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1. Introduction

After a lengthy struggle domestically and internationally, Japan is preparing for the ratification of the Kyoto Protocol. This short paper tries to show what policy measures the government of Japan has and does not have. The paper is meant also to indicate some of the basic and important issues in the consideration of international environmental agreements like the Kyoto Protocol. Although the issues discussed are far from comprehensive, I hope this might be some help in understanding Japanese environmental policy on global warming.

I also have to admit that most of the topics are confined to domestic issues, partly because proposed policies by the government also deals mostly with domestic issues. However, since the issue of global warming is truly a global phenomenon, balanced views will also be required.

2. Global Warming Prevention Policy by the Japanese Government

Toward the ratification of the Kyoto Protocol, the Japanese government announced a revised version of the Climate Change Policy Program (hereafter referred to as the "New Program") last March. The enactment of the relevant domestic legislation is to be proposed during the current ordinary session of the Diet.

Under the Kyoto Protocol, Japan has to reduce its total greenhouse gas emissions in 2008–2012 (hereafter referred to as the commitment period) to six percent below those of the base year of 1990[1]. The New Program basically covers the following areas: (I) establishment of a harmonized framework for the economy and the environment, (II) adoption of a step-by-step approach in order to secure implementation, (III) involvement of central and local governments, enterprises, and the public as a whole, and (IV) consideration of international cooperation.

In (I), the government hopes to attain economic revitalization through the process of pursuing the target of the Kyoto Protocol. This point will be part of the discussion on domestic measures. In (II), a three-stage approach is proposed — the first step is from 2002 to 2004, the second step is from 2005 to 2007 and the third step is the remaining period, the commitment period. In each step, attainment of the committed reduction of the greenhouse gases is to be checked and necessary procedures are to be taken in order to keep the promise. Based on the timeliness of relevant statistics, we need to check whether this procedure is actually feasible or not. Most of the statistics on the emissions of the greenhouse gases become available one or two years after the fact. In (III), the way to involve every party concerned will be an issue. This point is discussed in the issue of economic measures. In (IV), the agenda of the post Kyoto Protocol will be one of the most important international issues — an issue we will have to repeatedly consider.

In order to ratify the Kyoto Protocol the current reduction plan for individual greenhouse gases is proposed as follows (Table 1).

Table 1. Contribution Shares for the Attainment of the Kyoto Protocol (Unit: Percent change in Target Year/Base Year, expressed in contribution to the overall reduction)

CO_2 from Energy Sources	
Energy Conservation	
Development of New Energy Sources	
Fuel Switching	
Promotion of Nuclear Power Generation	±0.0%
Emission of CO_2, Methane and Nitrous Oxide from non-Energy Sources	-0.5%
Revolutionary Technological Development and Further Prevention Activities	-2.0%
HFCs, PFCs and SF_6	+2.0%
Removal by Sinks	-3.9%
Others (not mentioned in the official document)	-1.6%
Target Reduction	-6.0%

Source. Global Warming Prevention Headquarters (2002)

Emission of carbon dioxide from combustion of energy sources in the commitment period is to be the same level as that of the base year, thereby contributing zero percentage points to overall change in greenhouse gas (GHG) emissions. There are four sectors in this category: industry, commercial/residential, transport and energy conversion. Energy conversion usually refers to the internal use of energy in order to convert energy sources. The largest industrial sector in energy conversion is electric utilities. Carbon dioxide emissions emitted in the process of generation of electricity used in other sectors in the economy is usually allotted to the user sectors.

Total emission of carbon dioxide, methane (CH_4) and nitrous oxide (N_2O) from non-energy sources is to be half a percentage point below that of the base year. Reduction in CO_2 emissions from non-energy sources is to be attained through intensification of effective recycling, biomass usage, etc. Reduction of methane is through reduction in direct landfill food wastes, better management of farmland, and so on.

For the prevention of global warming, revolutionary technological development and intensified activities at all levels of the public are envisaged to contribute two percentage points to the overall reduction. In this category new types of energy-saving equipment are picked up as examples. However, practical use of such revolutionary measures within a decade is not a certainty. Various consumer efforts, including those for more efficient use of electricity, are also part of this category.

Within the change in overall emission, the hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulfer hexafluoride (SF6) is slated to increase two percentage points. Since in the business as usual (BaU) case, overall emissions are projected to increase by five percentage points, the industrial sector will have to make various efforts.

Removal by sinks (absorption) is to account for 3.9 of 6.0 percentage points reduction overall. These 3.9 percentage points represent 13 million tons of carbon absorption, the upper limit of credit for Japan for forestry management set at the Seventh Conference of the Parties to the United Nations Framework Convention on Climate Change (COP-7).

The above five targets do not add up to the overall reduction to six percent below the emissions of the base year, further reduction, equivalent to 1.6 percent of the 1990 level, is required

Table 2. Emissions of Greenhouse Gases (Unit: million tons C)

	GWP	Base Year	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
CO_2	1	306.7	306.7	313.0	317.0	310.9	331.1	332.1	337.1	336.4	323.7	334.1
Methane	21	8.3	8.3	8.3	8.2	8.2	8.1	8.0	7.9	7.6	7.4	7.4
N_2O	310	5.7	5.7	5.5	5.6	5.5	5.9	5.9	6.2	6.4	6.1	4.5
HFCs		5.5						5.5	5.4	5.3	5.2	5.3
PFCs		3.1						3.1	3.1	3.8	3.4	3.0
SF6	23,900	4.6						4.6	4.7	3.9	3.5	2.3
Total		333.8						359.3	364.3	363.5	349.3	356.6

Note. GWP refers to global warming potential and its figures indicate the relative ability of gasses to trap heat in the atmosphere, with CO_2 chosen as the reference gas.
Source. Ministry of the Environment

in order to meet the Kyoto target. The Kyoto mechanisms (emissions trading, joint implementation and the clean development mechanism) are to be used to fill the gap. Japan's reliance (in terms of percentage point) on these flexible mechanisms will be a very important issue.

The actual emission statistics fall short of the targets (Table 2). In 1999, the emission of carbon dioxide by energy and non-energy sectors combined is more than 9.0 percent above that of the base year. The year-on-year rate of increase was 3.2 percent. Sectoral figures indicate that industrial sector emissions had increased 0.8 percent since the base year whereas the transport sector had increased 23.0 percent, the household sector 15.0 percent, and the commercial sector 20.1 percent. These trends indicate that both the transport sector and the household/commercial sector are main areas in which further efforts will be needed.

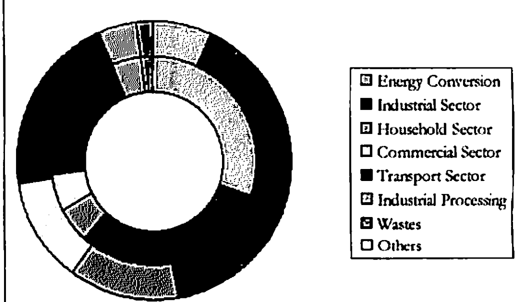
As of 1999 the emission of methane declined 11.2 percent since 1990. The agricultural sector, where the emission of methane is largest, registered downward trends from rice growing and animals (e.g., changes due to bacteria supplements to cattle feed). Emission of nitrous oxide decreased 20.4 percent during the same period, partly due to the installation of equipment for destroying nitrous oxide when producing adipic acid.

Since 1995 HFCs declined 2.7 percent, and PFCs declined 3.4 percent, and SF6 declined 50.1 percent.

3. Emissions of Carbon Dioxide from Energy Sources

In order to curtail the emission of greenhouse gases, the first targeted source will be the one that emits the largest share, carbon dioxide emissions from the combustion of energy sources.[2] Polices for both the demand and supply-sides are envisaged to play more active roles in the New Program. Graph 1 indicates the CO_2 emission shares of the players concerned. The inner circle shows the origins of the emissions. The outer circle is derived based on electricity purchases of the sectors.

Graph 1. Sectoral Shares in CO_2 Emissions in 1999



Among the various efforts proposed for energy conservation, voluntary initiatives by industry are advocated by *Keidanren* (Japan Federation of Economic Organizations, 1997) and other indus-

Table 3. CO_2 Emissions by Voluntary Initiatives (Unit: Million tons-C)

	1990	1999	2000	2005 (forecast)	2010 (goal)	2010 (BaU)
CO_2 Emissions	130.96	131.08	132.57	138.1	Below the Level of 1990	145.33

(Source) Keidanren

trial groups are expected to advocate similar measures. The thirty-six industries that participated in the *Keidanren* Voluntary Action Plan on the Environment emitted about 42.7 percent of all the energy related CO_2 emission in 1990 (76.7 percent of the total amount of CO_2 emitted by the industrial and energy-converting sectors in that year). *Keidanren* has declared that, instead of accepting the environmental taxes such as carbon tax, it would "endeavor to reduce CO_2 emissions from the industrial and energy-converting sectors in fiscal 2010 to below the level of fiscal 1990."

Among the thirty-six industries, there are four kinds of indices used to define the goals. Organizations in thirteen industries, such as Japan Automobile Manufacturers Association, have adopted direct targets on CO_2 emission amounts. Seven industries have adopted target for CO_2 emissions per unit of output. Organizations in three industries, including the Japan Iron and Steel Federation, have adopted the amount of energy consumed. Twelve industries have adopted targets on energy input per unit output. For the one remaining industry, the organization Japan Coal Energy Center has adopted specific targets for methane recovery, and electric power and wood consumption.

If this scheme succeeds, it has the merit that participating organizations are voluntarily restraining themselves from CO_2 emissions. However, not all of the industries are covered by this scheme. The problem of non-participating corporations poses problems in feasibility. Therefore, enlargement of the coverage is required. Also required will be more efficient evaluation techniques as well as a certification process by third parties, and both are reported to be in the midst of consideration. If attainment of the overall target becomes uncertain as the commitment period draws nearer, effective adjustment by the participating organizations might be difficult to accomplish, because the marginal abatement cost for reaching the stated target will be different. Although we have not seen a problem in terms of burden sharing, such a problem could emerge if industry faces stricter targets in the future.

We also take into consideration the possibility that certain industry organizations and/or participating corporations will not be able to fulfill their promises. The government might have to contract with each organization and introduce some kind of economic measures in the event of non-fulfillment. In this sense we need to further study the case of England, where voluntary action and economic measures coexist. The real challenge is to get this voluntary scheme to promote sufficient innovations in technology to reduce carbon dioxide emissions.

Another distinctive method, the Top Runner Program, was established in 1998. In its incorporation in the New Program, the Top Runner Program is going to be strengthened in some areas, including automobiles (mileage standards) and home and office electric appliances. The Top Runner Program aims at introduction of some of the best energy efficient standards in such industries. The standards of the foremost frontrunner equipments are in subsequent years to become the standards for currently less-efficient equipments so that the best available technology is spread throughout the market. This procedure, stipulated in the already-enacted Energy Conservation Law, is to be strengthened and utilized in other areas such as vending machines and boilers. Development and proliferation of hybrid automobiles, efficient coastal vessels, and industrial furnaces are also envisaged. Purchase of hybrid cars is partly subsidized by the government.

The New Program lists more than one hundred individual items to be considered for inclusion in the policy on the global warming. The targets are typically focused on specific equipment models, and manufacturers are tasked with being the main contributors for bringing about energy efficiency. More orchestrated and consistent effort is needed when dealing with the whole system, such as to transport demand management and modal shift of transportation. Without proper incentives, fanfare about an improved system will probably not result in its proliferation, because systems are more complicated than mere standards and specifications of individual equipments.

In order to check whether a bottom-up approach like the New Program will function in the macroeconomic framework of Japan, we need economic models to evaluate the reduction of the carbon dioxide emissions from various sources. The following is an example of such a model — one that was actually used in the government's evaluation processes.

4. A Simulation Model and Its Results

To show the economic feasibilities in the interrelated framework, we would like to introduce a computational general equilibrium model for the Japanese economy. The parameters were basically econometrically estimated and it was first reported in 1995 (Kuroda, et al. 1995). It has grown into a model which evaluates the short-and mid-term prospects for the Japanese economy.

The model has been developed to analyze economic interdependence quantitatively, trying to describe the equilibrium price and quantity for the market equilibrium condition in every sector. Presently, producers are divided into thirty-six industrial sectors, and consumers are divided into six household types classified by the age of the head of the family.

As for the producers, each industrial sector will present the short-term supply schedule decided by a short-term profit-maximizing behavior under the given conditions of the capital stock and the number of employees at the beginning of the period. The short-term supply schedule here is dependent on the prices of intermediate raw materials, including energy and labor services. Also relevant on the producer side is the decision on technological conditions, such as the intermediate input coefficient, labor coefficient, and capital stock. It is supposed here that given the long-term output outlook, and relative factor prices, and direction of technological progress, the producer will take the long-term cost-minimizing behavior. The long-run cost function, expressed by a set of translog functions, will decide the long-term cost-share of capital, labor, energy and raw materials, thereby deciding the inputs of these four kinds of factors. The capital stock here is described as the optimum level of capital stock, and the difference between the capital stock at the beginning of the period and the optimum capital stock will correspond to the optimum level of investment demand.

The model holds flexibility in providing the technological scenario exogenously for the industries in which a relatively clear outlook of the future technology is provided. Such industries are electric utilities and transport. Power source is classified into nuclear power generation, coal-thermal power generation, LNG-thermal power generation, petroleum-thermal power generation, hydroelectric power generation, new energy power generation, etc. In each generation system, utilization rate is endogenously determined, whereas the capacity is exogenously postulated by the future construction scenarios. The current version also incorporates the effects of voluntary initiatives the Top Runner Program, utilizing the results of other bottom-up models.

The level of labor input is to be decided in accordance with the optimum level of capital stock. Labor supply is classified into six individual age groups, and for each household is further divided into head-of-family labor supply and non-head-of-family labor supply. The labor supply of the head of family is insensitive to the wage rate in the labor market whereas the labor supply of the non-head of the family is assumed to be responsive to the wage rate and the income level of the head of family. This is an application of the Douglas-Arisawa Law for the Japanese labor market. Equilibrium rates of wages and labor inputs are decided in the labor markets of individual age groups. However, these rates of wages and labor inputs define the initial condition of the next period and are not flexible in the short-run.

Household consumption expenditure is split into two stages. In the first stage, disposable income is calculated from the labor income and capital income. Budget constraint and the prices of goods are used in a utility-maximization point of view to derive savings and consumption. In the second stage, consumption is determined by utility maximization based on the preferences relating to each of the goods and services. Here energy demand is calculated first. Energy usage in the household sector is divided into transport, heating, air-conditioning, hot-water-supply, kitchen and power usages. Energy improvement in automobiles and home appliances under the Top Runner Program are taken into consideration to derive the energy demand. After deducting the energy demand from the total consumption, other items of expenditure are derived based upon utility maximization. Needless to say, prices for every kind of consumption will change in the process, leading the equilibrium in all sectors. Under the given conditions of the intermediate input coefficient at the beginning of the period, the Leontief's inverse matrix will derive the domestic demand from the final demand. When every industrial sector, including the labor market, reaches its equilibrium, the balance of savings and investment is also achieved. The various parameters of the multi-sectoral general equilibrium model are basically estimated econometrically, mostly utilizing a database for 1960 to 1992.

Following are the main assumptions and results using the current version.

In the BaU scenario, the real GDP in 1985 prices will grow at the annual rates of 1.94 percent in 2000–05, and 2.03 percent in 2005–10. Final energy demand will grow from 363.6 million kilo liters (in petroleum equivalent) in 2000 to 417.85 million kilo liters in 2010. If energy saving efforts in commercial private transport, traffic and logistics are taken into account, the final energy consumption in 2010 will be about 409 million kilo liters. Corresponding figures of carbon dioxide emissions in 2010 will be 332 million tons C in the case of no energy saving efforts and 307 million tons C in the case of energy saving efforts. In the BaU, we incorporate the above energy saving efforts. If we look at the uses of the final energy consumption, expansion in the commercial sector's share is evident.

In terms of sectoral shares of carbon dioxide emission, electricity's increase will be the largest. Emission increases by the communications and wholesale/retail sectors will be major contributors in the commercial sector.

As for the energy demand of household, final energy consumption annually decreases 0.41 percent from 2000 to 2010. During the same period, the annual average decrease in energy consumption will be as follows in the six head-of-family age ranges: 0.18 percent, 15–24; 0.27 percent, 25–34; 0.30 percent, 35–44; 0.32 percent, 45–54;

Table 4. Main Results of the Keio Model

	Unit	1985	1990	1995	2000	2005	2010	1985-90	1990-95	95-2000	2000-05	2005-10	2000-10
Major Exogenous Variables								Annual Rates of Change (%)					
Population	10,000	12,105	12,361	12,557	12,689	12,768	12,763	0.42	0.31	0.21	0.12	-0.01	0.06
Exchange Rate	yen/$	238.54	144.81	94.06	110.00	110.00	110.00	-9.98	-8.63	3.13	0.00	0.00	0.00
Cap. of Nuclear Power Generation	10,000 kW	2,452	3,206	4,255	4,492	4,958	5,970	5.36	5.66	1.08	1.98	3.71	2.89
Crude Oil Prices (CIF)	$/bbl	27.21	22.76	18.26	20.00	24.00	30.00	-3.57	-4.41	1.82	3.65	4.46	4.14
Volume of World Trade	1 billion $	1,936	3,466	5,147	5,833	6,447	7,125	11.65	7.91	2.50	2.00	2.00	2.02
Major Endogenous Variables								Annual Rates of Change (%)					
Real GDP in 1985 Prices	1 billion yen	314,433	406,278	431,013	448,529	494,148	546,932	5.13	1.18	0.80	1.94	2.03	2.00
CO_2 Emissions	1 million tons C	248.8	289.1	308.8	315.1	327.8	332.0	3.00	1.32	0.40	0.79	0.25	0.52
Priamary Energy Supply	1 trillion kcal	3,954	4,820	5,432	5,590	5,856	6,126	3.96	2.39	0.57	0.93	0.90	0.92
Final Energy Demand (FED)	1 trillion kcal	2,717	3,202	3,508	3,622	3,728	3,845	3.28	1.82	0.64	0.58	0.62	0.60
CO_2/Final Energy Demand	g/cal	91.54	90.27	88.02	86.98	87.91	86.33	-0.28	-0.50	-0.24	0.21	-0.36	-0.07
Final Energy Demand/Real GDP	g/cal	8.64	7.88	8.14	8.08	7.54	7.03	-0.82	0.64	-0.15	-1.35	-1.40	-1.38
Shares of Electric Generation													
Nuclear	%	24.63	24.30	30.22	30.09	30.87	35.04						
Coal Thermal	%	13.33	11.90	13.81	15.94	21.39	21.24						
LNG Thermal	%	18.64	19.91	19.00	24.47	22.25	21.15						
Petroleum Thermal	%	20.07	20.75	14.85	8.03	4.80	3.44						
Hydroelectric	%	11.47	9.78	7.87	8.02	7.46	7.03						
New Energy Sources	%	0.15	0.22	0.29	0.42	0.49	0.56						
Private excl. Electric Utilities	%	10.48	12.03	12.70	12.55	11.80	10.18						
Pumped Hydropower	%	1.23	1.12	1.25	0.49	0.94	1.37						
Shares of FED													
Industrial	%	48.52	48.44	44.62	44.03	42.83	41.75						
Household	%	13.15	12.7	14.37	14.2	14.35	14.14						
Commercial (Offices)	%	23.38	25.08	25.24	25.71	26.69	28.18						
Transport	%	14.94	13.78	15.78	16.06	16.13	15.92						
Shares of Energy Sources in FED													
Coals	%	19.16	16.63	14.82	14.14	13.61	12.90						
Petroleum	%	57.55	58.15	58.25	56.89	56.44	56.54						
City Gas	%	4.46	4.68	5.25	5.77	5.87	5.96						
Electricity	%	18.83	20.54	21.69	23.20	24.08	24.60						

Source. Kuroda-Nomura (2002)

0.35 percent, 55–64; and 0.36 percent, 65 and over. The energy-saving efforts of relatively young households will be the smallest and attract some public concerns.

The main reason there is more carbon dioxide emission in the New Program than in the previous program's policy scenario is that the relative shortage in nuclear generation capacity is filled by the introduction of coal thermal generation plants.

5. Comparison between the Two Programs

As exemplified in the previous section, the supply side of energy needs more attention. The situation is best illustrated when we compare the previous Long-term Energy Schedule Program (1998) and the more recent one (2001), both of which provide background for the Climate Change Policy Program (both the original and the revised program).

Table 5 shows two different scenarios of the final energy consumption for the Japanese economy in 2010. The New Outlook (BaU) has volumes quite similar to those of the Previous Control Outlook. An increase in energy consumption in the commercial sector during the period of 1990–2010 is apparent; however, increase in that of the privately-owned passenger car sector appears set to be damped in 1999–2010 after a sharp increase in the 1990s. The expected total volumes of final energy consumption in the two Long-term Energy Schedule Programs are similar.

When we turn to the supply of primary energy, we notice that the total energy supply in the New Outlook is only one percent larger than the Previous Control Outlook, whereas the emission of carbon dioxide is much larger (Tables 6 and 7). Whereas the Previous Control Outlook shows stabilization in the emission of CO_2 in 2010, the New Outlook shows 6.9 percent increase. This is

Table 5. Final Energy Outlook (Unit: million kl in petroleum equivalence)

	1990		1999		2010			
					Prev. Control Outlook		New Outlook	
		% dist.		%dist.		%dist.		%dist.
Firms	264	75.7	293	73.0	292	72.9	298	72.8
Industrial	183	52.5	197	49.0	192	48.0	187	45.8
Commercial	39	11.2	50	12.3	53	13.2	66	16.1
Trucks, other	42	12.0	47	11.7	47	11.7	45	10.9
Household	85	24.3	109	27.0	109	27.1	111	27.2
Residential	46	13.3	55	13.8	60	15.1	60	14.7
Passenger cars	39	11.0	53	13.2	48	12.0	51	12.5
	349	100.0	402	100.0	400	100.0	409	100.0

Source. Ministry of Economy, Trade and Industry

Table 6. Primary Energy Outlook (Unit: million kl in petroleum equivalence)

	1990		1999		2010			
					Prev. Control		New Outlook	
		% dist.		% dist.	Outlook	% dist.		% dist.
Primary Energy	526	100.0	593	100.0	616	100.0	622	100.0
Petroleum	307	58.3	308	52.0	291	47.2	280	45.0
Coal	87	16.6	103	17.4	92	14.9	136	21.9
Natural Gas	53	10.1	75	12.7	80	13.0	82	13.2
Nuclear	49	9.4	77	13.0	107	17.4	93	15.0
Hydroelectric	22	4.2	21	3.6	23	3.8	20	3.2
Geothermal	1	0.1	1	0.2	4	0.6	1	0.2
New Energy	7	1.3	7	1.1	19	3.1	10	1.6

Source. Ministry of Economy, Trade and Industry

due to the fact that nuclear generation will increase at a decreasing rate and coal generation will increase faster than previously expected. The differences in the two Energy Outlooks and their corresponding changes in CO_2 emissions are expressed in Table 8. The expected number of newly built nuclear power plants decreased from twenty to somewhere around thirteen, and the gap is to be filled primarily by coal-firing thermal plants[3].

In order to decrease CO_2 emissions further, the New Program proposes three additional measures. First is an increase in energy conservation, which, if it is successful, will result in a decrease of 6 million tons C. Second is further introduction of new energy sources, resulting in an expected decrease of 9 million tons C. Increased use of solar energy is included in this category. Third is energy conversion, especially in the field of electricity generation by natural gas, resulting in an expected reduction of 5 million tons C. One typical example is conversion of old coal-burning thermal plants into efficient natural gas-combined cycle plants. All together the carbon reduction through the New Program is 20 million tons C greater than that previously planned. With these kinds of contribution, overall emission of carbon dioxide from energy sources is to be stabilized.

If coal use becomes a significant problem in order to meet the Kyoto target, we might need to think of different policy instruments such as greening of the development tax on power sources (to encourage less use of coal) and/or introduction of tax on ordinary coal, etc.

The above argument is based on expected annual economic growth of two percent over the

Table 7. Carbon Dioxide Emissions from Energy Sources

(Unit: million tons C)

	1990	1999	2010 Prev. Control Outlook	2010 New Outlook
CO_2 Emissions	287	313	287	307
(% Change from 1990)	(0.0%)	(8.9%)	(0.0%)	(6.9%)

Source. Ministry of Economy, Trade and Industry

Table 8. Difference based on the New Outlook

(Unit: Million ton-C)

Changes in Demand Side			+6
	Commercial/Residential Usage		+9
		Commercial	(+10)
		Residential	(-1)
	Industrial Usage		-4
	Transport Usage		+1
		Automobiles	(+2)
		Others	(-2)
Changes in Supply Side			+15
	Electric Utilities		+16
	Others		-1
Discrepancies due to Crossing Terms			-1
Changes in CO_2 Emissions			+20

Source. Ministry of Economy, Trade and Industry

first decade of the millenniums. So the next agenda is to discern what will happen if the growth rate of the Japanese economy becomes much lower than the BaU case. We have not come up with figures yet (checking the magnitude of changes is our next task) but we do know that the decrease in the growth rate alone will not solve all of the difficult problems in the implementation of the various kinds of domestic efforts.

6. Other Issues of Importance

There is a great deal of discussion on the Kyoto Protocol. Here we will sketch some random issues that are sometimes neglected in the discussion of the topic in Japan.

Roles of the Economics Measures

So far, most of the policy on global warming has been directed toward the production side. Two typical examples are the voluntary initiatives and the Top Runner Program. However, these measures do not cover all of the producers. On the consumer side, it is more difficult to provide proper incentives without using economic measures, because players are numerous and diversified.

In the environmental performance reviews on Japan by the OECD (2002), one of the recommendations concerning global warming is to further develop the national policy framework, using a balanced mix of policy instruments including an expanded use of economic instruments such as taxes and fees.

To effectively back the present policy measures, we will have to prepare some economic measures, because the problem of global warming is of long-term nature. At least, carbon tax is one option we always have in mind.

Cost-effectiveness vs. Domestic Measures

One of the debatable issues on the Kyoto Protocol is related to the cost in each participating country's marginal abatement schedule to attain the quantitative target. The schedules to reach the differentiated targets for 2008–12 are wide-ranging. When comparing a country that has already made a lot of energy-saving effort with one that has not (and thereby has a lot of room for reduction), the need for various schedules is apparent. As per the Kyoto Protocol, the developing countries, which have no limit on their emissions so far, will have a relatively low marginal cost schedule for abatement. Therefore, some economists such as Nordhaus and Boyer (1999) cast doubt on the future prospect of the Kyoto Protocol.

On the other hand, there is a strong argument, especially in Europe, that domestic countermeasures should play a much larger role than the application of flexible mechanisms such as international emissions trading, because industrialized countries have more capacity to develop new technologies and ways to reduce the emissions of greenhouse gases.

They hope that adoption of an international environmental agreement like the Kyoto Protocol will pave the way for more frequent and intense technological innovation and social reforms for environmental protection.

> Contrary to conventional economic wisdom, it does matter where emissions are being reduced; only the industrialized countries have the potential to come up with the required technological (and cultural) revolution to sketch the path towards a fossil-free economy (Otto, 2001).

The argument by the EU, in my view, is related to the approval of differentiated marginal abatement cost and has a background in common with the scheme of Uzawa (1991) whereby the tax rate is set to be proportional to the per-capita income.

We have also shown that, in a static world where effective income transfer (side-payment) is hindered by some reasons, the rate of carbon tax should be set to be different (Asako, Kuninori and Matsumura, 1995). See also Okuno and Konishi (1993).

The Porter Hypothesis

There has been widespread understanding that the increasing stringency of domestic environmental regulation will put home-based industries at a competitive disadvantage in the international marketplace. In contrast, Porter (1990) claims that strict regulations need not be a disadvantage, but that they can actually work in favor of domestic industry and can increase its international competitive position in the world market.

Palmer *et al.* (1995) claim that the addition of constraints on a firm's set of choices cannot be expected to result in a higher level of profits. However, they point out some validity in the Porter hypothesis in the following areas: strategic behavior involving interactions between polluting firms and between these firms and the regulating agency, and the presence of an industry that produces abatement technology and equipment as its output that for some reason has been overlooked and that somehow becomes realized in the wake of new and tougher environmental regulations (to be filled later).

In a similar vein, higher energy prices in the 1970s and more stringent environmental regulation both in the US and Japan supposedly promoted introduction of energy-saving equipments, such as more fuel efficient automobiles in Japan. Likewise, the issue of global warming is providing an incentive whereby increased energy price will bring about productivity increase in machineries industries (Murota and Takase, 2001). Using the Japanese data, we have at least shown that knowledge capital can be substituted for energy input, and therefore that an increase in energy prices will increase the knowledge capital, which will also likely have a positive external effect on the economy (Kuninori and Miyagawa, 1993).

Prices vs. Quantities

In general arguments on policy regarding global warming, we often encounter the problem as to which kind of mechanism to choose under uncertainty: quantity control mechanism or price control mechanism. If we impose a quantity control mechanism, like the Kyoto Protocol, marginal cost will be uncertain. On the other hand, if we impose a price control, like carbon tax, amount of emission reduction becomes uncertain. It is well known that Weitzman (1973) shows that if the slope of the marginal cost curve is steeper than the slope of the marginal damage cost curve in their absolute values, then price control is superior to quantity control, and vice versa.

Pizer (1998) showed in his simulation on global warming that price control mechanisms are by far more efficient than quantity control mechanisms. In addition, hybrid mechanisms incorporating both price and control mechanisms (Roberts and Spence, 1976) will not much improve the efficiency of price control mechanisms alone. If Pizer's argument is right, in the case of global warming, we should shed more light on price control mechanisms, both internationally and domestically. At the very least, we need to face the problem of uncertainty more squarely in the formation of future international agreements.

7. Concluding Remarks

Japan's economic situation has been problematic for more than a decade, and in terms of the marginal abatement cost for policy on global warming is concerned among the EU, Japan and the US, Japan's is by far the highest, followed by the EU and finally the US. In the pursuit of the ratification of the Kyoto Protocol it was shown, hopefully, that there are some intricate issues involved. With all the measures stated in the Japan's Climate Change Policy Program, Japan might well succeed in fulfilling the target. However, at least in some of the important areas, we know that important instruments such as economic measures are presently missing, so the attainment of the target is not certain. This indicates that even after the ratification of the Protocol we will need to keep an eye upon those difficult issues, and also devise new and comprehensive measures in order to secure the target. We also have to make post-Kyoto preparations, because the instruments we employ now will also facilitate the agenda in the post-Kyoto era. In order to do so, it will be necessary, especially in Japan, to evaluate policy both qualitatively and quantitatively.

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Note.

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1) For the global warming policy in Japan, fiscal years are mostly used in annual statistics.

2) In Japan emission of carbon dioxide from energy sources occupied about 88 percent of all GHG emissions in 1999. However, we should keep in mind that other GHGs are also important in meeting the target of the Kyoto Protocol (Burniaux 2000).

3) Babiker, *et al.* (1999) finds that in terms of welfare, attempting to meet Kyoto Protocol targets through rapid nuclear expansion rather than through applying uniform carbon tax or implementing a cap and trade system would be more costly.

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