
	Sea level rise (1990=0m)	m	0.06	0.07	0.07	0.10	0.11	0.12	0.15	0.19	0.24
Floods	Flooded area	1000km²	0.2	0.2	0.2	0.6	0.7	0.7	0.5	0.6	0.8
	Food damage cost potential	Trillion yen/year	1.3	1.3	1.3	4.4	4.7	4.9	5.1	6.1	8.3
Landslide disasters	Probability of slope failure	%	3	3	3	3	4	4	4	5	6
	Slope failure damage cost potential	Trillion yen/year	0.60	0.60	0.60	0.49	0.52	0.58	0.65	0.77	0.94
Beech forest (Japanese beech)	Suitable habitats for Beech forest	%	79	77	77	72	65	61	64	50	32
	Cost of damage due to loss of suitable habitats for Beech forest	100 million yen/year	778	829	851	1034	1273	1381	1325	1811	2324
Pine wilt	Areas at risk of pine wilt	%	15	16	16	22	26	28	27	37	51
Rice	Rice yield	t/ha	4.9	5.0	5.0	4.9	5.0	5.1	4.8	4.9	5.1
Sand beaches	Area of sand beach loss	%	13	13	13	19	21	23	29	37	47
	Cost of damage due to loss of sand beaches	100 million yen/year	116	118	121	176	192	208	273	338	430
Storm surges	Population affected by storm-surge flooding (western Japan)	10,000 people/year	12	12	12	19	20	21	32	37	44
	Population affected by storm-surge flooding (Japan's three major bays)	10,000 people/event	11	11	11	17	17	17	30	32	35
	Area of storm-surge flooding (western Japan)	km²/year	60	60	61	92	97	102	155	176	207
	Area of storm-surge flooding (Japan's three major bays)	km²/year	24	24	24	37	38	39	63	67	72
	Cost of damage due to storm-surge flooding (western Japan)	Trillion yen/year	2.0	2.0	2.0	3.1	3.3	3.5	5.4	6.2	7.4
	Cost of damage due to storm-surge flooding (Japan's three major bays)	Trillion yen/year	0.2	0.2	0.2	0.3	0.4	0.4	1.8	2.0	2.3
Heat stress	Heat stress mortality risk	—	1.5	1.6	1.6	1.8	2.1	2.2	2.1	2.8	3.7
	Cost of damage due to heat stress (heat stroke)	100 million yen/year	243	265	274	373	480	529	501	775	1192

Source: Project Team for Comprehensive Projection of Climate Change Impacts, 2009

temperatures and the sea level).

More specifically, such measures include construction of breakwater and embankment to prevent storm surge damage in water-related disasters and coastal areas, construction of temporary impounding facilities to mitigate flood damage due to localized heavy rains, securing of refuges for animals and plants that lose their habitats due to global warming in natural ecosystems, early detection and prevention of the perishing and loss of forests, and development of agricultural crops with high temperature resistance in the food field.

"The Stern Review: The Economics of Climate Change," a report on the result of studies conducted under the direction of the British Minister of Finance, notes that if no action is taken to cope with global warming, in other words, business as usual (BaU), that would "reduce welfare by an amount equivalent to a reduction in consumption per head of between 5 and 20%." The Stern Review also estimates the annual costs of stabilization of greenhouse gas (GHG) concentration in the atmosphere at 500-550ppm CO2e to be around 1% of gross domestic product (GDP) by 2050, a level lower than the intensity of measures assumed for Japan's mid-term goals.

Figure 2-1-2 shows the results of studies on the costs of domestic damage due to the impacts of global warming estimated under the Ministry of the Environment's Project for Comprehensive Projection of Climate Change Impacts. The impacts and damage are estimated to decrease considerably if GHG emissions are reduced through mitigation measures. If additional measures are not taken (BaU), however, up to ¥8.3 trillion in flood damage, ¥0.94 trillion in landslide disasters, ¥232.4 billion in cost of damage due to loss of suitable habitats for beech forest, ¥43.0 billion in cost of damage due to loss of sand beaches, ¥7.4 trillion in cost of damage due

Column We Answer Your Questions about Global Warming

Some erroneous descriptions have given rise to the recent controversy over the credibility of the IPCC Fourth Assessment Report (AR4).

However, these errors concern only a small portion of the AR4 that runs about 1,000 pages and the credibility of the AR4's scientific basis regarding global warming remains intact. Following the recent controversy, the IPCC has commissioned the InterAcademy Council (IAC) to conduct an independent review of the processes and procedures of the IPCC in preparing its reports. The IAC review results will be discussed at this year's IPCC Plenary Session and reflected in the IPCC Fifth Assessment Report (to be released in 2013-2014).

In this column, we explain about questions you might have regarding global warming based on scientific knowledge offered in the IPCC AR4 and other documents.

(1) Is there sufficient evidence that anthropogenic greenhouse gases are the major cause of global warming?

Not only anthropogenic factors such as greenhouse gas emissions but also natural factors including solar activity and aerosols discharged by volcanic eruptions cause changes in the global mean temperature, and a combination of various factors leads to temperature rises or decreases. Around the mid-20th century, there were periods when the global mean temperature stayed flat despite higher atmospheric concentrations of greenhouse gases due to other offsetting factors. The IPCC AR4 noted that based on the results of climatic simulations for 1906-2005, rapid global warming observed in the recent several decades cannot be reproduced without considering anthropogenic increases in greenhouse gas emissions.

(2) The biggest greenhouse effect comes from water vapor. So, isn't it true that a small increase in carbon dioxide emissions has little impact on the environment?

It is true that water vapor has the biggest greenhouse effect (about 60%), but carbon dioxide also plays an important role by contributing about 30% of the greenhouse effect. The amount of water vapor in the atmosphere is determined by exchanges (evaporation and precipitation) between the atmosphere and oceans/land surface. Thus, the amount of water vapor does not increase or decrease significantly due to human activities. Water vapor is believed to grow in amount in the atmosphere if temperatures rise which increasingly accelerates global warming, but much more contributory to temperature rises are carbon dioxide emissions by human activities. In other words, due heed certainly needs to be given to water vapor in that water vapor currently is a factor for the greenhouse effect and has potential to amplify global warming in the future. In order to contain the progression of global warming, however, it is more effective to curb emissions of carbon dioxide and other greenhouse gases.

(3) Isn't it true that the major cause of global warming is animated solar activity, etc. and not the increase in greenhouse gas concentrations?

As noted in (1), not only the increase in greenhouse gas concentrations but also animated solar activity (an increase in radiant energy from the sun) and other factors cause to alter the global mean temperature. However, the latest observation data on the number of sunspots, a good indicator of solar activity, shows that sunspots have stayed almost flat or tended to decrease since the mid-20th century, indicating little possibility of solar activity becoming more vigorous. Cosmic rays (electric atomic nuclei drifting in outer space) that reach the earth's atmosphere are said to form clouds, and there is a theory that cosmic rays decrease when solar activity becomes vigorous and a resultant reduction in the amount of clouds causes temperatures to rise. At present, however, there is no established correlation between cosmic rays and the amount of clouds and the physical mechanism involved has not been elucidated. After assessing scientific discussions concerning natural factors such as solar activity and cosmic rays, the IPCC AR4 has concluded that the increase in global average temperatures in the latter half of the 20th century is very likely due to the increase in anthropogenic greenhouse gas concentrations.

to storm-surge flooding (Western Japan), and ¥119.2 billion in cost of damage due to heat stress (heat stroke) mortality, respectively, is estimated each year in the 2090s.

Section 2 Economic Effects of Measures to Cope with Global Warming

Measures to cope with global warming are believed to have both positive and negative effects on the economy. As specific positive effects on the economy, considerable new business opportunities are conceivable in a diverse range of industries and services. The market for low-carbon energy products is one of fields with considerable potential going forward. Japan must strive to take advantage of these business opportunities.

Measures to deal with climate change may also help eliminate existing inefficiencies. At the corporate level,

the introduction of measures to cope with global warming may lead to cost savings, while at the level of the overall economy, climate policy measures are believed to be likely to lead to improvements in inefficient energy systems.

Furthermore, as secondary benefits of taking measures to deal with climate change, it can also be expected that health damage from air pollution would be reduced or forests that host the bulk of global biodiversity would be preserved.

Lastly, efforts to enhance energy efficiency and diversify energy sources and energy supply as part of measures to cope with global warming will contribute to securing national energy security and is also instrumental in clarifying a long-term energy-related policy framework.

Thus, what is important is the change in our way of thinking to view the promotion of measures to cope with global warming as one of pillars for new growth, instead of focusing only on increased burdens. The "New Growth Strategy (Basic Policies)," adopted by a Cabinet decision in December 2009, regards environment-related markets as sustainable growth areas with potential short-term and long-term demand, and in order to become "an environment and energy power through 'green innovation'," sets the targets of creating over ¥50

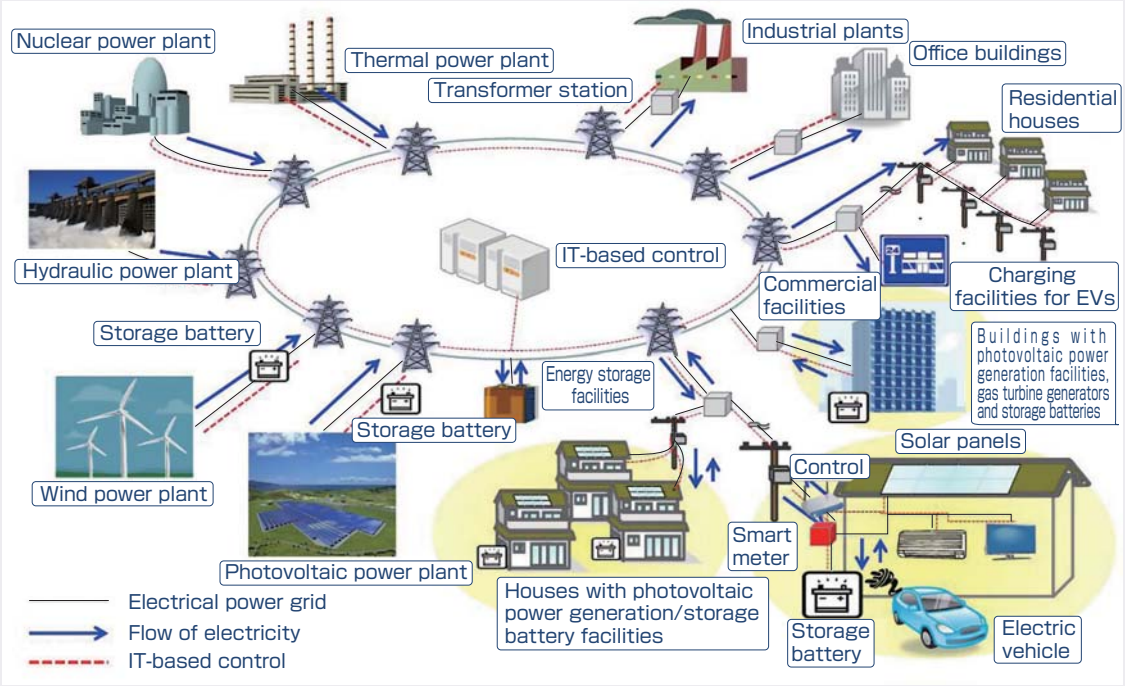
Column Smart Grid

The term "Smart Grid (next-generation power transmission network)" is being used to mean various things. For example, it is used to mean the power transmission and distribution network that incorporates dedicated equipment and software with communication functions and controls the flows of electric power from both the supply and demand sides to optimize them.

The ways in which the so-called "Smart Grid" is visualized differs among countries and regions. In the United States, the Smart Grid has attracted keen attention after the Obama administration placed it as the pillar of the Green New Deal, but appears to be aimed largely at replacing superannuated U.S. power transmission networks. Also in the background is that in the United States, unlike Japan, power demand is expected to keep growing going forward and the necessity is high to upgrade and beef up transmission lines.

In Japan, on the other hand, its power transmission network is known for high efficiency and high reliability. For example, comparison of hours of electric power outage demonstrates that Japan's power supply system is highly reliable. However, if renewable energy such as photovoltaic power generation and wind power generation come to account for a large portion of power supply, as in Europe, due to their vulnerability to weather and climate and unstable output, it will become necessary to take system stabilization measures to ensure the stable supply of electricity. For example, if power supply increases at a time when demand is low, it is necessary to take system stabilization measures such as curbing output of photovoltaic power generation or storing electricity in large stationary storage batteries in order to adjust the power supply and demand balance. In Japan, maintaining the stable supply of power and expanding the introduction of renewable energy are one of the purposes to work on the Smart Grid.

Conceptual Diagram of Smart Grid



source: Ministry of Economy, Trade and Industry, "Toward International Standardization Concerning Next-Generation Energy Systems"

trillion in new environment-related markets and 1.4 million new environment sector jobs by 2020. We describe this in greater detail in Section 4 of this Chapter.

Amid the global recession following the Lehman Shock, various companies, in search of new business, are trying to find opportunities in new fields. In particular, environmental businesses may be described as already expanding with further prospects for growth.

Utilization of natural energy is one area that is likely to increasingly grow in importance globally going forward. Demand for photovoltaic power generation, the typical use of natural energy, according to the International Energy Agency's (IEA) PV Roadmap 2009, is expected to expand about five times the present level by 2020 in terms of electricity generated. For Japan, which has sophisticated technology in photovoltaic power generation, this is the industry sector with growth potential going forward. As Japan plans to introduce measures to support the spread and expansion of renewable energies (solar light, wind, hydroelectric, geothermal, solar thermal, biomass, etc.), such as the creation of the electric power feed-in tariff system, promotion of installation of facilities using renewable energy, promotion of electric power system facilities, and adequate review of regulations, etc., the volume efficiency associated with the spread and expansion at home is expected to help lower manufacturing costs and boost international price competitiveness.

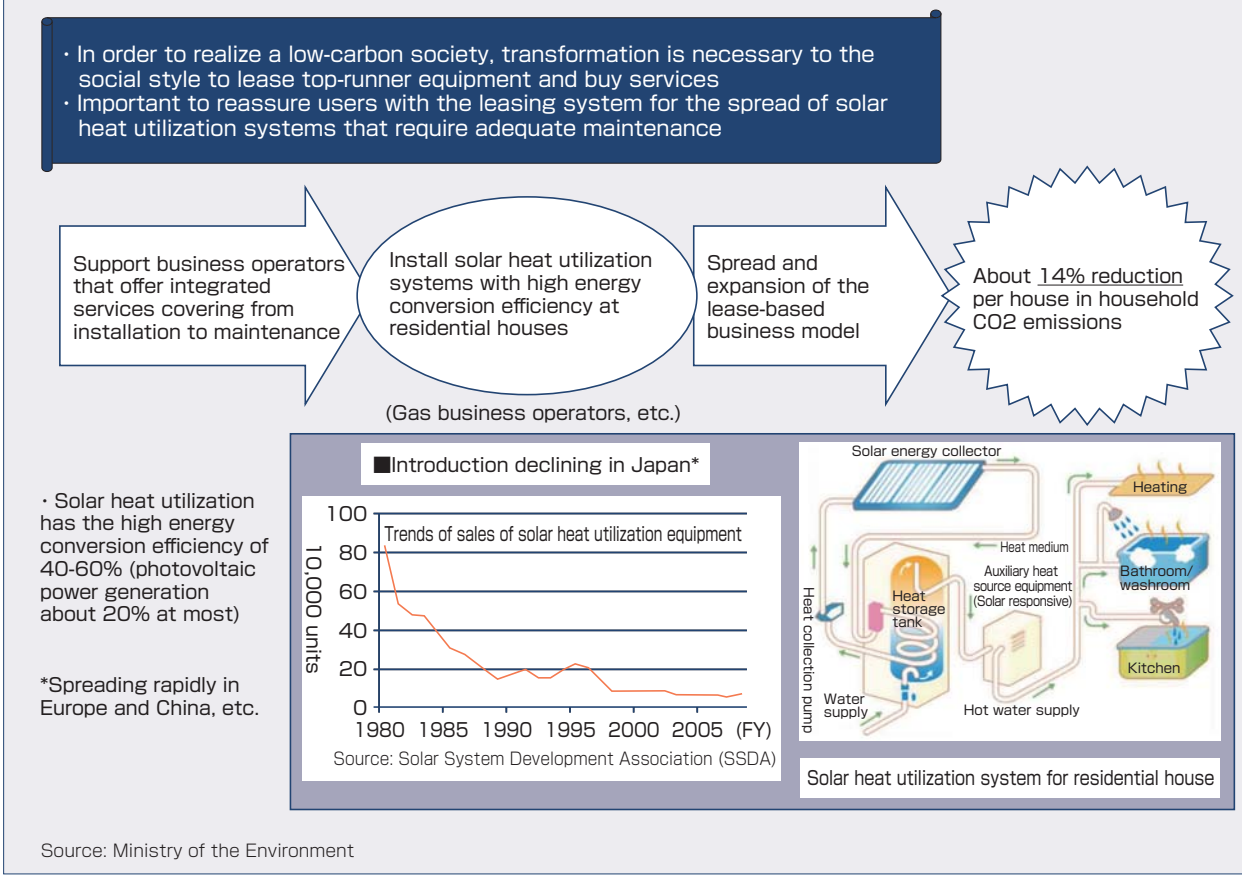
Furthermore, efforts are under way, notably in Europe and the United States, to introduce the "Smart Grid" designed to realize the efficient utilization of renewable energy. Japanese companies are also engaged in active business operations on the strength of their battery technologies, including solar cells and rechargeable batteries.

The Ministry of Economy, Trade and Industry, regarding the Smart Grid business as the next-generation business and in order to support Japanese companies with excellent products and services in going into overseas markets with their systems, established the "Study Group on the International Standardization Concerning Next-Generation Energy Systems" in August 2009 to proactively and strategically contribute to the international standardization of the Smart Grid. In January 2010, the Study Group came up with the "International Standardization Roadmap for Smart Grid," which sorted out and listed 26 important technological elements to be standardized.

In the future, it is also conceivable to develop new services by adding functions to operate security systems and home electric appliances to the Smart Grid.

Other than the Smart Grid, lithium ion and other rechargeable batteries that are a technology essential for electric vehicles, etc. are an area which Japan excels in. The Ministry of the Environment has supported research and development of high-capacity laminate lithium ion batteries, while the Ministry of Economy, Trade and Industry has also been promoting high-performance, low-price innovative storage batteries. Since FY2009, actually, electric vehicles and plug-in hybrid vehicles have been put on the market on a full scale, and going

Figure2-2-1 Concerning Acceleration of the Spread of Household Solar Heat Utilization Systems



Source: Ministry of the Environment

forward, electric vehicles mounted with high-capacity laminate lithium ion batteries are also set to be commercialized. Thus, rechargeable batteries have become an element indispensable for the development of next-generation environment-friendly products.

Measures to cope with global warming will reduce lighting and heating expenses at households. As an example of usage of energy from sunlight, solar heat utilization systems such as water heaters have a high energy efficiency of 40-60% and are also relatively cheap. Solar heat utilization systems are rapidly spreading in Europe and China, etc., and Japan is trying to develop a mechanism under which such systems can be used without safety concerns by spreading them mainly under lease contracts, which helps eliminate maintenance troubles (Figure 2-2-1).

Furthermore, when photovoltaic power generation, high-performance insulation and high-efficiency water heaters are introduced to single-family houses and at the same time electric appliances are replaced with energy-saving ones, for example, despite the costs of introducing these systems and new electric appliances, reductions in heating and lighting expenses can be expected. High-performance insulation of houses will also produce the secondary effect of creating a comfortable and healthy living space that is cool in summer and warm in winter.

Column The Stern Review

The "Stern Review: The Economics of Climate Change" is the report on economic impacts of the climate change problem the British government commissioned to the former World Bank Senior Vice President Nicholas Stern following the Group of Eight Summit in July 2005, which was released in October 2006. The Stern Review analyzed the economic costs of the impacts of climate change, and the costs and benefits of action to reduce the emissions of greenhouse gases using the following three different ways.

(i) Approach to considering individual factors

This is the approach of analysis to consider the physical impacts of climate change on the economy, on human life and on the environment using disaggregated techniques, and examine the resource costs of different technologies and strategies to reduce greenhouse gas emissions.

The Stern Review first made an analysis using integrated assessment models to estimate the overall impact of climate change in monetary units. The Stern Review also used models that makes it possible to examine the risks of most uncertain impacts using probabilities, and it estimated that "the monetary impacts of climate change are now expected to be more serious than many earlier studies suggested."

The Review estimated "the total cost over the next two centuries of climate change associated under BAU (business as usual) emissions involves impacts and risks that are equivalent to an average reduction in global per-capita consumption of at least 5%." Further, including direct impacts on the environment and human health (so called "non-market" impact) and weighting appropriately the disproportionate share of the climate-change burden falling on poor regions of the world, it is estimated that the total cost of BAU climate change would be increased to "the equivalent of around a 20% reduction in consumption per head, now and into the future."

(ii) Approach to using economic models

This is the approach of analysis that uses economic models, including integrated assessment models that estimate the economic impacts of climate change, and macroeconomic models that represent the costs and effects of the transition to low-carbon energy systems for the economy as a whole.

Assuming the following four ways to reduce greenhouse gas emissions:

- Reducing demand for emissions-intensive goods and services
- Increased efficiency, which can save both money and emissions
- Action on non-energy emissions, such as avoiding deforestation
- Switching to lower-carbon technologies for power, heat and transport,

the Review estimated the costs of stabilizing greenhouse gases at levels of 500-550ppm CO_2e in two ways: One is to provide an upper bound on costs by looking at the resource costs of measures in comparison with the costs of the BAU alternative, and the second is to use macroeconomic models to explore the economic system-wide effects of the transition to a low-carbon energy economy. As a result, on the basis of these two methods, it is concluded that "stabilization of greenhouse gases at levels of 500-550ppm CO_2e will cost, on average, around 1% of annual global GDP by 2050." A broad range of macro-economic model estimates led to an important corollary that "there is a high price to delay." The Stern Review also issued a warning: "Weak action in the next 10-20 years would put stabilization even at 550ppm CO_2e beyond reach – and this level is already associated with significant risks."

(iii) Approach to comparing costs

This is the approach of analysis to compare the estimated costs of mitigation with the estimated costs of climate change without action, and to compare the marginal cost of carbon abatement with the "social cost of carbon."

Introducing the latest knowledge about risks and assuming we remain on a BAU trajectory, the Stern Review estimated that "the social cost of carbon today … is of the order of $85 per tonne of CO_2." This number is well above marginal abatement costs in many sectors. Comparing the social costs of carbon

on a BAU trajectory and on a path towards stabilization at 550ppm CO_2e, the Stern Review estimated "the excess of benefits over costs, in net present value terms, from implementing strong mitigation policies this year, shifting the world onto the better path: the net benefits would be of the order of $2.5 trillion."

The Stern Review also states that "innovation driven by strong policy will ultimately reduce the carbon intensity of our economies, and consumers will then see reductions in the prices that they pay as low-carbon technologies mature."

The Stern Review, summarizing the results of analyses based on these three approaches, presented a simple conclusion: the benefits of strong, early action on climate change considerably outweigh the costs."

There is criticism of the Stern Review that the "discount rate" applied to economic model estimates has been set too low and this might have resulted in an overestimation of long-term impacts of climate change. Since many of the preceding economic analyses applied higher discount rates based on the observations of actual behaviors of people, certain researchers consider the Stern Review inappropriate. In contrast, in the Stern Review, Lord Stern argued that the discount rate should be set low and the long-term benefits should be given greater importance regarding the natural system affected by global warming and the human system that depends on the former for its subsistence.

Sources: Asia-Pacific Integrated Modeling (AIM) Team and the executive summary of the "Stern Review: The Economics of Climate Change" (translated by the National Institute for Environmental Studies)

Section 3 Global Movement on Climate Change

Damage from Climate Change has already started emerging, and it is necessary to take appropriate measures for mitigation and minimize the cost of damage. But only Japan's efforts cannot halt climate change, even if it sets an ambitious reduction target. No country can deal with this problem alone. Persistent discussions are ongoing in international negotiations, where the short-term interests clash between developed and developing countries, among developed countries or among developing countries.

1 The International Community's Responses So Far to Climate Change

The Kyoto Protocol adopted at the third session of the Conference of the Parties (COP3) to the United Nations Framework Convention on Climate Change (UNFCCC) in 1997 based on the UNFCCC committed developed countries to embark on international efforts to reduce greenhouse gas emissions and set numerical targets for greenhouse gas emission cuts by developed countries during the first commitment period (2008-2012). However, the Kyoto Protocol, which the United States does not ratify and developing countries are not subject to reduction targets, covers only about 28% of total global emissions of carbon dioxide from energy sources as of 2007. Global emissions of greenhouse gases are expected to continue to increase in tandem with economic development of developing countries with no reduction obligations. Under these circumstances, in order to reduce emissions of greenhouse gases effectively in the future, it is necessary to strive for measures to address climate change by the entire world, including the United States, which is yet to ratify the Kyoto Protocol, and China and other emerging economies whose energy consumption is expected to increase.

Regarding international negotiations on the post-2012 framework, the COP13 held in Bali, Indonesia, in December 2007 adopted the Bali Action Plan and decided to finalize the post-2012 framework by COP15 in 2009 with the participation of all parties to the UNFCCC.

Meanwhile, at the Group of Eight (G8) Hokkaido Toyako Summit held in 2008, the G8 leaders reached common understanding that they seek to share with all Parties to the Framework Convention on Climate Change the vision of, and together with them to consider and adopt in the UNFCCC negotiation, the goal of achieving at least 50% reduction of global emissions by 2050. At the G8 Summit in L'Aquila, Italy, in July 2009, the G8 leaders reaffirmed the goal of reducing global emissions by at least 50% by 2050, and as part of this, supported a goal of developed countries reducing emissions of greenhouse gases in aggregate by 80% or more by 2050 and also recognized the broad scientific view that the increase in global average temperature above pre-industrial levels ought not to exceed 2 degrees Celsius. Subsequently, then Prime Minister Yukio Hatoyama announced in a speech at the Summit on Climate Change in September 2009 that "For its mid-term goal, Japan will aim to reduce its emissions by 25% by 2020, if compared to the 1990 level, consistent with what the science calls for in order to halt global warming," which is premised on the establishment

of a fair and effective international framework in which all major economies participate and on agreement by those economies on ambitious targets. Further, in the Japan-U.S. Joint Message on Climate Change Negotiations issued by the Japanese and U.S. leaders, the two countries said they "aspire to reduce our own emissions by 80% by 2050 and endorse a global goal of reducing emissions by 50% by that year."

2 Achievements of COP15 and Remaining Problems

Regarding reductions of greenhouse gas emissions after the first commitment period of the Kyoto Protocol, Japan took the initiative toward COP15 through setting ambitious reduction targets in pursuit of the establishment of a fair and effective international framework in which all major economies participate and agreement on ambitious targets by all the major economies, and announcing its scaled-up support for developing countries under the "Hatoyama Initiative." Japan participated in negotiations on political agreement at COP15 in pursuit of agreement on a fair and effective framework in which major economies, including the United States and China, participate, and strove to pave the ground for assistance to developing countries in such areas as adaptation and capacity-building.

In negotiations at COP15 and the Fifth Session of the Meeting of the Parties to the Kyoto Protocol (CMP5), etc. held in Copenhagen, Denmark, December 7-19, 2009, as a result of consultations and negotiations at the leader level of nearly 30 countries and organizations from the night of December 17 and late night of December 18, following ad hoc working group discussions by negotiators in the first half of the session and ministerial-level consultations, the Copenhagen Accord was developed, and it was decided at a plenary meeting the following day that "the Conference of the Parities takes note of the Copenhagen Accord." It was also decided that the Ad Hoc Working Group on Long-term Cooperative Action under the Convention (AWG-LCA), which was due to disband at the end of 2009, will continue its work, along with the Ad Hoc Working Group on Further Commitments for Annex I Parties under the Kyoto Protocol (AWG-KP).

The process in the COP15 negotiations is as follows. In the first half of the negotiations, the AWG-KP chairman proposed that the Annexes to the Kyoto Protocol be revised to set the next set of reduction targets for developed countries. Many developing countries that call for the revision of the Annexes welcomed the chairman's proposal, but developed countries opposed to the chairman's proposal, arguing that the Kyoto Protocol alone is not sufficient to reduce greenhouse gas emissions globally and that a comprehensive and effective legal framework should be established to cover a developed country that has not ratified the Kyoto Protocol (the United States) and developing countries with no reduction obligations under the Kyoto Protocol (such as China and India).

The AWG-LCA chairman also presented another proposal, which drew the line among developed countries between the United States and the parties to the Kyoto Protocol. Later, when the COP chairman stated that she wanted to bring the discussions forward by presenting a new document based on the reports from the two ad hoc working groups, major developing countries such as China, India and Brazil rejected the idea, asserting that negotiations should be conducted on the basis of the reports from the two AWGs. Developed countries requested a meeting among a few countries and the presentation of a new proposal by Denmark, the COP host country, but developing countries continued to insist on the discussions on the basis of the proposals from the chairmen of the AWG-LCA and AWG-KP. Both sides remained as far apart as ever, threatening to jeopardize any progress in the negotiations.

Representing Japan, Prime Minister Hatoyama and Minister of the Environment Sakihito Ozawa again explained that Japan aims to reduce its emissions by 25% by 2020, if compared to the 1990 level, which is premised on the establishment of a fair and effective international framework in which all major economies participate and on agreement by those economies on ambitious targets, and announced the "Hatoyama Initiative", which provides financial assistance of approximately ¥1.75 trillion (about $15 billion), of which public finance comprises approximately ¥1.30 trillion (about $11 billion), giving an impetus to the progress in the negotiations in the negotiations in order to support a broad range of developing countries which are taking measures of mitigation, as well as those which are vulnerable to the negative impacts of climate change.

Amid these moves, a leader-level meeting among a small number of countries was held after a leaders' banquet at the night of December 17. The leaders from nearly 30 countries and organizations, took part in the meeting, including Prime Minister Hatoyama, U.S. President Barack Obama, British Prime Minister Gordon Brown, Australian Prime Minister Kevin Rudd, German Chancellor Angela Merkel and French President Nicolas Sarkozy as well as the leaders of China, India, Brazil, South Africa and representatives from developing regions, such as Alliance of Small Island States and African Group. Late at night on December 18, these countries hammered out the "Copenhagen Accord."

When the Copenhagen Accord was presented to the COP plenary session early on December 19, many countries, including developed countries, Alliance of Small Island States and least developed countries, endorsed the accord and sought the adoption on it, but a few countries opposed the adoption on the grounds that the preparation process of preparing the accord was not transparent. Ultimately, it was decided that the Conference of the Parties "takes note of the Copenhagen Accord."

The gist of the Copenhagen Accord is as follows:

(i) Recognize the scientific view that the increase in global temperature should be below 2 degrees Celsius, and enhance long-term cooperative action to combat climate change;

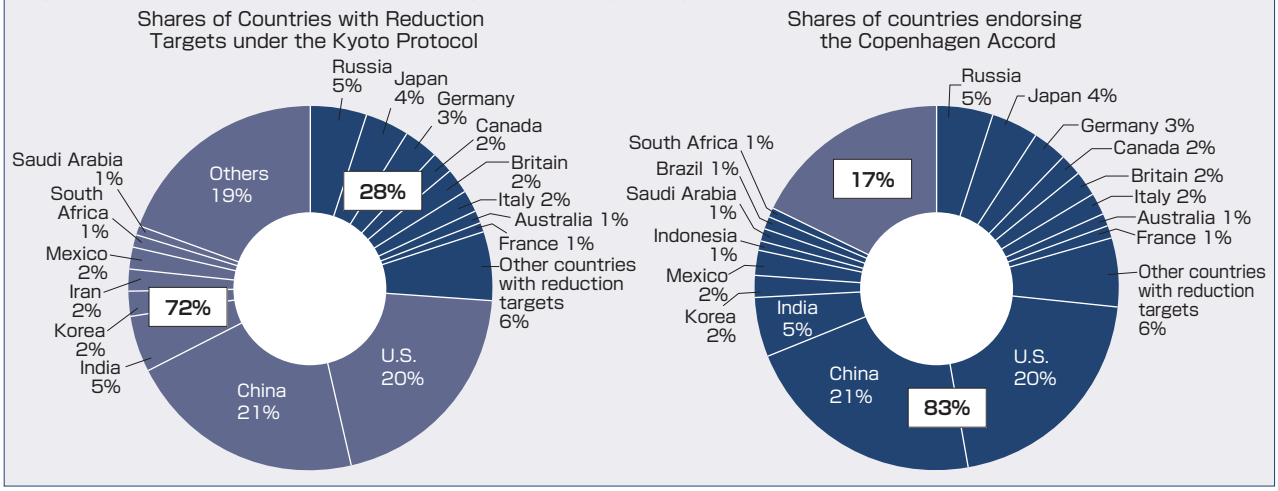
Figure2-3-1 Emissions Reduction Targets of Major Economies

Country	Emissions reduction in 2020	Base year
Japan	Reduce 25%, premised on the establishment of a fair and effective international framework in which all major economies participate and on agreement by those economies on ambitious targets	1990
U.S.	Reduce in the range of 17%, in conformity with anticipated U.S. energy and climate legislation, recognizing that the final target will be reported to the Secretariat in light of enacted legislation (Note 1)	2005
Canada	Reduce 17%, to be aligned with the final economy-wide emissions target of the United States in enacted legislation	2005
Russia	Reduce 15-20% (Prerequisite: appropriate accounting of the potential of Russia's forestry in frame of contribution in meeting the obligations of the anthropogenic emissions reduction, and undertaking by all major emitters the legally binding obligations to reduce anthropogenic GHG emissions)	1990
Australia	Reduce 5% up to 15% or 25% (Note 2)	2000
EU	Reduce 20%/30% (Note 3)	1990

Note 1: U.S.) The pathway set forth in pending legislation would entail a 30% reduction in 2025 and a 42% reduction in 2030, in line with the goal to reduce emissions 83% by 2050
Note 2: Australia) Will reduce its greenhouse gas emissions by 25% on 2000 levels by 2020 if the world agrees to an ambitious global deal capable of stabilizing levels of greenhouse gases in the atmosphere at 450 ppm CO2-eq or lower. It will unconditionally reduce emissions by 5% below 2000 levels by 2020, and by up to 15% by 2020 if there is a global agreement under which major developing economies commit to substantially restrain emissions and advanced economies take on commitments comparable to Australia's.
Note 3: EU) EU reiterates its conditional offer to move to a 30% reduction by 2020 compared to 1990 levels, provided that other developed countries commit themselves to comparable emission reductions and that developing countries contribute adequately according to their responsibilities and respective capabilities

Country	Emission targets/Mitigation actions
China	China will endeavor to lower its carbon dioxide emissions per unit of GDP by 40-45% by 2020 compared to the 2005 level, increase the share of non-fossil fuels in primary energy consumption to around 15% by 2020 and increase forest coverage by 40 million hectares from the 2005 level. These are autonomous actions.
India	Endeavour to reduce the emissions1 intensity of its GDP by 20-25% by 2020 compared with the 2005 level (excluding the agricultural sector). Mitigation actions are voluntary, and thus not legally binding
Brazil	Expects to reduce emissions by 36.1-38.9% compared with BAU. Specific actions include reduction in rain forests degradation; reduction in "Cerrado" (a type of vegetation in savanna regions) degradation; restoration of grain-growing land; improvement in energy efficiency; increased use of biofuels; increase in hydraulic power generation; alternative energy sources; and enhancement of the steelmaking industry, etc.
South Africa	Take mitigation action to reduce emissions 34% by 2020 compared with BAU, and 42% by 2025 compared with BAU. These actions require support from developed countries as well as the finalization of an ambitious, fair, effective and binding multilateral agreement at the meeting in Mexico under the Convention and the Kyoto Protocol. With international support, South Africa' s emissions are likely to peak between 2020 and 2025, plateau for about a decade, and then decline
Korea	Reduce greenhouse emissions by 30% by 2020 from the level of BAU emissions

Figure2-3-2 CO2 Emissions from Energy Sources (2007)



(ii) Annex I Parties (developed countries) submit emission reduction targets for 2020 and non-Annex I Parties (developing countries) submit mitigation actions, in the formats given in Appendix I and Appendix II, respectively, to the Secretariat by 31 January 2010;

(iii) Actions taken by Annex I Parties will be subject to measurement, reporting and verification (MRV). Mitigation actions taken by Non-Annex I Parties will be subject to international consultations and analysis after domestic MRV and mitigation actions taken with international support will be subject to international MRV.

(iv) Developed countries will collectively commit to provide new and additional resources approaching $30 billion for the period of 2010-2012, and also commit to a goal of mobilizing jointly $100 billion a year by 2020. The Parties decide that the "Copenhagen Green Climate Fund" shall be established as an operating entity of the financial mechanism of the Framework Convention on Climate Change.

(v) The Parties call for an assessment of the implementation of the Copenhagen Accord to be completed by 2015.

Over 110 countries which have already associated with the Copenhagen Accord account for over 80% of global emissions. Thus, it is important to position the Copenhagen Accord as an important basis for negotiations going forward (Figure 2-3-1, 2-3-2).

Under the Copenhagen Accord, Japan in January 2010 submitted to the UNFCCC Secretariat as the emission reduction in 2020 "25% reduction compared with the 1990 level, which is premised on the establishment of a fair and effective framework with the participation of all the major emitting countries and their agreement on

Column COP15 and Problems in Post-Copenhagen Negotiations on Climate Change

In this column, we listen to what Prof. Yukari Takamura of Ryukoku University, who is a member of the Global Environment Committee of the Central Environment Council, has to say about COP15 and post-Copenhagen negotiations on climate change.

How should we evaluate the Copenhagen Accord of which the Copenhagen Conference (COP15) has decided to "take note". As COP15 fell short of officially adopting it and only decided to "take note," the Copenhagen Accord became a political accord that is binding on only countries that consent to it. The fact that a majority of countries supported it does not automatically make the Copenhagen Accord the basis for negotiations on the next framework. This appears to be the basic difference from the case where the COP had officially adopted the Copenhagen Accord.

In light of the negotiations held so far, the Copenhagen Accord does represent progress in several areas. First of all, the Copenhagen Accord describes emission reduction efforts by industrialized countries and those by developing countries in the same document, making it an agreement that goes beyond the previous bipartite structure of "industrialized countries that make commitment" and "developing countries that avoid commitment." In response to the entirely new situation of the appearance of emerging economies that increased emissions rapidly over the past decade or so, the Copenhagen Accord offers prospects for transcending the dogmatic dichotomy and establishing an effective framework for prevention of global warming. Secondly, mitigation efforts by developing countries were promised concretely and institutionally, and their progress and effects will be subject to international verification. Unlike developed countries that are committed to the implementation of mitigation targets, developing countries implement mitigation actions and communicate their actions. Mitigation actions with international support will be subject to measurement, reporting and verification in accordance with international guidelines, while mitigation actions by developing countries not supported internationally will be subject to their domestic measurement, reporting and verification and they will communicate information on the implementation of their actions for international consultations and analysis. However, the extent and effects of international verification hinge on guidelines to be worked out going forward. Thirdly, there was agreement on the collective commitment of funding by developed countries at present and toward future. Developed countries will provide new and additional resources of $30 billion during the period of 2010-2012 with balanced allocation between mitigation and adaptation by developing countries. In the context of meaningful mitigation actions and transparency on implementation, developed countries also commit to a goal of jointly mobilizing $100 billion a year by 2020 to address the needs of developing countries, with the funding coming from a wide variety of sources, public and private.

Despite these positive developments, however, there seem to remain many problems. Above all, other than the aforementioned mitigation actions and funding goal, many of the matters that should form the basis of the next framework and on which agreement was expected at COP15 still remain unsettled. The Copenhagen Accord does not specify the ultimate legal form of the next framework, or whether commitments are legally binding commitments or not.

Furthermore, under the Copenhagen Accord, developed countries voluntarily decide emission reduction targets and make commitments to them, instead of determining reduction targets through international negotiations among states as was the case with negotiations on the Kyoto Protocol. It is deemed unclear whether this method of voluntary commitments as a whole can ensure the reductions by the levels enabling the achievement of the ultimate objective of preventing global warming or ensure the "comparability of mitigation efforts" over which Japan and other developed countries, other than the United States, have concerns.

The Copenhagen Accord worked out by the world's leaders and supported by a majority of countries in the international community, including the United States and emerging economies, provides a valuable hold to hang onto in advancing slow-moving negotiations on climate change. Key to negotiations on climate change going forward is how to forge final agreement on the next framework by reflecting matters agreed on under the Copenhagen Accord in documents of continuing negotiations and pushing forward negotiations on matters that are not yet sufficiently clear and matters on which there is no agreement yet.

ambitious targets." Japan presented its bold emission target in order to encourage other major economies to make ambitious efforts on measures to address climate change.

Going forward, regarding the post-2012 framework, Japan, based on the Copenhagen Accord, will take the initiative in pursuit of the establishment of a fair and effective framework in which all the major economies participate and the agreement by those economies on ambitious targets.

Section 4 Challenge 25 – A Promise to the Future Generation

As discussed in Section 3, persistent discussions are going on globally on how to proceed with measures to cope with global warming. In parallel with that, the major agenda is how Japan should implement measures to cope with global warming domestically and how Japan should perform the role imposed upon it by the international community.

1 Nationwide System to Realize Challenge 25

As IPCC has concluded that "global warming is beyond doubt," the global warming problem has now come to the situation that allows no further delay or wait and Japan, too, needs to steadily take measures to cope with global warming. Under the Copenhagen Accord, Japan has submitted the target of 25% reduction in 2020 to the UNFCCC Secretariat. In order to achieve the 25% reduction target over the coming 10 years, it is necessary to mobilize all possible policy tools.

To that end, it is essential for all Japanese citizens to join hands and work together, not to mention industries. The Japanese government named actions to preserve the "environment of the earth and Japan" and carry it over to the future generation the "Challenge 25" and has been undertaking active efforts to mobilize the forces of all entities for the campaign.

On the other hand, efforts to get out of the worldwide recession are just entering crucial stages. To that end, it is required to secure new and sustainable demand and employment. In response, the "New Growth Strategy (Basic Policies), adopted by the Cabinet decision in December 2009, has placed the strategy for becoming the world's top environment and energy power through "green innovation" at the top of areas of growth driven by Japan's strengths. Environment-related business can be described as an area of sustainable growth with potential demand, both short-term and long-term, at home as well as overseas. Also, the "Stern Review" released in Britain in October 2006 projected massive social costs in the future unless environment-related projects are addressed now.

Given these circumstances, now is the time to take drastic policy measures, including environment-related investments, to power economic growth and create employment. Furthermore, through these policy measures, we must transform the overall shape of our society into a sustainable one with a view to the future.

New Growth Strategy (Basic Policies)

At present, Japan may be in the long tunnel of decline. Major challenges are looming before us, including the scars from the Lehman Shock, public finances that have deteriorated to the state right after the end of the last war 65 years ago, and the fast plunge into the aging society with fewer children. However, opportunities for growth still abound if we address the current difficulties by looking at the Asian region as the frontier of growth and by taking advantage of Japan's original strengths as an environmental power and a major power in science and technology as well as huge personal financial assets (of approximately ¥1,400 trillion) and real assets like housing and land (¥1,000 trillion). The "New Growth Strategy (Basic Policies)," put together from such standpoint, lists the strategy for becoming an environment and energy power through "green innovation," or economic growth led by green innovation, at the top.

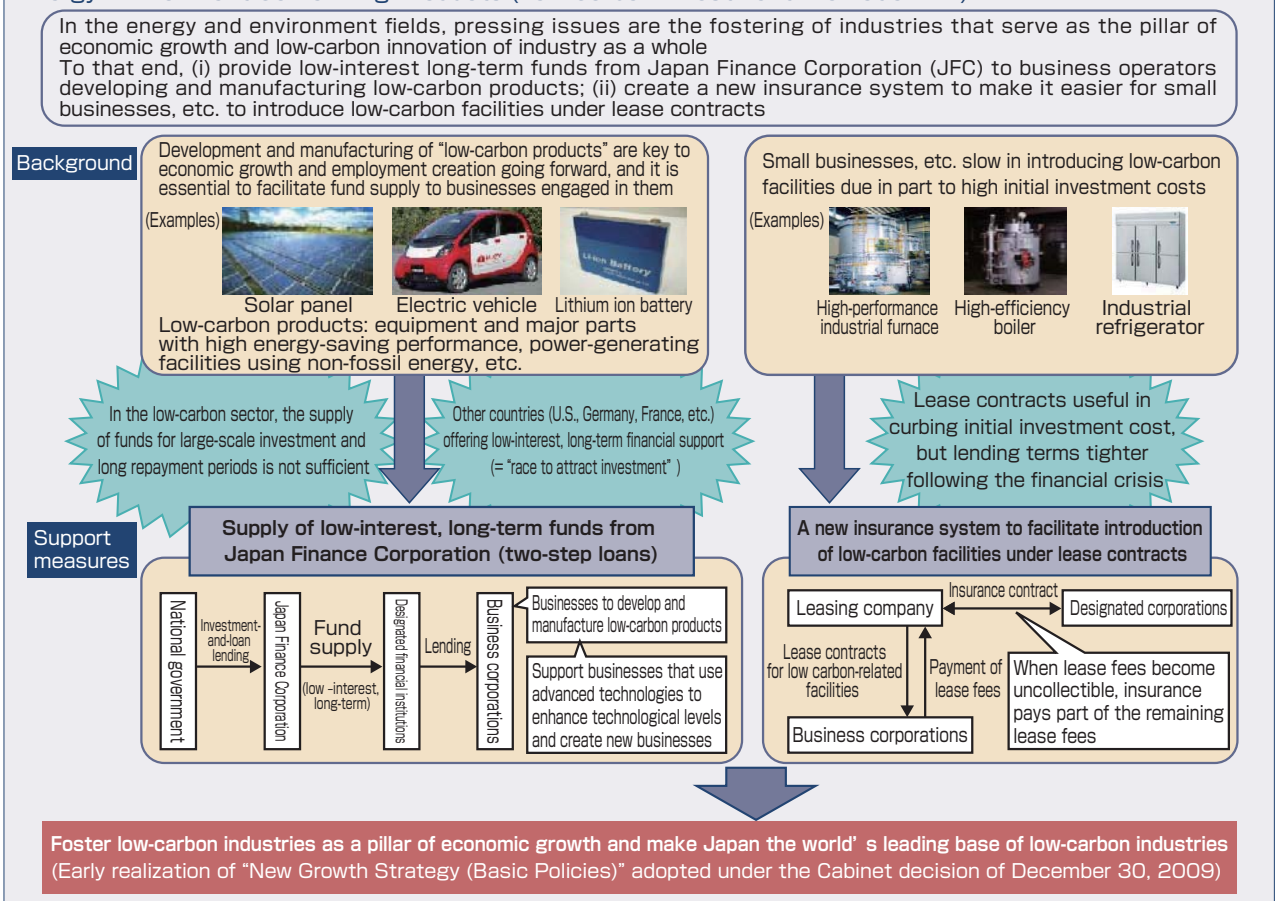
More specifically, as growth from green innovation, the New Growth Strategy states that "Japan will be transformed into a low-carbon economy and society through measures to support the spread and expansion of renewable energies (solar, wind, small-scale hydroelectric, biomass, geothermal, etc.) by expanding the electric power feed-in tariff system, promoting low-carbon investment and financing (Figure2-4-1), and expanding the use of information and communications technologies." Japan will be also "steadily pursue the use of nuclear power, while gaining the understanding and trust of the Japanese people, with safety as the top priority," it says.

The New Growth Strategy further states: "We will speed the development of innovative technologies including storage batteries, next-generation vehicles, improved thermal power plant efficiency, and information and communications systems with lower electric power consumption. Moreover, we will realize comprehensive greenhouse gas emissions reductions in the transportation and household sectors by promoting modal shifts, encouraging the use of energy-conserving consumer electronics and the like."

Japan will also achieve efficient electric power supply and demand through a Japanese-version smart grid linking electric power suppliers and electricity users via information systems, and spark new demand through related equipment in households, promoting this as a growth area. Further, Japan will also support the acquisition of shares in related growth markets overseas.

Lifestyle reforms through improving the comfort and quality of life are also an important challenge in trying to shift to a low-carbon society and realizing economic growth. The New Growth Strategy says that Japan will "promote zero-emission homes, offices, and other facilities through the spread of eco-housing, the expanded use of renewable energies, the spread and expansion of heat pumps, and the 100% adoption of light-emitting diodes (LEDs), organic electroluminescent lighting, and other forms of next-generation lighting," and states that this will also be directly linked to improving the comfort of living spaces and the quality of life and can be expected to "constitute the start of a major voluntary shift toward low-carbon lifestyles." In order to promote the realization of zero emissions in the household sector,

Figure2-4-1 Bill for the Act Concerning the Promotion of Businesses for Development and Manufacture of Energy Environment Conforming Products (Low-Carbon Investment Promotion Bill)



Source: Ministry of Economy, Trade and Industry

Japan will create an "environmental concierge system" providing advice to individual households.

Japan also needs to simultaneously create "green cities" by promoting the rebuilding and remodeling of superannuated buildings. "To make Japan's urban areas into 'green cities' with low greenhouse gas emissions, we will fundamentally revise the approach to urban planning, urban renewal, and urban redevelopment from an environmental and low-carbon perspective … We will also devise the necessary deregulation and support measures to promote the redevelopment, rebuilding, and remodeling of superannuated office buildings and other structures that have problems relating to greenhouse gas emissions and safety," according to the New Growth Strategy.

In order to reform the socioeconomic structure in this manner, individual local areas also need to achieve reforms of their socioeconomic structures. To that end, the Japanese government will support initiatives to create an eco-friendly society, including promoting the use of public transportation and other measures to create low-carbon urban and regional structures, advancing renewable energies and constructing a smart grid to support them, realizing thorough and appropriate resource recycling, utilizing information and communications technologies, and turning homes and other buildings into zero-emission structures. Japan will implement intensive investment projects with not only the environment but also health and tourism as the main pillars, making use of a comprehensive policy package including regulatory reforms and green tax reforms, thus marking "the first step toward the transformation to a sustainable socioeconomic structure originating from self-supporting local regions."

Through the comprehensive implementation of these measures, Japan will seek a transformation to a low-carbon society, by also setting economic growth goals as the creation of over ¥50 trillion in new environment-related markets and 1.4 million new environment sector jobs by 2020, according to the New Growth Strategy.

Green Taxation for Climate Change Policy (Promotion of a Low-Carbon Society)

The greening of the tax system, including the handling of so-called environmental taxes, is an important issue as well. The tax reform plan for FY2010 adopted the "good tax cuts and bad taxation" approach concerning individual indirect taxes. This approach means that when specific goods and services have impacts on the environment and health, etc., tax burdens are mitigated when impacts are favorable and increased when impacts are adverse. Based on the "good tax cuts and bad taxation" approach, the tax system in response to global issues was considered.

Regarding the gasoline tax, local gasoline tax and light

Figure2-4-2 Key Tax Reforms Related to Climate Change Policy in Other Countries

Awareness of environmental problems heightened from the 1980s, and international negotiations on the Framework Convention on Climate Change started (from 19990)		
· 1990	Finland	So-called carbon tax (additional duty) introduced
· 1991	Sweden	CO_2 tax introduced
	Norway	CO_2 tax introduced
1992 Framework Convention on Climate Change adopted【Took effect in March 1994】, Earth Summit held in June (Rio de Janeiro)		
· 1992	Denmark	CO_2 tax introduced
	Netherlands	General fuel tax introduced
· 1993	United Kingdom	Hydrocarbon oil duty raised in phases (until 1999)
· 1996	Netherlands	Regulatory energy tax introduced
1997 Kyoto Protocol adopted【Took effect in February 2005】		
· 1999	Germany	Mineral oil tax raised in phases (until 2003), Electricity tax introduced
	Italy	Excises on mineral oils revised (coal, etc. added)
· 2001	United Kingdom	Climate change levy introduced
October 2003 "EC Directive on the Community framework for the taxation of energy products and electricity" issued【Took effect in January 2004】: Member states set tax rates in excess of the minimum rate for energy products and electricity		
· 2004	Netherlands	General fuel tax integrated with the existing energy taxation (Fuel tax on coal continues (Tax on coal)). Regulatory energy tax restructured into energy tax
· 2006	Germany	Excises on mineral oils restructured into Energy tax (coal added)
· 2007	France	Coal tax introduced
· 2008	Switzerland	CO_2 levy introduced

Source: Data from relevant governments and OECD

oil delivery tax, all imposed on fossil fuels, provisional tax rates set in April 2008 to run for 10 years, were abolished under the tax reform for FY2010. However, these tax rates were retained, for the time being, in consideration of the strained state of public finance and the impact of fossil fuel consumption on global warming. More specifically, while the higher provisional tax rates were abolished, it was decided that tax rates of the gasoline tax, local gasoline tax and light oil delivery tax would be maintained at the pre-reform levels for the time being. However, if the average benchmark gasoline retail price exceeds ¥160 per liter for three successive months, the portions of fuel taxes in excess of the tax rates set under main rules would be suspended. Further, for the automobile weight tax, graded multiple tax rates were established in accordance with environmental burdens of automobile bodies as part of the greening of the tax system. The so-called "eco-car tax reduction" scheme was also maintained.

Meanwhile, regarding overall environmental tax systems, European and other countries have been revamping and strengthening environmental tax systems, including energy and automobile-related taxes, since the 1990s (Figure 2-4-2). In Japan, the ratio of environmental tax revenues to gross domestic demand (GDP) is low relative to the ratios in European countries. Concerning taxation for climate change policy, the Ministry of the Environment convened the expert committee on green tax system and its economic analysis, etc. of the Central Environment Council to deliberate on an economic analysis, etc. of green tax system, including tax for climate change policy. In FY2009, the Ministry of the Environment requested the creation of a tax for climate change policy, while the Ministry of Economy, Trade and Industry also asked for the consideration of a tax for climate change policy. A supplementary provision of the law to partially revise the Income Tax Act in FY2010 referred to the tax for climate change policy and said that "it shall be considered for the time being, including the handling of a tax rate, in order to work out a final draft toward implementation in FY2011."

Preferential measures for the promotion of low emission vehicles and energy efficient homes were also incorporated in the FY2010 tax reform plan.

Further, the FY2010 tax reform plan called for consideration of the international solidarity tax in order to resolve global issues. The international solidarity tax is drawing attention as one measure to cope with global issues, including environmental problems as well as the international financial crisis and poverty problems. Various taxation methods are under discussion, including the method to tax international financial transactions to secure resources for measures to deal with financial crises and to curb speculative activities, and the method to tax cross-border transportation to secure resources for development support in developing countries. The idea is spreading internationally, with France, Chile and Korea already introducing the airline-ticket solidarity tax.

Regarding the use of revenues from environment-related taxes, it is noteworthy that an economic model analysis conducted by the Task Force of the Ministerial Committee on the Global Warming Issue found that if the climate change policy tax is introduced as a levy on all carbon emissions based on the carbon content and revenues from the tax are appropriated for measures to cope with global warming, the impact on real disposable income would be reduced significantly compared with the case of all revenues flowing back to the household sector.

Enactment of the Basic Act on Global Warming Countermeasures and Promotion of Measures

In order to clarify the basic direction of Japan's measures to cope with global warming, the bill for the Basic Act on Global Warming Countermeasures was

Figure2-4-3 Outline of the Bill of the Basic Act on Global Warming Countermeasures (Cabinet decision on March 12, 2010)

○Purpose

In recognition of the challenge common to all humankind of prevention of global warming and adaptation to global warming as well as the importance of efforts to prevent global warming under a fair and effective international framework, create a society that emits as little greenhouse gas as possible, can contribute to the global greenhouse gas emissions reduction, and promote global warming countermeasures while ensuring economic growth, stable employment and stable supply of energy, thereby contributing to preserving the global environment and ensuring the present and future healthy and culturally-rich lives of the Japanese people

○Basic Principles

Set forth the following principles as global warming countermeasures:
- Creation of a society that can reduce greenhouse gas emissions while realizing sustained economic growth that ensures prosperous lives of the people and international competitiveness of industry, through the establishment of new lifestyles,
- Active promotion of global warming countermeasures through international cooperation
- Development of industries contributing to the prevention of global warming, expansion of employment opportunities and job stability
- Coordination with energy-related policies and securing of stable energy supply
- Gaining of the understanding about effects and impacts on economic activities and people' s daily lives

○Mid- and Long-Term Goals

- Greenhouse gas emissions reduction goals: Reduce emissions by 25% by 2020 from the 1990 level, premised on the establishment of a fair and effective international framework and agreement on ambitious targets. Also, reduce emissions by 80% by 2050 from the 1990 level, and in this case, the national government shall endeavor to share with all economies the goal of at least halving the global greenhouse gas emissions by 2050.
- Raise the share of renewable energy to 10% of primary energy supply by 2020

○Basic Plan

Formulate a basic plan for the comprehensive and systematic promotion of global warming countermeasures

○Basic Measures

<Concrete measures of particular importance to cope with global warming>
- Creation of a domestic emission trading system (Consider a legislative measure to obtain the final draft within around one year after coming into force of this Act)
- Consideration of a tax for measures against global warming to be implemented from FY2011 and "greening" of the overall tax system
- Establishment of the feed-in tariff system for the whole amount of renewable energy, other measures to promote the use of renewable energy

<People' s daily lives>
- Promotion of energy saving in machinery, appliances, buildings, etc.
- Promotion of voluntary activities
- Promotion of education and learning
- Publication of information on greenhouse gas emissions, etc.

<International cooperation, etc.>
- Securing of international cooperation
- Establishment of a mechanism for evaluation of contribution to emissions reductions in other countries through the provision of technologies and products

<Community building>
- Measures concerning the formation of local communities by the concentration of urban functions, etc.
- Control of greenhouse gas emissions related to transportation through appropriate use of automobiles, etc.
- Preservation and strengthening of absorption of greenhouse gases through development and conservation of forests, promotion of greenery, etc.
- Measures necessary for local governments

<Manufacturing=Monozukuri>
- Promotion of development of innovative technologies
- Promotion of energy saving in machinery, appliances, buildings, etc.
- Shift to energy with less emissions of greenhouse gases, promotion of efficient use of fossil fuels
- Creation of new businesses contributory to prevention of global warming
- Measures concerning nuclear power
- Adaptation to global warming
- Reflection of public opinions in policy formation

Source: Ministry of the Environment

adopted by the Cabinet decision in March 2010 and subsequently submitted to the Diet. The bill incorporates the basic principles concerning global warming countermeasures; responsibilities of the national government, local governments, business operators and citizens; mid- and long-term goals of greenhouse gas emissions reductions, the basic plan for the comprehensive and systematic promotion of global warming countermeasures; and basic measures, etc. (Figure 2-4-3).

The bill for the Basic Act on Global Warming Countermeasures states its purpose as follows: In recognition of the challenge common to all humankind of preventing and adapting to global warming, as well as the importance of efforts to prevent global warming under a fair and effective international framework in which all major economies participate, in order to bring about a society that emits as little greenhouse gas as possible, can preserve and strengthen the absorption of greenhouse gases and can adapt to global warming by contributing to the global greenhouse gas emissions reduction, taking the initiative in the international community to move away from fossil fuels while promoting transformation of the socioeconomic structure, the purpose of this Act is to promote global warming countermeasures while ensuring economic growth, stable employment and stable supply of energy.

The bill sets forth a variety of matters to achieve this purpose as mentioned above. Of them, particularly important are the basic principles, mid- and long-term goals and basic measures. We outline them below.

First, the bill sets forth the basic principles in implementing measures to cope with global warming, which incorporate the following seven items.
- Create a society that can reduce greenhouse gas emissions, and preserve and strengthen the absorption of greenhouse gases while realizing sustained economic growth that ensures the prosperous lives of the people and international competitiveness of industry through the establishment of new lifestyles and other means;
- Actively promote global warming countermeasures through international cooperation by leveraging knowledge, technology and experiences, etc. accumulated in Japan and also in accordance with the

status of Japan in the international community;
- Facilitate the dissemination of research and development, and their results, of technology contributing to the prevention of global warming, etc.;
- Facilitate the development of industries contributing to the prevention of global warming, etc. and an expansion of employment opportunities and ensure job security for those engaged in businesses affected by the promotion of global warming countermeasures;
- Ensure coordination with energy-related measures in a manner that secures the stable energy supply;
- Ensure coordination with measures for disaster prevention, preservation of biodiversity and securing of stable supply of food, etc.
- Gain the understanding of business operators and citizens about the effects and impacts of global warming countermeasures on economic activities and people's daily lives and pay due heed to appropriate fiscal management.

The mid- and long-term goals include the mid- and long-term goals for greenhouse gas emissions reductions and the mid-term goal concerning the supply of renewable energy, both of which cite specific figures. Regarding the former, the bill sets the goals of reducing greenhouse gas emissions by 25% by 2020 from the 1990 level, premised on the establishment of a fair and effective international framework in which all the major economies participate and their agreement on ambitious reduction targets, and of reducing emissions by 80% by 2050 from the 1990 level, and in this case, the bill states that the national government should endeavor to share with all the economies the goal of at least halving the global greenhouse gas emissions by 2050. Regarding the latter, in relation to the achievement of the mid- and long-term

Figure2-4-4 Mid- and Long-Term Roadmap for Global Warming Countermeasures (Outline)
– Draft Proposal by Minister of the Environment Sakihito Ozawa -

【Things that I would like to convey in the Mid- and Long-Term Roadmap】
1) Global warming countermeasures are an urgent issue necessary to protect the environment of Japan and the rest of the world. The roadmap proposes a path of measures and policies for reducing emissions by 25% by 2020 and by 80% by 2050.
2) Promoting environmental investments and practicing a low-carbon lifestyle (or an eco-friendly lifestyle) will allow people to live comfortable, affluent lives – not lives based on tolerance. The efforts of each and every citizen via Challenge 25 are needed in order to achieve mid- and long-term objectives.
3) It is important not to focus on burdens alone but to think of global warming countermeasures as a pillar of new growth. Investing in the construction of a low-carbon society will generate a variety of benefits, including the cultivation of new markets and jobs, revitalization of communities, and ensuring of energy security.

Daily life - Spread of Zero-emission Residential Houses and Buildings -

【Goal】 100% achievement rate of revised energy-saving standards for new buildings*
- Establishment of zero-emission standards that integrate structures (buildings), energy-consuming appliances and other household electronics, and energy-creating devices such as solar light
- Make fulfillment of energy-saving standards and zero-emission standards mandatory
- Tax system, etc. for promotion of new construction and improvement of old buildings
- Making the labeling system and environment performance display mandatory
- Support for making homes zero-emission from a home/GHG consultant
- Creation of a mechanism that visualize housing performance and provides incentives in accordance with reduction amounts

Community Building - Creation of Walkable Communities -

【Goal】 Reduction of driving distance per passenger by 10%*
- Formulate an "action plan to create a low-carbon society" in all municipalities
- Close proximity of residential, commercial and business areas to the station and within the walking distance
- Extension of LRT and BRT, and expedited construction of planned rail routes
- Development of space for sidewalks and bicycles
- Support for promotion of the use of public transportation
- Maximization of the utilization of unused heat in urban areas
- Development of low-carbon municipal districts utilizing local natural resources
- Making distribution and interregional passenger transportation low-carbon

Daily Life - Making Railroad, Marine and Air Transportation Low-Carbon -
- Promotion of introduction of energy-efficient rail cars, ships (eco-ships) and aircraft (eco-planes)
- Promotion of introduction of low-carbon fuels
- Mechanism for cargo owners to choose low-carbon carriers

Community Building - Realizing Zero Carbon Rural Communities -
- Formulation and achievement of "zero carbon plans" in all communities
- Promotion of the use of lumber in buildings, etc., promotion of the use of biomass resources, and utilization of forests, farmland, etc. as sinks
- Spread local energy business models across the country

Daily Life - Environment-Friendly Automobile Market -

【Goal】 Sales of 2.5 million units of next-generation vehicles*
- Heavier/lighter taxation based on CO2 emissions
- Phased tightening of gas mileage standards
- Certification of E10 vehicles
- Promotion of introduction of hybrid and electric vehicles
- Development of high-performance and next-generation batteries
- Promotion of eco-driving and car sharing

Monozukuri - Worldwide Spread of Japanese Low-Carbon Manufacturing

【Goal】 Reduce energy consumption by 30-40%(by 2050)
- Development of markets that reward emission-cutting companies
- Creation of an environment that supports emission-cutting companies financially
- Promotion of information disclosure via financial statements, etc.
- A public disclosure system for calculation reports that evaluate lifecycle emission amounts
- Support for efforts through a GHG consultant system for small businesses
- Support for development of innovative technologies
- Fostering of engineers who engage in "monozukuri" low-carbon manufacturing
- Thorough discontinuation of use of chlorofluorocarbons (control of emissions of three greenhouse gases, including hydrochlorofluorocarbons)

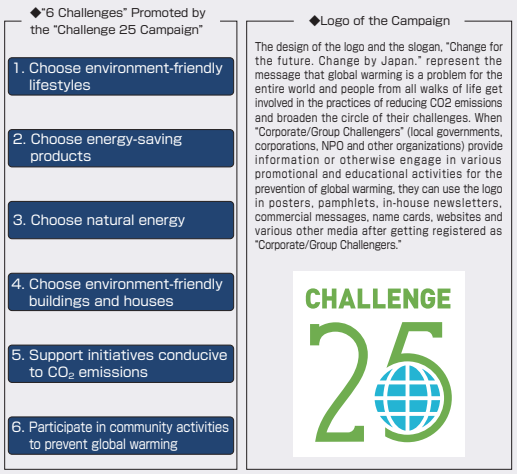
Energy Supply - Next-Generation Energy Supply Aimed at a Low-Carbon Society -

【Goal】 Raise the ratio of renewable energy to at least 10% or more (by 2020), achieve the 100% diffusion rate of smart grid systems (by 2030)
- The feed-in tariff system at levels encouraging business investment (the internal rate of return of 8% or more, etc.), and the green certificate system for heat
- Nurturing of companies and areas that seek to spread the use of renewable energy by reducing business risks and initial burdens
- Making introduction of renewable energy mandatory, and reforming social systems in accordance with diffusion levels
- Enhancement of the power grid and storage systems to withstand the introduction of the large amount of renewable energy, and development of the smart grid
- Making thermal power generation low-carbon using fuel conversion and high-efficiency thermal power generation technology, and expanded use of nuclear power generation, with safety as the top priority

Core Social Systems for Creating a Low-Carbon Society
- The cap-and-trade domestic emission trading system and the tax for global warming countermeasures

Note: Goals without any specified year for achievement are intermediate goals on the road to 2020
Source: Ministry of the Environment

Figure2-4-5 Challenge 25 Campaign



Source: Ministry of the Environment

goals for greenhouse gas emissions reductions, the bill sets the goal of raising the share of the supply of renewable energy to the total annual supply of primary energy in Japan to 10% by 2020.

In addition to the establishment of three major systems – the domestic emission trading system; consideration of the tax for global warming countermeasures and the review of the overall tax system; and establishment of the feed-in tariff system for the whole amount of renewable energy, the basic measures provide for measures for the spread and expansion of the use of renewable energy other than the feed-in tariff system for the whole amount of renewable energy; measures concerning nuclear power; promotion of rationalization of energy use; measures concerning transportation; promotion of development of innovative technologies; promotion of education and learning; promotion of voluntary activities; measures concerning the formation of local communities; preservation and strengthening of the absorption of greenhouse gases; adaptation to global warming; measures for international cooperation; and reflection of public opinions in policy formation, etc.

Of the three major systems specified in the basic measures, the domestic emission trading system, designed for steady reductions in greenhouse gas emissions, sets limits on greenhouse gas emissions by greenhouse gas emitters during a certain period and also allows transactions of greenhouse gas emissions with other emitters for compliance with the limits. The government will consider a necessary legislative measure, in parallel with the consideration of the tax for global warming countermeasures, to obtain the final draft within around one year after coming into force of the Act on Global Warming Countermeasures. In considering the necessary legislative measure, the government will consider the scope of emitters, the method to set the limits on greenhouse gas emissions by emitters during a certain period and other necessary matters concerning the appropriate implementation of the domestic emission trading system. Concerning the method to set the limits on greenhouse gas emissions during a certain period, the government will consider a formula of setting the limits on emissions as an absolute amount of greenhouse gas emissions, in principle, while also considering a formula of setting the limits on emissions as per unit of output and other amounts that indicate the scale of business activities.

The bill also calls for the formulation of a basic plan for the comprehensive and systematic promotion of global warming countermeasures (the Basic Plan). In order to present an image of measures and polices for achieving the goals of reducing greenhouse gas emissions by 25% by 2020 and by 80% by 2050, as well as potential economic effects of these measures and policies, the Ministry of the Environment announced the "Mid- and Long-Term Roadmap for Global Warming Countermeasures (Draft Proposal of Minister of the Environment Sakihito Ozawa)" on March 31, 2010 (Figure 2-4-4). We plan to carefully examine the draft by listening to opinions of the Japanese people going forward in order to make it a much better roadmap.

Furthermore, given such a path of action, we are building up the "Challenge 25 Campaign," a popular movement to promote the Challenge 25 in which all people join hands to protect the "environment of the earth and Japan" and carry it over to the future generation, and will move on to reduce CO_2 emissions from a variety of activities, ranging from manufacturing operations to people's daily lives, by encouraging the practices of the "6 Challenges," including the choice of environment-friendly lifestyles and the choice of energy-saving products (Figure 2-4-5).

Japan will also take the initiative in international negotiations to build a fair and effective framework in which all major countries, including the United States and China, will participate. In order to serve as a bridge between developed and developing countries, Japan will push ahead with measures to support developing countries that actively take mitigation measures under the "Hatoyama Initiative," while closely monitoring developments in international negotiations going forward.

Column The Challenge 25 Campaign, a Popular Movement for Prevention of Global Warming

The world is poised to stand up against global warming, which threatens the survival of mankind.

Japan has ratified the Kyoto Protocol and made a commitment to the world that it will reduce greenhouse gas emissions by 6% from the 1990 level between 2008 and 2012.

At the U.N. Summit on Climate Change in New York in September 2009, then Prime Minister Yukio Hatoyama unveiled Japan's goal of reducing its greenhouse gas emissions by 25% from the 1990 level by 2020, premised on the establishment of a fair and effective framework in which all major economies participate and agree on ambitious targets. The Japanese government is mobilizing all policy tools available to prevent global warming, naming this endeavor as the "Challenge 25" to protect the environment of the earth and Japan and hand over our earth for future ages children.

On January 14, 2010, the government launched a popular movement for this purpose, the "Challenge 25 Campaign," calling on the Japanese people to practice specific actions to reduce carbon dioxide. Well-known people playing active roles in various quarters are also participating as a cheering squad for the campaign. We would really appreciate if you all could participate in this campaign.

"Challenge 25 Campaign" Cheering Squad Captain
Yuzo Kayama,
Actor, singer-songwriter

I am Yuzo Kayama, captain of the cheering squad for the Challenge 25 Campaign. Many people in Japan may not yet have taken concrete actions for the prevention of global warming, but I am sure they feel they must start doing something for the future of the world. I will be making a fresh start and take on the challenge of reducing CO_2 emissions together with everyone else. Please join us in this campaign.

"Challenge 25 Campaign" Super-Adviser
Hiroshi Komiyama
Doctorate of Engineering (University of Tokyo, 1972), 28th President of the University of Tokyo, Chairman of Mitsubishi Research Institute, Inc. since April 2009; adviser to the President of the University of Tokyo

I live in an eco-house and achieved by 81% reduction of CO_2 emissions. In addition, there are other advantages, too. I have no dew formation in the house, it is no longer cold in a washroom, and the initial cost can be recouped. Livability is the key. I will do my best as super-adviser. I would like to ask you to take on the challenge of cutting CO_2 emissions.

"Challenge 25 Campaign" Cheering Squad
Aya Ueto
Actress

I am doing my share of eco-friendly activities by using "my chopsticks" and carrying "my bag." Recently, we are seeing an increasing number of handy, eco-friendly electric appliances, such as cell phones mounted with solar panels. I will keep practicing eco-friendly efforts in my daily life and stay on the diet with CO_2. Let's join on the CO_2 diet together.

"Challenge 25 Campaign" Cheering Squad
Motoko Obayashi
Sportscaster, sports ambassador of the Japanese Olympic Committee

I hear that we might not be able to ski or play beach volleyball 50 years or 100 years from now. Athletes like me are engaged in activities such as sending messages to children for the prevention of global warming at various competition sites. I plan to make more such efforts going forward.

"Challenge 25 Campaign" Cheering Squad
Takeshi Okada
Coach of Japan's national soccer team, promoter of the Global Environment Initiative (GEIN)

I am into efforts to fight global warming, such as serving senior promoter of a group trying to spread the use of renewable energy in Japan. Looking back on my own daily life, however, I have to admit that I am not doing things which I should. I will make more efforts from now on.

"Challenge 25 Campaign" Cheering Squad
Aya Sugimoto
Actress, writer

I feel troubled every time I see wild animals and the beauty of nature sacrificed for economic development. On each occasion, I also feel the arrogance and folly of mankind. I intend to get involved in eco-friendly activities with love and compassion, and would like to sharpen my environmental consciousness.

"Challenge 25 Campaign" Cheering Squad
Ai Sugiyama
Professional tennis player, holder of the world record of participation in 62 successive Grand Slam tournaments, won Grand Slam doubles titles three times, took part in four Olympic Games

I feel temperature rises due to global warming in my bones when I take part in tennis tournaments overseas. Hot weather is making players' environment increasingly more harsh. I plan to start with replacing electric appliances with energy-saving ones in my efforts to shift to an eco-friendly lifestyle.

"Challenge 25 Campaign" Cheering Squad
Tetsuya Bessho
Actor, Representative of "Short Shorts Film Festival & Asia"

Working as an actor, I also serve as representative of an international short film festival and we set up the "Stop! Global Warming" division in 2008. Each year, we receive films with messages for the prevention of global warming from film creators around the world. We would like to send out messages with the mind against global warming to people in Japan as well as the rest of the world. Let's practice the challenge for prevention of global warming together.

2 Efforts by Various Entities Leading to the Challenge 25

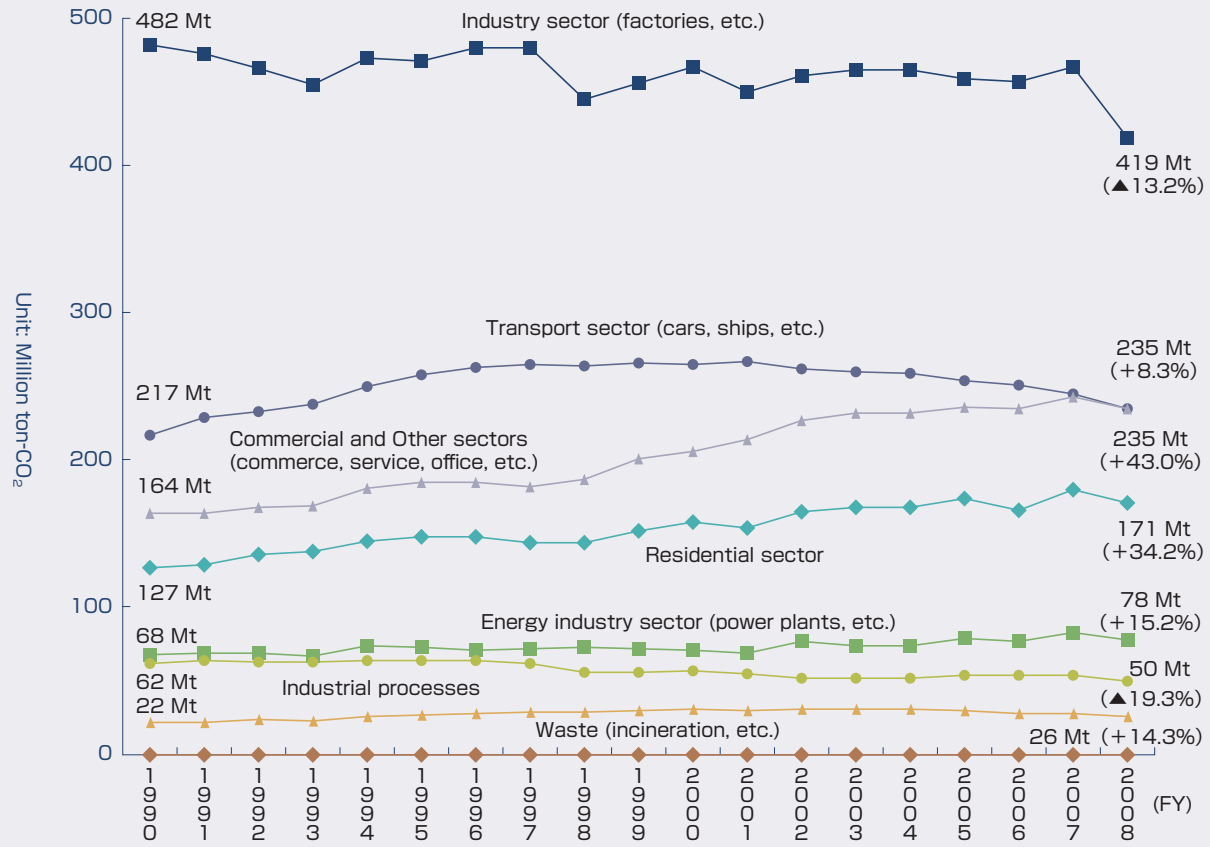
In tandem with government actions as described above, private-sector companies and all other entities heightened their consciousness about global warming and began to make various efforts to reduce carbon dioxide emissions. The "Survey on Environment-Friendly Business Practices," conducted by the Ministry of the Environment since FY1991, shows that over nearly the past 10 years, the largest group of companies have "set forth policies for efforts" to fight global warming and the ratio of such companies has continually been increasing. The Ministry of the Environment also conducts the "Fact-finding Survey on Environmentally Friendly Lifestyles" via the Internet for a questionnaire survey on people's awareness of environmental problems and their behaviors. In the survey results of recent years, the largest group of respondents cited "global warming" as the area of environmental issues they are most interested in, and the ratio of people giving this reply has stayed in the range of 80-90%. These results clearly show people's rising awareness of global warming.

Despite these survey results, Japan's total carbon dioxide emissions unfortunately have not been reduced much in recent years. Total emissions of greenhouse gases in FY2008 amounted to 1,282 million tons (CO_2-equivalent), and were 1.6% higher compared with the base year under the Kyoto Protocol (FY1990 for CO_2, CH_4 and N_2O, and 1995 for HFCs, PFCs and SF_6)*.

Looking at trends of emissions by sector, emissions in the industry sector (factories, etc.) and the transport sector (cars, ships, etc.) have been on the moderate decline due to the effects of various efforts, carbon dioxide emissions in the commercial and other sectors, including commerce, service and office, etc. and the residential sector have been on the increase, canceling out the reductions in the industrial and other sectors (Figure 2-4-6). Reductions of carbon dioxide emissions in the industry and other sectors from FY2007 to FY2008 apparently stemmed from the rapid business slowdown in the latter half of the fiscal years in the aftermath of the financial crisis.

The increasing trend of emissions in the commercial and other sectors, including commerce, service and office, etc. can be traced to an increase in the gross floor space of offices and retail outlets, etc., the associated increase in air-conditioning and lighting facilities, and increased power consumption due to the progress of office

Figure2-4-6 Trends of CO_2 Emissions by Sector (after Allocation of Emissions from Power and Steam Generation)



Note: Figures in parentheses are percentage changes in the FY2008 emissions by each sector from the base-year emissions
Source: Ministry of the Environment

* Total emissions of greenhouse gases in FY2008 is 3.4 % lower compared with the base year (under the kyoto Protocol in FY1990), if estimated by using actual level of unclear power generation in 1998 when its performance was not effected by long suspension.

automation. One of reasons for the higher emissions in the residential sector is increased power consumption resulting from a rise in the number of households. The energy consumption pattern of these sectors is to purchase and use ready-made energy-consuming equipment and appliances and lack professional knowledge

Column Solutions by "Visualization" -- Toward Compatibility of Profit Generation by Companies and Reduction of CO2 Emissions

Greenhouse gases generated by energy consumption are a major source of global warming. In order to protect the comfortable way of life and the livable earth for our descendants, not only companies and industrial plants but also retail outlets and residential houses have been called upon to make energy-saving efforts in recent years.

Since energy like electricity and gases is intangible, we normally cannot see an amount used. However, through "visualization" of an amount used, it is possible to make a detailed analysis of when, where and how much energy is being used. Even in the commercial and civilian sectors of offices and homes, where it was previously thought to be difficult to take measures to reduce carbon dioxide emissions, an unexpectedly large amount of uneven or wasteful use of energy can be found by "visualization" of an amount of electricity consumed.

In recent years, a business was launched to identify the wasteful and uneven use of energy at plants and offices of customer companies and provide advice on improvements through "visualization" of an invisible amount of energy used. Energy-saving and environmental activities based on this technology are also becoming active.

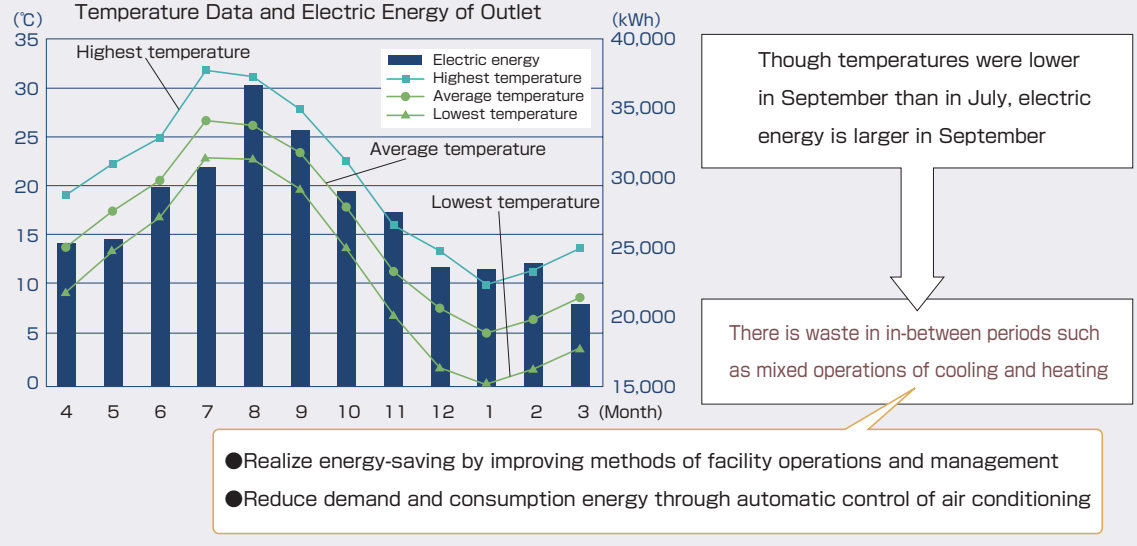
Particularly in the manufacturing sector, where energy-saving activities have been going on for long years, people tend to think that all conceivable improvement measures have already been taken. But more precise energy measurement and "visualization" of each facility and production line should find that there still is unexpected room for further improvement.

Also, the civilian and commercial sectors, which have been increasing carbon dioxide emissions year by year, are assumed to have further room for energy-saving efforts. In the case of companies that operate multiple outlets, attention tends to be focused on energy consumption at these outlets. However, by looking at companies' overall operations and through management of business bases that consume a large amount of energy, such as distribution centers, warehouses and manufacturing plants, we are likely to find further room for reducing carbon dioxide emissions.

Energy-saving activities based on "visualization" have produced remarkable results, notably in the "Kyoto model," of robust eco-friendly activities at municipal kindergartens and elementary, junior high and high schools in Kyoto. Furthermore, through environmental education that utilizes the "visualization" technology, efforts are under way to nurture human resources for building a sustainable society. Energy-saving and environmental activities can be expected to broaden further, spreading from schools to homes and local communities.

Going forward, with the spread of photovoltaic power generation, etc. and through the optimum accommodation of electricity such as prioritized utilization of renewable energy that does not emit carbon dioxide, it can be expected that the compatibility of the comfortable way of life and reductions of carbon dioxide emissions will become feasible and a society that enriches both the environment and people's livelihood will be realized.

Examples of Improvements by "Visualization"



Source: Prepared by the Ministry of the Environment based on data provided by Omron Corp.

about places in offices or homes and how much of carbon dioxide is being emitted. Thus, it is deemed difficult for these sectors to reduce emissions as the industry sector (factories, etc.) does by reviewing and altering their own processes. However, as seen from the results of the "Fact-finding Survey on Environmentally Friendly Lifestyles," people today are thought to be interested in making their own efforts to reduce carbon dioxide emissions. Since the commercial and residential sectors have not yet taken substantial actions to reduce emissions and have a lot of waste and unevenness in the use of energy, there is much to be done in these sectors.

From the viewpoint of further room for global warming countermeasures, it is also very important to take possible measures for the whole spectrum of the supply chain, paying attention not only to the seemingly most principal carbon dioxide emission processes like the process of manufacturing but also to emissions from the process of raw materials procurement (upstream) as well as the processes of shipments and distribution of products, use and disposal, etc. (downstream). In considering countermeasures throughout the supply chain, companies should take note of not only emissions caused by their own activities but also emissions stemming from activities of affiliated companies in business operations, including those overseas.

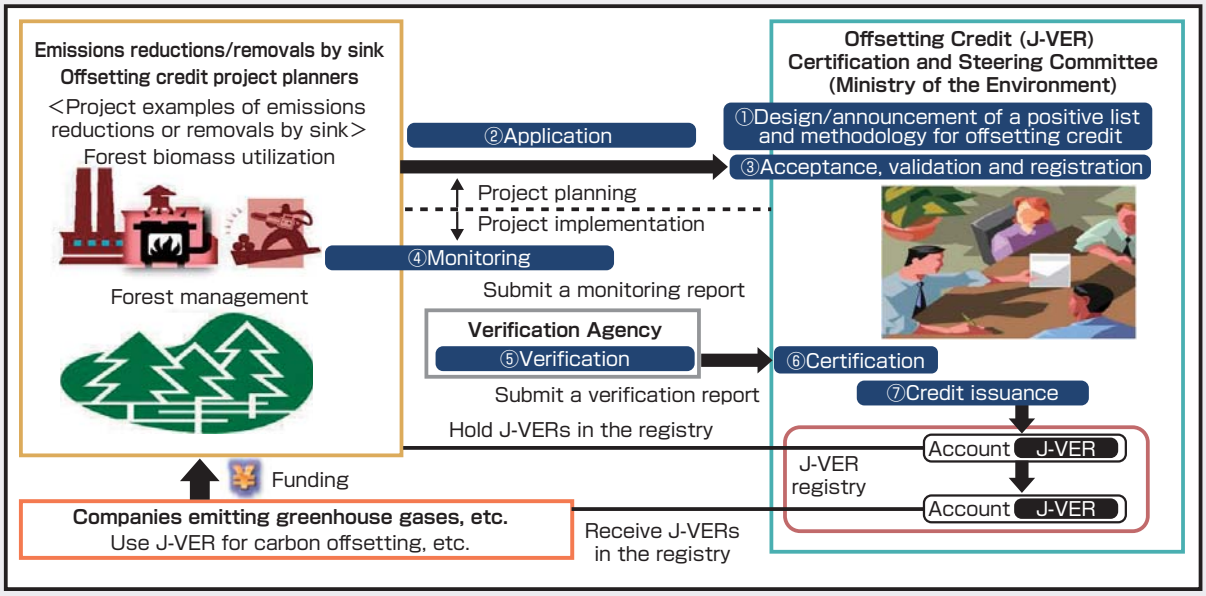
As an example of emissions reduction efforts through the entire supply chain, a diversified chemicals manufacturer succeeded in reducing carbon dioxide emitted in the processes of ore refining to manufacturing by 74% compared with emissions it emits when the company starts from ore refining on its own by focusing on the resources procurement process and switching to the closed loop recycling of scrap aluminum. If Japanese companies are procuring parts overseas or have transferred assembly processes abroad and are emitting large quantities of carbon dioxide, they could transfer Japanese technologies overseas and cut emissions from operations there. Another Japanese manufacturer found that there is considerable room, or waste, in the average trucking load by focusing on the distribution process, an area to which little attention has been paid hitherto. The spread of these efforts is much desired going forward.

If we are to extend the approach of capturing the whole process ranging from upstream to downstream operations comprehensively nationwide, there may be companies in various industries that have to depend on the procurement of raw materials overseas with the low degree of environmental-friendliness, or there may be companies that import products that emitted large quantities of carbon dioxide in the process of manufacturing. In Japan, on the other hand, there are a lot of products that have been manufactured in environmentally friendly processes or that have high environmental performance. It is conceivable that such products are exported and are contributing to emissions reductions in destination countries. Looking at such instances comprehensively, it is desirable that Japanese industry as a whole develops an industrial structure that makes it possible to reduce carbon dioxide emissions from a global perspective.

On this basis, the Japanese steelmaking industry's emissions are about 40% less than overseas steelmakers in terms of an amount of carbon dioxide emitted to produce the same amount of crude steel. By exporting large quantities of steel produced with this excellent technology, it is assumed that Japanese steelmakers are

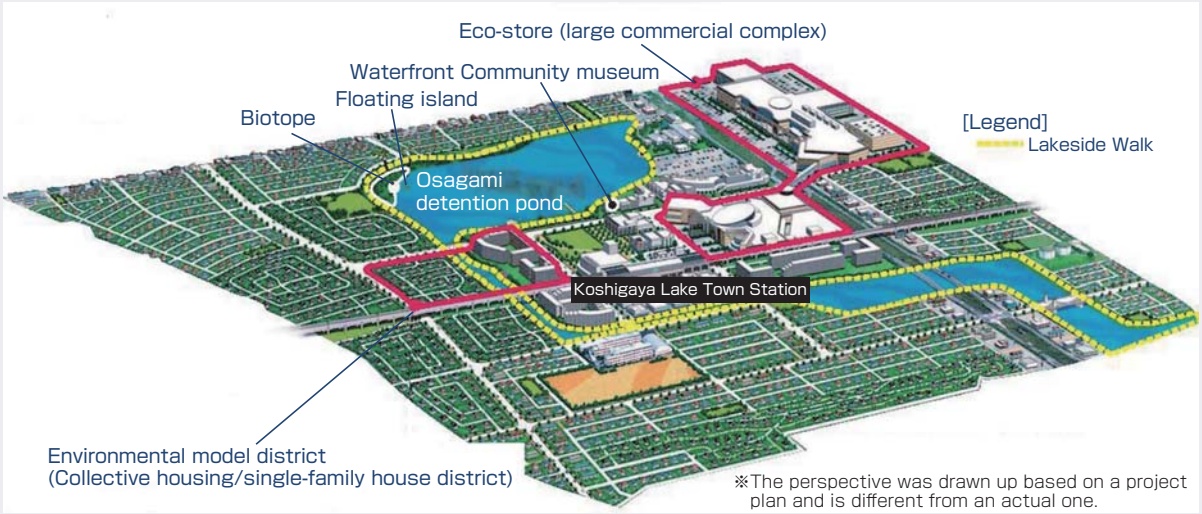
Figure2-4-7 Offsetting credit (J-VER) Scheme

○The scheme for certifying amounts of greenhouse gas emissions and removals by sink in projects undertaken in Japan as offsetting credit (J-VER) with certain reliability used for carbon offsetting. The scheme was created by the Ministry of the Environment in November 2009.
○Under the scheme, funds for carbon offsetting by citizens, companies and municipalities, etc. (funds to purchase J-VER) flow back to planners of domestic emissions reduction/removal projects, such as local forest management and local industries



Source: Ministry of the Environment

Figure2-4-8 Koshigaya Lake Town Land Readjustment Project



Source: Saitama Regional Branch Office, Urban Renaissance Agency

contributing to emissions reductions by 14 million tons (equivalent to a little more than 1% of Japan's gross emissions) globally in 2007, the net of the impact from steel Japan is importing from foreign countries. A Japanese automaker, in its "Sustainability Report 2009," stated that the company has sold a cumulative total of over 1.8 million hybrid vehicles, including to overseas markets, claiming that the cumulative global effects of carbon dioxide emissions reductions would exceed 10 million tons. In water purification technologies used, for instance, for seawater desalination, Japanese companies excel in the reverse osmosis membrane method. One membrane maker estimates that it has contributed to reducing carbon dioxide emissions by some 9.4 million tons globally in 2007 by spreading its membrane technology worldwide to replace the conventional evaporation method. As demonstrated by specific examples cited above, some Japanese companies have already been playing major roles in reductions of greenhouse gas emissions overseas. By continuing similar efforts in various industry sectors, Japan, as stated in the New Growth Strategy, should aim to reduce global greenhouse gas emissions by about 1.3 billion tons-CO2, almost the same amount as Japan's gross emissions, by taking advantage of superb technologies developed in the private sector.

Provision of information, or "visualization," on carbon dioxide emissions from various goods and services used by people (both individuals and corporations) who are aware of global warming problems and want to reduce carbon dioxide emitted from their daily life or business activities should give a strong boost to their actions and behaviors. Also, in response to people's growing consciousness of global warming, we are entering an era in which active efforts to reduce emissions of carbon dioxide help enhance the brand value of companies and their products. Against this backdrop, for example, there are an increasing number of companies that donate carbon dioxide emission rights purchased overseas to the national government for carbon offsetting while trying to improve the image of their brands by offering goods and services that come with carbon offsetting. Regarding the green electricity certificate system, essentially a similar scheme to carbon offsetting, the amount of contracted electric energy has been increasing sharply in recent years. As for the government's responses regarding carbon offsetting, for example, the Ministry of the Environment is operating the offsetting credit (J-VER) system to contribute to reductions and removals of carbon dioxide emissions by supporting carbon offsetting and at the same time to direct a flow of private-sector funds to mountainous villages for local revitalization (Figure 2-4-7).

In order to support small businesses' efforts to reduce carbon dioxide emissions, in tandem with the trial implementation of a domestic integrated market for emission trading, the domestic credit system was initiated in October 2008 for the certification of greenhouse gas emissions reduced by small businesses by employing technologies and funds provided by large corporations, which then use certified amounts to help achieve reduction targets incorporated in their voluntary action plans, etc.

We have also seen the emergence of bold attempts to reduce carbon dioxide emissions from residential houses and commercial facilities in communities as a whole. Tokyo's Chiyoda Ward, pursuant to an ordinance on global warming countermeasures enacted in January 2008, started replacing street lights managed by the ward office with energy-saving lights in FY2008 as part of its initiative to reduce electric energy used in ward facilities. Assuming that all of the 5,501 street lights managed by the ward are replaced with energy-saving ones, electric energy used would be reduced by some 2.5 million Kwh, an amount equivalent to the annual consumption of electric energy by some 700 households. In Koshigaya, Saitama Prefecture, meanwhile, the "Koshigaya Lake Town" land readjustment project, for which the Urban Renaissance Agency serves as a constructor, is aimed at community-building for

environmental coexistence, establishing dedicated lanes for bicycles and building a compact town by locating most of residences within walking distance of 15 minutes from a railway station. The project also makes use of cool air flowing from a detention pond as well as the solar central heating for a housing complex. A large-scale commercial complex at the project site has introduced high-efficiency air conditioning using city gas (the hybrid gas eco-system) and photovoltaic power generation, reducing carbon dioxide emissions by 20% compared with conventional shopping centers.

The Koshigaya Lake Town, for its eco-friendly community-building efforts, won the project gold award of the international awards for environmentally sustainable community-building at the LivCom2009, the only international awards system in this area.

As seen above, companies' voluntary purchases of carbon dioxide emission rights and relatively expensive green electricity and the private sector-led large-scale projects explicitly aimed at carbon dioxide emissions indicate the penetration of the significance of global warming countermeasures among people and also suggest the generation of specific methodologies for economic growth while preserving the environment at the same time.

Efforts and measures to cope with global warming are not limited to Japan alone. Besides, if solutions to global warming problems would come only at the expense of people's cultures and affluence, no countermeasures could be implemented on a sustained basis. Innovative technologies are required to take countermeasures without sacrificing the standards of living. As cited in the New Growth Strategy, Japan's environmental technologies are so excellent as to be able to contribute to reducing global carbon dioxide emissions and also prove to be the largest strength of the Japanese economy going forward.

We do not need to mention again Japan's technological edge in hybrid vehicles, rechargeable batteries or heat pumps. Aside from these technologies, Japanese companies command a global market share of 90% for electric energy-saving displays and materials for organic EL, which is very promising as the next-generation lighting (Figure 2-4-9), and Japan also has the world's leading technologies and market shares for power semiconductor devices used in photovoltaic power generation systems and hybrid vehicles, whose market is continuing to expand at an annual rate of nearly 20%. Furthermore, as mentioned earlier, the New Growth Strategy has set forth the goal of reducing worldwide greenhouse gas emissions by at least 1.3 billion tons of CO2 equivalent using Japanese private-sector technology. Indeed, Japan can be described as being in a good position to fully realize the "environment-led economic development."

However, given the state of affairs in other countries and fierce international competition, it is not necessarily easy to spread Japanese products and technologies worldwide. Japan's energy-saving technologies require sophisticated knowledge about maintenance and management for their optimum operation, and some developing countries may find costs of technological transfers too high, and the adequate protection of intellectual property rights is essential for companies' continued development efforts and diffusion of developed technologies. Therefore, for the transfer and spread of Japanese technologies, it is necessary to specify and develop technologies most suitable to the conditions of recipient countries, foster human resources to maintain and manage transferred technologies, provide appropriate financial support and improve legal systems. In order to facilitate these efforts, we should also consider ways to proceed with these efforts in "win-win" relationships with counterparty countries by effectively utilizing mechanisms for support for developing countries through the Hatoyama Initiative and by building a mechanism for appropriate evaluation of contributions by companies that offer Japan's renowned clean technologies as well as product infrastructures and production facilities.

On the other hand, Japan's industry should not forget to lead the world in the pursuit of further sophistication of environmental technologies and take the initiative in introducing top-runner production technologies. According to a survey by the New Energy and Industrial Technology Development Organization (NEDO), if the thermal efficiency of Japan's coal-fired thermal power plants is replaced by top-runner equipment, it would potentially reduce carbon dioxide emissions by about 4 million tons.

These endeavors would have to overcome difficult technological challenges, but Japan's underlying strength certainly has that potential and Japan is being called upon to use its technological prowess to contribute to solving the problem of global warming. In the course of overcoming these challenges, it is possible that we will see the birth of "export products" that strongly power the Japanese economy going forward.

Figure2-4-9 Organic EL Lounge

Photo: Yamagata Promotional Organization for Industrial Technology

Column Quantum Dot Photovoltaic Power Generation

The solar cell technology is of extreme importance for global warming countermeasures. However, the energy conversion efficiency of solar cells is approaching the silicon-based theoretical limit of 29%, thus calling for the development of new materials or new structures to carry solar cells beyond this limit. Expectations are high that quantum dots will play an important role in breaking through the performance limit of existing solar cells. Ideally, the use of quantum dots should make it possible to raise the energy conversion efficiency to at least 60%. When light-collection systems are used, it is possible to generate the equivalent amount of electricity with 1/1,000 of an area of existing solar panels.

Semiconductor quantum dots are the innovative basic technology born in Japan in 1982 through research by Prof. Yasuhiko Arakawa and other researchers. In the solar cell mechanism, when sunlight hits semiconductors, electrons move to create the current of electricity. However, electrons move around freely on existing silicon-based semiconductors, and only electrons that reach electrodes can be taken out, creating the limit on electricity produced. Suppose that a box called "quantum dot," with a size of 10 nanometers (1 nanometer is one billionth of a meter), is placed in here. If the box's potential is low for electrons, electrons become confined in the box and lose the freedom of movement (See a chart on the right). Electrons confined in the box reach electrodes quite efficiently. We can control the energy of electrons (oscillation frequency) by changing the shape of the box. It is just like the way that wind instruments have different tones and pitches according to their shapes. As shown in a chart on the left side, we can change the properties of electrons freely by capturing and confining them in the small box called quantum dots.

Main factors for the energy loss that impose limits on the energy conversion efficiency of solar cells are the transmission loss from not being able to absorb energy from all wavelengths of solar light and the thermal loss that occurs when energy that is larger than the optical energy that can be accepted, causing energy to turn into heat within semiconductors. By utilizing the energy discreteness of quantum dots, it becomes possible to control the thermal loss. Through various forms of ingenuity, we can also eliminate the transmission loss. Through these steps, ideally, it is possible to achieve the energy conversion efficiency of 60% or over.

Up until now, compound semiconductors were mainly used as materials for quantum dots. But it is expected that silicon-based quantum dots will come into being ultimately. At the moment, however, there is a mountain of hurdles to clear before this can be achieved, and long-term research and development efforts required. For example, complete control over the size and location of quantum dots is essential, along with development of high-quality materials. Further, there remain a lot of things that need to be clarified fundamentally.

Quantum dots are an area of research where Japanese researchers have led the world in promoting research and development activities. Regarding the application of the technology to quantum dot solar cells, it is hoped that they can contribute to the realization of high-efficiency solar cells by further gathering up the excellence of intellectual capital in Japan. However, it would be dangerous to have bloated expectations in the short run and long-term research and development efforts over a span of 20 to 30 years are required. Going forward, Japan needs to establish the research and development structure for quantum dots, including the fostering of many researchers and developers from a broad spectrum of research areas. In the future, quantum dot solar cells will certainly be positioned as one of the most important infrastructure devices for the generation of green innovation.

Conceptual diagram of quantum dot and electron microgram

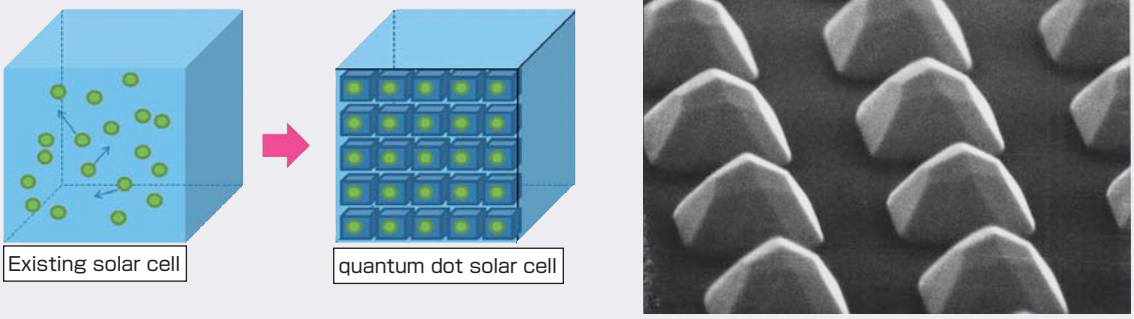


Photo: Prof. Yasuhiko Arakawa, Director of the Institute for Nano Quantum Information Electronics (NanoQuine), University of Tokyo

3 Life of the Future Generation after Reductions in Greenhouse Gas Emissions

What is a low-carbon society, a society after emissions of greenhouse gases were reduced thanks to global warming countermeasures in which each and every entity took part, is like? In the preceding sections, we have asserted that environmental measures should not be taken as constraints on economic growth and we instead should encourage green innovation for economic growth and promote the environment industry. Global warming countermeasures require efforts over a long span of time. How does the Japanese society look in 2050, the target year of long-term goals?

There are a variety of ways to reduce carbon dioxide emissions, and there are also a variety of scenarios for the starting years of introduction of technologies and policy measures. Needless to say, the shape of society in 2050 will change depending on what scenario is put into place.

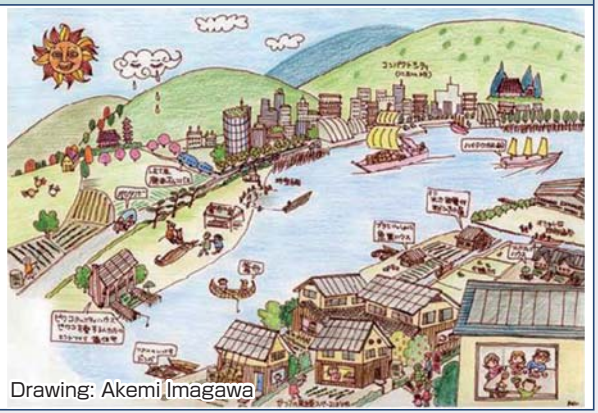
The desirable socioeconomic shape is not uniform and varies among people. For example, the Ministry of the Environment, under the "Comprehensive Research Project Concerning the Establishment of Methods for Multifaceted and Comprehensive Evaluation, Forecast and Planning of Mid- and Long-Term Policy Options toward the Post-Global Warming Society (hereinafter referred to as "the Japan Low-Carbon Society Scenarios towards 2050 Project"), a strategic R&D project sponsored by the Global Environment Research Fund (GERF), assumed economic development/technology-oriented Scenario A and community/nature-oriented Scenario B and envisioned their respective concrete images, including demand for energy and services, using the backcasting approach of first assuming desirable socioeconomic visions of 2050, then investigating whether the visions are feasible and lastly verifying what should be done to realize the visions (Figure 2-4-10).

Under economic development/technology-oriented Scenario A, the rate of technical progress is high against the backdrop of active investment in technological development by both the corporate and government sectors, with economic activities vigorous in the society as a whole to maintain per-capital GDP growth of 2% annually. Supporting the high economic growth, on top of the advancement of technology, are active personal consumption and the strong willingness to work. For employment, there is little discrimination between the young and old or between genders, with no nationality-based barriers. The norm for employment is the ability, character and expertise of each individual, and in this sense, the equal opportunity for employment has been achieved. Most of domestic work previously taken care of by women is either outsourced or mechanized, allowing people to have much time to spend on realizing "personal dreams," like using time outside work for career progression. Personal consumption is robust, as people readily accept new technologies, products and services, leading to relatively short replacement cycles. The numbers of people per household declines, individuals have precedence over families, and young and elderly people living alone increase. The population increases in urban areas than in rural regions, and more people prefer collective housing over single-family detached houses, tending to choose convenient lifestyles.

In community/nature-oriented Scenario B, per-capita GDP growth is lower at 1% a year, but people are sufficiently provided with necessary services, with volunteer and other activities not covered by economic data undertaken actively. As it is possible to get sufficient medical services and education in rural regions as well,

Figure2-4-10 Two Social Visions for Building a Low-Carbon Society

Scenario A: Vigorous, growth-oriented	Scenario B: At ease and self-sufficient
Urban/individuals first	Decentralized/community-oriented
Technological breakthrough by centralized production and recycling	Local production for local consumption, production and consumption of what is necessary, "Mottainai" spirit
Pursuit of a more convenient and comfortable society	Respect for social and cultural values
Per-capita GDP growth of 2%	Per-capita GDP growth of 1%



Drawing: Akemi Imagawa

Source: Prepared by the Ministry of the Environment based on "2050 Japan Low-Carbon Society Scenario Team" (National Institute for Environmental Studies (NIES), Kyoto University, and Mizuho Information and Research Institute)

with inconvenience in daily life all but eliminated, many people move to areas (including rural regions) more suited to their lifestyles, resulting in the dispersion of population and capital from urban centers to rural regions. As a consequence, people who live in single-family detached houses increase, with many people owning houses with gardens in agricultural communities, and the number of people and floor space per household are likely to increase. As for working life, the pattern of husbands and wives adjusting their work to secure enough income to support their families' life plans will have spread and taken firm root. Family members share domestic work, or in many cases, they make use of charge-free services offered by volunteers or NGOs in communities. People have more time to spend with family members, and an increasing number of people use their leisure time for hobbies, sports and individual enrichment courses, or engage in volunteer activities, farm work and community activities. The socioeconomic image presented under Scenario B is a community where diverse characters respect others and live with the wisdom of cooperating on the basis of their respective strengths.

Actually, Scenarios A and B under the Japan Low-Carbon Society Scenarios towards 2050 Project, commissioned by the Ministry of the Environment, are not much different from various other long-term projections for the future of the Japanese society previously presented and are well within the various assumptions. So, the Project estimates that the two scenarios, in reality, would probably move ahead in harmony or cutting across each other in times, eventually leading up to these socioeconomic visions. The Project also demonstrated that under both scenarios, it would be possible to reduce carbon dioxide emissions by 70% by 2050 from the 1990 level. Furthermore, on the basis of the Project's research results, the Ministry of the Environment, taking economic efficiency and policy feasibility into account, examined whether it is technologically possible to secure the supply of energy to meet demand while cutting carbon dioxide emissions by 80%. The conclusion of the examination is that the 80% reduction is possible.

It is also possible to imagine the future vision from the perspective of technological innovation. The concrete image of a low-carbon society, depicted by the Global Environment Committee of the Central Environment Council in FY2008 based on hearings with a total of 18

Figure2-4-11 Concrete Image of a Low-Carbon Society - Community

Big cities/midsize cities

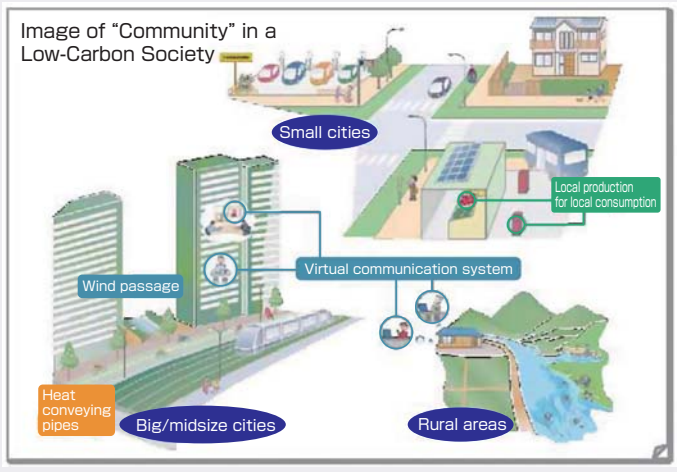
- ■Formation of a livable and bustling compact city
- ■Roads improved for safe riding of bicycles
- ■Use of personal moving vehicles
- ■Public transport network combining railways, buses and LRT in accordance with the size of city and existing infrastructure
- ■Higher ratio of collective housing, proximity of residence to workplace
- ■Active utilization of unused urban energy like sewage, sludge, etc. (the same applicable to small cities); with heat conveying pipes in place, effectively utilize waste heat and other energy sources at the district level
- ■The heat island phenomenon mitigated, with greenery for wind passage and waterfront secured
- ■Can observe starlit sky thanks to reduced outdoor lighting and advertisement
- ■Flood-control facilities in place to prevent urban flooding due to concentrated downpours

Small cities

- ■When the number of households declines, business & commercial facilities and residential areas concentrated around the core railway station, with green space and farmland preserved in surrounding areas
- ■Buses, with substantially enhanced convenience thanks to progress of ICT, play a central role as public transportation systems; buses with various sizes in operation depending on demand (the same applicable to rural areas)
- ■ Farmland surrounds urban areas, a favorable environment for local production for local consumption
- ■For mid-rise buildings, the ratio of wooden buildings using domestic lumber and wooden/steel frame hybrid buildings rise
- ■Due heed paid to local livelihood, history and culture by building natural rivers; flood control, together with preservation and creation of the biological environment and river landscape make cities resilient to natural disasters

Rural areas

- ■Secure CO_2 sink via promotion of forest development and preservation
- ■Primary industries revitalized by expansion of operational size and efficient production
- ■Automobiles have a high ratio as means of travel, but they are motor-driven or powered by biofuels
- ■Most of houses and structures wooden
- ■Sources of supply energy and products are biomass based on waste generated in areas, unused biomass such as rice straws and thinned wood, and resource crops
- ■Efforts to utilize biomass that abounds in rural areas spreading nationwide under partnership among local parties
- ■Due to sophisticated communication systems, jobs available while living in nature-rich rural areas; also possible to receive sufficient medical services and education in rural areas
- ■Further public functions via forest development and preservation contributing to prevent mountain disasters; adaptation according to rural conditions



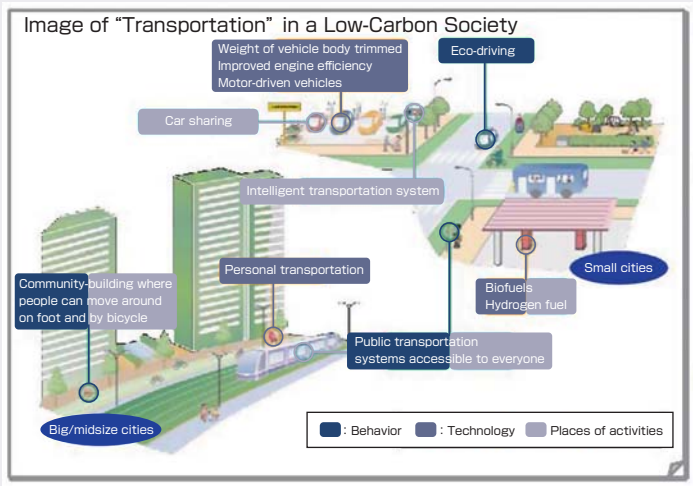
Community Size and Components of a Low-Carbon Society
Components with higher diffusion rate than other areas underlined

	Big cities/midsize cities	Small cities	Rural areas
Transportation	Walk/bicycles	Walk/bicycles	Walk/bicycles
	Personal moving vehicles	Personal moving vehicles	Personal moving vehicles
	Railway/LRT	Railway/LRT	Railway/LRT
	Buses	Buses	Buses
	Automobiles (motor-driven, biofuels)	Automobiles (motor-driven, biofuels)	Automobiles (motor-driven, biofuels)
Housing/structures※	High-rise housing/structures	High-rise housing/structures	High-rise housing/structures
	Mid-rise housing/structures	Mid-rise housing/structures	Mid-rise housing/structures
	Low-rise housing/structures	Low-rise housing/structures	Low-rise housing/structures
Energy	Solar light/heat	Solar light/heat	Solar light/heat
	Heat accommodation	Heat accommodation	Heat accommodation
	Wind power	Wind power	Wind power
	Bio energy supply sources	Bio energy supply sources	Bio energy supply sources

※Broad classification: Low-rise 2-3 stories; mid-rise 4-7 stories; and high-rise 8 or more stories

Source: Prepared by the Ministry of the Environment based on "2050 Japan Low-Carbon Society Scenario Team" (National Institute for Environmental Studies (NIES), Kyoto University, and Mizuho Information and Research Institute)

Figure2-4-11 Concrete Image of a Low-Carbon Society - Transportation



Behavior

- With "visualization" of CO2 emissions for each transportation means and intelligent transportation systems, movers have access to information on operations of public transportation systems anytime and choose transportation means with less environmental burden based on information obtained
- Co-ownership and rental are main forms of vehicle use in urban areas
- Residents actively participate community-based manufacturing in various forms
- Cargo owners and distributors proactively choose low-carbon transportation means

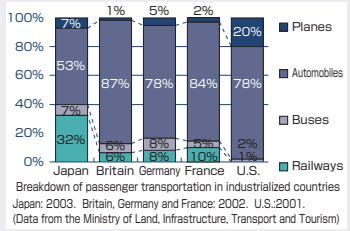
Technology

- Individual automobiles become substantially efficient with the spread of lighter auto body, improved engine efficiency, and motor-driven vehicles (plug-in hybrid vehicles, electric vehicles, fuel cell-powered vehicles)
- Various kinds of (single-passenger) personal moving vehicles introduced; choices of transportation means substantially wider
- Intelligent transportation systems contribute to easing traffic congestion and improving transportation efficiency; autonomous driving of moving vehicles realized; substantially higher safety of vehicles greatly reduces traffic accidents

Foundations supporting behavior and technology

- Public transportation systems like railways, buses, monorails & LRT operate with the appropriate selection and combination in accordance with the size of cities and their characteristics
- Distribution managed in a sophisticated way with advanced information technology; with freight infrastructure such as freight railway stations and port facilities well developed, the low-carbon distribution system in place with the appropriate combination of railways, ships, automobiles and trucks (greater efficiency with mass transportation systems and joint collection/delivery of cargos)
- Compact cities friendly to pedestrians, bicycle riders and the elderly formed with transit malls and dedicated bicycle roads with stations of public transportation systems at the core
- Under the well-developed car sharing system, people rent cars with right sizes when necessary
- bicycle rental services spread widely under management systems utilizing sophisticated information technology
- Roads with smooth traffic without jam-up realized through promotion of measures to ease congestion, such as loop road construction, to deal with bottleneck railroad crossings, and diversified and flexible expressway tolls; automobile traffic operations more efficient via improved provision of road traffic information using intelligent transportation systems

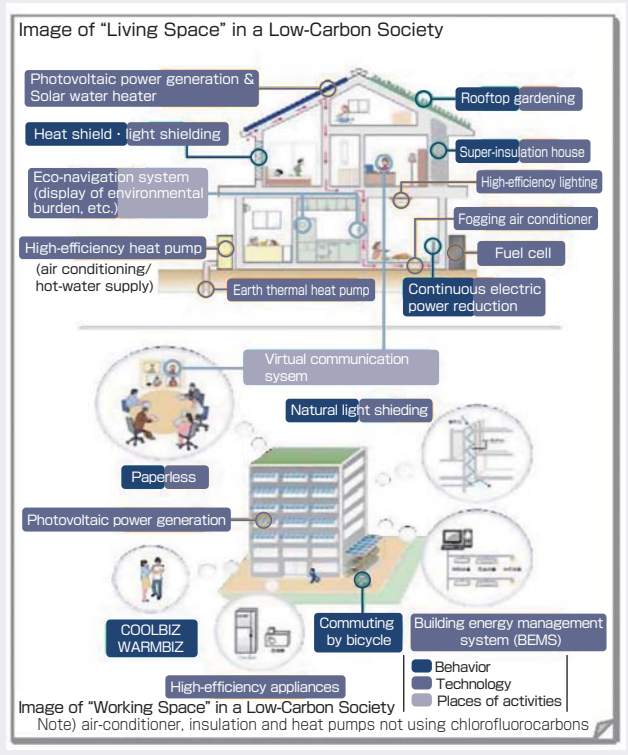
Japan' s pride: High utilization rate of public transportation systems



Superb moving vehicle technology

Source: Prepared by the Ministry of the Environment based on "2050 Japan Low-Carbon Society Scenario Team" (National Institute for Environmental Studies (NIES), Kyoto University, and Mizuho Information and Research Institute)

Figure2-4-11 Concrete Image of a Low-Carbon Society - Living Space



Behavior

- Practices firmly in place to avoid wasteful use of energy at home and workplace and effectively utilize natural energy
- Energy-saving actions practiced based on accurate information provided via "visualization" technology
- Family members, condominium residents and company employees cooperate to achieve energy saving with the strong environmental consciousness not to use energy wastefully
- Regardless of locations of residences, people can utilize sophisticated information technology to build the work environment similar to that in company offices at home or at facilities near their home, creating substantially greater latitude in working styles; companies can choose locations more freely and can operate on the global marketplace without having offices in big citeis

Technology

- Appliances with high energy efficiency (high-efficiency heat pump, high-efficiency lighting, etc.), made on the strength of Japan' s "monozukuri" manufacturing prowess, and natural energy utilization technologies have been developed and spread widely
- Electricity and heat are consumed in a rational combination of those produced at home or within buildings using solar energy and fuel cells and those externally provided via system power and heat conveying pipes
- Lighting and air conditioning operated in accordance with movements of dwellers using IT-based sophisticated control technology

Foundations supporting behaviors and technology

- Wooden houses and buildings spread widely; many mid-rise buildings also becoming wooden
- Designers and professionals who can build houses suitable to climate conditions of respective regions nurtured; buildings that take in nature nicely, are comfortably warm without heating even during winter and provide comfortable living space widely spread
- High-quality housing usable for long years ("200-year houses"), construction methods to lengthen the life of buildings, and eco-friendly home renovation widely spread; existing houses command the expanding share in the home market
- Infrastructure well developed for "visualization" of CO2 emissions from appliances people are using anytime and anywhere (display of environmental burden, advice on environment-friendly behaviors)

Source: Prepared by the Ministry of the Environment based on "2050 Japan Low-Carbon Society Scenario Team" (National Institute for Environmental Studies (NIES), Kyoto University, and Mizuho Information and Research Institute)

experts and public comments, offers the social vision as shown in Figure 2-4-11, and the panel said it is necessary for all entities in society to make efforts toward realizing a low-carbon society following the basic principles of (i) carbon minimum; (ii) simple life with an actual feeling of affluence; and (iii) realization of the coexistence with

nature.

There are numerous technologies contributory to global warming countermeasures that have yet to spread widely or are still far from commercialization but are quite promising for the future. For example, waste heat generated from industrial plants, power stations or waste incinerators is relatively widely utilized within these facilities. In Denmark and some other countries, waste heat is being utilized on a much wider scale. For instance, Copenhagen has completed the regional heat supply system for the total piping extension of 1,500 km, with about 500,000 residents connected to the regional heating network. About 60% of heat sources for the heat supply system are cogeneration plants using fossil fuels or biomass as fuels, with 20-30% coming from waste heat from waste incinerators. In Japan, the heat-carrying distance in heat supply operations is only about 2 km at most at present, far limited compared with cases in Europe or the United States. However, given that utilization of thermal energy as heat offers high energy efficiency and there is a large quantity of heat not utilized at the moment, expectations are high that infrastructure for utilizing waste heat will be improved going forward and effective utilization of waste heat makes headway in Japan as well.

In overland traffic in the traffic and transportation sector, in addition to electric vehicles already in practical use, we may be standing at the doorstep of an era when we see hydrogen automobiles and vehicles powered by fuel batteries running on urban streets as common scenes. Among vehicles powered by internal-combustion engines, aircraft and ships, on top of automobiles, are also seeing the wave of innovation coming toward them. Oceangoing vessels that carry large quantities of goods used to be powered by wind in the Age of Geographical Discovery. Going forward, they may be again powered by "renewable energy" like wind power and sunlight. A private-sector project launched in April 2008 envisioned the Eco-ship (Figure 2-4-12), which employed fuel cells instead of conventional diesel engines burning fuel oil, and also used wind power and sunlight. With clues from sharkskin, special coating was applied to the bottom of the ship to mitigate the resistance of water. The Eco-ship can reduce carbon dioxide emissions by 69% more than conventional containerships. The same project aims for the development of a zero-emission ship, which emits no carbon dioxide, by 2050.

Figure2-4-12 Example of the Eco-ship Concept

Photo: Nippon Yusen Kaisha (NYK Line)

At present, solar light and biomass are already being utilized as energy sources to replace fossil fuels. Among things that have not yet reached the stage of commercialization is oil production from botryococcus and other microalgae. Oil productivity of microalgae is far greater than corn and other oil-producing plants. If demand for oil is to be met by oil produced from corn, we would need an area 14 times larger than all arable land on the earth. In theory, however, microalgae can satisfy all demand for oil with only 1.8-4.2% of all arable land on the earth. Further, as the ultimate renewable energy technology, we may be generating electricity in outer space by utilizing sunlight by around 2050. Departing from an era when we have to use limited resources on the earth savingly, that is the technology to utilize inexhaustible and clean solar energy in a stable manner without worrying about weather conditions. Electricity produced would be sent to the earth using microwave and laser. This might sound incredible, but it is not a story that would only come true several hundred years down the road. In fact, the Japan Aerospace Exploration Agency, an independent administrative institution, seriously expects that this "technology" may become applicable around 2033.

Column Potential of Microalgae

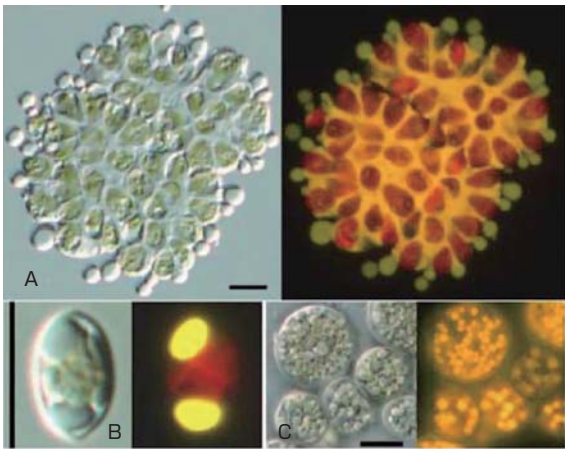
Microalgae are known as organisms that have produced oil shale. Algae have many species that produce significant amounts of fat and hydrocarbons, and the utilization of algae as biomass energy material has been under research mainly in the United States since right after the oil crisis in 1970s. Oil production capacity of algae is estimated at about 47 to 400 tons/ha, 25 to 120 times the capacity of oil-producing plants such as corn, soybeans, safflower, sunflower, oilseed rape and oil palm.

For example, if half of the amount of oil used in transportation in the United States is to be covered by algae oil, an area of a pool needed to cultivate algae is about 1.9 million to 5.6 million hectares, only one-seventh to one-twentieth of the area of the State of Colorado. Since energy consumption by the transportation sector accounts for about 70% of the total energy consumption in the United States, a project to develop a technology to produce diesel oil from algae in the country's vast deserts has been drawing keen attention.

Botryococcus braunii (hereinafter referred to as just "botryococcus") is known to produce hydrocarbons equivalent to 20-70% of heavy oil per alga body dry weight. Botryococcus is characterized by its capability of "producing oil components in both cells and colonies," and thus, it is possible to extract only oil without destroying cells. Generally speaking, oil of vegetable origin oxidizes metals and residual oil gets solidified. But hydrocarbons produced by microalgae can be refined and utilized just as fossil fuels using existing systems. The University of Tsukuba has obtained this promising botryococcus strain, and is proceeding with research and development through the large-scale use in open system for its cost advantages.

The University of Tsukuba's research and development goal for the moment is to "improve the oil production efficiency by one digit (1,000 tons/ha in terms of yield)." It plans to demonstrate the development by a full-scale production plant by 2020 and hopes to apply it to society by 2025.

In recent years in Japan, the depredation of abandoned agricultural land has become a serious issue. If we install microalgae cultivation tanks on all abandoned agricultural land totaling 220,000 hectares, there is the possibility that we can produce 220 million tons of oil, which is equivalent to Japan's annual oil imports, and also can reduce carbon dioxide emissions by about 657 million tons-CO2/year. While there may be competition for land from photovoltaic power generation, it is possible that "needs for fire power of oil" still exist in a low-carbon society in the future for manufacturing of industrial materials and as fuel for aircraft.



Oil-producing microalgal strain established as cultivated strain from selective culture sample
A. Botryococcus cultivated strain selected under the 20mM $NaHCO_3$ condition
B. Monocellular green alga strain selected under the 0.35% seawater condition
C. Chlorococcum-like green alga selected under the 20mM $NaHCO_3$ condition

References and photos: "Prospects of Algal Biomass Energy," Prof. Shin Watanabe, Graduate School of Life and Environmental Sciences, University of Tsukuba

Conclusion

In this chapter, we discussed the damage caused by global warming and the economic benefits of measures to cope with the problem, and then introduced various global warming countermeasures being implemented in Japan and overseas. There are various options as to how to proceed with global warming countermeasures, but in any case, solutions to the global warming problem should not sacrifice our cultures and affluence of our life. Everything in our daily activities is related to the progress in global warming. And its adverse impacts not only affect us but also continue to haunt children in the future. We will immediately stand up to fight the problem and aim to create a sustainable economic society with reduced emissions of greenhouse gases, a new Japan.

Column The Space Solar Power System

The Space Solar Power System (SSPS) is an energy supply facility that collects solar light, an inexhaustible and clean energy, in stationary orbit some 36,000 km above the equator and sends it to the earth.

Various ideas have been considered thus far in Japan and in other countries regarding the configuration and shape of the SSPS. For example, the microwave SSPS generates electricity using solar cells in stationary orbit and converts it into microwaves for transmission down to the earth. On the earth, microwaves received are converted back into electricity for use as electric energy. By building a light collection facility with a diameter of several kilometers in stationary orbit, it is possible to generate electricity of around one million kW (equivalent to power generation by a nuclear power plant).

Concept of energy transmission by microwave

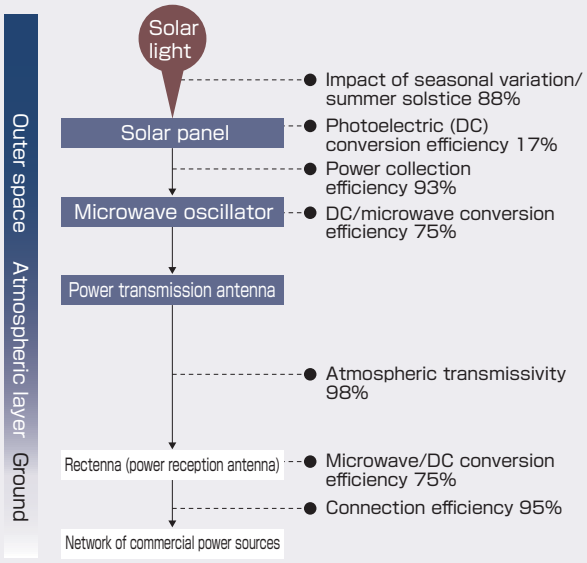
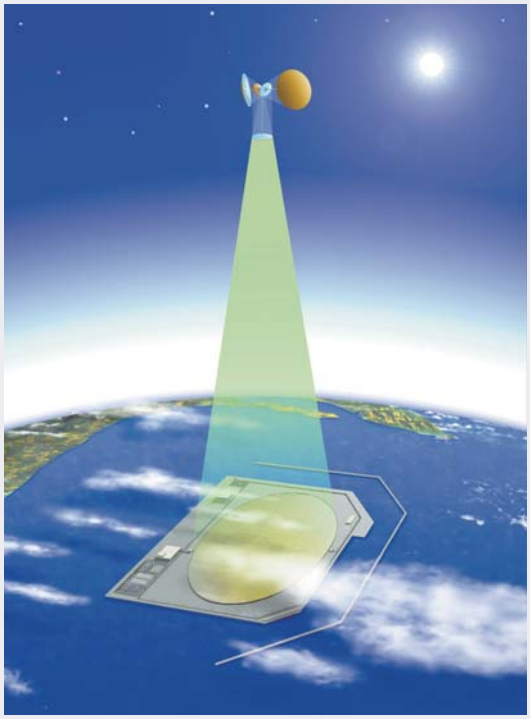


Image of microwave SSPS



Source: Japan Aerospace Exploration Agency website