

**Urban Environmental Transitions and
Corresponding Policies in Japan:
Experiences and Lessons for Developing Countries**

BY

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ABSTRACT

Japan, with a history of rapid urbanization and pollution debacle, offers a remarkable series of experiences and lessons for combating urban environmental problems. In this paper, the institutional frameworks for urban environmental management are introduced, including administrative departments, environmental law legislation and urban planning. The urban environmental transitions in Japan are classified to four periods of time: public hazard control phase, energy saving and amenity-town phase, eco-city and cycling economy promotion phase and low carbon society development phase. The main environmental issues, responding policies and consequent improvements in each stage are analyzed. In today's developing countries, it is deemed that they probably need to spend much shorter period of time and deal with the increasing overlaps of sets of environmental burdens. Nevertheless, from the experiences of Japan, we believe that a strict law and regulatory system, strong emphasis on urban land use planning and environmental planning, and widespread engagement of citizens and enterprises are the keys to success. We wish to provide useful references for the developing cities especially those in Asia which share similar features and are now combating the same environmental challenges that Japan had once faced.

KEYWORDS: Japan, urban, environment, policy, experience, lesson

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Chapter I Introduction and literature review

Our world today has moved into urban age. The world's population living in urban area is expected to grow from 50% in 2006 to 60% by 2030, 67% by 2050(OECD, 2008; United Nations, 2013). The majority of new urban population growth will occur in developing countries, which means many developing cities are facing increasingly pressure on the environment during the very fast urbanization process in the coming decades. These pressures include city sprawl, lack of green spaces, air and water pollution, excessive noise, sub-standard housing, poor sanitation, global climate change, etc. How urban environmental pressures are addressed not only affects urban dwellers' life quality, but also has impact on the achievement of sustainable development locally, regionally and globally(OECD, 2008).

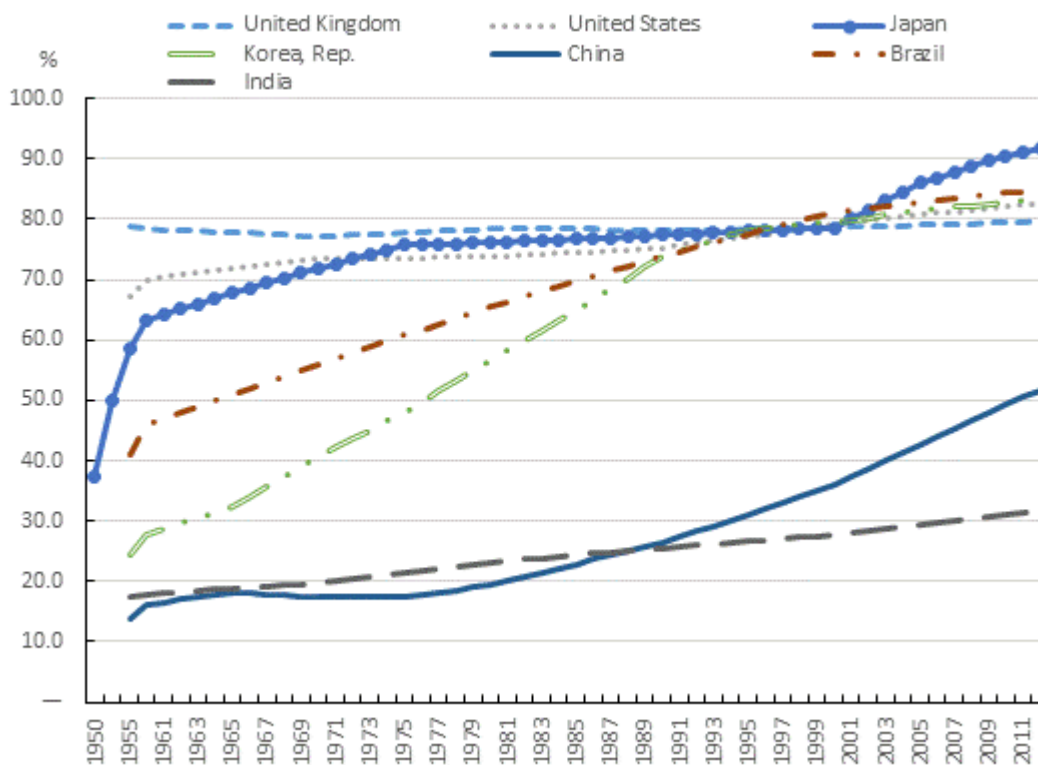


Figure 1 seven countries' urbanization rate from 1950-2011

[Source: the data of 1950-1960 is from UN urbanization prospects, <http://esa.un.org/unup/CD-ROM/Urban-Rural-Population.htm>. The data of 1960-2011 is from World Bank, <http://data.worldbank.org/>. Last accessed on July 26, 2014]

Japan, one of the most highly and densely urbanized countries in the world, whose urbanization level increased from 37.3% in 1950 to 91.7% in 2012 (Brooks, Donaghy, & Knaap, 2012; Statista, 2014), as showed in Figure 1, offers a remarkable series of lessons for dealing with urban environmental problems. Japan experienced a significantly rapid urbanization process during 1950s and 1960s, compared with earlier developed countries such as United Kingdom and United states. It began to increase relatively quickly since 2000, after slow growing for three decades. It finally reach 91.7% in 2012, which is higher than United Kingdom and United states (Figure 1).

Japan has a history of “pollution debacle” during its rapid urbanization process and its achievements of environmental protection are considered to be outstanding. Japan has been described as a leader in the development of pollution control technology, a pioneer of innovative environmental policy measures, an ecological front-runner and a global environmental leader (Graham, 2004; Maddock, 1994; OECD, 1994, 2002, 2010; Schreurs, 2004). Meanwhile, a number of studies stated that Japanese urban planning, urban governance and environmental management developed very differently from those of western developed countries (B. F. D. Barrett, 2005; Schreurs, 2002; Shelton, 1999; Sorensen, 2004). Although there is some controversy of Japanese urbanization policies, mainly because of over-concentration of population and economic activities in large cities and the resulting environmental problems (Brooks et al., 2012), Japan’s experiences and lessons on urban environmental management are believed worth noting and offer sound references, especially to a number of Asian countries which in some degree have imitated Japan's development model.

Currently, there is a consensus that, a holistic, cross-sectorial and long-term approach to integrate urban design with spatial planning, social objectives, energy and transport policy, and other environmental policies (e.g. waste, energy, water) is vital for addressing urban environmental pressures and pursuing urban environmental sustainability, and multi-level governance and the harmonization of policy tools are central for such integration (Cities Alliance, ICLEI, & UNEP, 2007; European Commission, 2010; Janicke & Jorgens, 2000; OECD, 2008, 2013a; Stigt, Driessen, & Spit,

2013; World Bank, 2009). There are already a number of researches studying Japan's environmental policies. Some of them summarized the policies in terms of different environmental sectors such as water, air, solid waste, soil, etc.(Fujikura, 2011; Mitsuhashi, 2001). Some focused on different kinds of environmental approaches such as governance, law system, management instruments, etc.(B. F. D. Barrett & Therivel, 1991; B. F. D. Barrett, 2005; Imura & Schreurs, 2005; Ren, 2000). And others concentrated on specific cities(B. Barrett, 1994; Fujita & Hill, 2007; Kumagai & Yamada, 2008; OECD, 2013b; Shimada, 2011) or historical development (Tsuru, 1970, 1999). In some recent reports of OECD and World Bank, Japanese cities have been assessed as successful practices in urban environmental management (Corfee-Morlot et al., 2009; Hammer, Kamal-Chaoui, Robert, & Plouin, 2011; OECD & CDRF, 2010; OECD, 2012). For instance, Corfee-Morlot (2009) stated that Japan and Korea appeared to have developed the most comprehensive of approaches to green regional (urban) development strategies of the OECD countries. However, so far, there is no study to explore the progress of Japan's integrated urban environmental policies. Thus, the authors try to introduce and analyze the initiatives, focusing on the integration of urban planning and environmental policies taken by the Japanese government to counter urban environmental issues, from an historical perspective.

Chapter II Methodology and data Collection

The research questions in this study include the followings: (1) How many stages in the history of Japan's urban environment, including problems and relevant policies and planning? (2) What are the main policies in different stages? (3) How about the improvements of Japan's urban environment?

The approach in this comparative study is a qualitative methodology. The policy documents and reports, collected from government website, international organization and other scientific journals, are surveyed and analyzed to provide a context that responds to the research questions. The data of Japan's urbanization rate, air pollution and greenhouse gas emission, energy consumption, municipal waste generation, etc. is collected to give a general understanding of Japan's environment. At the same time, Tokyo was selected as an example city to illustrate the achievements of Japan's urban environmental policy and planning. The data of Tokyo's urban ambient air quality, greenery coverage, greenhouse gas emission, energy consumption, municipal waste generation etc., in a long timeline, is analyzed.

In this paper, firstly, institutional arrangement and main instruments of urban environmental management in Japan are introduced. Consequently, the authors elaborate on the major environmental issues that occurred in Japan's major cities and their corresponding policies in different development stages since 1950s. After analyzing, inducting and summarizing, it was divided into four main stages: (1) Public Hazard Prevention and Treatment Phase (1950s - 1960s); (2) From Resource Saving to Environmental Friendliness and to Global Environmental Concerns Phase (1970s to 1980s) ; (3) Eco-city and Cycling Economy Promotion Phase (1990s); (4) Low Carbon Society Development Phase (2000s).

Chapter III Results

3.1 Institutional frameworks for dealing with urban environmental issues

3.1.1 Division of Government Administrative Powers

The Japanese central government consists of totally 12 ministries or national agencies including Cabinet Office, Ministry of Internal Affairs and Communications (MIC), Ministry of Justice (MOJ), National Police Agency (NPA) etc. If urban environment is divided into natural environment and manmade environment, and environmental issues are classified into urban, regional and global levels, then the Ministry of Land, Information, Transport and Tourism (MILT) is responsible for the manmade environmental issues, and the rest fall into the responsibility of Ministry of the Environment (MOE). Meanwhile, due to the causes of urban environmental issues are mostly from the social economic activities such as resource consumptions and emissions of waste gas, waste water and waste solids, the urban environment is also largely related to the administration of Ministry of Economy, Trade and Industry (METI), and Ministry of Agriculture, Forestry and Fisheries (MAFF). Moreover, the Cabinet Office headed by the Prime Minister is crucially influential to the urban environment administration due to its unique political position engaging in the discussions, planning and policymaking. In 2011, the Japanese central government's budget for environmental protection reached 1.2 trillion Yen, among which, 31% is from METI, 19% from MILT, 19% from MAFF, and 17% from MOE, these four ministries mounted 86% of the total (MOE, 2012).

The Japanese local government body includes two levels, namely, prefectural level and city-town-village level. Prefecture is the first level of administrative area, including namely Tokyo-to, Osaka-fu, Kyoto-fu and Hokkai-do, and other 43 prefectures. With some exception of Tokyo-to, each prefectural level administrative area is divided into "city", "town", and "village" level governments. All of these governments are "regional autonomous entities", meaning, they are independent self-governing authorities, they have to obey the national laws, but have the rights to stipulate their own ordinances. Particularly in terms of environment, the regional standards are often higher than the national ones. Thus, the city government plays the most direct role in shaping the urban environment.

According to the MIC (2010), urban construction takes up to 19% of local government’s expenditure on average. Though decreasing annually, this number still remained 13% in 2009. If the subsidies from national or prefectural level governments for infrastructure construction such as roads and seashores are counted, the practical expenditures could double the aforementioned account.

3.1.2 Solving urban environmental issues by environmental law legislation and implementation

The current framework of environmental laws in Japan is illustrated in Figure 1. The Ministry of Environment oversees the general designs, planning and detailed contents of policies. In terms of implementations, it also guides or coordinates with other ministries. The National Diet and central government also employ four major approaches to deal with the urban environment, besides legislations.

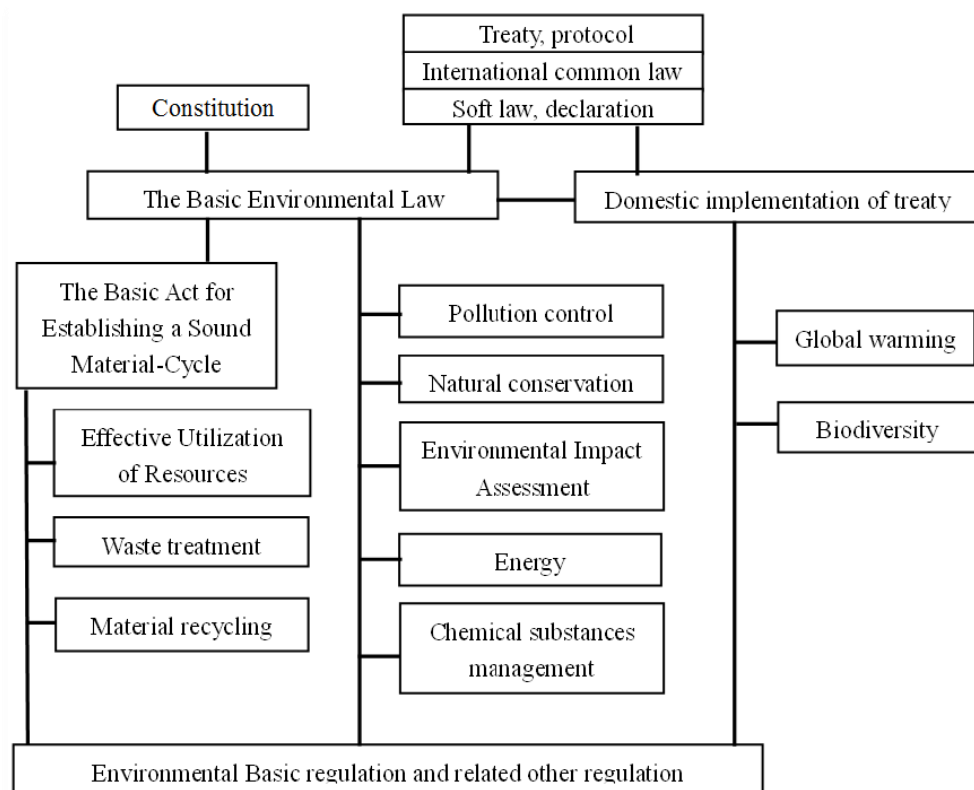


Figure 2 Environmental legislation in Japan
[Source: (Matsumura Y., 2004, P38, translated and revised)]

- (1) Planning Approach. It refers to the government’s making urban planning goals, implementation phases, implementation methodologies, implementation bodies (including the government, public

organizations or communities, companies, individuals) and their roles, supervision and monitoring mechanism, indicator standards etc. For instance, the 2008 revision of Basic Act on Global Warming Countermeasures mandates that prefectures and cities with 200,000 population and above must conduct “Climate Change Countermeasure Implementation Plan” to effectively reduce CO₂ emissions.

- (2) Regulation Approach. It refers to government’s making a range of environmental indicators and standards concerning atmosphere, noise, water, soil among others, the failing of which’s implementation would result to punitive consequences. It includes regulations for conducts, accomplishments and procedures these three aspects. In terms of urban constructions, it mandates that projects of certain scale must conduct environmental evaluation, commercial buildings reaching certain area must comply with the corresponding environmental standards. The local standards are comparatively higher than the national ones.
- (3) Economic Approach. Under the market principles, monetary incentives are given to the various implementation bodies for environment policies, with the examples like economic subsidies and reductions: direct subsidies, fee collections, deposit system, financing and taxation, carbon trading and alike. Even though the Japanese society has already imposed disposal fees for municipal solid wastes, electric wastes, packaging reclining, with other potential incentives being discussed, the urban development related incentives however, are mainly manifested by direct subsidies and taxation reductions, especially for the eco-town projects.
- (4) Government project Approach. It refers to that the government invests fully or partially in the constructions of infrastructures, public services, academic research bodies, etc. for realizing the environmental goals. In Japan, all such expenditures are enlisted in the budgets of the ministry.

Besides, the above mentioned approaches, there are other ones such as information approach, self-improving approach like environmental accounting, cooperate social responsibility (CSR) reports, product energy consumption rating and other public activities, which apply to corporations and individuals, all of which contribute to the urban environment directly.

3.1.3 Solving urban environmental issues by urban planning and its implementation

Cities are important sites for addressing environmental problems; the urban land-use or spatial planning is believed to have important impact on urban environment (Cowell R & Owens S, 2006; Dodman D, McGranahan G & Dalal-Clayton B, 2013). Japan is amongst the earliest countries that have urban planning legislations. As early as 1888, Tokyo had introduced the urban planning regulations known as Town Planning Ordinance. In 1919, the promulgation of City Planning Law and Urban Building Law became the first Japanese urban planning framework, during the same period when urban planning frameworks were established in the UK and US.

Japan is amongst the earliest countries that have urban planning legislations. As early as 1888, Tokyo had introduced the urban planning regulations known as Town Planning Ordinance. In 1919, only a few years after the UK and the US, the promulgation of City Planning Law and Urban Building Law were established, becoming the first Japanese urban planning framework.

The City Planning Law mandated that: in the process of urban development, the land use should be classified by the purpose of constructions, known as “zoning system”. There were three types of zones, including residential zones, commercial zones and industrial zones among non-designated zones. However, there was no prohibition of building residential constructions in the industrial zones at that time. As a result, it did not fundamentally separate the residential area from the industrial area. In 1950, Building Standards Act was conducted to replace the Urban Building Law, in which, four classifications of zones were defined, namely, residential, commercial, semi-industrial and industrial zones. Furthermore, it regulated that schools and hospitals should not be constructed in the industrial zones.

With the rapid economic development at that time, the dramatic expansion of urban land had led to large scale urban sprawl, to prevent which, the Japanese central government amended the City Planning Law in 1968, adding “Area Division system”, which divides the city planning area into Urbanization Promotion Area and Urbanization Control Area. In the Urbanization Control Area, large

scale of development or construction is not allowed. Despite of several revisions in the subsequent years, the basic framework of the City Planning Law remains unchanged since 1968.

There are two levels for Japanese city planning (MILT, 2003). The first one is the “Master Plan for City Area Planning Area” conducted by the Prefectural government which designates city planning area and development directions. The second one “Municipal Master Plan” is conducted by city level governments which includes 1) basic urban development policy and goals; 2) urbanization promotion area and control area division; 3) land use zones which now composed of 12 standard land use zones and other special land use zones. Each type of land use has strict restrictions on land use purposes, floor-area ratio and building coverage ratio, and building shapes among others; 4) urban infrastructure planning, including road, park, sewage system, waste treatment plant, etc. 5) district plans which provide regulations and incentives for urban development projects. Besides the master plan, cities must also comply with other related laws and regulations and conduct “basic environmental plan”, “green plan”, “urban landscape plan”, “water way maintenance plan”, “barrier-free transportation plan” and so on.

The urban planning in Japan has three types of implementation tools: 1) Registration. Each building or project must be scrutinized by the city government, fully complying with the Urban Planning Law, Old Town Rebuilding Law and Basic Building Act plus other related regulations. If the scale exceeds a certain level, the owner has to obtain the prefecture governor’s permission for construction. 2) Direct investment for infrastructure. Examples would be the direct funding for constructing roads or parks. 3) Economic incentives. Governments interfere by the means of providing subsidies or preferential policies to companies or individuals.

3.2 Urban Environmental Issues and Corresponding Policies in Different Times

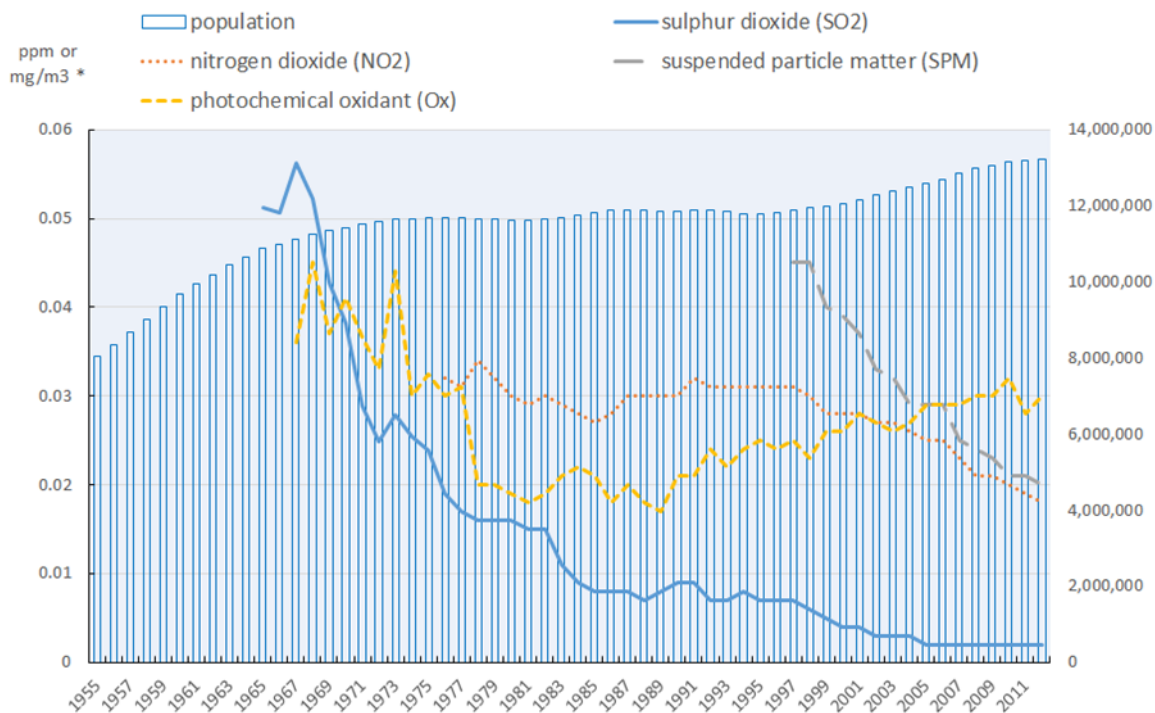
Japan’s environmental issues can be dated back its early industrialization age at the begging of the 20th Century. These environmental issues and policy focuses have been reflected in the annual publications of environment white book (MOE, 2014), for example, during 1969 - 1971, these white

books are called *Public Hazards White Book* , while from 1972 - 2006, they are entitled *Quality of the Environment in Japan* or *Annual Report on the Environment in Japan* , during 2007 - 2008, it's called *Annual Report on the Environment and the Sound Material-Cycle Society in Japan* , since 2009 and forward, it's called *Annual Report on the Environment, the Sound Material-Cycle Society and the Biodiversity in Japan* . From the viewpoint of the white book contents, “environment” is defined as the comfortable living environment without public hazards, based on 1967 version of the *Basic Law for Environmental Pollution Control* (which was replaced by *Basic Environmental Law* in 1993); “Recycling Society” refers to the efficient use and recycling of resources based on 2000's publication of *Basic Law for building a Sound Material-Cycle Society* ; “Biodiversity” refers to the protection and repair of ecosystems, based on the biodiversity international protocols and 2002 version *Second National Biodiversity Strategy of Japan* (the Third one was enacted in 2007).

3.2.1 Public Hazard Control Phase (1950s to mid-1970s)

The most rapid 20 years of urbanization in Japan was seen during 1950s to 60s, during which time, public hazards were also the most drastic and caused national sensations. The four largest public hazards namely, “Itaiitai Disease” (1955), “Minamata Disease” (1956), “Yakaichi Asthma”(1960) and “Daini Minamata Disease”(1965) caused by the industrial water and air pollutions were all outbreaking during this period. Who would solve the problems caused by these public hazards and how became the national concern at that time, and in 1967, and Japanese government enacted *Basic Law for Environmental Pollution Control* , where, “public hazards” is defined as “the environment pollution caused by entrepreneurial activities or individual activities, the damages to human life and health caused by atmosphere pollution, water pollution, noise, vibration, land subsidence, stench etc., or the impediments to the comforts of human lives.” From the perspective of causes, there are generally two types of public hazards, namely, “industrial hazards” and “urban and living hazards”. The first one refers to the public hazards caused from the industrial processes, mainly including: atmosphere pollution and stench due to the emission of waste gas from factories, river, water body, soil pollutions caused by the factory waste liquids and mining waste water discharges, noises and

vibrations from factory or transportations, land subsidence due to the industrial land underground water usages among others. The later refers to the public hazards caused by incompleteness of necessary residential infrastructure constructions, and the public hazards caused by individual living behavior or consumptions, including atmosphere pollution from heating and automobile exhaustions, river body pollutions caused by sewage or hygiene infrastructure incompleteness or garbage disposal, automobile noise and vibration, traffic congestions, insufficient daylighting due to constitutions and so on. A number of regulations or laws were enacted subsequently in the following years, such as the Air Pollution Control Law and Noise Regulation Law in 1968, Water Pollution Control Law and Waste Disposal and Public Cleansing Law in 1970, Offensive Odor Control Law in 1971 (when environmental agency was established), and 1976's Vibration Regulation Law etc. The effects of those regulations or laws can be illustrated by the change of ambient air quality in Tokyo (Figure 3). Tokyo municipal government began to realize the serious air pollution at the end of 1960s, which followed the surge of population between 1950s and 1960s, and then all the pollutants, except Ox, decreased significantly as a result of the following five decades' efforts.



Note: Unit of SO₂, NO₂ and Ox is ppm, unit of SPM is mg/m³.

Figure 3 Tokyo's annual average of SO₂, NO₂, SPM and Ox from 1965-2012

[source: data from Tokyo Statistical Yearbooks. (<http://www.toukei.metro.tokyo.jp/tnenkan/tn-eindex.htm>. Last accessed on July 26, 2014)]

In the fields of urban planning, the article 2 of 1967's Basic Strategy for Public Hazards brought up by the Public Hazard Council states that "Public Hazards should be prevented by land use regulations", which laid the foundation for major revisions of the Urban Planning Law in 1968.

In the fields of living environment, the Japanese government set up long term low rate loan entitled "public financing for housing" for the families with certain level of capital, in order to solve the urban housing issues; In 1951 Public Housing Law was enacted to provide "public housing" for the low-income families by the central government's funding, refer to Table 1. In 1955 "Housing Fundraising Association" was established for the "collectively funded houses" for the middle income families in the big cities. These policies have greatly improved the urban living environment.

Table 1 Public housing in Japan (March 2007)

Year	Number of Households (thousand)	Percentage (%)
1945-54	23	1.1
1955-64	127	5.8
1965-74	727	33.2
1975-84	586	26.8
1985-94	405	18.5
1995-2006	323	14.7
Total	2190	100.0

[Source: The Building Center of Japan, 2008, A Quick Look at Housing in Japan (6th edition)]

3.2.2 Energy Saving and Amenity-Town phase (mid-1970s to 1980s)

By the 1970s, Japan had seen great improvements for its industrial pollutions due to the measures taken during the previous phase, however, due to the wide spread of private cars and massive consumptions, urban air pollutions and wastes became the "crown jewels" of the new area.

Nevertheless, the worldwide oil shocks in 1973 and 1978 had made Japan's priority in economic and social recoveries, didn't take seriously the automobile exhaustion problems, what is more, they even lowered the mission standards for NOx, and the Environment Impact Assessment Law passed by the National Diet was once stopped. There were three key events that left major influences to Japanese environmental policies during this period.

(1) Enacting and Implementation of Energy Saving Law . The oil shocks had made Japan realized the importance of energy saving and supplies due to its own low energy self-sufficiency. To ensure the efficient usage of energy for factories, transportations and constructions etc., Act on the Rational Use of Energy , also known as Energy Saving Law was enacted in 1979. Though the initial intention was not to solve resource and environment related problems but to safeguard the national economy, this law had raised the national awareness for energy saving especially in the business sector, and greatly promoted energy saving technologies. Till now, this law has been revised several times, and become one of the pillars for the CO₂ emission reductions in Japan. Meanwhile, then Ministry of International Trade and Industry (MITI) also specifically discussed the resource recycling law, planning and specific measures, although not implemented due to various reasons, but it laid foundation for the 1991 legislation (Kurasaka H., 2004).

(2) "Amenity Town" planning. Another key event of this period is the high attention paid into the quality of urban living environments, the focus of which was in public green area constructions at that time. The post-war Japanese government had made plans for regulating the public green area, however, real efforts was seen in the enacting of Nature conservation Law in 1972 and Urban Green Area Reservation Law in 1973. Since then, the "Urban Parks Readiness Five Year Plan" had been revised 6 times, until the year 2003, it was merged into "Social Capital Readiness Five Year Plan", which regulates that: There should be 4 children's parks and one neighborhood park per km²; One local part per 4 km²; The constructions of sports park and general park should be appropriate with the urban scale (Maruta R., 2005). In 1970, the average area for park per citizen is 2.1 m², which grew to 9.9 m² by 2011 (MIC, 2012). Another turning point for the improvement of urban lives at this time

was the 1977 OECD’s evaluation report for Japan (OECD, 1978), in which, it acknowledged the results for reducing pollutions, specially the local government’s efforts in setting up their local standards higher than national ones, suggesting Japan’s entering into OECD country standards from the previous the public hazards country in terms of national environment. But OECD also raised serious criticisms against the land use problems, traffic conditions, lack of infrastructures, and aesthetics in the big cities (OECD, 1986). Under that circumstance, MOE prioritized the improvement for urban environment and came up with a serious of actions. In 1984, the “Amenity Town Plan” was initiated, offering financial subsidies to the cities that carry out this plan. From 1990, annually acknowledgment were given to those “Amenity Towns” with considerable outcomes with a total 115 entities acknowledged in 2002, until 2003, at which time, this acknowledgement was changed into “Recycling, Coexisting and Participating Cities”.

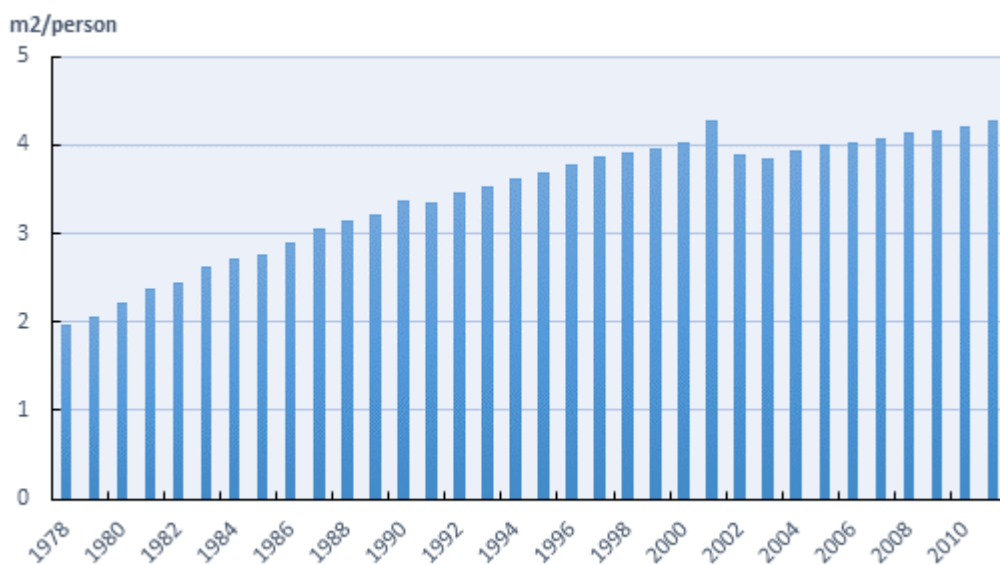


Figure 4 Tokyo’s municipal park area per capita from 1978-2011

[source: Tokyo Statistical yearbooks. (<http://www.toukei.metro.tokyo.jp/tnenkan/tn-eindex.htm>.

Last accessed on July 26, 2014)]

Reviewing the prefaces of environment white books of Japan during 1977 and 1987, realizing “Amenity Towns” were the indispensable key words that showcased Japanese government’s determination in improving urban environment qualities, during which time, numerous cities made

plans for “Amenity Town” projects. According to Nishimura’s (1989) study to 8 cities, “Amenity” refers to the abundant green area, clean air, transparent water, beautiful street views, quiet living neighborhood, and the quality of natural environment. Despite of the absence of “amenity” in title, many cities had set up regulations for urban environment. Take Tokyo prefecture for example, Tokyo Metropolitan Plan to Double Greenery was initiated in 1984, and in 1987 Tokyo Metropolitan Plan to Manage the Environment was made (Tokyo Bureau of Environment, 2010a). Consequently, Tokyo’s municipal park area per capita increased from 1.98m² in 1978 to 4.29m² in 2011, more than twice larger, as showed in Figure 4.

(3) Global environmental concerns. In the 1980s, international organizations shifted the tides to the environmental protections and developments (Kurasaka H., 2008). In 1985, the Vienna Convention for the Protection of the Ozone Layer was rectified; in 1987, Our Common Future was published by the United Nations World Commission on Environment and Development (WCED); IPCC was established in 1988, alongside the Japanese government’s incremental awareness for international environment concerns. In 1988, the enacting of the Law Concerning the Protection of the Ozone Layer Through the Control of Specified Substances and Other Measures curbs the related emissions of the hazardous martial, soon after that, in 1989, Tokyo Metropolitan set up the related policies for global environmental issues.

3.2.3 Eco-city and Cycling Economy Promotion Phase (1990s)

In 1989, the Japanese ear name was changed from “Showa” to “Heisei”, which is 100th Anniversary for many cities in Japan. Therefore, the former Japan Environmental Agency’s Environment White Book strongly promoted the concept of “restoring the urban ecological circulation system” and brought up the goal of constructing “ecopolis” (eco-city) (Japan Environmental Agency, 1989). Naito (1993) summarized MOE’s concepts for “eco-city” as: “being environmental friendly, livelihoods that reduce the burdens for region and the earth”; “sustainable, stable and recyclable metabolism”; “bio-coexistence”. To realize “eco-city”, we must “development energy saving, water recycling, waste disposal technologies”, “develop economic incentives for

social system”, “change living behavior”. In the following year, MOE selected Kobe city and Yasucho city for pilot projects conduction, however, due to the rather advanced concept at that time, its consolidations were hardly realized, resulting in the calling off of projects. Despite the setbacks, this endeavor laid the theoretical foundation for the “eco-city” and zero emission industrial clusters of “eco-town” in the 1990s.

The 1992 United Nations Convention on Environment & Development was held in Rio de Janeiro, where the sustainable developments of human society and global environmental problems especially the global warming, and biodiversity gained momentum. Japan’s MOE enacted Basic Environment Law , which was based on 1967’s Basic Law for Environmental Pollution Control and 1972’s Nature conservation Law , to cope with the global environmental issues and the needs for waste disposal and recycling, in the attempt to realize the goals for “reducing environmental burdens, realizing recycling society”, “coexistence between man and nature”, “mutual participation of public and government”, “promote international solutions for environmental issues” among others. It required that government of different levels must conduct long term plan and action plan for the environment preservation, signaling the transformation of attention from public hazards to living environment, resource and environmental issues.

During the same period, Ministry of Construction of that time (currently the Ministry of Land, Infrastructure, Transport and Tourism) announced the Outline for Environment Policies in January 1993, stating that all the cities within the three metropolitan areas and cities with population of 250,000 and above, must conduct Urban Environment Plan and promote such acts from other cities of smaller scale. Urban Environment Plan mainly focuses on the water environment, nature conservation, urban green area, integrated transportation systems, every saving and recycling systems ext., it also mentioned the “eco-city” system and selected 20 cities for pilot projects from 1993 to 1996. Their publication of Eco-city Development Guidebook (Japan Ministry of Construction, 1993), three models of eco-city were brought up, namely, Energy Saving and Reuse City, Water Recycling City, and Climate Resilient Natural Coexisting City, with detailed explanation of planning philosophy

and methodology. For the implementation, there are two approaches: 1) direct investment construction. To directly develop the so called “next generation of cities”, employing renewable energies such as solar power, waste heat recovery system, fire street block system, information communication system, municipal solid waste treatment system etc.; 2) economic incentive policies. It provides economic incentives to promote the participation from private-owned enterprises, such as giving tax reductions for the companies to recover waste heat, offering low rate financing to the green building construction or new technology companies. These direct investments could benefit the urban infrastructure construction for the undeveloped areas without heating or cooling facilities among others.

Japan during this time was already highly regarding the resource and environmental issues, in 1991 the Law for Promoting the Use of Recyclable Resources was introduced, the amended Waste Disposal and Public Cleansing Law was also introduced, in 1997 the the Container and Packaging Recycling Law was in acted, the widely discussed and drafted Basic Act for Establishing a Sound Material-Cycle Society was carried out in 2000. Japan has already made remarkable achievements in reusing and recycling of solid waste. Using 1990 as a base year, the Figure 5 shows that Japan’s municipal waste slightly increased during the first decade and then turned to decrease in the next decade, while the domestic GDP rise gradually during almost all that period. In 2010, Japan’s municipal waste was reduced by 10%, compared with it of 1990. The decoupling was more significant in Tokyo, while Tokyo’s per capita GDP tripled during 1976 and 2011, the per capita municipal refuse collection halved (Figure 6). Meanwhile, Japan’s Ministry of Economy, Trade and Industry also putted emphasis on stabilizing recycling economy, and brought up the concept of “3R Policy”, meaning: reuse, reduce and recycle. In 1997, MOEI and MOE jointly promoted “Eco-town” projects to build zero emission industrial zone, where all the waste material are utilized by other parties as resources within the area, closing the material cycle meanwhile furthering the regional economic development. During the 9 years of implementation (1997 - 2005), a total of 26 zero emission industrial zones had been approved (METI, 2008).

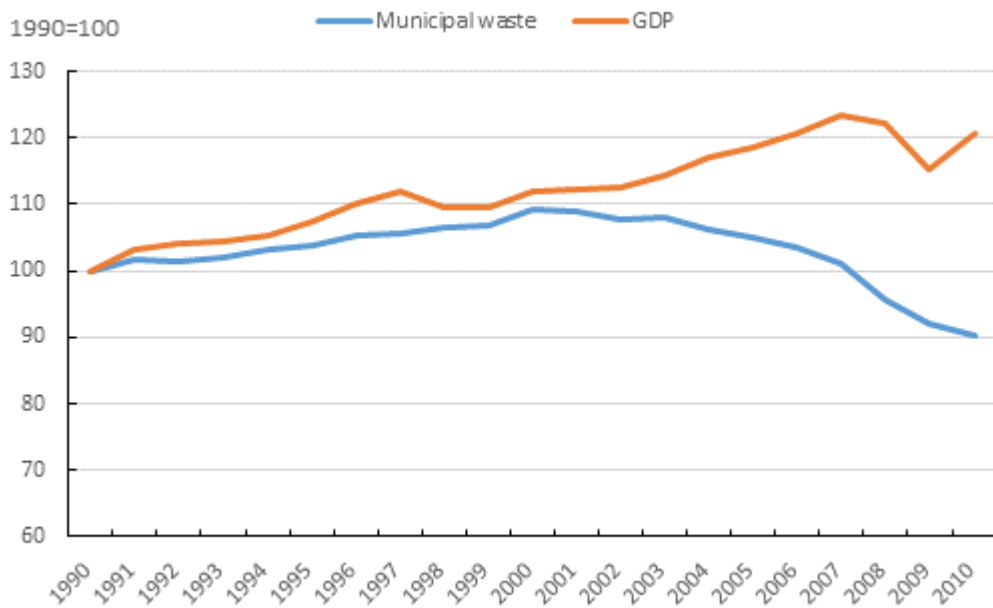
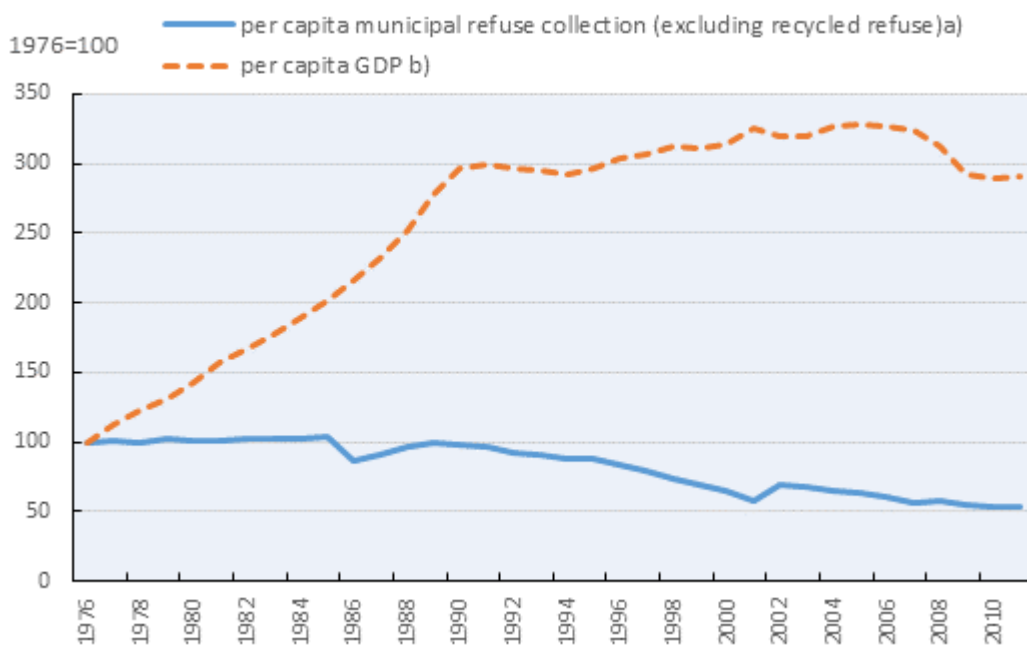


Figure 5 Change of Japan's municipal waste and GDP from 1990-2010
[source: OECD (<http://stats.oecd.org/#>). Last accessed on July 26, 2014.])



a: per capita refuse collection = (annual refuse collection-recycled refuse)/population.
b: Regional GDP of Tokyo-to at current prices.

Figure 6 Change of Tokyo's per capita refuse collection and per capita GDP from 1976-2011
[Source: refuse and population data is from Tokyo Statistical yearbooks.
(<http://www.toukei.metro.tokyo.jp/tnenkan/tn-eindex.htm>); GDP data is from Cabinet Office, Government of Japan.

(http://www.esri.cao.go.jp/jp/sna/data/data_list/kenmin/files/contents/main_h23.html). Last accessed on July 26, 2014.]

The 1990s was the most active time for Japan's perceptions in the international organizations to protect the global environment, especially for carbon emission reductions. Ever since the announcement of Kyoto Protocol in 1997 drafted by IPCC, in the following year, Japanese government introduced the Law Concerning the Promotion of the Measures to Cope with Global Warming and Guidelines for Measures to Prevent Global Warming . In 1999, the Cabinet of Nation introduced Climate Change Countermeasure Principle , which laid the foundations for its low carbon society developments in the 21st Century.

3.2.4 Low Carbon Society Development Phase (2000s)

In 2001, the Japan's Environment Agency was updated into Ministry of Environment, a sign indicating the national concern and high regards towards the environmental issues from the Japanese government. In the following years, MOE had produced significant outcomes to tackle the climate change issues; in 2002, Japan officially rectified the Kyoto Protocol , in the same year, two revisions were made for Law Concerning the Promotion of the Measures to Cope with Global Warming and Guidelines for Measures to Prevent Global Warming . Shortly after the Kyoto Protocol came into effect in February, 2005, the Cabinet established "Department of Climate Change Countermeasure Promotion", revised and enacted Law Concerning the Promotion of the Measures to Cope with Global Warming , and conducted Kyoto Protocol Target Achievement Plan .

According to the Kyoto Protocol, Japan was to reduce its greenhouse gas (GHG) emission by 6% compared to the 1990 level, during the first commitment period from 2008 to 2012. In reality, Japan's GHG emission raised 9% by 2007 compared to the 1990 baseline (MOE, 2008a), as a result, the Japanese government revised the Law Concerning the Promotion of the Measures to Cope with Global Warming and Kyoto Protocol Target Achievement Plan . To showcase the leading status of international environmental endeavors, the back then Japanese Prime Minister Fukuda made pledges to the developed countries for grand reductions of 50% GHG by 2050 in the 2008 G8 Summit meeting

took place in Hokkaido Toyako, Japan. To realize this pledge, the government set up the official long term goals of “60% - 80% carbon reduction compared to the 1990 level” and establishing “low carbon society”, and the Cabinet approved the Action Plan of Building a Low Carbon Society (MOE, 2008b). According to this action plan, Japan is to realize the low carbon society through four aspects: (1) development of innovative technology and dissemination of best available technology; (2) establishment of national laws and regulations for carbon trading, taxation, financing, emission visualization etc. (3) local (including towns and villages) decarbonization development; (4) national low carbon education and production, improvement of living habits etc.

In September, 2009, Japan Democratic Party won the election, replacing long-time ruling Liberal Democratic Party of Japan, had basically continued their environmental policies despite of their many differences in political views. For example, shortly after the first Prime Minister Hatoyama of Democratic Party took office, he made the official pledge in the UN conference (New York) that Japan would reduce its GHG emission by 25% by 2020 compared to 1990 level. In June, 2010, the Democratic Party established “New Growth Strategy” to develop world leading “environmental future city” among its 21 national projects (Prime Minister of Japan and His Cabinet, 2010a). In October of that year, the “environmental future city” was given concrete contents including decarbonization, coexistence with nature, capping with “health and medicare” issues in the aging society of Japan, and also “creating human-centered social values” among others (Prime Minister of Japan and His Cabinet, 2010b).

To facilitate the implementation of the Action Plan of Building a Low Carbon Society, the post-2008 constructions of Japanese low carbon cities have manifested the following four features: (1) Local government’s Climate Change Countermeasure Implementation Plan (refer as the Plan) include both administrative planning and local planning. For local planning, the law requires prefectures, executing cities (19), core cities (41) and example cities (40) are mandatory to conduct such plan with specific middle term and long term GHG emission reduction targets and action plans, while other places are encouraged to conduct such plan. To help the local governments with their

CO₂ emission calculation and projects, MOE published the Manual for Quantitative Evaluation of the Co-Benefits Approach to Climate Change Projects to provide with the detailed data and calculation methodologies (MOE, 2009). According to the statistics in 2011, in terms of government administration, all the prefecture governments had conducted their own “Plan”, with the average CO₂ emission reduction rate of 9%, and government of other levels would complete it by the end of 2011. In terms of regional planning, the mandatory cities would have their regional planning completed by the end of 2011, and for those non-mandatory cities, 25% of which would have either completed or in the process of conducting such planning (MOE, 2011). After announcing its Tokyo Climate Change Strategy in June 2007, Tokyo Metropolitan Government introduced Asia’s first cap-and-trade emissions trading program, to take effect in fiscal 2010, showing its leadership in Japan as well as in Asia (Tokyo Bureau of Environment, 2010b).

(2) Development of eco-model city. In order to improve the environment quality meanwhile boost the local economy, the working group under Japanese National Cabinet Secretariat started selecting the eco-model cities from April, 2008 (MOE, 2008c). Their selection criteria include: considerable quantity in CO₂ reduction, exceeding 30% CO₂ reduction by 2020 and 50% by 2050; able to become pilot model cities both domestically and internationally; possess local features; multi-involvement from citizens, enterprises, universities and non-governmental organizations (NGOs) and practically implementable; suited for long term development and promote local vitality, activity engage in promoting environmental educations for future generations and sustainability. By far, 13 cities (including Kitakyushu, Yokohama, and Kyoto) have been selected. Full support was given by the national government, and “Association for Low Carbon Cities” was established to promote and support the related activities.

(3) Development of eco-city projects. From 2008, the Ministry of Land, Infrastructure, Transport and Tourism (MLIT) started to promote the projects of low carbon cities, known as “Promotion for Leading Urban Environment”, which include not only the traditional infrastructure constructions, but also social support and economic incentives for low carbon planning and implementation. Some specifics include 1/2 of local public projects are funded by MLIT and 1/3 for the civil projects. An approximate of 30 projects

annually could be chosen for funding (MLIT, 2008). Compared to Cabinet Secretariat's selection for eco-model cities, these projects focus mainly on districts within the city. Therefore, some of eco-model city projects were also chosen and supported. (4) Enactment of Low Carbon City Development Guidelines. From May 2008 to June 2009, 10 working group meetings were conducted by MILT to discuss the future urban development strategy in Japan, the first item of which, was to development eco-compact cities (MLIT, 2009a). Base on this strategy, MILT published "Low Carbon City Development Guidelines" (MLIT, 2009b), its core idea is to realize the low carbon eco-compact urban structures, with detailed methodologies for related carbon calculation.

Japan's urbanization process had inflicted huge damages to the environment and ecosystem, even caused drastic environmental hazards and social problems. With the improvement of its economic level and changes of international environment, Japan's urban policies evolved from preventing public environmental hazards to pursuing healthy, comfortable living environment, and to coexisting with nature, resource recycling and coping with global environmental issues. As a higher goal for development, currently Japan's urban policies come back to the very fundamental issues - the health and wealth of human lives. Figure 7 illustrates the significant achievements of Japan's environmental policies. Compared with the level of 1990, generally, the energy consumption showed a trend of growing until 2006 and then dropped. Though of the growing energy consumption, the total emission of four main air pollutants, including SO_x, NO_x, CO and non-methane VOCs which are considered closely relative with energy consumption, significantly decreased during these 20 years. The emission of SO_x, NO_x, CO and non-methane VOCs were reduced by 26%, 17%, 46% and 19% respectively. At the same time, although the GHG emission slightly increased compared with the 1990 level, the rise is smaller the rise of energy consumption.

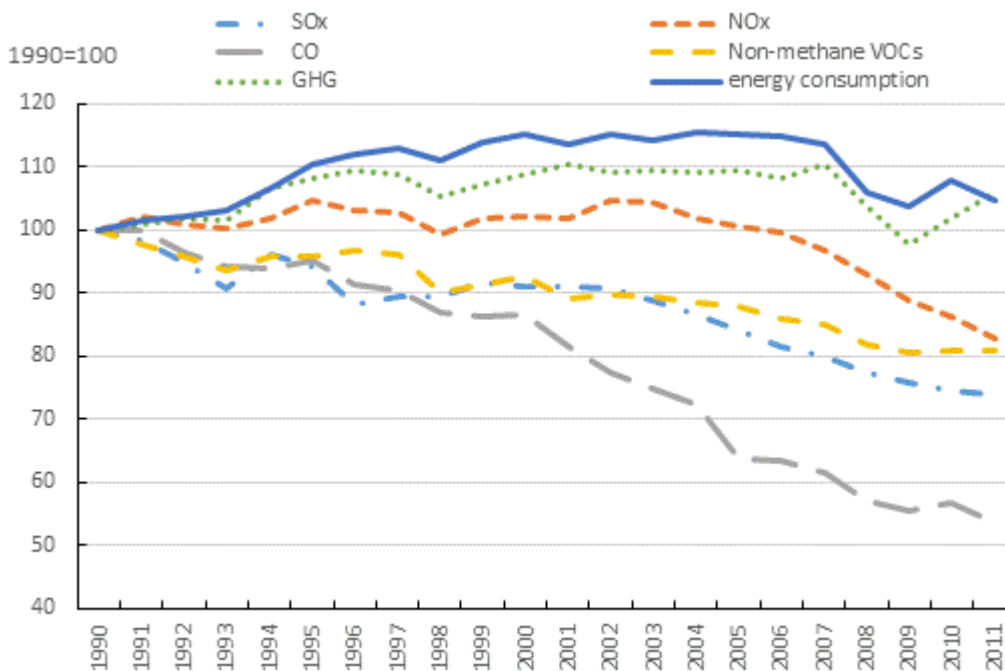


Figure 7 Change of Japan's air pollution emission, GHG emission and energy consumption from 1990-2011

[Source: data of air pollution emission is from OECD (<http://stats.oecd.org/#>), data of energy consumption is from Ministry of Economy, Trade and Industry (http://www.enecho.meti.go.jp/statistics/total_energy/), data of GHG emission is from Ministry of Environment (<http://www.env.go.jp/earth/ondanka/ghg.html>) Last accessed on July 26, 2014.]

Unfortunately, one of the worst nuclear tragedies in human history - the Fukushima Nuclear Incident took place in Japan in March 2011; about 30% of Japanese domestic electricity was from nuclear power then. Japan has reduced GHG emission on average 8.4 percent in the first commitment period of Kyoto Protocol compared to 1990 levels, more than the target of 6%, but it was because the land use, land-use change, and forestry (LULUCF) and the purchases of Kyoto Units were taken into account (MOE, 2013). In fact, the GHG emission has risen significantly although the energy consumption declined in recent years, the real average annual domestic GHG emissions between 2008 and 2012 were 1.4 percent above 1990 levels (Figure 8). The more serious result is seen in Tokyo (Figure 9). Because of the change of the distribution of electric power generation sources, the GHG emission of Tokyo surged in recent years, and it increased by 20.4% compared with the base year level. At the same time, the amount of energy generated by nuclear power dropped from 2495 PJ in 2010 to 139 PJ in 2012, and the share of fossil fuels in the energy rise from 82.7% to 92.5%.

Consequently, the GHG emission rose significantly although the whole energy consumption declined; the real average annual domestic GHG emissions between 2008 and 2012 were 1.4 percent above 1990 levels.

The Fukushima Nuclear Incident also has a remarkable impact on environmental policies. The Basic Act on Global Warming Countermeasures proposed by DPJ in October 2010 was suspended as a result. In the “New Growth Strategy” brought up in the post-Fukushima period, though compact and eco-cities are still the major “features” in the policies of the following three years (Japan National Strategy Office, 2011), the environment future cities are also being proceeded, the detailed implementation plans were only mentioned in MOE’s 2012 annual budget, not at all mentioned in other ministries such as METI or MLT.

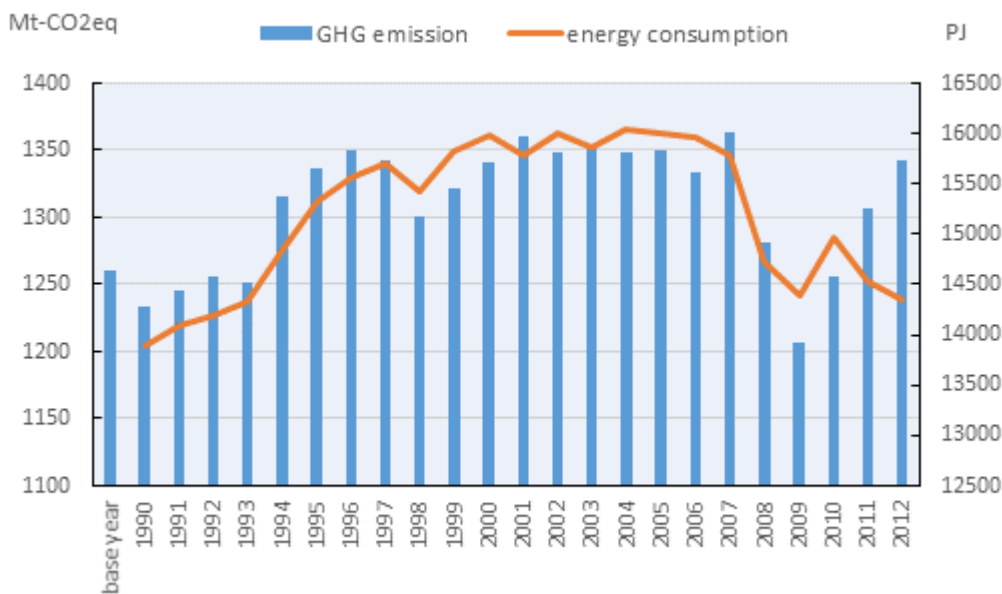
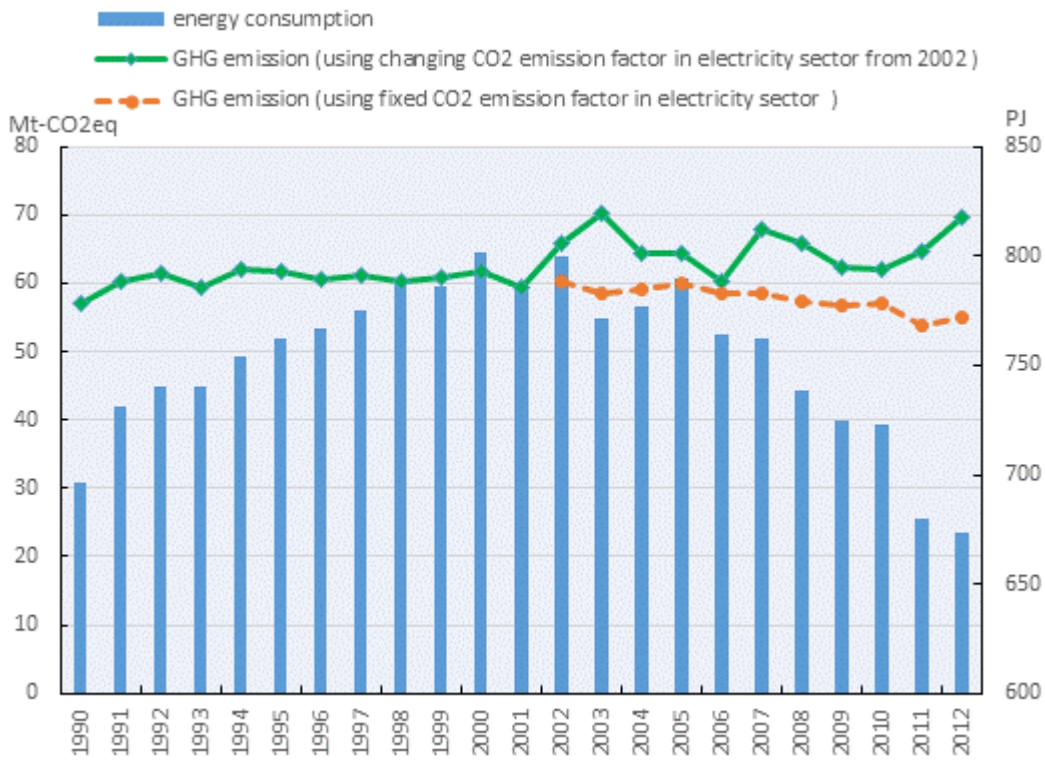


Figure 8 Japan’s GHG emission and energy consumption from 1990-2011
 [source: Ministry of Economy, Trade and Industry (http://www.enecho.meti.go.jp/statistics/total_energy/), Ministry of Environment (<http://www.env.go.jp/earth/ondanka/ghg.html>).Last accessed on July 26, 2014.]



Note: The CO₂ emission factor of electricity sector changes with the distribution of electric power generation sources.

Figure 9 Tokyo's GHG emission and energy consumption from 1990-2011

[Source: Tokyo Bureau of environment.

(http://www.kankyo.metro.tokyo.jp/climate/other/emissions_tokyo.html). Last accessed on July 26, 2014.]

Chapter IV Conclusion

As analyzed above, Japan has made dramatic improvements in urban environment since 60 years ago. At present, the latest OECD report (2010) praised that Japan has shown leadership in several environmental areas, its energy intensity of the economy and waste generation per capita is among the lowest in OECD countries (OECD, 2010). The successful experiences of Japan's urban environmental management can be classified to three aspects: (i) Japan is responding to its environmental challenges largely via legal and regulatory actions. As mentioned, Japanese government prioritized legislation, enacted various laws to specific problems and revised them as the situation changes. (ii) Japanese government attaches importance to the role of planning in urban environmental management. Japan is one of the earliest countries that enacted urban planning law. The governments value the land-use or spatial planning as an effective measure for pollution prevention and environmental improvements. Meanwhile, the government has strengthened environmental planning since 1990s; local city governments are required to formulate urban environment plans which are focusing on promoting eco-city, eco-town, low-carbon city, etc.

In addition to government regulations, public environmental awareness and the cooperation of individuals, corporations and governments are also key factors, which cannot be deeply analyzed due to the limitation of space in this paper. The importance of social movements, great public participation and supervision, conscious actions of enterprises, etc. for environmental protection await further research.

Currently, Japan is still facing several environmental challenges, among others, three issues are focused: (i) Air pollution challenges have been a constant struggle for city managers. The level of photochemical oxidants showed an increasing trend, due to emissions from stationary and mobile sources. For example, Tokyo has not been able to meet the environmental standards regarding photochemical oxidant yet (Tokyo Metropolitan Government, 2012). (ii) GHG emissions increase mainly due to a high share of fossil fuels in the energy. As mentioned above, after the 2011 Fukushima Nuclear Incident, the Japanese government is facing even bigger challenges in reducing GHG

emissions. (iii) The high-quality urban environment requires more green and natural spaces. For example, the abundant green and water areas in Tokyo decreased in size during the period of rapid economic growth, and the situation continues to get worse (Tokyo Metropolitan Government, 2012). Continuous efforts are still required for Japan to become a nature human coexisting sustainable society.

Although the experiences of Japan are recommended to be learned, the differences between Japan and other countries should be noticed. The result of Marcotullio's (2005) comparison research of urban environmental transitions between New York City and Tokyo showed that, while New York City underwent a series of environmental problems in sequential order and over a long period of time, Tokyo's experiences were more compressed in time and telescoped. In fact, the transition of Japan's urban environmental burdens, shifting from localized, immediate and health threatening ones to global ecosystem threatening ones, has cost about 60 years since 1950s. Unfortunately, when looking at the currently developing countries, it is deemed that they probably need to spend much shorter period of time and deal with the increasing overlaps of sets of environmental burdens. Nevertheless, from the experiences of Japan, we believe that a sound law and regulatory system, strong emphasis on urban land use planning and environmental planning, and widespread engagement of citizens and enterprises are the keys to combat the environmental issues.

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Appendices

Table 2 seven countries' urbanization rate (1950-2012)

Country	United Kingdom	United States	Japan	Korea, Rep.	China	Brazil	India
	GBR	USA	JPN	KOR	CHN	BRA	IND
1950	79.0	64.2	37.3	21.4	11.8	36.2	17.0
1953			50.0				
1955	78.7	67.2	58.4	24.4	13.9	41.1	17.6
1960	78.4	70.0	63.3	27.7	16.2	46.1	17.9
1961	78.3	70.4	64.2	28.6	16.6	47.1	18.1
1962	78.2	70.7	65.1	29.6	17.0	48.1	18.3
1963	78.1	71.1	66.0	30.5	17.3	49.1	18.4
1964	77.9	71.5	66.9	31.4	17.7	50.1	18.6
1965	77.8	71.9	67.9	32.4	18.1	51.0	18.8
1966	77.7	72.2	68.7	34.0	17.9	52.0	19.0
1967	77.5	72.6	69.5	35.7	17.8	53.0	19.2
1968	77.4	72.9	70.3	37.4	17.7	54.0	19.4
1969	77.3	73.3	71.1	39.0	17.5	54.9	19.6
1970	77.1	73.6	71.9	40.7	17.4	55.9	19.8
1971	77.2	73.6	72.6	42.2	17.4	56.9	20.1
1972	77.3	73.6	73.4	43.6	17.4	57.9	20.4
1973	77.5	73.6	74.2	45.1	17.4	58.8	20.7
1974	77.6	73.6	74.9	46.6	17.4	59.8	21.0
1975	77.7	73.7	75.7	48.0	17.4	60.8	21.3
1976	77.8	73.7	75.8	49.8	17.8	61.7	21.7
1977	78.0	73.7	75.9	51.5	18.2	62.7	22.0
1978	78.2	73.7	76.0	53.2	18.6	63.6	22.4
1979	78.3	73.7	76.1	55.0	19.0	64.5	22.7
1980	78.5	73.7	76.2	56.7	19.4	65.5	23.1
1981	78.5	73.9	76.3	58.4	20.1	66.3	23.3
1982	78.4	74.0	76.4	60.0	20.8	67.2	23.6
1983	78.4	74.2	76.5	61.6	21.5	68.1	23.8
1984	78.4	74.3	76.6	63.2	22.2	69.0	24.1
1985	78.4	74.5	76.7	64.9	22.9	69.9	24.3
1986	78.3	74.7	76.8	66.7	23.6	70.7	24.6
1987	78.3	74.8	77.0	68.5	24.3	71.5	24.8
1988	78.2	75.0	77.1	70.3	25.0	72.3	25.1
1989	78.2	75.1	77.2	72.1	25.7	73.1	25.3
1990	78.1	75.3	77.3	73.8	26.4	73.9	25.5
1991	78.2	75.7	77.5	74.7	27.3	74.7	25.8
1992	78.2	76.1	77.6	75.6	28.2	75.4	26.0
1993	78.3	76.5	77.7	76.5	29.2	76.1	26.2
1994	78.3	76.9	77.9	77.4	30.1	76.9	26.4
1995	78.4	77.3	78.0	78.2	31.0	77.6	26.6
1996	78.4	77.6	78.1	78.5	31.9	78.3	26.8
1997	78.5	78.0	78.3	78.8	32.9	79.0	27.0
1998	78.5	78.4	78.4	79.1	33.9	79.8	27.2
1999	78.6	78.7	78.5	79.3	34.9	80.5	27.5

Country	United Kingdom	United States	Japan	Korea, Rep.	China	Brazil	India
2000	78.7	79.1	78.6	79.6	35.9	81.2	27.7
2001	78.7	79.4	80.1	80.0	37.2	81.5	28.0
2002	78.8	79.7	81.6	80.3	38.5	81.8	28.3
2003	78.9	80.1	83.0	80.7	39.9	82.2	28.6
2004	78.9	80.4	84.5	81.0	41.2	82.5	28.9
2005	79.0	80.7	86.0	81.3	42.5	82.8	29.2
2006	79.1	81.0	86.9	81.7	43.9	83.1	29.6
2007	79.2	81.3	87.8	82.0	45.2	83.4	29.9
2008	79.3	81.6	88.7	82.3	46.5	83.7	30.3
2009	79.4	81.9	89.6	82.6	47.9	84.0	30.6
2010	79.5	82.1	90.5	82.9	49.2	84.3	30.9
2011	79.6	82.4	91.1	83.2	50.5	84.6	31.3
2012	79.8	82.6	91.7	83.5	51.8	84.9	31.7

Source: the data of 1950-1960 is from UN urbanization prospects, <http://esa.un.org/unup/CD-ROM/Urban-Rural-Population.htm>. The data of 1960-2011 is from World Bank, <http://data.worldbank.org/>.

Table 3 Japan's air pollutants emission, GHG emission and energy consumption (1990-2011)

pollutants	SO_x	No_x	CO	Non-methane VOCs	energy consumption	GHG emission
unit	Tonnes , Thousands	Tonnes , Thousands	Tonnes , Thousands	Tonnes , Thousands	PJ	Tonnes of CO ₂ equivalent, Thousands
1990	1 012.2	1714.9	4 433.1	1 933.8	13889	1234
1991	995.4	1753.8	4423.7	1891.3	14092	1246
1992	960.8	1731.2	4272.5	1855.1	14200	1256
1993	919.3	1716.5	4172.2	1811.2	14337	1251
1994	971.5	1748.6	4168.6	1851.6	14824	1315
1995	954.2	1793.9	4222.5	1854.8	15318	1336
1996	891.1	1767.9	4050.9	1868.3	15567	1350
1997	906.7	1762.2	4013.5	1856.8	15702	1343
1998	906.4	1704.1	3858.6	1739.5	15428	1301
1999	929.3	1747.2	3829.7	1767.7	15814	1322
2000	922.5	1753.9	3845.2	1793.6	15975	1341
2001	920.9	1745.1	3614.6	1726.5	15784	1361
2002	918.7	1796.4	3427.1	1738.7	16006	1348
2003	899.5	1788.5	3320.4	1727.8	15872	1352
2004	874.8	1747.7	3201.9	1711.1	16043	1348
2005	849.2	1722.9	2822.4	1699.7	15996	1350
2006	826.1	1706.1	2807.6	1659.6	15968	1333
2007	810	1661.7	2724.8	1643.8	15790	1364
2008	784.7	1596	2525.9	1584.9	14720	1281
2009	766.7	1525.3	2452.7	1555.3	14393	1206
2010	755.5	1477.1	2512.5	1563.5	14973	1256
2011	747.5	1422.1	2370.3	1566.3	14529	1307

Source: data of air pollution emission is from OECD (<http://stats.oecd.org/#>), data of energy consumption is from Ministry of Economy, Trade and Industry (http://www.enecho.meti.go.jp/statistics/total_energy/), data of GHG emission is from Ministry of Environment (<http://www.env.go.jp/earth/ondanka/ghg.html>)

Table 4 Japan's municipal waste and GDP (1990-2010)

	Municipal waste	Japan's GDP
Unit	Tonnes , Thousands	US \$, constant prices, constant PPPs, OECD base year, millions
1990	50257	3276516.3
1991	51132	3385438.9
1992	50903	3413166.6
1993	51268	3419005.3
1994	51800	3448531.1
1995	52224	3515513.4
1996	52908	3607270.2
1997	53098	3664828.8
1998	53605	3591416.9
1999	53699	3584257.9
2000	54833	3665172.3
2001	54681	3678200.6
2002	54199	3688850.8
2003	54271	3751012
2004	53376	3839563.3
2005	52720	3889582.4
2006	52024	3955429.3
2007	50816	4042139.7
2008	48106	4000035.3
2009	46252	3778954.3
2010	45359	3954752.4

Source: OECD (<http://stats.oecd.org/#>)

Table 5 Tokyo's annual average of SO₂, NO₂, SPM and O_x (1965-2012)

	sulphur dioxide (SO₂)	nitrogen dioxide (NO₂)	suspended particle matter (SPM)	photochemical oxidant (O_x)	Population
	ppm	ppm	mg/m ³	ppm	
1955					8,037,084
1956					8,348,969
1957					8,681,040
1958					9,010,534
1959					9,349,323
1960					9,683,802
1961					9,936,970
1962					10,180,203
1963					10,432,526
1964					10,639,361
1965	0.0512				10,869,244
1966	0.0507				10,973,070
1967	0.05625			0.036	11,104,969
1968	0.05225			0.045	11,252,775
1969	0.0428			0.037	11,340,417
1970	0.0382			0.041	11,408,071
1971	0.0289			0.0366	11,521,226
1972	0.0248			0.033	11,598,152
1973	0.0278			0.044	11,636,797
1974	0.0254			0.03	11,654,642
1975	0.0238			0.0324	11,673,554
1976	0.019	0.032		0.03	11,674,000
1977	0.017	0.031		0.031	11,669,000
1978	0.016	0.034		0.02	11,659,000
1979	0.016	0.032		0.02	11,637,000
1980	0.016	0.03		0.019	11,618,281
1981	0.015	0.029		0.018	11,626,000
1982	0.015	0.03		0.019	11,650,000
1983	0.011	0.029		0.021	11,700,000
1984	0.009	0.028		0.022	11,759,000
1985	0.008	0.027		0.021	11,829,363
1986	0.008	0.028		0.018	11,888,000
1987	0.008	0.03		0.02	11,887,000
1988	0.007	0.03		0.018	11,873,000
1989	0.008	0.03		0.017	11,863,000
1990	0.009	0.03		0.021	11,855,563
1991	0.009	0.032		0.021	11,894,000
1992	0.007	0.031		0.024	11,887,000

	sulphur dioxide (SO₂)	nitrogen dioxide (NO₂)	suspended particle matter (SPM)	photochemical oxidant (O_x)	Population
1993	0.007	0.031		0.022	11,849,000
1994	0.008	0.031		0.024	11,796,000
1995	0.007	0.031		0.025	11,773,605
1996	0.007	0.031		0.024	11,808,000
1997	0.007	0.031	0.045	0.025	11,881,000
1998	0.006	0.03	0.045	0.023	11,939,000
1999	0.005	0.028	0.04	0.026	11,983,000
2000	0.004	0.028	0.039	0.026	12,064,101
2001	0.004	0.028	0.037	0.028	12,165,000
2002	0.003	0.027	0.033	0.027	12,271,000
2003	0.003	0.027	0.032	0.026	12,388,000
2004	0.003	0.026	0.029	0.027	12,482,000
2005	0.002	0.025	0.029	0.029	12,576,601
2006	0.002	0.025	0.029	0.029	12,704,000
2007	0.002	0.023	0.025	0.029	12,848,000
2008	0.002	0.021	0.024	0.03	12,973,000
2009	0.002	0.021	0.023	0.03	13,048,000
2010	0.002	0.02	0.021	0.032	13,159,388
2011	0.002	0.019	0.021	0.028	13,196,000
2012	0.002	0.018	0.02	0.03	13,230,000

Source: Tokyo Statistical yearbooks. (<http://www.toukei.metro.tokyo.jp/tnenkan/tn-eindex.htm>)

Table 6 Tokyo's municipal park area per capita (1978-2011)

	municipal park area per capita
	m2
1975	1.78
1976	-
1977	-
1978	1.98
1979	2.07
1980	2.22
1981	2.39
1982	2.45
1983	2.63
1984	2.72
1985	2.77
1986	2.89
1987	3.05
1988	3.15
1989	3.22
1990	3.37
1991	3.36
1992	3.47
1993	3.53
1994	3.63
1995	3.7
1996	3.79
1997	3.88
1998	3.92
1999	3.97
2000	4.02
2001	4.27
2002	3.9
2003	3.85
2004	3.95
2005	4.01
2006	4.04
2007	4.08
2008	4.15
2009	4.17
2010	4.21
2011	4.29

Source: Tokyo Statistical yearbooks. (<http://www.toukei.metro.tokyo.jp/tnenkan/tn-eindex.htm>)

Table 7 Tokyo's municipal refuse, population and GDP

	refuse collection	Total recycled refuse	population	per capita per day (exclude recycled refuse)	Regional GDP of Tokyo-to at current prices	per capita GDP
unit	t	t		g/d	million yen	thousand yen/person
1976	5932350	52100	11674000	1380.0	28086787	2405.9
1977	5988455	66524	11669000	1390.4	31400908	2691.0
1978	5959070	77668	11659000	1382.1	34202766	2933.6
1979	6039305	76782	11637000	1403.8	36818363	3163.9
1980	6006132	81524	11618281	1397.1	40041380	3446.4
1981	6014832	88235	11626000	1396.6	43831968	3770.2
1982	6110932	91370	11650000	1415.6	46775757	4015.1
1983	6148002	94658	11700000	1417.5	49789885	4255.5
1984	6163346	105747	11759000	1411.4	53196336	4523.9
1985	6269387	122379	11829363	1423.7	57356852	4848.7
1986	5348229	142915	11888000	1199.6	61719319	5191.7
1987	5630087	164399	11887000	1259.7	66212489	5570.2
1988	5975348	178238	11873000	1337.7	72112630	6073.7
1989	6144544	193445	11863000	1374.4	79080148	6666.1
1990	6085830	229515	11855563	1353.3	84406722	7119.6
1991	6007154	247990	11894000	1326.6	85564400	7193.9
1992	5823960	272545	11887000	1279.5	84722426	7127.3
1993	5693372	302853	11849000	1246.4	84141622	7101.2
1994	5620473	357353	11796000	1222.4	83100569	7044.8
1995	5541481	355858	11773605	1206.7	84122248	7145.0
1996	5435760	421385	11808000	1163.4	86279180	7306.8
1997	5331773	564427	11881000	1099.3	87725386	7383.7
1998	5100169	664289	11939000	1017.9	89567348	7502.1
1999	4940003	793987	11983000	947.9	89650236	7481.5
2000	4862393	931591	12064101	892.7	91024125	7545.0
2001	4876303	1340033	12165000	796.4	95235116	7828.6
2002	5204323	936105	12271000	953.0	94340299	7688.1
2003	5172759	913851	12388000	941.9	95260912	7689.8
2004	5046661	943058	12482000	900.7	98078234	7857.6
2005	5035348	980373	12576601	883.3	99384119	7902.3
2006	4969187	1122220	12704000	829.6	99873101	7861.5
2007	4810902	1148869	12848000	780.9	99948888	7779.3
2008	4910202	1137534	12973000	796.7	97330017	7502.5
2009	4756419	1140705	13048000	759.2	91799505	7035.5
2010	4643734	1107557	13159388	736.2	91447507	6949.2
2011	4609819	1063725	13196000	736.2	92387777	7001.2

Source: refuse and population data is from Tokyo Statistical yearbooks.

(<http://www.toukei.metro.tokyo.jp/tnenkan/tn-index.htm>); GDP data is from Cabinet Office, Government of Japan. (http://www.esri.cao.go.jp/jp/sna/data/data_list/kenmin/files/contents/main_h23.html)

Table 8 Tokyo's GHG emission and energy consumption

	GHG emission (using changing CO₂ emission factor in electricity sector from 2002)	GHG emission (using fixed CO₂ emission factor in electricity sector)	energy consumption
	Mt-CO ₂ eq	Mt-CO ₂ eq	PJ
base year	57.81		
1990	57.11		696
1991	60.12		731
1992	61.37		740
1993	59.49		740
1994	61.93		754
1995	61.71		762
1996	60.53		767
1997	61.21		775
1998	60.31		788
1999	60.8		786
2000	61.83		802
2001	59.46		786
2002	65.68	60.37	800
2003	70.14	58.64	771
2004	64.35	59.05	777
2005	64.26	59.98	790
2006	60.19	58.41	764
2007	67.78	58.5	762
2008	65.83	57.45	738
2009	62.17	56.64	725
2010	61.89	57.16	723
2011	64.77	53.77	680
2012	69.6	54.9	673.8

Source: Tokyo Bureau of environment.

(http://www.kankyo.metro.tokyo.jp/climate/other/emissions_tokyo.html)