Chapter 3

Technologies to Support Measures for Mitigating Global Warming

The previous chapters explained that global warming resulting from human-caused massive CO_2 emissions may threaten the basis of our living. This chapter will discuss the role of Japanese environmental technologies to assist international efforts to build a sustainable society by mitigating global warming and the significance of development and effective utilization of those technologies.

Section 1: Transformation into a Sustainable Society

1. Policy for a "Sustainable Society"

Chapter 2 explained important organic interactions among diverse living creatures, the atmosphere, water and soil on the Earth that support material circulation, and that such a support system is essential for the continued survival of human beings. It also explained that human activities in recent years have polluted the atmosphere, water and soil, threatening ecosystems and their core element, biodiversity. Actually, more and more people have become aware of the fact that geo-environmental resources are exhaustible and limited. Now we need to build a "sustainable society" on this planet, with its limited resources, by making efforts to protect the material circulation, ecosystems and human society from destruction.

The concept of "sustainability" was introduced for the first time in 1987 by the U.N.'s World Commission on Environment and Development (WCED) in its final report, "Our Common Future" (known as the "Brundtland Report"). In the Brundtland Report, "sustainable development" is defined as development that "meets the needs of the present generation without compromising the ability of future generations to meet their own needs." Since then, the idea of "sustainable development" has become widely known throughout the world. For example, this idea was introduced as a key concept to the Rio Declaration on Environment and Development and Agenda 21, which were respectively agreed upon during the U.N. Earth Summit in 1992. Now the idea of "sustainable development" is a common keynote of geo-environmental conservation efforts in the world.

In the Third Basic Environment Plan, which was adopted during the Cabinet meeting in April 2006, a "sustainable society" is defined as "a society where we are able to ensure global and local protection of a healty, nature-rich environment, protect human well-being for individual citizens and hand over such protection to future generations." In order to build such a society, we need to solve existing problems regarding (1) limited resources on the Earth and (2) the limited ability of nature to manage human-caused pollution.

Mineral resources and fossil fuels are all limited. From the standpoint of the security of a stable supply of energy resources, it is important to reduce consumption, improve waste collection and recycling, and promote the development of alternative materials and the use of recyclable materials. For example, metallic materials are renewable and thus need to be recycled properly and efficiently. Also, replacement of fossil fuels with renewable energies such as solar energy or biomass should be promoted.

Regarding issue (2) above, we should make sure that the amount of human-caused emissions of pollutants will not exceed the potential of natural systems (the atmosphere, waters, soils, organisms, etc.) to handle them. For example, the excess of human-caused CO_2 emissions over the potential of forests, etc. to absorb CO_2 is a major cause of global warming today. Therefore, it is necessary to reduce and control CO_2 emissions with an understanding of the potential of natural systems.

2. Age of Massive Consumption of Fossil Fuels

After the Industrial Revolution, society has established a mechanism in which industrial products of high quality and low cost are mass-produced through automated processes in large factories and are then mass-consumed by consumers. Through this mass-production/mass-consumption system, advanced countries have obtained fortune and prosperity far beyond what people had experienced before. Developing countries also seek to build the mass-production/mass-consumption structure with the hope of gaining similar fortune and prosperity.

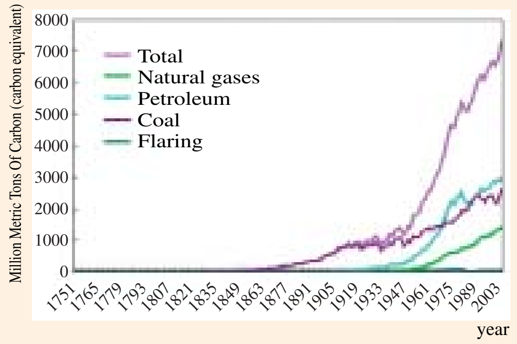
It was fossil fuels including coal and petroleum that made it possible to materialize the said mechanism. Fossil fuels came to be consumed more and more, with increasing speed, as the world promoted mass production and mass consumption (Figure 3-1-1).

It can be estimated that a continuing heavy consumption of fossil fuels at the current pace would result in an exhaustion of those resources on Earth in the near future. Humans are about to use up those fossil fuels in such a short period of time after the Industrial Revolution, despite the fact that it took hundreds of millions of years for those fuels to be formed and stored, in the course of a long process from carbon sequestration through photosynthesis, stabilization as organic substances, to underground accumulation.

The heavy consumption of fossil fuels has also invited the excess of CO_2 emissions over the potential of natural systems to handle them.

Modern human society has consumed a large volume of fossil fuels out of limited resources and released a more-than-absorbable amount of CO_2 into the atmosphere. As a result, the atmospheric CO_2 concentration has been rising higher and higher. It can be said that modern society is far from sustainable.

Figure 3-1-1: Global CO_2 Emissions from Fossil-Fuel Burning and Gas Flaring



Source: Carbon Dioxide Information Analysis Center (CDIAC) of the U.S. Department of Energy

In order to protect the integrity of ecosystems with an understanding of their significant contribution to the basis of our living and ensure sustainability of humanity, we must build a society where a balance between emissions and absorptions of the atmospheric GHGs (including CO_2) can be maintained so that global warming will not reach a critical level.

Section 2: Current Status of Countermeasures and the Contribution of Technologies

Global CO_2 emissions as of 2004 were 26.5 billion tons in total. Of those, the United States occupied the largest share at 22.1%, followed by China at 18.1%. Japan was in the fourth position, accounting for 4.8%. In FY2005, Japan emitted a total of 1.36 billion tons of GHG (CO_2 equivalent), which was up 7.8% from 1990 (1995 for HFC, PFC and SF_6). Various countermeasures against global warming have been introduced so far in Japan, and the following paragraphs will explain the current status of the implementation of those countermeasures and the significant contribution of our technologies to those measures.

1. Status of Various Countermeasures against Global Warming

In an effort to global warming countermeasures, the international society adopted the U.N. Framework Convention on Climate Change in May 1992 and the Kyoto Protocol in December 1997 (entered into force in February 2005).

The Kyoto Protocol sets numerical targets of emissions reduction for respective countries, with the goal of reducing collective GHG emissions from all advanced countries during 2008 and 2012 by 5% compared to the year 1990. Under the Protocol, Japan is required to attain a 6% reduction.

In this situation, the Japanese government established, through the Cabinet meeting in April 2005, the Kyoto Protocol Target Achievement Plan, which covers necessary policy measures to be taken to attain the reduction target. Those policy measures included in the Plan can be categorized into the following four types: (1) policy measures concerning GHG emissions reduction and removals, (2) cross-sectoral measures including national movements and efforts to be initiated by public organizations, (3) measures for establishing the foundation for activities, such as the promotion of technology development and international cooperation, and (4) policy measures concerning the Kyoto mechanisms (Figure 3-2-1). Those respective policy measures are explained in detail in the Plan. For example, category (1) covers the measures for forest sink, and category (3) covers the CCS (Carbon Dioxide Capture and Storage) technology and "adaptability" improvement measures (See Columns). Based on this Plan, the integral promotion of diverse measures is underway, including the implementation of energy-saving measures, introduction of renewable energies and promotion of national movements to review life styles, etc.

Approximately 90% of the total GHG emissions in Japan are regarded as energy-originated carbon dioxide. Policy measures for reducing such CO_2 emissions include technology-based "measures for individual energy-related equipment," and "promotion of efforts at individual workplaces and businesses, etc." as well as "establishment of low-carbon socioeconomic mechanisms, including urban and regional structures and public transport systems." Figure 3-2-2 shows the overview of those policy measures for reducing energy-originated carbon dioxide.

Figure 3-2-1: Gist of the Kyoto Protocol Target Achievement Plan

Target

- Ensure 6% reduction commitment under the Kyoto Protocol
- Steady implementation of a continuous as well as long-term GHG emissions reduction on a global scale

Basis Idea

- Integration of the environment and the economy
- Promotion of technological innovation
- Promotion of participation and collaboration by all the stakeholders
- Utilization of various policy measures
- Prioritization of the evaluation and review process
- Ensuring international collaboration

Targets of GHG reduction/ absorption

GHGs	Target: Emissions in FY2010 (million tons-CO_2)	Target: Compared to FY1990 (Total emission over the base year)	Projected reduction in FY2010 under existing measures (+12%*) * Total reduction with projected increase caused by economic growth and reduction by existing measures over actual achievement in FY2002 (+13.6%)
(1) Energy related CO_2	1,056	+0.6%	▲4.8%
(2) CO_2 from Non-energy source	70	▲0.3%	▲0.4%
(3) Methane	20	▲0.4%	
(4) N_2O	34	▲0.5%	
(5) Other GHGs	51	+0.1%	▲1.3%
Sink including forests	▲48	▲3.9%(*)	▲3.9%(*)
Kyoto Mechanism	▲20	▲1.6%*	▲1.6%*
Total	1,163	▲6.0%	▲12%

* Difference between reduction target(minus 6%) and domestic measures.
(*) It is necessary to conduct a detailed review and adjustments as to numerical estimates based on the inventory of GHG emissions and removals since the estimated amount of emissions as of the base year (1990 in principle), which was figured out at the time of the establishment of the Target Achievement Plan, is not consistent with the estimates today.

Policy measures to accomplish the target

1-1. Policies and measures on GHGs emissions reduction and sinks

(1) Policies and measures on GHGs emissions reduction
1) Energy related CO_2
- Promote measures on energy related apparatus as well as on individual facility/stakeholder
- Take measures to shift socio-economy including urban/regional structure and public transportation infrastructure into low carbon one

2) CO_2 from Non-energy sources
- Promote the use of blended cement and promotion of reduction of reduction measures on CO_2generated by waste incineration

3) Methane
- Reduction of final disposal volume

4) N_2O
- Improvement of incineration prcess in incineration facility for sewage sludge and municipal solid waste

5) Other GHGs (HFC,PFC,SF_6)
- Promote systematic actions by industries and development and use of alternatives
- Collect HFC filled in apparatus as refrigerant complying with regulation

(2) Policies and measures on GHGs sinks
a. Securing absorption
- Comprehensively and steadily promote measures to achieve the goals of the Basic Plan for Forest and Forestry

b. Promote urban greening

1-2. Cross-sectoral measures
- GHG accounting, reporting and announcement
- Promotion of environment-conscious attitudes in business activities
- Public awareness raising campaign
- Initiative by public institutions
- The daylight saving time
- Policy mix (The idea of introducing an environment tax will be discussed.)

1-3. Basic measures
- Domestic system to account GHG emissions and absorption
- Promotion of technology development and R&D
- Promotion of international collaboration and cooperation

2. Policies and measures on the Kyoto mechanisms
- Promotion of overseas projects for emission reduction, etc.
- Efforts to obtain GHG Credits

Organizational arrangements
- Annual review and quantitative assessment of the Plan in FY2007
- The Headquarters will take the lead in steadily implementing the Plan

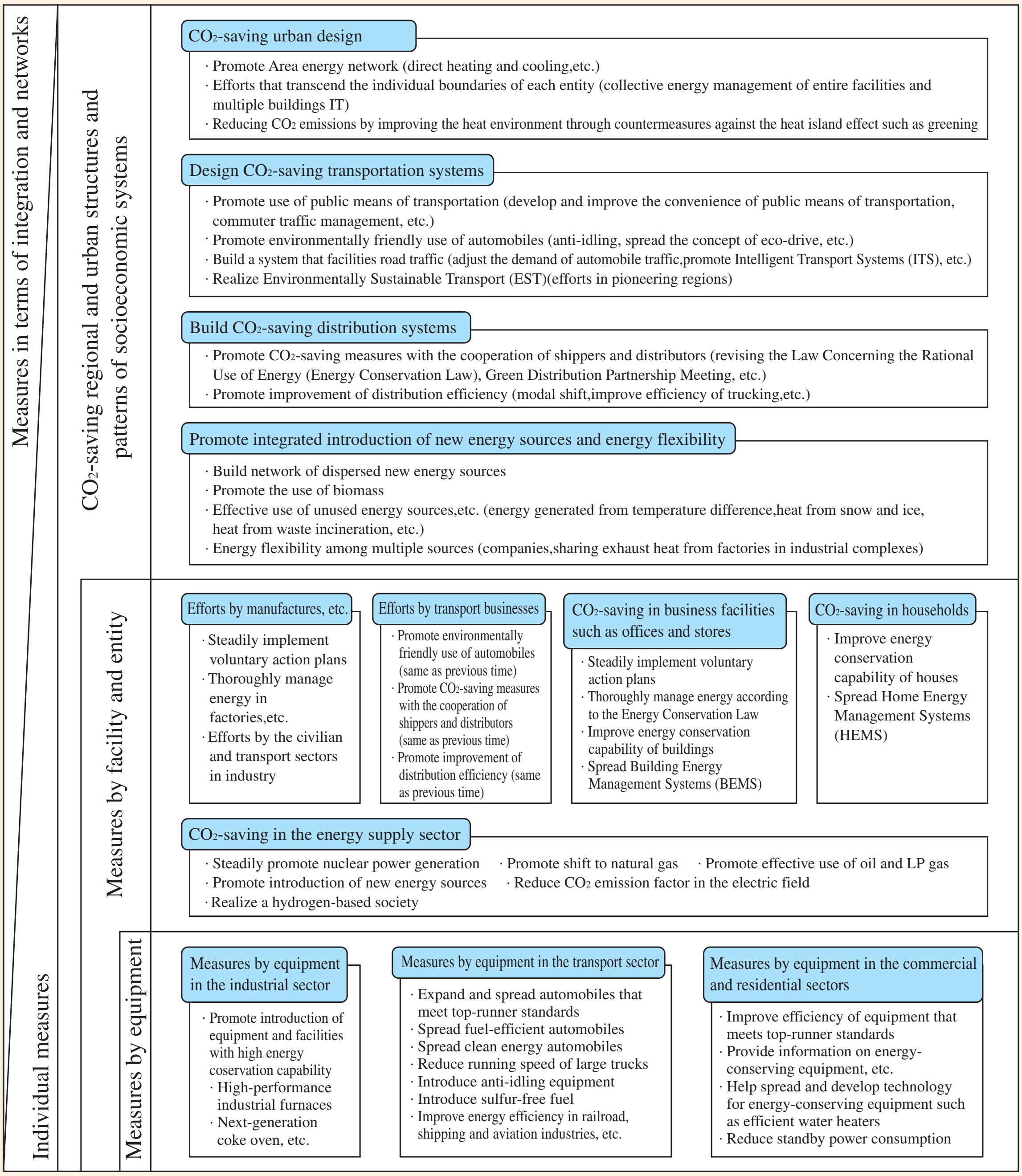
Source: Ministry of the Environment

Column : Measures to Ensure our "Aadaptability"

It is expected that accelerating global warming will have local and global impacts such as a rising sea level and changes in agricultural production, water sources, ecosystems and their core factor, biodiversity. Even our best efforts to mitigate GHG emissions would probably not arrest global warming completely. Facing this reality, we need to not only promote conventional GHG reduction measures but also think about how we should "adapt" ourselves and our socioeconomic systems to climate change.

Measures to ensure our "adaptability" include the promotion of the efficient use of water in preparation for increasing dry weather along with accelerating global warming, improving disaster-prevention facilities in preparation for heavy rains, constructing breakwaters to prevent or mitigate any damage that can be expected from a rising sea level, constructing seashore barriers through tree planting, etc. in preparation for coastal flooding, and introducing alternative cropping patterns, crop replacement or selective breeding in preparation for any defective growth of farm produces as a result of any extreme climate event.

Figure 3-2-2: Overview of Measures Concerning Energy-originated Carbon Dioxide Sources



Source: Ministry of the Environment

2. Significant Role of Technology in Implementing Global-Warming Mitigation Measures

When we make efforts to reduce GHG emissions, it is necessary to promote institutional development, including reform of conventional systems and mechanisms as well as improvement of people's attitude and behaviors. In implementing the policy measures mentioned in the Kyoto Protocol Target Achievement Plan, the development and effective utilization of advanced technologies would certainly make great contributions to our efforts to achieve targets. The following sections will explain the significant role of technology in implementing global-warming mitigation measures, especially in the category of measures for reducing energy-oriented carbon dioxide that occupy a large share of GHG emissions in Japan.

(1) Measures for forming CO_2-saving regional and urban structures and socioeconomic systems

Those measures include CO_2-saving urban design. Technologies that are considered to contribute to the promotion of such measures include the "co-generation" technology, which is designed to use waste heat (generated by heat engines) to simultaneously generate both electricity and useful heat (for air-conditioners, water heaters, etc.) to improve overall energy efficiency, BEMS (Building Energy Management System) and HEMS (Home Energy Management System), which use information technologies to monitor indoor conditions for ensuring energy-saving control and management.

(2) Measures according to facility and by entity

Those measures can be roughly divided into "measures to be promoted by the demand sectors" and "measures to be promoted by the supply sectors."

a. Measures to be promoted by the energy-demand sectors such as the industrial sectors and the transport sector

All energy users should make efforts to reduce the total amount of their CO_2 emissions in their activities. Here, technologies that are expected to make significant contributions to CO_2 emission-reduction efforts include energy-saving process technologies, instruments and control technologies, etc. for the industrial sectors, eco-drive management systems, information systems to improve logistics efficiency, etc. for the transport sector, and insulating materials, solar power systems, etc. for the residential sector.

b. Measures to be promoted by the energy-supply sectors such as nuclear power plants

Energy suppliers also need to make efforts to promote the use of low-CO_2 emission factor sources. For example, the role of nuclear energy is particularly important in promoting global-warming mitigation measures since no carbon dioxide is generated in the process of nuclear-power generation. It is necessary to promote further utilization of nuclear energy, with an understanding that the first priority is to regain people's trust in the safety of nuclear energy and secure nuclear safety. It is also important to promote cooperation between public and private sectors to facilitate steady promotion of nuclear energy as a key energy source. Also, technologies to commercialize or utilize new energies such as solar energy and technologies to promote the use of natural gases are expected to make further progress in the future.

Column : CO_2 Capture and Storage (CCS)

The CCS technology makes it possible to ensure long-term carbon sequestration by capturing CO_2 from large point sources (e.g., power plants, mines of natural gases), isolating it from other gases, and subsequently storing it in underground geological formations or in the ocean, instead of releasing it into the atmosphere.

The forms of CO_2 storage can be roughly divided into underground storage and ocean storage. The approach of underground storage tends to inject collected, separated CO_2 into underground geological formations for the purpose of removing CO_2 from the atmosphere. The approach of ocean storage tends to inject collected, separated CO_2 into deep ocean basins for the purpose of isolating it from the atmosphere.

Researches are underway to improve understanding of underground storage and ocean storage respectively. Some underground storage projects have already been carried out on a commercial basis in Norway, including the North Sea project conducted by a petroleum/gas developer. In Japan, the Research Institute of Innovative Technology for the Earth (RITE) has been carrying out an experiment in Nagaoka City, Niigata Prefecture to verify the feasibility of injecting carbon dioxide into an aquifer system, as a subsidized public project managed by the Ministry of Economy, Trade and Industry. This experiment has injected carbon dioxide totaling about 10,000 tons (carbon equivalent) into the approx. 1,100-meter-deep aquifer for the period of eighteen months starting from July 2003. Currently, post-injection conditions are being monitored.

Also, technologies to isolate and collect carbon dioxide from other gases have been developed and researches are underway to study those technologies.

Table 3-2-1: Contribution of measures and technologies concerning Energy- originated Carbon Dioxide

Forming CO_2-saving regional and urban structures and socioeconomic systems

	Measures	Relevant technologies (examples)
CO_2-saving urban design		
1	Promote Area energy network	district heating and cooling, co-generation, fuel cells
2	Efforts that transcend the individual boundaries of each entity	BEMS, BA-FA integration platform technologies
3	Reducing CO_2 emissions by improving the heat environment through countermeasures against the heat island effect such as greening	Greening of special spaces such as rooftops, artificial-waste heat-control technologies, water-retentive pavement, solar-reflective paint, sewage/spring-recycling technologies
Design CO_2-saving transportation systems		
1	Promote use of public transportation	LRT, IC card technologies
2	Promote environmentally friendly use of automobiles	anti-idling equipment, eco-drive management system (EMS)
3	Build a system that facilitates road traffic	Intelligent Transport System (ITS), Vehicle Information and Communication System (VICS)
4	Realize Environmentally Sustainable Transport (EST)	LRT, CNG bus
Build CO_2-saving distribution systems		
1	Promote CO_2-saving measures with the cooperation of shippers and distributors	Information systems to improve logistics efficiency
2	Promote improvement of distribution efficiency	new technology such as the next generation domestic vessels (Super Eco-Ship)
Promote integrated introduction of new energy and energy interchange		
1	Build network of dispersed new energy sources	MicroGrid
2	Promoting use of biomass	Technologies for utilizing biomass resources, technologies for conversion/utilization of biomass energies
3	Effective use of unused energy sources	Technologies for utilizing unused energies (energy generated from temperature difference using seawater, sewage, etc.,heat from snow and ice),technologies to use waste heat(heat from waste incineration)
4	Energy conservation through cooperation among multiple businesses	Companies sharing exhaust heat from factories in industrial complex (high-efficiency heat-storage equipment)

Measures according to facility and by entity

	Measures	Relevant technologies (examples)
Efforts in manufactures,etc.		
1	Steadily implement on voluntary action plans	Energy-saving process technologies, energy-saving production facilities and systems, development of high-function steel materials, etc.
2	Thoroughly manage energy by plants, etc.	Instruments and control technologies
3	Efforts by the civilian and transport sectors in industry	development of lighter and more functional materials,products that are highly energy-efficient
Efforts by transport businesses		
1	Promote environmentally friendly use of automobiles (same as the above)	anti-idling equipment, eco-drive management system (EMS)
2	Promote CO_2-saving measures with the cooperation of shippers and distributors (same as the above)	Information systems to improve logistics efficiency
3	Promote improvement of distribution efficiency (same as the above)	New technologies such as next generation domestic vessels (super eco-ships)
CO_2-saving in business facilities such as offices and stores		
1	Steadily implement on voluntary action plans	Introduction of energy-conserving equipment, replacement of conventional machines with energy-conserving equipment
2	Thoroughly manage energy according to the Energy Conservation Law	BEMS
3	Improve energy conservation capability of buildings	Energy-saving technologies for building skeleton (structural materials, windows, insulating materials, etc.)
4	Spread Builiding Energy Management Systems (BEMS)	BEMS
CO_2-saving in households		
1	Improve energy conservation capability of houses	Energy conservation renovation work, heat insulation materials, photovoltaic power generation systems, glass with a high energy conservation capability (multiple-layer glass), sashes with a high energy conservation capability (wooden or plastic), greening of rooftops or wall surfaces
2	Spread Home Energy Management Systems (HEMS)	HEMS
CO_2-saving in the energy supply sector		
1	Steadily promote nuclear power generation	Improvement of the nuclear power plant's capacity factor, nuclear fuel cycle technologies
2	Promote introduction of new energy sources	Utilizing sunlight, wind power and biomass(use of heat from biomass, solar and waste incineration, fuel derived from biomass, photovoltatic and wind power generation, power generation from waste)
3	Promote shift to natural gas	Improving efficiency of gas turbines and gas engines, natural gas cogeneration, highly efficient gas air conditioning, GTL (gas-to-liquid) technologies for natural gases, dimethyl ether, methane hydrate
4	Reduce CO_2 emission factor in the electric field	Improvement of the heat efficiency of thermal power generation, thermal storage systems
5	Promote effective use of oil and LP gas	Petroleum co-generation systems, highly efficient boilers with low NO_x, LPG co-generation systems, gas engine boilers
6	Realize a hydrogen-based society	Fuel cells, hydrogen manufacturing

Measures and policies, etc. by equipment

	Measures	Relevant technologies (examples)
Measures and policies, etc. by equipment in the industrial sector		
1	Promote introduction of equipment and facilities with high energy conservation capability	various kinds of energy-conserving equipment, high efficiency industrial furnaces, high efficiency boilers, next-generation coke ovens, fuel efficient construction machinery
Measures and policies, etc. by equipment in the transport sector		
1	Expand and spread automobiles that meet top-runner standards	automobiles that meet top-runner standards (introduction of LPG passenger autobobiles, etc.)
2	Spread fuel-efficient automobiles	Technologies to improve fuel efficiency, clean diesel passenger automobiles
3	Spread clean energy automobiles	Hybrid automobiles, natural gas automobiles, electric automobiles, methanol automobiles, fuel cell automobiles
4	Reduce running speed of large trucks	Speed-limiting device
5	Promote environmentally friendly use of automobiles (same as the above)	Anti-idling systems, eco-drive management system (EMS)
6	Introduce sulfur-free fuels	Sulfur-free petroleum fuel
7	Improve energy efficiency in railroad, shipping and aviation industries etc.	Light vehicles, vehicles with VVVF equipment(*), electrical propulsion ships, ships equipped with electronically-controlled engines
Measures by equipment in the commercial and residential sectors		
1	Improve efficiency of equipment that meets top-runner standards	Energy-saving technologies for those machines and equipment covered by the top-runner standards (Air-conditioners, fluorescent lamps, television sets, electric refrigerators, gas cooking appliances, electric toilet seats, passenger vehicles)
2	Provide information on energy-conserving equipment, etc.	Various kinds of energy-conserving equipment, energy conservation technologies
3	Help spread and develop technology for energy-conserving equipment such as efficient water heaters	Natural refrigerant heat-pump water heaters, latent heat recovery type water heaters, gas engine water heaters(miniaturization and facilitating installation),electromagnetic cookers, electric kettle using a vacuum-insulation panel, electric washer and dryer heat-pump laundry, highly-efficient commercial-use air conditioners utilizing heat pump technology, highly-efficient commercial-use water heaters and low temperature natural refrigerant freezer units that do not use chlorofluorocarbons, integrated systems combining energy-efficient refrigerators and freezers, and air conditioning for the use of retail stores, light emitting diodes (LEDs), fluorescent lamp using an inverter system, Hf lamp
4	Reduce standby power consumption	Equipment of low standby power consumption

Note: (*) VVVF stands for vehicles equipped with a mechanism that efficiently controls the revolutions per minute of the motor without using electrical resistance.
Source: Ministry of the Environment

(3) Measures for individual energy equipment

Technology makes a great contribution to the implementation of measures for individual energy equipment, and here are some examples.

In the industrial sector, energy-saving equipment, high efficiency industrial furnaces and boilers have been introduced to improve the efficiency of the combustion process and enhance energy-saving performance. In the transport sector, technologies to develop lightweight vehicles, technologies to improve engine efficiency and control technologies for hybrid vehicles help improve fuel economy and enhance energy-saving performance. In the residential/commercial sectors (Commercial and other sector, and residential sector), there exists a water heater with the function of latent heat recovery (where heat released into the atmosphere in the form of vapor can be recycled). Also, LED makes a great contribution to lighting equipment. Thus, technologies help improve energy efficiency and energy saving.

For more information on technologies that contribute to the improvement of energy efficiency and energy saving and support policy measures to reduce energy-oriented carbon dioxide, see Table 3-2-1.

Besides the contribution to reduce energy-originated carbon dioxide, technologies also play a significant role in the measurement and future estimation. Furthermore, their indirect contributions are also noteworthy. For example, an anti-idling system would encourage more drivers to resist engine idling, and LRT (Light Rail Transit) systems would increase the convenience of public transport, resulting in the increase of public transport users. Also, there are some energy-saving products for home electricity users (power outlet called “Eco-Tap,” outlet equipped with a timer, etc.) that make it possible to conveniently shut off the power without unplugging a unit, and such products would help promote the reduction in standby power consumption. Those technologies make great contributions to the improvement of people’s attitudes toward energy saving and adoption of ecology-conscious lifestyle.

Thus, many of the measures that we have been implementing under the Kyoto Protocol Target Achievement Plan greatly benefit from the development and commercialization of technologies and their indirect effects. In making our continued efforts to global warming countermeasures in the future, the development and utilization of technologies should have significant meaning, along with institutional development and reform of people’s attitude and behaviors.

Section 3: Our Past Experiences to Overcome Environmental Problems with Technologies

Having faced various pollution problems in the past, Japan overcame each of those problems by introducing diverse environmental conservation measures. One of the elements that helped us successfully tackle the problems was technology.

The development and introduction of an environmental conservation technology costs a business a large amount of additional expenditures. At the same time, however, such technology contributes not only to environmental conservation but also to improvement of the business’ technological strengths and international competitiveness, as well as creation of new business opportunities and the comfort of people. This section will explain past examples of how environmental conservation technologies made significant contributions to the Japanese society.

a. Flue gas desulfurization facility to reduce sulfur oxides (SOx) emissions

After World War II, Japan had achieved rapid industrial restoration at an unprecedented pace, which was amazing to other countries. At the same time, the increase of smoke generated by plants nationwide aggravated air pollution rapidly in Japan.

In order to overcome this industrialization-caused air-pollution problem, our industrial sectors promoted the use of low-sulfur petroleum and invested in the development and introduction of a flue gas desulfurization facility. As a result, the number of businesses that introduced such desulfurizer increased significantly during the period from the mid-1960s to mid-1970s (Figure 3-3-1), successfully mitigating air pollution.

By exporting technology developed through the commercialization of flue gas desulfurization facilities, Japan could help developing

Flue gas desulfurization facility
Photo: courtesy of Mitsubishi Heavy Industries, Ltd.

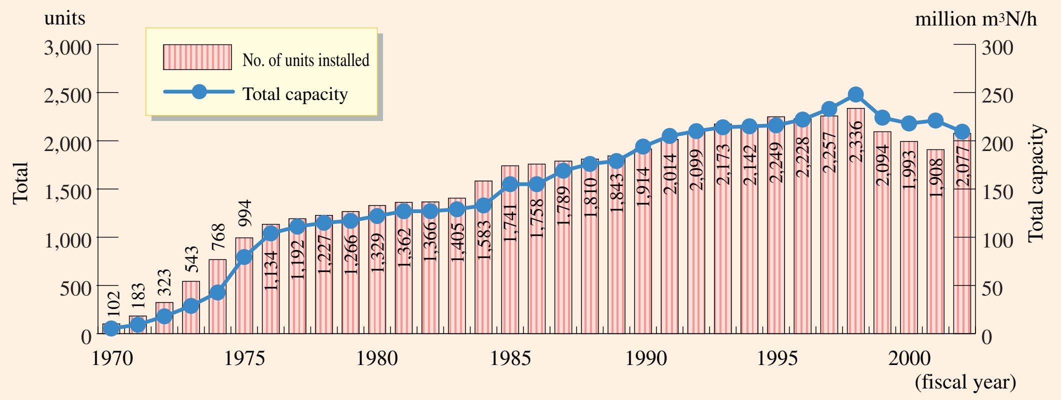
Column : Countermeasures against Smoke Damage in the Area around Besshi Copper Mine

In the middle of the Meiji era, the area around Besshi copper mine in Ehime Prefecture started to suffer crop damages in farmlands caused by sulfurous acid gas generated at a local refinery. In an effort to solve this problem, the refinery was moved to a uninhabited neighboring island in Niihama, but an air current above the Seto Inland Sea brought the sulfurous acid gas to the entire Toyo region, resulting in extensive damage to farm produce in that region.

To solve this problem, the manager of Besshi copper mine attempted to introduce the desulfurization technology to produce sulfuric acid from the refinery-producing sulfurous acid gas as well as the technology to produce fertilizers by using sulfurous acid (ammonium sulfate). Through repeated trials, the technologies have been improved to successfully materialize practical application. Those technologies put an end to long-lasting smoke damages that suffered Besshi copper mine for about fifty years, and also made it possible for the region to maintain their local agricultural businesses while enjoying the benefits of their key industry of copper business (a key industry in Japan at that time). Also, the idea of producing agricultural fertilizers by using sulfurous acid is quite close to today's concept of a sustainable society, where it is based on recycling wastes to produce useful goods.

countries in Asian fight the growing air-pollution problems they face in their industrialization. Such strengths and skills also lead to expanding business opportunities.

Figure 3-3-1: State of Installation of Flue Gas Desulfurization Facilities by year (FY1970-2002)



Source: Compiled from *Survey on the State of Stationary Sources Relating to Air Pollution*, Ministry of the Environment

b. Energy-saving efforts by the industrial sectors after the oil crises

The outbreak of the Fourth Middle East War in October 1973 triggered a crude oil price hike, and this first oil crisis greatly threatened advanced industrial countries worldwide who were highly dependent on Middle East petroleum for energy sources to support their socioeconomic activities. At that time, Japan's dependence on imported petroleum was enormous, accounting for as much as three-fourths of the entire domestic demand for energy fuels. To survive this crisis, business owners and managers aggressively promoted the introduction of energy-saving technologies, such as the continuous casting technology introduced by the steel industry, in an effort to maximize cost performance. Later, even after the industries regained stable economic growth and stabilization of crude oil prices, Japanese businesses continued their investments in development and research of energy-saving technologies. As a result, the introduction of effective energy-saving technologies has spread widely, including energy-efficient equipment, recycling techniques, and collection of waste heat and waste energy.

Now, Japan enjoys world-class industrial energy efficiency (Figure 3-3-1). Our efforts to lower the demand of energy input in the manufacturing process not only reduced environmental loads but also led to cost reduction in production activities, contributing greatly to the improvement of the international competitiveness of Japanese industries.

Table 3-3-1: International comparison of energy efficiency

Iron and Steel

Integrated steelworks energy consumption intensity

Japan	South Korea	EU	China (large scale)	China (whole country)	United States	Russia
100	105	110	110	120	120	125

(Japan Iron and Steel Federation)
Source: Data from the Korea Iron and Steel Association and the China Iron and Steel Association, and individual interviews

Chemicals

Electric power consumed in relation to production of electrolytic caustic soda

Japan	Taiwan	South Korea	China	United States	Western Europe	Eastern Europe
100	100	100	104	110	119	115

(Japan Chemical Industry Association)
Source: *SRI Chemical Economic Handbook*; Japanese Soda Industry Association, *Soda Handbukku (Soda Hand book)*

Paper

Total energy consumption for paper and paperboard produced (before adjustments for imported and exported pulp)

Japan	United States	Canada	Sweden	Germany
100	144	134	123	52

(Japan Paper Association)
Source:
Data from Japan from Japan Paper Association follow-up report for 2003, for United States from the American Forest & Paper Association's *annual statistics for 2002*; for Canada from Forest Product Association of Canada, *Environmental Reports 2000-2001*; for Sweden and Germany from Confederation of European Paper Industries, *Energy Profile 2001*.
Since Germany relies largely on recycled pulp and imported pulp, its energy consumption related to pulp production is low. In addition, demand for quality such as whiteness of toilet paper is relatively low in Germany, which can also be considered a factor contributing to low energy consumption.

Cement

Energy consumption per clinker ton (for 2000)

Japan	Western Europe	South Korea	Central and South America	China	United States	Russia
100	130	131	145	152	177	178

(Japan Cement Association)
Source: "Toward a Sustainable Cement Industry Substudy 8: CLIMATE CHANGE (March 2002)" (Battelle)

Note: Energy intensity is a value that represents energy efficiency. The lower the energy intensity value, the better the energy efficiency.
Source: Nippon Keidanren "Results of the Fiscal 2006 Follow-up to the Keidanren Voluntary Action Plan on the Environment (Summary) -Section on Global Warming Measures - < Performance in Fiscal 2005 >"

c. Technologies for motor vehicles to address exhaust-gas restrictions and to improve fuel economy

In Japan, motor vehicles came to be widely used by the public from the latter half of the 1960s. Accordingly, the problem of air pollution caused by vehicle exhaust emissions became conspicuous. Under such circumstances, the government introduced control over vehicle exhaust emissions and strengthened regulations from time to time. Today, Japan has the strictest vehicle exhaust-emission restrictions in the world (See Section 3, Chapter 2 of Part 2).

Japanese automakers have been promoting technology development to address the issue of aggravated air pollution caused by vehicle-exhaust gas. There are a wide variety of such development projects including improvement of engine-combustion control and heat efficiency, introduction of lightweight vehicles, and catalyst for exhaust-gas purification. Through the industrial efforts to promote those RD&D projects and commercialization, Japanese automakers have established its world-class status in terms of technological strengths in the field of exhaust-gas control.

Japanese automakers have also been promoting technological innovations aimed at improving fuel economy, and they have now established world-leading technology aimed at ensuring improved fuel economy.

Such improvements as to control of exhaust gas and fuel economy have not only contributed to environmental conservation, such as air-pollution mitigation and CO_2 emission reduction, but also produced added product value and improvement of international competitiveness. Today, there is a worldwide tendency for government-imposed restrictions over vehicle exhaust gas to be stricter and stricter in response to people's increasing interest in environmental issues. This trend is an advantage for the Japanese auto industry, which has been making great efforts to create more sophisticated environmental technologies that will lower exhaust-gas emissions and improve fuel economy. Actually, after the second oil crisis (1979), Japanese cars, which are small and energy-efficient, increased in sales substantially in the U.S. market.

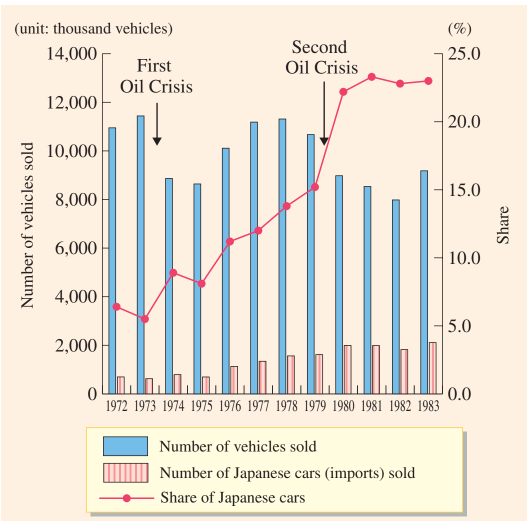
d. Soil contamination in those lands previously occupied by plants

Since the early 1990s, facts of serious soil contamination have been revealed one after another in lands planned to be used for town redevelopment, and drew much public attention. Since Japan is a small country, the issue of land use in urban areas is treated carefully especially when land use for a particular purpose is changed or redevelopment is planned. In response to the situation, various RD&D projects for the disposal of underground pollutants have been promoted according to purposes of land use and types of contaminant, where techniques to confine pollutants as well as technologies to isolate and dispose of contaminated soils are being studied.

Technologies to decontaminate soils contribute to the protection of human health in neighboring areas and also to the removal of negative factors in land-utilization efforts. In addition, soil purification of a contaminated idle land helps prevent deforestation of other land that would otherwise be developed as an alternative, and also helps create business opportunities and promote regional vitalization. According to a survey conducted by the Geo-Environmental Protection Center, the total amount of money paid during fiscal year 2005 to contracts for soil-contamination surveys or soil-decontamination projects registered at 162.4 billion yen, and such expenditures are expected to continue to increase in the future (Figure 3-3-3).

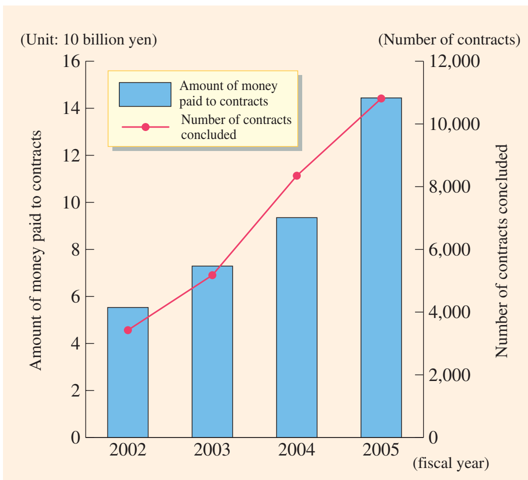
Thus, technologies helped Japan to overcome various environmental problems in the past. The significant contributions of technologies are not limited to the effects of environmental conservation but extend over various benefits, including improved international competitiveness and new business opportunities. In our efforts to global warming countermeasures, the significance of technologies is enormous, as mentioned above, and is expected to further increase as global warming accelerates in the future.

Figure 3-3-2: Trend of car sales in the U.S. market for new American cars and imported Japanese cars



Source: Compiled from the data of the U.S. Department of Commerce by the Japanese Ministry of the Environment

Figure 3-3-3: Expanding geo-environmental businesses



Source: Geo-Environmental Protection Center *Results of the fact-finding survey on soil-contamination researches and countermeasures (during FY2005).*

Section 4: Global Warming Countermeasures

The previous sections explained how important technology development and wide utilization of effective technologies are to the promotion of global warming countermeasures. Also, Section 3 discussed specific meaningful achievements attained from technology development and wide utilization of developed technologies. This section will provide overviews of current conditions of how technologies that are effective to mitigating global warming are actually being used and producing effects. Here, based on the understanding of the current status of CO_2 emissions in respective major sectors in Japan, a focus will be put on those technologies that are being practically used and are expected to come into widespread use in the future and will thereby reduce CO_2 emissions substantially.

1. Current Status of CO_2 Emissions in Japan

(1) Overall conditions

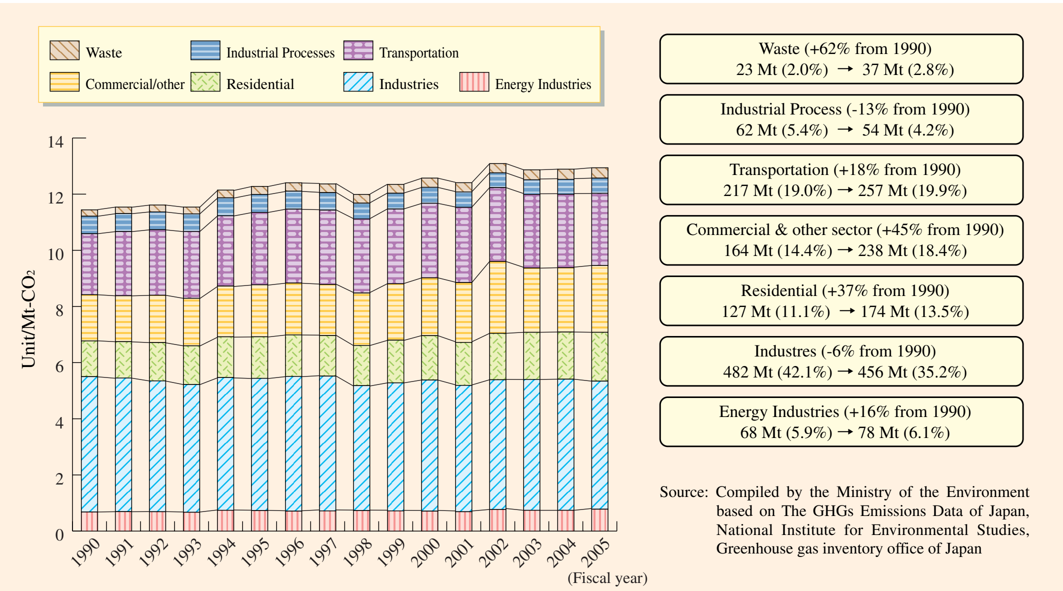
Figure 3-4-1 shows changes over time of CO_2 emissions in major sectors in Japan, and the data begins with the year 1990, which is the base year under the Kyoto protocol.

(2) Status of the industrial sector

As mentioned in the previous section, the industrial sector started introducing various energy-saving technologies after the oil crises, and since then this sector has been continuing its energy-saving efforts. As shown in Figure 3-4-1, however, the level of CO_2 emissions attributable to activities within the industrial sector still constitute a large proportion of Japan's total emissions and therefore needs to promote further emission-reduction measures toward the achievement of their assigned target under the Kyoto protocol. At the same time, when compared to the base year 1990, emissions caused by the industrial sector have declined.

This declining tendency indicates the effective wide utilization of excellent energy-saving technologies in Japan in comparison with other countries. The aforementioned data of international comparison on CO_2 emissions intensity by industry in major manufacturing sectors (Table 3-3-1) is evidence of Japan's superiority in emission-reduction efforts. Therefore, it can be expected that the export of Japanese advanced technologies to foreign countries would be contributive to those countries pursuing emission-reduction efforts. In this light, Japan is capable of making valuable contributions to the international society's global warming countermeasures.

Figure 3-4-1: Trends in CO_2 emissions in Japan



(3) Status of the commercial and residential, and transport sectors

In contrast to the industrial sector, CO_2 emissions caused by the commercial and residential, and transport sectors have increased substantially from the base year 1990 (44.6% increase for commercial and other sector, etc., 36.7% increase for residential and 18.1% increase for the transport sector). Also, those three sectors collectively account for as much as 57% of all CO_2 emissions in 2005. At the same time, however, it can be translated into a large reduction potential expected from those sectors, and this potential could be realized by way of an adoption of emission reduction measures by a large number of representatives from these three sectors. Thus, it is important to understand how technologies could specifically contribute to CO_2 emission reduction in those sectors in particular, and the following subsections will explain the details of such potential, while focusing on those technologies at the stage of practical utilization.

2. Statuses of Practical Application of Various Technologies to Products and Systems

Technologies could contribute to CO_2 emission reduction only after they are successfully applied to products or systems, commercialized and widely utilized.

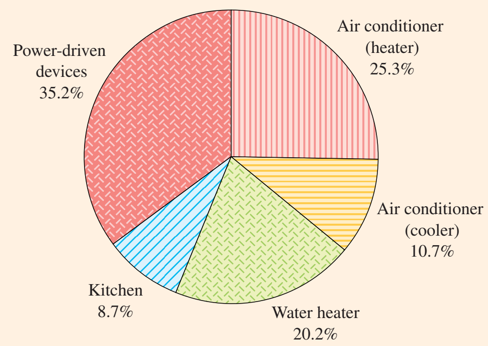
Here are examples of such applications that have a large potential of wide utilization. Those can be roughly divided into technologies for energy users and technologies for energy suppliers.

(1) Energy saving technologies for energy users

Figure 3-4-3 and Figure 3-4-4 show the CO_2 emission structure in the commercial and residential sectors, including households, offices and business facilities. Those figures show that water heaters, air conditioners and power unit (refrigerators, lighting equipment, etc.) collectively occupy a large proportion of the CO_2 emissions. Also, about 90% of the total CO_2 emissions generated by the transport sector are attributed to the use of motor vehicles, and about 50% originate from private passenger cars, as shown by Figure 3-4-5.

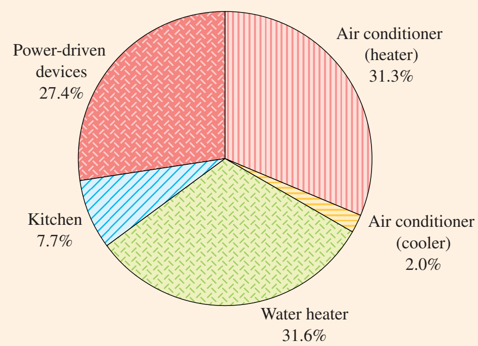
Since the CO_2 emissions attributed to the said equipment and machines are large, reduction of them would produce substantial effects, and it is therefore important to work aggressively on those equipment and machines. The following subsections will explain the potential of CO_2 emission reduction expected mainly from the said equipment and machines through the promotion of technology utilization.

Figure 3-4-4: Structure of CO_2 emissions in commercial and other sector (FY2005)



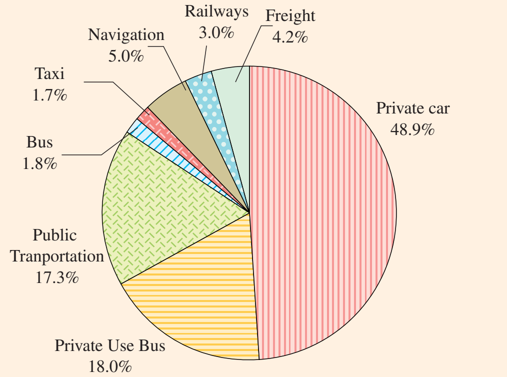
Source: Compiled by the Ministry of the Environment based on the Institute of Energy Economics, Japan, *Handbook of Energy & Economic Statistics in Japan*

Figure 3-4-3: Structure of CO_2 emissions in residential sector (FY2005)



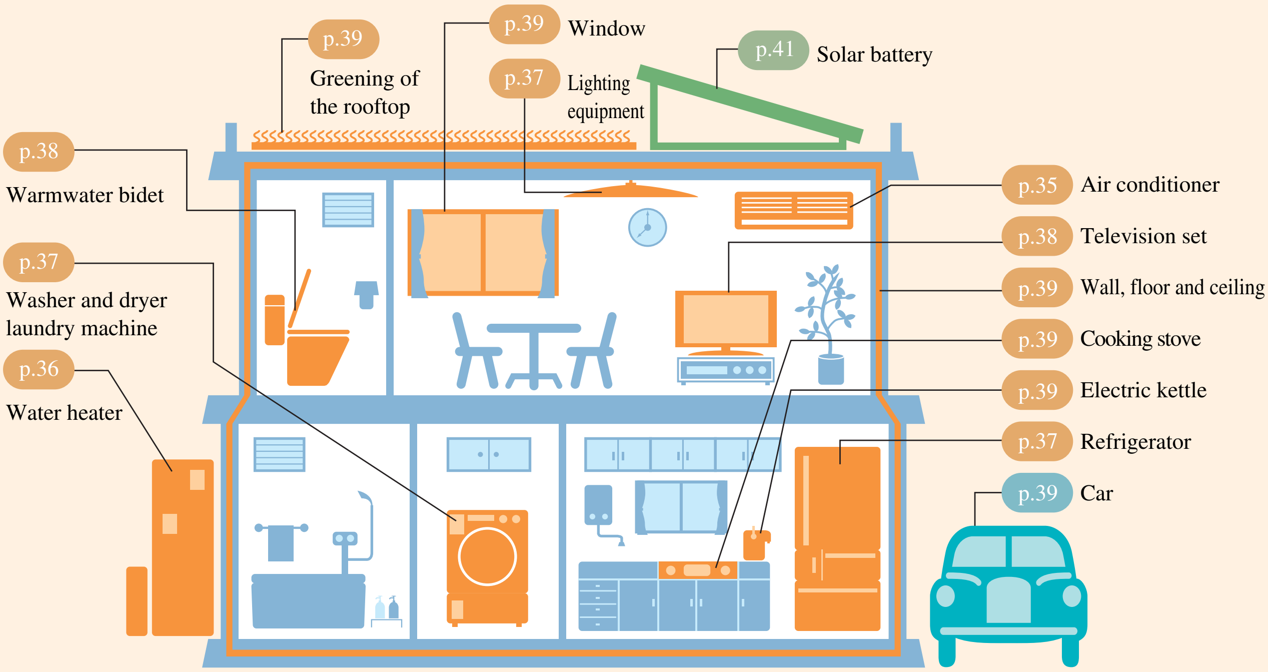
Source: Compiled by the Ministry of the Environment based on the Institute of Energy Economics, Japan, *Handbook of Energy & Economic Statistics in Japan*

Figure 3-4-5: Structure of CO_2 emissions from the transport sector (FY2005)



Source: Compiled by the Ministry of the Environment based on Greenhouse Gas Inventory Office of Japan, of the National Institute for Environmental Studies, National GHGs Inventory Report of Japan

Figure 3-4-2: Potential application of environmental technologies to households



Source: Ministry of the Environment

a. Thermal and heat pump technologies

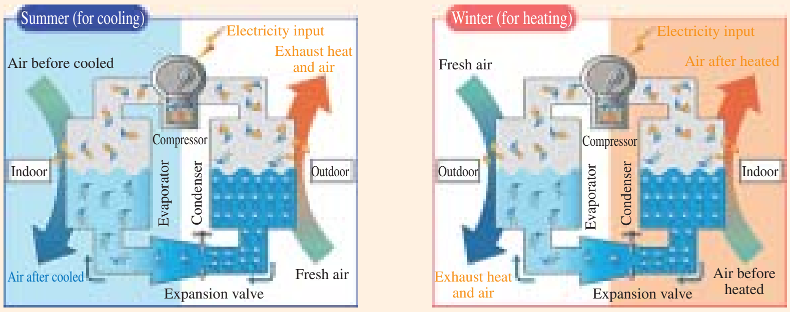
Heat pump technology, which moves collected atmospheric heat from one location to another, is being applied to air conditioners, food refrigerators and freezers, etc. This technology allows for the use of low-temperature thermal energy in a highly efficient manner. Recent improvements of various technologies have upgraded performance of heat pumps to a large extent. Actually, the use of heat pump technology has been expanded to include water heaters and dryers and washing machines , resulting in enormous energy-saving effects. In addition, heat pump air conditioners capitalizing on the use of underground heat or the use of sewage or river water as a heat source have been commercialized.

Also, advanced technologies to improve thermal efficiency, such as the technique of phased use of heat, latent heat recovery system, etc. are applied to commercial products one after another.

(a) High-efficiency air conditioners

Today, most houses and offices have air conditioners and many of them have a heating system in addition to a cooling system. Since air conditioners are the major electricity consumer in homes, improvement of their energy efficiency is especially demanded.

Figure 3-4-6: Mechanism of heat pump



Source: Tokyo Electric Power Company

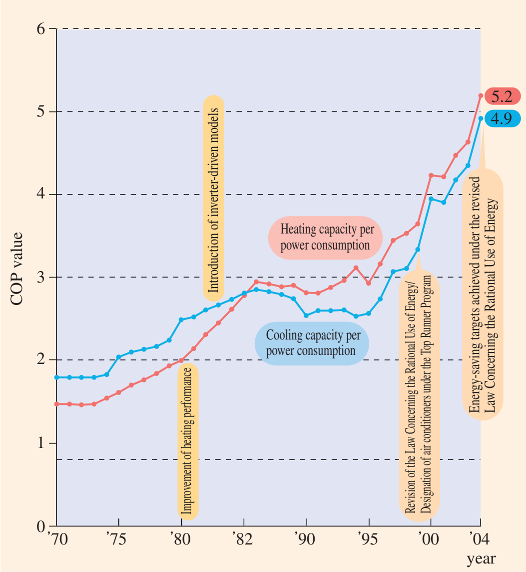
Actually, through the development and commercial application of high-efficiency heat pump technology and new control technologies, energy efficiency of air conditioners has improved greatly in recent years.

For example, some of the latest high-performance models have an excellent COP value of 6 or higher ("COP" or "Coefficient of Performance" is an index representing energy consumption efficiency in term of the cooling/heating capacity per power consumption of 1kW). These are much lower CO_2 emissions than those of conventional products. Actually, the recent COP trend for air conditioners (Figure 3-4-7) shows a rapid improvement of efficiency in the last decade. You can save your money for electricity charges if you buy one of the latest high-performance models to replace your old one.

The number of air conditioners being installed at home in Japan is estimated to be more than 120 million units today, and quite a few of them are considered to be conventional models. Therefore, much energy-saving effects can be expected from replacement of those models with the latest models.

In addition, those high-performance models have various energy-saving functions, including a system to create a pinpoint air current that would effectively and immediately make users feel warmth when they turn on the heater and a system of automatic cleaning of internal structures (the latter system prevents dust accumulation from causing deteriorated operation efficiency). It can be said that the latest models embody an integrated improvement of convenience, economy and environmental-friendliness.

Figure 3-4-7: COP trend for air conditioners (in terms of sales)

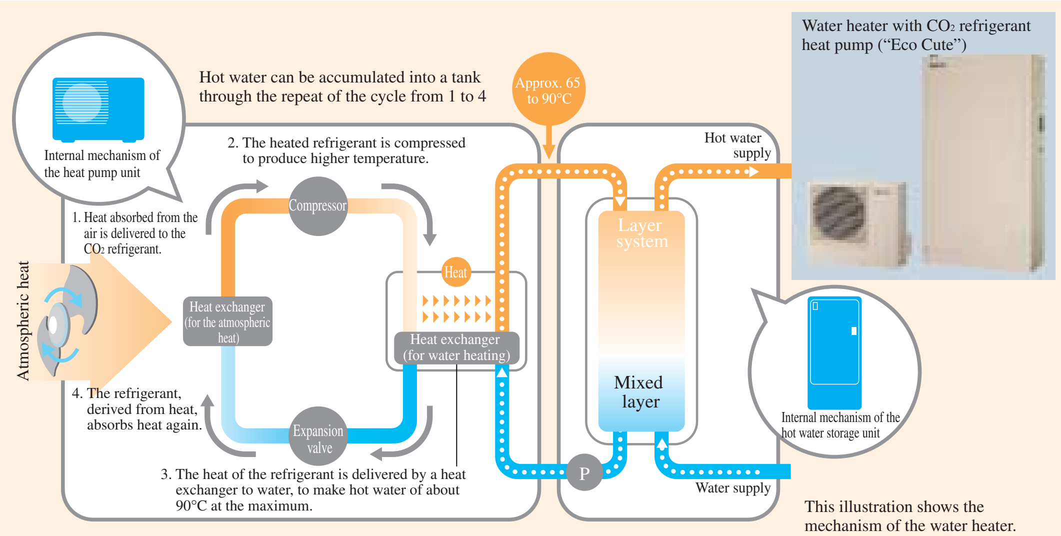


Source: Jyukankyo Research Institute Inc.
"Fact sheet on energy-saving electric home appliances" issued by the Ministry of the Environment

(b) Electric water heater with natural refrigerant heat pump and high-efficiency gas water heater with the latent heat-recovery function

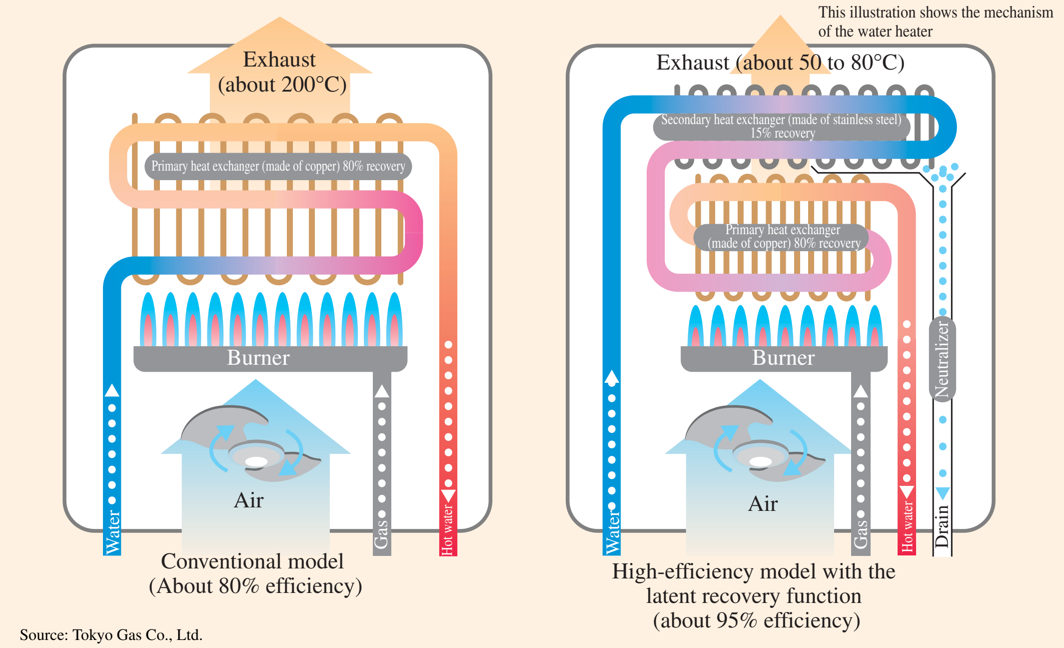
The electric water heater with a natural refrigerant heat pump (known under the trade name "Eco Cute") has been developed to use carbon dioxide as a refrigerant together with a heat pump system, just like ones used in many air conditioners, where electricity and atmospheric heat is used to heat water.

Figure 3-4-8: Mechanism of the electric water heater using a natural refrigerant heat pump



Source: Tokyo Electric Power Company
"Fact Sheet on energy-saving houses" issued by the Ministry of the Environment

Figure 3-4-9: Mechanism of gas water heater with the latent heat-recovery function



Source: Tokyo Gas Co., Ltd.
"Fact Sheet on energy-saving houses" issued by the Ministry of the Environment

Because of the use of atmospheric heat, this water heater is energy-efficient, allowing for about a 30% saving of primary energy as well as about a two-fold reduction of CO_2 emissions, when compared to combustion-type products. This makes it possible for users to save a lot of money for electricity charges when compared to conventional models.

The high-efficiency gas water heater with the latent heat recovery function has also been developed and widely distributed as an energy-saving product (known under the trade name "Eco-JOES"). The function of latent heat recovery from vapor contained in exhaust gas allows for about a 95% efficiency, instead of about 80% for conventional models.

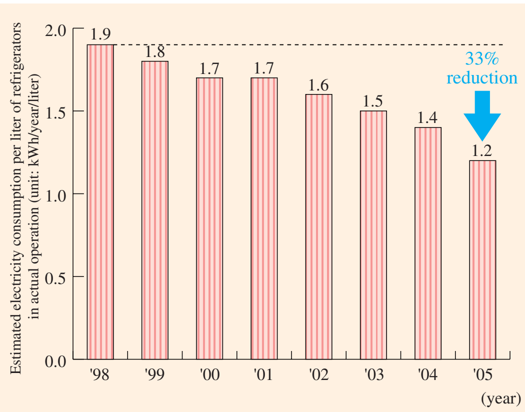
In addition, the gas engine heat pump system is now being widely used.

(c) Electric refrigerator

Electric refrigerators have also improved their energy-saving performance significantly through the introduction of advanced refrigeration technology, insulation technology, control technology and so on.

For the last twenty years, electric refrigerators have achieved more than the three-fold reduction in electricity consumption per liter of capacity. During the past several years, the improvement of their energy-saving performance has been further accelerated, achieving more than 30% reduction in overall electricity consumption. It means that replacement of a conventional model with one of the latest high-performance models would result in great energy-saving effects (Figure 3-4-10).

Figure 3-4-10: Changes over time in yearly electricity consumption of 450-liter-capacity electric refrigerators in actual operation



Source: Final Report by the Electric Refrigerator Evaluation Standards Subcommittee of the Advisory Committee on Natural Resources and Energy
"Fact sheet on energy-saving electric home appliances" issued by the Ministry of the Environment

(d) Heat-pump washer & dryer laundry machine

In recent years, more and more households have come to use an electric dryer for laundry. Those laundry machines with an electric drying system generally consume a lot of electricity when compared to those using a non-electric drying process, but the latest models introduce heat pump technology, which allows for substantial energy saving and more than twice the reduction in electricity consumption. Those heat-pump models have been launched by several manufacturers one after another recently.

b. Energy-saving technology for lighting equipment

Lighting products have also been substantially improving their energy-saving performance through the introduction of advanced materials and devices.

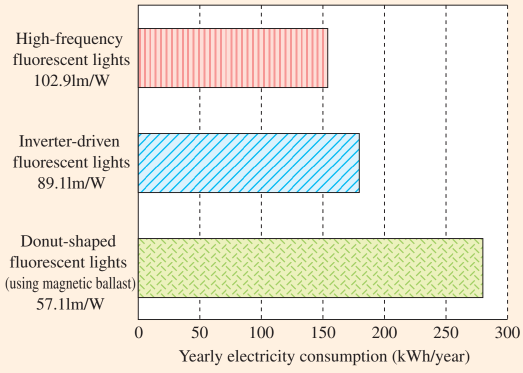
Light bulbs have increased their efficiency by introducing inverter-driven fluorescent lights, high-frequency (Hf) fluorescent lights, etc. (Figure 3-4-11). Those products are also user-friendly, as they light instantly and do not flicker.

The energy efficiency of electric bulb-type fluorescent lamps is four or five times higher than that of incandescent light bulbs. The former is more expensive than the latter in terms of unit price, but is more economical in the long run due to higher durability and a lower consumption of electricity (Figure 3-4-12).

Also, LED (light emitting diode) has excellent energy-saving characteristics, including low electricity consumption, longer life and a small size. LED has already been successfully introduced in traffic signals and display components, and it can be expected to be widely utilized for general lighting equipment in the future. In addition, organic electroluminescence (EL), which is the technology to electrify illuminable organic materials, has several advantages, such as low electricity consumption, the ability to create a thin product and foldablity. Organic EL has been already practically applied to display components, and is expected to be widely applied to lighting equipment in the future.

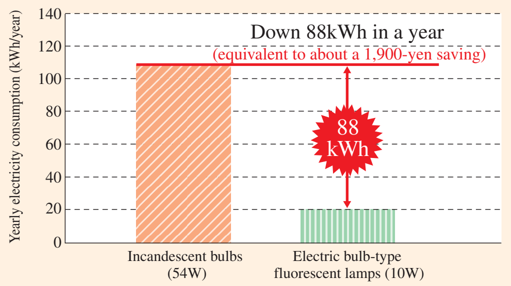
Reflectors made of high-performance reflective materials are also drawing attention. Installing such reflectors in a way that creates an appropriate angle of reflection would substantially improve lighting effects and reduce electricity consumption, and such techniques have already found practical applications. As a matter of fact, in 2006 the Ministry of the Environment succeeded in achieving about a 30% year-on-year energy saving at the Ministry's main office in Kasumigaseki, Tokyo, by installing such reflectors with fluorescent lights and adjusting their illumination intensity.

Figure 3-4-11 Comparison of energy-saving performance among diverse fluorescent lights



Source: Jyukankyo Research Institute Inc.
"Fact sheet on energy-saving electric home appliances" issued by the Ministry of the Environment

Figure 3-4-12 Comparison of electricity consumption between electric bulb-type fluorescent lamps and incandescent light bulbs



Source: Jyukankyo Research Institute Inc.
"Fact sheet on energy-saving electric home appliances" issued by the Ministry of the Environment

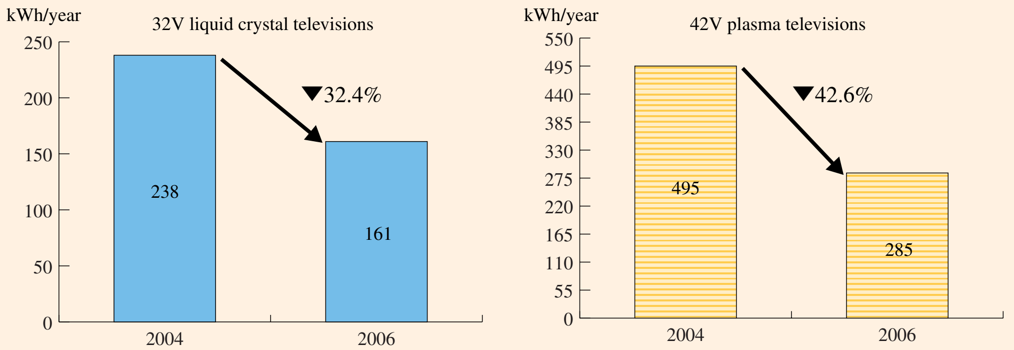
c. Energy-saving technologies for other electric home appliances

Recent trends in the television market can be characterized by the widespread introduction of thin displays, including liquid crystal displays and plasma displays, coexisting with conventional cathode-ray tubes (CRT). Since thin televisions have a wider display in general, they tend to increase electricity consumption. However, energy-saving performance has been improving at the same time, resulting in overall reduced power consumption when size and system are the same. As far as medium-sized or smaller televisions are concerned, there is a general tendency for liquid crystal televisions to consume less electricity than plasma televisions or CRT televisions. Energy-saving efforts under the top-runner standards have been also promoted for televisions.

The demand for warmwater bidets has been increasing recently, where user needs are diverse. Some people use it for comfort, some use it because of health problems, and others need it during cold weather. Although those products consume electricity to warm a seat, etc., their energy-saving technology has been upgraded at the same time. For example, the "instantaneous heating system" has been recently introduced, where the heating system is activated on demand. This system consumes less electricity than the conventional "hot water storage system," as the former does not require power for heat retention even though its instantaneous electricity consumption is large. In addition, in an effort to save the electricity to be used for warming a seat, an automatic on/off power control function as well as a sensor to detect a user for automatic heater activation have been developed (Figure 3-4-14).

When compared to conventional electric kettles, latest-model counterparts equipped with a vacuum-insulation panel have a superior energy-saving performance for heat retention. This vacuum-insulation technology makes it possible to achieve about an

Figure 3-4-13: Energy-saving technologies for television sets (comparison between 2004 models and 2006 models)



- Improved permeability of liquid crystal panels
- Decreased electricity demand of fluorescent backlight bulbs
- Decreased electricity demand of backlight driving circuit
- Improved efficiency of materials used in a backlight unit (reflector and fluorescent screen)
- Improved image quality and energy saving through the backlight control system interlocked with video signal

- Improved panel efficiency (Improved fluorescent materials)
- Improved illumination efficiency of sustained discharge
- Improved efficiency of pre-discharge emission
- Improved reactive power
- Optimized driving system
- Improved control circuit (new LSI system)
- Reduced standby electricity consumption (IPD (Intelligent Power Device) for semiconductor device for switch mode power supply)

Source: Japan Electronics and Information Technology Industries Association

80% reduction in electricity consumption for heat retention and a combined reduction of about 50% in electricity consumption for water boiling and heat retention. Those models also use various advanced technologies such as control technology and material technology.

d. Energy-saving technologies for kitchen appliances

Cooking stoves have improved their energy efficiency. The improved efficiency of gas ranges, for example, is attributable to various technical improvements, including optimized flame angles, downsized burner diameter and optimized air supply for combustion.

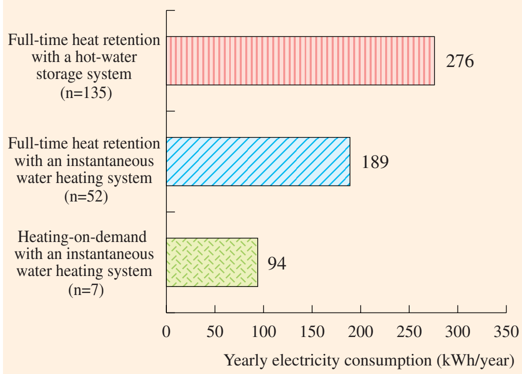
Figure 3-4-15: Heat-insulation performance by type of glass/sash

Level of heat insulation	Structure
High 35.7	Plastic sash + High performance heat shield double-glazed glass
35.7	Wooden sash + High performance heat shield double-glazed glass
35.7	Aluminum sash of double-sash structure with single-layer glass + Resinous inner window with double-glazed glass
53.5	Aluminum sash of heat insulation structure + Double-glazed glass
53.5	Aluminum/resin-compound sash + Double-glazed glass
71.4	Aluminum sash + Double-glazed glass
Low 100	Aluminum sash + Single-layer glass

(Heat insulation performance)

Source: Japan Construction Material & Housing Equipment Industries Federation
"Fact Sheet on energy-saving houses" issued by the Ministry of the Environment

Figure 3-4-14: Comparison of yearly electricity consumption by type of warmwater bidets



Source: Product brochures published by respective manufacturers as of July 2006
"Fact sheet on energy-saving electric home appliances" issued by the Ministry of the Environment

e. Energy-saving technologies for buildings

In order to ensure heat-insulating performance of a building, it is important to pay attention to windows because they easily let in heat. When compared to single-layer glass sheets, double-glazed glass, especially high performance heat shield double-glazed glass, exhibit excellent energy-saving performance. It is also necessary to pay attention to the thermal conductivity of sliding frames in sash windows, and the use of wooden or resinous frames that have a low thermal conductivity would be effective for improving energy conservation.

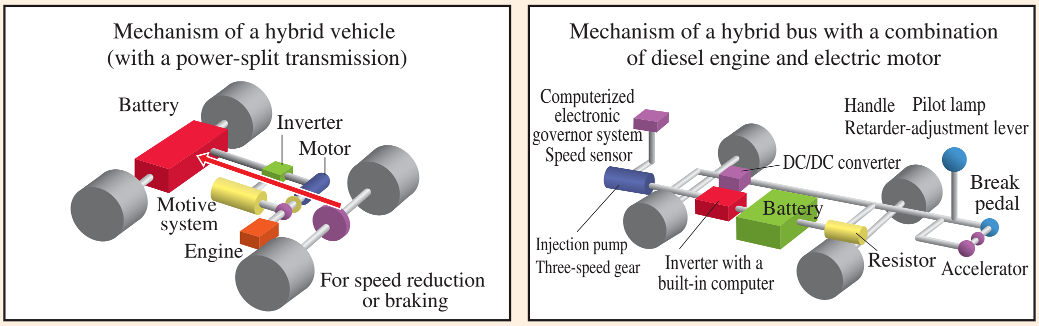
In addition, it is necessary to use insulating materials for walls or ceilings when structures other than windows have low heat-insulating performance. Improved building-wide heat-insulating performance would be beneficial not only in terms of energy saving but also in terms of the comfort of the people inside, since it would reduce a temperature gap between room air and the surfaces of floors, walls or ceilings. Such improved insulation could be obtained all the more effectively through the introduction of advanced material technology, component technology, design technology and construction technology.

Rooftop greening and wall greening are also effective for moderating the heat, as they improve light-shielding performance and insulation and have the effect of the transpiration of plants, resulting in a decrease in radiant temperatures of a building. Actually, those greenings have been increasing recently, with the support of various technology developments, including light-weight soils, automated water supply systems, etc. Also, rooftop and wall greenings are expected to enhance CO_2 absorptions.

f. Technologies for motor vehicles

About 90% of transport-attributed CO_2 emissions come from motor vehicles. In order to reduce those CO_2 emissions, it is important to introduce various measures integrally, including transportation-demand management efforts to control or reduce automobile traffics, promotion of a modal shift for better traffic management ("modal shift" means a shift from road transportation

Figure 3-4-16: Mechanism of a hybrid vehicle



Source: NEDO (New Energy and Industrial Technology Development Organization)

Column : ESCO (Energy Service Company)

The ESCO program, which represents one of the emerging business models, has been launched and expanding. An ESCO project offers energy-saving services to clients, such as building owners; and saved energy expenses or cut utility costs, which result from the project implementation, will be appropriated for payment (remuneration) to the project operator, future ESCO project expenses, etc. This mechanism allows building owners to introduce energy-saving measures without paying extra money and while enjoy continuing cost reduction after the completion of payment to the project operator.

The ESCO program effectively supports the comprehensive implementation of various energy-saving measures. In this respect, this business model is a "technology" that uses the wisdom of achieving energy savings in a profitable manner. Implementation of ESCO projects makes it possible to promote comprehensive energy-saving measures including the introduction of various energy-saving equipment and systems, BEMS-utilized monitoring practices and efficient operation controls.

Households used to be outside the scope of the ESCO program, since energy-saving achievements obtainable from individual households are so small in size that they could not pay as a profitable business. However, the Ministry of the Environment received a noteworthy proposal from Biwako Bank and others who were entries in the Ministry-sponsored competition program for environmental policy measures (http://www.env.go.jp/press/press.php?serial=7992). The proposal suggests the use of the ESCO scheme for the introduction of preferential interest rates for consumer loans that would encourage private citizens to buy on credit energy-saving latest-model electric appliances to replace their conventional machines. This proposal, titled "Promotion of energy saving at households under the home-version ESCO scheme through multilateral cooperation," received an award in the competition. Thus, it is expected that private enterprises will play more important roles in promoting CO_2 emission reduction in the residential sector in the future.

Column : Mechanisms to Promote Wide Utilization of Technologies

Recent achievements from technology development have been remarkable, and various products with an embedded energy-saving system are commercialized one after another today. In order for those products to be widely used and produce substantial energy-saving effects, it is necessary to promote publicity of those products so that more and more consumers and businesses will be aware of them and come to use them. In short, the development of tactics or mechanisms for effective publicity is necessary in addition to the development of technologies themselves. Here are some examples of such mechanisms that have been actually introduced to facilitate the wide distribution and utilization of energy-saving products.

1. Labeling system

In order to promote the wide utilization of environmentally friendly products, it is necessary to provide appropriate, easy-to-understand product information that motivates people to choose those products.

In this aspect, the labeling system is considered to be effective, since people can easily identify energy-saving products by a mark or label attached to respective qualified products. There are several kinds of marks and labels, including the high-efficiency proof called “eco mark” as well as the label showing fuel economy for motor vehicles, the “energy-efficiency” label certifying the observation of the Law Concerning the Rational Use of Energy, etc. Starting from October 2006, the energy-efficiency labeling system has been introduced for air conditioners, electric refrigerators and television sets, where the uniform “energy-efficiency” label is supposed to be attached to all of the said designated products, to show whether or not the product satisfies the energy-saving standard under the said Law (Top-runner standards under the Top Runner Program). In addition, the label shows the level of energy-efficiency of the product through a five-grade evaluation system, yearly electricity consumption, and estimated yearly cost for electricity charge. Thus, the label allows consumers to easily identify and evaluate energy-saving products.

2. Financing programs

The introduction of energy-saving measures requires an initial investment. There are various financing programs that make it easier for businesses to make such investments. For example, an environmental activities evaluation program known as “Eco Action 21” allows medium- and small-sized business to enjoy a preferential interest rate, provided that they use a loan for introducing environmental protection measures (http://www.ea21jp/). This financing program encourages businesses to take actions for environmental protection.

Figure 3-4-17: Uniform Energy-Saving Label

Source: The Energy Conservation Center, Japan (ECCJ) to railway transportation or marine transportation, which is more efficient), improvement of distribution systems, reform of urban structures, etc. Besides, it is quite essential to improve fuel economy for motor vehicles, and therefore the promotion of relevant supporting technologies would have significant, immediate energy-saving effects.

Hybrid vehicles use two or more distinct powers or fuel sources, such as a combination of an engine and a motor, and can be characterized by a very high energy-saving performance and a significant reduction of exhaust gas. Among the widely used hybrid system configurations for passenger cars is that which combines gasoline engines with electric motors, wherein the battery is charged not by an external power source but by the engine's rotation, and a vehicle can run on just the engine, just the battery or a combination of both. A combination of a diesel engine and an electric motor is also seen in some commercially marketed passenger cars. These hybrid vehicles use high-level control technology. Also, battery technology plays an important role.

Electric vehicles and natural gas vehicles had many requirements and difficulties for commercialization and wide utilization, including the battery-recharging system, installation of charge stations for user convenience and the necessity of frequent recharging or refilling. On the other hand, hybrid vehicles do not require any new facilities or frequent recharging, and are user-friendly, allowing people to easily enjoy the energy-saving benefits.

Although the prices of hybrid vehicles are relatively higher than conventional cars, hybrid vehicles will reduce fuel consumptions substantially (which means substantial reduction in CO_2 emissions) and also improve fuel economy significantly.

In addition, conventional vehicles with a gasoline or diesel engine also benefit from technologies. Their fuel economy has been improved considerably with the introduction of the improved fuel-injection system, control system, adoption of a continuously variable transmission, etc.

g. Facility-wide maintenance systems

In recent years, much attention has been paid to BEMS (Building Energy Management System) and HEMS (Home Energy Management System). Those systems intend to achieve comprehensive energy saving for an entire building or house, where a building-wide status of energy supply and demand is monitored to integrally promote comprehensive, efficient operation of equipment and facilities inside the building.

(2) Energy-saving technologies for energy suppliers

Technologies to be used by energy suppliers include the efficiency improvement technology used by power plants as well as the energy shift from conventional energy sources to new sources of low CO_2 emissions.

This section will focus on solar energy, wind energy and biomass energy, all of which are renewable, relatively familiar to consumers, and are currently at the diffusion stage in commercial and residential, and transport sectors. Those energies have come into widespread use partly because of the enforcement of the Law Concerning Special Measures for Promotion of the Use of New Energy (RPS Law), which binds electric utility companies to the requirements to use the designated amount of new energies, such as solar power and wind power.

a. Solar energy technologies

One of the major forms for the use of solar energy is the power-generation system using solar cells.

Solar cells convert solar energy directly into electricity. Sunlight collected on a rooftop is used to generate electricity, and this process causes no CO_2 emissions. In recent years, solar cells have been becoming increasingly commonplace among ordinary households.

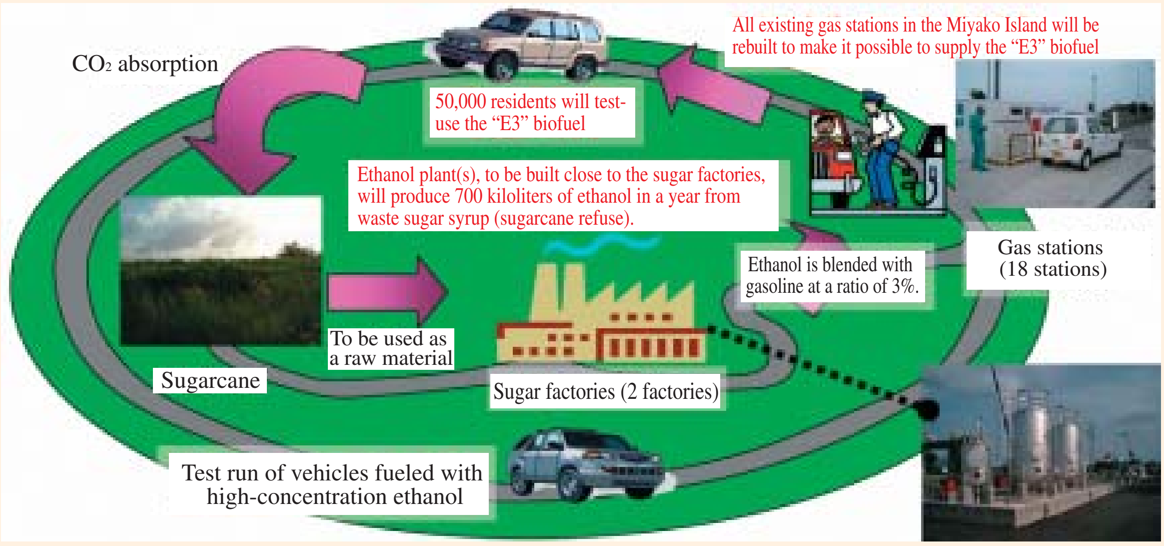
Here, key technologies include the conversion device from sunlight to electricity and control systems for electricity utilization.

Also, the level of efficient use of solar heat has been improved, thanks to emerging technologies, such as solar heat collection and heat accumulation.

b. Wind energy technologies

Wind power is considered to have a large potential for effective utilization as an energy source, including the utilization of ocean wind. Although there are some disadvantages, such as instable power or voltage, the use of wind power has been increasing. Since the efficiency of electricity generation can be increased when wind blows stronger and a wind turbine is larger, there is an upsizing tendency for wind turbines. Also, small-sized wind-power generators, which have an advantage of user-friendliness while having a

Figure 3-4-18: "Bio-ethanol Island" plan in Miyako Island



Source: Ministry of the Environment

disadvantage of low efficiency, are practically utilized today, and the combined use of such a small wind-power generator with a solar cell has been commercialized as well.

c. Biomass energy technologies

Biomass energy is obtainable from renewable, biodegradable organic resource (except fossil fuels). It is a sequestrated energy in the form of plant materials converted from sunlight through photosynthesis, and CO_2 emissions caused by the use of such energy can be deemed as offsettable by the breeding of plants, etc.

In addition to traditional materials such as firewood and charcoal, more and more new materials are currently achieving increasingly widespread use. For example, used cooking oil is being used for diesel fuel, livestock excreta is being used for methane fermentation, and natural materials are being used for ethanol fermentation. In particular, bio-ethanol draws a great deal of attention today as a biofuel alternative to gasoline (for motor vehicles). Currently, various technologies to produce bio-ethanol fuels are at the commercialization stage, including the use of discarded wood construction material, non-standard farm produces, wastes generated during food processing and byproducts such as sugarcane syrup. In January 2007, the world's first commercial-scale plant to produce ethanol from wood construction waste was established in Osaka Prefecture. The plan is that, starting from fiscal year 2007, demonstration projects for regional mass-introduction of bio-ethanol fuels for local transport systems will be launched in some metropolitan areas as well as in Miyako Island, Okinawa Prefecture.

Thus, various energy-saving products, systems and technologies are at the stage of commercialization and expanding utilization, including the aforementioned heat pump technology for utilization of unused heat, integral and comprehensive energy control systems, and new-energy-utilizing technologies allowing energy suppliers to avoid emitting CO_2. CO_2 emissions can be expected to be substantially reduced through the expansion and acceleration of the use of those technologies.

3. Development of National Campaigns

The aforementioned energy-saving technologies would fail to contribute to CO_2 emission reduction if not widely utilized among the public. In this light, it is necessary for grassroots activities to improve people's actions and change their lifestyles.

The national "Team Minus 6%" project initiated by the Prime Minister, which aims to promote large-scale civic campaigns to global warming countermeasures, is now in operation, and its activities have been expanding to involve many citizens, businesses and organizations, with registered membership numbering about 1.1 million individuals and about 11,000 companies and organizations as of March 2007. For example, the "Cool Biz" campaign, which advises people to save energy by limiting air

Column : The "UCHI-ECO (Home-Eco)" Campaign

In October 2006, Mr. Masatoshi Wakabayashi, Minister of the Environment, announced the launch of the "UCHI-ECO (home-eco)" campaign, which aims to promote people's daily efforts at home in the fields of food, clothing and housing to global warming countermeasures.

This campaign makes specific energy-saving proposals to the general public in the fields of clothing, food and housing. They include home-version "Cool Biz" and "Warm Biz" to seek comfortable indoor living in summer/winter while limiting air conditioning, the wise choice of food that would cool down your body in summer and warm up your body in winter, the effort to turn off electric appliances immediately after use, and the use of energy-saving fluorescent lights or bulbs (http://www.team-6jp/).

Figure 3-4-19: An example of the "UCHI-ECO (home-eco)" campaign logo

Source: Ministry of the Environment

conditioning in the summer while seeking clever ways to spend hot days comfortably, and the winter counterpart "Warm Biz" campaign are respectively estimated to have reduced CO_2 emissions by about 1.14 million tons (summer of 2006) and about 1.41 million tons (fall and winter of 2005). The "UCHI-ECO (home-eco)" campaign has also been increasing its participants, where people are advised to global warming countermeasures by making daily efforts at home in the field of food, clothing and housing.

Thus, development of national campaigns play important roles in promoting global warming countermeasures. The awareness of individual citizens has significant impact on the effective utilization of CO_2 emission-reduction technologies and products, and national campaigns are expected to produce enormous energy-saving effects, if promoted successfully. Therefore, it is necessary to promote them extensively through combined efforts among diverse entities, while seeking ecology-conscious lifestyles.

Section 5: Visions of the Future Utilization of Global Warming Countermeasures

In making our efforts to global warming countermeasures, technology plays important roles. This section will explain visions of how Japanese technologies could be effectively utilized for promoting global warming countermeasures into the future, with the focus on the following three directions: the promotion of thorough utilization of available technologies, new innovative technologies and the development of technologies for ensuing harmony between nature and people.

1. Ensuring Diffusion and thorough Utilization of Available Energy-Saving Technologies

Section 4 explained specific technologies pertaining to global warming countermeasures closely related to people's daily lives and discussed how they are actually being used in the commercial and residential sectors (households, office, etc.) in particular and how they effectively reduce CO_2 emissions. The promotion of replacement of conventional models with energy-saving models with the said technologies can be expected to produce substantial effects in terms of CO_2 emission reduction.

The first part of this section will explain the potential for CO_2 emission reduction expected from an extensive introduction of energy-saving equipment to households, offices, buildings, etc.

(1) Simulative analysis of the potential CO_2 emission reduction expected from the introduction of energy-saving equipment to households

a. Introducing high-efficiency home appliances

Here are three estimation examples as to the potential CO_2 emission reduction expected from the replacement of conventional appliances with energy-saving models together with the introduction of some improvements (heat insulation, etc.) to house fittings.

(a) A household of a family consisting of a married couple in their forties and children living in a detached house

A married couple in their forties has two children and they live in a ten-year-old detached house (of their own) with three bedrooms.

This family has an air conditioner, electric refrigerator, lighting equipment and gas range, which the family bought at the time they built the house, as well as a television set, washing machine, electric clothes dryer, warmwater bidet, water heaters, etc., which the family bought later but is now considering replacing. Suppose the family is going to replace all of those appliances with up-to-date energy-saving models, and also replace existing window glasses with multiple-layer glasses that have high heat insulation performance in order to improve air-conditioning efficiency.

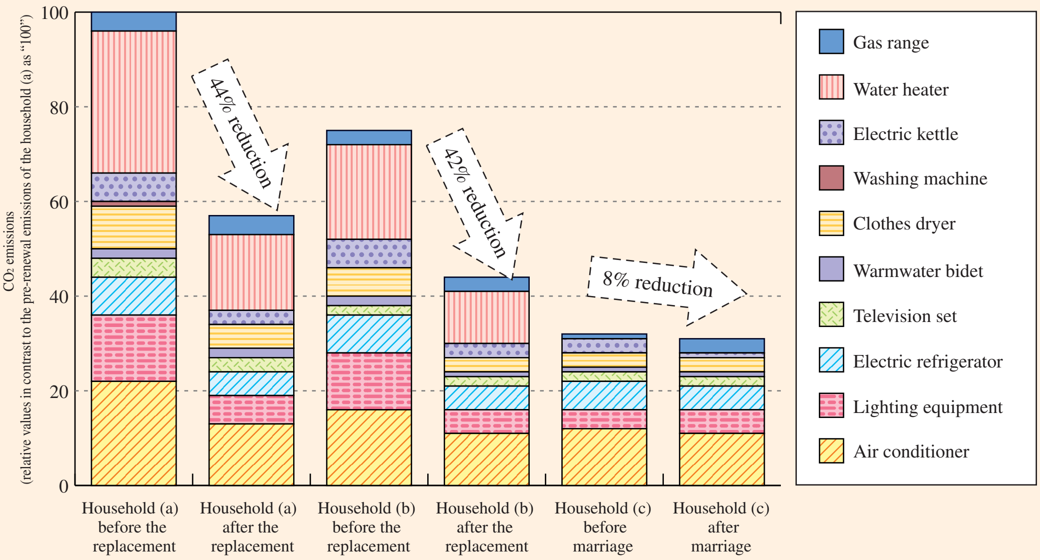
The resulting effects are estimated to be more than a two-ton reduction in CO_2 emissions per year. This is about a 40% reduction in emissions when compared to the emissions before the replacement, and is equivalent to a nearly 150,000-yen saving of yearly utility costs (gas and electricity charges). Furthermore, as a result of the introduction of double-glazed window glasses, the family will enjoy reduced energy costs for their air conditioner as well as enhanced comfort from the avoidance of condensation nuisance.

(b) A household of a married couple in their sixties living in a detached house

An elderly couple in their sixties lives in a ten-year-old detached house (of their own) with three bedrooms. Although the age and size of this house are the same as those of house (a) above, the operation hours of electric appliances and lighting equipment are different between households (a) and (b) due to the difference in their lifestyles.

Suppose this couple is going to replace their air conditioner, electric refrigerator and lighting equipment, as well as an old television set, washing machine, electric clothes dryer, warmwater bidet and water heater with the latest energy-saving models, and also replace existing window glass with multiple-layer glass that has high heat-insulation performance in order to improve air-

Figure 3-5-1: Changes in CO_2 emissions as a result of the replacement of home appliances for the three households



Note1: Calculation method

The reductions in CO_2 emission have been based on the estimated yearly reduction in electricity and gas consumption as a result of the replacement. The energy intensity of 0.378kg-CO_2/kWh (*1) for electricity and 2.08kg-CO_2/Nm3(*2) for gas are applied. The new products to replace existing products are assumed to be the latest models with the highest energy-saving performance in the industry as of 2006. Specifically, the new television set is assumed to be a liquid crystal television, and the new warmwater bidet is assumed to have the instantaneous heating function. The new water heater is assumed to be an electric model with a natural refrigerant heat pump, replacing a gas-fueled water heater. The new lighting equipment is assumed to consist of inverter-equipped Hf fluorescent lights, introduced in place of the conventional magnetic fluorescent lights and bulb-type fluorescent lights, replacing incandescent light bulbs.

The assumed electricity/gas consumption before the renewal is based on the industrial data on average general models of the relevant year of production. The assumed year of production is determined based on the results of the Consumer Confidence Survey conducted by the Cabinet Office on average life of electric home appliances, etc. Other technical data of electric appliances are based on information from The Japan Refrigeration and Air Conditioning Industry Association, final report by the Electric Refrigerator Evaluation Standards Subcommittee, Energy Efficiency Standards Subcommittee of the Advisory Committee on Natural Resources and Energy, information from Japan Electronics and Information Technology Industries Association, the handbook "*Wa-no-Kurashi*" (meaning "eco-life") published by the Ministry of the Environment and the handbook "How to choose and use energy-saving products" published by the Energy Conservation Center, Japan.

(*1) Guidelines for Measurement of Greenhouse Gas Emissions from Businesses issued by the Ministry of the Environment (July 2005)

(*2) Emission factor under the system of emissions calculation, reporting and announcement

Note2: The estimations are based on the assumption that the replacement takes place at a reasonable time for renewal. The purchase of the mentioned electric appliances can be estimated to require one million yen or more, and the renewal of water heater and window glasses is estimated to cost an additional 500,000 yen or so.

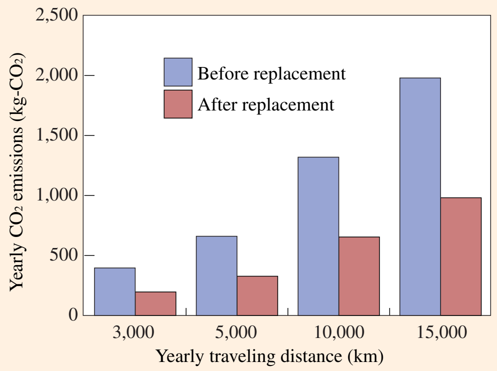
conditioning efficiency.

The resulting effects are estimated to be slightly less than a two-ton reduction in CO_2 emissions per year. This is about a 40% reduction in emissions when compared to the emissions before the replacement, and is equivalent to more than a 100,000-yen saving of yearly utility costs.

(c) A household of a single male in his thirties who is getting married soon and is currently living in a rented apartment

A single male in his thirties is getting married soon. Upon marriage, he is going to move to a rented apartment with one bedroom, from the current one-room rented apartment that he moved into ten years ago, when he first started his current job. Suppose he is going to replace all of his electrical appliances with up-to-date energy-saving models when he moves.

Figure 3-5-2: Effect of CO_2 emission reduction through the replacement of a conventional car with a new model



Note: The estimations are based on the assumption that a 1500cc-gasoline vehicle is replaced with a hybrid vehicle of the same size. For the estimates, the 10.15-mode fuel consumption is applied.

Source: Ministry of the Environment

The new refrigerator, television set and washer-and-dryer laundry machine he is going to buy will all be bigger in size than the current ones. Furthermore, his household will be upsized from a single to two. Still, however, CO_2 emissions in his new household can be estimated to be possibly lower than the present, thanks to the high-efficiency models.

Figure 3-5-1 shows the summary of the estimations for the above three households.

b. Replacing a private car with a high-efficiency model

Now let's see how much CO_2 emission reduction can be expected from the replacement of an existing conventional car with a new model that has excellent fuel economy.

The amount of CO_2 emissions to be generated by the use of a car greatly depends on the way it is driven and on traveling distance. A traveling distance varies significantly among households. Figure 3-5-2 shows four examples of different traveling distances.

(2) Simulative analysis of the potential CO_2 emission reduction that can be expected from the introduction of energy-saving technologies to a building for business use

Now, let's figure out the potential CO_2 emission reduction that can be expected from the introduction of currently available energy-saving technologies to existing buildings for business use. Two examples follow: the first one represents the case wherein operational optimization is thoroughly introduced to existing facilities and equipment and the second one represents the case wherein moderate capital investments are made to introduce energy-saving measures in addition to the said optimization. Here, the capital investments are limited to those that are expected to pay off in a relatively short period time, such as a replacement of conventional lighting equipment with new models. The building concerned is assumed to be an average construction located in Tokyo (with eight stories above ground and one below, having the total floor space of about 7,500 square meters).

a. Introducing the thorough operational optimization to existing facilities and equipment

The potential CO_2 emission reduction effects that can be expected from the introduction of operational optimization, such as outdoor air-intake control, use of outdoor air for indoor cooling, etc. has been figured out based on the assumption that existing facilities and equipment, such as air conditioners, pumps, heat source equipment, lighting equipment, power outlets, water heaters, water supply systems, drainage systems and elevators, continue to be used. The result is about a 2.6% reduction of CO_2 emissions in a year (equivalent to about 23 tons) (Figure 3-5-3).

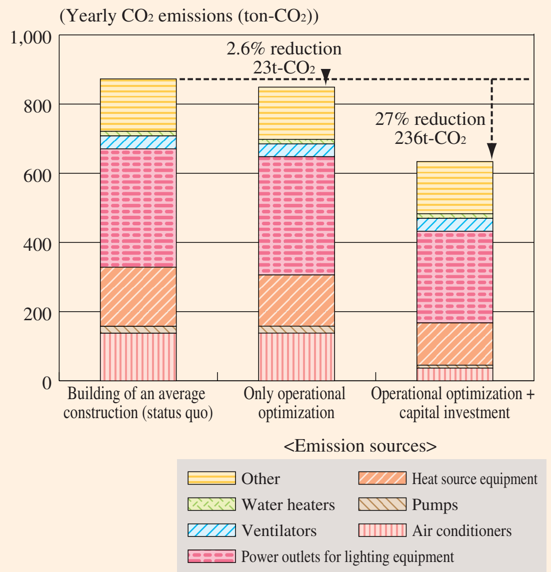
b. Introducing capital investments to major facilities and equipment

The potential CO_2 emission reduction effects that can be expected from the introduction of capital investments in addition to the optimization as mentioned above has been figured out. Here, the capital investments are limited to those considered to pay off in a relatively short period of time and include the installation of an inverter to introduce variable air-volume control for air-conditioning systems, the installation of an inverter to introduce flow control of coolant and hot and cold water for pumps, the installation of high-efficiency lighting system, and the installation of a total heat exchanger for recovery of exhaust heat and air. The calculation result is about a 27% reduction of CO_2 emissions in a year (equivalent to about 236 tons) (Figure 3-5-3).

Building conditions are diverse and appropriate energy-saving measures and the resulting effects vary according to the buildings. However, as shown by the above estimations, a considerable amount of energy conservation can be achieved through the introduction of low-cost, currently available energy-saving technologies to existing facilities and equipment, without any building reconstruction.

As mentioned above, it is possible for homes as well as buildings for business use to achieve relatively large effects of CO_2 emission reduction in a relatively short period of time by introducing currently available energy-saving technologies. (It

Figure 3-5-3: Potential CO_2 emission reduction expected from introducing energy-saving measures to a building for business use.



Note: The estimations are made by using the "management tool for intensity of energy consumption" of the Energy Conservation Center, Japan
Source: Ministry of the Environment

Column : An Example of the Successful Introduction of Energy-Saving Measures to a Building for Business Use

Energy-saving technologies or measures to be introduced into buildings for business use should be cost-effective in terms of initial investment as well as expected reduction of running costs after the introduction. ESCO programs are being inaugurated in support of the increasing number of measures with significant energy-saving potential (See the Column in Section 4).

Recently, an energy-saving project was carried out under the ESCO program for a building (hereinafter referred to as "Building X") located in the Tokyo metropolitan area (with six stories above ground and a total floor space of about 47,000 square meters).

The project included the renewal of a freezer and a water chiller/heater, the installation of an inverter, the introduction of a new control system for air conditioners and the introduction of BEMS. As a result of the project, this building succeeded in reducing CO_2 emissions by about 15%.

It is known that the introduction of the cogeneration system is quite effective especially for large-sized buildings such as hotels that have a large thermal demand. Many of those buildings are reported to have achieved as much as a 20% reduction in CO_2 emissions through the introduction of the cogeneration system.

Table 3-5-1: Energy-saving measures introduced to Building X

Renewal of heat source equipment to introduce high-efficiency models	Two water chiller/heaters have been replaced with a high-efficiency turbo freezer and two high-efficiency water chiller/heaters, and quantity control has been introduced.
Introduction of the DDC (direct digital control) systems to air-conditioners	PMV control system (that ensures user comfort while controlling and conditioning), the control system for outdoor-air intake for indoor cooling, CO_2 control system and the on/off control-optimization system have been introduced.
Introduction of an inverter to fans	Fans in which inverters are installed have load-corresponding air volume.
Introduction of an inverter to pumps	Water pressure optimization has been introduced for the secondary water supply system with the introduction of a pump inverter for hot and cold water and coolant. Flow control has been introduced for the primary hot and cold water and coolant.
Introduction of BEMS	BEMS, which monitors two buildings simultaneously, has been introduced to enhance integral energy control.
Introduction of high-efficiency lighting equipment	A total of 2,000 fluorescent lights and downlighters have been replaced with newer models.

Source: "Implementation Examples of the ESCO Projects" issued by the Energy Conservation Center, Japan (ECCJ). Compiled by the Ministry of the Environment.

Turbo freezer and water chiller/heater Photo: courtesy of ECCJ should be noted that air conditioners, refrigerators and other machines using CFC gas as a refrigerant should be treated carefully when discarded, as CFC gas causes the greenhouse effect several thousands times more intensively than carbon dioxide, and therefore a release of CFC gas into the atmosphere would be devastating, possibly voiding our efforts for reducing CO_2 emissions.)

However, the introduction of such effective technologies has not yet been promoted thoroughly. But it means there exists a large potential: the introduction of state-of-the-art energy-saving machines and equipment or operational optimization of existing equipment could reduce CO_2 emissions considerably. Thus, in order to effectively promote emission reduction, not only technology development but also the efforts to expand thorough utilization of available technologies is extremely important.

Column :Technologies with High Potentialities

Here are some examples of potential technologies that are currently at the RD&D stage but are expected to produce substantial effects to mitigate global warming in the future, especially in the commercial, residential and transport sectors.

(1) Storage technologies (for electricity and heat)

Electricity is being widely used today. Although this energy is very convenient in general, it has an efficiency problem, since it is difficult to use electricity in a remote location from a power plant or supply line, as it cannot be stored easily. Therefore, it is hoped that high-performance batteries or condensers for accumulating an electric charge (lithium battery, sodium-sulfur battery, large-capacity capacitor, etc.) will be developed. For example, it would be quite useful if there were a durable large-capacity capacitor that can be recharged quickly and would scarcely deteriorate even after repeated charge and discharge. Such capacitor would make it possible to commercialize plug-in hybrid vehicles or other high-performance, high-efficiency electric vehicles that people dream of.

Electric double layer capacitor
Photo: courtesy of Nippon Chemi-con Corporation

Heat is generated in various energy-consumption activities, and a potential for energy efficiency improvement exists here too. An effective heat storage device would make it possible to use stored heat regardless of time and place. An idea of a “TransHeat Container” is a technology to store and transport heat without time/space restrictions, such as day and night, cold place and hot place, and winter and summer. The development and commercialization of such technology as well as peripheral supporting systems are pending.

Fuel cells, which can convert chemical energy directly to electricity, are also potential electricity storage devices, where electricity could be stored in the form of hydrogen with the utilization of water electrolysis technology for hydrogen production. Early commercialization of such fuel cells is also pending.

TransHeat Container Photo: courtesy of Sanki Kogyo Co., Ltd.
This container carries a tank equipped with a latent heat-storage system, and is used to supply heat to a remote place by road transportation.

(2) Utilization of cryogenic heat or unused heat

Consumption of thermal energy leads to a reduced heat temperature, which means a lower value of “exergy” (available energy). For example, high-temperature vapor has a high exergy, and can thus be used as a power source or for power generation. On the other hand, when the temperature of the water vapor lowers to that of the surrounding air, the low-temperature water is not able to provide energy. In the process of a temperature shift from high to low, waste energy is released into the atmosphere, and the idea of collecting such waste energy at every state of temperature shift would be quite noteworthy from the standpoint of energy efficiency improvement.

Here, there is a hope for the development of the so-called “cascade” technology. This technology would allow for thermal energy to be consumed gradually and thoroughly, at any stage regardless of the level of its energy, which would maximize energy efficiency. The cascade-like stage-by-stage utilization of thermal energy can be depicted as a linear flow from “engine” or “gas turbine” to “vapor turbine,” “hot water for water heater” and “warm water for air conditioner,” for instance.

Also, cryogenic heat draws attention. Cryogenic heat remained unused until its potential as an energy source came to be revealed thanks to an emerging potential technological application, and the value of cryogenic heat is now being recognized. For materializing practical utilization of cryogenic heat, it is hoped that the binary power-generation technology for geothermal power, etc. will be promoted.

(3) Control technology for sophisticated integration

There is a technology that aims to improve energy efficiency by making integrated controls of an entire system in a comprehensive manner. Here, the system includes products, buildings and regional networks, and such technology is already being put to use in some areas. It is important to further promote such control technology from the standpoint of energy efficiency.

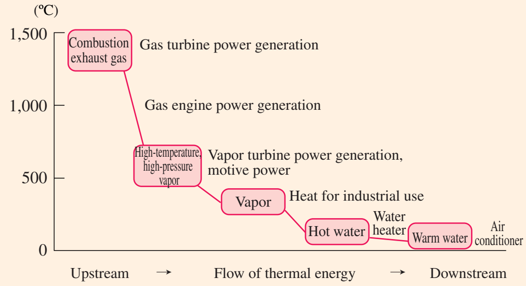
It is hoped that this technology will be integrated with information technologies to establish regional networks of local businesses for the purpose of energy trade, for example. Also, a system for effective utilization of dispersed energies, such as natural energies, could be materialized through the practical use of control technology.

(4) Development of new materials or devices

Development of sophisticated high-performance materials or devices that have a new function or ability could possibly provide a breakthrough in our fight against global warming. Here, utilization of microtechnology or nanotechnology might be effective. For example, such new materials that support effective, efficient utilization of energy include carbon nanotubes, which are hoped to upgrade semiconductors, thermo-electric materials (which would allow for mutual conversion between thermal energy and electric energy) and organic electroluminescence, which is a promising material for lighting equipment. RD&D activities for those new materials are in progress.

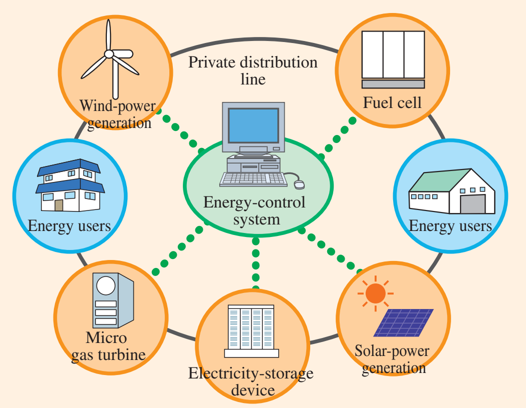
There are other potential innovative technologies such as the CCS (CO_2 capture and storage) technology (See the Column in Section 2) and nuclear reactor technologies. It is hoped that the development and promotion of those technologies will effectively contribute to global warming countermeasures.

Figure 3-5-4: Cascade-style utilization of thermal energy, in the case of heat generated through the combustion of natural gas

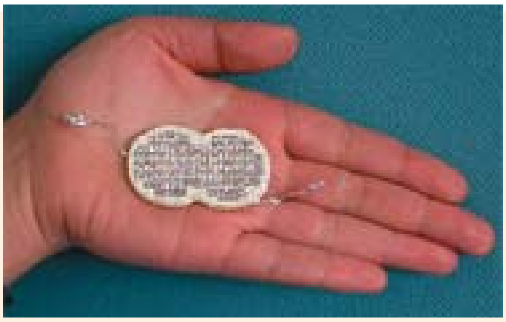


Source: Hiroshi Morishima, “The new century for natural gases,” Gas Energy News (2003)

Figure 3-5-5: System for the control of dispersed energy (Micro-grid)

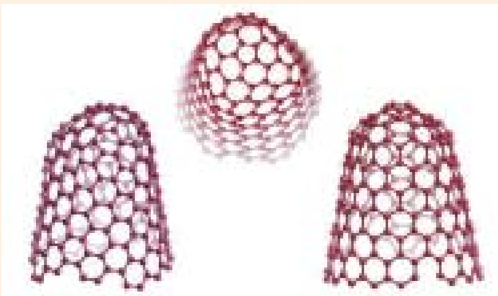


Source: New Energy and Industrial Technology Development Organization (NEDO)



Ceramic thermo-electric module composed of 140 pairs of thermo-electric junctions
Photo: courtesy of National Institute of Advanced Industrial Science and Technology (AIST)

Figure 3-5-6: Carbon nanohorn



Sources: NEC Corporation, Japan Science and Technology Agency (JST)

2. Promoting the Development of New Innovative Technologies

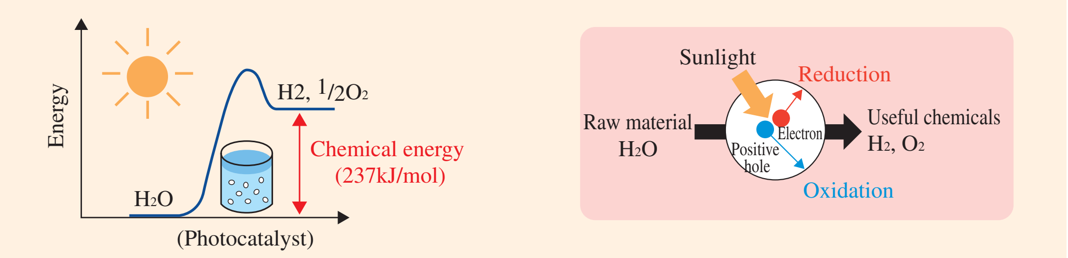
Section 4 and the previous subsection of this section (Section 5) explained effective currently available technologies with a focus on the commercial, residential and transport sectors. In addition to those existing technologies, there are many potential technologies at the RD&D stage, and if those potential technologies come into widespread use in a practical manner in the future, further CO_2 emission reduction can be achieved in the said sectors, covering offices, households and motor vehicles. Promotion of technology development could invite various innovations in our socioeconomic activities. Moreover, those innovations could induce further technological innovations, which we hope will facilitate our efforts to global warming countermeasures.

3. Ensuring Harmony with Nature

Previous sections and subsections discussed the significance of technology development and wide utilization of available effective technologies in pursuing our measures for reducing greenhouse gas emissions. As explained in Chapter 2, human beings are part of ecosystems and our survival depends on the integrity of ecosystems. Therefore, it is necessary for us to ensure harmony between human activities and ecosystems, especially when we develop and introduce new technologies.

When we think of global warming countermeasures from this standpoint, utilization of natural or biological mechanisms is one of the important fields for future technological innovation. For example, in the field of agriculture, it is hoped that an appropriate balance will be maintained between the measures to cope with the natural environment and changes thereto such as cropping period optimization or breed improvement and the R&D projects aimed at strengthening environmental resistance with the utilization of genetic recombination technique. Also, there are projects to study artificial photosynthesis. They use solar energy to synthesize oxygen and organic matters from water and carbon dioxide or decompose water into hydrogen and oxygen.

Figure 3-5-7: Artificial photosynthesis



Source: Research Center for Solar Energy Chemistry, Osaka University

The goal of our development and utilization of global warming countermeasures is not limited to the reduction of GHG emissions in Japan. Japanese technologies and embedded products are strongly hoped to contribute to the international society, particularly the Asia-Pacific, not only in terms of the contribution to the reduction of GHG emissions or solutions to energy issues but also to the mitigation of other environmental problems such as air pollution. Also, as energy-saving needs are getting stronger and stronger all over the world today, demand for our technologies is estimated to be quite strong in the international market. In this respect, the development and promotion of our energy-saving technologies are considered to be quite meaningful in terms of economical benefits and improvement of international competitiveness of Japanese industries and businesses.

As discussed in Section 1 above, our society needs to be transformed into a sustainable one as accelerating global warming becomes evident. In the course of pursuing environmental protection, including global warming mitigation, our society benefits from technology in various ways as mentioned above. If we promote effective utilization of our technologies with a focus on the above-mentioned three directions, such technology will continue to play an important role in our society as a key element of global warming countermeasures, and the materialization of such innovations will open the door to a new society.

Conclusion: A Low-Carbon Society

As mentioned above, accelerating global warming is a fact. Actually, we have various impacts in the form of extreme climate events, such as extraordinarily hot weather, frequent formation of high-intensity tropical depressions, an increase of heavy rain, rising sea-surface temperatures, etc. Human beings benefit from ecosystems in various ways in the form of ecosystem services supported by biodiversity. However, global warming is affecting ecosystem services adversely and seriously. According to the IPCC's Fourth Assessment Report, global mean temperature increase due to global warming is projected up to 6.4°Cby the end of 21th century. Thus, our earth faces truly critical conditions.

In order to avoid the crisis, we need to accelerate our global warming countermeasures. The Japanese government has been reviewing the Kyoto Protocol Target Achievement Plan with a view to clarifying the direction of our environmental policy in regards to measures to be implemented both inside and outside the country, and is now finalizing the "Becoming A Leading Environmental Nation Strategy in the 21st Century: Japan's Strategy for a Sustainable Society" as a guideline for Japan's contribution to future international frameworks.

It is necessary to combine our short-term and long-term efforts based on the said national plan. First of all, we need correct knowledge and information. That's why this report focuses on specific information regarding global warming and technologies effective to reduce GHG emissions; it will help readers understand the current status and potentialities of technologies for emission reduction in our everyday living. Implementation of global warming countermeasures requires the integral promotion of technology development, institutional reforms and behavioral improvement. In other words, we need institutional developments such as the creation of social mechanisms to facilitate thorough utilization of effective technologies as well as behavioral revolutions such as changes in actions or lifestyles on the part of all members of the general public. Through those efforts and reforms of socioeconomic systems, to be promoted nationally and regionally, we need to create a "low carbon society" on this earth so as to protect ourselves and future generations as well as the foundation for human survival. On May 24, 2007, Prime Minister Abe announced a strategic package titled "Cool Earth 50," which consists of three major proposals to tackle global warming. This initiative is supposed to play the central role in the "Becoming A Leading Environmental Nation Strategy in the 21st Century: Japan's Strategy for a Sustainable Society " We have now started working together to make "a low carbon society" a reality.

Invitation to Cool Earth 50 delivered by Prime Minister of Japan, Shinzo Abe

[The Issue]

○ We must create a new framework which moves beyond the Kyoto Protocol, in which the entire world will participate in emissions reduction.

○ Three concerns have been raised about the endeavor to create a new framework. However, we can overcome all these concerns.

1. Wouldn't endeavors to reduce greenhouse gas emissions hinder economic growth?
2. Even if your own country takes steps to address the issue, it will not lead to the resolution of the issue on a global scale unless other countries also take action.
3. Isn't it unfair to ask developing countries to take steps?.

○ Japan has overcome serious pollution and oil crises, and reduced oil consumption by 8 percent even though its GDP has doubled. The keys for resolving the issues were advanced technologies, social mechanisms and traditions harmonious with the environment, and the solid will of our people.

[Overview of the Proposal]

○ "Today, I would like to extend an invitation to a beautiful planet, Earth in the year 2050."

○ "I am calling my initiative "Cool Earth 50," a strategy consisting of the following three pillars.

Pillar 1: a long-term strategy to reduce the emissions of greenhouse gases globally

○ Propose a long-term target of cutting global emissions by half from the current level by 2050 as a common goal for the entire world.

- ○ Present a long-term vision for developing innovative technologies and building a low carbon society.

Pillar 2: three principles for establishing an international framework to address global warming from 2013 onwards

- ○ proposition to the world “3 principles” in designing a concrete framework for addressing global warming beyond 2013.
  1. All major emitters must participate, moving beyond the Kyoto Protocol, leading to the global reduction of emissions.
  2. The framework must be flexible and diverse, taking into consideration the circumstances of each country.
  3. The framework must achieve compatibility between environmental protection and economic growth by utilizing energy conservation and other technologies.
- ○ we will create under international cooperation a new financial mechanism to extend support to developing countries with high aspirations
- ○ we will expand the endeavor for improving energy efficiency to the entire world. we will promote international efforts to expand the use of nuclear power, as well as providing assistance such as infrastructure development.
- ○ we will study methods such as an integrated approach to fight pollution and global warming; emissions trading; and economic incentives.

Pillar 3: Launching a national campaign for achieving the Kyoto Protocol target.

- ○ The Kyoto Protocol Target Achievement Plan will be reviewed to ensure Japan achieves its Kyoto Protocol objective to reduce emissions by 6 percent.
- ○ The Government will promote its initiatives and urge municipalities and major business entities to accelerate their actions for reduction of emissions.
- ○ We will launch a national campaign and call for efforts and creative ideas with the motto of reducing greenhouse gases by “1 person, 1day, 1kg.”
  We will solicit and adopt new proposals from the people for expanding the national campaign.

[Conclusion]

“My vision of ‘a beautiful country’ is also about raising a question: should we not transform our civilization in order for humanity to continue its path of development while striking harmony with the global environment. So, let us join hands and work together to make “Cool Earth” a reality.”