WWF

WWF Scenario for Solving the Global Warming Problem
Index for 2010 and 2020
By Haruki Tsuchiya, Dr.

Prologue

Nearly four years have passed since COP3 or the Kyoto Conference was held in December 1997. At the Kyoto Conference, the developed countries, for the first time approved the resolution to set up timetable and quantitative targets to reduce emission of greenhouse gases (GHG). On the road towards the Kyoto, there were intense debates over how much reduction would be possible. The AOSIS or the Alliance of Small Island States, threatened by rising sea levels due to global warming, insisted at a very early stage, that the developed countries should reduce emissions by 20% from the 1990 level. The EU took initiative in the negotiations by agreeing to a 15% reduction. The United States and Japan did not clarify the target reduction quantity till the very end. And finally when their proposed reduction plan was presented, they set the lowest target for CO_2, i.e. 0%.

In autumn of 1997 prior to the Kyoto Conference, before the government proposal was publicized, a number of citizens organizations including WWF presented a reduction plan by a large margin based on a reduction scenario drawn up by civil society initiatives. WWF publicized "Key Technology Policies to Reduce CO_2 Emission in Japan" (1) in which it was shown possible to reduce emissions by 15% by 2010 from the 1990 level by the latest technologies available then. However, the Japanese government insisted the position of the 0% reduction of CO_2 emissions, or to stabilize the 1990 emission level. Even after the 6% target was set for Japan in the Kyoto Conference, the government did not change its position.

If the 0% reduction of CO_2 is definite, then how does the government plan to reach the target of 6%? Soon after the Kyoto Conference, the Fundamental Principles to Promote Global Warming Measures was adopted in which the following reduction plan was presented.

CO_2	0.0 %
CH_4, N_2O	- 0.5 %
3 industrial gases including HFCs	+2.0 %
Forests (sink)	- 0.3 %
Reduction including uncertain elements, and new technology	- 2.0 %
Emission trading and Joint implementation	- 1.8 %
Expansion of absorption sources	- 3.4 %
Total	- 6.0%

According to this plan, the reduction based on concrete policy measures is only 0.8% and the rest is largely depending on absorption by forests. Afterwards, this plan became the foundation of the Japanese government's negotiating position. The basic argument that takes into account of sinks from existing forests has become the government position for all negotiations on the Kyoto Protocol.

Setting a limit of 0% reduction of CO_2 emission, on the other hand, made Japan's negotiation position inflexible. Since there is no room to increase reduction of CO_2 emission more than 0%, to achieve 3.7% reduction by forest absorption has become a supreme task to achieve. Thus, the government did not have any cards or room to show various elements in negotiating with other countries. As a result, Japan failed to negotiate in the direction in which the Kyoto Protocol would make contributions to environmental conservation. On the contrary, Japan put on the negotiation table only arguments that were negative from an ecology point of view.

Meanwhile, the Bush administration totally rejected the Kyoto Protocol and announced that the United States will withdraw from it. With this new development that the US, a country with 1/4 the GHG emission of the world, is walking out, the Protocol is now facing a threat to its survival. The US government says that they will propose a new plan in place of the Kyoto Protocol. However, as long as looking at the Bush administration's energy policy paper, it is very unlikely that their proposal will lead to significant reductions in emissions and that the plan will be an alternative to the Kyoto Protocol. The Kyoto Protocol was a result of concessions through long negotiations of coordinating the different interests of countries. Once a country interjects doubt into the process, the balance between countries will be destroyed in an instance.

This report shows how it is possible to reduce CO_2 emissions in Japan and to make the Japanese government be more positive in its negotiating position for environmental purposes. With this report, we will help Japan to take leadership in ratifying the Protocol that will open up the door of enforcement of the Protocol and save the Protocol from the present crisis.

This report shows that far more reduction than 6% stipulated in the Kyoto Protocol can be possible. First, the scenario of the AIM (Asian Pacific integrated Model), the computer model, we used has already shown that minus 2% is possible. In WWF Japan's scenario, we sought for 10% reduction by adding new technologies. Further, as we considered it is quite realistic to utilize the Clean Development and Joint Implementation mechanisms, we allocated 2% reduction from utilizing such mechanisms for clean technology projects, among others.

We tried to simulate possible ways to reduce much more than 6%. Primarily, because we wanted the government to have negotiating cards. But even more importantly, we believe the target reduction level set by the Kyoto Protocol is not at all sufficient to prevent global warming. The IPCC (Intergovernmental Panel on Climate Change) in its second assessment report (in 1995) warned, "In order to stabilize the atmospheric CO_2 concentration at the present level, its emission shall be immediately reduced by 50 ~ 70 % and need to strengthen reduction efforts." Comparing with this assessment, the average 5.2% reduction agreed in the Kyoto Protocol is far too small.

At the same time, the numerical target for reducing emissions is also a tool to change the present social structure toward a low-carbon society. Social and economic structure can be changed along with implementation of measures to reduce emissions. In this sense, having clear targets is important. How to achieve the target is in a real sense, how to change the social and economic structure and it will set the future direction of society. This report shows how the introduction of technology can change the social structure and people's life-style. It aims to develop low-carbon society while achieving even larger reductions of CO_2 emissions in the future.

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Table of Contents

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By Dr. Haruki Tsuchiya

Executive Summary

In 1997, WWF Japan made a report for the COP3 entitled "Key Technology Policies to Reduce CO^2 Emission in Japan". Since then, WWF Japan has been studying workable policies for solving the global warming problem. For our report this time, we have worked on a scenario based on the latest knowledge and information.

1) Features of the WWF Scenario

There are four major elements in the scenario

1. Advanced technologies with high efficiencies;
2. Transformation to service economy;
3. Reforming our lifestyle
4. Clean Development Mechanism/Joint Implementation (CDM/JI)

Table 1 : Structure of the WWF Scenario

	Directions/policies of Scenario	Contents
Advanced Technologies with High Efficiencies	Despite present progress in variety of technological innovations, it remains uncertain if we can achieve feasible functions and lower costs of fuel cells and LED lighting. However, in the case of photovoltaics, their cost declines along with the learning curve. This indicates that not only research and development, but wide promotion of penetration holds a major factor to reduce the costs. Thus, in this scenario, this mechanism shall be actively pursued.	Hybrid cars Fuel cell vehicles Highly efficient fluorescent lights LEDs (Light Emitting Diodes) Inverter-controlled motors Fuel cell co-generation Amorphous transformer Highly efficient industrial furnaces Photovoltaics Wind power Biomass
Service Economy	In place of businesses that handle production, sales, usage and disposal of goods, businesses that provide services, repairs and recycling through rentals or leases shall be encouraged. This policy is consistent with the direction for a sustainable waste/resources management-oriented society in which materials and resources are used for longer terms with better care. At the same time, such businesses will help to create new employment.	To encourage renovation businesses To encourage rent-a-car businesses or car-sharing businesses Automobile maintenance Repair and recycle of electrical home appliances Office rental services Service for highly efficient utilization of motors (ESCO) Distribution of highly efficient light bulbs

Reforming our lifestyle	To date, our society has allowed over consumption of energy and resources. From now on, it is necessary to work for a lower consumption lifestyle through tax reform and/or incentive measures.	Incentives to promote small light-bodied cars Eco-train commuter passes Eco-driving licenses Usage-control of excessive lighting, cooling, heating and air conditioning
CDM/JI	Reduction of greenhouse gases shall be done in the most cost-effective way through energy conservation or clean technology projects between developed and developing countries (CDM), as well as between developed countries (JI).	Construction of natural gas power plants Installation of photovoltaics, wind power, biomass and biogas power generation facilities Energy conservation technology transfer

2) Simulation Method and Results

We used the AIM (Asia-Pacific Integrated Model) model of the National Institute for Environmental Studies, for calculating the simulated effects of the proposed new technologies and policies. The AIM model has already shown clearly that the emissions of greenhouse gases can be minus 2% in 2010 from the 1999 reference year level, by incorporating various technologies including home insulation system, improved efficiency of electric appliances and changes in industrial technologies. Through the above proposals, WWF scenario has shown that a 10% reduction as a whole, from the 1990 level can be possible. We tried to work out an additional 2% reduction from the 1990 level by using CDM/JI.

Table 2 CO_2 Emissions by WWF Scenario
(Ratio to 1990 level in brackets with 1990 being100%)

Sector	1990	1998	2010	2020
Industry	514	499 (97)	451 (88)	391 (76)
Household	139	152 (109)	124 (89)	100 (72)
Business	123	143 (116)	114 (93)	104 (85)
Transportation	217	265 (122)	205 (94)	162 (74)
Energy Transformation	57	61 (107)	54 (94)	44 (76)
Total	1,051	1,120 (107)	948 (90)	802 (76)

Unit: million tons CO_2

Table 3 Final Energy Consumption (Ratio to 1990 level in brackets with 1990 being 100%)

Sector	1990	1998	2010	2020
Industry	7,548	7,823 (104)	7,594 (101)	6,903 (91)
Household	1,797	2,078 (116)	1,975 (110)	1,841 (102)
Business	1,484	1,865 (126)	1,734 (117)	1,763 (119)
Transportation	3,171	3,893 (123)	3,018 (95)	2,382 (75)
Total	14,001	15,659 (112)	14,321 (102)	12,889 (92)

Unit; GJ

3) Policy Recommendations

If the above policies are implemented now, there is a good possibility that the Japanese government can reduce greenhouse gases more than the target level agreed at COP3.

1. Foreword

The objectives of the WWF Japan's Scenario study project is to assess the possibility of reducing GHG (Greenhouse Gas) by 2010 and 2020 in Japan and to make significant contributions to global environmental solutions.

In general, to reduce GHG is considered to hamper economic development and lower our living standards. But, once we review our life-styles, it is quite clear that there are quite a few areas that can be improved, such as technologies with low energy efficiencies and over consumption of raw materials and energy.

Shifting from low efficient energy technologies to the latest and higher efficient energy technologies stimulates research and development, promotes technological innovation and creates economic development. To reduce over consumption of materials and energy means to improve our life-style to be more comfortable. It does not mean to reduce economic activities, but to create a society functioning on lower consumption of resources. The WWF Scenario is seeking for these possibilities.

In developing the WWF Scenario, the following areas were looked into:

- Efficient technologies already known
- State-of-the-art technologies that are expected to be introduced for wide use in society
- People's knowledge and experiences to be utilized in service sector
- Attempts to shift economic mechanisms toward lesser resource consumption, such as leasing and rental business
- Life-style reform through tax and social mechanisms
- Energy projects that can be achieved overseas.

Afterwards, through computer simulation and modeling, possible emission reductions were quantitatively assessed.

1) Structure of WWF Scenario

There are four major elements in the scenario.

- Advanced technologies with high efficiencies
- Transformation to service economy
- Reforming our lifestyle
- Clean Development Mechanism/Joint Implementation (CDM/JI)

Table 1 : Structure of the WWF Scenario

Elements	Directions/policies of Scenario
Advanced Technologies With High Efficiencies	There are many highly efficient technologies available. But, in many cases, it takes time for wider penetration. Despite present progress in variety of technological innovations, it would take time to lower costs. However, in the case of photovoltaics, not only research and development, but also how fast its utilization can be promoted widely have been major factors to lower costs. Thus, if we can use this mechanism in positive way, technologies with high efficiencies can be promoted widely in the society.
Service Economy	In place of businesses that handle production, sales, usage and disposal of goods, businesses that provide services, repairs and recycling through renting or leasing shall be encouraged. This policy is consistent with the direction for a sustainable waste/resources management-oriented society in which materials and resources are used for longer while positively utilizing people's knowledge and experiences. At the same time, such businesses will help to create new employment.
Reforming the lifestyle	To date, our society has allowed over consumption of energy and resources. From now on, it is necessary to work for a lower consuming life-style through tax reform and/or incentive measures.
CDM/JI	Reduction of GHG shall be done in the most cost-effective way through energy conservation or clean technology projects between developed and developing countries (CDM), as well as between developed countries (JI).

Based on the above fundamental ideas, more than forty measures to reduce CO_2 emission are proposed in the WWF Scenario. Table 2 shows the breakdown by energy consumption sectors.

Table 2 CO_2 emission reduction measures

sector	Energy conversion and industries	Transportation	Commercial	Household
Advanced Technologies with High Efficiencies	LED (Light Emitting Diodes) Amorphous transformer Inverter-controlled motors Digitalization of paper through IT revolution	Hybrid cars Fuel cell vehicles	LED Hf fluorescent lights Guidance lights with LED Fuel cell co-generation Amorphous transformer Energy conserving vending machines	Highly efficient refrigerators Internal burning gas cooking stove Passive solar Fuel cell co-generation LDC personal computers
	ESCO(Inverter	Rent-a-car	Repair and	Repair and

Transformation to service economy	control motor) Extending lifetime of a building through renovation business	businesses Automobile maintenance	maintenance of electric appliances Office rental services Distribution of highly efficient light bulbs	maintenance of electric appliances Distribution of highly efficient light bulbs
Reform of life-styles		Incentives to promote small light-bodied cars Eco-driving licenses Eco-train commuter passes	Control of over consumption of lighting, over heating and over cooling	Decrease the stand-by electricity consumption

2) Simulation Method and Results

We used the end use model of the AIM (Asia Pacific Integrated Model) model jointly developed by the National Institute for Environmental Studies and Kyoto University, for calculating the simulated GHG reduction. This model has already been used for international scenario studies such as IPCC's assessments, and is very well known as the end-use type model that can assess energy technology for the end use. The WWF Scenario sets up numerous technologies and needs to calculate in the manner that the technologies are rightly incorporated without controversies.

In this report, we focused only on CO_2 emissions among other GHG. Out of six GHG agreed to be reduced at COP3, CO_2 has the most influence on the greenhouse effect constituting nearly 90% of all GHG. The five GHG stipulated in the Kyoto Protocol are methane, di-nitrogen monoxide (N2O), HFC (hydrofluorocarbon), PFC(perfluorocarbon) and $SF_{6,}$
Methane and di-nitrogen monoxide are emitted from agriculture facilities. HFC is used for coolant materials in heating and cooling appliances and facilities, coolant materials and foam insulation in refrigerators. SF_6 is used as insulation gas in facilities like power transformer stations. Needless to say, it is important to reduce emissions of these GHG. But, we do not touch upon them in this report. Instead, we only worked on CO_2 emission from energy and energy-related use.

2. Advanced Technologies with High Efficiencies

At present, a variety of technologies with high-energy efficiency is being developed. In this chapter, the hypothesis is that once mass production of new technologies begins, such as fuel cell vehicles, fuel cell co-generation, and amorphous transformers, the learning effect works and we can achieve lower costs.

As methods accelerate wider use or distribution of new technology whose costs are lowered to certain level through research and development effort, it is effective to allocate government subsidies not just to research and development but also to penetration in society. A well-known success is the case of photovoltaics (PV) in Japan.

The cost of PV has dropped dramatically in the past 20 years. According to analysis using the learning curve, the cost has been reduced by 82% when the cumulative production of PV is doubled. In the 1980s, subsidies for research and development worked effectively and in the 90s subsidies to promote the utilization resulted in lower cost [(2)]. By utilizing this mechanism of subsidies for promotion, we may stimulate mass production that can achieve lower costs as shown in the learning curve, and accelerated distribution of new technologies should be possible.

We assessed the possibilities to widely apply the state of the art energy efficient technologies that are just about to go into the phase of commercial use. The result of each category of technology is reported below.

However, the well-known energy conservation technologies such as insulating houses and air tight houses are already included in the technical list of AIM. Thus, we do not make any specific explanations about them in this chapter.

1) Hybrid Cars

Combining an engine and a motor, a hybrid car's fuel economy is twice as high as a gasoline car. A Toyota hybrid car first released to the market in 1997 is highly efficient with a fuel economy of 28km per liter, two times higher than general passenger car. Toyota hybrid car has already sold 50,000 cars by the end of 2000.

The development of hybrid cars is very competitive among automobile companies. Honda has announced its new car, "Insight" that can drive 35km per liter. Daihatsu announced a plan to develop and sell a hybrid light car. The hybrid car can run using existing gasoline and does not require new investment for fuel supply infrastructure. Thus, its use may grow very quickly. By as early as 2010, it is expected to be a strong competitor against the fuel cell vehicles.

The hybrid car is a revolution in automobile technology. It can be effectively used as the car with the highest efficiency till the higher efficiency fuel cell car is used widely. In WWF Scenario, it is estimated that hybrid cars would have 60% share of all automobiles by 2010.

In order to reach this level, the policy to promote hybrid cars will be important. For example, at national and local governments policy level, they can give precedence to hybrid cars when buying official vehicles or allocating specific space for hybrid cars in public car-parks. If they can help send out a message of how important the hybrid car is for our future, we will be able to promote the hybrid car to a very popular level.

2) Fuel Cell Vehicles

The fuel cell vehicle is a car that runs on electricity generated by a fuel cell. At present, this technology is undergoing the most competitive development in the automobile world. The fuel is hydrogen and hot development is taking place in the area of hydrogen generation. Fossil fuels are one of the sources of supply for hydrogen. But in the future when hydrogen from photovoltaic cells can be used, fuel cell vehicles will be used as the car with very little environmental impact.

Compared with conventional gasoline cars, the fuel cell car has a higher efficiency during acceleration and as it can use a regenerative brake, it will be an extremely high efficient car for use in the city. The development of automobile with fuel cells depends on how to lower the costs for PEM (proton exchange membrane) and platinum catalyst (estimated weight of platinum is 10 -20 grams).

The fuel cell stack 15 years ago was as big as the vehicle itself and but has become so small that it can be installed under the hood of a light car. Its volume has been improved very rapidly to less than one liter for 1kw. Mass production of fuel cell cars has been announced by major car manufacturers; Toyota aims for commercial production in 2003 and Daimler-Chrysler in 2004.

The major question is how to supply hydrogen. Natural gas, methanol and gasoline are possible sources. A highly efficient system shall be developed whereby hydrogen shall be injected into a bombe or hydrogen absorbent alloy in the car depending on whether the hydrogen shall be obtained through reforming device in the car or at the gas station.

In the WWF Scenario, it is estimated that 3% of all passenger cars will be fuel cell cars by 2010 and 60% will be fuel cell cars by 2020, taking over from hybrid cars.

The size of automobile fuel cell should be 30 - 50 kW. But, when using the cell for household co-generators, 1 - 2 kW should be sufficient. Once the fuel cells for cars are mass-produced, fuel cell co-generating systems may become practical at home and businesses, providing electricity, hot water and heating at the same time igniting a new energy revolution.

3) Inverter-Controlled Motors and Motors with High Efficiency

Rotary machines such as fans, blowers and pumps can be efficient when using an inverter for the current control. In conventional systems, these hydrodynamic machines work by a stable current speed adjusted by the damper control. But, using the inverter control that can rotate the motor at the required number of revolutions, it is possible to allow only the required amount of hydraulic power to be sent. It is found that in this way, the energy consumption can be reduced by 30 - 50%.

It has already become common sense to use the inverter control for small motors and motors used in home appliances. The motor and control are used as one device.

However, conditions are quite different in the case of large motors. In particular for the industrial sector, how to apply inverter controls on motors using high voltages between 250 and 400kW is presenting a very large challenge. The potential market is estimated to be more than 2000 MW.

The improved efficiency ratio of the high efficiency motor to the conventional motor ranges from a few percentage points to 5%. It does not seem so significant. However, for motors that run over 3000 hours per year, it is more economical and rational to replace them with high efficiency motors. The technology of high efficiency motors continues to be improved. Not only can high efficiency motors be used for new installations, they also can replace conventional motors.

4) Co-generation

Co-generation uses oil or gas as fuel and provides electric power and heat through combined utilization of power generation and exhaust heat produced by diesel engines, gas engines and gas turbines . When they are used only for the purpose of power generation, only about 30% of total energy input is being utilized. If there is a need for heat, the exhaust heat can be recovered.

Co-generation can raise energy efficiency as much as nearly 80% by recovering exhaust heat. When fuel cells are supplied on a mass-production basis in the future, co-generation by fuel cells will be widely used. Even at present, co-generation by oil and gas is economical and is very effective for reducing CO_2 emissions.

It is being increasingly used in many facilities including both Japanese and western style hotels, hospitals, restaurants and supermarkets. Since the potential demand is very large, we need to promote it for a much wider use.

5) Lighting Technology

It is said that 50 - 60% of electrical consumption is for motors and around 20% is for lighting. It is not clear how much electricity is exactly used for lighting purposes. But, lighting is extremely important area for energy conservation efforts.

The fluorescent light's efficiency is 4 - 5 times higher than incandescent lamps. The lifetime of incandescent lamp is 1000 hours and that of fluorescent is 6 - 7000 hours. It has an excellent economic feature. The fluorescent bulb of 22 watts that can provide the same luminosity and color rendition as the 100 watts incandescent lamp is currently being sold on the market and is rapidly expanding its share. In reality however, incandescent lamps of various shapes and sizes are still being used. We need a policy to promote the shift to use fluorescent bulbs.

The highly efficient technologies on the fluorescent lights are emerging. The high frequency cycle inverter fluorescent lights has 20% higher efficiency than the conventional type and sufficiently economical. But, change over from the conventional fluorescent lamps is very slow. There is a wonder why replacement does not happen in factories and offices at much faster speed.

The non-filament streetlights are lamps without filaments. It is a new technology to light fluorescent lamps using the high frequency of 13MHz. Its efficiency is twice as high as that of the conventionally used mercury lamps. It requires large amount of investment at the early stage, but the maintenance costs will decline over its service lifetime that is well over 60,000 hours. It can be used as a streetlight and has already been commercialized for that purpose.

It is important to raise the efficiency of emergency lights that are always on in the building throughout the year, i.e. 8,760 hours. The high luminosity emergency light of the cold cathode fluorescent tube (CCF) type mostly used for the back light of personal computers requires one-fourth to one-seventh the electric power consumption of conventional fluorescent type emergency lights. But, the price is the same. Since it was officially approved under the national fire protecting law, shipments of CCFs have increased to 60% of all emergency light shipments at present. The number of emergency lights in Japan is now 8 million, totaling 180MW. By 2010, the majority of emergency lights shall be replaced by the CCF-type.

The lighting technology that may be able to provide illumination with a higher efficiency and longer service lifetime than fluorescent lights is the LED (Light Emitting Diode).

Traffic lights and emergency lights with LED technology are already being produced commercially. These lights have sufficient economic efficiency because they require less energy and last longer.

LED emergency lights can decrease power consumption to half of that of a CCF-type emergency light. The commercial product has been made and announced. All that is needed is to promote it.

There are 970 thousand LED traffic signals installed at 170 thousand street crossings in Japan. Each of those LED traffic signals use three colors, i.e. red, yellow and blue. One of the three incandescence lamps must be on throughout the year. While the presently used traffic signal with incandescent lamps is 70 -80 W, the LED signal is only 16 - 22 VA (approximately 17W), thus using one-fourth the power consumption of regular traffic signals.

The efficiency of LED as luminous lights is not higher than fluorescent lights at present. But, it is expected to be two times that of a fluorescent light in several years. However, because of their high luminosity, LED lights are now beginning to be used for signal lights in factories, and it is possible to be used for traffic lights. LED lighting is being encouraged for capturing/processing digital images such as in inspection devices used in the factory. In such facilities, the disconnection of electric light bulbs can cause problems, but you do not have to worry about that with LED lighting systems. For certain purposes, practical use of LEDs may begin quite early, and along with the learning curve, their costs are expected to drop. By 2010, LEDs may take over conventional lights in hotels, retail stores and restaurants. Higher lighting efficiency itself is a way to conserve energy, but it also means less heat is created, thus decreasing the burden for cooling, as an additional effect.

6) Amorphous Transformer

Transformers take in electricity and convert it into high or low voltages depending on the purpose and then supply that converted electricity. Current transformers use silicon steel plates. Instead, transformers using amorphous metals are increasing. The amorphous transformer decrease the iron loss that happens while there is no load (caused by the electric eddy current) to one-fifth, and copper loss (happens when electric current is flowing) to two-thirds, and the total loss to one-half of that of conventional transformers. The efficiency changes by operation factor. The lower operation factor is, the more efficiently the iron loss is decreased. The amorphous transformer exactly fits this objective.

The areas that the amorphous transformer can be applied include the transformer in the energy conversion sector, the transformer installed at the entrance of a factory that uses high electric voltage in the industrial sector and the transformer used in large commercial compounds and in large office buildings in the commercial sector.

In the WWF Scenario, we researched the possibilities of application in these sectors. In the case of replacement of conventional transformers and for new installations, we estimated their applications.

The market is extraordinarily large. Amorphous transformers are still expensive compared to conventional silicon steel plate transformers. But, once production ramps up, the learning effects can lower the cost and accelerate its usage.

7) Energy Conservation of Vending Machines

There are 2.54 million vending machines each using 603 watts of average rated electric power and 342 watts of average power consumption. According to the research of the National Institute for Environmental Studies, it would be possible to conserve 54% of this energy consumption without incurring a significant increase in cost. [3]

The methods to conserve energy are external installation of motors, incorporation of internal box into one unit, air tight design for the inside and delivery chute area, elimination of excessively bright lighting, strengthened insulation system and utilization of highly efficient compressors.

The service lifetime of a vending machine is around seven years. Therefore, there is a good possibility that all vending machines can be replaced by energy efficient ones by 2010. However, some problems do exist. The owner of the vending machine is the maintenance company that supplies soft drinks. But the actual electricity bill is paid by the store or business where the vending machine is installed. Even though the energy conservation type vending machine is installed, the benefits of it will go to the store and not to the owner. In this case, the incentives to conserve energy would not work well. It is important to set up a consultative body to improve the owner-vender relationship and find a way to develop a mutually beneficial system.

8) Information Technology (IT) Revolution and Non-Materialistic Economy

Innovations in microelectronics technology are expected to continue for sometime in the 21st century. The development to improve the functions of large-scale integrated circuits and to lower prices will continue. Along with the explosive expansion of the communications infrastructure, microelectronics is now integrated into the social system in various ways.

Some say that information technology (IT) is playing a key role in changing the structure of the economy from that of the smokestack economy to that of the information economy. Such good examples can be seen in the rapid expansion of the Internet, daily use of e-mail communications, increased electronic publications and the emergence of electronic commerce. Most definitely, IT has the potential to raise the energy and resource efficiency in society.

The most significant benefit of the IT revolution is that much information can be disclosed very easily at low cost to many people. In the long run, this is a change towards a direct democracy. Even just limiting the effect to the environment, energy and resource issues, it is beyond our capability to assess how significant it will be when everyone can easily access all related information. The result might be the unprecedented consciousness revolution that leads society to energy conservation, recycling and changes in life-style. Nobody can deny that the many TV images from the West had a very powerful effect behind the collapse of Cold War at the end of 1980s. The same analogy can be applied to the Internet. The IT revolution improves quality and increase the volume of open information to the public, and assists people in their decision-making.

In the developed countries, the production of goods is at the level of maturity. In such an economy, a desire for more economic growth should be focused in the areas that are not related to material resources. In short, new steps towards a non-materialistic economy or the digital economy without friction will begin. It is economic activities for producing beneficial services for people without significantly consuming iron, cement, or paper. Such activities must make people’s quality of life richer, while absorbing unemployment and making contributions to income redistribution. These are the roles expected of IT.

The things expected to happen are the use of telecommunications in place of transportation, the use of electronics as an alternative to paper resources, the resulting higher speeds by combining telecommunications and computer power, and new business related to the efficient use of resources and energy.

In December 1998, the Climate Energy Center, a Washington based non-profit organization, published a report, “Online shopping is useful to reduce CO_2 emissions.” According to the report, Amazon.com, the famous online bookstore, uses only one-sixteenth the energy of a large-size book store, and as they do not require book shelves or display space, they only need a small budget for building space and maintenance costs. On the users side, if you use online businesses, the required energy is less than driving to a shopping center. Different from conventional businesses that sell goods in a brick and mortar store, the online store can keep their stores and inventory small and do not need to pay for lighting or air-conditioning.

The future of the online market, both “B-to-B” (Business-to-Business) and “ B-to-C”

(Business-to-Consumer) seems be over-hyped. But, they have the potential to drastically change our ways of shopping and doing business. It is full of potential of new business opportunities including, small-scale production, electronic purchasing of parts and materials, online bidding and one-to-one marketing.

According to the research of the Ministry of Posts and Telecommunications, satellite offices and the video conferencing will allow more people to work at home and will change office working conditions. And by the early 21st century, transportation demands are estimated to decrease. In the US, it is said that the number of flights used by businessmen is decreasing due to the popularization of the Internet. There is a freight handling business that uses the Internet for information on cargo demand, thus improving the load rate of empty trucks.

In one collective housing complex in Japan, a trial is being carried out on the joint-use of electric cars. In this experiment, IT is playing a major role in making reservations. It is not so new to argue the alternative roles between transportation and telecommunications. But, in reality their relationship was not that of substitution, but beneficial synergy. In short, telecommunications helped to expand transportation. Now, this relationship is about to truly change. It is already clear that e-mail is helping to reduce the need for transportation.

Active use of computers may substitute the use of paper. There is growing possibility of delivering printed matter like brochures and manuals, books and newspaper by the Internet or other electronic tools, instead of delivery by trucks.
When digital publication advances further, PDAs (personal digital assistant) and small and portable terminals will be available as exclusive readers. When newspapers, news pictures, comics and fiction are supplied through the Internet, the need for paper will decrease. Presently, 40% of the books are sent back from bookstores to publishers. Bookstores are facing difficulties to keep space for new books that are published in large quantities everyday. The publishing companies are now beginning to work on electronic publications of comic books and on-demand publications that revive out-of-print books. Britannica stopped printing their encyclopedia but the contents can be searched on the Internet. Sooner or later, books printed on paper may be limited only for those of very expensive publications. Books and images transferred by the Internet can be read as if you were turning each page using a small electronic reader. They are the digital newspapers and books.

Comparing the energy input of conventional newspapers/books and the electronic reader, digital newspaper and books conserve paper usage and may raise energy efficiency by 40 – 220 fold. But, in case of the electronic reader, you can not see an entire page of newspaper at once, and still many technical matters are remaining unsolved such as the environmental effect of battery disposal and improving liquid crystal display contrast.

The IT revolution also has a wider potential of higher efficiency not only in electronic publications but also in areas relating to material resources and energy consumption. The increased Internet shopping decreased the number of retail stores, made energy consumption for lighting and air-conditioning unnecessary and made it possible to reduce the size of inventory.

Certainly, there are problems in the IT revolution. We need to analyze whether specific small parcel transportation is more energy efficient than bulk transportation. The convenience of electronic mail can also increase the flow of junk-mail that results in the unnecessary over flow of information exchange. Saving time with IT technology has the potential to create a fast growing economy.

Table 3 lists the effects of the IT revolution on material resources and energy. As described so far, the IT technology has both potentials and problems. The WWF Scenario emphasizes the digitalization of paper. It estimates that 1 million tons of paper consumption will be reduced by digital newspaper and books.

Table 3 Effects of the IT revolution on Material Resources and Energy

Social changes brought about by the IT revolution	Effects on material resources	Effects on energy consumption
Wider range of information on resources, energy and environment are provided	Increased recycling of resources Shift to less resource consuming lifestyle	Spread of energy conservation consciousness
SOHO (small office, home office) Satellite office TV conference system	Decreased investment in office construction and facilities building	Decreased needs for transportation service
Electronic commerce (B-to- C and B-to-B)	Decreased investment in store and storage construction and facility building	Decreased public transportation needs Increased small individual package delivery service
Transmission of digital books, newspaper, music and images/pictures	Decreased paper consumption	Decreased freight transportation needs
E-mail	Decreased paper consumption	Decreased public transportation needs
Junk mail		Increased wasteful consumption of electricity
Detailed computer management of delivery system	Improved material yield Improved inventory turnover ratio	Improved transportation efficiency Improved loading efficiency
One-to-one marketing	Decreased loss of estimated production	Decreased bulk delivery Increased small package delivery
Highly efficient products by computer control		Decreased energy consumption
Energy Star Plan	Increased electronic circuits for power saving purposes	Decreased power consumption
Increased stand-by computer and telecommunication machines	Increased material resource consumption	Increased power consumption
Increased speed of production and consumption by reduced time	Increased material resource consumption	Increased new demands for public transportation Increased new demands for cargo transportation

9) LCD Personal Computer

There are two types of personal computer displays. One is the CRT (Cathode-ray tube) and the other is the LCD (liquid crystal display). Comparing their power consumption, the CRT display consumes 120W and LCD display consumes less than 20W, one-sixth of that of the CRT. At present, LCDs are more expensive than CRTs. However, LCDs generate less heat. There is less need for cooling even during summer. It requires a smaller space so that more effective use of office space may be possible. Because of these features, an increased number of companies are introducing LCD displays.

In places where the computers are used longer hours per year or many computers are used in a smaller space, the LCD computer is more economically beneficial as it requires less power supply capacity. With further increase of LCD production, the costs will be lower, the LCD may have more economic benefits than the CRT even in the area of just electric power consumption.

3. Service Economy

In the present society, economic activities are operated based on production, distribution and consumption of goods. However, the value generated by services, and not by production of goods has become larger in recent years.

In replacing businesses that handle production, sales, usage and disposal of goods, businesses that provide services, repairs and recycling through renting or leasing shall be encouraged. This is consistent with the direction for a sustainable waste/resources management-oriented society in which materials and resources are used longer with better care. At the same time, such businesses will help to create new employment.

This kind of shift to the service economy decreases activities depending on the goods. Instead it has the potential to generate new economic activities which require less consumption of resources and energy. In this chapter, we will focus on these activities. As examples of the service economy, we report the following cases including the renovation business and the car rental business.

1) Encourage Renovation Business

Though it increases demands for repair materials, the building renovation business can decrease consumption of material resources, as it can prolong the buildings' life and decrease demands for new construction materials. According to our life-cycle assessment of buildings, a wooden house with $100m^2$ floor space releases about five tons of CO_2 calculated in terms of carbon, when it is newly constructed. If you made this house to be used 5 years longer by renovation, then emissions of CO_2 will be decreased accordingly to the extended lifetime. In this report, we estimate that demands for renovation will be 100,000 houses per year by 2010. Sales of newly-built houses is relatively a simple business. But, in case of the renovation business, you must meet the individual complex needs of each customer. So, the service economy business will be a major factor. The successful development of this business is related to the level of social maturity. It implies challenges that we must solve in the future.

2) Encourage Car Maintenance Business

Here, we consider the mechanism that can support the car maintenance service. People have less interest in maintenance and check-up of cars because fewer problems are occurring and the term for mandatory inspection was extended. The driver of a vehicle that runs on public roads and streets must maintain his/her car to run always at the best condition. The one well-known example shows that when you drive a car for 50km whose air tire pressure is 0.5kg/cm^2 less than normal level, you would waste about 150cc of fuel (stated in “A Better Environment for Future Generation”, Japan Automobile Manufacturers Association Inc.). If you continue to drive 10,000km, you would waste 30 liters of fuel. Assuming you are driving a small car with a fuel economy of 12km/liter, if you drove 10,000km, the annual fuel consumption will be 833 liters. In case your tire pressure is the same as above, you would waste as much as 3.6%of your annual fuel consumption or the equivalent of 30 liters of fuel over a year’s time.

From this estimation, maintenance service that provides periodic inspections of a car’s running condition is extremely important. Good automobile maintenance can contribute to improved fuel consumption and safety. Such maintenance service shall include checking of the air pressure in the tire, adjusting the wheel alignment, checking the load weight (remove unnecessary things from the trunk), lessen the air resistance (by cleaning the car regularly), changing the engine oil and checking the brake shoe.

To encourage drivers to have their cars inspected, they need to be rewarded. For example, one incentive can be that the service station rewards the driver with a point every time he brings his car in for inspection. After the driver accumulates a certain number of points, both the service station and customer are rewarded. For example, the service station receives some form of a subsidy and the customer receives tax credits. Even if the actual value of the subsidy is small, it is important to disseminate information that the national or local government is encouraging car maintenance.

Another example is to train someone who has sufficient knowledge about automobiles to become an expert on car maintenance. You could then certify such persons as an “eco-drive keepers” or “eco-drive mechanics” who help to maintain your car. Automobile maintenance will help to encourage the service economy as a whole. In this report, we assume 8 million vehicles will receive this service by 2010, and fuel consumption will be improved by 3%.

3) Encourage Car Sharing and Car-Rental Business

The attempt to share cars is showing progress in Europe. In 1991, the European Car Sharing Association was established, initiated by Germany and other major European countries. The car sharing system in Germany requires first that you become a member, paying 240 Deutsche marks for the annual membership. Then, you receive a handbook and a personal key or card. You can reserve a car any time you want through the internet or telephone. One hour in advance is almost always good enough to reserve a car. You can select all types of vehicles from buses to small passenger cars. When you want to use a car, you go to the car “station” where your reserved car is parked. Using your personal key or card, you receive the car key from a safety box at the car station and drive away. No staff is required at the car station and the car stations are situated near residential areas. After using the car, you park the car at the same car station and return the car key to the safety box.

The car sharing system of Switzerland is well known as a success story in the Energy 2000 Plan [(4) (5)]. As of 1998, already 20,000 people have used the system in which 900 cars in 600 stations are used. In the beginning, telephone reservations were only possible, but now, you can make reservations via the internet. When a reservation is made, the data is transferred from the reservation center to the car. The person who made the reservation can open the car with a smart card. All data is recorded in the computer installed in the car and it will retransfer to the reservation center automatically.

Early market research indicated that many of the potential customers did not have any questions on the principles of the car sharing idea. The most frequently asked question was "Can I use a car any time when I need it?" Another question asked by many people was "Is a car station located in a convenient place close to my house?"

Eleven years have passed since car sharing began in Switzerland. Now, 70% of the population has heard of the term "car sharing" and 50% know what it is. It is reported that car-sharing users who gave up owning a car have shortened their annual driving distance to 72% of the annual distance they drove when they used to own a car. The users began using public transportation.

When you own a car, you tend to think it would be a waste if you do not drive, because you have already paid a lot for the car. But, if you have to pay each time when you use a car, your way of thinking changes.

There is a trial of this type of car system using an electric car and information technology in Japan. The Association of Electronic Technology for Automobile Traffic and Driving began the trial car sharing program using electric cars in Minato-mirai district of Yokohama City. The target users are business persons. The users can reserve cars by the internet or telephone. The pick-up and return system for the car is self-service. The Japan Electric Vehicle Association started an experiment of a similar system using small electric cars in Kyoto City. The users confirm the reservation by inserting their membership IC cards in the terminal installed in the car "station". The same card can be used as a car key when driving.

These kinds of experiments can stimulate the present car-rental business in the end. The car-rental business will therefore, supply services that can improve the fuel economy of a car. They could also carry out professional car maintenance that in reality will be the service of supplying longer utilization of resources.

4) Maintenance and Repair Service of Home Appliances

In many cases, home appliances are sold at discounted prices by the super discount stores. Their main work is to sell home electrical appliances. When an electrical product sold by them needs to be repaired, the cost may be very high or it takes a long time. It is much easier for the consumer to buy a new product than asking for it to be repaired. But, in many cases, the products can easily be repaired by changing a part.

One such company saw this problem as a business opportunity and has achieved a runaway success in the repair business. When a customer brings in a broken television or a video deck, the company opens the back of the appliance in front of the customer, to check for broken parts. If they find a problem, they estimate the required hours or days and how much it will cost to repair. All of this is done for free of charge.

If the customer agrees to the cost estimate, then the repair work will begin. In general, repairs are usually completed within two days. If it takes longer than two days, the company is penalized $2 a day. Consumers tend not to ask for a repair if it takes a long time. Keeping the repair time short is an extremely effective way to win consumers.

Repair costs generally range between $30 and $120. But, depending on the conditions and the types of products, the costs may be more.

This company offers a visiting repair service. But, there are limits in terms of time and distance. Repairs outside of the shop are limited to within 10km.

One outstanding characteristic of this kind of home appliance repair shop is its very close relationship with the local community. This home appliance repair business company is so successful that they are developing the chain shops in other places in Japan.

Generally, the repair business is considered low technology. But it is not true. First, you need information and experience relating to the very many electrical appliances. Second, you need information on how to repair or how to get replacement parts. This company manages such information on a computer database that can be used for the next repair service. They keep a stock of important parts that can be used any time. Thus, the repair business is an information service industry of quite high quality.

In the present aging society, people who have difficulties to go out are increasing. For them, electrical appliances are becoming increasingly indispensable tools for survival. This is a potentially large market to exploit.

The repair business may also effectively utilize community "experts" who have rich experiences and deep knowledge on electrical appliances. Until recently, this kind of work was considered not profitable as business, because it requires a lot of time and work. But, if we define such work of finding solutions as business, then it is exactly here that we can find potentially a new business.

It is important to make recycling and repairs as a business. What the government can do in this sense is to establish support and incentive policy measures. Such measures can include establishing a system that encourages consumers to use repair shops, to provide tax credits for repair business managers/owners, to support the training of repair technicians and to support the collection of repair knowledge and information. Once this service becomes stable as a business, it can not only promote the more effective use of resource materials, but also provide employment opportunities for senior citizens.

5) Improving Insulation in Office Buildings

The cost of heating in a office depends on the insulation capacity of the building. In case of the tenant office buildings, owners of the building are not likely to make any investments for improving the insulation, because they want to keep the maintenance cost as low as possible. In such a case, the tenants of the office are likely to consume a lot of energy for heating. This means that there is no possibility for tenants, who pay the energy cost, to conserve energy.

We need a mechanism that can provide some incentives for energy conservation to the owner of the building. To do so, a system of information disclosure and assessment is needed. The energy conservation criteria of the building must be clearly disclosed, and the tenant must be able to access this information.

The service economy has a potential to solve this problem. The building owners may provide services derived from the building at the lowest cost utilizing their knowledge and experiences. They shall receive rewards for the service from the tenants. Then, both the tenants and the owners would understand how large the running cost is in the building's life cycle cost. The owner and tenants would be able to work jointly towards saving energy. A consultative body as a social system shall be formed to discuss these interests. They can start by discussing feasible actions.

6) ESCO (Service business for efficient use of motors)

ESCO, the Energy Service Company makes energy conservation a business. At present, ESCO mainly improves the energy efficiency of lights and insulation in public buildings. ESCO first proposes the energy saving plan to the owner of the building. When accepted, they carry out the energy-saving construction. They are paid a part of the energy cost saved by the plan, as a reward. This business is about to begin in Japan, as well.

Hitachi applied for a business model patent on their energy conservation business. In this model, Hitachi lends a inverter-controlled motor to the factory and is paid part of the saved energy cost. Their first business model called HDRIVE has been established.

It is generally well known in the industry that using an inverter to control the rotation of the motor (used in fans, blower and pumps) can save between 30 and 60% of the energy costs compared to that of the damper control type motor.

Inverter-controlled motors for 10-20kW low voltage motors (200-400V) are already being sold. The cost of the inverter is several tens of thousands of yen. The cost of the inverter and construction can be recovered in about three years. The motors of this type are increasingly being used for several kilowatt motors and home electrical appliances. There are motors that are incorporate together with an inverter in one unit.

However, industrial inverters of 250-500kW high voltage motors (3000V class) are not that developed yet. But, it is estimated that this type of motor occupies 80% of the inverter-controlled motor market. The HDRIVE of Hitachi is targeting high voltage motors as business customers.

Just looking at the steel industry, there are 2000 applicable motors. And in oil refineries, there are 2000 to 3000 motors. All industries as a whole, the demand for inverter-controlled motors could be estimated at 10,000 only for fans, blowers, and pumps. It had been regarded in the past that energy conservation devices would not be applied rapidly in these areas, because the payback period was as long as 5 to 10 years.

HDRIVE introduced a new concept in this sector. Hitachi standardized the motor and inverter control system to reduce costs. It further reduced the costs by providing different combinations to satisfy individual user’s demand. Hitachi will not sell the system as a whole, but will keep it and manage it as their asset, so that they can introduce a recycling system and have the freedom to upgrade the design as they wish. Needless to say, they would offer funds for the investment at the initial stage. All of these aspects has allowed Hitachi to develop an energy conservation business model. It is a business model not to sell hardware, but to sell energy saving services.

The cost of electric power for industrial use is as low as 3-10 cents/kWh. Therefore, it is not easy to recover the investment. But they estimate that it will take 10 years to recover the investment over a 15-year service lifetime. Assuming the present power consumption is 100, then HDRIVE’s energy saving system can lower it to 70. The saved cost is 30 that is shared by the factory and Hitachi. Obtaining profits from the saved energy cost is the same method that ESCO uses. The patent application was made not for the hardware, but for the measuring methods that makes energy conservation possible.

The estimated production is to cover about 50%, or about 2100 MW of the total demand of 10,000 units by 2020. This kind of new business model is considered to be one of the new directions for the Japanese economy.

7) Highly Efficient Light Bulbs Distribution Plan

There is a very big potential for raising the efficiency of lighting. Just changing an incandescent lamp to a fluorescent lamp, you can reduce power consumption to between one-third and one-fifth, and make the lamp last six times longer, up to 6000 hours.

In Japan, the price of fluorescent bulbs equivalent to an incandescent bulb of 60-100w is $12-$15. Fluorescent lights surpass the economic performance of incandescent lights when it reaches 1000 hours of use. Fluorescent lights are not very popular in restaurants and commercial facilities because they prefer the color rendition of incandescent lights. But, fluorescent lights with color rendition as good as incandescent lights are being sold on the market. A distribution plan of highly efficient lights is effective in order to disseminate information about such luminous lights with high performance to many people. Below are some examples of light bulb distribution plans in other countries.

(a) Light bulb distribution plan of Freiburg in Germany

In 1996, the Freiburg Energy and Water Supply Corporation (FEW) distributed free exchange tickets to all the 105,000 households, to whom they supply electricity by FEW. The tickets were specifically for exchanging incandescent bulbs with fluorescent bulbs whose power consumption is one-fifth of incandescent bulbs.(6)
The funds for this program came from the slight increase in electricity costs that were paid by the users. The life of an incandescent light is 1000 hours. But, before this energy saving light bulb reaches 1000 hours of usage, the investment is recovered while saving electric power.

(b) The compact fluorescent light (CFL) project in India

One example of the project to raise the lighting efficiency in the developing countries is the Compact Fluorescent Light Project of Karnataka Province in India. In this project, the electric power company provides investment to the CFL manufacturer, and the power committee buys the products, i.e. CFLs at the wholesale price to supply two to four fluorescent lights per household free of charge. Each household pays a portion of the CFL cost out of their monthly electricity bill. The remaining cost is shared between the electric power company and the power committee. In this way, the electric power company can save money that would otherwise be used for building a new power plant to meet the growing demand for energy. At the same time they do not incur such penalties as blackouts in the industrial sector or delays in constructing a new power plant. This results in additional benefits. The production of CFL is 1.8 million bulbs per year and the total cost is $1200 million. But the project brings in benefits worth many times more than that. In Bombay or Mumbay, there is a similar project called BELLE.

(c) The ILUMEX project in Mexico

There is the ILUMEX project in Mexico. In Mexico, the subsidy for household lighting is high. The lowest level is 1.8 cents/kWh. Under these conditions, CFL is not economical as it should be. ILUMEX is to be implemented as a joint project of GEF (Global Environmental Fund), United Nations and World Bank. The budget is twenty million dollars and 1.5 to 2 million CFLs will be produced. In the Mexican system, the more power that is used, the higher the cost per kWh becomes. Therefore, some households would have more advantage from this project. Each household pays six dollars for one CFL, or $1.65 as a down payment and pays the rest on a monthly basis through the electricity bill. The pay back period is estimated to be 1.5 to 2 years.

In the WWF Scenario, we investigated the high performance fluorescent light distribution plan, in order to increase usage of fluorescent bulbs, Hf high-performance fluorescent lights (20% higher efficiency than conventional fluorescent lights) and LED lights in the household and commercial sectors (such as restaurants).

In our distribution plan, local governments, electrical appliance retailers, electrical appliance repair business, ESCO and other related people are invited to join as major players. They raise funds and buy high performance luminous lights in large quantities from manufacturers. These high-performance lights are then sold to households, retail stores and factories at discount prices. Discount tickets shall be distributed through local government offices and electrical appliance stores. This plan takes advantage of bulk-buying that provides discounted prices for buying efficient light bulbs.

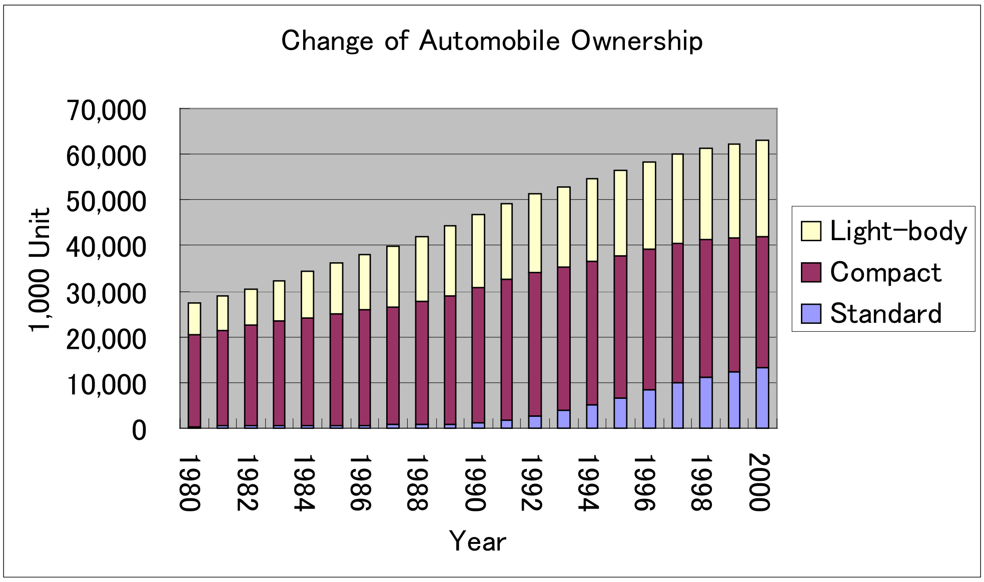
4. Reform of Lifestyle

Today's society has accepted over consumption of energy and materials. But now, we need to change this to a new society where energy is used in very efficient way. To do so, we need policies such as tax system, and create incentives that can clearly indicate a goal where the society is heading for and can stimulate people to change their daily activities towards that direction where resources are not over-consumed. In concrete terms, we looked into the following methods.

1) Incentives to Promote Small and Light-Bodied Cars

In the late 1990s, the number of passenger cars over 2000cc rapidly increased in Japan. In 1992, the number of standard passenger car (over 2000cc), the small passengers car (661-1999cc) and the light-bodied car (less than 660cc) were respectively 2.82 million, 31.13 million and 21.03 million. But in 2000, that unit increased to 13.23 million, 28.82 million and 17.30million. In those eight years, the standard passenger car increased 4.7 times by 10.41 million units, the small passenger car decreased by 2.31 million units or 0.92 times and the light-body car increased 1.2 times or 3.73 million units.

Figure 1. Change of automobile ownership (unit: 10,000)



During the latter half of 90s, Japan's economic growth declined and people's income did not increase. However, the number of people who began driving larger cars rapidly increased. This increase happened due to a tax measure implemented in 1989. The tax which reduced for the standard passenger and many people purchased larger cars. However, the average number of passengers in a car remains 1.2 to 1.3 persons. In other words, it does not mean the increased number of passengers was the factor for the increase in large cars. This is an example of the tax measure's failure to guide people toward a less consuming lifestyle. The amount of fuel consumption is determined by the body weight if engines and other conditions are the same as shown in Fig.2.

Figure 2. Weight and fuel consumption of gasoline vehicles

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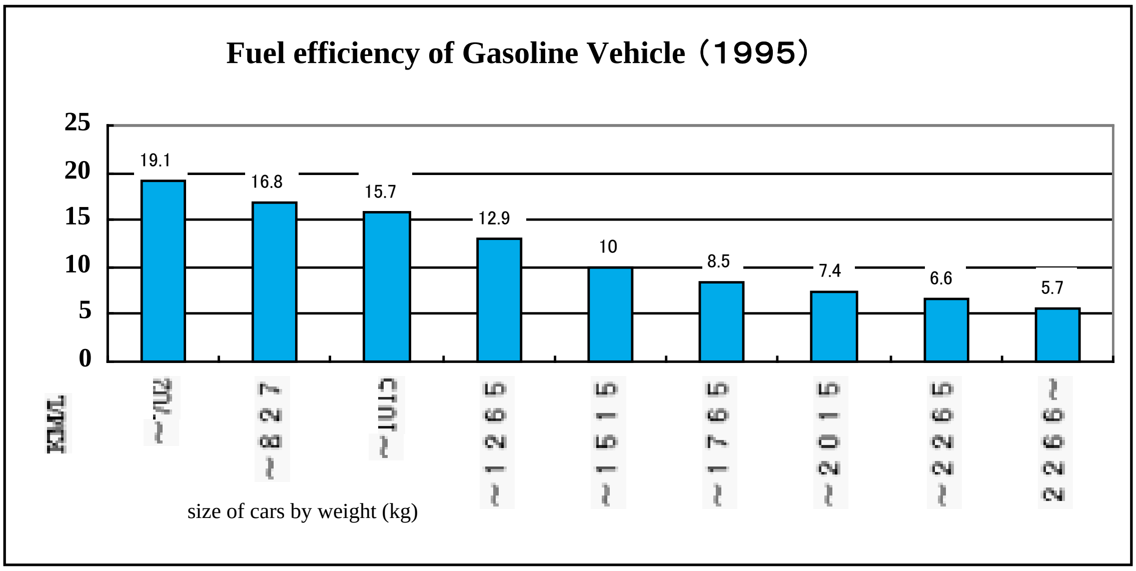


As for the policy to facilitate lifestyle reform, we need to revive the automobile tax system of the end of the 1980's in order to reduce the number of standard passenger cars, and implement measures to increase small passenger cars and light-bodied cars. In reality, it is not easy to simply go back to the past, if users' preferences have changed. However, they did respond very quickly to the change in the automobile tax system. Thus, the reverse reaction may possibly happen.

Furthermore, a full scale "green tax by fuel efficiency" should be implemented. When one buys a car having high fuel efficiency, tax reduction measures can be applied to car acquisition tax and car ownership tax, (not for just one year when the car was bought, but for the entire period the person own the car). In this way, one can learn which type of car is better to choose.

2) Eco-Train Commuter Pass

One of the incentive measures implemented in Europe is the issuing of local eco-train/bus commuter pass. In Freiburg City, the pass can be shared by anybody. During the weekend, two adults and a child can use one pass on all public transportation.

Furthermore, as an incentive measure to promote eco-commuting, part of the revenue from the parking lots is subsidized for companies to buy commuting passes for workers who use public transportation to commute. There is a discount system for collective purchasing, or the number of passes bought at one time. This can promote ecological commuting.

The increased number of commuters will have a secondary effect of increasing customers on the shopping streets near and around the station.

It is possible to implement similar eco-train pass in Japan. First, make the present commuters train or subway pass usable during the weekend and holidays by the holders' family. Usually, people go in directions opposite to that of the work place during the weekend. So, make the passes valid in any direction for the same one-way distance covered by the pass. So, as long as you are riding within the radius of the one-way distance covered by the pass, you can use the pass with your family. If you go beyond the limit, you must pay for the additional distance. This measure will reduce cars on the streets and the train companies may increase their sales turnover on holidays.

It is not easy to calculate how much energy can be saved by this system. We estimated that using the pass 10 times a year would be equivalent to 10 trips by car with the average driving distance of 100km one way. In other words, a family can reduce their driving distance by 2000km by using the pass 10 times a year. If 3 million people use their passes 10 times a year, it could reduce driving mileage of 3 million cars by 2000 km each.

3) Eco-Driving Licenses

In the Energy 2000 Plan of Switzerland, training courses to teach driving techniques to improve the fuel efficiency of cars are carried out in four places including the Veltheim Safety Driving Center(VSZV), the Swiss Post Office(Prevention Training Safety Department), the Touring Club Schweiz(TCS), the Swiss Road Transport Association(ASTAG) (7). The course is comprised of the following "Four Principles of Eco-driving", using both actual driving lessons and a driving simulator.

1. Use the high gear as much as possible and drive at low rotation level.
2. Smoothly and gradually accelerate.
3. Quickly shift to high gear, and slowly shift to low gear.
4. Do not excessively use the brakes or change gears, and always be an alert driver.

The eco-driving courses started in 1993. 15,700 people were trained under the program by 2000. The trainees learned to save 10 to 15% fuel without lowering their speeds. The total effect of the program is that 19 million liters of fuel were saved each year. As a result, eco-driving has proven to be safe, economical and ecological.

In the case of Japan, 90% of the passenger cars have automatic transmission. Though the principle on shifting gears can only be applied to vehicles with manual transmission such as trucks and utility vehicles, the principles on acceleration and braking can be applied to automatic transmission vehicles. Eco-driving focusing on gear-changing skills is not widely reported in Japan, but it is very important.

The Ecology Mobility Foundation for Promoting Personal Mobility and Ecological Transportation (ECOMO) and the Japan Automobile Federation (JAF) have jointly proposed "10 eco-driving points" that can easily be used by all drivers.

1. Stop unnecessary idling.
2. Drive at economical speed.
3. Regularly check up your car and maintain the appropriate air pressure in the tires.
4. Stop unnecessary rev up of engine.
5. Stop quick starts, quick accelerations, sudden braking, and do not “tailgate” other cars.
6. Quickly change into the higher gears.
7. Stop illegal parking that blocks traffic.
8. Moderately use the heater and air-conditioner.
9. Share rides with others and use public transportation as much as possible.

The “Eco-Drive License” we propose here is to encourage eco-drivers. When you receive your new driver’s license or you have renewed your driver’s license, you shall take a eco-drive training course, a driving lesson and a driving test. Actual driving or driving simulators can be used for the eco-driving test. You are given an eco-driving license if you pass the test. The eco-driving training course and test shall be made by combining the various driving techniques described above.

The eco-drive license holders are to have priority to use public parking and enjoy discounted parking fees.

The eco-driving license could be available not only for general passenger cars, but also for commercial vehicles. Once a business owner understands that eco-driving can save fuel, he/she can definitely recommend company employees or staff to get the license.

The effect of eco-driving is estimated that 8 million people will reduce fuel consumption by 6% by 2010.

4) Controlling Excessive Lighting, Cooling and Heating

There are often excessive use of cooling, heating and lighting in hotels, restaurants and department stores. We suggest the following to control such excessive use.

First, get an energy usage diagnosis by special energy conservation technicians and other experts such as ESCO’s specialist and electrical products repair service technicians. When the expert finds excessive energy usage, the expert will propose a solution.

Energy saving can be made at any facilities such as public buildings, large-scale commercial facilities and factories. When the proposed solution is implemented, the one who proposed the solution shall receive certain rewards. In this way, we expect that excessive usage of lighting, cooling and heating can be controlled.

5) Reduction Stand-by Electricity

From various research and studies, 20-35W of stand–by electricity is consumed in an average house in Japan. The average electric power consumption per household is at the 200-350W level. So, it is assumed around 10% of the total electricity use of a home is related to stand-by electricity.

Electrical appliances consume energy even when they are not used, such as television sets, air-conditioners, audio devices, microwave ovens, electric toothbrushes and electric toilet seats. You are unconsciously wasting electricity everyday for 8760 hours a year in the form of stand-by electric power.

Because of stand-by electricity, an appliance can instantly be turned on. This is a really insignificant convenience. This is also a matter of lifestyle. The stand-by electricity is included in the design of the appliance.

When the designer tries to lower the price of an electrical appliance, he tends to ignore the cost of the electricity to be paid by the consumer, because of severe price competition. Suppose one appliance uses 1W of stand-by electricity, then, 20 appliances will use 20W of energy at home. We think the volume of energy that can be allowed is up to 0.1 W. The effective way to prevent excessive use of stand-by electricity is to legally prohibit manufacturing and sales of products that require over 0.1W stand-by electricity. With such legislation, engineers can freely design products that consumes no stand-by electricity, disregarding price competition.

5. Introduction of Renewables

Regarding the introduction of renewables, the perspectives and targets of the National Advisory Committee for Energy (METI) is widely known. But, the target figures set by the Committee were re-written many times in the past using larger figures. One may say the larger figures were estimated, because the perspectives became clearer due to technological progress. However, the figures reflect the reality that the government was reluctant to promote renewables, or they were controlling the introduction of renewables.

The wind power generation capacity has already become more than 130MW in 2000. Recently, it is said that the government's estimates will be re-written to 3000 MW in 2010 (see table 4). The government perspectives and estimates cannot catch up with reality. Wind generation in Germany has already passed 5000 MW.

Regarding photovoltaics, its cost has continuously been declining. If the present progress continues, by the time PV capacity reaches 1000 MW cumulatively, it will gain economic competitiveness over conventional energy sources and penetrate widely into the market. Among the places applicable for solar, some places will have higher productivity (annual income per acreage) than food production. Such conditions may accelerate penetration.

Regarding biomass, the government set the perspectives and target on black liquor and scrap wood (by 2010, 5.17 Gl in terms of standards, and 5.92 Gl in terms of policy measures). The present biomass power generation in Japan has a very low profile and it is almost non-existent when compared with the situation in northern Europe. But there are vast potentials. It is important to stimulate technological innovation in this sector in the future.

Table 4: Introduction of renewables

	Govt. target 2010 (standard case)	Govt. target 2010 (policy measure case)	WWF Scenario 2010	WWF Scenario 2020
Photovoltaics	230 MW	5,000 MW	10,000 MW	30,000MW
Wind power	40 MW	300 MW	8,000 MW	16,000 MW
Solar heat	1,09 Gl	4,5 Gl	1,33 Gl	2 Gl
Biomass			0.7 Gl	2,08 Gl

- The government target was released in 1998.
- Gl = giga liter: annual heat supply in terms of the oil equivalent

6. Clean Development Mechanism (CDM) and Joint Implementation (JI)

CDM and JI will reduce GHG in the most cost effective way through energy conservation or clean technology projects between developed and developing countries (CDM), as well as between developed countries (JI). They were set up by COP3 as the flexible measures to implement the Kyoto Protocol.

In CDM, the developed country provides technical and financial assistance to the developing country to reduce GHG emissions, and the result of the reduction quantity will be assessed as credits for the developed country.

The details of CDM and JI are yet to be finalized. But, it is widely known that, if you invest the same value of funds to reduce GHG emissions, in many cases, it would be much more cost effective to implement the reduction project in the developing countries than in the developed countries.

WWF calculated the emission reduction amount actual overseas projects are carried out. This was to assess the size of the projects necessary to achieve a 2% reduction figure.

The results are shown in table 5. The baseline here shows the cases without CDM or JI. They are the projects to be used as the basic reference or criteria when determining the reduction volume. We assessed how much GHG emissions can be reduced in reference to the baseline.

The projects are assumed to begin in 2003 and the cumulative effects in 2010 are estimated as a result of the projects as shown in Table 5.

Table 5. CDM/JI projects

Project	Scale	Baseline	Reduction (unit:1.000 tonC)
Natural gas power plant	2,000 MW	Coal thermal power plant	1,436
Renovation of existing power plant	3,000 MW	Existing conventional coal power plant	396
High fuel efficient small car	1 million	Conventional car	160
Hybrid car	1million	Conventional car	400
CNG vehicle	200,000	Conventional car	72
Inverter-controlled motor	1,000 MW	Conventional motor	226
High-performance motor	500 MW	Conventional motor	31
Fluorescent light	1,500 MW	Incandescent lamp	619
LED guide light	50 MW	Fluorescent light	55
Solar Photovoltaics	1,000 MW	Coal thermal power plant	377
Wind power	1,000 MW	Coal thermal power plant	661
Biomass power generation	500 MW	Coal thermal power plant	826
Biogas power generation	200 MW	Coal thermal power plant	286
Solar heat	500,000 t (in terms of gas)	Gas	3,000
Total			5,846

In these listed projects, those with higher economic efficiencies are the energy conservation ones. In the case of solar power generation, many developing countries have longer hours of sunshine per year and in many cases they show higher economic efficiency than projects carried out in Japan.

In total, the reduction will reach 5.8 million tons in terms of carbon equivalent. This volume could be added as 2% reduction from 1990 level in 2010. We also assumed that the CDM/JI of the same size would be conducted in 2020.

7. Simulation

We used the end use model of the AIM (Asia Pacific Integrated Model) model jointly developed by the National Institute for Environmental Studies and Kyoto University, for the calculation of the WWF Scenario. In this chapter, we will introduce briefly about the AIM simulation model and describe its standard case and the contents of the WWF Scenario.

1) The AIM Model

The joint project team of the National Institute for Environmental Studies and Kyoto University has developed the AIM model. Their objectives are to assess the generation of the greenhouse gases, the GHG emissions reduction measures and the environmental effects of the climate change that is in fact the result of GHG emissions.

The AIM End-Use model (the model on the final consumption of energy) first set up the detailed conditions and terms on energy services and machines/devices. Then using them as the premise, it simulates how energy conservation will be carried out.

This model is the so-called “bottom-up” type model. It aggregates in an exogenous manner the volume of energy service by sector breakdown and selects the most economically efficient technology to meet the needs of energy service in each sector. Then, it estimates the final energy consumption, multiplying the volume of energy by the energy efficiency determined as a result of the selection of technology. To select each technology, the model takes into account the energy cost during the early stage of technology introduction. Thus, it can make numerical assessments on to what extent the emissions can be controlled in such occasions as:

When energy prices are raised through the policy implementation such as carbon tax or;

When earlier investments were reduced because subsidies are provided.

In this model, the growth rates of the macro-economy and production volume in each sector are forecasted and provided in an exogenous manner. Thus, each sector can make extremely rational selection of technology regardless the availability of countermeasures. Therefore, in this model, it simulates to what extent CO_2 can be reduced only by technological improvements of efficiency, without reducing the volume of energy service in the future or without causing any changes in future production and daily life. Contrarily, simulation can also clarify the necessary measures to motivate technological efficiency improvement at the desirable standards. However, the direct impacts of higher energy prices such as, downward pressure on energy demands, or reduced monetary savings are placed outside of the model analysis.

The basic structure of the AIM model is shown below.

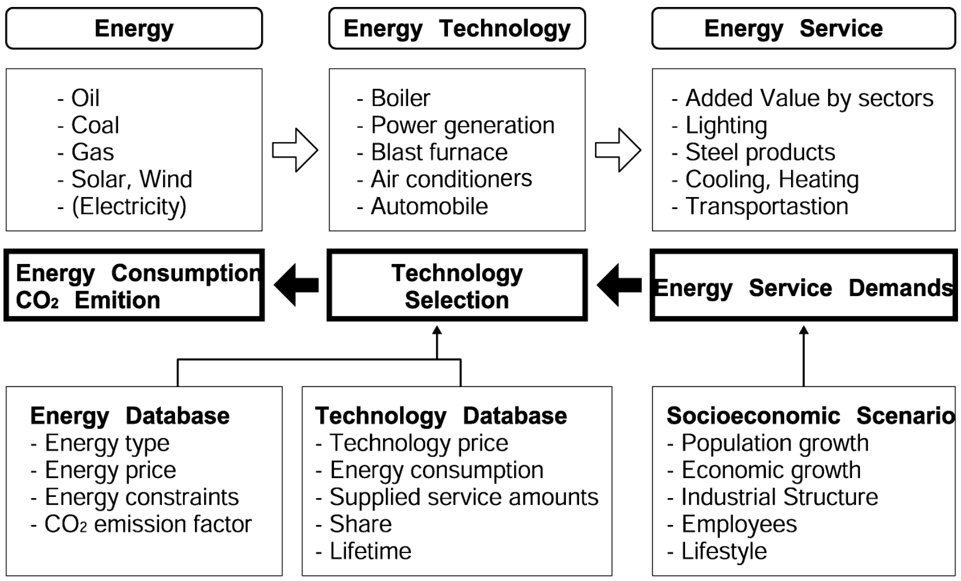


Fig.3 AIM End Use Model

There are many uncertainties included in the direction of economic development in the future. Thus, the AIM End-Use model investigates many scenarios. One of their scenarios was applied as the standard case of the WWF Scenario. The contents of the standard scenario is listed in the table 6.

Table 6. Standard Scenario

	Contents
Basic themes	*Aims at compatibility of de-materialized society and economic development through technological innovations.
Population, Households, Labor	* Declining birth rate is slightly moderated (same level with the moderate case of the demographic estimation by the National Institute of Social Security and Population Research). *The average household in 2030 will be 2.42 persons. *Greater participation/contribution of women and aged people in society and public affairs.
Economics, Industry	*Sharp growth will be experienced in environmental-related industries, taking priority in investments aimed at environmental conservation. Relatively high economic growth is achieved, as economic development will be taken seriously, placing environmental conservation at the center of the economy.
Lifestyle	* By improving the resource efficiency through technological development, the shift to an environmental/ecological lifestyle can be achieved without lowering the demands for service.
Land, Transportation	*The distance between home and working place becomes closer, and the city becomes more congested. * The LRT and in-city mono-rail will be the major transportation within the city.
Energy system	* The fuel cell will be much more widely used. * A great increase in natural gas thermal power generation plants and natural gas will be the core of the energy structure.

Table 7 shows the figures set up for the basic scenario.

Table 7. Basic estimates for calculation

	2010	2020
Economic growth rate (annual average)	1.60%	1.40%
Population (million)	128.4 m	126.4 m
Crude steel production (million)	9.12 m	8.265 m
Share of the tertiary industry	65.4%	67.1%
Number of household (million)	49.4 m	49.7 m

In this scenario, economic development and a “low-carbon” society is compatibly achieved through development and widespread usage of environmental technologies, and the introduction of recycling technologies and technologies for air-contamination countermeasures will show greater progress. Four nuclear power plants are planned to be built by 2010.

2) The Model Cases

In addition to the standard case, the AIM End-Use model can calculate “the countermeasure case” in which it applies the prepared technology list to reduce CO_2 emissions. We combined the WWF Scenario with it and calculated the following three cases:

(i) Standard Case (the case of standardized technology)

In this case , the usage share of the energy consuming technology is assumed not to change in the future.

(ii) Countermeasure Case,

In this case, the investment for energy conservation is to be made. This case estimates how much CO_2 emissions could be reduced due to progressive introduction of technologies requiring high investment costs at the beginning.

(iii) WWF Scenario

It calculates the contents in which the various technologies and policies explained so far are incorporated.

3) Technologies Incorporated in the AIM Model

The contents shown in Table 8 are already taken into AIM. In the Countermeasure case in which these contents are applied, the CO_2 emissions in 2010 will be 2% less than the 1990 level.

Table 8. List of technologies taken in the AIM

Sector	Energy saving technology and renewables technology
Industry	Next generation coke oven, Coke dry quenching process, Dry top pressure recovery turbine, Vertical type cement mill, Improved kiln burner, blast-furnace slag cement, Combined cycle generation, High performance naphtha cranking device, Power recovery turbine, High-efficiency black liquor boiler, High-performance industrial furnace, etc.
Household	Energy-saving insulation standard, Energy-saving air-conditioner, Energy-saving refrigerator, Hf inverter fluorescent light, Fluorescent bulb, Energy-saving television, etc.
Commercial	Energy-saving air-conditioner, Gas turbine co-generator, Energy-saving air-conditioner delivery power, Utilization of unused energy, Light/lamp with sensors, etc.
Transportation	Less fuel consuming gasoline car (direct drive engine, CVT), fuel saving diesel vehicle, etc.

4) WWF Scenario

In the WWF Scenario, we looked in to the technologies and policies listed in Table 9 to simulate. Some of the listed technologies have been increasingly used at present. Such conditions are assessed in the Countermeasure case. The WWF Scenario's calculation is supplemental to it.

Table 9. Technologies and policies used in the WWF Scenario

Technologies/ policies	**Achievements by 2010**	**Reduced CO_2 emissions by 2010 (1,000 tonC)**	**Achievements by 2020**	**Reduced CO_2 emissions by 2010 (1,000 tonC)**
1) Energy conversion sector				
Pole transformer	Will have introduced amorphous transformers equivalent to 80,000 MVA	1,320	Will have introduced amorphous transformers equivalent to 157,500MVA	2,590
2) Industrial sector				
Inverter-controlled motor	Will have introduced fans, blowers and pumps controlled by inverters equivalent to 2,000 MW	750	Fans, blowers and pumps will be controlled by inverters equivalent to 4,000 MW.	1,520
Factory Transformer	Will have introduced amorphous transformers equivalent to 58,000 MVA	960	Will have introduced amorphous transformers equivalent to 124,920 MVA.	2,060
Introduction of high-efficiency motor	Motors with 5% higher efficiency will be used to cover 30,000 MW	850	Motors with 5% higher efficiency will be used to cover 60,000 MW	1,700
Introduction of high-efficiency luminous lights	Will have introduced HF fluorescent lights twice as efficient, providing 8,000 MW in total.	1,110	Will have introduced HF fluorescent lights twice as efficient, providing 12,000 MW in total.	1,650
Introduction of LED lighting	Will have introduced LED lights twice as efficient, providing 2,000 MW in total.	1,370	Will have introduced LED lights twice as efficient, providing 6000 MW in total.	4,130
Make a house last longer by renovation S	100,000 wooden houses will be renovated every year to prolong their usage. This reduce energy for producing construction wood by 460,000 ton/c.	460	150,000 wooden houses will be renovated every year.	690
subtotal		5,500		11,750

3) Transportation sector				
Introduction of hybrid cars	60% of passenger car will be hybrid cars with twice the efficiency of conventional cars	10,080	30% of passenger car will be hybrid cars.	5,040
Introduction of hybrid trucks	20% of trucks will be hybrid trucks with twice the efficiency of conventional trucks.	660	30% of the trucks will be hybrid trucks.	980
Introduction of fuel-cell passenger cars	3% of passenger cars will be fuel-cell cars that are 2.5 times more efficient than the conventional passenger cars.	600	60% of passenger cars will be fuel-cell cars.	12,100
Revise the tax system for passenger cars to that of the 1980s.	Cars with more than 2000 cc engine displacement will decrease from 13 million to 3 million. (back to the '92 level)	2,400	Cars with more than 2000 cc engine displacement will total 3 million.	2,400
Alleviated tax for light-bodied vehicles	Among passenger cars, 8 million small cars will be replaced by light-bodied cars.	1,920	8 million cars will be replaced by light-bodied cars.	1,920
Eco-driving license	8 million drivers have acquired an eco-driving license when they acquire a new license or re-new their license. They will improve fuel economy by 6%.	380	16 million drivers have acquired the eco-driving license.	770
Encouraging car maintenance	8 million automobiles will have improved fuel efficiency by 3% by checking tire air pressure and other types of maintenance.	190	16 million cars will undergone maintenance.	380
Eco-commuter pass	The commuters pass will offer a holiday discount for the family. 3 million people will take the train 10 times a year instead of driving cars. 2000 km of driving distance per car will be decreased.	480	6 million people will use the system	960
Encouraging car-rental business	The usage of cars will decrease due to the policy to encourage car-sharing and car-rental business.	190	6 million people will use the system.	380
Subtotal		16,920		24,940

4) Commercial sector				
High-efficiency transformer	Amorphous transformers equivalent to 14,000 MVA will be installed in commercial complexes and buildings.	230	Amorphous transformers equivalent to 26,000 MVA will be installed	430
Co-generation	Gas engine or fuel-cell co-generation equivalent to 3,000 MW will be supplying 80% of electric power consumption.	1,510	Gas engine or fuel-cell co-generation equivalent to 9,000 MW will be introduced.	4,530
Introduction of non-filament street lights	High-frequency non-filament light bulbs equivalent to 200 MW, with twice the performance of mercury-vapor lamps will be introduced as street lights.	140	High-frequency non-filament street light equivalent to 500 MW will be introduced.	340
LED traffic lights	980,000 traffic lights at 170,000 intersections will be LED types.	90	All traffic lights will be LED type.	90
Replace incandescent lamps to LEDs	Incandescent lights, equivalent to 2,000 MW, in hotels and coffee shops will be LED lights.	1,200	Incandescent lights, equivalent to 4,000 MW, will be LED lights.	2,390
Replace fluorescent lights with LEDs	Fluorescent lights, equivalent to 2,000 MW, in hotels and coffee shops will be LED lights with twice the performance.	690	Fluorescent lights, equivalent to 4,000 MW, will be LED lights.	1,380
Replace emergency lights with LEDs	LEDs will be introduced to 70% or 180 MW of the high-luminosity emergency lights. Performance will be increased four-fold.	160	Will cover 100% of all emergency lights.	230
LCD personal computers	20 million CRT personal computers (120W) will be replaced with LCDs (20W).	800	40 million computers will be LCD personal computers.	1,590
To improve insulation efficiency of rental offices	Relationship between 100,000 owners and tenants will be improved.	500	Relationship between 100,000 owners and tenants will be improved	500
Reduction of stand-by electricity	Stand-by electricity of person-al computers, copy machines, and faxes will decrease. (1 million machines)	130	Reduction of stand-by electricity. (2 million machines)	260

Digitalization of paper through the IT revolution	1 million tons of paper used for brochure, newspaper and books will be digitalized.	500	3 million tons of paper used for brochure, newspaper and books will be digitalized	1,500
Improvement of vending machine energy efficiency	Power consumption of 2.54 million vending machines will be reduced by 54%.	770	Power consumption of vending machines will be reduced by 70%.	1,000
Introduction of heat-recovery hot water boilers	The efficiency of gas hot water boilers will be improved by 15% by recovering the heat in the exhaust gas. This type of hot water heater will cover 20% of the hot water demand in hotels and restaurants.	70	200,000 unit of 62kW type will be introduced.	140
Energy-saving elevators	100,000 hydraulic elevators will be replaced with elevators requiring no mechanical rooms.	110	200,000 such elevators (the popular 3.7kW type) will be introduced	220
Promotion of the energy management system for buildings	Introducing a computer system to control the lighting, air-conditioning and heat sources in the building will save 6% of the energy costs.	380	The system will be applied to 15% of the energy for business use.	560
Subtotal		7,270		15,180
5) Household sector				
LCD television	20 million CRT TVs (150W) will be replaced with LCD TVs (50W).	550	There will be 40 million LCD television sets.	1,100
LCD personal computers	12 million CRT personal computers (120W) will be replaced with LCD personal computers(20W).	250	There will be 24 million LCD personal computers.	500
High-performance refrigerators	All households will have electric refrigerators with twice the efficiency of presently used conventional models.	2,680	Refrigerators with 2.5 times efficiency than the present conventional model will be used by every household in Japan.	3,220
Fuel cell co-generation	Fuel cell co-generation using gas as fuel, will be used by 2 million households.	810	10 million households will use co-generation.	4,070
Reduction of stand-by electricity	The 20W per household for stand-by electricity will be reduced.	1,550	The 30W per household for stand-by electricity will be reduced.	2,330
Heat recovery type	The water-heater that recover		All households using gas will	

water-heater	heats in the exhaust gas will save 15% of the hot water demand of 20milion households.	580	have this type of water-heater.	870
Passive solar power system	Passive solar system will save 40% of the heating and hot water demand of 2 million households.	320	The system will save 60% of the heating and hot water demand of 3 million households.	720
Internally burning gas cooker	The gas cooker or cooking oven's efficiency will be improved by 18% being used by 70% of all households.	230	All households use the cookers.	330
Subtotal		6,980		13,140
6) Renewables sector (including the ones making achievements at present)				
Photovoltaics	10,000 MW	1,890	30,000 MW	5,660
Wind power	8000 MW	3,300	16,000 MW	6,610
Solar heat	1.33 Gl	960	2 Gl	1,440
Biomass	0.7 Gl	500	2.08 Gl	1,500
Subtotal		6,650		15,200
Grand total of WWF Scenario		44,630		82,800

8. Result of Simulation

AIM's "standardized technology" case forecasted CO_2 emissions in 2010 would increase 13% from the 1990 reference level. The countermeasure case made it clear that the CO_2 emissions in 2010 would be reduced by 2% from the1990 level, incorporating and aggregating various technologies already practiced such as improved home insulation, higher efficiency of electrical devices/appliances and conversion of industrial technologies.

The results of calculating the WWF Scenario excluding CDM/JI, showed the CO_2 emissions volume would be reduced by 10% in 2010 and 24 % in 2020 from the 1990 level.

Tables 10 and 11 show the volume of CO_2 emissions reduction and the final energy consumption by sector breakdown.

Table 10: CO_2 Emissions by WWF Scenario (excluding CDM/JI)

(Ratio to 1990 level in brackets with 1990 being100%)

Sector	1990	1998		2010		2020	
Industry	140	136	(97)	123	(88)	107	(76)
Household	38	41	(109)	33	(86)	26	(69)
Commercial	34	39	(116)	31	(92)	28	(84)
Transportation	59	72	(122)	56	(94)	44	(74)
Energy conversion	15.7	17	(107)	15	(96)	12.3	(78)

Total	287	305	(107)	257	(90)	217	(76)

Unit: million tons C

Table 11: Final Energy Consumption (excluding CDM/JI)

(Ratio to 1990 level in brackets with 1990 being 100%)

Sector	1990	1998	2010	2020
Industry	7,548	7,823 (104)	7,594 (101)	6,903 (91)
Household	1,797	2,078 (116)	1,975 (110)	1,841 (102)
Commercial	1,484	1,865 (126)	1,734 (117)	1,763 (119)
Transportation	3,171	3,893 (123)	3,018 (95)	2,382 (75)
Total	14,001	15,659 (112)	14,321 (102)	12,889 (92)

Unit; GJ

By adding the CDM/JI to the above CO_2 emissions, the WWF Scenario forecasted the possibility of reducing 12% in 2010, and 26% in 2020 from the 1990 reference level.

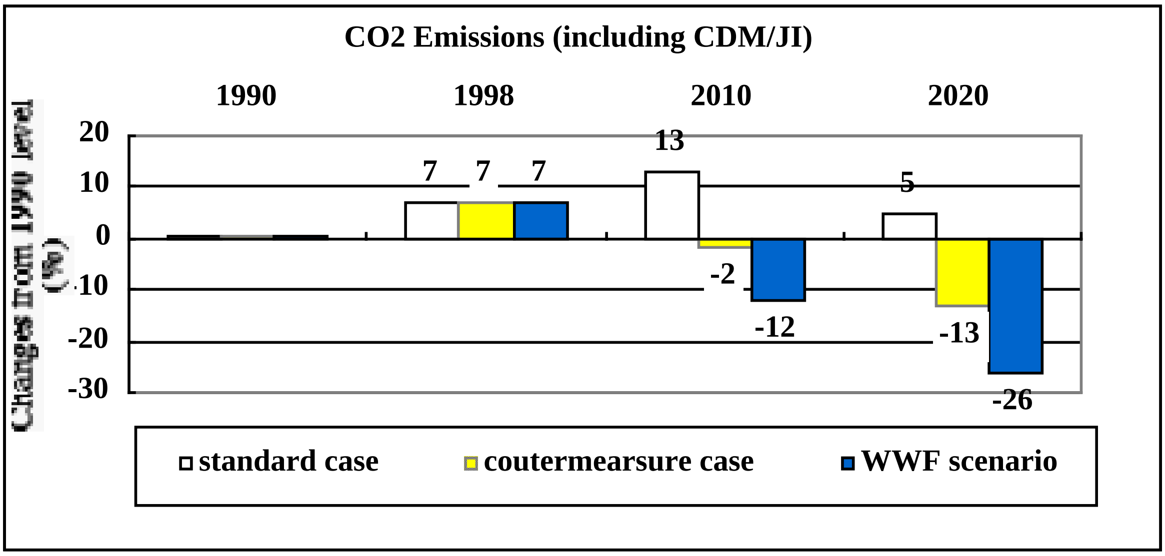
Looking at the CO_2 emissions in 2010, 88% of the 1990 reference emissions in the industry sector would be achieved, 86% in the household sector, 92% in the business sector, 94% in the transportation sector and 96% in the energy sector. The estimation of the same for 2020 are, 76%, 69%, 84%, 74% and 78% respectively.

The reduction of CO_2 emissions of transportation sector in 2010 is estimated not to be very significant. But, in 2020, it would be reduced to 74% taking into account that high-efficiency vehicles such as fuel-cell cars will be used. The relatively small volume of reduction estimated in the commercial sector is partially due to a response to the transformation to the service economy.

The major conclusions from the simulation are shown below.

1) It is possible to reduce by 12% Japan's GHG emissions from the 1990 level by 2010, by implementing policies that seriously promote high energy-efficient technologies, changing to the service economy and changing people's lifestyle while promoting CDM/JI.

Fig.4



2) 10% reduction will be possible in Japan, and 2% will be reduced by overseas cooperation through CDM/JI for the total of 12%.

9. Recommendation

In order to achieve reduction of CO_2 emissions, four major policies will be effective.

- Positive promotion of new technologies
- Transformation to service economy
- Reforming our lifestyle
- Clean Development Mechanisms/Joint Implementation (CDM/JI)

If the policies investigated in this report are implemented, there is a positive potential for Japan to reduce GHG emissions more than the target set in COP3.

In this report, we estimated the potential introduction of various technologies, policies and measures to simulate the possible reduction of CO_2 emissions. However, this report does not cover the implementation methods or introduction costs in detail. Rather, we limit this report to showing how much reduction would be possible if this scenario is realized.

The recommendations derived from the WWF Scenario are shown below.

1) The automobile tax system shall be seriously reviewed and the tax system for passenger cars in the end of 1980s must be revived. At the same time, the Green Tax System shall be applied in full scale to encourage using light-bodied cars and compact cars.

2) Referring to the success of solar photovoltaics promotion, official subsidies shall be diverted to not only research and development but also to promote and encourage the use of energy-saving technologies and new technologies. Policy support shall be extended not only to research and development of the hybrid car, the fuel-cell car and LED lighting, but also to their promotion.

3) Well-equipped policies to encourage the new service economy is needed, such as ESCO, increased use of high-performance lights, electrical appliance repair service, automobile maintenance and car-rental service.

4) Policies to facilitate lifestyle reform such as eco-driving license and eco-commuters pass shall be implemented.

5) Policy implementation shall reflect the mechanism that can be workable when the ESCO service to control excessive lighting, heating and cooling are incorporated into the service economy.

6) Legislative restrictions shall be sought to keep stand-by electricity of each electric appliance at zero or below 0.1 watts. The technology to reduce stand-by electricity is already available. Therefore, it is considered to be effective to implement such restrictions as a standard in the electric manufacturing industry. Without such standard, the industry would be caught in the spiral of price competition, and they would not work towards the reduction of stand-by electricity.

To reduce greenhouse gas emissions has became a serious challenge for human beings to survive the 21st century. Just simply implementing the Kyoto Protocol will not be enough. Much more reduction of GHG emissions is needed. To do so, the policies shown in this report will be very effective.

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