A Roadmap towards Low Carbon Kyoto

2009 Oct.

Research Team of
Sustainable Society Kyoto

Introduction

The question of, “How to achieve a sustainable society?” is one that has passed through various stages of discussions. Initially, it began with the clarification of the sustainable society concept, and then progressed to the qualitative envisioning of what a sustainable society would look like in the future. We have now reached the stage where the roadmap to accomplish the target is drawn out and defined as quantitatively as possible. This process is identified as “backcasting”. The public at large may not be familiar with this new method. This is because; so far government programs have been using the “forecasting” method, where the current scenario is analyzed to estimate the future scenario.

This pamphlet reports on a study conducted for the city of Kyoto using the backcasting method. The basis for judgment and co-efficiency related to the feasibility of preparing this roadmap involves a few uncertain elements which need to be defined at the policy implementation stage. These elements include the priority and continuity of numerous policies, the cost of measures and the degree of complexity in terms of policy and the degree of progress in technical development. In this study, these elements have been assigned values that are thought to be appropriate at this point in time, and calculations have been made based on this. In order to establish these parameters accuracy, and enable these values to be put to actual use in the related fields; a variety of data needs to be gathered.

Although this study may include some uncertain elements in calculation, this is the first Roadmap to be accomplished for a local government using the backcasting method.

It is our hope that the results of this pioneering effort will be one that will find a widespread usage in the future for various plans to prevent global warming at the local government level.

The Research Team of Sustainable Society Kyoto is made up of volunteers, participating in a private capacity, who are interested in transforming Kyoto into a low carbon society. Our activities are conducted in close cooperation with Kyoto City and are based on the municipal government's policies and data, but the results are not officially authorized by the municipal government. At present however, the Kyoto Municipal Government is pursuing activities that are based partly on our achievements, and I believe that sooner or later these results will receive formal public recognition.

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Overview of the Roadmap towards Low Carbon Kyoto

What would Kyoto as a low carbon city be like? And who would have to do what to achieve this goal, and when would they have to do it? The achievement of a low carbon city would require city-wide debate and action. Moreover, a great deal of information would be needed with regards to societal development and low carbon technologies.

The Research Team of Sustainable Society Kyoto has constructed this Roadmap to a low carbon society for use as a basis for this discussion. To forecast the future societies scenario; firstly,we assumed moderate economic growth of about 1.3% per year and a gradual decrease in population (Table S-1). As a point of reference, we used the most recent low carbon measure, entitled "Kyoto City Environmental Model City Plan of Action," which was completed in March 2009. The major findings are as follows.

1) It is technically possible to reduce CO_2 emissions in 2030 by 40% or more as compared to 1990 (Fig. S-1). This will require the widespread adoption of actions far greater than the current situation; in the usage of highly energy-efficient equipment, better-insulated buildings, use of renewable energy, energy-saving behavior and other measures.

2) A path exists where it will enable the necessary measures to be widely adopted in the 20 years between 2010 and 2030. If actions are promoted smoothly by 2025, 90% or more of the final measures will be able to be implemented (Fig. S-2).

3) In order for measures to be disseminated, incentives must be provided as Kyoto Municipal Government policies. Most of the incentives are already included in the measures currently being planned by Kyoto City.

4) Most of the entities that must take action in order to achieve actual reductions are citizens and companies in the private sector. In line with this, the understanding and cooperation of the general public and companies in the private sector will be needed in order for the policies induced by Kyoto City to be accepted and lead to action.

Table S-1 Estimation result of scenario quantification in 2030

	2005	2030	2030/ 2005
Population (10^4)	147	140	0.95
No. of households (10^4)	65	65	0.99
GDP (bill yen)	6124	8305	1.36
GDP per capita (mill yen/capita)	4.15	5.94	1.43
Gross output (bill yen)	9938	13400	1.35
Primary industry	17	19	1.13
Secondary industry	2735	3542	1.30
Tertiary industry	6947	9507	1.37
Passenger transport volume (mill p-km)	9251	8192	0.89
Freight transport volume (mill t-km)	3484	4571	1.31

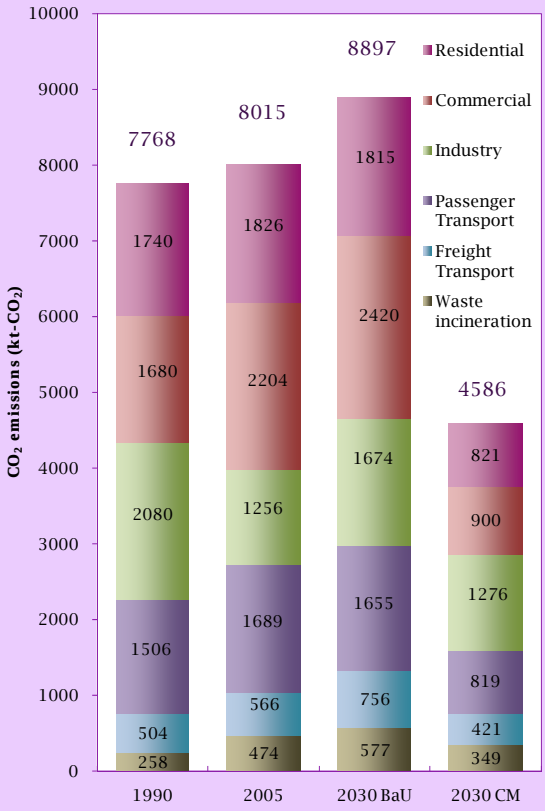

Figure S-1 CO_2 emissions

This Roadmap is a joint effort by members of the Research Team of Sustainable Society Kyoto. The team is not requesting for all these elements to be implemented. Rather, we want this Roadmap to serve as a springboard for debates by many relevant parties regarding the path towards a low carbon society. From this point on, the debate must focus on the following points in particular.

1) There are a combination of measures that can be taken to achieve a 40% reduction in emissions as compared to 1990 levels in 2030. The combination shown here is only one example. The desirability of the measures should be debated by the participants from different viewpoints to enable the best possible measure option to be later implemented in Kyoto.

2) This Roadmap has been created by envisioning which measures will be effective in leading to the dissemination of direct measures. However, these must be verified to determine whether or not they are sufficient. Moreover, additional measures may be needed in the event that some measures are not effective.

3) Implementing measures will require considerable expenditures of funds and labor. Due to the informational constraints, only the resources provided by the Kyoto Municipal Government for policy implementation were evaluated for the purposes of this study. However, many of the measures will require funds that come directly or indirectly from the citizens and companies in the private sector. A study is needed to determine whether this is within the acceptable range..

4) Many measures are not designed solely to reduce CO_2 emissions. Since improved energy efficiency is also a way of reducing costs, there is often a net economic benefit. Moreover, improvements in the use environment for public transport also constitute an improvement in the convenience of transport. Such benefits other than the reduction of CO_2 emissions should also be considered.

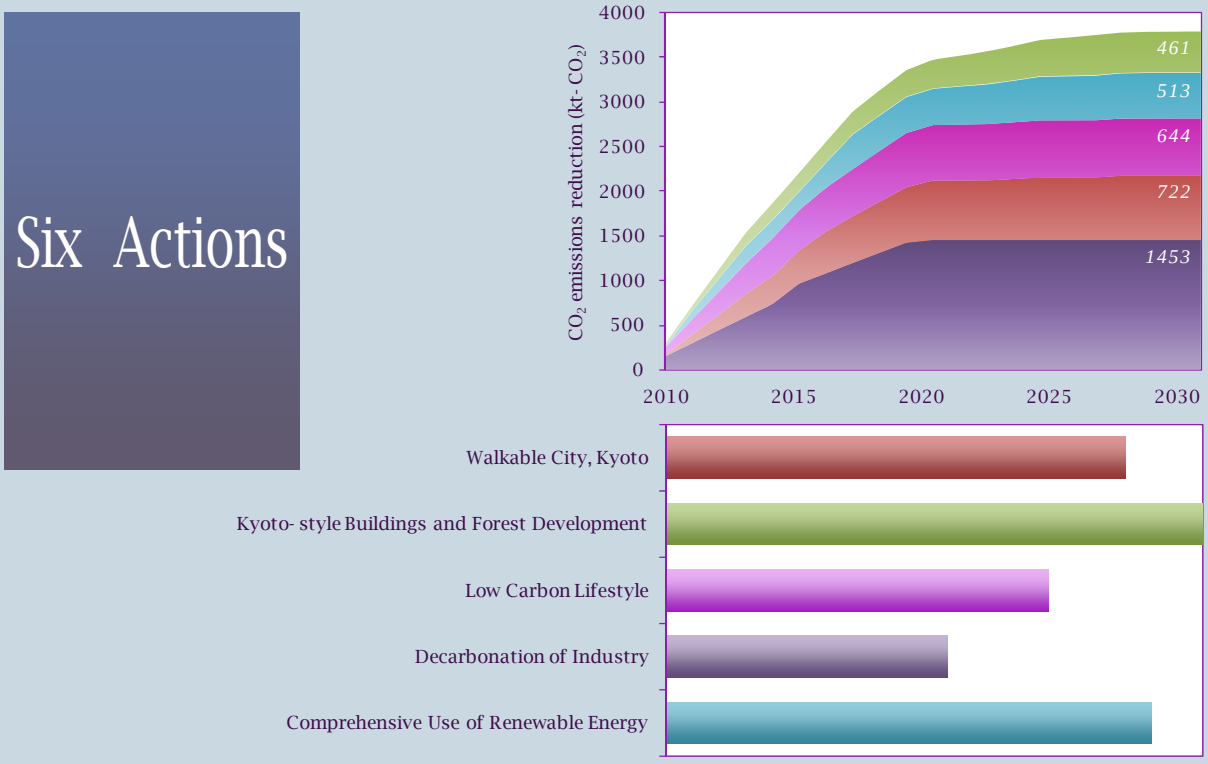

Figure S-2 CO_2 emissions reduction*1 (above) and the period of time needed for implementation (below) of each action*2

*1 Of the reductions in CO_2 emissions, those resulting from measures in the electric power generation sector are not included here.

*2 Of the six actions, Action 6 "Establishment of a funding mechanism" is not shown in the diagram, as there are no emissions reductions associated with the measure itself.

Kyoto in 2030: A Low Carbon City

Designing a roadmap towards the achievement of a low carbon city begins by drawing a picture of Kyoto in the year 2030. Based on past and continuation trends of the current state of affairs, the major target of reducing greenhouse gas emissions by nearly half would appear to be unachievable. For this reason, we must begin by stepping back from the current situation and envisioning the future scenario in which the objective has been already achieved in Kyoto.

Envisioning the Society in Qualitative Terms

In order to study greenhouse gas emissions and low carbon measures, we envisioned the social and economic situation in Kyoto that constitutes a precondition for the achievement of these goals. There are a variety of possibilities for the direction of development in the Kyoto of the future, but for this study we envisioned a society with moderate growth in which the distinctive features of Kyoto are highlighted to an even greater extent. We noted in qualitative terms the values, lifestyle, society & industry, tourism and city structure of the Kyoto of the future.

Values

"Spiritual richness" is more highly valued, and people aspire less to "efficiency, competition and vitality" than "therapeutic healing, measures and peace of mind." As a result, Kyoto's stature as "the home of Japan's spiritual culture" has been enhanced. People believe in maintaining a balance between work and personal life and living fulfilling lives overall while also working to contribute to society and the community. However, the innovative spirit of Kyoto has not changed, although the efforts sometimes do not work out, the city makes it a point to incorporate new technologies, products, and services.

Lifestyle

The population continues to age and decrease. The number of people living alone has increased, and the size of households has decreased slightly. People value not only their jobs but also the time with their family and participation in a variety of communal volunteer activities. All Household members take part in doing housework. People use their free time in various ways; however, many people spend it in the city. People also continue educational courses that are in line with their hobbies .

Economy and industry

Many industries, both traditional and venture industries have developed with high added value as a result of the distinctive "Kyoto Brand." The city's economy is supported by state-of-the-art technology and tourism-related industries. Demand for these industries has risen due to the desire of people to spend their free time, and there has been growth in service industries related to hobbies, cultural pursuits and entertainment. Kyoto vegetables are popular nationwide, however due to the limited land area, production is main-

Table 1 Quantitative assumption in 2030

Indicator	Set Value	Part of Background Scenario Used as Basis
Population makeup	2030 estimates in "Future Estimated Population of Japan by Municipality and Ward " (published in 2003 by the National Institute of Population and Social Security Research) used	Progressive aging
Population distribution	2 point reduction (20.2% -> 18.2%) in constituent ratio of inner city area (Kamigyo-ku, Nakagyo-ku, Shimogyo-ku, Higashiyama-ku) and 2 point increase (24.3% -> 26.3%) in constituent ratio of western area (Nishikyo-ku, Ukyo-ku) as compared to reference year	High-level use of city centers restricted to preserve scenic beauty
Average number of persons per household	2.15 (2.36 in 2000)	Slight decrease in average size of household
Time usage	Employed males: housework time 0.5 hour increase; work time 1 hour decrease; study, research, hobby, entertainment and volunteer activities 0.5 hour increase Females: housework time 1 hour decrease; study, research, hobby, entertainment and volunteer activities 1 hour increase	Work time is comparatively short; housework is shared among family members; continuing education is popular; volunteer activities are considered important
Employment rate	Males in their 60s: 70% (57% in 2000) 70s or older: 40% (18% in 2000) Females in their 30s - 50s: 70% (52 - 58% in 2000) 60s: 50% (31% in 2000) 70s ore older: 15% (7% in 2000)	Balance between work and private life
Breakdown of consumption	4.5 point increase (86.4% - 90.9%) in percentage of expenditures on tertiary industries	Increase in hobby, cultural pursuits and entertainment related services
Exports	Growth at 1.43%/year: textiles, dyeing & finishing, commerce, entertainment services, restaurant, inns and other accommodations, research Growth at 1.17%/year: other industries	Industries mentioned in the scenario were predicted to have a high growth rate while other industries were predicted to have a low growth rate; overall growth rate was
Other	Import ratio: same as reference year Government consumption expenditures : 1.3%/year growth Public-sector fixed capital formation: same as reference year Labor productivity: growth at 2.7%/year for primary and secondary industries, 1.8%/year for tertiary industries Commuting destination ratio: same as reference year Driver's license acquisition rate : 2005 acquisition rate for people in their 20s is continued	

tained at the current scale and is focused as a side business. Progressively more food is produced and consumed locally, and also produced and consumed when they are in season and have the best flavor. There has been enormous growth in renewable energy use, energy-saving technologies, emissions trading and other environmental businesses. The average annual economic growth rate for the economy as a whole is approximately 1.3%.

Tourism

Due to the effect of various incentive policies such as preservation of scenic beauty, the number of tourists to Kyoto has been maintained at the current level of approximately 50 million, even as Japan's population decreases. There has been a shift from "quantity" to "quality" that includes, among other things, a desire for authenticity in terms of traditional industries, and cultural arts, as a result, this has increased the average amount of money spent by each tourist.

City structure

The intensive use of the city center has been restricted in order to preserve scenic beauty, therefore the city structure has not changed very much and has not become more compact. The area of forests, farms and greenery has been maintained at approximately the present level. Effective use of existing buildings is being pursued, and the total floor area of buildings has remained roughly constant due to the population decrease and height restrictions. The percentage of permanent residential population (nighttime population) living in suburban areas has increased slightly.

Quantifying the Envisioned Society

Based on this scenario, a quantity estimation model (ExSS; for details, see page 21) was used to estimate integrated socioeconomic activities. The sections in the scenario that deal with the increase and decrease of quantitative indicators were extracted and the extent of past changes and the values for other regions in Japan were taken into account to establish quantitative conditions for estimation. Table 1 shows the conditions that were established and the corresponding parts of the scenario. This model estimated that the population would decrease 5%, from 1.47 million in 2005 to 1.4 million in 2030. Due to progressive aging, the percentage of population aged 65 and older will increase to 28% (Fig. 1). As the number of persons per household will decrease, however the number of households will remain generally the same as the 2005 level (850,000) despite the decrease in population. As it is envisioned; with the steady decline in population, the number of senior citizens and women in the workforce would increase, therefore the demand for labor in the industrial sector in the city will be met. In terms of industry, based on an annual economic growth rate of 1.3%, the growth rate in the demand for personal services is particularly high. This is due to the envisioning of high demand for tourism-related restaurants and accommodation businesses and so on. With the decline in the population, the volume of passenger transport is predicted to decrease 11% from the 2005 level. The increase in the production of manufacturing industries, the volume of freight transport is expected to increase by 31%.

Greenhouse Gas Emissions

Future greenhouse gas emissions were calculated based on two cases. The first case is the "business as usual" scenario.. Here, the configuration of energy demand and other greenhouse gas emissions are maintained at the present levels.. As a result, changes in greenhouse gas emissions will happen only when there are changes in the socioeconomic conditions. The second case is the scenario with “counter measures”. . This case envisions the socioeconomic conditions to be as of the business as usual (BaU) case. However, it is assumed in this case, the emission reduction measures will be implemented until the low carbon targets are achieved. At the business as usual (BaU) case in 2030, emissions increased 11% from the 2005 levels to 8,897 kt-CO_2 (a 15% increase from 1990 levels). This increase is mostly due to the increase in energy demand in the industrial and com-

Table 2 Estimation result of scenario quantification in 2030

	2005	2030	2030/ 2005
Population (10^4)	147	140	0.95
No. of households (10^4)	65	65	0.99
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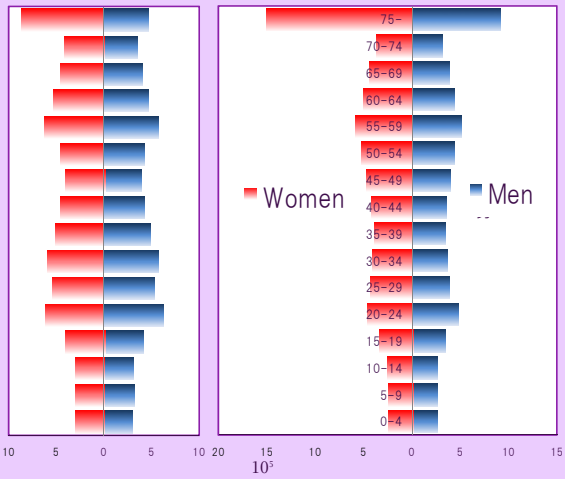


Figure 1 Age pyramid in 2005 (left) and 2030(right)

Based on the settings shown in Table 1, the gross output figures for each industry is determined through interindustry analysis. The interindustry tables for 2005 and 2030 are shown on Page 23. It is envisioned that the industrial situation of Kyoto in 2030 will be one in which will experience high growth in the textile products and tourist related industries (commerce and industries that are included in personal services),. Meanwhile, finance, insurance, real estate, public services and other industries with a high volume of production in the base year (2005) will also be significant in 2030. The result is that there will be no major changes in the overall configuration of industry in Kyoto from the base year.

mercial sectors due to the economic growth. Emissions from these sectors are expected to increase 33% and 10%, respectively, from the 2005 levels. In terms of household emissions, the population is expected to decrease, therefore the average number of persons per household will also decrease, and this will result in the same number of households. Therefore the household emission will be similar to that of the base year. In contrast, in the counter measure case, many direct measures are introduced and it is estimated that a 40% decrease from 1990 levels is achievable. The decrease is particularly high in the commercial and passenger transport sectors, with emissions decreasing to half or less as compared to the business as usual case. Here it is identified that all sector in Kyoto emits about the same volume of greenhouse gases, therefore in order to see a major decrease in overall emissions, all sectors will have to play a role in reducing emissions.

Low Carbon Measures

Emission reductions by sector and type of direct measure are as seen in Fig. 4. The largest reduction in this category is provided by improving energy efficiency in the commercial sector: 974 kt-CO_2 amounting to approximately 20% of total emissions reductions. This includes the popularization of highly energy-efficient equipment as well as the improvement in building insulation which results from the efficiency in the heating and cooling system. It can be seen that Kyoto's industrial structure is centered on tertiary industries, and that there is potential for major improvement in energy efficiency at offices, commercial establishments and so on. The next highest reduction comes from the improvement in the energy efficiency in homes. In the passenger transportation sector, the highest amount of reduction comes from improving energy efficiency. Approximately the same degree of emissions reductions are produced by modal shifts, the use of different fuels, and the shift to natural energy. However, in order to achieve this level of reductions from the modal shift, the measures envisioned here for increase the percentage of people utilizing public transport must be successful.

The detailed list of direct measures that have been envisioned for 2030 and their levels of effectiveness is as seen in Table 7 on page 10. All of these measures must be implemented by 2030 in order to achieve the low carbon objectives.

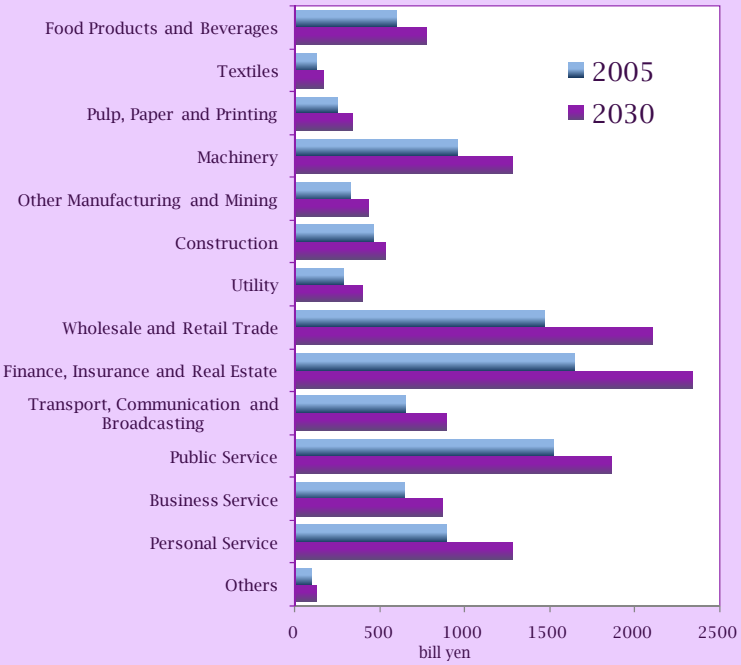


Figure 2 Output by industry

The industries consolidated in the figures are as follows.

Other manufacturing and mining (mining, lumber · wood products, furniture · fittings, chemical products, oil · coal products, plastic products, cement · cement products, other ceramic · earthenware products, steel, nonferrous metals, metal products, other manufacturing industry products)

Utilities (power, gas · heat supply, water supply, waste treatment)

Public services (civil service, university, other education, research, medical treatment · health care · social security, other public services)

Other (agriculture, forestry, fisheries, collection, processing and treatment of renewable resources, office supplies, category unknown)

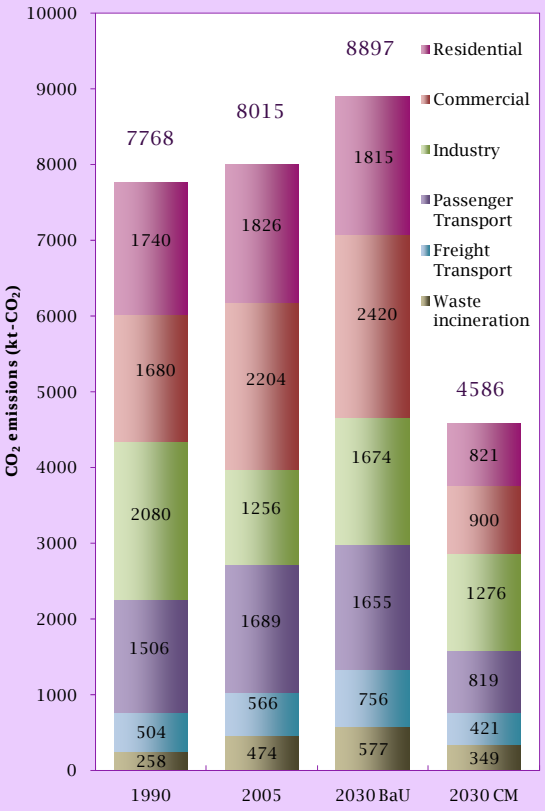


Figure 3 CO_2 emissions

The ExSS model was used to estimate energy demand and greenhouse gas emissions. This is the same model that is used to estimate socio-economic indicators. From the socioeconomic indicators estimated on the previous page, the demand for energy services and energy use technologies; the energy demand and the volume of greenhouse gas emissions resulting from energy demand are calculated. (Energy services are those that provide utility through the use of energy, such as air conditioning, heating, lighting, automobiles, and trains.. Energy demand is calculated by dividing the demand for energy services with energy efficiency.)

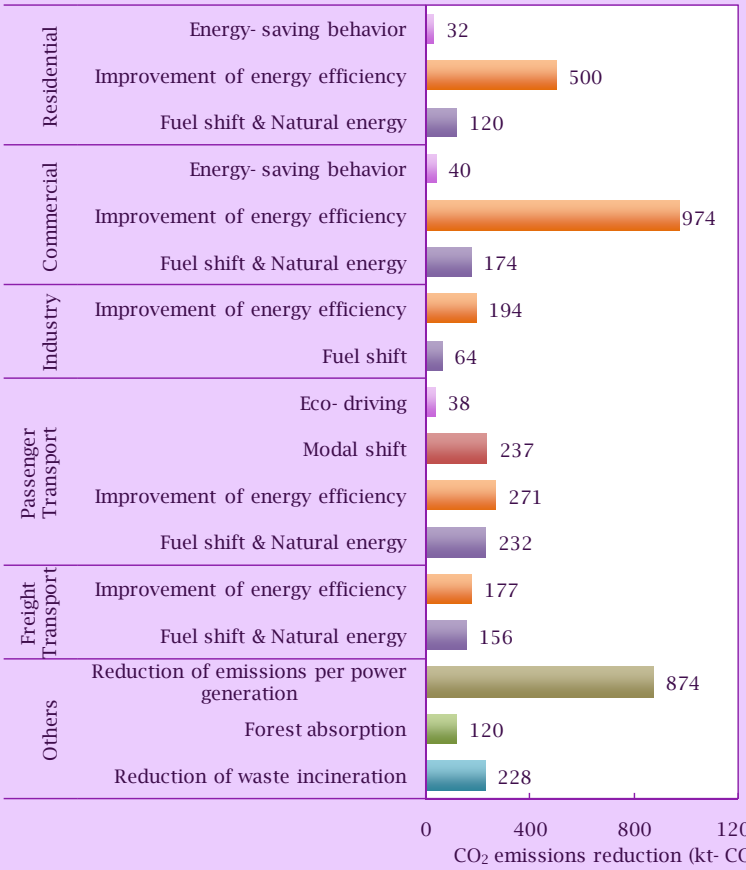


Figure 4 CO_2 emissions reduction

The difference between the Business as Usual (BaU) case and the counter measure case is identified as the volume of emission reduction. The detailed emission reductions by sector for direct measures are as seen on page 10.

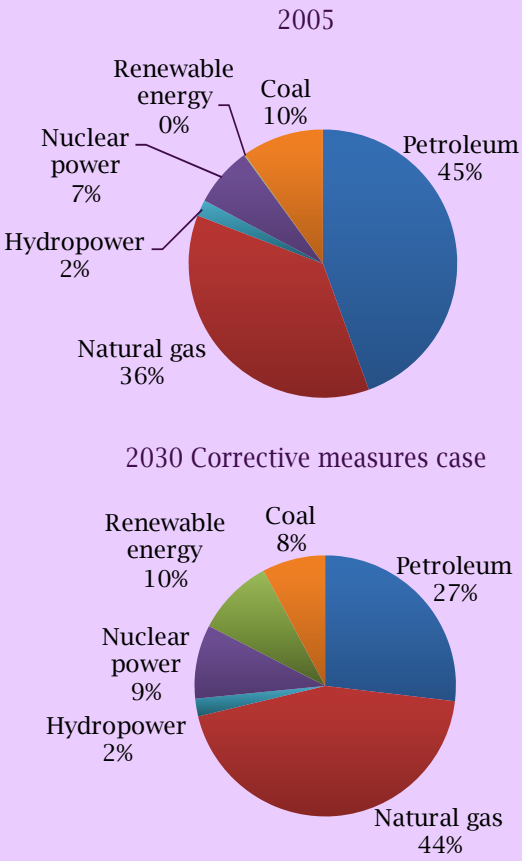


Figure 5 Distribution of primary energy supply

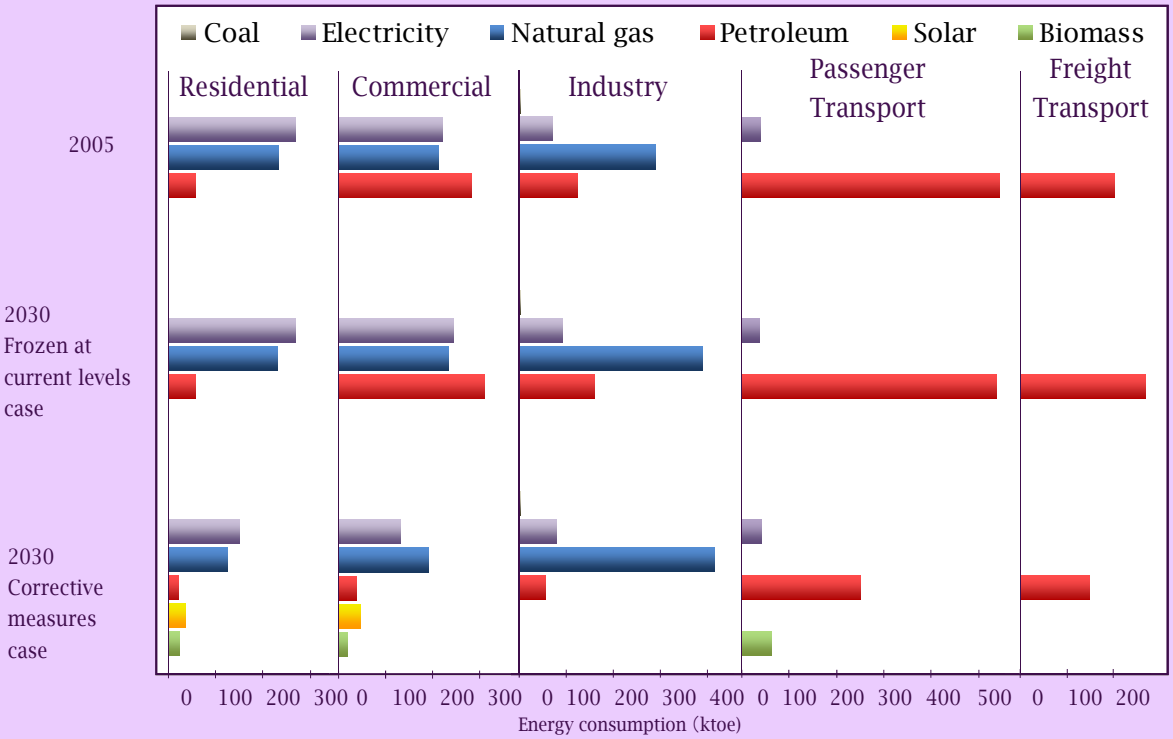


Figure 6 Final energy demand by sector

Power consumption that is supplied by photovoltaic power generation is subtracted from "Electric power" and included in "PV/SWH." In 2005, electric power, oil and natural gas made up almost the total amount in each sector. In the counter measures case, improved energy efficiency will reduce overall energy consumption, and there will be a shift to PV/SWH and biomass that will produce lower CO_2 emissions. However, industrial sectors in which technologies for the use of renewable energy have not yet been developed, there will be a shift from oil to natural gas.

Table 3 Direct measures in 2030

Sector	Low- carbon countermeasure	Data		Source	Category (*)	Identified implementation intencity		Emissions reduction (kt- CO_2)	Action (**)
Household sector	Air conditioner							50.1	3(***)
	Highest energy efficiency air conditioner	COP	6.60	2	E	Diffusion ratio (cooling and heating)	50%		
	High energy efficiency air conditioner	COP	2.54	1	E	Diffusion ratio (cooling and heating)	50%		
	High energy efficiency kerosene heating	COP	0.88	1	E	Diffusion ratio (heating: kerosene)	80%	12.9	3
	High energy efficiency gas heating	COP	0.88	1	E	Diffusion ratio (heating: gas)	80%	25.8	3
	High energy efficiency oil water heater	COP	0.83	1	E	Diffusion ratio (hot water: oil)	70%	6.1	3
	Gas water heater							55.0	3
	Latent heat recovery- type water heater	COP	0.83	1	E	Diffusion ratio (hot water: gas)	50%		
	High energy efficiency gas water heater	COP	0.83	1	E	Diffusion ratio (hot water: gas)	50%		
	Heat pump water heater	COP	4.50	3	E	Diffusion ratio (hot water: electricity)	70%	48.9	3
	High energy efficiency gas cooker	Thermal efficiency (base year= 1)	0.55	1	E	Diffusion ratio (cooking: gas)	70%	12.3	3
	High energy efficiency IH cooker	Thermal efficiency (base year= 1)	0.86	1	E	Diffusion ratio (cooking: electricity)	70%	8.0	3
	Fluorescent light								
	LED (substitute fluorescent light)	Electricity consumption (conventional type= 1)	2.67	1	E	Diffusion ratio	50%	24.1	3
	Hf inverter fluorescent light	Electricity consumption (conventional type= 1)	1.33	1	E	Diffusion ratio	50%		
	Incandescent light							51.5	3
	LED (substitute incandescent light)	Electricity consumption (conventional type= 1)	8.70	1	E	Diffusion ratio	50%		
	Bulb- type fluorescent light	Electricity consumption (conventional type= 1)	4.35	1	E	Diffusion ratio	50%		
	Refrigerator							72.1	3
	Super high energy efficiency refrigerator	Electricity consumption (conventional type= 1)	2.92	1	E	Diffusion ratio	50%		
	Highest energy efficiency refrigerator	Electricity consumption (conventional type= 1)	2.33	1	E	Diffusion ratio	50%		
	TV							31.9	3
	LCD TV	Electricity consumption (conventional type= 1)	2.27	1	E	Diffusion ratio	50%		
	Highest energy efficiency TV	Electricity consumption (conventional type= 1)	1.54	1	E	Diffusion ratio	50%		
	House insulation							100.7	2
	Next generation level	Thermal loss (base year= 1)	0.36	4	E	Diffusion ratio	40%		
	New standard	Thermal loss (base year= 1)	0.43	4	E	Diffusion ratio	40%		
	Energy- saving behavior	Energy service demand reduction ratio	10%	5	B	Diffusion ratio	25%	32.4	3
	Photovoltaic generation	Potential(ktoe)	295	6	S	Diffusion ratio	10%	26.9	5
	Solar water heating	Potential(ktoe)	1037	6	S	Diffusion ratio (hot water: all)	10%	38.8	5
	Other energy efficiency improvement				E			0.2	3
	Other fuel shifting				S			27.3	3
	Total							**625.1**	
Commercial sevtor	Air conditioner (cooling only)							41.3	4
	Super high energy efficiency air conditioner (cooling only)	COP	5.00	2	E	Diffusion ratio (cooling: electricity)	50%		
	Highest energy efficiency air conditioner (cooling only)	COP	4.07	1	E	Diffusion ratio (cooling: electricity)	50%		
	Cooling (gas)							19.1	4
	High energy efficiency gas heat pump	COP	1.60	8	E	Diffusion ratio (cooling: gas)	40%		
	High energy efficiency absorption tiller (gas)	COP	1.35	7	E	Diffusion ratio (cooling: gas)	40%		
	High energy efficiency absorption tiller(oil)	COP	1.35	9	E	Diffusion ratio (cooling: oil)	70%	3.2	4
	High energy efficiency boiler (oil)	COP	0.88	1	E	Diffusion ratio (heating: oil)	70%	25.1	4
	High energy efficiency boiler (gas)	COP	0.88	1	E	Diffusion ratio (heating: gas)	70%	75.4	4
	Air conditioner (heating only)							67.0	4
	Super high energy efficiency air conditioner (heating only)	COP	7.40	2	E	Diffusion ratio (heating: electricity)	90%		
	Highest energy efficiency air conditioner (heating only)	COP	4.44	1	E	Diffusion ratio (heating: electricity)	10%		
	High energy efficiency oil water heater	COP	0.87	1	E	Diffusion ratio (hot water: oil)	70%	16.0	4
	Gas water heater							64.2	4
	High energy efficiency gas waterheater	COP	0.87	1	E	Diffusion ratio (hot water: gas)	50%		
	Latent heat recovery- type water heater	COP	0.85	1	E	Diffusion ratio (hot water: gas)	50%		
	CO_2 cooling medium water heater	COP	3.00	1	E	Diffusion ratio (hot water: electricity)	100%	64.2	4
	High energy efficiency gas cooker	Thermal efficiency (base year= 1)	0.55	1	E	Diffusion ratio (cooking: gas)	70%	27.0	4
	IH cooking heater	Thermal efficiency (base year= 1)	0.86	1	E	Diffusion ratio (cooking: electricity)	70%	11.6	4
	Incandescent light							131.6	4
	Timer controlled LED (substitute fluorescent light)	Electricity consumption (conventional type= 1)	3.95	1	E	Diffusion ratio	50%		
	Illumination controlled LED (substitute fluorescent light)	Electricity consumption (conventional type= 1)	3.36	1	E	Diffusion ratio	50%		
	Incandescent light							20.6	4
	LED (substitute incandescent light)	Electricity consumption (conventional type= 1)	4.55	1	E	Diffusion ratio	50%		
	Bulb- type fluorescent light	Electricity consumption (conventional type= 1)	4.55	1	E	Diffusion ratio	50%		
	High- intensity evacuation light	Electricity consumption (conventional type= 1)	4.18	1	E	Diffusion ratio	70%	0.5	4
	Large scale computer (energy- saving type)	Electricity consumption (conventional type= 1)	1.18	1	E	Diffusion ratio	70%	3.1	4
	Personal computer (energy- saving type)	Electricity consumption (conventional type= 1)	2.47	1	E	Diffusion ratio	70%	3.3	4
	Copier (energy- saving type)	Electricity consumption (conventional type= 1)	1.45	1	E	Diffusion ratio	70%	0.9	4
	Fax machine (energy- saving type)	Electricity consumption (conventional type= 1)	1.45	1	E	Diffusion ratio	70%	0.6	4
	Printer (energy- saving type)	Electricity consumption (conventional type= 1)	1.45	1	E	Diffusion ratio	70%	1.2	4
	Elevator (energy- saving type)	Electricity consumption (conventional type= 1)	4.01	1	E	Diffusion ratio	70%	5.4	4
	Ventilation							50.1	4
	with energy- saving fan	Electricity consumption (conventional type= 1)	2.00	1	E	Diffusion ratio	50%		
	with low- pressure duct	Electricity consumption (conventional type= 1)	1.82	1	E	Diffusion ratio	50%		
	Vending machine (energy- saving type)	Electricity consumption (conventional type= 1)	2.17	1	E	Diffusion ratio	70%	11.5	4
	Traffic light (LED type)	Electricity consumption (conventional type= 1)	3.75	1	E	Diffusion ratio	70%	1.4	4
	High energy efficiency transformer	Electricity consumption (conventional type= 1)	2.53	1	E	Diffusion ratio	70%	13.3	4
	Other electric appliances							61.2	4
	30% energy- saving type	Electricity consumption (conventional type= 1)	1.43	1	E	Diffusion ratio	50%		
	10% energy- saving type	Electricity consumption (conventional type= 1)	1.11	1	E	Diffusion ratio	50%		
	Building insulation	Thermal loss (base year= 1)	0.50	1	E	Diffusion ratio	100%	231.1	2
	BEMS	Energy demand reduction ratio	10%	10	E	Diffusion ratio	25%	24.4	4
	Energy- saving behavior	Energy service demand reduction ratio	10%	5	B	Diffusion ratio	25%	40.3	4
	Photovoltaic generation	Potential(ktoe)	295	6	S	Diffusion ratio	10%	26.9	5
	Solar water heating	Potential(ktoe)	1037	6	S	Diffusion ratio (hot water: all)	5%	49.6	5
	Other fuel shifting				S			70.8	4
	Total							**1161.8**	
Industrial sector	Energy efficient equipments				E			184.7	4
	High energy efficiency boiler	Thermal efficiency(base year= 1)	1.09	11		Diffusion ratio	80%		
	High energy efficiency furnace	Thermal efficiency(base year= 1)	1.67	12		Diffusion ratio	80%		
	High energy efficiency morter	Electricity consumption(base year= 1)	1.25	11		Diffusion ratio	80%		
	Inverter control	Electricity consumption(base year= 1)	1.05	11		Diffusion ratio	80%		
	Fuel shifting	From oil to gas			S	Shifting ratio	60%	63.9	4
	Increase in the ratio of seasonal vegetable production	Ratio of CO2 emissions against non- seasonal vegitable produc	0.7	17	E	Ratio of selling seasonal vegitables	36.2%	0.3	4
	Increase in the ratio of wooden buildings	Ratio of CO2 emissions against non- wooden buildings	0.6	17	E	Diffusion ratio	30%	9.0	4
	Total							**257.9**	
Passenger transport sector	Vehicle							270.7	1
	Hybrid vehicle	Fuel cost (conventional type= 1)	0.6	1	E	Diffusion ratio	50%		
	High energy efficiency vehicle	Fuel cost (conventional type= 1)	0.8	1	E	Diffusion ratio	50%		
	Modal shift	From vehicle to;			B			236.7	1
	Intra area trip	walking and bicycle				Shifting ratio	15%		
		train and bas				Shifting ratio	30%		
	Inter area trip	bicycle				Shifting ratio	10%		
		train and bas				Shifting ratio	30%		
	Trip to outside of the city	train				Shifting ratio	30%		
	Bio fuel	From oil to bio fuel			S	Diffusion ratio	20%	231.7	5
	Eco- driving	Fuel efficiency improvement ratio	24%	13	B	Diffusion ratio	20%	37.8	1
	Total							**776.9**	
Freight transport sector	Vehicle							176.9	1
	Hybrid vehicle	Fuel cost (conventional type= 1)	0.6	1	E	Diffusion ratio	50%		
	High energy efficiency vehicle	Fuel cost (conventional type= 1)	0.8	1	E	Diffusion ratio	50%		
	Bio fuel	From oil to bio fuel			S	Diffusion ratio	20%	156.2	5
	Total							**333.1**	
waste incineration & power supply	Bio- methanol power generation			17		production of electricity (ktoe)	18.8	53.8	5
	Reducing the amount of waste incineration			17		Rate of CO_2 emissions reduction	40%	228.1	3, 4
	Improvement of CO2 intensity of power generation					CO_2 emission per generation (tC/toe)	0.78	873.9	(****)
	Fuel shifting			14					
	Generation efficiency improvement								
	Coal	Generation efficiency	48%	15					
	Gas	Generation efficiency	55%	16					
Total								**4310.7**	

* B: Energy-saving behavior E: Improved energy efficiency S: Shift to different fuels ** Numbers indicate the number of the Action that includes that measure . Note that the name of the measure may not be the same as the name of the measure included in the Action. *** Some are included in Action 4. **** Reduction of CO_2 emissions from power generation is not included in Actions.

Sources for data on direct measures

1. "Report of a Study on Scenario Creation and Simulation Projects," Chapter 4, "Corrective Measure Scenarios" Mizuho Information & Research Institute, Inc. (2005). 2. "Energy-saving Performance Catalog, Winter 2007" Energy Conservation Center, Japan (2007). 3. "Handbook of Environmentally Friendly Technologies for Buildings," Osaka Prefecture website. 4. " Report of a Study Team on the Formulation of Technologies to Reduce Greenhouse Gas Emissions in FY 2000" Ministry of the Environment (2001). 5. "Report of the Shiga Prefecture Research Project on Creation of a Sustainable Society" Shiga SD2030 Research Team (2005). 6. "Report of a Study on the Formulation of a New Energy Vision for the Kyoto City Region" Environmental Bureau, Kyoto Municipal Government (2000). 7. Announced February 2003 on the Osaka Gas website. 8. Announced January 2005 on the Yanmar Co., Ltd. Website 9. Hitachi Appliances, Inc. website 10. "Technology Strategy Map (energy field): Ultra-long Term Energy Technology Vision" Ministry of Economy, Trade and Industry (2005). 11. Shimada, K., Tanaka, Y., Gomi, H., Masuoka, Y: "Development of techniques for formulating long-term regional scenarios for the achievement of a low carbon society and pioneering application of these techniques in Shiga Prefecture" Environmental Systems Research, Vol. 34, pp. 143 - 154 (2006). 12. "Report of the Achievements of a Project to Introduce and Field-test a High-performance Industrial Furnace" New Energy and Industrial Technology Development Organization. (NEDO) (2005). 13. Announced September 2007 on the Recoo website. 14. "Prospects for Energy Supply and Demand in 2030" Supply and Demand Subcommittee, Advisory Committee on Natural Resources and Energy (2005). 15. Clean Coal Power R & D Co., Ltd. website. 16. Nihon Keizai Shimbun, morning edition, March 14, 2008. 17. Kyoto City Environmental Model City Plan of Action (draft). 18. Some of the improvements in home energy efficiency are included in Action 4. 19. Improvements in the emissions factor for electric power are not included in Actions.

Roadmap to a Low Carbon City

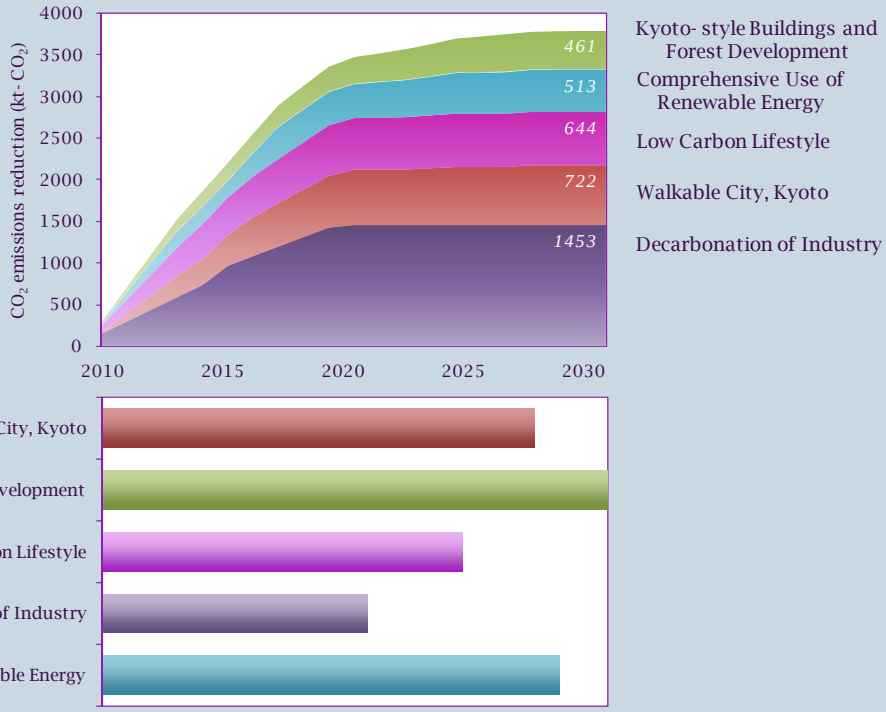
Up to this point, we have envisioned Kyoto in year 2030 to be a city in which a 50% reduction in CO_2 emissions has been achieved. This is the first step in backcasting: envisioning the goal of being low carbon society. From this point on, we will focus on the second step: the construction of a roadmap to take us from the present situation towards the goal. What path should we take in order to reach our target of the envisioned Kyoto in 2030?

For the image of Kyoto in 2030, only the elements that directly reduce emissions have been incorporated, and the necessary quantities for these elements have been calculated. The direct measures that are needed to achieve a 40% reduction of carbon dioxide emissions in 2030 involve significant quantities. For example, bolder policy intervention such as, an 80% adoption rate for better-insulated homes is required; if not, there is no way this image will be achieved in the next 20 years. For this reason, the government must implement numerous measures and encourage a broad adoption of direct measures. This will require a great deal of time; however, the resources and funds that can be expended on this effort are limited. Accordingly, a certain amount of time will be needed for the execution of each of these measures.

The general public and companies in the private sector will be the entities who will actually implement most of the direct measures. Therefore their acceptance will be needed by the government (mainly the Kyoto municipal government) to implement measures to achieve a low carbon society. Therefore, the general public and companies in the private sector must be included among the entities implementing the roadmap. For this reason, the roadmap must specify both the direct and indirect measures that are needed, as well as the entities implementing these measures. Moreover, based on the restrictions on the resources and funds that can be allocated, dynamic optimization techniques should be used to enable this roadmap determine when these measures should be initiated and when they should be completed in order to arrive at the envisioned Kyoto in the year 2030 . In this study, we have cited the "Kyoto City Environmental Model City Plan of Action" to be introduced as one of the possible measures. In January 2009, Kyoto was selected as an environmental model city. Environmental model cities are cities which are selected by the Prime Minister's office as cities that have established high targets for major greenhouse gas reductions and are making pioneering efforts in this area, these cities are eligible to receive assistance for these endeavors. Each of the selected cities have formulated an action plan for achieving the reduction targets. Kyoto's action plan covers a wide-ranging and includes more than 100 measures. However, the specific programs in this action plan covers a period of only five years:, up to 2014. In this study, we used this action plan as a starting point and, prepared a schedule of all the measures that must be introduced by year 2030 within the identified time period. Following this we create a roadmap showing the time line and sequence for the implementation of all the necessary measures.

Due to the large number of measures over all, these measures are divided into six main action categories in accordance with the categories in the Kyoto City Environmental Model City Plan of Action.. The reduction volumes and implementation time period for each action are as seen in the diagram below. The organizational chart in pages 12 and 13 illustrates the overall relationship between these measures. Following this, the measures that are included in each action category,, the reduction volume for each measure and the schedule for implementation is discussed.

Six Actions



The upper figure shows the increase in emissions reductions per year for each Action. The colors used to identify the Actions are the same in both upper and lower figures. As a significant proportion of the measures achieve their 2030 target reductions in the 10 years leading up to 2020, the increase in reductions after 2020 is a gentle one. Of the six Actions, Action 6 "Establishment of a Funding Mechanism" is not shown in the figures, as there are no CO_2 emissions reductions in the action itself. In addition, of the CO_2 emissions reductions, those resulting from corrective actions in the electrical power generation sector are not included.
The lower figure shows the start and end times for all of the measures included in each Action. All of the Actions begin in 2010, and in the case of the quickest one, Action 4 "Decarbonation of Industry," the final policy is completed around 2020. In contrast, as upgrading buildings will take a considerable amount of time, Action 2 "Traditional Kyoto-style Buildings and Forest Management" will require all of the time leading up to 2030.

Low Carbon Measure Diagram


*1 KICS- LLC: Kyoto Information Card System, LLC
*2 LRT: Light Rail Transit
*3 KES: KES Environmental Management System Standard
*4 KESC: KES Community
Walkable City, Kyoto
Modal shift (automobile to railway)
Modal shift (automobile to bus)
Modal shift of visitors
Diffusion of eco- vehicle
Diffusion of eco- driving
Amenity in the usage of railway
Light Rail Transit
Bus priority
Sightseeing campaign using public transport
Public transport information service
Promotion of buying eco- vehicle
Enlightenment for eco-driving
Implementation of KICS- LLC*1 model project
Increase of KISC- LLC project
Increase of railway use
Planning of LRT*2 system
Construction of LRT system
Operating LRT
Using LRT system
Board of bus using system promotion
Increase of bus lane
Promotion of bus lane system
Introducing public transport priority system
Increase of bus use
Campaign sightseeing using public transport
Planning intelligent bus transit system
Operating intelligent bus transit
Increase use of public transport by visitors outside of the city
Improvement of sightseeing information display
Public transport information service by website
Increase use of public transport by visitors outside of the city
Construction of electric vehicle recharge stations
Eco- vehicle promotion
Planning eco-vehicle subsidy
Eco- vehicle subsidy
Diffusion of eco- vehicle
Training of eco-driving
Diffusion of eco- driving
Establishment of a Funding Mechanism
Promotion of options by funds
Kyoto citizen environmental fund
Forest environment tax
Kyoto carbon offset
Operation of Kyoto citizen environmental fund
Design of forest environment tax system
Implementation of forest environment tax system
Development of Kyoto carbon offset model project
Full- scale operation of Kyoto carbon offset system
Low Carbon Lifestyle
Improvement of efficiency in residential equipments
Energy-saving behavior in houses
Reducing municipal waste incineration
Enlightenment in lifestyle
Environmental education
Eco- point
New recycling plan
Encouragement of eco-household accounting
Energy saving consulting service
Promotion of eco- community association
Diffusion of energy saving labeling
Diffusion of energy efficient home appliance
Diffusion of energy saving behavior
Training of eco-supporters at Miyako Ecology Center
Environmental education in school
Implementation of Children's Eco- life Challenge Project
Diffusion of energy efficient home appliance
Diffusion of energy saving behavior
Operating eco-point system
Diffusion of energy efficient home appliance
Implementation of new national recycling society plan
Reducing municipal waste
Comprehensive Use of Renewable Energy
PV/SWH
Fuel shift of automobile (petroleum to biomass)
Power generation by biomass
PV/SWH for public buildings
Promotion of PV/SWH for houses
Sustaining BDF production
Promotion of biofuel
Bio methanol power generation
Power generation by waste incineration
Creating a installation specification of PV/SWH for public building
Installation of PV/SWH on public building
Subsidize system of PV
Diffusion of PV devices
Collection of used cooking oil
R&D of Gasified methanol development
Setting guideline of biofuel use
Differentiate taxation of biofuel use
Diffusion of biofuel use in national scale
Fuel shift of vehicle from oil to biofuel
R&D of Gasified methanol
Construction of bio methanol plant
Operation of bio- methanol power generation
Power generation from solid waste incineration

Action 1　Walkable City, Kyoto

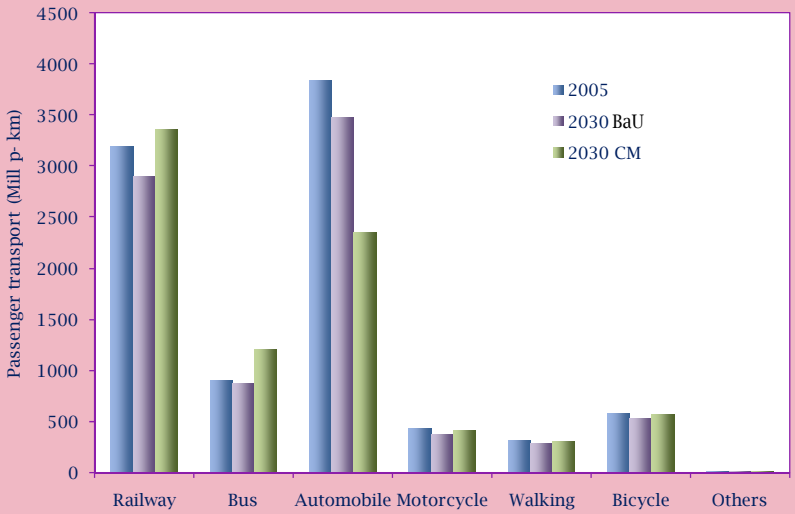
The "Walkable City, Kyoto" action is targeted to reduce CO_2 emissions in 2030 by 722 kt-CO_2. The measures that need to be implemented here promote an urban design that prioritizes pedestrians and public transport, in order to reduce CO_2 emissions in the transport sector. We estimate this measure will be completed by year 2020 because, Kyoto City has already actively been promoting this measure.

However, other measures such as road pricing and the introduction of light rail transit (LRT) involve long-term construction works or more significant changes to the transport structure and will take a longer time frame, therefore, all these measures will not be completed until 2028.

The objective of "Promotion of mobility management" is to promote the use of public transport by the general public. "Implementation of transport demand management (TDM)" is needed to bring about a voluntary change in the attitude of the general public. This measure will employ educational pamphlets and related maps to encourage the use of public transport, opinion surveys of transport behavior and so on.

"Construction of pedestrian transit malls" is a measure designed to bring about a shift from the use of privately owned automobiles to the use of public transport by the general public. The sidewalks along Shijo-dori in the city center will be widened to secure a comfortable pedestrian space and promote a modal shift on the part of the general public. The use of pedestrian transit malls by the general public will enable CO_2 emissions to be reduced by 32 kt-CO_2.

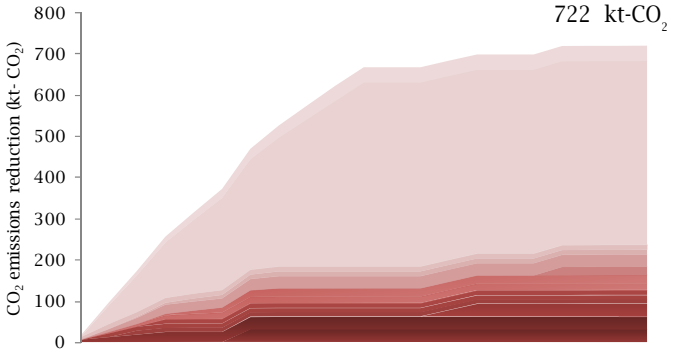
Since Kyoto city has a large numbers of tourists visiting, compared to other areas in Japan, it is important to encourage these tourists to use public transport as well. "Attraction of tourists using public transport" is the measure that will be employed to promote the use of public transport by tourists. Publicity campaigns will be held at major train stations in the Kinki and Chubu districts to invite tourists to come to Kyoto by public transportation. Moreover, the introduction of “smart” bus services that travel between tourist spots in the city will encourage tourists to use public transport to travel within the city as well. These measures will reduce CO_2 emissions by 12 kt-CO_2.



In the "business as usual" case , the modal share for means of transport is the same in 2030 as it was in 2005. In the "counter measure" case , a modal shift has occurred from privately owned automobiles to other means of transport, with the result that the automobile share has decreased and the share of public transport, bicycle and pedestrian transit has increased.
In the "counter measure" case , the modal share for means of transport within the region that was occupied by automobiles has shifted 10% to trains, 20% to buses, 8% to pedestrian transit, and 7% to bicycles. Moreover, inter-regional transport within the city by automobile has shifted 10% to trains, 20% to buses, and 5% each to pedestrian transit and bicycles. Transport to places outside the region by automobile has shifted 30% to trains.

Figure 7　Passenger transport volume

Walkable City, Kyoto



	Actor
TDM implementation	G
Designing pedestrian transit mall	G
Pavement widening	G
Use of pedestrian transit mall	C
Construction of car- park	G
Management of car- park	G
Promotion of park and ride	C, I
Study on road pricing	G
Construction of road pricing facility	G
Implementation of Road pricing	G
Reducing vehicle inflow by road pricing	C, I
Introducing IC card	I, G
Increase of public transport use (by IC card)	C, I
Improvement of public transport timetable	I, G
Increase of public transport use (by timetable improvement)	C, I
More convenient terminal	I, G
Increase of public transport use (by more convenient terminal)	C, I
Public bicycle parking area	G
Ordinance of bicycle parking area on commercial buildings	G
Planning subsidy scheme on bicycle parking area	G
Subsidize bicycle parking area	G
Increase of bicycle parking area	I
Promotion of bicycle parking area	G
Increase of bicycle parking area	C, I
Implementation of KICS- LLC model project	I, G
Increase of KISC- LLC project	I
Increase of railway use	C, I
Planning of LRT system	I, G
Construction of LRT system	I, G
Operating LRT	I, G
Using LRT system	C, I
Board of bus using system promotion	G
Increase of bus lane	G
Promotion of bus lane system	G
Introducing public transport priority system	I, G
Increase of bus use	C, I
Campaign sightseeing using public transport	I, G
Planning intelligent bus transit system	I, G
Operating intelligent bus transit	I, G
Increase use of public transport by visitors outside of the city	C, I
Improvement of sightseeing information display	I, G
Public transport information service by website	I, G
Increase use of public transport by visitors outside of the city	C, I
Construction of electric vehicle recharge stations	I, G
Eco- vehicle promotion	I, G
Planning eco- vehicle subsidy	G
Eco- vehicle subsidy	G
Diffusion of eco- vehicle	C, I
Training of eco- driving	I, G
Diffusion of eco- driving	C, I

C: Citizen I: Industry G: Government O: Outside of the city

Action 2 Kyoto-style Buildings and Forest Management

The "Traditional Kyoto-style Buildings and Forest Management" action is targeted reduce CO_2 emissions in 2030 by 461 kt-CO_2. This action comprises of two main action measures; namely, to promote the dissemination of highly energy-efficient low carbon buildings, and to promote the absorption of CO_2 through forest planting, greening and so on.

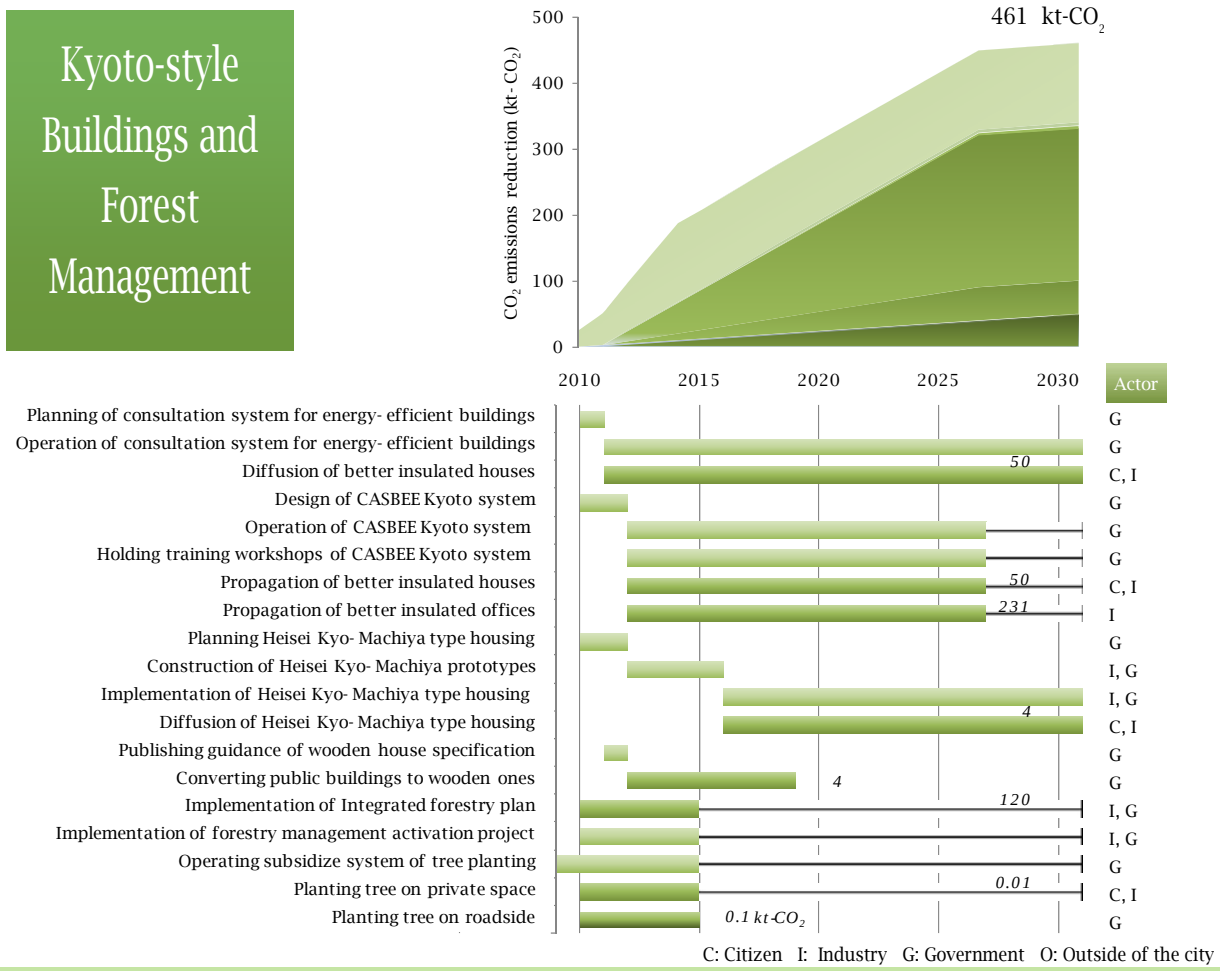
The upgrading and renovation of buildings is a time consuming measure, and it is identified,, even if efforts are made to start work immediately in 2010, a minimum time period of 20 years will be needed for completion of works. Conversely, forest management will reach the necessary level of completion in only about five years, however this effort will need to be continued and maintained from then on.

"Improvement of consultation system for energy-efficient buildings " is a measure to promote the conversion of buildings to highly insulated residences when renovating existing homes. To promote this measure, an energy-efficient building consultation system will be initiated, and an "energy-efficient residence advisor program" will be launched to train and dispatch advisors who are experts on energy-efficient buildings for homes. This measure will increase the number of city residents who improve their home insulation system, making it possible to reduce CO_2 emissions by 50 kt-CO_2.

"Implementation of CASBEE Kyoto system" is a measure targeted to encourage companies in the private sector and individuals to construct buildings with excellent insulation and shading from the sun's rays, by means of a Comprehensive Assessment System for Building Environmental Efficiency (CASBEE) system for Kyoto. This system recognizes buildings that make an outstanding effort to preserve scenic beauty and create a low carbon society. The CASBEE Kyoto program will promote the construction of residential areas and offices with improved insulation, reducing CO_2 emissions by 50 kt-CO_2 (residences) and 231 kt-CO_2 (offices).

The objective of "Converting residences to wooden buildings" and "Converting public facilities to wooden buildings" is to reduce CO_2 emissions during the constructing of new buildings. The development of forests, which is a main source of carbon sink, will be enhanced with the use of timber which is produced from within the city. This will further enhance and encourage the local timber industry.

Kyoto-style Buildings and Forest Management



Action 3　Low Carbon Lifestyle

The "Low Carbon Lifestyle" action is targeted to reduce CO_2 emissions in 2030 by 644 kt-CO_2. This action comprises of three main actions measures; namely, breaking away from the large consumption lifestyle, shifting to equipment with outstanding energy efficiency, and encouraging the general public to conserve energy.

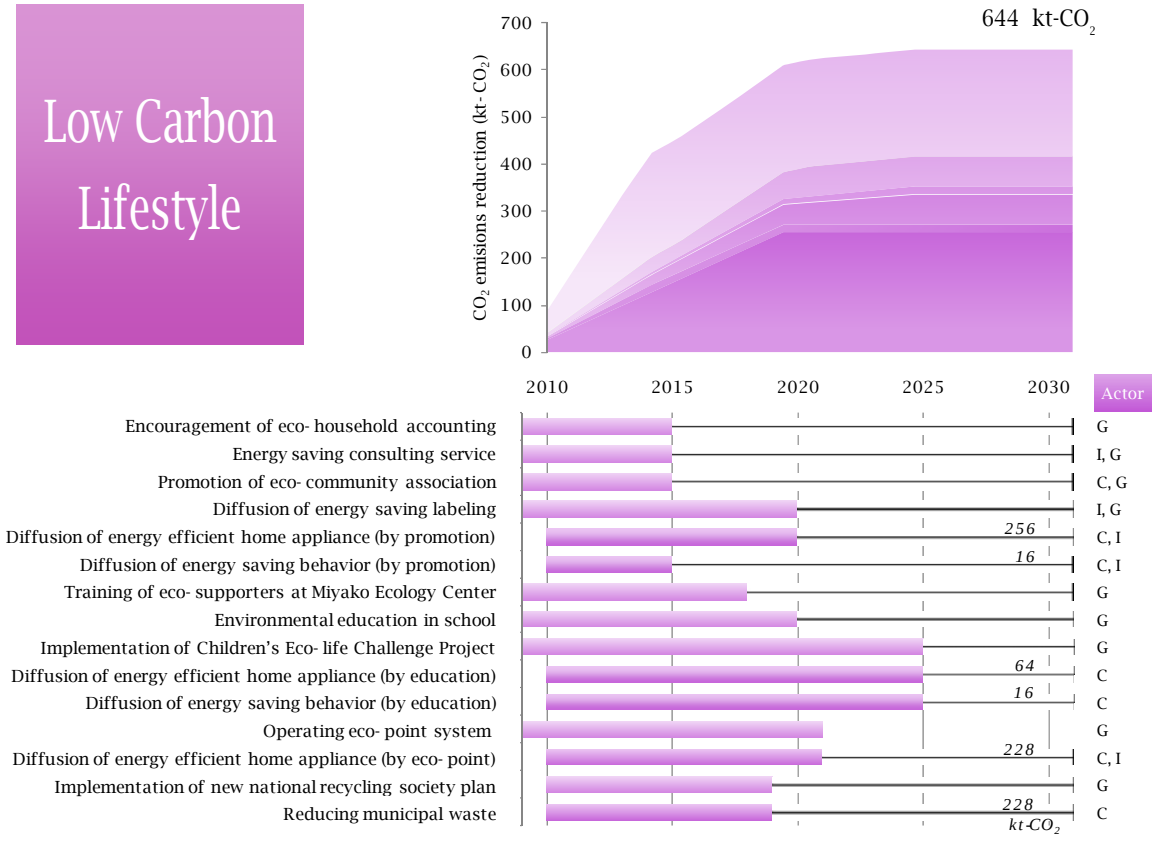
With the cooperation of the general public, these measures could be implemented immediately, but it will take time for these efforts to become widespread. Most of these measures will be widely adopted within the first 10 years, however, the effects of long-term measures such as; educating elementary and junior high school students will not be transpire until 2025 or thereafter.

"Encouragement of eco-household accounting" is a measure to encourage the general public to purchase highly energy-efficient products when they buy new household appliances. A web-based eco-household account book will be introduced to educate people about the advantages of using energy-efficient of household appliances. This will promote not only the purchase of energy-efficient household appliances but also encourage and instill an energy-saving attitude in the general public. These educational activities will result in a reduction of CO_2 emissions by 272 kt-CO_2.

"Training of eco-supporters at Miyako Ecology Center" is a measure to cultivate environmental volunteers who will be active in the community as environmental leaders. The purpose of this measure is to promote the dissemination of highly efficient equipment and energy-saving behavior through the change in public attitude brought about by the activities of the "eco-supporters" trained here.

Moreover, "Environmental education in schools" and " Children's Eco-life Challenge Project " will be conducted on an ongoing basis with the aim of producing a reduction in CO_2 emission in the medium to long term. The " Children's Eco-life Challenge Project is a children's version of the eco-household accounting, implemented by the city in cooperation with companies in the private sector and environmental NPOs. These education and training efforts will reduce CO_2 emissions by 80 kt-CO_2.

Low Carbon Lifestyle



C: Citizen　I: Industry　G: Government　O: Outside of the city

Action 4 Decarbonation of Industry

The action of "Decarbonation of Industry" is targeted to reduce CO_2 emissions in 2030 by 1,453 kt-CO_2. This action comprises of two main action measures; namely, measures to promote research and development into state-of-the-art environmental technologies through industry-academia-government cooperation, and measures to promote a shift to environmentally friendly industries and commercial enterprises in cooperation and companies in the private sector. It is estimated that target level of implementation can be achieved by 2022 through the establishment of a framework to encourage active investment.

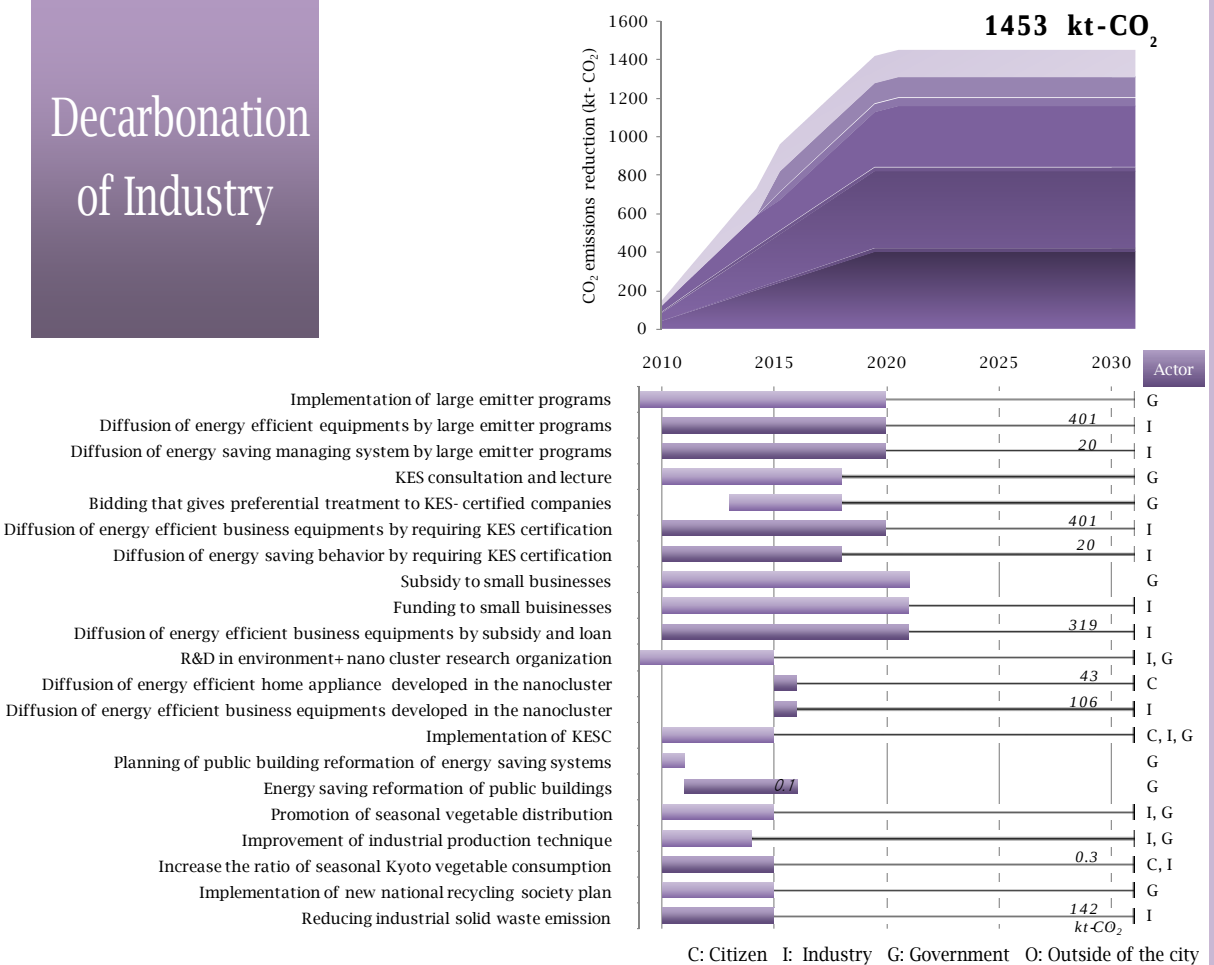
"Large emitter programs" are programs in which companies in the private sector that use large quantities of energy are defined as "large emitters" and are required to submit a 3-year greenhouse gas reduction plan and to report emissions annually. This will promote active efforts by these companies who are major CO_2 emitters, to increase the efficiency of the facilities and equipment at their workplaces and promote an energy-saving practice within the workplace. This activity will be able to reduce CO_2 emissions by 421 kt-CO_2.

"Promotion of KES certification" is a measure aimed for the small and medium-sized companies. The implementation of the KES environmental management system is to be incorporated into small and medium-sized companies. This will then promote the introduction of highly energy-efficient facilities and equipment and encourage energy-saving behavior at small and medium-sized companies.

Bidding that gives preferential treatment to KES-certified companies will help popularize KES certification. In addition, grants and financing will be provided to small and medium-sized companies to enable them to introduce highly energy-efficient facilities and equipment. Energy-saving practices and the introduction of highly energy-efficient facilities and equipment by small and medium-sized companies will be able to reduce CO_2 emissions by 740 kt-CO_2.

"Promotion of technical development and dissemination of results" is a measure that promotes the development of technologies to combat global warming through research at "environmental nanoclusters," where state-of-the-art advanced materials that will contribute to the environmental field are developed through industry, academic and government cooperation, using nanotechnology as the key technology. Research and development by environmental nanoclusters will promote the dissemination of highly efficient facilities and equipment at homes and offices, and together these efforts will be able to reduce CO_2 emissions by 149 kt-CO_2.

Decarbonation of Industry



Action 5 Comprehensive Use of Renewable Energy

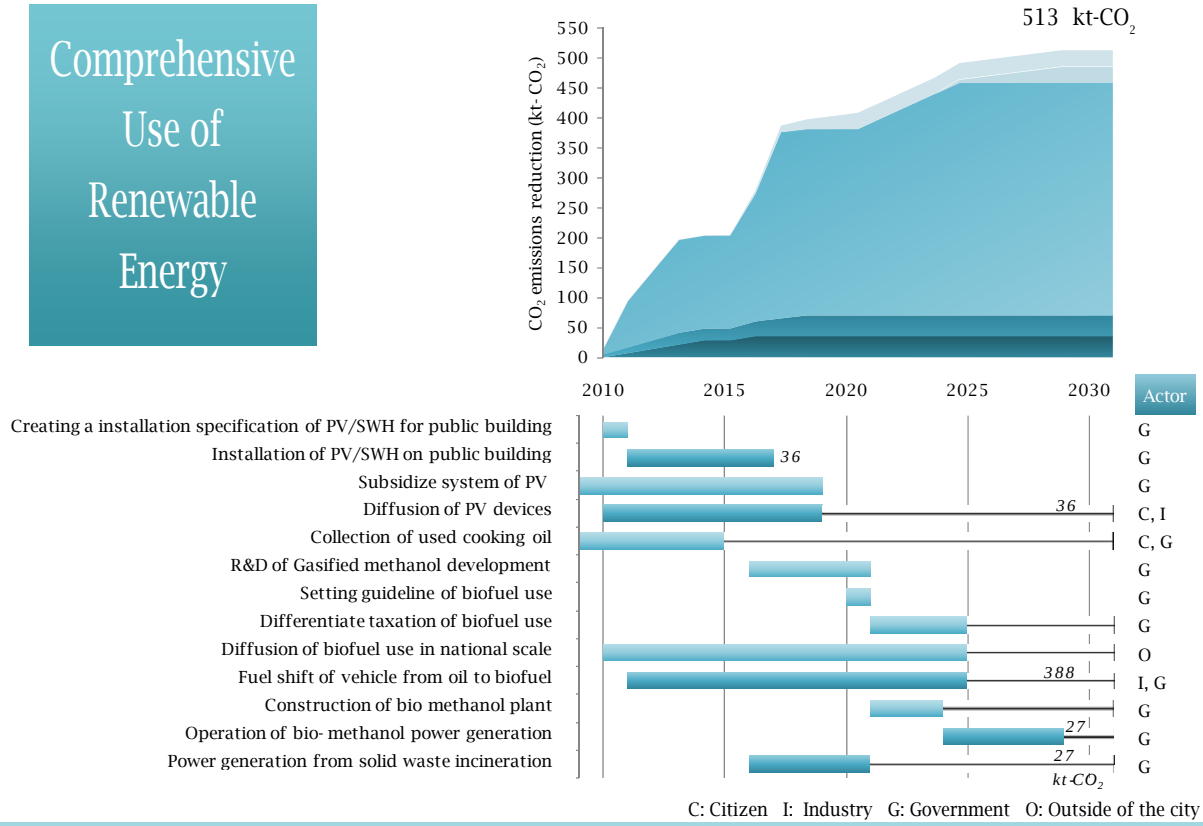
The "Comprehensive Use of Renewable Energy" action will be able to reduce CO_2 emissions in 2030 by 513 kt-CO_2. This action comprises of two main action measures; namely, to increase the use of photovoltaic power and solar water heaters (PV/SWH), and to promote the creation of energy from wastes.

An economic mechanism will enable the target level of photovoltaic power generation to be achieved by 2020, and the equipment use will be continued thereafter as well. Research and development activities will be conducted for the development of biogas from waste and, it is estimated that the need for this techonology will arise by 2027.

"Promotion of PV equipment installation in private sector facilities" and "Installation of PV/SWH in public facilities" will be implemented as measures to promote the use of photovoltaic power generation systems and solar water heaters. "Promotion of PV equipment installation in private sector facilities" will provide assistance for installing solar energy equipment in homes in order to promote dissemination in the general public. "Installation of PV/SWH in public facilities" will be promoted by the city as an initiative for new public facilities. The dissemination of PV/SWH equipment will be able to reduce CO_2 emissions by 72 kt-CO_2.

"Promotion of biomass use" is a measure introduced to promote the use of biofuel in automobiles. In order to dissemination this measure nationwide, a gasified methanol development technology will be developed in Kyoto through industry-academia-government cooperation. Tax incentives will also be provided for the use of the biodiesel fuel manufactured using this technology as an effort to encourage greater use of biofuel. Nationwide efforts to encourage biofuel use and implementation of this unique Kyoto policy will increase the dissemination of biofuel, thus making it possible to reduce CO_2 emissions by 388 kt-CO_2.

Comprehensive Use of Renewable Energy

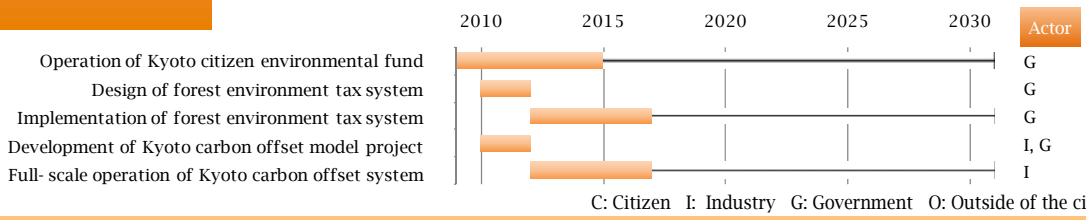


Action 6 Establishment of a Funding Mechanism

The purpose of the "Establishment of a Funding Mechanism" action is to develop a mechanism for obtaining the funds needed to implement low carbon measures. This action involves the establishment of a Kyoto Citizen's Environmental Fund in anticipation of the income from the forest environment tax and carbon offset projects. This is in line to create a mechanism to provide economic support for forest management and other efforts. It will create an economic system for promoting efforts by individual citizens and companies in the private sector to reduce greenhouse gas emissions.

"Development of Kyoto carbon offset model project" is one of the policies that will utilize the Kyoto Citizen's Environment Fund. Companies in the private sector will identify the emissions that are difficult to be reduce in their activities for the year and, they will be able to offset these by purchasing environmental credits obtained from the use of solar energy generation and the other energy efficient activities. The reductions in emissions resulting from these actions are interconnected with other actions.

Establishment of a Funding Mechanism



Many of the measures in this roadmap will be initiated in 2010, the first year of the plan. One reason for this is that implementation of these measures has already begun or has already been decided in the Kyoto City Plan of Action. However, implementation of measures from an early stage is significant in several ways.

In many cases, the low carbon measures are policies of another department. For example, introduction of a system that prioritizes public transport is not only a low carbon measure but also a transport policy. Effectiveness as a transport policy will be greater if the policy is implemented sooner rather than later. Improved energy efficiency will reduce costs and may provide an economic benefit. Measures that are effective in ways other than the reduction of greenhouse gas emissions should be achieved as soon as possible.

Quick implementation may cause the policy to become a symbol of the city. Implementing the policy before other cities will make it newsworthy and improve the stature of the city.

Medium to long term planning has many uncertainties. Implementing measures well in advance of the deadline is the foundation of project management.

If enormous funds are poured into this effort, it may be possible to achieve the reduction targets in a shorter time period in advance from the target number of years. However, as noted above, implementing measures from an early date is good for several reasons. This Roadmap illustrates that most of the policies will be completed by 2025. However, this by no means signifies that it would be all right to postpone the implementation period.

Moreover, the funds which are needed to implement policies must be provided by the government, general public and companies in the private sector. However, this study has considered only the funding burden that is most likely to be borne by the (Kyoto Municipal) government.

Research Methodology

Overview of Research Methodology

The backcasting method is defined as "calculating back to the present from a specific target point." This is done "to determine the potential for future physical implementation of that target and the type of measures that will be needed to arrive at that point." 1) This process can be divided into two stages: envisioning of the target point, and calculating backward from that point (in other words, searching for a pathway to arrive at that target point). Fig. 8 shows a conceptual diagram of the backcasting method. When attempting to achieve an objective such as a low carbon society which requires a major transformation of society, it is very likely that the objective cannot be achieved by starting from the present state and extending techniques that can be implemented. For this reason, first a normative envisioned scenario of the situation in which the target has been achieved is drawn out, without being constrained by current and past trends. This is used as the target point that must be reached, and one works back from that point to the present location to determine the path that must be taken. This method makes it possible to depict what a certain region would look like as a low carbon society, and also enables study of what must be done now in order to ultimately arrive at that target. The backcasting approach itself is not particularly a unique methodology. This method of calculating backward is something that we used on a daily basis. What needs to be specifically identified here is; how this approach should be applied to a practical, quantitative and comprehensive problem that involves the whole society, such as the achievement of a low carbon society. For this reason, the backcasting method is developed as a practical method of application. This method involves dividing the process into two stages as noted above and constructing estimation tools (models) to provide the quantitative data needed at each stage, and then applying these models in the form of computer programs to Kyoto City. The Roadmap described in this report is the result of the application of this method.

Stage 1 Defining the Target

The first stage in the method is to envision the future society as the target. The basic approach is to "determine what direct measures will be needed to achieve emission targets based on a given socioeconomic situation that has been envisioned." Accordingly, greenhouse gas emissions will be permitted on the status of socioeconomic activity.

(1) Establish a framework

First, determine the framework for creating the overall low carbon society scenario. This involves determining the target region, reference year, target year, target activities, environmental targets, number of scenarios and so on. The target year should be far enough in the future to achieve the necessary changes but close enough that it can be envisioned by people in the region.

In studying scenarios for the society of the future, often multiple scenarios are created and a comparative study of these scenarios are conducted. However, most of the low carbon plans prepared by local governments around the world are based on a single socioeconomic assumption. Public targets are compiled by local governments in the form of a "Vision" statement. However, considering the inherent instability and uncertainty involved in making predictions about the society of the future, and in particular the openness of the regional economy, a sensitivity analysis should be conducted at least for crucial hypotheses (the rate of economic growth, the structure of industry and so on).

(2) Envision the socioeconomic situation (scenario creation)

Before conducting a quantitative analysis, create a qualitative picture of the future society, including such factors as lifestyle patterns, industry, land use and so on. The following are some of the methods that can be used to do this.

- Existing concepts, plans and targets in each field for that region
- Interviews with influential persons, workshops etc.
- Simple extension of the present situation or freezing it in place
- Documents and plans relating to the future of the country or even larger region

A method that will be as meaningful as possible for subsequent policy deployment, considering the actual policymaking process, should be selected. Ultimately, the envisioning of the socioeconomic situation serves only as a premise for the achievement of a low carbon society. Based on this perspective, for the purposes of this study it was decided not to go into the methods used to envision specific socioeconomic situations (for example, the growth rate for a certain industry).

(3) Quantify the envisioned socioeconomic situation

Establish the indicators that will serve as the input values for estimating the society of the future based on the situation envisioned in (2). Here exogenous variables or parameters are entered as values for the ExSS model. The envisioned socioeconomic factors that are thought to have a particularly great impact on greenhouse gas emissions are the economic growth rate for the nation as a whole, the exports for each industry, the population distribution and the employment rate.

(4) Collect low carbon direct measures

Collect the direct measures that you think can be introduced by the target year. In addition to energy use technologies, these might include changes to the transportation structure, renewable energy, energy-saving practices, carbon sinks and so on.

(5) Establish the direct measures for the target year

Establish the number of direct measures collected in (4) to be introduced and determine technical coefficients (energy efficiency, etc.) relating to energy demand and CO_2 emissions. Standards for determining the combination of direct measures might include cost minimization, ease of acceptance by stakeholders, technical achievability and so on.

(6) Identify estimates and direct measures

Enter the exogenous variables and parameters established in (3) and (5) and estimate the socioeconomic indicators and greenhouse gas emissions. Socioeconomic indicators include population, the added value of the region, production for each industry, transport demand and so on. If the target for greenhouse gas emissions has been achieved, proceed to step (7). If not, return to step (5) and study the number of direct measures to be introduced.

(7)Finalize the list of direct measures

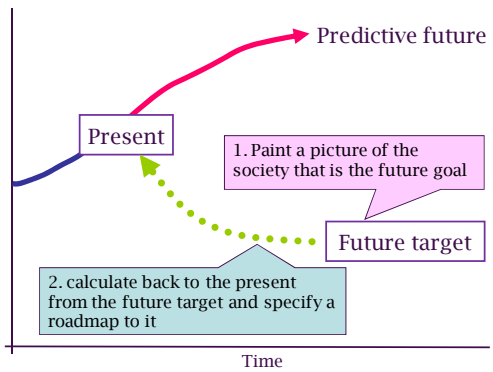


Figure 8 Idea of backcasting

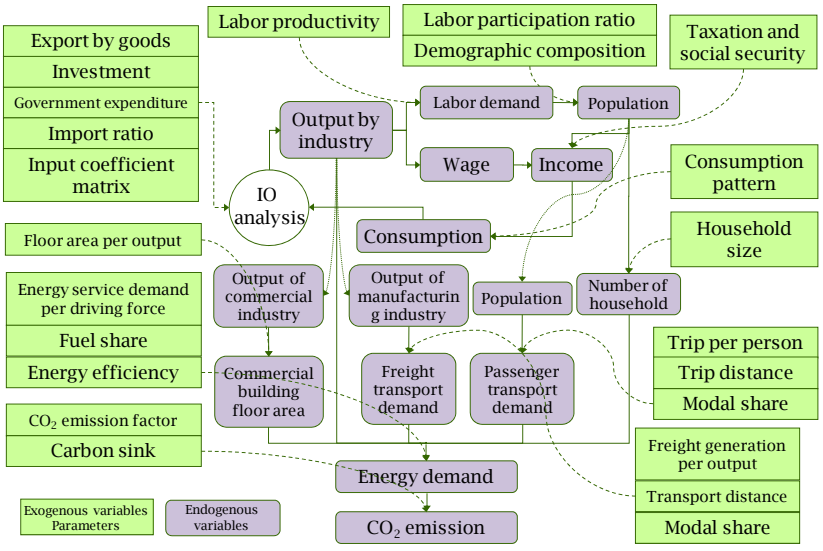


Figure 9 ExSS calculation flow

1) Robinson, J., B.:Futures under glass A resipe for people who hate to predict, Futures, pp820-842, 1990.

Finalize the list of the direct measures whose introduction is envisioned and the reduction in emissions for each direct measure. This indicates the state of low carbon direct measures that will become the final targets at the next stage. An example of such a list is shown in Table 3 on page 10 of this pamphlet.

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Fig. 9 shows the configuration of the ExSS model. The figure shows seven blocks, the exogenous variables and parameters that are entered in each block, and the variables that are transferred between blocks. The model is depicted as a simultaneous equations system that determines a unique solution based on the given exogenous variables and parameters. The figure focuses only on CO_2 emissions from energy consumption, but it can also be used to handle other greenhouse gases and other environmental load (for example, atmospheric pollutants).

Stage 2 Searching for a Roadmap

In the second stage of the process, a roadmap leading to the society depicted in the scenario is established. The basic approach is to determine what type of measures should be implemented and when they should be implemented, in order to arrive at the dissemination rate for the direct measures in the target society. It should be recognized that achieving the dissemination rate for the direct measures in the targeted society will be no easy task. For this reason, the government must formulate a plan and implement measures in accordance with that plan in order to encourage the dissemination of direct measures. For example, a program which provides subsidy for the purchase of ecologically friendly vehicles in order to encourage the dissemination of such vehicles could be introduced.

In this stage, measures are established to disseminate the direct measures identified in the first stage, and the period of time needed for implementation of each measure in order to achieve the low carbon targets is calculated. It is also in this stage that the emissions reductions for each direct measure identified in the ExSS model are allocated to the measures for reducing greenhouse gas emissions.

(1) Establish measures

First, establish the measures which are needed to disseminate the direct measures envisioned for the targeted society. To establish measures, first think of possible barriers to the dissemination of the direct measures, and propose a measure to remove those barriers wherever they are present. Next, determine whether there will be any barriers to the implementation of that measure. Repeat this process until all barriers have been removed. If there is already a short-term plan in the target region, you may also refer to the measures in that plan.

(2) Define the requirements for measures

Define the requirements for each of the measures established in (1). The necessary requirements are as follows.

- Direct reductions in greenhouse gas emissions: The greenhouse gas reductions obtained through 100% implementation of the measure (kt-CO_2/year). Use the value estimated using the ExSS model
- Effort needed to implement measure: The effort that must be expended to begin 100% implementation of the measure (initial input).
- Effort needed to continue measure: The effort that must be expended each year in order to continue 100% implementation of the measure.
- Integrated effect of measure implementation: Effects (relative value) of measure other than direct and indirect reductions in greenhouse gas emissions during 100% implementation of the measure.
- Shortest implementation period: The shortest time thought necessary for 100% implementation of the measure.
- Earliest starting year: The earliest year in which measure implementation can begin. Implementation of the measure cannot begin prior to this year.
- Necessary prior measure: Another measure whose 100% implementation is needed prior to the implementation of a certain measure. For example, "sidewalk widening work" is a necessary pre-existing measure for "use of pedestrian transit malls."
- Necessary parallel measure: Another measure needed for 100% implementation of a certain measure. The more effective the parallel measure is, the greater the effectiveness of the measure in question will be. For example, "subsidy program for purchase of environmentally friendly vehicles" is a parallel measure for "dissemination of environmentally friendly vehicles."

An upper limit is also established for the total amount of effort that can be expended each year.

The team conducted interviews at the Kyoto City Office regarding these values and established values that are thought to be appropriate at this point in time.

(3) Prepare a schedule for implementation of measures

Based on the exogenous variables and parameters established in (1) and (2), calculate the period of time needed for implementation of each measure, using the backcasting tool (BCT). The BCT establishes the difference between total effectiveness and total effort as a target function and uses mixed integer programming (MIP) to maximize this value. Fig. 10 shows the structure of a BCT.

(4) Propose a roadmap

The BCT calculates the period of time needed for implementation of all of the envisioned measures in order to arrive at the target society in the future, based on a limited amount of expendable effort. Moreover, by also incorporating benefits other than reductions in greenhouse gas emissions that result from the measures, it is able to take into consideration the priority of each measure for the local government. This makes it possible to propose this roadmap to serve as a foundation when the local government prepares actual medium- and long-term plans aimed at the achievement of a low carbon society.

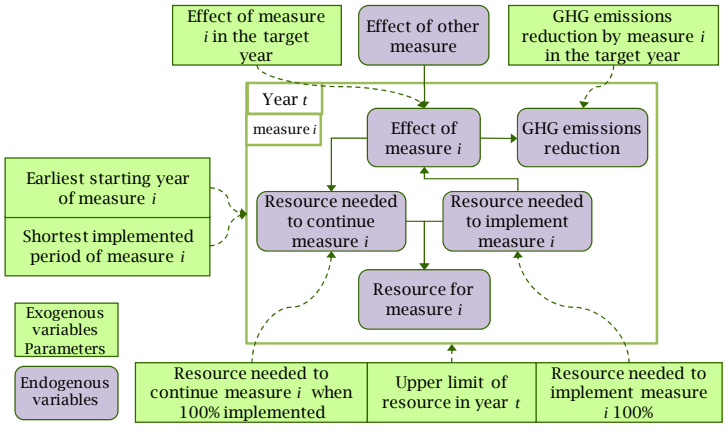


Figure 10 BCT calculation flow

Statistical Data Collection and Estimation

A large volume of socioeconomic data and data on energy consumption and provision is needed to determine the present state of CO_2 emissions and calibrate the ExSS model. As Kyoto is a city designated by government ordinance, data collection was comparatively easy. However, Kyoto City does not prepare and publish the interindustry tables needed for an analysis of industrial structure, so for the purposes of this study an interindustry table for industries in Kyoto in the year 2005 was prepared independently.

Table 4 shows the sources for the statistical data used in this study. The next page shows the interindustry tables for 2005 and 2030 that were estimated (consolidated into 15 sectors), in addition to energy consumption.

Table 4 sources for the statistical data

Statistics	Year
Kyoto city regional accounting	FY2005
Kyoto prefecture regional accounting	FY2005
Industrial Statistics	2005
Establishment and enterprise census	2004
population Census	2005
Kei-han-shin parson trip survey	2000
Kei-han-shin commodity distribution survey	2005
School basic survey	FY2005
Kyoto prefecture Input-Output table	2000
Kyoto city energy balance table	2000
Compendium of energy statistics	FY2000
Kyoto city Input-Output table	2000
Kyoto city Input-Output table	2005
Input-Output table (Japan)	2000
Input-Output table (Japan)	2005
Survey on motor vehicle transport	FY2005
Monthly report of number of automobiles	Mar. 2004
Kyoto city compendium of statistics	2006
Annual statistics on railway and transport	2005
The survey of transport energy	2007
Land and transport statistics directory	2005
Kyoto city regional new-energy survey report	2000

Table 5 IO table of Kyoto City in 2005 (Unit: bill yen)

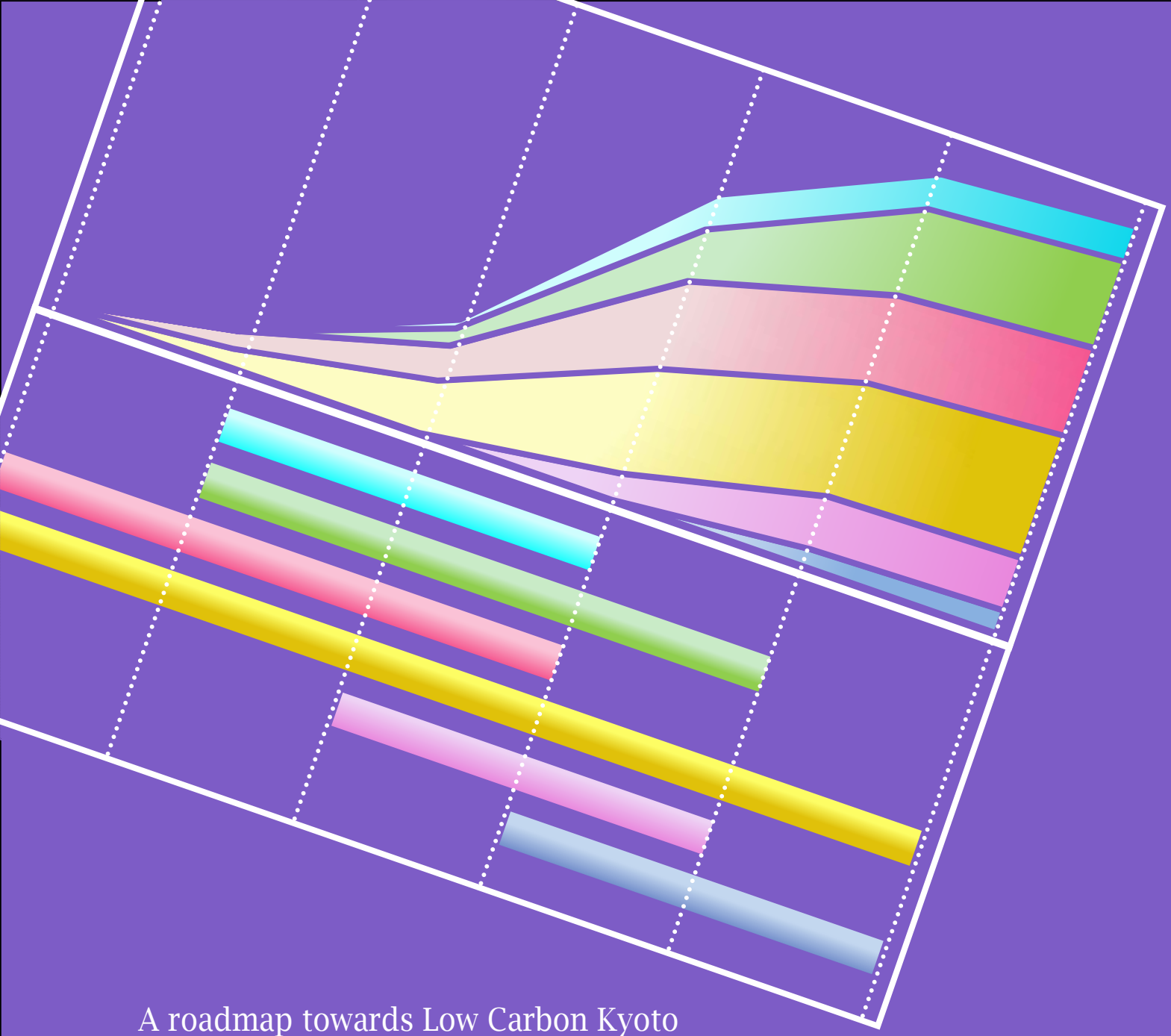
No.		01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	Total intermediate input	Private consumption	Government consumption	Fixed capital formation	Export	Import	Total input (domestic production)
01	Agriculture, Forestry and Fishing	1	95	0	0	0	2	1	0	0	0	0	3	0	17	0	120	31	0	2	4	- 139	17
02	Food Products and Beverages	1	92	0	0	0	0	0	0	0	0	0	9	0	93	0	195	250	5	0	496	- 348	598
03	Textiles	0	1	12	0	2	1	1	0	5	1	1	4	1	3	1	33	44	0	3	106	- 61	125
04	Pulp, Paper and Printing	0	26	2	67	6	5	3	1	22	12	4	30	31	8	12	228	14	0	0	153	- 141	254
05	Machinery	0	0	0	0	204	4	8	0	2	0	7	13	55	1	1	297	111	0	389	846	- 686	956
06	Other Manufacturing and Mining	1	52	22	21	102	86	127	8	17	5	39	112	20	25	9	646	98	0	24	256	- 698	326
07	Construction	0	1	0	1	1	2	1	15	1	9	4	12	1	5	0	52	0	0	414	0	0	466
08	Utility	0	13	4	5	12	8	4	14	32	7	13	50	6	41	1	210	131	21	0	45	- 119	288
09	Wholesale and Retail Trade	1	44	5	11	37	13	29	2	19	3	13	42	18	49	7	293	427	0	111	982	- 342	1470
10	Finance, Insurance and Real Estate	1	10	5	8	13	6	8	7	134	109	43	27	46	38	14	469	973	0	0	211	- 13	1640
11	Transport, Communication and Broadcasting	1	26	3	11	17	11	32	5	105	27	55	50	29	39	6	419	180	0	8	238	- 192	653
12	Public Service	0	7	1	0	54	10	2	5	6	1	5	13	3	2	3	113	320	925	0	174	- 10	1522
13	Business Service	0	34	3	13	32	18	38	30	103	86	66	79	62	39	3	606	47	0	71	174	- 243	655
14	Personal Service	0	0	0	0	0	0	0	0	3	1	4	12	5	22	1	50	468	0	0	585	- 212	891
15	Others	0	9	1	3	7	3	3	2	18	13	4	8	6	7	0	85	0	0	0	7	- 14	78
	Total intermediate input	7	410	58	142	487	167	256	90	470	274	255	465	283	391	58	3814	3093	951	1022	4276	- 3218	9938
	Total value added	10	188	67	112	469	159	210	198	1001	1365	398	1057	371	501	19	6124						
	Total input (domestic production)	17	598	125	254	956	326	466	288	1470	1640	653	1522	655	891	78	9938						

Table 6 IO table of Kyoto City in 2030 (Unit: bill yen)

No.		01	02	03	04	05	06	07	08	09	10	11	12	13	14	15	Total intermediate input	Private consumption	Government consumption	Fixed capital formation	Export	Import	Total input (domestic production)
01	Agriculture, Forestry and Fishing	2	124	1	0	0	2	1	0	0	0	0	4	0	25	0	158	4	0	3	5	- 150	19
02	Food Products and Beverages	1	119	0	0	0	0	0	0	0	0	0	11	0	134	0	267	200	5	0	668	- 364	775
03	Textiles	0	2	15	0	2	1	2	0	8	1	1	5	2	5	1	44	35	0	5	151	- 63	172
04	Pulp, Paper and Printing	0	34	2	88	8	6	3	2	31	16	5	38	42	11	17	304	11	0	0	207	- 185	337
05	Machinery	0	0	0	0	273	5	9	1	3	0	9	16	74	1	2	394	88	0	514	1139	- 857	1278
06	Other Manufacturing and Mining	2	67	32	28	136	114	146	11	24	7	53	137	27	36	12	830	78	0	32	345	- 854	431
07	Construction	0	1	1	1	2	2	1	20	1	13	6	15	1	7	0	70	0	0	465	0	0	536
08	Utility	0	16	6	6	16	11	4	19	46	10	17	61	8	59	1	282	191	23	0	61	- 158	399
09	Wholesale and Retail Trade	1	58	7	15	49	17	33	3	27	5	17	51	24	71	10	387	624	0	147	1420	- 477	2101
10	Finance, Insurance and Real Estate	1	13	6	11	18	7	9	10	192	156	58	34	62	55	17	649	1421	0	0	284	- 19	2335
11	Transport, Communication and Broadcasting	1	34	4	15	23	14	37	7	150	38	76	61	38	57	7	564	262	0	11	321	- 263	895
12	Public Service	0	10	1	1	72	13	3	7	9	2	6	16	4	3	3	149	468	1022	0	237	- 13	1863
13	Business Service	0	44	4	18	43	24	43	42	147	120	90	96	84	56	3	815	68	0	93	234	- 327	883
14	Personal Service	0	0	0	0	0	0	0	0	4	2	5	15	7	32	1	68	684	0	0	837	- 309	1280
15	Others	0	12	1	4	9	4	3	3	26	19	5	11	8	10	0	115	0	0	0	0	- 20	96
	Total intermediate input	8	532	80	188	651	222	294	124	671	388	349	570	382	563	73	5095	4134	1051	1270	5908	- 4058	13400
	Total value added	11	244	92	149	627	210	242	275	1430	1947	545	1293	501	717	22	8305						
	Total input (domestic production)	19	775	172	337	1278	431	536	399	2101	2335	895	1863	883	1280	96	13400						

Table 7 Energy consumption (Unit: ktoe)

	2005							2030 Frozen at current levels case							2030 Corrective measures case						
	Coal	Petroleum	Natural gas	Biomass	Solar & Wind	Electricity	Total	Coal	Petroleum	Natural gas	Biomass	Solar & Wind	Electricity	Total	Coal	Petroleum	Natural gas	Biomass	Solar & Wind	Electricity	Total
Residential	0	59	232	0	0	269	560	0	59	230	0	0	267	556	0	24	126	9	27	173	359
Agriculture, Forestry and Fishing	0	7	0	0	0	0	8	0	8	0	0	0	0	9	0	3	4	0	0	0	7
Food Products and Beverages	0	6	22	0	0	6	34	0	7	29	0	0	8	44	0	3	29	0	0	7	39
Textiles	0	69	159	0	0	3	231	0	95	219	0	0	4	317	0	34	247	0	0	3	285
Pulp, Paper and Printing	0	1	22	0	0	6	30	0	2	30	0	0	8	39	0	1	27	0	0	8	35
Machinery	1	3	39	0	0	36	79	1	4	52	0	0	48	106	2	1	44	0	0	47	93
Other Manufacturing and Mining	0	8	43	0	0	18	70	0	11	57	0	0	24	92	0	4	46	0	0	23	73
Construction	0	24	4	0	0	0	28	0	27	5	0	0	0	32	0	8	15	0	0	0	24
Utility	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Wholesale and Retail Trade	0	76	57	0	0	60	194	0	73	55	0	0	58	186	0	9	45	2	7	33	97
Finance, Insurance and Real Estate	0	52	39	0	0	41	132	0	50	38	0	0	39	126	0	6	31	2	5	23	66
Transport, Communication and Broadcasting	0	8	6	0	0	6	19	0	7	5	0	0	6	18	0	1	4	0	1	3	9
Public Service	0	77	58	0	0	61	196	0	92	69	0	0	73	234	0	11	56	3	9	42	121
Business Service	0	26	15	0	0	17	58	0	26	14	0	0	15	55	0	5	15	1	2	9	31
Personal Service	0	46	35	0	0	36	117	0	66	50	0	0	52	168	0	8	41	2	7	30	87
Others	0	3	2	0	0	1	6	0	3	2	0	0	2	8	0	0	2	0	0	1	4
Passenger Transport	0	543	0	0	0	39	582	0	537	0	0	0	36	572	0	251	0	62	0	42	355
Freight Transport	0	202	0	0	0	0	202	0	270	0	0	0	1	270	0	150	0	47	0	1	198
Total	1	1209	735	0	0	601	2546	1	1336	856	0	0	641	2834	2	517	733	128	58	445	1882



A roadmap towards Low Carbon Kyoto

August 2009

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