A Study on Environmental Prediction in Japan

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Abstract

In previous studies we showed that a reduction of water use leads to a reduction of CO_2 emissions, and that the amount of CO_2 emissions associated with water use that is going to be reduced in 2020 is estimated to be equal to about 1% of the total CO_2 emissions of 1990, the Japanese government has implemented policies to promote and subsidize water-saving and energy-saving equipment for the home. At the same time, discussion is underway to develop a scheme under which the amount of CO_2 reduction achieved through the use of water-saving devices, which are becoming increasingly popular, can be converted into carbon credits that can be traded not only domestically but also bilaterally between countries. In this report, we provide an overview of the progress in a study on how to determine the CO_2 emission factor, which is a prerequisite for carbon credits, as well as the prospect for tying a reduction in water use to credit schemes.

Keywords

saving water, measures against global warming, CO_2, CO_2 emission factor, carbon credits.

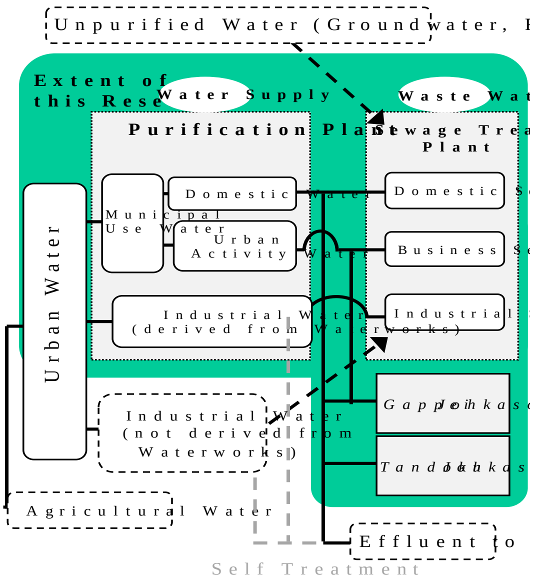
1. Examples of the CO_2 Emission Factor for Water

Measures to achieve a low-carbon society are being taken in various fields. Japan is obligated to reduce total greenhouse gas emissions by 6% compared with 1990 during the first commitment period (2008 to 2012) of the Kyoto Protocol. Additionally, Japan declared at the United Nations Climate Change Summit in 2009 that its goal was to reduce emissions by 25% compared with the 1990 level by 2020. To that end, various industries in Japan have published voluntary action plans to curb global warming, while the government has implemented a number of policies to expedite the as-yet-fruitless efforts of reducing CO_2 emissions from households. A government subsidy for energy-saving appliances and eco-cars (ecologically friendly cars) was followed in March 2010 by an eco-point system for housing, the purpose of which was to subsidize the purchase of eco-friendly devices at the time of building a new house or renovating an existing house.

The Kyoto Protocol introduced three market-based Kyoto Mechanisms as flexibility measures to help parties meet their targets for greenhouse gas reduction. They were: (1) the Clean Development Mechanism, (2) Joint Implementation, and (3) International Emission Trading.[1)] These measures allow parties to reduce greenhouse gas emissions in developing countries, which cannot necessarily bear the cost thereof, by providing them with effective technological support, and count the credits toward meeting their own targets. These are several ways of converting the amounts of reduced greenhouse gas into commodities and certifying and using them as Kyoto credits.

To implement these mechanisms, the CO_2 emission factor becomes essential, as it determines how different activities are converted into greenhouse gas emissions. Emissions of CO_2 associated with water use include emissions arising from the energy consumed to supply purified water and to treat sewage. A conversion factor (CO_2 emission factor) used to calculate such emissions was provided in the Environmental Household Bookkeeping System[2)] published by the Ministry of the Environment in 1996. However, this conversion factor has not been recalculated or updated since then.

Previous studies have shown that a reduction in water use in households leads to a reduction in CO_2 emissions, which has a subsequently notable impact on the overall reduction in CO_2 emissions.[4)] Therefore, with a view to understanding the effect of the widespread use of water-saving equipment on the reduction in CO_2 emissions in greater detail, we conducted a study to estimate the average CO_2 emission factor for water use between 1990 and 2020 in Japan, using the total amount of water treated throughout Japan, and the energy consumed in treating it. It is expected that *johkasou* (treatment tank) systems, which were developed in Japan as non-centralized wastewater treatment systems, will continue to be installed, as they are easy to install in areas without



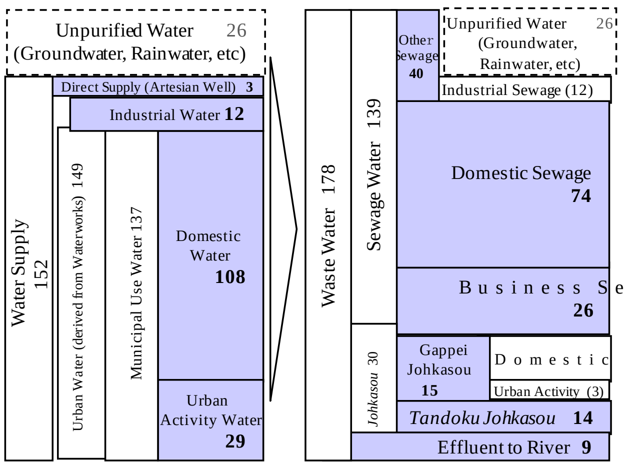


Fig. 1 Water Category and Extent of this Study

Fig. 2 Water Balance in Japan (Fiscal 2007)

wastewater treatment systems, and are less affected by the decrease in population.[5)] Therefore, in this study, water treatment by *johkasou* systems—for both water supply and sewage systems—was also taken into consideration.

1.1 Establishing the water balance

Based on the total water resource utilization status and sewage treatment status, we established the extent of the evaluation used in this study. The forms of water use, the categories of the forms of wastewater treatment, and the extent of the evaluation in this study are shown in Figure 1. We specify the forms of water that consume energy during treatment processes as the subjects of evaluation, and include municipal-use water and industrial water supplied from purification plants on the supply side, and all wastewater coming into the sewage treatment plants, domestic sewage and business sewage coming into *gappei johkasou* (sewage treatment tanks that treat domestic wastewater), and domestic sewage flowing into *tandoku johkasou* (sewage treatment tanks that treat only toilet wastewater) on the wastewater side. The total volume of water treated in Japan and percentage of population using treated water are reported in "Water Supply Statistics[5)]" and "Water Resources of Japan[6)]" regarding water supply, and the data for wastewater are given in "Sewage Statistics[7)]" and "Waste Disposal in Japan[8)]." Based on these statistical values, we established a water balance between supply and wastewater.

The setting for the water balance in Fiscal 2007 is shown in Figure 2. About 90% of the total water supply was used as municipal-use water, about 80% of which was domestic water. About 3% of the total supply was direct supply (artesian wells, etc.) that did not go through a waterworks. In addition, about 80% of wastewater was treated sewage, and about 20% of it was unclear sewage, which included groundwater. According to research guidelines for a comprehensive plan to improve the handling of sewage,[9)] the amount of groundwater can be estimated to be 10 to 20% of the estimated maximum daily discharge of wastewater, which is calculated from the sum of domestic sewage and business sewage. Analysis of the most recent sewage statistics[7)] showed the estimated maximum daily discharge of wastewater to be 1.6 times (as the national average) the average daily discharge of wastewater. When we applied this figure, the amount of water from unaccounted-for origins, possibly including groundwater, came out to be 16% of the estimated maximum daily discharge of wastewater calculated from the sum of domestic sewage and business sewage, falling within an acceptable range.

Using the same categorization shown in Figure 2, we estimated the amount of each type of water from 1990 to 2020. The amount of supplied water increased from 1990 as the population grew, and, having peaked in 2000, entered into a continuous decline. The wastewater volume tends to increase in general from 1990, and slightly decreases after peaking in 2004, and then shows a tendency to level off. As the percentage of the population using public sewage systems has increased, and replacements for *gappei johkasou* and *tandoku johkasou* systems have advanced since 1990, the rate of change in the categories is dramatic. In 2020, around 87% of total wastewater will be treated sewage.

1.2 Relation between water-treatment volume and electricity consumption

We defined emissions of CO_2 associated with water use as those resulting from the consumption of energy used for water treatment in water supply, sewage systems, and *johkasou*. In the categorized management of greenhouse gases according to the Ministry of the Environment, CO_2 emissions originating from energy consumption in water supply and sewage treatment are categorized in the "Commercial & other sector" under the label of "waterworks." The Greenhouse Gas Inventory Office of Japan at the National Institute for Environmental Studies, on the other hand, categorizes emissions associated with domestic water as "CO_2 emissions from households.[10]" In sewage and *johkasou* systems, additional non-energy-derived greenhouse gases, such as CH_4 and N_2O, are emitted at the time of treatment, sludge incineration, and landfilling, but they are accounted for in the category of "wastes," and not treated in the same way as energy-derived gases. Although it has been reported that emissions of non-energy-derived greenhouse gases in sewage systems account for about a half of all greenhouse gas emissions from sewage systems (converted to CO_2 volume),[11] this study followed the example of the conversion factor in the Environmental Household Bookkeeping System published by the Ministry of the Environment, and only takes into consideration energy-derived emissions in evaluating the impact of water use on CO_2 emissions from among consumer-related categories, especially from households.

With regard to energy consumption in water supply and sewage treatment, we used the electricity and energy consumption values published in "Water Supply Statistics[5]" and "Sewage Statistics,[7]" respectively, for each fiscal year. However, as fuel consumption in "Water Supply Statistics,[5]" is covered a limited time of period, we used the most recent value from Fiscal 2008 as the basis, and estimated values for the other years on the assumption that fuel consumption is proportionate to the volume of treated water. We calculated the energy consumption in *johkasou* systems by multiplying the electricity consumption of the blower, the pump, and the screen of a typical *johkasou* unit in each category by the number of installed *johkasou* units in the corresponding size-based category published in "Waste Disposal in Japan[8]" for each fiscal year, and totaled the resulting figures.

Figures 3 and 4 show the changes in electricity consumption and the volume of treated water in water supply and sewage systems, respectively, over the years. Both in water supply and sewage systems, changes in the volume of treated water and electricity consumption show similar trends from 1990 to 2008 (based on actual figures). It is evident that the numbers for water supply fluctuate little from one year to the next, whereas electricity consumption in sewage systems has been increasing every year in proportion to the increase in the volume of treated water (that is, the population requiring water treatment). Consequently, we calculated the estimated electricity consumption values from 2009 onward assuming that they would be proportionate to the volume of treated water (the population requiring water treatment). We applied the same principle to the numbers regarding *johkasou* as well.

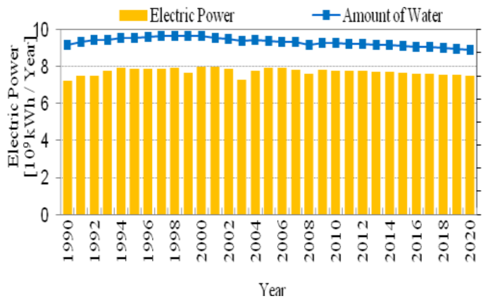


Fig. 3 Changes in Electricity Consumption and Consumption Volume of Treated water in Water Supply

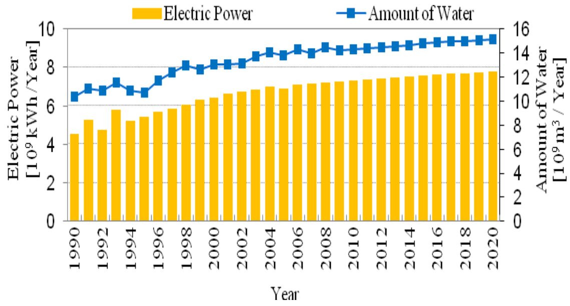


Fig 4. Changes in Electricity and volume of Treated Water in in Sewage Systems

1.3 Estimation of CO_2 emission factor associated with water use

We calculated the CO_2 emissions for water supply, sewage systems, and *johkasou* by multiplying the CO_2 emission factor for each fiscal year by the electricity and fuel consumption values. We estimated the CO_2 emission factor for electricity for years later than 2009 based on the record values announced for each year by the Federation of Electric Power Companies of Japan (1990 – 2009) and used the same 2012 objective value published by the Federation for the years until 2020.

Figure 5 shows a breakdown of CO_2 emissions associated with water use for water supply, sewage systems, and *johkasou* for Fiscal 2007. Water supply and sewage systems accounted for about 40% each, and *johkasou* for about 20%. In addition, we found that 95% of CO_2 emissions associated with water use originated in electricity.

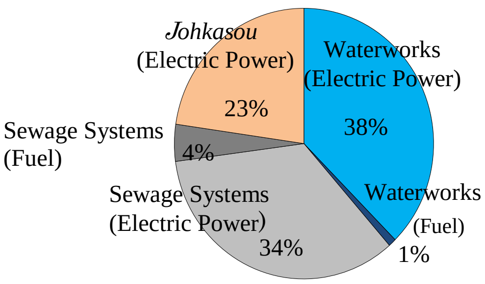


Fig. 5 Breakdown of CO_2 Emissions factor for Water Associated with

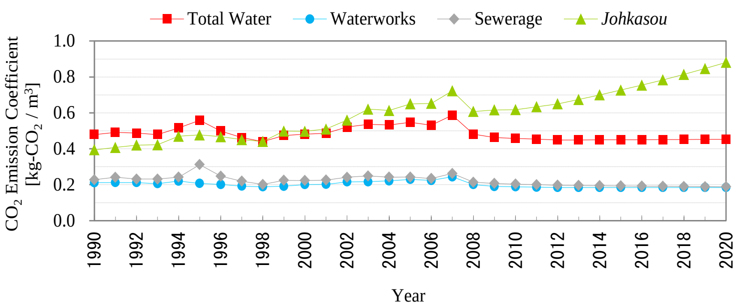


Fig. 6 Changes in CO_2 Emision use (Facility-Based)

Of all the CO_2 emissions associated with water use, those associated with electricity use accounted for about 90% each fiscal year. Electricity consumption by sewage and *johkasou* systems has increased every year, but CO_2 emissions are greatly affected by the fluctuation in the CO_2 emission factor for electricity. Between 1990 and 2008, which are the most recent years for which we have actual figures, CO_2 emissions from both sewage and *johkasou* systems were least in 1998, when the CO_2 emission factor for electricity was lowest, and most in 2007, when the factor was highest.

Figure 6 shows the CO_2 emission factor associated with water use for water supply, sewage systems, and *johkasou* systems and the overall factor for all of them. It is clear that the emission factor shifts from 0.44 to 0.59 kg-CO_2/m^3 from 1990 to 2020. In 2008, when the calculation was made based upon the immediate record value, it was 0.20 kg-CO_2/m^3 for water supply, 0.21 kg-CO_2/m^3 for sewage systems, 0.61 kg-CO_2/m^3 for *johkasou*, and 0.48 kg-CO_2/m^3 for the total CO_2 emission factor associated with water use. Furthermore, the water-derived electricity consumption for this year was 0.48 kWh/m^3 for water supply and 0.50 kWh /m^3 for sewage systems. The only CO_2 emission factor that has been published by the Ministry of the Environment to this day, for both water supply and sewage systems, is 0.59 kg-CO_2/m^3 (the Environmental Household Bookkeeping System 1996[6)]), and differs from the CO_2 emission factor that we arrived at for the same year in this study, which was 0.45 kg-CO_2/m^3. While the Environmental Household Bookkeeping System[6)] consisted of interindustry analyses based on the interindustry table for 1990, this study used as its basis cumulative calculations of energy consumption in water supply and sewage systems. The discrepancy may be attributed to the difference in the calculation methods.

It is evident that the CO_2 emission factor associated with water use reached a maximum in 2007 when the CO_2 emission factor for electricity reached a maximum, and that it has shifted as the CO_2 emission factor for electricity has improved since then. However, it was expected that the CO_2 emission factor would increase from 2008 in concurrence with the switchover from the *tandoku johkasou* systems to the *gappei johkasou* systems.

In this study, we estimated the average CO_2 emission factor associated with water use for Japan based on the total water-treatment volume and energy consumption required for treatment in order to gain a detailed understanding of the effect the popularization of water-saving devices will have in reducing CO_2 emissions. We found that the CO_2 emission factor associated with water use is greatly affected by fluctuations in the CO_2 emission factor for electricity, and changed between 0.44 and 0.59 kg-CO_2/m^3 from 1990 to 2020, as around 90% of CO_2 emissions associated with water use originate in electricity consumption.

While we incorporated the expected improvement in the CO_2 emission factor for electricity in our predicted values for the future in this study, data on expected improvement in efficiency in facilities such as pumps and blowers in water supply, sewage and *johkasou* systems have not been released and thus we could not incorporate them. In the future, the prediction for the emission factor needs to be reviewed if data on expected improvements in efficiency for facilities such as pumps and blowers in water supply are disclosed.

1.4 Estimation of CO_2 Emission Factors for Water Use in Other Asian Countries

This study has demonstrated, using the example of Japan, that the CO_2 emission factor for water can be estimated by using the amount of water treated in water supply and sewage systems facilities and the energy consumed thereby. It has also been shown that, because more than 90% of energy consumed in water supply and sewage systems facilities was electricity in this particular example, the CO_2 emission factor for water was in practice determined by the CO_2 emission factor for electricity.

Water supply and sewage systems facilities are being improved in other Asian countries as well. The rapid filtration process and the activated sludge process are considered to be the standard process for water supply and sewage systems, respectively. As Japan has helped these countries improve their facilities through official development assistance, it can be presumed that the estimated energy consumed in treating a unit volume of water (water treatment energy efficiency) in their designs of water-treatment processes is not too far removed from that used in Japan. Table 1 shows CO_2 emission factors for electricity (based on gross generation) in some Asian countries, and Figure 7 shows household water consumption in a range of countries. While the amounts of water consumed need further verification in each country, it can be surmised that the reductions in water use in other Asian countries, where CO_2 emission factors are high, may potentially have a greater impact on CO_2 reduction than that estimated for Japan.

Table 1 CO_2 Emission Factors in Asian Countries (Based on Generating-end Output)

	CO_2 EF for Electricity (kg-CO_2/kwh: GG)	Ratio (vs. Japan)
Japan	0.41	100
China	0.78–0.93	190–227
Taiwan	0.65	159
S. Korea	0.61	149
Vietnam	0.59	144

EF: Emission Factor, GG: Gross Generation
Source: Japan International Cooperation Agency
Climate Finance Impact Tool for Mitigation
Trial Version 1.0 June 2011

http://www.jica.go.jp/activities/globalization/FIT2011/mitigation_j.html
Emission Factor (Generating end) as of Fiscal 2008

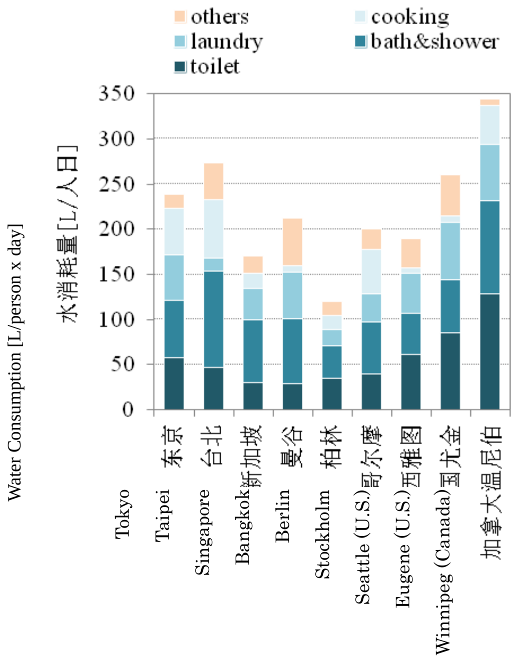


Fig. 7 Household Water Consumption in Various Countries[12)]

2. Possible Use of Carbon Credits for Water Use Reduction

2.1 Overview of Carbon Credits/the Clean Development Mechanism

The Kyoto Protocol offers market-based mechanisms as complementary means to help parties with commitments meet their targets specified by the protocol for greenhouse gas reduction, allowing them to use carbon credits (Kyoto credits) in conjunction with domestic efforts. Depending on the countries involved and the frameworks of activities, the three mechanisms below are available. Figure 8 shows an overview of the Clean Development Mechanism. It allows a country to implement an emission-reduction project in developing countries that have no targets for CO_2 emission reduction and to earn carbon credits (emission rights) commensurate to the amount of CO_2 reduced as a result of the project. These credits thus earned by the country that offered the technologies and/or funds can then be counted toward its own efforts to reduce emissions.

- ☐ CDM : Clean Development Mechanism
- ☐ JI : Joint Implementation
- ☐ IET : International Emission Trading

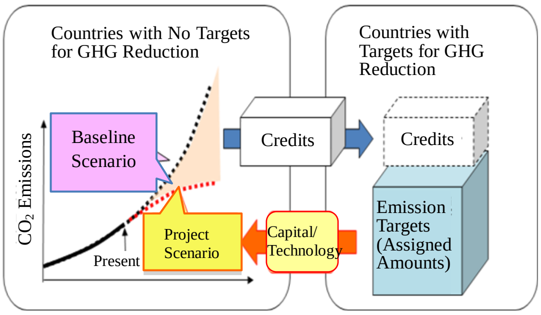


Fig. 8 Overview of the Clean Development Mechanism[1)]

Meanwhile, Japan is experimenting with domestic and bilateral carbon credit schemes as ways to make these mechanisms more accessible to small and midsize domestic enterprises.

2.2 The Domestic CDM Scheme

Figure 9 shows an overview of the domestic CDM scheme. As is the case with Kyoto credits, the amount of the reduction in CO_2 emissions resulting from a project is determined and converted into carbon credits. A reduction in household water use has been proposed as another way of reducing CO_2 emissions that be considered applicable to this mechanism, and the method of implementation is currently under discussion in the Domestic CDM Certification Committee. The proposed method for calculating credits is based on the CO_2 emission factor for water, as mentioned earlier.

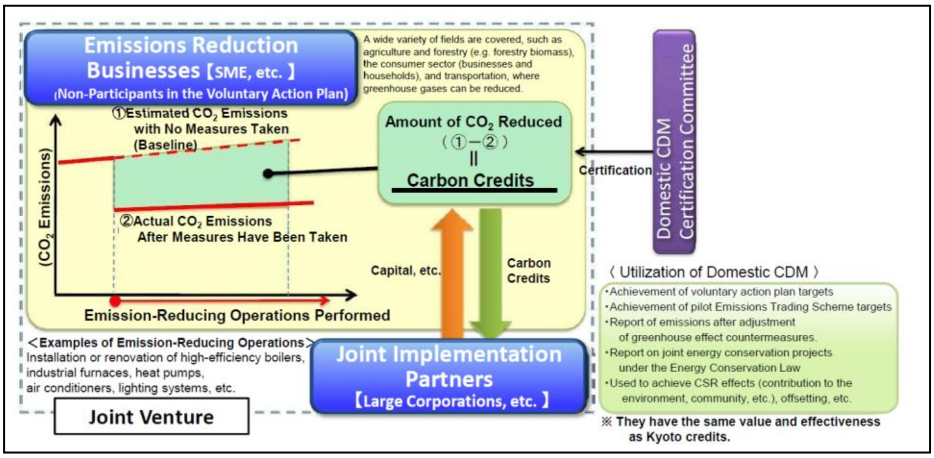


Fig. 9 Overview of the Japan's Domestic Clean Development Mechanism [1)]

2.3 Overview of the Investigation into the Feasibility of the Bilateral offset Credit Mechanism

The bilateral offset Credit Mechanism has been aggressively proposed by the Japanese government at different venues, including the East Asia Summit in November 2011, with the hope of having it integrated into the discussion on the new international rules for 2013 and later, which is to be held at COP 17 of the United Nations Framework Convention on Climate Change. The Ministry of Economy, Trade and Industry and the Ministry of the Environment are currently investigating its feasibility in Japan. As for the feasibility of reducing CO_2 by installing water-saving equipment in households, Mitsubishi UFJ Morgan Stanley Securities, TOTO, Kitakyushu City, and Meiji University are conducting research on the potential reduction in Dalian, China, as part of the Feasibility Study of New Mechanisms conducted by the Global Environment Centre Foundation and the Ministry of the Environment of Japan.

Thus, reducing CO_2 emissions by reducing water use is coming to be recognized as a viable scheme to curb global warming. A reduction in water use not only contributes to curbing global warming, but also has other benefits such as conservation of electricity and the efficient use of water resources. Further studies are needed on estimations of the potential contribution to the environment that can be obtained by reducing water use in different countries, in order to promote the building of water-saving societies.

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