

Preface

From the latter half of 1970's, the destructive situation of the global environment came to be known to human beings clearly by the earth investigations from the space satellites and the field investigations conducted in the developing countries. In 1980's, scientists reported devastating situations, such as enlargement of ozone hole at the South Pole and rise of atmospheric temperature, which had deteriorated deeply and widely in many places of the earth escaping from human eyes. In 1990's, the warnings of marine scientists and discoveries in geology, paleontology, and the weather science clarified the mechanism of the collapse of the earth ecosphere which entangles every living creature on the earth.

Authors have explained and warned against this mechanism of the global collapse in our previous books as follows: "global warming" which is caused by greenhouse gases, especially carbon dioxide accumulating rapidly in the atmosphere, changes the oceanic circulation and causes the crumbling of the methane hydrate that sleeps at the bottom of the sea. This crumbling brings about the eruption of methane, which is also a greenhouse gas, to the atmosphere. Terminally, this positive feedback, we call it "Satan's cycle", can bring about carbon dioxide intoxication of all humankind. Global warming is not a kind of the problem in which only strong persons can survive in the environment deterioration but a problem in which all human beings cannot survive if it were left at its present course. Human cooperation and integrated global countermeasures are necessary.

Recently, a lot of people came to see what "global warming" meant as the climate change was actively simulated by the super computer. The scientific visualization enables us to see how global warming, which comes into actuality at a high probability within this century, brings about local climate changes, such as droughts in the rain forest regions including Amazon and dissolution of permafrost regions including Siberia. However, "Satan's cycle" concealed in the ocean, whose danger authors have described, has so far not been considered in most of the simulations. Therefore, the situations are more critical than are reported in general. That is why, we strongly hope the society takes our messages described in our former books, "The human race ruins in 80 years" and "Challenge at Satan's cycle", more seriously.

Although the crisis is coming closer, the framework of human actions to cope with the

global warming has not been formed and the majority of the people are still indifferent to this problem as is shown in the confusion over Kyoto Protocol. On the other hand, among the people, who have earnestly struggled with global warming problem, feeling of powerlessness and despair seems to spread

The main objective of this book is to give clear vision about the future society, which has overcome the global warming problem, to form common understandings of what society we are seeking for and in which fields we will make our best efforts to cope with this problem. The proposals which authors described in this book are very effective countermeasures to deal with global warming. One of the proposals, from the field of environmental economics, proposes formation of management mechanism for fossil resources which controls carbon dioxide emission and, at the same time, produce fund to be used for adaptation of the society to global warming. The second proposal is the formation of power network to supply renewable energy worldwide which is to be produced, mainly, by solar, wind and hydro power generators. The Bering Strait dam to be used for power generation and to stop the diminution of the sea ice in the Arctic Ocean is also stated. The third proposal is concerning the technology to sequester the carbon dioxide that has accumulated too much in the atmosphere. All these proposals still need social acknowledgment, however, these proposals have very big potential in the evasion of global warming.

Francis Bacon who is called as the parent of the modern science said, "Nature looks like prostitutes who live anywhere", and explained that nature can be transformed to any direction according to the needs of human beings. Modern science of initial age believed blindly that natural resources can be used according to men's desire, did not notice limit of the global environment, and constructed an industrial society and economy that disregards the ecosystem and material recycle of the nature.

It is not far from now that we found out the life maintenance mechanism of human beings can work only in the global ecosystem, and we cannot live apart from the blessing of the global ecosystem even with the advanced science and technology. We have acquired science and technology which can destroy the whole earth, but didn't know how to use them. Man should use this power to recover the harmony of the human sphere and the global ecosphere, not to expand human sphere.

The proposals of this book are the technologies and systems to make the harmony of the

human sphere and the global ecosphere. What we have to comment at this point is that to make the coordination of these two spheres by using the proposals, human sphere should be in harmony. The recognition of the importance of every living creatures and the recognition of oneness of human beings play very important role to form the harmonization in human sphere.

Even though we can stop global warming fortunately at some level, the disaster caused by global warming will have gone beyond the handling capacity of one country. We should have constructed the global cooperation system before the damages of global warming appear more clearly. If we place the responsibility for environmental deterioration on other countries and keep on asking for limited resources, we will destroy each other before the earth put a red card before us and will vanish from the earth permanently as a "Failure in the life evolution". When we observe the ecosystem, we can find out that many species are living in harmony, which apparently exceeds the food cycle system. We human beings are also supporting each other even though we live in different countries by exchanging fruits of our works, cultures, information, friendship and love. We should recall that the world is beautiful and comfortable, because many living creatures are there. It is very important to believe that we are responsible for and able to make the coordination of the human sphere and the ecosphere.

The second objective of this book is to give basic information about Global warming to as many people as possible and to encourage them to fight against this problem. This is why we used the style of science fiction novel in Chapter 1, where one of the authors experiences the world of 2050 to make everyone imagine the society in which global warming has been overcome. From Chapter 2 to 9, basic information about earth environment, and strategies and technologies to fight against global warming are described as plainly as possible. At the end of this book, inventions and the discoveries to which Japanese have much contributed are described to encourage Japanese young people to be interested in science.

We sincerely hope that reading this book will be a chance for the people working in the office or at home to think about how they can fight against the global warming issue with courage. If this book can help your courageous activity, that will be our great pleasure.

Chapter 1 One day in 2050, where global warming has overcome

I was spending a tedious summer in hot Tokyo in 2006. The reason was very apparent that I was asked for by a publishing company to write a book which enlightens young people about measures for controlling global warming. The human race's one-sided defeat continued in the fight between global warming and human race. The modern industrial society is still increasing material accumulation using fossil resources, like former Japanese navy couldn't stop building antiquated huge battleships until the end of World War II. I didn't know how I can explain this situation to young people.

When I close my eyes, horrible scenes appear one after another in my eyes; in the computer display simulation results are showing incandescent earth, methane bubbles are coming up to the surface at Niigata offshore ocean, black surface of Arctic Ocean which has lost surface sea ice and the desert spreading over Amazon. Ten years ago, I tried to apply mathematical method, called least square method, to the concentration rate of carbon dioxide in these hundred years and have forecasted its future concentration. The graph showed almost vertically increasing accumulation of carbon dioxide. I couldn't have forgotten the trembles I felt at that time. In that evening too, I could make very small progress and unconsciously I dozed over the desk, and dreamed a dream.

A lovely boy of about seven years old was standing surrounded by illuminating small lights in the dark. "Professor, ----" the boy made his eyes round sparkingly and said. " Professor, --Don't worry so much! Our earth will not be ruined. ---- I will take you to the future!"

I woke up feeling dazzling light. In front of me, I saw a face of a doctor with grayish hair, who was smiling and looked still youthful. He said with steady voice. "Are you awake? How is your feeling? " I tried to move my body. However, the pain spread around my whole body.

"Don't try to move professor. You were long asleep by the cold sleep. Professor, it is August 2050, now." I was so astonished and felt like be awakened again.

"You are the first person who has experienced cold sleep. You hoped for sleeping forty years to see the future society which has overcome the global warming. Everyone in Japan knows you wake up today by net news."

"Then, how did the global warming go along? Is the society functioning still well?" I

heard it hastily.

“We have already prepared a presentation for you, Dr. But, it is too early for you to do anything. You had better stay calm and relax. When you come to be able to sit on the wheelchair, we will explain everything to you at once” The man smiled at me.

After that, I spent several days for rehabilitation. The senses of my hands and legs recovered gradually, but it was really hard for me even to turn over in bed. Pains and weary feelings attacked me from every part of my body. For these days, many medical and nursing apparatus, such as medical bed, which can change shape and enable me to have nutrition and take shower without moving, and those keep my body and mouth clean, helped me much. The room seems to be one for intensive care. It had no window, but still was calm and comfortable with pale pink wall, moderate luminescence, paintings on the wall, heat healing music. The attitudes of nurses were also sophisticated and comfortable. The temperature was well controlled and I couldn't find out any signs of energy shortage. There was something like TV display on the wall, but the Doctor didn't permit me to watch on it.

Then, the day I could see the sun light came. Attended by a doctor, with a nurse pushing my wheelchair, passing through the corridor, I came out to the large lobby of the hospital, which was full of sunlight. I got dizzy with the dazzling sunshine. When my eyes got used to it, I saw, through a glass window stretching from the floor to the ceiling, a scene like a yard of a university, mountains I had ever seen and blue sky. A track of monorail ran beside the yard.

“These are Zao mountains aren't they? It is awesome to see such many withered trees. It should have been caused by high temperature. The trees, bottom of the mountain, are recent planted trees, aren't they” Oh, but many young people are walking! They look sound. Is the earth saved?” I said. “Still, we are on the way of fighting.” The doctor replied. “However, the major part of the social change has finished. Most of the people believe our present society is managed well and we will overcome global warming.” I said “That is quite great. Would you please tell me what have happened to the earth and how you have coped with the problems?” “We know you will say so. We have prepared a presentation for you.”

In front of the room, named experiencing room, many people, look like researchers were waiting us. One of the researchers, a person with gray-white moustache, smiled at and bowed to me, and said “It's been quite a long time, since I met you, Professor.” I

wondered who he was for a while, and remembered at last. He was a student of my laboratory! I was embraced by a very nostalgic feeling and entered into the room.

“Then, I start by explaining about this room.” The man with gray-white moustache stated talking. “This room is quite different from old-style audiovisual room. This room uses not only visions and sounds, but also air stream, scents, imperceptible vibrations and infrared rays to make the images more realistic. Professor, would you please move to the seat with the headgear” I moved to the seat with somebody’s help. The lightings of the room was darkened and headgear was placed on my shoulder. A clear voice was heard from microphones close to my ears. “Now I will start my presentation with visual images, but all of the attendants can talk each other. Professor, if you have any questions, please don’t hesitate to ask me anytime. Then, I will start.”

Just in front of me, vision of Tokyo City emerged. It seemed that some of the cameras were set on cars. Many beloved Tokyo sites, such as the Imperial Palace, the Diet building and many skyscrapers close to Tokyo station were shown. The number of skyscrapers apparently increased. I asked “Is the Diet building partially rebuilt? It looks to be modernized. What has happened to the Capital Highways? Oh, the streets are not so much crowded as before, and the cars are all electric automobiles!”

He said, “Tokyo was reformed to a relatively large extent. Thirty years before, Second Kanto Earthquake hit Tokyo. The number of casualty was not very large as expected, but old buildings and highways were severely damaged. At the opportunity of reconstruction, the reformation of Tokyo City was conducted. Many capital functions were allocated to local cities, because functions of Tokyo were paralyzed fairly long time owing to the severe damages on communication and life lines caused by the earthquake. Many housing complex were built and spare areas were used for parks and green areas, because old wooden houses in some old Tokyo areas were severely damaged. Because of this city reformation, Tokyo is said to have changed to a more inhabitable area than before. Most vehicles, other than some special use cars, were replaced by electric automobiles. Not only cars but also all of the housing equipment are operated by electricity. In old days, it is said that complete electrification of the society leads to increase of carbon dioxide emission. However, this opinion has diminished because the ratio of thermal power generation has decreased to a very low level. Today, almost all energy for office and housing use is supplied by electricity.”

“That is the point I want to know. How did you realize the supply of abundant electricity, without using fossil resources? Could you explain to me?”

“Then, I will take you to the important spot. Professor Nishizawa, your dream was

actualized.”

Suddenly, huge vision of the ocean came up to me. A structure looks like long bank which extended interminably to the sky appeared. The bank was separating the ocean into two parts; one was dark blue ocean, and the other was more blight Turkish stone color one. The bank had many water gates and seawater was spouting from them. A large gate which enables ship passage was also seen on the bank. Immediately, I understood what this was.

He said, “Professor, this is the Bering Strait Dam which was constructed twenty years before. This dam utilizes seawater level difference of Arctic sea and Pacific sea, and supplies us inexhaustible hydroelectric power. The length of the dam’s bank is about 100km. The amount of the electricity generated by the dam can meet the demand of Siberia and Canada. The electricity is also transmitted to Japan. Well, let’s see next site. I will change the image.”

Then the view changed to a desert area where frocks of wind power generators are spreading to the horizon. It looked like the Gobi Desert.

He said, “This is the Wind power farm located on Tunhuang China. This wind power farm was constructed here because of the constant strong wind of this site. Many this scale wind farm were constructed all over the world.”

I commented. “It is wonderful to see that nations have made agreements on the construction of these huge plants. Especially, I was wondering if the agreement for Bering Strait Dam could be reached or not, because this dam makes huge effects on the climate of the U.S, Russia and European nations” The man continued. “There are so many things I have to explain. First, I begin with the explanation of the Bering Strait Dam.

“This is a satellite photo of Arctic Ocean in the summer of 2006. The area of Arctic Ocean covered with sea ice has decreased severely, and black surface of the sea has enlarged. The sea ice covered only 25% of the Arctic Ocean in the summer of this year. The Arctic Ocean has pouch like shape surrounded by Eurasia and North America, and has an entrance only between Norway and Greenland. The surface of the Arctic Ocean was covered with sea ice all the year round because of the limited exchange of seawater with other oceans. In addition, a mechanism which develops the surface sea ice of the Arctic Ocean exists. On the surface of Arctic Ocean, a layer of cold water, derives from fresh water from continents and melted sea ice and has a salinity density of 25‰, worked as a cap on the Ocean. This layer prevented the current, which flows into Arctic Ocean from Atlantic Ocean and has fairly high temperature and a salinity density of 35‰ from coming up to the surface of the Arctic Ocean. The sea ice of the Arctic Ocean

was the product of these special conditions. After 1998, the seawater temperature of the Pacific Ocean increased rapidly in the area around the Bering Strait, and the current of Pacific Ocean, which has higher temperature than that of the Arctic Ocean, began to flow into Arctic Ocean. Japan Agency for Marine-Earth Science and Technology found out this mechanism of rapid decrease of Arctic Ocean sea ice. Further, the increase of speed of the flow of the warm seawater was found out, which derived from the increase of sea circulation cause by the decrease of sea ice. These discoveries brought about the idea of controlling warm current from the Pacific Ocean to stop the warming of the northern hemisphere by increasing sea ice of the Arctic Ocean.”

“Do you know how much increase of the temperature could be induced by the melting of the Arctic sea ice?”

“The climate system research center of Tokyo University simulated that the world average temperature will increase by 2C and the temperature of Arctic region will increase by 10C in fifteen years when all of the Arctic Ocean sea ice melt.”

“Didn’t Russian or European countries’ government oppose to the Bering Strait Dam plan by saying it might bring about ice age?”

“Environmental assessment was conducted from every possible respect. The changes of seawater temperature, current and atmosphere were thoroughly simulated. Simulations showed the damages caused by global warming can be largely mitigated by reducing current flowing into Arctic Ocean from Pacific Ocean, and global temperature can be controlled by changing the amount of the flow. Russian government finally agreed with the construction of Bering Strait Dam because global warming brings about many severe economical damages to Russia, such as break down of building’s basis, caving of road etc. caused by melting permafrost. “

I said, “Some researchers said that the decrease of sea ice on Arctic Ocean causes shortage of production of cold heavy seawater, which leads to the stoppage of seawater sinking to the deep ocean. They said this stoppage means stagnation of deep current, which causes decrease of warm seawater flow from Atlantic Ocean to Arctic Ocean, and the temperature of Arctic region fall dramatically. How did it come out?”

“Before the construction of the dam, the sinking to the deep ocean was decreasing, but it recovered after the dam construction. The deep current is circulating steadily now.”

“That is great! Then, the construction of Bering Strait Dam should have required large amount of investment. How did the constructors acquire the necessary investment?”

“From now, I would like to start explaining about United Nation Fossil Resource Managing Organization (UNFRO). This organization is the fruit of fierce arguments concerning post Kyoto Protocol system for the reduction of greenhouse gas emission.

The Kyoto Protocol is, in short, a greenhouse gas emission reduction regulation, in which industrialized countries agree on legally binding target of emission reduction for each country. According to the Kyoto Protocol, the countries which reduced the emission amount more than they agreed are given emission credits. The countries which couldn't reduce the emission amount can purchase the emission credits to observe----

“You don't have to explain such basic information now. I just want to know why the world could agree upon such drastic plan as fossil resource control, and how the organization can produce a large capital”.

Two figures were shown on the screen. (Figure & Table 7.1, 7.4)

“The left figure is a simplified illustration of interest conflict and money flow under the Kyoto Protocol regime. Countries can be classified into three interest groups. First group is industrialized countries which hope to regulate greenhouse gas emission while they emit large part of green house gases. Second group is fossil resource producing countries which want to stop the regulation of emission, implicitly or explicitly. Third group is industrializing countries which hope for economical development depending on fossil resources. In the Kyoto Protocol regime, flow of the capital exists mostly within the industrialized countries. To the fossil resource producing countries, which receive severest damage from the regulation, receive no compensation. For the developing countries, some economical merits are given through Clean Development Mechanism (CDM), however, the amount of economical merits supplied by this system is not large enough and merits are supplied only under very strict conditions. It was very difficult for industrializing countries to develop environment-friendly industry by the capital provided by CDM.”

He continued, “The right figure shows money flow under UNFRO. Under this regime, the organization has purchased or borrowed all of the fossil fuels and selling the resources to all nations at an equal relatively high price. This revenue is used for subsidy for both industrialized and industrializing countries to develop the new energy and industrial mechanism which fit for the earth ecosystem. At the same time, the revenue is also used for adaptation to the global warming and payment for fossil resource producing countries. In short, fossil resources are now under control of a public cooperation, like Tobacco public cooperation.”

“It is quite wonderful that resource producing countries agreed with this regime.” I said. “They agreed because there were no other alternatives.” The man with moustache replied. “Around 2010, the next regime to reduce the global warming gas emission, which succeeds to Kyoto Protocol was under fierce argument. The U.S didn't accept any agreement which doesn't require regulation of green house gas emission to the

industrializing countries. On the other hand, developing countries didn't accept any target of emission reduction for them. Many industrialized countries had difficulty in attaining the agreed on target. Under these conditions, it was quite difficult for the limited countries to accept severe emission target. On the other hand, the greenhouse gas accumulation was reported to be accelerated and damages caused by global warming started to appear. All the countries were waiting for the measure to solve this situation. At that time, the idea of UNFRO was proposed by the U.S. and Japanese government. Many researchers and some countries readily expressed affirmative opinions to the idea, however, fierce opposite opinions were emerged. On the other hand, none governmental organizations and leaders of many religions supported this idea. Afterwards, the fossil resources producing countries also began to accept this idea recognizing the economical merit of this plan which assures the stable revenue of these countries. It was quite an epoch-making event to transfer national sovereignty concerning energy resources to global organization. It is quite awful to imagine what happened if each country should have continued to assert national interest furthermore”

I said, “You mean, the fund derived from this organization supported construction of infrastructure, such as the Bering Strait Dam, don't you?”

He replied, “That's true. The consensus to introduce renewable energy throughout the world was formed at the international conference for renewable energy held in Germany in 2004 and United Nations Sustainable Development Committee. However, the accumulation rate of greenhouse gas was so rapid that it was quite difficult to control the increase of temperature within 2C which was proposed by EU, even though many countries made efforts to introduce renewable energies. The capital supplied by UNFRMO worked as an engine for accelerative introduction of renewable energy. Then, I have one more good news to you, professor. A very important infrastructure necessary for renewable energy society was constructed by using the money supplied by the organization.

I replied, “I know what you mean. That's it. The global power network is actualized, isn't it?”

“Yes, it is. Renewable energies are usually produced in the areas which is quite distant from the high demand areas. In addition, renewable energies are largely affected by weather, and their energy supplies tend to fluctuate much. For these reasons, when the ratio of renewable energy in the energy supply increases, exchange of electricity in global scale and mutual assistance in emergency are necessary. Former Ac power transmission technology had the problem of transmission loss when electricity is

transmitted more than tens of kilo meter. For this reason, trunk lines surrounding earth and advanced control system were constructed with Dc power transmission technology which was actualized by the SIT technology invented by Professor Nishizawa. The solar battery, for example, can generate electricity only in day time. This truck lines transmit this electricity to the area where power supply is necessary at night for lighting use. Please see this figure.” In my view, Dc power lines spreading all over the earth were appeared.

“Thorough examination was conducted on what technology to use for the construction of power network. After all, Dc transmission method was adopted which can transmit electricity with very small loss through ten thousand kilo meter lines by using high temperature superconductivity cable. The industrializing countries can export domestic renewable energy through this infrastructure. Pleas see this image.”

It was a photo of desert area in Arabia Peninsula. There are many polygons can be observed on it.

“These are the power generation bases of solar batteries. The government of Saudi Arabia invested abundant capital in this renewable energy. This power generation base has grown up to one of the main industries of Saudi Arabia, because the solar batteries had price competitiveness. The price of the solar batteries has deceased to one tenth from the beginning of 2000’s to 2020’s by technological revolution. The main part of the renewable energy’s cost comes from the land cost. For this reason, the area with small population density can be utilized.”

“So, Japan’s night is illuminated by Sandi’s sun shine. OK. Then, If possible, please teach me the fundamental information. I would like to know the composition ratio of primary energy, greenhouse gas density and average temperature of the earth.”

“Roughly speaking, in the year of 2000, the amount of primary energy which was consumed in the world was ten billion ton when converted into crude oil. In the ten billion ton, the amount of fossil fuels, such as oil, coal, and natural gas, consists of 8.8billion ton and nuclear and hydro energy were 0.6 billion crude oil ton, each. On the other hand, the amount of carbon dioxide absorbed by the ocean was only 3.5 billion crude oil ton. The plants on the land as the whole had no ability of absorbing carbon dioxide. For these reasons, in the year of 2000, the amount of carbon dioxide accumulated in the atmosphere was 5.3 billion crude oil ton. When these figures are examined, the idea of halving the amount of fossil fuel used in to world by the year of 2050 to keep the increase of temperature within 2C form the industrial revolution was necessary to stop the global warming but looked unreal from the view point of energy supply.

However, the expansion of energy consumption was considerably controlled by each country's efforts. After 2010, the amount of industrialized nations' energy consumption remains at the same level or at moderate increase. The amount of energy consumption of industrializing nations didn't increase so much as expected in 2000's, because of introduction of energy saving technology and strategies which don't solicit consumption as before. The investment, which sums up to two hundred trillion dollars in these thirty years, enabled the generation of electricity of 6.4 billion crude oil ton by renewable power generators. In addition, the electricity of 1.2 billion crude oil ton is generated. Now, the consumption of fossil resources reduced to 5.5 billion crude oil ton in total in 2050. On the other hand, the carbon dioxide fixation is conducted to the amount of one billion crude oil ton per year. In total, the world achieved the emission reduction target of greenhouse gas in 2050. For these reasons, the accumulation rate of carbon dioxide in the atmosphere is controlled within 1ppm. The carbon dioxide density in the atmosphere today is 490ppm. The world average temperature has risen 2.2C from the beginning of the industrial revolution."

I understand the severe fight with the global warming is still on the way.

"So, to control the carbon dioxide concentration under 450ppm was impossible." I mentioned.

He continued, "The carbon dioxide concentration, which was 280ppm before the industrial revolution, exceeded 370ppm in 2000. In these days, European countries asserted that the carbon dioxide concentration should be controlled within 450ppm to stop global warming within 2C. However, the accumulation of carbon dioxide, which was around 1.5ppm in 1990's increased to over 2ppm, some times to 2.5ppm in 2000's. In 2010's, the accumulation increased to 3ppm, which came up to 4ppm in 2020's. However, after 2020, the rapid energy conversion from the fossil energy to renewable energy started and accumulation ratio decreased. It reduced to around 1ppm or over in 2040's. Now, we are working to reduce it to zero all over the world."

I asked, "Five point five billion crude oil ton of fossil resources are still used now. For what purpose are these used?"

He replied, "Recently, fossil fuels are seldom used for power generation. Fossil resources are mainly used for industrial use, such as petrochemical production and steel production. Fossil fuels are still used only for aviation fuel. As I told you, UNFRO as the sole public corporation sells fossil resources to these industries at a relatively high price, and the profit from this business is used for energy and industry conversion. The subsidy from UNFRO is also used for the humanitarian aids to those countries which have suffered damages from climate change."

“Oh, I can imagine the difficulties southern island countries suffering. Please tell their situation later. By the way, before seeing their situation, please explain me about the ocean fixation of carbon dioxide. You said one billion ton of carbon dioxide is fixated in the ocean, didn't you?”

“The carbon fixation in the ocean researched at the beginning of the 2000's, was something like to dispose diluted liquid carbon dioxide to the deep ocean. The environmental impact of the disposal was very much worried, because the water solution of carbon dioxide is acid, of course. In addition, capturing carbon dioxide from the emission gas of thermal generation plant takes energy and cost. Sinking carbon dioxide to the deep ocean also takes large cost. These are the reason why the experiment and research for this fixation method was ceased. Underground fixation of carbon dioxide was also examined but this research is also ceased because in case of eruption of fixated carbon dioxide terrible damages are caused to the surrounding area. By substituting these methods, ocean carbon fixation method which uses waste including plastic and biomass was invented.”

“You mean Multipurpose Material Conversion System(MACS) was put into practical use.”

“Yes, that's true. In the industrialized society, especially in Japan, organic wastes, such as plastics and sewage sludge were incinerated. There was no other way than incineration, because ocean disposal of wastes was strictly regulated by London Convention and the shortage of final disposal dump in Japan was very severe. However, the situations have changed since the material resolution device called Multipurpose Material Conversion System (MACS) which uses hydrothermal chemistry was invented in the middle of 2000's This device has the ability of converting wastes to oligosaccharide and amino acid, which are nutrients of microorganisms, with small energy real quickly. The incineration of wastes was ceased and much part of organic wastes is dumped into the ocean after the treatment of MACS.

“How did the energy use of the biomass, such as bio ethanol go along?”

“Biomass was utilized as a material for ethanol in Brazil from 1990's. It is reasonable to use biomass, which rots and is resolved to carbon dioxide when left as it is, as a source of energy. However, precious rainforests were lost, because people began to produce biomass fuel by planting much more sugar cane than before in Brazil. Price of corn increased because corn formerly used as a fodder was used as a fuel material. After all, when electrification of society and expansion of renewable energy proceed, people recognized that enough energy can be supplied without using biomass energy. That is the reason why the usage of the biomass, which is not efficient as an energy source, has

decreased. Now, only farmers utilize biomass energy for their domestic use. Later, the main usage of remaining biomass changed into carbon fixation. The utilization of MACS spread over the world, because the ocean carbon fixation through MACS system became the object of subsidy from UNFRO.”

“You said the amount of carbon fixation is around one billion crude oil ton. I wonder if there is so much biomass as one billion ton a year.”

“This figure includes the amount of plastic garbage which was incinerated before. The amount of sludge and domestic animals waste is very large. Recently, the amount of forestry waste is increasing. In many parts of the world, the growth rate of forests increased.”

“How did the desertification proceed? Then, if possible, would you please show me the present scenery of each region of the world?”

“I see, professor. But, how is your feeling? Don’t you have some rest? You are already sitting more than thirty minutes.”

“No problem, I am now feeling better. Please continue.”

“Then, I will start from the images of China. China of 2000’s experienced desertification in northern area including Hwang Ho region, and in the southern area experienced frequent flood damages caused by harvesting timber and increasing severe rains. Generally speaking China is not a country with abundant rain. This is the vision of the dry up of Hwang Ho. The dry up, first occurred in 1972, frequently appeared in 1990’s. To stop this dry out, agricultural water intake was restricted, and at the same time, examination of construction of three waterways ,which deliver Chang Jiang water to Hwang Ho region, started. In addition, China made efforts to recover lost forests. China expanded the reforestation operation to the Hwang Ho region where reforestation is difficult because of the effect of global desertification. So, the ratio of the forest coverage has fairly recovered in China. On the other hand, China, where many cities in coastal area, like Shanghai, experienced urbanization and motorization, made their best efforts in constructing sustainable cities, which are prepared for the limitation of energy and environment. China has introduced Chinese truck lines of super express railways and expanded them. In addition, it has constructed public transport lines to connect cities and their neighboring areas. I would like to mention that Japanese engineers largely contributed to the forestation, and construction of railroads, and the capital derived from the UNFRO supported these projects.

As for the food production, China has much increased the crop production by introducing organic farming method which utilizes the sludge treated by MACS. The country is also producing tens of times of sea algae than Japan, by planting large type

of seaweed on the coast of one thousand three hundred kilo meters long, from the coast of Dalian to Fuzhou. In addition, China has succeeded in the introduction of the aquaculture and it has world largest fishery production now. For these reasons, China is producing almost all the necessary food for itself. As for energy, China has constructed wind, hydro and solar power generation bases, in addition, it has large amount of coal reserve. The amount of oil imported by China has not increased so much as expected. However, there still are some restrictions for the ownership of Luxurious cars.”

“How did the countermeasures for air pollution work?”

“The air pollution problem has migrated through many countermeasures, and the acid rain problem of Japan has resolved.”

“Are there any effects caused by the increase of the sea water level?”

“This is a common problem of the world. Every country took the measures, such as building the breakwaters. On the other hand, in China, the city planning was made to protect lives and properties in case of flood caused by the high-tide etc. The residents living in the below-sea-level-area are gradually migrated. However, migration is difficult in other countries.”

“China’s situation is going fairly well, isn’t it?”

“That’s true. Thing are not going bad in Monsoon Asia, because it has relatively large amount of rain fall; still, the high-tide of Bangladesh causing severe damages.”

“How does the Bangladesh government cope with the high-tide?”

“The sea level has increased close to fifty centimeter from 2000 level all over the world. So, in the rainy season, Bangladesh’s situations are quite severe, however, many shelters for floods were prepared by the subsidy from UNFRO. At present, the refugee outflow haws not occurred, yet. However, within fifty years, the situation will be worsened, and emigration, population adjustment or construction of some gigantic breakwater will be necessary. This area faces severest situation in the world, as Amazon region faces.”

“What happened with the south east Asia countries, such as Thailand, Myanmar, and Vietnam?”

“These countries controlled deforestation at an early stage. With their forests and abundant rain, they suffer little from the global warming, but these countries’ modernization stopped at their city area.”

“It’s no problem. There is no need to force modern life style.”

“Then, the energy generated by hydro-power plants in these countries are exported to Japan.” “That is the reason why the world power network was constructed. OK Then,

please show me the situation of Amazon area. I am most worried about this area.”

The images of forests close to Amazon River seen from the satellite were appeared. Many areas which formerly were covered with rain forests are used as arable land and pasture. I remembered the impact I received when I was informed by Peter Cock of British Ecosystem Hydrology Center that the Amazon region would be a desert. The explanation started.

“When the Amazon River dried up at the middle of the river in 2005, the world was astonished by the speed of climate change. By the increase of sea surface temperature of Atlantic Ocean, the dynamics of atmosphere changed and the rain, which usually falls at the west of Amazon region, close to Andes, fell on Atlantic Ocean, which caused the drought of Amazon region. Even though people are reported the future desertification of Amazon, they didn’t know how to cope with the situation. The deforestation of forests worsened because the conomy of the nation heavily depended on export of farm products and the production of bio ethanol was increasing. The beginning stage of reduction of the rain didn’t affect to the agricultural industry. The burn agriculture continued and the virgin forests are said to vanish soon. UNFRO started to subsidize for protecting the virgin forests of Amazon with the reason that the forests are fixating carbon dioxide. Therefore, about forty percent of the virgin forests, including Indio’s preservation area were left as it were.”

“You mean the economical activities and forests cannot coexists?”

“Without strong regulation of the government, or strong will of the residents to protect the environment, the forests cannot be preserved. The desertification of the Amazon region worsened as could be seen clearly from the satellites. At present, the desert is expanding at the mouth of Amazon River.”

“What kind of countermeasures will be taken?”

“Irrigation canals are under constructing. The possibility of large dam to keep the rain of the rainy season within the continent is under examination.”

“I hope they can be along term countermeasures.”

“Then, show me the situation of North America.”

I saw considerable amount of reforestation in the southern part of the Grate planes. In southern states forest remains as they were. In western states including California, there were not much signs of reforestation.

“Because of the groundwater shortage and reduction of rain fall, which have been supported production of crops, the production of crops has fairly reduced. Many people are escaping from the Louisiana and Florida because of the repetitive damages form hurricanes. The U.S. government decided to return some of the granary area to the

forests, to increase the precipitation by reforestation. The amount of crops for fodder use could be reduced by utilizing the technology to manipulate the waste wood to domestic animal's food. The amount of the bio ethanol produced from corn decreased, because the demand for human food has increased."

"Was it possible to supply the huge energy demand of the U.S. with renewable energies?"

"The renewable energy source of the U.S. is quite abundant, because it has huge wind resources and large desert area which can be used for solar power generation. However, for stabilizing the power supply, the many nuclear power plants were constructed."

"The storage of high radioactivity waste might be easier in the U.S. than in Japan, however, it can worsen pollution from Uranium mine."

"The U.S. still faces many environmental problems. Some of them are water problems. The forests in the northern area have deteriorated by the increase of temperature and shortage of rain. California faces water shortage problem. Some industries and people are moving from California to eastern states."

"Then, please inform me about other areas. I am worried about other regions, such as Europe, Africa and Australia."

"The northern countries of Europe have established renewable energy systems and constructed stable societies, though the frequency of floods increased. The southern part of Europe suffers damages very severely from global warming. The heat wave which hit France, Spain and Italy in 2003 was just an omen of future temperature increase. The high temperature wind, comes from Sahara in summer, frequently hits Mediterranean countries. The average temperature of Italy and Spain has increased by five degrees in 2050."

"How are the European people coping with the situation?"

"In Spain and France, the rainfall has reduced, and agricultural production has severely decreased. Many people are emigrating to South America or other countries."

"Aren't there any effective countermeasure?"

"Long term drought is the severest problem to cope with. Formerly, people have to move or die. At present, they are making much effort to recover forests in this region. After all, the only countermeasure to cope with the desertification is reforestation. When the area of the forest enlarges, forests work as reservoirs of water and give good influence to the precipitation of the region. People are emigrating from Mediterranean countries, because it takes a long time to recover the region's climate. As for the people of these countries, South America countries and Russia, which is seeking for work force for construction of infrastructure, are accepting immigration. However, for the people

living in the Middle East Asia and northern part of Africa, who are also suffering from drought, the emigration is more difficult because of their cultural and language problem. The United Nations World Food Program (WFP) is providing food for them, however, they are still suffering from severe food conditions. The only relief is that population density is not so high in this area.

“How is the situation in other area of Africa?”

“In Africa, population increase brought about deterioration of the environment. The amount of river water per capita has much decreased in many areas. In the rain forest of the central Africa region, food supply is still safe because the precipitation increased in this area. However, in the southwest area, precipitation has decreased and desertification started. The U.N. is supporting the region through reforestation and food aid, etc.”

“Then, please tell me about India and Australia.”

“The population of India increased, but it stopped in 2040’s. No food crisis has happened in India, because the precipitation in this area is increasing. A world center of the computer software production locates in India, which brought about industrial development in this area. As for Australia, the government decided to restore forests by reducing export of crops and animal products, because the precipitation of this area has declined. The Australian government is trying to restore ecosystem by using Australia continent’s primeval plants.”

I deeply sighed. I understood general situation of the world.

I asked, “Did the blow out of the Methane -hydrate happen in some area of the ocean?”

“Small scale blow out of the Methane occurred at offshore of Nigata, Indonesia and Bermuda sea area. The next spot where the researchers have misgivings of blow out of Methane is the Kuroshio region at the south of Japanese inlands. South-east sea earthquake and Southern sea earthquake are anticipated at the spot. Researchers are praying that the blow-out might not happen, because if the blow out of the Methane occurs at this spot, rapid increase of global temperature happens.”

“The danger of the ecosystem crisis is still there, with all the efforts of human beings. OK. I understood the overview of the situations. Then at the last of your presentation, please explain me about the situations of Japan.”

“First, I would like to talk about foods situations in Japan. The situations in Japan are quite different from those in most other countries, because we were importing large amount of foods from all over the world. The global warming didn’t give large damages to Japanese domestic agricultural production. The schedule of rice cultivation changed in western Japan. The amount of snow-thawing water declined in Hokuriku and Kanto

regions. These are samples of weather conditions worsening. However, the precipitation in summer didn't decrease, and the precipitation in rainy season increased. For these reasons, the damages of global warming in Japan were not large when compared to those in countries which suffered desertification. The problem was the amount of crops in the global market. The country which produces crops will sell them to Japan even though such sales might cause shortage in their domestic market, because Japan still has very strong purchasing power. However, this might lead to the starvation of other countries. Japan increased rate of food self-sufficiency, but it is still importing large amount of food and fodder. This import is criticized by other countries."

"Didn't the trade surplus decrease by the increase of energy price?"

"As for the high fossil fuel price, it hasn't caused increase of import amount because the import volume has decreased. In addition, the half of the money to the UNFRO comes back to Japanese government as a subsidy. Japan shows a large loss in the trade of electricity. This is because geographic conditions are a severe handicap for the production of renewable energy in Japan. On the other hand, the technological superiority in the production of automobiles, electric machines and precision machines has not changed. World people recognized that it is because Japanese people have preciseness, dexterity and patience and talent in the engineering fields.

"Did the population of Japan decrease radically? How did the falling birth rate go along?"

"The birth rate of Japan decreased sharply in 2000's and 2010's. People of these decades are said to have forgotten human value."

"You mean that people in this age appreciated the value of human, don't you?"

"You are right. In 2000's it is said that the worsening environment is caused by too much population, and the number of human being should be reduced. It is natural to reduce birth rate at an area where population is rapidly increasing. However, the idea of soliciting population reduction, while keeping the lifestyle of using much fossil fuels and keeping on deforestation, is now denied. If the human being has no value, why should the people of the world have to cooperate to support the people of the countries which suffer severe damages by the global warming? When the lifestyles and economic systems of human are adjusted to the earth ecology system, human beings can be an existence which can bring about blessings to both human beings and the earth. The Japanese of 2000's are said to have placed too much importance on economic growth and have forgotten to bring up people of the next generation who work for next decades. In recent decades, Japanese engineers contributed to the improvement of local and global environment, all over the world. Japanese engineers played active parts in constructing

the power grid, and introducing the MACS and energy saving technologies. World people are appreciating the strategic change, a change to put much more importance on human value, of Japan, which contributed to bring up many scientists and engineers who work for the world.

“Didn’t the residential situation of Japan give difficulties to the young people in bringing up the children?”

“It is argued that if everything is put on market mechanism, the population concentrates on cities to seek for efficiency of economic activities, and, in the cities, the activities for nurturing the children, who produce no economic value, will be neglected. To make it easier for young people to bring up the children, the main object of the strategies was to allocate young people to rural cities. The endeavors to reestablish local economy have shown moderate progress through establishment of many industries, such as agriculture, forestry, fishery, welfare, sight seeing, and education industry. The agriculture industry was subsidized to increase the self-sufficiency rate of food. In the fishery villages, coastal aquaculture was developed by leaning the success of China. In forestry villages, the woods were utilized not only for chamber and pulp raw material, but also for carbon dioxide fixation. The MACS system came to be evaluated for its ability to fixate carbon dioxide, and it produced new industry in forestry villages. The sight seeing industry prospered, because workers of Japan are given longer vacations than before through work sharing system, etc., Children are now spending their summer in the summer schools, located on northern part of Japan and Japan Alps, because the summer temperature of the cities became too severe for children”

“What is the birth rate now?”

“It is one point eight, professor.”

“So, the pension has survived, hasn’t it? It is wonderful that Japanese young family is enjoying their family life now more than those people lived in Japan in 2000’s. In 2000’s the birth rate was only one point two, in Japan”

“That is true. I think so, too.”

I was attacked by a strong sleepiness.

“Professor, you look so tired. Then I will stop today’s presentation, now”

I was delivered to my room unconsciously. I enjoyed long comfortable sleep without seeing any dreams.

Maybe I have slept more than a whole day.

I was awakened by a bright sunshine from the window. The room seemed to have been changed while I was sleeping. The doctor appeared. “How are your feeling today?” “It’s

quite good. I am hungry.” “After finishing your breakfast, you can go out for a short time. If you have any place you want to go, we can take you to the spot.”

I suddenly feel like seeing the ocean. I said, “Is it possible to see the ocean?”

He replied, “Then, I will prepare for a car.”

“Oh, if possible,” I point out the monorail which can be seen from the window. “I want to take ride of the monorail seen over there”

The doctor replied. “Yes. Professor, the monorail is bound for Sendai, so ,I will prepare a car there.”

After the meal, I took ride of the monorail accompanied by the doctor and a nurse. “How comfortable this train is! Even I can ride for hours. ” “This monorail is used for commuting for every working people of this research city. Professor, fifty years before, workers commuted by a packed train, didn’t they?” “Yes, of course. It was so severe to work in Tokyo.” “We, of this age, will not choose such workplaces. We choose best place for bringing up the children in determining workplaces, so we select local cities.” “How can you educate your children for entrance examinations?” “In this age, except for several very difficult universities, everyone will be admitted for the universities. For this reason, competition for entrance examination is not severe. In return, to graduate from the universities, students have to study very hard. It was called the American way , wasn’t it?” “Yes, it looks to be a better way. Now, young people looks very nice with self-confidence inside. Fifty years before, many students didn’t have their confidence.” “They know they have so much work to be done by them for the society. In addition, the education to grow their cultural identity formed their self-confidence.” “What does education for cultural identity mean?” “ It means to educate Japanese history, arts and culture. The history of science is also educated. We learned about you in our textbooks, Professor Nishizawa.” “Stop it! But, it is very important for everyone to know about his good point, because it works as a “psychological shelter”, which enables them to accept new information and to contribute to the world. It is very important to be self-confident. The next question is to what point one can be self-confident -----.” “ I read your book you published fifty years before. You said Japanese should be self-confident in their engineering ability.” “I also mentioned that Japanese should be self-confident in their characteristic of loving peace.” “Yes, that is true. Japan has experienced no war within one hundred years.”

Then, we changed to the car, and ran along the ocean. The breakwaters seems to be strengthened, however, there was no change in the scent of the ocean and the light of the waves. There was a small beach surrounded by breakwaters and children were playing with sea water. I wanted to have a closer look.

“Is it possible to go close to the beach?” I asked to the driver. The car stopped aside of the beach of the creek where children are playing. They are playing with floating cycle and are diving in the sea.

I said, “It is a merit of global warming. When I lived in Sendai, children were not playing like this in Sendai’s ocean.”

One tanned boy ran toward me. He bowed to me and said, “Hello, professor!”

I remembered the face of the boy. He was surrounded by the twinkling light of the ocean. He said to me. “Don’t you remember? I said our earth will not be ruined.”

Chapter 2 The truth of Global warming

To cope with the global warming problem, we have to recognize the total mechanism of global warming. Global warming is not a problem where just the atmospheric temperature increases but a problem whose mechanism has deep connection with the ocean, living creatures' and human activities. However, in this chapter, we will describe only the mechanisms of warming concerning the atmosphere, topics concerning the ocean will be treated separately in the chapter 3. The problems concerning the human sphere will be stated in chapter 7 and after. On the other hand, even though the relationships among global warming, ocean and human sphere are not described in this chapter, the mechanisms of the atmospheric phenomena themselves are very complicated, and they will take much space if we try to describe them precisely here. The main object of this book is to make readers of this book understand the possible methods to mitigate the global warming. For this reason, we stated only very important points to understand the whole mechanism of global warming. Much important information concerning atmospheric system was omitted. For this information, please refer to our former books or other specialized writings.

Birth of the earth and change in the atmospheric components of the earth

The history of the cosmos started with the Big-bang of fifteen billion years ago. The solar system to which our planet earth belongs was given structure about ten billion years after the Big-bang, and the earth was formed with the gases and dust of the solar system about 4.6 billion years before. There are two groups of the planets. One is the group of small planets, such as Earth, Mercury, Venus and Mars, which are composed of the rock with large specific gravity, and the other is the group of larger planets, such as Jupiter, Saturn, Uranus and Neptune, which contain large amount of gases and have smaller specific gravity. The latter is rotating in outer orbits of the solar system. On the surface of the smaller planets, at the beginning of the planet creation period, carbon gathered to the surface on the melted planet, reacted with Oxygen and stayed there as carbon dioxide. The earth atmosphere at the creation period had carbon dioxide concentration of 80% and was in super-greenhouse state. Similar super-greenhouse state can be seen in present Venus. On the Venus, 97% of the atmosphere is occupied by the carbon dioxide, the temperature is 460 degrees Celsius and no water or living creatures exists. When the temperature of the earth decreased to 300 degrees Celsius, suddenly, vapor in the atmosphere started to pour onto the surface of the land as heavy

rains, and the earth was filled with large amount of liquid water. In this way, the primeval ocean was formed about four billion years before. At that time the atmospheric pressure was ten to one hundred times of present one, and huge amount of carbon dioxide was contained in the air. The temperature of the primeval ocean was about one hundred to two hundred degrees Celsius by the green house effect. The surface of the earth was literally a scorching hell

Fixation of the carbon dioxide at the bottom of the ocean

The emergence of the ocean means establishment of the huge storage place for carbon dioxide. The carbon dioxide is highly soluble to the water. That is why the concentration of carbon dioxide in the atmosphere gradually decreased through the existence of the ocean. However, it still took time for the earth to evolve into a planet which is filled with flourishing living creatures. The atmospheric temperature decreases to only about 70 degrees Celsius even though maximum amount of carbon dioxide dissolves into the ocean, because carbon dioxide has a limit in dissolving into the ocean. The living things that can survive in such an environment are only some kind of bacterium. However the mechanisms of Plate tectonics worked which decreases the concentration of the carbon dioxide in the atmosphere. When the drift of the crust has started was unknown yet. However, at some stage of the earth evolution, the oceanic crust started to be born at the mid-oceanic ridge, drift on the bottom of the ocean and sink into the sea trench. The carbon dioxide, which was absorbed in the ocean, reacted with calcium and accumulated on the seabed as calcium carbonate (Limestone). Through the mechanism of the Plate tectonics, calcium carbonate was taken into inside of the earth and fresh seabed and continental crust, which provide calcium to the ocean, were supplied. For this reason, the ocean could continue to absorb carbon dioxide in the atmosphere, and the concentration of carbon dioxide in the atmosphere decreased radically. F&T2.1 shows the change of atmospheric element on the geological timetable. This mechanism can be explained more precisely as follows;

The convection of the plates created continental crust which was made of a mass of granite. The seabed of basalt, which has the density of 3.0 (g/cm³), sink to the sea trench with lighter substances, which have accumulated on the seabed, and melt together to form granite on the upper side of the mantle, as shown in F&T2.2. The granite has a density of 2.7 (g/cm³) which is smaller than the density of the substance constituting the mantle. 3.3(g/cm³) For this reason granite stays on the top of the

mantle and forms the continents. The earth was a planet of water, where surface was mostly covered with the ocean and only the ridges of the craters and volcanoes like Hawaii islands appear above the water, before the creation of the granite. When the vast continents emerge, the weathering of the land rocks, mainly granite, starts. When the surface of the rock is weathered by the rain, inorganic materials starts to be solved in the water and the minerals run into the ocean through river. Especially much amount of calcium reacted with carbon dioxide in the ocean and accumulated on the seabed as calcium carbonate. The ocean can absorb additional carbon dioxide as the carbon dioxide dissolved in the sea water was extracted as limestone. Through this process, the concentration of the carbon dioxide in the atmosphere decreased, and the environment where living creature can evolve into many species was prepared.

The calcium carbonate, which slipped down to the underground by the movement of the plate, melts into the magma of high temperature, erupts to the surface of the earth as carbon dioxide or volcanic ash through volcanic activities. For this mechanism, carbon dioxide is supplied to the atmosphere constantly from the underground, and carbon dioxide in the atmosphere never dries up.

MEMO Plate tectonics

Plate tectonics is one of the most eminent scientific discoveries in the human history. The surface of the earth is covered with over ten solid plates which have thickness of sixty to one hundred km. The plates are moving in asunder direction at a speed of several centimeters per a year. The crashes of the plates become a cause of the orogeny which forms geographical features of the earth. The plates drift on the asthenosphere, a flowing sphere of upper mantle. Each plate mutually parts, comes in contact and slips or shifts sidewise, and forms the geographical structure of the earth surface. In the submarine topography, the mid-oceanic ridge is the place where plates are formed, and the sea trench is the place where plates slip down. The plate tectonics formed the grand theoretical framework of recognition of the earth that the continents drift with the ocean crusts. Further more, this theory solved most important geoscience problems, such as the explanation of the distribution of continents and sea, deep layer earthquake, orogeny and differentiation of living things, smoothly within these fifty years. The quest for the metalliferous deposit and oil resources became epoch-makingly easier by the application of the plate tectonics theory.

Emergence of biosphere

The scenario of the emergence of the oldest life is thought as follows. High energy, such as thunders poured into the ocean which is prepared for the evolution of life, and organisms, such as amino acid and nucleic acid, are gradually synthesized, and an organic soup was created. Then the organisms gathered like a drop of oil and concentrated. The oldest microorganism was born on the earth about 3.6 billion years ago. This microorganism was an anaerobic microorganism which cannot live in an atmosphere containing oxygen. The descendant of this oldest living creatures is the group of high temperature bacterium which lives with the bait of iron and sulfur. near the bubbling eruption hole of sulfur and magma at the sea trench of three to four thousand meters in depth. The microorganisms which conduct photosynthesis appeared three billion years before. Primitive algae appeared 2.8 billion years before and the cyanobacterium appeared two billion years before. These creatures discharged huge amount of oxygen into the seawater. When the sea water was saturated with oxygen, oxygen is discharged from the ocean to the atmosphere. Recent researches introduced a theory called "snow ball earth." According to this theory, when the concentration of oxygen increased and carbon dioxide decreased, the surface of the earth, which had been warm by the green house effect of the carbon dioxide, was cooled, and the whole earth was covered with the ice in 2.3 billion years before.

The earth, once covered with the ice, again was warmed by the carbon dioxide, which was supplied to the atmosphere by the volcanoes, and got out of the snow ball earth state. The photo creatures, which survived the snowball earth era, flourished on the earth again. The concentration of the oxygen in the atmosphere started to increase rapidly six hundred million years before. The ozonosphere began to be formed over the atmosphere, and the land came to be protected from the severe ultraviolet rays, and the expansion of the plants to the land came to be full-scale. According to the theory of the plate tectonics, the continents which once gathered to a super-continent six hundred million years before, began to be disjointed again. The creatures which were given birth in the ocean evolved into plants and animals and succeeded in forming their bridgeheads on the land, where the environment is severer than that of the ocean. The plants finally formed huge forests and the mammals appeared two hundred fifty million years before, and the Dinosaur enjoyed a glory period in one hundred million years before.

Mass Extinction

It is not true that the creatures have developed without difficulties. Within these six hundred million years, there were five mass extinctions in the history of life. (F&T2.3) It is once in one hundred million years on the average. The closest one was the extinction which happened sixty five million years before and exterminated the dinosaurs, when a huge meteorite crashed into the earth. At the Yucatan of Mexico, the collision point, there exists a huge crater with a diameter of two hundred km, and it is said that a meteorite of 10 km diameter is said to be buried. The tremendous dust produced by the collision of the huge meteorite went up to the troposphere and stratosphere, the earth was covered with the thick cloud containing the dust and the light of the sun was intercepted long after the incident. Plants which require sun light for photosynthesis died out and, according to the food chain, herbivorous dinosaurs and carnivorous dinosaurs were exterminated. On the other hand, two hundred fifty million years ago, at the end of the Permian, the ocean experienced the state of hypoxia, and ninety five percents of the species of life were exterminated. The causes which brought about this mass extinction will be stated more in the chapter 3 where the risk of methane hydrate is explained.

Paradox of the dark sun

By the way, what kind of effect did the trend of the radiation of the sun, which has the dominating power in the formation of environment on the surface of the earth, give to the temperature of the atmosphere? According to the theory of the evolution of fixed star, 4.6 billion years before, the energy radiated from the sun was only seventy two percent of the present one. The earth of present atmospheric composition will completely freeze at once if the earth receives such small amount of energy from the sun. However, the concentration of the carbon dioxide was about four hundred times of the present rate. The radiation of the sun constantly increased since then. On the other hand, the concentration of the carbon dioxide almost constantly decreased in the following three billion years. At the beginning of the Proterozoic, the concentration decreased to seven to eight times of present rate. Since then, the concentration didn't change much, apart from the short term fluctuation, and stayed at a rate several times larger than the present one. Fortunately, the increase of solar radiation and the reduction of the concentration of carbon dioxide in the atmosphere occurred simultaneously. For this reason, the climate of the earth stayed within the limit of life existence. (T&F2.4

paradox of the dark sun) By the way, the ice age, which started forty million years before and ended ten thousand years before, is said to be the era, when the temperature of the atmosphere was the lowest and, at same time, the concentration of the carbon dioxide in the atmosphere was the lowest, in the history of the earth. The reason why such an ice age began will be stated in Chapter 3.

What is the green house gas?

In the atmosphere, there are quasi-stationary elements and variant elements. The volume ratio of the quasi-stationary elements, such as nitrogen, oxygen and argon, doesn't change according to the height, season and place, and the volume ratio of the variant elements, such as vapor, carbon dioxide and methane, changes largely. The important characteristic of the variant element is that these gases absorb the energy of infrared ray, which radiates from the earth to the space. The gases radiate the energy, which they captured, again as infrared rays at a proportional rate to the fourth power of the gases' absolute temperature. In the meteorology, this characteristic of the gases is said to be active in thermodynamics, and such gases are called to be heat-trapping gases, or green house gases

The F&T2.5 shows the contribution of each green house gas to the greenhouse effect of present atmosphere, which is increasing the surface temperature of the earth by thirty three degrees Celsius. Most of the greenhouse effect derives from the water vapor and carbon dioxide. The readers of this book will be suspicious why the effect of water vapor is not discussed in the argument of the global warming when you see the big number of water vapor radiation (about 67%). This is because water vapor is a temperature dependent green house gas. The amount of water vapor is determined by the temperature. When the temperature is stable, excess of the vapor is removed from the atmosphere as rains. For this reason, it is understood that not the water vapor, but the other greenhouse gases controls the greenhouse effect. This is why the change of other green house gases is paid attention.

The mechanism of the green house effect and the window of the atmosphere

The mechanism of green house effect is shown in T&F2.6, which explains the case of carbon dioxide as an example. When carbon dioxide concentration increase in the atmosphere, the energy radiated from the sun is increasingly absorbed by carbon dioxide. When the energy is trapped, the connecting part of C and O of the carbon

dioxide molecule, where one carbon atom and two oxygen atoms are connected, vibrates like an accordion. When the excited state, the vibration of the connecting part, ceases, infrared rays are radiated and this energy will be the source of the warming.

F&T2.7 illustrate the atmospheric window, which is narrowed by the increase of the green house gases. The sun light has its radiation in the wave length range of 0.0 to 4.0 μ m. The wave length of the infrared rays radiated from the surface of the earth distributes from 4-5 to 50 μ m. This is why the solar radiation is said to be the short wave radiation and the infrared radiation is said to be the long wave radiation. In the bottom figure of F&T2.7, the absorption rate of the atmosphere for each wave length is shown. The molecular signs attached to the abscissa show the working area of the green house gases. According to this figure, the atmosphere is transparent to the solar radiation (the atmosphere is not absorbing solar radiation) and opaque to the infrared rays (the atmosphere is absorbing infrared rays). Especially, the atmosphere is completely opaque due to the function of the water vapor in the range over 15 μ m, and the atmosphere completely absorbs the upward infrared rays from the earth surface. So to speak, the earth atmosphere is a leather bag with a small hole. This mechanism enables the atmosphere to store energy, like water in the bag, within it, when it receives solar energy. As is shown in T&F2.7, the absorption rate of the atmosphere for the infrared rays is low at the wave length range of 8 to 13 μ m. Thus the upward infrared rays' radiation from the surface of the earth effectively goes through the atmosphere and disperses to the outer space. That is why the wave length range of 8 to 13 μ m can be said as the "hole of a leather bag" or "atmospheric window". The element which decides the width of the window is the concentration of the green house gases, which is under discussion worldwide.

The greenhouse effect not always plays a villain role. Actually, the greenhouse effect has protected the lives of the earth from the severe outer space environment, by embracing the earth like cotton. The average temperature of the surface of the earth was kept comfortable around fifteen degrees Celsius for these ten thousand years. Without this effect, the surface temperature of the earth is said to be cooled to minus eighteen degrees Celsius. For example, the Mars, which is more distant from the sun than the earth and has a low carbon dioxide concentration, has the green house effect of one to two degrees Celsius and has the surface temperature of minus fifty degrees Celsius. The Venus, which is closer to the sun than the earth and has a higher carbon dioxide concentration, has the surface temperature of four hundred degrees Celsius. However,

the greenhouse effect, which has been playing an important role, has come to threaten the existence of the creatures, especially, the existence of the human beings by the too much accumulation of carbon dioxide in the atmosphere which alter the ecosystem of the earth.

The global warming through human activities

In this chapter, we have stated that the surface temperature of the earth was under the control of the effect of the GHGs, especially carbon dioxide. We also described how the GHGs warm the atmosphere. From now, we state how the human beings' activities affected the composition and temperature of the atmosphere, and report the forecast of the future human emission of the GHG, concentration of the GHG in the atmosphere, and the temperature.

The human beings affected the composition of the atmosphere through the destruction of the forests and mass consumption of the fossil fuels. The utilization of the fossil fuels to seek for the wealthy lives started from the use of coal at the middle of the 19th century, went through the fuel revolution at the middle of 20th century and reached the mass consumption of oil and natural gas at present. The deflection of the atmospheric temperature in the former one thousand years from the average temperature between 1961 and 1990 is shown in F&T2.8. The effect of the human activities to the atmosphere in these two hundred years is shown in F&T2.9.

Two hundred years ago, the concentration of carbon dioxide in the atmosphere was 280ppm, and 590 billion tons of carbon was contained in the atmosphere. In these two hundred years, the amount of carbon dioxide returned to the atmosphere from the trees by the reduction of the forests is 190 billion tons, and the amount of carbon emitted by the use of fossil fuels is 280 billion tons. In total, 470 billion tons of carbon is added to the atmosphere. If all of the carbon dioxide remains in the atmosphere, the concentration of carbon dioxide would be 500ppm and the amount of carbon would be more than 1000 billion tons. However the concentration of carbon dioxide in 2000 is 360ppm. This means 60% of the carbon dioxide emitted by the human activities is absorbed somewhere and 40% was accumulated in the atmosphere. Many researches revealed that half of this carbon dioxide was absorbed in the ocean of middle to high latitude, and the other half of the carbon dioxide was absorbed in the forests of middle to high latitude. The concentration of carbon dioxide is increasing these tens of years at an average rate of 1.5ppm. After 2000, it increased more than 2.5ppm in some years. According to the report of IPCC, the carbon dioxide concentration which exceeded

380ppm in 2006 was the highest one in these twenty million years. For this reason, in these one hundred years by 2000, the average temperature of the earth has increased by 0.6 degrees Celsius, and in the north hemisphere it increased by 0.9 degrees Celsius, and in Japan it increased by 1.5 degrees Celsius.

MEMO IPCC

IPCC (International Panel on Climate Change) was established in 1988, as a co-sponsored international organization of the United Nations Environment Program (UNEP) and the World Meteorological Organization (WMO). IPCC is consolidating and publishing the newest scientific, technological and socio-economic information relevant for the understanding of the risk of human induced climate change under the participation of the scientists and government officials of many countries. Concerning the information about former, present and future climate, this book cites datum of the Forth Assessment Report (FAR) of IPCC as much as possible. FAR consists of three reports from separate working groups. First working group assesses the scientific aspects of the climate system and climate change. Second working group addresses the vulnerability of socio-economic and natural systems to climate change, negative and positive consequence of climate change, and options for adapting to it. Third group assesses options for limiting greenhouse gas emissions and otherwise mitigating climate change.

The projection of the emission of the GHG and temperature increase

The proceeding of the climate change can be altered by our choice in technology, economic system and social system. We will discuss what society to choose in the following chapters. At present section, we explain the long-term emission scenarios shown in the Special Report on Emissions Scenarios (SRES) of IPCC in 1996. GHG emissions are the product of very complex dynamics systems, determined by driving forces such as demographic development, socio-economic development, and technological change. Their future evolution is highly uncertain. Scenarios are alternative images of how the future might unfold and are an appropriate tool with which to analyze how driving forces may influence future emission outcomes and to assess the associated uncertainties. They assist in climate change analysis, including climate modeling and the assessment of impacts, adaptation, and mitigation. The possibility that any single emissions path will occur as described in scenarios is highly uncertain.

Four main scenario groups (A1,A2,B1,B2) are constructed by using two axes as shown in F&T 2.10. One axis is whether the society puts its priority in the economical development or in the protection of the environment. The other axis is whether the world conducts united actions or sets the priority on protecting regional cultures and economies. (Contents of the scenario are shown in F&T2.11)

The A1 scenario, which describes a future world of very rapid economic growth, develops into three groups that describe alternative directions of technological change in the energy system. The three A1 groups are distinguished by their technological emphasis: fossil intensive (A1FI), non-fossil energy sources (A1T), or a balance across all sources (A1B) (where balanced is defined as not relying too heavily on one particular energy source, on the assumption that similar improvement rates apply to all energy supply and end use technology)

Chapter 3 The Ocean where key to the climate change lies

The hydrosphere and carbon circulation system of the earth

The increase and decrease of the carbon dioxide in the atmosphere can be understood as the circulation of carbon among the blocks of the earth surface. Usually, the surface of the earth can be divided into four blocks; atmosphere, hydrosphere, biosphere and lithosphere. In the former chapter, concerning the long term change of the composition of the atmosphere, we have stated that the carbon dioxide in the atmosphere was first absorbed in the ocean, then the mechanism of plate tectonics and plants dramatically decreased its concentration, and recently its concentration has increased rapidly through the human utilization of fossil fuel and forests. This change can be recognized as the transfer of the carbon dioxide by the human beings from the lithosphere and biosphere to the atmosphere, which was once moved from atmosphere to the hydrosphere, lithosphere and biosphere. The main theme of this chapter is the relationship between the hydrosphere and atmosphere concerning carbon dioxide transfer. The fundamental question is whether the carbon dioxide will keep on moving from the atmosphere to the ocean as before. The backlash of the carbon from the ocean to the atmosphere is worried about. F&T 3.1 shows the amount of carbon, which exists in each sphere, and the amount of carbon in circulation.

740 billion tons of carbon exists in the atmosphere when calculated from the amount of carbon dioxide. In the biosphere, it is supposed that about 550 billion tons of carbon exists as living creatures and 1.2 trillion tons of carbon exists as dead bodies. This carbon amount is about two point four times of that in the atmosphere. This figure differs from a laboratory to another, and the difference comes up to several folds. The hydrosphere fixates far larger amount of carbon. The hydrosphere has two hundred and seventy times of mass and one thousand and one hundred times of calories of the atmosphere, and stocks thirty four trillion nine hundred three billion (34,903,000,000,000) tons of carbon, which is forty seven times of that in the atmosphere. Apart from the argument of the accuracy of these figures, the ocean is stocking tremendous amount of carbon dioxide.

Next, let's see how the carbon dioxide distributes vertically in the ocean. (F&T3.2)

The carbon dioxide in the atmosphere is absorbed in the ocean from the surface of the ocean. In the ocean, 1% of the carbon dioxide exists in the form of gas, and 99% of the carbon dioxide is dissolved in the sea as ions, which make sea water a weak acid. In the

shallow sea water, from the surface to several meters, the pressure of carbon dioxide in the ocean is the same with that of the atmosphere by the effect of waves. In the deeper part of the ocean, the pressure of the carbon dioxide decreases from the atmosphere level. The oceanic mixing layer, where sea water and air are mixed well, spreads close to one hundred fifty meters. Under the mixing layer, a layer called thermocline continues to the depth of one thousand meters. The concentration of the carbon dioxide in the deeper sea depends on the conditions of the seabed. Compared with the North Atlantic Ocean, in the North Pacific Ocean has considerably higher density of organism and carbon dioxide. This is because, in the deep cold water circulation, the Atlantic Ocean lies upstream and the Pacific Ocean lies downstream.

There are three kinds of ocean circulations. One is the surface circulations, which flow at a level shallower than one thousand meters, second is the deep circulations, which flow at a level deeper than three thousand meters, third is the circulations of intermediate level. The surface circulations are the ocean currents, such as Kuroshio Current and Oyashio Current, which have relationships with the water temperature, salinity and the wind. The surface currents circulate around the earth at a speed of two thousand five hundred kilometers per a year.

As for the deep circulations, we will explain them in the next section in detail. It starts from the offshore of the Greenland, and flows from the north hemisphere to the south hemisphere, then, after circulating the earth, comes back to the north hemisphere and returns to the Greenland. The speed of its circulation is fifteen kilometer a year. It takes four thousand years for a circulation.

The Global Ocean Conveyor Belt

Recently, around the Labrador Sea in the west of the Greenland and at the Weddell Sea in the Antarctic Circle, deep convections, massive sinking of the sea water toward the bottom of the Ocean, were found out. The sea water sinks because of the two reasons; one is the segregation, which happens when the sea water freezes and salt is expelled, the other is the increase of the sea water density caused by the low temperature. This phenomenon is confirmed by the investigation conducted by the Geochemical Ocean Sections Study. (GEOSECS) The U.S. government investigated the distribution of the tritium, a radioactive substance, in the ocean, to examine the effect of nuclear tests, which were conducted by the U.S. and the former Soviet Union since 1955. The tritium is distributed in the sea water within several hundred meters from the surface throughout the ocean, however, the distribution reached to the depth of three thousand

meters in the North Atlantic Ocean. This deep convection of the sea water was the start point of the deep circulation, where sea water of one hundred times of Amazon River (two hundred million tons per second) sinks at the width of one hundred kilometers at the speed of ten centimeters per second to the deep ocean. This deep current flows to the west by the effect of the earth rotation, and goes down to the south along the east coast of the South and North America. This flow is merged by the deep cold water, which is produced at the Weddell Sea in the Antarctic Region. Then, this deep current separates into two deep currents. One of the currents goes to the Indian Ocean and the other goes to the North Pacific Ocean and comes up to the surface there. The deep current of two degrees centigrade is warmed up here by the solar energy, and becomes a warm current. This current goes back, through the reverse course of the deep current, on the surface of the ocean. Finally, this current, which is pulled by the deep convection of the sea water at the Labrador Sea, separates from the Mexico Bay Current and flows toward the Greenland. (F&T3.3) Labrador Sea and Weddell Sea are known as the only places of the deep convection. According to the measurement by the carbon isotope, it takes two thousand years for the sea water to come back to the surface.

The reason of the temperature drop in Cenozoic era

The present situation of the deep current, which has come to be acknowledged to people recently, was found to be formed after the beginning of the Cenozoic era. (In geology, the era after the Cretaceous is called the Cenozoic era.) Today, the deep current starts from the Labrador Sea, but at the beginning of the Cenozoic era, the deep current started from the Tatis Sea, which lay close to the equator. There was no ice cover at the two poles, reflecting the warm climate of the era. All of the sea was covered with the warm sea water of almost same temperature. For this reason, “sea water with heavy specific gravity for its coolness” didn’t exist, and “sea water with heavy specific gravity for its high salinity” was produced near the equator where the evaporation of the sea water was active. This “sea water with heavy specific gravity for its high salinity” consisted of the deep current of that era. The sea water temperature was supposed to be around fifteen degrees Centigrade even at the bottom of the ocean.

However, the Tatis Sea was closed up by lands through the continental drift. On the other hand, ice covers at the two poles (especially at the South pole) spread because of the gradually decreasing temperature of the earth. This incidence changed the temperature of the deep sea water radically. The person who found the change is Dr. James Kenet of Santa Barbara School of the California University. Dr. Kenet

investigated the oxygen isotope of the husks of benthic foraminifera to analyze the sea water temperature change. This investigation made clear that the temperature of the deep sea water decreased from fifteen centigrade to two centigrade during the Cenozoic era. The place where the high density sea water is produced changed from the equator region to the pole regions because of the cooling of the pole regions' ocean. Most of the seabed, which occupies seventy percent of the earth surface, was filled with the sea water near freezing point.

The temperature drop of the deep sea water became one of the reasons for the radical density decrease of carbon dioxide in the atmosphere. The cool water deep convection worked as an effective pump to convey carbon dioxide to the deep water, because the cooler water dissolves more carbon dioxide. The strength of the wind increased, because the temperature difference between the equators and the two poles produced the active circulation of the atmosphere. This made a flow of surface sea water, and enabled upwelling of the deep sea water which contains abundant nutrients. The botanical planktons, mainly diatoms, which conveyed much carbon dioxide to the seabed, flourished at the upwelling area of the ocean. Later, we will describe more in detail about the effects of the plankton proliferation, which lead to the cooling of the earth. (F&T 3.4) For these mechanisms, during the Cenozoic era which last sixty five million years since the Cretaceous, the temperature, which was extraordinarily warm in Cretaceous, was decreased to today's moderate level of about fifteen degrees Centigrade in average. This climate enabled the mammal, a homeothermal animal which has high body temperature control ability, to flourish.

The importance of the Arctic Ocean and the reduction of the ice cover

Now, we understood that the geographical features of the two poles, which enable the development of the ice cover and produce the cold deep water, brought about the cooling of the earth since the beginning of the Cenozoic era. The shape of the Arctic Ocean resembles to a bag. The Arctic Ocean is surrounded by the Eurasia Continent, North America Continent and the Greenland, and has a relatively wide window between the Greenland and the Europe. Many rivers from Canada and Siberia flow into this ocean. This river water decreases the salinity of the surface sea water. These conditions promote development of the ice cover.

One more special reason exists which is promoting the development of the ice cover in

the Arctic Ocean. The stratification of the Arctic Ocean is found out as another key. The intermediate layer, which lies at the depth from 200 to 900 meters of the Arctic Ocean, is filled with the warm sea water, which comes from the Atlantic Ocean. In ordinary conditions, this water comes up to the surface of the sea and disturbs the development of the ice cover. However, in the Arctic Ocean, the surface sea water of low salinity is working as a cap to prevent the rising of the warm water. The salinity of the surface sea water of the Arctic Ocean is 27‰, on the other hand, the salinity of the warm sea water of the Atlantic Ocean is 35‰. This difference of the salinity is preventing mixture of these two layers.

The ice cap, which is formed under these delicate conditions, plays an important role for maintaining the earth climate. Dr. Takatoshi Takizawa of [the Marine Science & Technology Center](#) explains this role as a radiator of the earth. That is, the ocean close to the equator, which receives abundant heat of the sun, plays the role of an engine, and the two poles are playing the role of radiators. This radiator system depends on the white color of the ice cap. The black color has the characteristic of absorbing heat easily. The surface of the sea, which usually has blackish color, absorbs 90% of the heat derives from the sun. However, once the ice cap spreads over the ocean, the situation changes dramatically. The white ice reflects 90% of the heat from the sun. For this reason, the ice cap decreases the temperature and this decrease of the temperature develops the ice cap. It means that the ice cap has the effect of chain reaction in which increase of the ice cap lowers the temperature which leads to the development of ice cap. This chain reaction is called the “Ice- Albedo effect.”

Dr. Ayako Abe of [the University of Tokyo Climate System Research Center](#) conducted a simulation to investigate what will happen, when all of the ice cap of the Arctic and Antarctic Ocean vanishes. The object of this investigation was to examine the role of these ice caps. The result of the simulation showed that, the global warming of the earth, which has completely lost the ice cap, worsen dramatically and the average temperature of the globe increases by two degrees Centigrade in fifteen years. The areas, such as Hudson Bay, and Okhotsk, where sea ices develop regardless of their low latitude, suffer the effect of the warming most, and the temperature of these areas increases by ten degrees. Dr. Abe said, if the ice caps start to decrease, the effect of the warming will be accelerated.

To our regret, this very important ice cap of the Arctic Ocean is radically decreasing in

their extent and thickness. The satellite observation of the Arctic Ocean started in 1978. At the beginning of the 1980's, the Arctic ice cap occupied 7.5 million km² in every September. After that, the area steadily decreased with slight fluctuation of year to year. In the September of 2004, it diminished to 6 million km². In the September of 2005, it became to 5.3 million km² which was the smallest in the history of the observation. A researcher of the United States Department of Defense, who has observed the distribution of the Arctic ice cap for many years, published a serious expectation that in the Arctic Ocean all the ice cap will vanish in the summer after 2010. In the Arctic region, the average temperature of the last ten years already increased two to three degrees from the average temperature of the last fifty years. In Alaska and Siberia, the time of thaw is observed to become two to three weeks earlier than before. It is worried that the reverse Ice-Albedo effect is already emerging.

The stoppage of the deep current

An observation shows the warming of the Arctic region is effecting to the deep current. EU is conducting observational and modeling efforts to understand the mechanisms governing water masses formation and circulation in the Arctic and Sub-Arctic Seas in a joint program, called European Sub Polar Ocean Program (ESOP) from 1990. The main object of this program is to investigate the situation of the thermohaline circulation, especially the deep convection around the Green Land. Many oceanographic ships continually researched the salinity and temperature of the sea around the Green Land. As a result of this investigation, an eerie phenomenon was found out. The chimney-like down flow, called a plume, which used to flow down to the depth of four thousand meters, reached only to the depth of several hundred meters since 1990's. This means that the high density sea water which forms the deep current is not produced.

The next question we must face is what kind of environmental change will happen when the deep current stops. Thirteen years ago, at the beginning of the Younger Dryas time, the stoppage of the deep current caused a sudden drop of the temperature. However, there is no research which accurately foresees what will happen if the deep current stops when the earth is warm. Dr. Blocker, who has solved the secret of the deep current stoppage at the beginning of the Younger Dryas time, says, "The ices of the Green Land inform us that the earth climate can change from one state to another suddenly without notice. There are two modes in the earth climate and this can shift suddenly. I think the factor which brings about the shift is the change of the ocean circulations, however, the mechanism of ocean circulations has not been clarified fully yet." A simulation says that

when the deep current stops, the heat transportation of the Gulf Stream weakens, which makes the temperature of Europe relatively low, even though the temperature of other parts of the world increases. However, so many things are left unknown about the deep current, such as the relationship between the deep current and Kuroshio current, and the relationship between the deep current and the El Nino. For these reasons, many scientists say it is impossible to predict what will happen when the deep current completely stops. However, many unprecedented phenomena already have emerged on the ocean. These are the two of them.

1. At many upwelling places of the ocean, the upwelling is weakening. The temperature of the surface sea water is increasing and the warm sea water works as a cap on the sea and prevents convection of the ocean. The nutrients of the surface sea water are decreasing, which prevents the proliferation of botanical planktons. The absorption of carbon dioxide by the ocean decreases.
2. The influence of the warm currents is going north. The currents of higher temperature are hitting the seabed, where methane hydrate lies. The possibility of sudden collapse of methane hydrate layers increase.

We will explain in detail about these two mechanisms later. When these two mechanisms are activated, the global warming comes into a mode where no human control can work. What we can say now is that the destructive climate change of the deep past earth occurred simultaneously with the stoppage of the deep current. (See MEMO: Mass extermination case of Pelm) To maintain the Arctic ice cover and deep convection might be the final defense line of the human tackle against the global warming. Aren't there any measures to recover the Arctic ice cap and the deep current circulation? Very fortunately, crews to solve these problems are found out recently. We will explain about these crews in the next section.

MEMO Will the scenario of the Day After Tomorrow come true?

The cinema of the Day After Tomorrow told us a story; The stoppage of the deep current weakens the going north of the Mexico Bay current, which brings about the sudden decrease of the temperature in Europe and North America. This story based on the fact that a similar incident happened at the beginning of the Younger Dryas time thirteen thousand years before.

When long ice age ended and the temperature started to rise thirteen thousand years ago, suddenly, the temperature began to decrease and the average temperature of the

earth decreased by five to seven degrees. This cold age is called the Younger Dryas. By many investigations, the sudden stoppage of the deep current was thought to be the cause of the sudden drop of the temperature. At that age, because of the warming of the temperature, huge fresh water lakes were formed in the North America Continent or at the Scandinavia Peninsula. By some reasons, this large amount of fresh water flowed into the North Atlantic Ocean, which lowered the salinity of the sea water. For this reason, the production of cold dense sea water was disturbed and the deep convection of the sea water stopped. The going north of the warm current was weakened, which brought about the cooling of the Europe.

One difference of today and the Younger Dryas is that the Arctic region was covered with thick ices widely at the Younger Dryas, and today, the ice cap almost vanishes in the summer. Nobody knows whether the warming continues or the cooling is brought about, if the deep convection stops at a warm era like today.

The influence of the Pacific Summer Water and the Bering Strait Dam

Recently, a report was published by the Institute of Observational Research for Global Change as a result of the global warming information observational research program, which states that relatively warm sea water of the Pacific Ocean, which flows into the Arctic Ocean through the Bering Strait, effects largely to the reduction of the Arctic Ocean ice cover.

According to this report, from 1970's, when the satellite observation began, to the middle of the 1990's, the ice cover decreased at a constant rate, however, after the second half of 1990's, the decreasing speed of the ice cover was accelerated. This kind of ice cover reduction emerged only in the western Arctic region, where the Pacific Summer Water inflows. (F&T 3.5) The sea water temperature of north-east region of the Bering Sea (62-66 north 164-170 west) increased from 8 degrees centigrade to 9 degrees centigrade from the first half of 1990's to 2004. The sea water temperature of the Canadian basin at the depth of forty to sixty meters increased rapidly from -1.5 °C to 0°C. For this reason, this program concluded that the rapid decrease of the ice cover was not caused by the "atmospheric warming" nor by the "wind change", but by the "oceanic warming" which is resulted from the inflow of the warm Pacific water to the Arctic Ocean. In addition, this program indicated that the reduction of the ice cover strengthens the water circulation of the Arctic Ocean and the inflow of the Pacific warm water into the Arctic Ocean, and this mechanism is worsening the ice cover reduction.

On the other hand, a Japanese researcher has conducted simulations to clarify the effect of closing up the straits of the Arctic Ocean and controlling the amount of the sea water inflow, on the deep current and global environment. The name of the researcher is Dr. Hiroyasu Hasumi of the Center for Climate System Research of the University of Tokyo. Dr. Hasumi conducted a research for the sensitivity of the global thermohaline circulation to the interbasin water transport by straits' throughflow. He investigated Bering Strait, Fullum Strait, which lies at the east of the Greenland, and the water ways north of the Hudson Bay.

Bering Strait

The Bering Strait lies at the north end of the Pacific Ocean and at the end of the Bering Sea. The width of the Strait is less than 100km, and the depth of the Strait is about 50 meters. It is the only strait connecting the Pacific Ocean and the Arctic Ocean. The salinity of the Pacific Ocean is low compared with that of the Atlantic Ocean, and the water level is higher in the Pacific Ocean. The sea water runs from the Pacific Ocean to the Atlantic Ocean because of the water level difference. This sea water runs to the North Atlantic Ocean. This sea water, for its low salinity, weakens the formation of deep sea water at the high latitude of the North Atlantic Ocean. The deep convection of the Atlantic Ocean can be increased by 20% by closing the Bering Strait.

Fullum Strait

The Fullum Strait, which lies between north end of the Greenland and the Spitsbergen island which lies east of the Greenland, has a depth of more than 2500ms. At the upper layer of the Strait, the East Greenland Current flows, and at the middle layer, the West Spitsbergen Current, which sends warm and high salinity sea water come from the Atlantic Ocean to the middle layer of the Arctic Ocean, flows, and at the bottom of the Strait, cold water from the Arctic Ocean to the Greenland flows. This strait is very deep and has very complex waterflow. For this reason, the control of the current at the Fullum Strait is impossible.

The water ways north of the Hudson Bay

At the north of the Hudson bay, there are many water ways which are connecting the Arctic Ocean and the Baffin Bay among many island. The throughflows run from the Arctic Ocean to the Baffin Bay, then go through the Labrador sea to the North Atlantic Ocean. Much part of the Pacific water, which come from the Bering strait and has relatively low salinity, goes through these waterways out of the Arctic Ocean. This

Pacific water flowing through the waterways does not give much effect on the deep convection which occurs in the Labrador Sea directly, and flow out to the south with the West Greenland current and the Labrador Current. (F&T3.7) In the simulation, where the waterways north of the Hudson Bay are closed, the Pacific water flows through the Fullum Strait and lowers the salinity of the East Greenland current, which weakens the deep convection and the thermohaline circulation of the Atlantic Ocean.

The simulation conducted by Dr. Hasumi doesn't count on the reduction of Ice Cap by the throughwater of the Bering Strait and Ice-Albedo Effect, which the Institute of Observational Research for Global Change found. If the simulation is conducted counting on these elements, the effects of the stopping of the throughflow of the Bering Strait on the climate of the Arctic Region will be much more than the 20% increase of the deep convection.

We, authors, strongly propose that the governments of the nations should start the assessment of the effect of this Bering Strait Dam, which controls the throughflow of the Strait, in cooperation and real quickly. The detailed topography of the seabed might be classified into the military secrets. There might be some other difficulties for the US and Russia to cooperate in this region concerning the experience of the Cold War. However, by all means, the environmental effects of the Bering Strait Dam, whether it can control the temperature of the Arctic area through the increase of the ice cap, should be examined real quickly. The Bering Strait is a relatively shallow Strait with the depth of around fifty meters, and its width is less than 100 kms. The construction of a dam of this size is not impossible if all the efforts of the world are concentrated on this construction, but the period when the construction is possible is only half of the year, and the material supply sites are far away from the Bering Strait. For these reasons, this construction will be the severest one that human beings ever have experienced. However, this dam has the largest effects as a measure to mitigate the global warming, and can provide the carbon dioxide free clean energy for a long period of time for the human beings through the generation of the electricity. The capital necessary for the construction of this dam, which might exceed a half trillion dollars, can be supplied from the world fossil resources managing organization. (a public corporation for fossil resources)

Transition of the photo planktons

At the preceding section, we have stated a method to evade the stoppage of the

thermohaline circulation of the North Atlantic Ocean. From now, we will state two major dangers we might face when the thermohaline circulation stops briefly. For more detail, please refer to our former book, "Tackle with the Satan's cycle" which is specialized in this theme.

In the preceding section, we stated that: Recently, in parallel with the slowing down of the deep convection, the upwelling of the deep current is ceasing in many sea areas and the surface temperature of the ocean is increasing. The warm sea water is covering the ocean like a cap and is preventing the circulation of the ocean. The nutrients of the surface water decrease, which prevents the proliferation of the photo plankton, and the amount of carbon dioxide absorbed in the sea decreases.

However, to tell more precisely, the photo planktons whose proliferation is disturbed by the lack of the nutrients are mainly diatoms. There are some groups of photo planktons which can grow in a sea of poor nutrients. The main species of that sort are the group of Coccolithophorid. If Coccolithophorid proliferates on behalf of diatoms, the amount of carbon dioxide which is absorbed in the ocean decreases. (F&T 3.8)

The characteristic of diatoms is their larger size compared with other botanical planktons. There are various forms of diatoms. Majority of them have a size of around 10 to 20 μ . On the other hand, most of the Coccolithophorid have a size of around 4 μ . This means the diatoms have one hundred times larger volume than the Coccolithophorid. In addition, diatoms form chain colonyies, which are very convenient for the predators. For this reason, zooplanktons and fish flourish in the diatoms rich ocean. Thus, the feeding chain of the diatoms rich ocean is very effective. This is why the diatoms rich ocean absorbs large amount of carbon dioxide. In the Coccolithophorid rich ocean, zooplanktons and fish cannot flourish. In addition, Coccolithophorid has the characteristics of forming a shell of Calcium carbonate. In the process of forming this shell, when Calcium carbonate is produced, the sea water is acidified until new Calcium is supplied from the land, and carbon dioxide is discharged from the sea. For this mechanism, the density of carbon dioxide in the atmosphere increases rapidly, when the diatoms rich ocean changes to the Coccolithophorid rich ocean. Very unfortunately, recently the huge proliferation of the Coccolithophorid in the Bering Sea and at the offshore of the California is reported.

Dr. Yamanaka of the Hokkaido University conducted a simulation to examine the effect of this photo plankton transition with a scenario of stabilizing the carbon dioxide atmospheric concentration at 550ppm in 2100. The result shows that the carbon dioxide concentration, which is stabilized at 550ppm after 2100 in the original case, increases at the same rate of today and goes up to 800ppm in 2200.

Danger of the methane hydrate

If the temperature of the surface current increases, by the stoppage of the thermohaline circulation or by other phenomena concerning the global warming, the danger of the sudden collapse of the methane hydrate emerges. Methane hydrate is a gelatinous substance of a crastorat structure where a methane molecule is surrounded by water molecules forming a cage. This substance is called the burning ice, because it burns when it is ignited. Methane hydrate is stable even at a temperature of more than zero degrees Celsius when it lies under a place of high pressure, such as seabed. The organism, which fell down to the seabed as marine snow and was decomposed to methane through an anaerobic decomposition, forms methane hydrate on the seabed. This methane hydrate occupies large part of the hydrocarbon amount which lies on the surface of the continental crust, and is distributed widely on the continental shelf and in the permafrost layer. The amount of the methane hydrate is said to be ten trillion tons, which is twice of that of all the fossil fuels. The most dangerous characteristic of methane hydrate is its sensitivity to the change of the pressure and the temperature. In the shallow ocean, methane hydrate sometimes causes blow out like an eruption of volcanoes and forms large craters. In the deep ocean, methane hydrate dissolves in the sea water taking a long time and forms a large hole, which is called a pockmark. In both cases, large amount of methane, which has a warming effect more than twenty times larger than the carbon dioxide, is discharged from the ocean to the atmosphere. The amount of the methane, which was discharged to the atmosphere by a blowout, which occurred at the offshore of the Norway eight thousand years ago, is supposed to be three hundred fifty billion tons. If this amount of methane is discharged to present atmosphere, the average temperature of the earth will increase by 4 degrees Celsius in ten years. However, methane is decomposed to carbon dioxide in ten years in the atmosphere, thus, the global warming effect caused by methane doesn't continue for a long time, which is different from the global warming effect of carbon dioxide.

Start of the Satan's Cycle

This chapter started from explaining the role of the ocean as a storage of carbon dioxide, and then described the importance of the geographical features of the two poles in producing the deep current of low temperature, which lead to the cool, from the timescale of one hundred million years, temperature of today. Then, we stated that the sea surface temperature of the Arctic Region and the North Atlantic Ocean was increased by the man-made global warming, which lead to the reduction of the ice cap of

the Arctic Ocean and is weakening the deep convection of the Atlantic Ocean. We believe, from these explanations, the readers already have understood that if the ocean's warming cannot be stopped, the transition of the photo planktons and the chain collapse of methane hydrate, which has been accumulated in the cool ocean of these forty million years, will bring about the positive feedback of temperature and carbon dioxide concentration, where no human effort to alter the situation can work. (F&T3.9) Large-scale animals of the land will be exterminated by the toxicity of carbon dioxide (F&T3.10) or by the toxicity of hydrogen sulfide (See MEMO: Extermination at the end of Perm)

We, authors, think the feasibility study of the Bering Strait Dam is the most urgent problem, to maintain the ice cap of the Arctic Ocean and stop the rapid global warming which starts from the Arctic Region, in addition to other technological and industrial change, such as conversion of energy from fossil fuel to renewable and introduction of energy saving technologies, which were described in other chapters. To enable this huge project, we believe the establishment of a public corporation for fossil resources is necessary, which monopolize the production and sales of fossil resources. This transformation of human sphere will be stated in chapter 7. If human beings cannot accomplish these projects, the concentration of carbon dioxide in the atmosphere will increase, as is shown by the expression of Nishizawa for forecasting the atmospheric concentration of carbon dioxide. (T&F3.11 An expression of least square method which use historical measurements of atmospheric carbon dioxide concentration to predict future concentration by mathematical method) This expression indicates that a temperature and an atmospheric composition, with which no human beings can survive, will be brought if dramatic change does not occur in human sphere.

MEMO Extermination at the end of Perm

The living creatures, whose numbers and varieties have dramatically increased through the Cambrian Explosion, have experienced five large extinctions. The largest extinction among them is the one at the end of Perm, when 95% of the species have exterminated two hundred and fifty million years ago (Permian-Triassic (PT) boundary) Two hundred and fifty million years ago, many continental crusts gathered through the mantle convection and a super-continent Pangaea was formed. This continent disturbed the balance of the earth and some part of Pangaea fell into deep inside of the earth. This downward flow is called a cold plume. Pushed by the cold plume, some part of mantle came out to the surface of the earth. This flow of the substances is called a super plume. Now, the erupted substances lie in Central Siberia Plateau as lava plateau which has

the area of five times of Japan. This super plume heated the surface of the earth and chain collapse of the methane hydrate, which lay at the bottom of the ocean, was brought about. For this reason, the temperature near the equator increased by close to nine degrees Celsius, and the temperature close to the poles increased by around twenty degrees Celsius. The deep circulation stopped and marine organisms were exterminated by the lack of oxygen.

In addition to the toxicity of carbon dioxide, the toxicity of hydrogen sulfide, which was generated in an ocean of oxygen deprivation, might have influenced strongly to the extermination of the living things of land. Earth scientists, named Lee R. Kump and Michael S. Aethur of Pennsylvania State University reported that when the density of oxygen decreases in the ocean, the ocean environment becomes suitable for the proliferation of the anaerobic sulfate reduction bacillus, which produces huge amount of hydrogen sulfide. Their theory tells us that when the density of hydrogen sulfide increases over some critical value in an ocean of oxygen deprivation, the chemocline, which is separating the hydrogen sulfide rich deep sea water and oxygen rich surface sea water, rapidly rises to the sea surface, and toxic hydrogen sulfide gas is discharged to the atmosphere. Hydrogen sulfide not only chokes humans, but also destroys the ozonosphere which is protecting us from the ultraviolet rays of the sun

Chapter 4 The warming world of 2050

Warming world

In chapter 3, we have stated about “Satan’s cycle” which might happen when no action is taken to the worsening global warming. When the Satan’s cycle starts, extreme increase of the temperature happens, and finally, withering of the plants, hypoxia of ocean, enormous rise of the sea level and extinction of large living things of land caused by carbon dioxide and hydrogen sulphide follow. Even before the start of such disaster, global warming gradually shows its influence on the ecosystem, and our lives and industries.

We put an assumption that in the near future, human beings start corresponding to the global warming by constructing cooperative relationships. However, as the earth is something like a huge ship, it takes much time from the start of the direction change to the response of the earth conditions. For this reason, we have to expect that considerable global warming has happened in the world of 2050. Concerning the impacts, adaptation and vulnerability of global warming to the ecosystem, society and human health in the preparation of the third report of IPCC, the working group II took charge, and conducted forecasting of the world where the temperature of the atmosphere increased to several degrees. In this chapter, base on the report of this working group II, adding new information and our comments, we will describe the world of 2050 where inevitably we have to face global warming.

Scarce forecasting ability

IPCC reports are based on thousands of specialists’ thesis, furthermore, these thesis have passed the screening of specialists of same research field. However, the research in the field of examining the impact of global warming is just in the beginning stage. This situation can be observed by the statements in the report summarized as follows;

Progress to date has focused largely on mitigation issues of how to reduce the increase of average temperature of the earth and only secondarily on issues of impacts, vulnerability, and adaptation at the regional scale. No adequate discussion has done even on the recognition of the effects or method for calculation of the cost. In addition, even if the common recognition can be shared about the trend of the climate, we don’t have the ability of forecasting or calculating damage of extreme event. (such as

tremendously large hurricane) Almost no assessment has conducted on how we can minimize the damage.

Regional assessment of the climate change can be obtained from the coarse-scale outputs of general circulation models (GCMs) by three main methods: simple interpolation, statistical downscaling, and high-resolution dynamical modeling.

Water Resources

In the IPCC report, possible streamflow changes under two climate change scenarios are shown as in F&T 4.1 which compares the average streamflow between 1961 and 1990, with the forecasted streamflow of 2050. This change of average streamflow is largely dependent on confidence in the projected changes in precipitation. In the Figure, increase in streamflow is seen in high latitudes and Southeast Asia and the decrease in streamflow is observed in central Asia, Mediterranean, and southern Africa. Changes in other areas, such as North America and India, vary between climate models.

Peak streamflow will move from spring to winter where snowfall currently is an important component of the water balance. Flood magnitude and frequency are likely to increase in most regions. Water quality generally would be degraded by higher water temperatures.

Each country has different management capacity concerning increase and decrease of water resources. Much part of the damage caused by the water stress is determined by non-climatic elements.

Agriculture and food security

A few degrees of projected warming will lead to general increase in temperate crop yields, with some regional variation. In the tropics, where some crops are near their maximum temperature tolerance, yield would decrease generally. Advanced research suggests that the increase of CO₂ concentration causes beneficial effects on the production of crops. In addition, research on agricultural adaptation to climate change also has made important advances. Altering of planting dates and cultivar selections can ameliorates the adverse effect of temperature increase. For these reasons, the impacts of climate change within a few degrees on aggregated production of agriculture are estimated to be small. On the other hand, most studies indicate that mean annual temperature increase of 2.5°C or greater would harm expansion of food supply. However, the report of working group II of IPCC is written in a tone of argument that world food

crisis caused by global warming will not occur until 2050.

However, Lester R Brown, the former head director of The Worldwatch Institute published severer forecast. He says in the Central Asia and in the north part of China rivers are drying up because of decreasing precipitation. In India and Nile basin, shortage of water has become apparent. In addition, in granary area of the U.S., pumping up of water from the aquifer is coming closer to the end of its water resource, and the production of grain is decreasing. Market price of grain is forecasted to increase from near future, because increase of meat consumption further tightens the demand-supply balance.

The ecosystem of high latitudes and high mountains suffers major impact and plant productivity of arid region and semi-arid region decreases. In many regions of the world, considerably different ecosystems from today's ones will be formed, because ecosystems cannot move as a whole. Concerning woods production, it is forecasted that global warming will bring about the global increase of supply except for some region where precipitation decreases, if no human elements, such as deforestation, are considered.

Coastal Zones and Marine Ecosystems

Global climate change will result in increase in sea-surface temperature and sea level; decrease in sea-ice cover; and changes in ocean circulation and vertical mixing, even though it does not reach to stoppage of thermohaline circulation. Changes in upwelling rates would have major impacts on coastal fish production and coastal climates.

If warm events associated with El Ninos increase in frequency, plankton biomass and fish larvas abundance would decline and adversely impact ocean biodiversity. Fluctuations in fish abundance are increasingly regarded as biological response to medium-term climate fluctuation in addition to overfishing and other anthropogenic factors.

Adaptation by expansion of marine aquaculture may partly compensate for potential reduction in ocean fish catch. Marine aquaculture production has more than doubled since 1990, and in 1997 represented approximately 30% of total commercial fish and shellfish production for human consumption. However, future aquaculture productivity may be limited by ocean stocks of herring, anchovies, and other species, and pollution of coastal areas.

Human Settlement

The most widespread serious potential impacts are flooding, landslides, and avalanches driven by projected increases in rainfall intensity and sea-level rise. A growing literature suggests that a very wide variety of settlement in near every climate zone may be affected. Riverine and coastal settlements are believed to be particularly at risk, but urban flooding could be a problem.

The next most serious threats are tropical cyclones (hurricanes or typhoon), which may increase in peak intensity in a warmer world. Tropical cyclones combine the effects of heavy rainfall, high wind, and storm surge in coastal areas and threat settlements of more than tens of millions people by flooding. For example, estimate of the mean annual number of people who would be flooded by coastal storm surges increase several-fold (by 75 million to 200 million people, depending on adaptive responses) for mid-range scenarios of a 40-cm sea-level rise by the 2080s relative to scenarios with no sea-level rise.

The heat wave also can be an disruptive events for human inhabitants.

MEMO Increasing threat of tropical cyclones

Dr. Kerry A Manuel of MIT published his research concerning the increase of tropical cyclones power in the warming world in Nature in 1987. The summary is as follows;

When the concentration of the carbon dioxide is assumed to be doubled, the increase of ocean surface temperature will add vapor, which works as energy of tropical cyclone, in the atmosphere, which produces typhoon whose central pressure reaches to 825 to 850 hectopascal and hurricanes and cyclones whose central pressure reaches to 800 to 825 hectopascal (F&T 4.2), and wind, wave and surge of unprecedented size will be caused. This thesis is partly proved by the damage of hurricanes since 2004.

Insurance and other financial services

The financial services sector, which offers insurance and disaster relief, banking and asset management services, is a unique indicator of potential socioeconomic impacts of climate change because it is sensitive to climate change and it integrates effects on other sectors. The costs of extreme weather events have exhibited a rapid upward trend in recent decades (F&T 4.3). Yearly global economic losses from large events increased from US\$3.9 billion yr in the 1950s to US\$40 billion yr in the 1990s (all 1999 US\$, uncorrected for purchasing power parity). Part of the observed upward trend in historical disaster losses is linked to socioeconomic factors, such as population growth,

increased wealth, and urbanization in vulnerable area, however, the growth rate in human-induced and non-weather-related losses has been far lower than that of weather-related events.

Recent history has shown that weather-related losses can stress insurance companies to the point of impaired profitability, consumer price increases, withdrawal of coverage, and elevated demand for publicly funded compensation and relief.

Human Health

There is little published evidence that changes in population health status actually have occurred in response to observed trends in climate over recent decades. However, higher temperatures would alter the geographic ranges and seasonality of transmission of vector-borne infectious diseases --- extending the range and season for some infectious diseases.

If heat waves increase in frequency and intensity, the risk of death and serious illness would increase, principally in older age groups and the urban poor.

Changes in food supply resulting from climate change could affect the nutrition and health of the poor in some regions of the world. 790 million people are estimated to be undernourished at present. Populations in isolated areas with poor access to markets will be particularly vulnerable to local decreases or disruptions in food supply.

Health impacts associated with population displacement resulting from natural disasters or environmental degradation are substantial.

Regional Analysis

Africa

Although the equatorial region and coastal areas of eastern and southern Africa are humid, the rest of the continent is dry subhumid to arid. The dominant impact of global warming will be a reduction in soil moisture in subhumid zones and a reduction in runoff. Africa is the continent with the lowest conversion factor of precipitation to runoff, averaging 15%. Current trends in major river basins indicate decreasing runoff of about 17% over the past decade.

In shared river basins, regional cooperation protocols minimize adverse impacts and potential for conflicts. Trends in regional per capita water availability in Africa over the past half century show that water availability has diminished by 75%. Although the

reduction in river flows is apparent in sub-Saharan West Africa, the trend mainly reflects the impact of population growth. The combination of continued population increases and global warming impacts is likely to accentuate water scarcity in subhumid regions of Africa. The continent already experiences a major deficit in food production in many areas, and potential declines in soil moisture will be an added burden. Inland and marine fisheries provide a significant contribution to protein intake in many African countries, however they are vulnerable to drought.

Most of Africa's largest cities are along coasts and are highly vulnerable to extreme events, sea-level rise, and coastal erosion because of inadequate physical planning and escalating urban drift.

Asia

Food insecurity appears to be the primary concern for Asia. Crop production and aquaculture would be threatened by thermal and water stresses, sea-level rise, increased flooding, and strong winds associated with intense tropical cyclones. Change in cultivation method, development of ultra-heat-resistant rice cultivars, and effective conservation and sustainable management of marine and inland fisheries are required. An increase in the intensity of cyclones combined with sea-level rise would result in more loss of life through storm surges in low-lying coastal areas in India and Bangladesh.

Surface runoff is expected to decrease drastically in arid and semi-arid Asia under projected temperature increase. Especially, surface runoff in Kazakhstan would be substantially reduced, causing serious implications for agriculture and livestock. Water would be a scarce commodity in many south and south-east Asian countries.

In boreal Asia, permafrost degradation resulting from global warming would influence harmfully to the social infrastructures. In addition, in boreal Asia, the frequency of forest fires is expected to increase.

In Japan, the precipitation decreases in winter, and the surface runoff of Kanto region will decrease in spring season. In west Japan, to avoid the extreme high temperature, changing the cropping calendar is required.

In this chapter, we have described almost no project of each country's government to tackle with the global warming, however, we will introduce China's success in

aquaculture in MEMO, because is so remarkable. About the China's project, Nansui-Hokutyo, a project to deliver water from south to north part of China to mitigate drying up of the north area, will be stated in Chapter 5, where water power generation is described.

MEMO .Seaweed plantation technology and coastal fisheries

The research group of Dr. Ichiro Sakai of Kagoshima University developed a seaweed plantation technology for forming fish gathering place with Konbu, a species of kelp, through the research of seaweed which help forming ocean ecosystem. The Chinese government worked with this seaweed plantation on the coastline of 1300 km from Dalian to the offshore of Fujian, and has made great success in coastal fisheries. The kelp grows to the length of six meters in a half year. The production of kelp reaches to 0.75 million tons, which is thirty times of Japanese production. The kelp purifies ocean and forms ecosystem for coastal fisheries. When the fish catch of coastal fisheries are compared between China and Japan, Chinese catch increased to the triple in these fifteen years, on the other hand, Japanese catch decreased to a half in the same period of time. (F&T 4.4)

Australia and New Zealand

The Australia/New Zealand region spans the tropics to mid-latitudes and has varied climates and ecosystems, including deserts, rainforests, coral reefs, and alpine areas. The climate is strongly influenced by the surrounding oceans. The Australia ecosystem originally had the weakness of low precipitation. In addition, deforestation of forests, which has accomplished original evolution, was conducted to introduce exotic species, such as sheep. This produced significantly vulnerable ecosystems. Australia has significant vulnerability to the drying trend projected over much of the country for the next 50 – 100 years because substantial agricultural areas currently are adversely affected by periodic droughts, and there already are large areas of arid and semi-arid land. Dryland salinization and removal of forest cover are threatening the lives of indigenous people. Increasing frequency of ENSO phenomenon leads to floods and prolonged drought. New Zealand is a smaller, more mountainous country with a generally more temperate, maritime climate – may be more resistant to climate changes than Australia. In New Zealand, the damages of flood and droughts are caused by ENSO, too.

Europe

Present-day weather conditions affect natural, social, and economic systems in Europe in ways that reveal sensitivities and vulnerabilities to climate change in these systems. Climate change may aggravate such effects. Vulnerability to climate change in Europe differs substantially between subregions. Southern Europe and the European Arctic are more vulnerable than other parts of Europe.

As for water resources, flood hazard is likely to increase across much of Europe, on the other hand the risk of water shortage is projected to increase particularly in southern Europe.

Agricultural yields will increase for most crops as a result of increasing atmospheric CO₂ concentration. However, soil properties will deteriorate under warmer and drier climate scenarios in southern Europe and agricultural production systems may be threatened in this region.

The concentration of industry on the coast exposes it to sea-level rise and extreme events, necessitating protection or removal. Especially Mediterranean cities are facing threats. The insurance industry faces potentially costly climate change impacts. Heat waves are likely to reduce the traditional peak summer demand at Mediterranean holiday destinations. Less-reliable snow conditions will impact adversely on winter tourism.

A range of risks is posed for human health through increased exposure to heat episodes and extension of some vector-borne diseases

This working group II report of the third assessment report of the IPCC states that the adaptation potential of socioeconomic systems in Europe is relatively high because of economic conditions and a stable population, and well-developed political, institutional, and technological support systems. However, the adaptation potential for natural systems generally is low. This sentence can be understood that the socioeconomic systems in Europe is adaptable to climate change only because the population has the capacity to move within the region, and the ecosystem of Southern Europe will be destroyed by global warming.

The future forecast of the third assessment report was conducted before 2001. In 2007, when the authors are writing this book, many situations described in the third report as situations of future warmed world have already emerged, such as the heat wave which hit France and Italy in 2003 and killed more than fifteen thousand people. That is why

information of IPCC report has profound importance which we have to receive sincerely in making decisions for the future world.

Latin America

There is ample evidence of climate variability at a wide range of time scales all over Latin America, from intraseasonal to long-term. El Nino is associated with dry conditions in northeast Brazil, northern Amazonia, the Peruvian-Bolivian Altiplano, and the Pacific coast of Central America, whereas southern Brazil and northwestern Peru exhibit anomalously wet conditions during El Nino. La Nina is associated with heavy precipitation and flooding in Colombia and drought in southern Brazil. If El Nino or La Nina were to increase, Latin America would be exposed to these conditions more often.

It is well established that Latin America accounts for one of the Earth's largest concentrations of biodiversity, and the impacts of climate change can be expected to increase the risk of biodiversity loss. Observed population declines in frogs and small mammals in Central America can be related to regional climate change. The remaining Amazonian forest is threatened by the combination of human disturbance increase in fire frequency and scale, and decreased precipitation from evapotranspiration loss, global warming and El Nino. Tree mortality increases under dry conditions that prevail near newly formed edges in Amazonian forests.

From August to October of 2005, Amazon experienced record breaking drought. The water level of huge river, whose width is more than 10km, decreased five to ten meters, and the bottom of the river appeared. The cause of drought is generation of vertical updraft on the Atlantic Ocean which was produced by the increase of surface temperature of the Atlantic Ocean. This vertical updraft produced rain on Atlantic Ocean by using vapor, which usually moves to the west and forms rain cloud at Andes and rains at the upstream of Amazon. According to the forecast of the earth simulator, a super computer in Japan, the surface temperature of Atlantic ocean increases further, and the Amazon will frequently be covered with the down current and dry up.

Dr. Peter Cocks of British Centre for Ecology and Hydrology reported that, according to his simulation, from the middle of the 21st century, extinction of forests will start gradually from down stream to upper stream of Amazon by drying, and forests will change into desert. In 2100, two thirds of the forests will be lost and a desert wider than the Arabian Peninsula will spread.

Studies in Argentina, Brazil, Chile, Mexico, and Uruguay project decreased yields for

Numerous crops (e.g, maize, wheat, barley, grapes) even when the direct effects of CO₂ fertilization and implementation of moderate adaptation measures at the farm level are considered, especially the yield decrease of maize will be large.

MEMO El Nino and La Nina

El Nino is a phenomenon, when sea surface temperature of wide area, which spreads in the Pacific Ocean equatorial zone from the coastal area of South America to the center part of Pacific Ocean close to date-line, increases by several degrees Celsius from average year, and it continues for a half year to one and a half year. It appears once in several years. On the contrary, a phenomenon, when sea surface temperature of the same area decreases from the average year, occurs. This phenomenon is called La Nina. Both phenomena is said to have relationships with unusual weather of many regions of the world.

When El Nino occurs, not only surface of the ocean, but also inside of the ocean has changed. In addition, El Nino has close relationship with atmospheric change.

In usual years, at the east part of the South Pacific Ocean the atmospheric pressure is high, and the atmospheric pressure is low near Indonesia. According to the atmospheric pressure difference, trade wind blows from east to west on the surface of the Pacific Ocean equatorial zone. This trade wind accumulates warm sea water at the surface of the ocean to the depth of several hundred meters in the Indonesian neighboring sea which locates in the west. On the other hand, in the east, on the offshore of South America, cold sea water is welling up from the deep part of the ocean. Thus sea surface temperature is high in the west and low in the east. Over this west warm water area, vertical updraft is generated and clouds are produced one after another.

When El Nino occurs, trade wind is weak, the warm sea water in the west ocean is thinner than usual, and upwelling in the east ocean is weak. For this reason, the surface sea temperature of the east Pacific Ocean equatorial zone is higher than usual. Accompanying this, the sea area where clouds are vigorously generated moves to the east from the usual location. (F&T 4.5)

As for the surface pressure, it was known that when pressure increases (or decreases) from the average year at the high pressure area of the east part of the South Pacific Ocean, the pressure near Indonesia decreases (or increases) from the average year, from the beginning of this century. This phenomenon is called to be Southern Oscillation. Nowadays the Southern Oscillation and El Nino are regarded as atmospheric side and ocean side of a phenomenon where ocean and atmosphere are closely related. For this

reason, recently these two phenomena are called to be El Nino Southern Oscillation (ENSO).

North America

The results of simulations regarding the impacts North America will suffer in global warming is different from one simulation to another. In addition, each region in the continent will experience quite different impacts, some are positive and others are negative.

Negative impacts include increase of damages caused by tropical cyclones, increase of heat wave frequency and water shortage. In a region where water shortage happens, it may not be possible to continue to provide current levels of reliability and quality for all water users. Some regions are likely to see increased market transfers of available water supplies from irrigated agriculture to urban and other relatively highly valued uses.

Small to moderate climate change will not imperil food and fiber production. However, there is potential for increased drought in the U.S. Great Plains/Canadian Prairies, and opportunities for a limited northward shift in production areas in Canada. (Lester R Brown pointed out a threat of drying up of underground water)

Inflation-corrected catastrophe losses have increased eight-fold in North America over the past 3 decades. Private insurers are experiencing weather-related profit losses and insolvencies have been observed.

In the southeast part of America, risks of hurricane increase. At the north part of the gulf of Mexico, large-scale expansion of low oxygen area may appear.

Twentieth century data for the Arctic show a warming trend of as much as 5 degrees Celsius over extensive land areas. In developed areas of the Arctic and where the permafrost is ice-rich, special attention will be required to mitigate the detrimental impacts of thawing, such as severe damage to buildings and transport infrastructure.

In the Antarctic, a marked warming trend is evident in the Antarctic Peninsula, with spectacular loss of ice shelves. There has been no significant change in the Antarctic sea ice since 1973, although it apparently retreated by more than 3 degrees of latitude between the mid-1950s and the early 1970s.

Collapse of the West Antarctic Ice Sheet would lead to a global sea-level rise of several meters, which may be very difficult to adapt to. Although disintegration might take many hundreds of years, this process could be triggered irreversibly in the next century.

Reduction in the extent of highly reflective snow and ice will magnify warming. Freshening of waters from increased Arctic runoff and increased rainfall, melt of Antarctic ice shelves, and reduced sea-ice formation will slow the thermohaline circulation of the North Atlantic and Southern Oceans and reduce the ventilation of deep ocean waters.

Several climate model simulations show complete shutdown of the North Atlantic thermohaline circulation with high warming. Although complete shutdown may take several centuries to occur, regional shutdown of convection and significant weakening of the thermohaline circulation may take place within the next century.

MEMO Decrease of Antarctic krill

The joint research team of Canada, South Africa and British Antarctic Survey, reported in *Nature*, a British science magazine, that the amount of Antarctic krill, which is supporting the food chain of Antarctic region, decreased by 80% from the level of 1970's. This report says that this reduction have relationship with the decrease of sea-ice, which plays a role to protect Antarctic krill from predators, such as a whale, and decreased by the raise of sea water temperature caused by global warming. The research team warns that the decrease may harm the population of whales and penguins.

The research team constructed a database which includes the research results of 99 countries. It examined the change of living density of Antarctic krill from 1926 to 2003, and found out that the density decreased by about 80% after 1976. On the contrary, a kind of jelly fish which prefers warmer sea water increased by 80% in the same period. It was also found out that the population of Antarctic krill strongly affected by the area of sea ice in winter. The report concluded that the decrease of living density of Antarctic krill was caused by the decrease of sea ice which was reduced by the rise of sea water temperature which increased by 2.5 degrees Celsius in these fifty years. This report also mentioned another possibility that the reduction of photoplankton, which is caused by the increase of ultraviolet rays through the enlargement of ozone hole, may have induced the decrease of Antarctic krill. Antarctic krill is a kind of crustacean resembling to shrimp who grows to more than five centimeters. It explosively flourishes in summer and is playing very important role in the food chain of Antarctica as the main food of whales, penguins, fur seals and fishes. It is also paid attention as a food resource and captured by Japanese fishing boats.

In this chapter, we have stated fundamental information and research reports based on the third assessment report of the IPCC, to make readers of this book easier to imagine the world of 2050, where the average temperature of the earth increased by 2 degrees Celsius. Some readers might have acquired an impression that, the adverse impacts caused by global warming differs from region to region. However, even if the adverse impacts are not so large for one's own country for a while, it can never be permitted not to participate in the global endeavor to tackle with global warming. If some countries do not participate in, every country of the world will suffer tremendous damages sooner or later

In 2050, the damages which began to appear at the beginning of 2000's would have increased their severity and scale, and devastating situations would have occurred in many parts of the world. In 2050, situations which cannot be handled by one country would have happened. A regime which can manage that kind of situation with global cooperation should have been constructed before that time. For this object, following notions might be important. First notion is that, the life is the most important value. The second notion is the oneness of living creatures. And the third notion is that the earth is the only place we can live.

To stop global warming, we, human beings should immediately change our socioeconomic activities. How can we construct vision of our future with which we can change our socioeconomic activities? In the following chapters, we will describe the technologies and social systems which will help us in constructing our future vision that we really hope for.

Chapter 5 Energy supply system that support new era

This chapter 5 and chapter 6 come into a description of engineering which helps forming a harmony between the human sphere and other spheres. In chapter 5, mainly energy systems and technologies are explained, and in chapter 6, we will state about material circulation and possibility of biomass utilization

At the end of chapter 2, we mentioned about the SRES of IPCC, and stated that there are mainly two scenarios to decrease the emission of the GHG. One is to change the life styles and social systems into more non-material oriented ones. The other is to change the energy supply technologies and systems into non-fossil ones. Then, we said that changing the energy supply technologies and systems is more reliable way to reduce GHG emission.

However, we know that many readers of this book have not recognized that the renewable energy has the potential to substitute fossil fuels. It is quite natural for people, who know that the new energies consist only 1% and hydro energy consists only 4% of the Japanese primary energy composition, not to recognize the potential of the renewable energy. (F&T 5.1) However, when one imagines the method to reduce the carbon dioxide emission to, say, one fifth, roughly speaking, it is necessary to substitute fossil fuel with renewable energy as primary energy for the power generation. In addition, it is necessary to supply energy for transportation and household with electricity that is produced by renewable energy. The reason why the fossil resources for industrial use are treated separately is that there is no alternative for some industries. The power generation loss which occupies 28% of the total primary energy seems to be huge in this figure, however, the direct use of fossil resources also produce huge loss when the chemical energy stored in the fossil fuels is converted to thermal energy and then to kinetic energy. The electrification of the society doesn't mean the increase of the loss of the society. For example, the electric vehicles have higher energy efficiency than engine cars. Energy efficiency of the electric vehicles is 26% (power generation efficiency;36% × energy efficiency of an electric vehicles;70%), on the other hand, efficiency of the engine cars is 15% (energy efficiency of making gasoline from crude oil; 84% × energy efficiency of an engine; 18%)

Then, the most fundamental question is whether we can generate electricity which can meet all demand of our country. For this reason, in this chapter we start from examining potential of the basic energy technologies, such as photovoltaic generation,

wind power generation and hydro power generation. After that, we will briefly state political movement concerning renewable energy in Japan and in the world. In this section, Chinese water and energy situation are briefly reported. At the last part of this chapter, we will describe the world power network, the direct current power transmission and the high temperature superconducting cable, which are inevitable social infrastructures and technologies to construct a world energy supply system based on renewable energy

Solar power generation

The earth receives solar energy of one hundred seventy trillion kilo watt, which can satisfy the energy demand of the human sphere within one hour. In addition, the life of the sun is greatly long compared with the human history. This means solar energy can be regarded almost permanent energy. For the utilization of the solar energy, the solar battery, which converts solar energy to electric energy with the photoelectric effect of the semiconductor, is the most prominent technology. (F&T5.1.2) A brief explanation of the system of the solar battery is as follows; When a semiconductor with pn junction receives light, a hole with the electricity of the plus (where electron came off) and an electron with the electricity of the minus are generated. These are separated by pn junction, and + and - electric charges are accumulated in both electrodes. When these electrodes are connected, currents flow.

The solar battery has following characteristics in addition to the characteristics of solar energy;

1. The energy can be extracted in a form of electric energy.
2. The energy efficiency does not change depending on the scale of power generation (for example between 1W and 1MW)
3. The solar battery can work by diffused light of cloudy sky.
4. The battery has nearly permanent durability because it has no mobile parts.
5. The main material of battery is silicon, which has the second largest concentration in the earth crust. This means there will be no shortage in materials for solar battery

Three kinds of silicon solar battery

The solar battery can be classified into three categories, silicon, compound and organic semiconductor, with their materials. Majority of the solar batteries are silicon solar

battery, which is classified into monocrystalline, polycrystal and amorphous one. The typical production process of silicon solar battery is shown in T&F5.2.

Among the three silicon battery, monocrystalline silicon solar battery was the first to be developed and its conversion efficiency (the ratio at which the solar energy is converted to electric energy) is more than 20% at small area. This monocrystalline type is used for residential use, however, the production process is complicated and production cost is high. To solve these problems, polycrystal silicon solar battery was developed, which is produced from a wafer, cut out from silicon ingot. This polycrystal silicon battery has slightly low conversion efficiency, but production cost can be decreased.

The amorphous silicon (a-Si) solar battery has quite different production process from above two solar batteries. In the production process of the a-Si solar battery, a certain gas, such as SiH₄, is resolved by glow discharge and silicon layers are formed on the substrate, such as glass. For this reason;

1. The production process is simple
2. The energy consumption for the production is low (process temperature of lower than 300 degrees Celsius)
3. The material amount is small (the thickness is less than 1 μ m; 300 μ m for crystalline type)
4. Large product can be produced easily (utilization of gas reaction)
5. Electricity of practicable high voltage can be produced by a single cell (utilization of accumulative structure which is peculiar to the a-Si solar battery)

The conversion efficiency of a-Si solar battery is low (about 15%), however, a-Si solar battery has excellent features as a low cost solar battery. The solar battery of this type had a defect of losing power in a short term under direct sunshine, but, products which have overcome this problem began to be produced.

Evaluation of photovoltaic generation

When the solar battery is evaluated as an energy source, a concept called energy recovery year is important. The energy recovery year is an indicator which shows how many years the solar battery system takes to recover the energy which was consumed in the production of the solar battery system. This indicator depends on the energy conversion efficiency and the production amount. When the solar power generation

system of one hundred thousand kW per year, the energy recovery year of the a-Si solar battery is 1.1 years and that of the polycrystal solar battery is 1.5 years. The endurance of the solar battery is more than 20 years. For this reason the solar battery is thought to be very efficient as a new energy source.

The trend and forecast of the solar battery cost are shown in T&F5.3. The production cost is decreasing very rapidly and is forecasted to fall below one hundred yen per a Watt. This is because of development of production technology and increase of the production.

The production of the solar battery is increasing rapidly in recent years. In 2003, the total production of the world was 744MW, and in this year, total installation reached to 1809MW. Japan, the U.S. and EU produce most of the world solar battery. The installation of the solar battery is forecasted to increase steadily in the future. The European Renewable Energy Council (EREC) predicts the solar battery supplies 25% of the total demand in the world. (T&F 5.4)

The defects of the solar battery are that it cannot generate electricity at night and that the power generation depends much on the weather. For these reasons, some people might worry about introducing solar battery as the main energy source of the future society. To solve these problems, the world power network, which authors have long advocated, will work. To ease the demand-and-supply unbalance, human should construct the world network of the superconducting cable which enables high voltage direct current transmission. Details of this world power network will be stated later.

Wind power generation

The wind is a flow of air. Thus, the energy the wind contains is kinetic energy. The wind power generation alters this kinetic energy of air to kinetic energy of wind mill rotation, then to electric energy by dynamo. The amount of energy wind contains is unlimited judging from the view point of human use, however, the density of wind energy is low and the wind energy is proportional to the cube of the wind speed. For this reason, in the selection of wind power generation site, searching for strong wind site is most important. Thus, the wind power generation site is limited.

NEDO (New Energy and Industrial Technology Development Organization) has prepared the nationwide wind state map and it shows considerable amount of wind resources exist in Japan (F&T 5.5) Based on this map NEDO stated that Japanese wind resource is 1.4GW by the most pessimistic forecast and 35.2GW by the most optimistic forecast. NEDO says when the offshore wind power generation is considered, the

resource can be estimated ten times of these.

Because the wind power generation technology is a matured technology compared with the solar battery technology, the cost of wind power generation will not decrease dramatically as is the case of the solar battery. However, the wind power generation technology already reaches to the practical level and the production cost of the wind power generation has superiority to other generation technologies in EU and the U.S. (F&T5.6) On the other hand, the production cost depends not only to the annual average of wind speed but also the turbulent flow element of the wind. For this reason, the production cost of the wind power generation in Japan is not equal to that of the United States and EU. In Japan, a typical case is as follows; a wind mill, whose construction cost is three hundred thousand yen per kW, and is constructed at the site of annual average wind speed of 6m per second, can generate electricity at a cost of 16.6 yen per KWh, which is equal to the electricity sales price for business use.

One of the technological target of wind power generation is the introduction of variable velocity operation which is an advanced technology fitting Japanese wind state as an alternative of fixed velocity driving. The other expected new technology is multipolar dynamo which directly drives the dynamo by the wind mill and omits the masoc cogwheel which increases mechanical noise and weight.

Success of wind power generation

As for wind power generation, California State and Denmark were famous as success cases until 1980's. After 1990's the wind power generation spread in Germany, Denmark and Spain. The commonality of these three countries is that they have introduced "fixed price purchase system" which legally force electric power companies to purchase renewable energy, such as wind power, at a certain preferential price. First, Germany has introduces "Power supply act (EFL)" in 1990. This is a law which forces regional electric power company to purchase renewable energy at 90% of the average power sales price. After the example of EFL, Denmark introduced similar law in 1992, and Spain introduces similar law in 1994. This is why the amount of wind mill installation in these three countries occuppies 83% of the EU wind power and about 60% of the world wind power at the end of 2003. At the end of 2003, Germany has wind mill installation of 14.61 GW, Spain has 6.41GW and Denmark has 3.11GW.

Based on the success of Germany and other countries, EU recognizes renewable energy as the key of the energy strategy from the following four aspects; preventing global warming, energy security, industrial development and expansion of employment, and

regional development. In 1997, EU published a plan to increase the production of renewable energy to 12% of the primary energy by 2010, which is double of the present ratio in its "renewable energy white paper." In 2001, EU resolved the "renewable energy order" and set the target to generate 22% of its electricity by renewable energy by 2010. As we have stated in this section, the wind power generation already has occupied important position, and, according to the forecast of EREC, 25% of the electricity will be supplied by the wind power generation in the world, in 2040.

Conditions that restrict the wind power generation increase

As is stated before, "fixed price purchase system" which legally forces regional electric power company to purchase renewable energy at a certain preferential price, solicited the spread of wind power generation in Germany. On the other hand, England, Sweden and Italy have introduced "fixed ratio system", another system for prompting renewable energy generation, which forces electric power companies to supply renewable energy more than a fixed ratio. Japan introduced fixed ratio system, too, in the "Special treatment law for new energy use(new energy RPS law)." "fixed ratio system" was adopted to introduce market mechanism in the formation of energy price, to supply renewable energy cost efficiently. However, those countries which introduced fixed ratio system went backward in the introduction of renewable energy. Japanese new energy RPS law is also criticized for delaying the diffusion of the wind power generation, especially because of the low target of the renewable energy diffusion.

On the other hand, some are expressing their concern for increasing the production of renewable energy without coping with the problem of instability of supply and system connection.

The introduction of fixed price purchase system cannot be the ultimate method for promoting steady increase of renewable energy, because the introduction of high fixed price will bring about flooding of small scale producer, which decrease the productivity of generations and increase problem for system connection. However, obviously, the fixed ratio system has big problems. It is already became apparent that because of the disparity in negotiating power between the small scale renewable energy producers and large electricity suppliers, electricity suppliers prefer biomass generation, which has stable production, and the wind power generating companies cannot grow.

This problem can be solved by a "fixed price purchasing system" on the conditions that the price is set enough low that only efficient renewable energy producers can acquire profit and that the price is adjusted strictly, say, prices at high demand hours are set

high.

At the same time, it is necessary to force the regional electricity suppliers to place long term contracts with the power producing companies, which can meet some requisites. The new energy RPS law is urged to be revised.

Hydro - power generation

Hydro-power generation is a method of power generation, which uses the potential energy of the land water derived from the rain or snow by the natural water circulation. The power generation output is proportional to flowing quantity and the effective head. Hydro- power generation is criticized for forcing surrounding areas go under water, or for worsening the water quality of the rivers which affects negatively to the ecosystem. However, it played major role in the production of renewable energy so far, as a method of power production which can generate power steadily and for a long period of time because of long duration of the plant. Out of the 1351 billion kWh, total power generation of the world in 1996, 63.2 % was produced by thermal power, 19.2% by hydro-power, 17.2% by nuclear power and 0.4% is by geothermal power. In addition, in case of hydro power generation, over 70% of the water-power resources are undeveloped. The water –power resources in each region of the world are shown in T&F5.7.

In Japan, 70% of the water-power resources are already developed and in North America and Europe considerable part of the resources are developed, however, in Russia, South America, Southeast Asia, China and Africa, large part of the water-power resources are not developed yet. For this reason, China is making efforts to develop the water-power resources, such as the construction of the Three Gorges Dam. When the Bering Strait Dam is constructed, huge amount of electricity will be produced from the dam.

The production cost of the hydro-power generation at a large-scale hydroelectric power plant is cheap, close to two yen/kWh. On the other hand, the production cost of hydro – power generation at middle to small scale dams is about fifteen yen/kWh which is higher than the cost of solar and wind power generation.

The site of hydro –power generation tends to be remote from the place of electricity consumption. The water-power resources were not utilized because of the under development of the transmission of the electricity. For further development of the water-power resources, the technology for large-scale and long distance electric power transmission was hoped for.

MEMO Chinese Sankyo Dam

The construction of Sankyo Dam and power plant, a national project of China, is a construction of world largest dam and power plant, which dams up the Chang Jiang, the third longest river of the world, and is used for flood prevention, power generation, water transportation and water supply. The design plan of this dam was proposed by Sun Wen in 1919, and the movement for construction started from the severe flood in 1954, and the construction started in 1993. This dam and plants will be completed in 2009, and the construction is said to be the most difficult construction ever since the construction of the Great Wall. The amount of storing water of Sankyo Dam is 39.3 billion cubic meters, which is twice of all storing water in Japanese dams.

In this construction twenty six dynamos which has 0.7 million kW power are set up and total generation capacity will be 18.2 million kW, and annual capacity will be 84.68 billion kWh. To generate this amount of electricity by thermal generation, coal will be required 50 million tons a year, and if oil is used, 25 million tons a year will be necessary. Consequently, 100 million tons of carbon dioxide emission will be reduced.

This dam also has control function of flood which can work even at a large rain of once in every one hundred years. This dam enabled transportation of ten thousand tons of ships from Shanghai to Chungking. This dam also increases flow in the dry season for irrigation, in addition, the dam water is used for "water delivery to northern region", on its way, the water irrigates arable land.

MEMO Water delivery to northern region project

The total water resources of China is 2.8 trillion cubic meters a year, which is the 6th of the world. However, the water resource per capita is one fourth of the world average, and is 88th of the world. China is classified in countries which lack water resources. In addition, Chinese water resources distributed largely to Chang Jiang region, and the Hwang Ho region and the northwest interior region, where 36% of Chinese people live, are a dry area where only 12% of Chinese water resources exist. For these reasons, the project plan of "water delivery to northern region" was proposed from 1950's and now under construction in many places. The central line for this water delivery, which starts from Sankyo Dam and reaches to Beijing will be completed in 2020's.

The beginning of renewable energy international politics

As we have mentioned hereto, the technological potential of renewable energies was made clear by 1990's. The discussion moved to how the political and economical regime of each country receives the technology and what kind of measures and systems we can make with this technology for preventing global warming and supplying energy. Under such conditions, Germany and other EU countries decided to introduce wind power generation, and they became the moving power of the growth of renewable power generation in the world. The power generation systems which grew most in 1990's are wind power generation and photovoltaic generation, and each of them grew at the annual growth rate exceeding 20%. The renewable energy market, which expanded to twenty billion dollars (about 2.2 trillion yen) in 2003, is expected to grow at a rate of 20% a year in the future. The accumulated investment from 1995 to 2003 came up to 100 billion dollars (11 trillion yen). 700 billion dollars (about 80 trillion dollars) is said to be invested in OECD by 2030. (F&T.5.8)

Germany, the front runner in this field, already conducts 10% of the total power generation by renewable energy, and produces employment of 130 thousand people and economic effect of 8 billion euro in this field. In addition, Germany is reducing 35 million tons of carbon dioxide emission in 2000 by the use of renewable energy. Now Germany's action is a symbol of integration of economy and ecology. The renewable energy begins to share an important role in the world economy now.

In the negotiation concerning the Kyoto protocol, EU proposed 15% reduction of carbon dioxide emission in 2010 from 1990 level, and took the leading role. The concrete alternative energy policy was the base of its proposal. Since then, EU continued to discuss renewable energy issue in the international politics stages. The proposals of investment to the renewable energy in G8 in July, 2000 and G8 Genoa summit in 2001 was a part of the preparation for the "World summit for sustainable development" (Johannesburg summit)

Johannesburg summit and International convention for renewable energy in 2004

World summit for sustainable development, which was held from the end of August to the beginning of September, 2002 in Johannesburg of South Africa with the leadership of UN, has determined the trend of international politics for renewable energy, which set renewable energy to the core of the energy strategy and solicit investment in developing countries in this field. The importance of this summit lies where renewable

energy became the main topics of the international politics. Before this summit, many people expected an agreement for soliciting the introduction of renewable energy. However, the international negotiation concerning the annual target of renewable energy introduction was break down by the strong opposition from the countries led by the U.S.

On the last day of the Johannesburg summit, EU published a declaration that EU will devote to the real spread of the renewable energy through setting their own target and supporting developing countries, and proposed independent participation to each country. It was the start of the Johannesburg renewable energy committee (JREC). In the place of the conference many nations declared agreement on the proposal. By 2004, eighty nine countries have joined JREC. In JREC many participating countries declares high concrete targets to increase the production of the renewable energy. To attain this target, joint research projects are started and policies and measures to solicit the spread of the renewable energy have been discussed by the parties.

(JREC: <http://library.iaea.org/dbtw-wpd/textbase/pamsdb/jr.aspx>)

"The international conference for renewable energy 2004", which was hosted by the government of Germany, was held in Bonn Germany, in June 2004. In this conference, learned by the failure in Johannesburg, setting world target for introducing renewable energy was omitted from the main objects of the conference to avoid the repulsion from the U.S. and Japan.

Three documents are arranged in this conference. First is the "Policy Proposal" which gathered preferable policies to spread the renewable energy. Second is the book of the advanced approaches which were gathered from governments, international organizations, NGO's and other groups by self return. Chinese policy, which declared to produce 10% of its electricity by renewable energy by 2010, and Philippines program which declared to expand renewable energy production to twice by 2013, were most remarkable policies in this book. Third was the political declaration which stated renewable energy to be the most important and widely available energy source. This political declaration (Bonn declaration) was adopted by common consent on the last day of the conference.

As we have described in this chapter, the world trend of spreading renewable energy is very strong, especially in Europe. At the same time, this speed of energy conversion, which is asserted by EU, is found to be necessary to stop the chain of global warming, by the recent research concerning global warming. On the other hand, it was made clear that the world has to prepare some social infrastructures to introduce renewable energy

at this speed. The remaining part of this chapter, we will describe the social and technological infrastructure necessary to be prepared for the introduction of the renewable energy.

International connection of electricity systems and world power network

For the renewable energy to be used widely in the society, some problems have to be solved. One problem is that the power generation site is far from the consumption place. The other problem is that it cannot supply according to the demand, and that the production changes by time zone and the season. To expand the supply of the renewable energy, it is necessary to form international connection of electricity systems and the world power network to make up the demerits of renewable energy.

The merit of the international connection of electricity systems are as follows:

1. It enables trade of renewable energy from the countries which have low cost energy, such as wind, photovoltaic and tidal power to the countries where large demand exist.
2. It reduced composite load by combining each countries demand which changes by season and time difference.
3. It increases reliability of supply by enabling assistance in case of emergency and electricity trade.

The connection of electricity systems, in other words, trade of electricity, is already popular in North America and EU and is providing benefits to participants.

The electricity trade between the U.S. and Canada is the export of Canadian electricity to the U.S., which is produced by Canadian cheap and abundant water resources, according to long term contracts. In Western Europe, large international electricity supply system, which consists of twelve countries, has historically developed. The electricity exporting country is France, which has abundant nuclear power.

Most of the electricity trade is based on long term contracts between electricity companies. However, there are some other form of contracts, such as sharing of power plants and premeditated electricity trade considering the demand fluctuation owing to season and time difference. Spot electricity trade contracts are seldom seen yet. Western Europe electricity system is connected with England, Scandinavian countries, Eastern Europe and Russia by direct current power transmission.

The formation of the world power network starts from the connection of the present regional electricity distribution systems. The North America and Europe systems will conduct consolidated system planning in the near future. International electricity transmission system will also be developed in ASEAN countries in Southeast Asia and in South America. Japanese electricity system will be connected to some of these systems as a large demand region. However, we believe Japan should be in the position of spreading the power network, even though Japan has some geopolitical weakness, considering the inevitability of the network for the utilization of renewable energy, because the storage of electricity is very difficult. Japan should start from the formation of the Pacific Rim power network. F&T5.10 shows a multi terminal direct current system which is connecting provenance regions, where abundant energy resources exist, and high demand regions. Each region of the earth has specific abundant resources of wind, hydro, and photovoltaic energy. Thus, each region will have its own combination of power supply. The formation of world power network enables distribution of the energy to the high demand region from many regions of the world, instead of making a large electricity storage system. The world power network will be managed by globally consolidated plan of electricity system. Computers and communication network will enable the advanced control of the network. The communication cable will be an optical fiber combined with the power cable, and the communication network will be integrated to the power networks.

High-pressure direct current power transmission and superconducting cable

Ships and vehicles are indispensable for the transportation of fossil resources, and similarly, electric power cables are indispensable for the transmission of electricity. However, the long distance electricity transmission was impossible for the electricity loss, when an alternating current power transmission technology is used. However, the power converters made of semiconductor devices, such as thyristor, transistor, and diode which are called SI family, which were invented by Nishizawa, one of authors enabled the direct current transmission of high voltage and large current. The key was the semiconductor devices, SI family, whose power loss is nearly zero.

The merit of direct current transmission is as follows; The construction cost of transmission line is cheap and economical especially for long distance cable transmission. Stability problem does not exist which is different from the case of alternating current power transmission, which is preferable for high-power transmission. Connection of asynchronous systems is possible. Current control is easy

and quick. Operation control is easy. For all the North America and Europe electricity system connection, direct current transmission technology is used. This direct current transmission technology is an indispensable element technology for the world power network.

Recently the last element technology necessary for the formation of the world power network was established. It is the high temperature superconducting cable. The first superconductive material was a metal group superconductor, which showed super conductivity at the temperature of -269°C , the boiling point of helium. Recently a oxide group superconductor was developed, which shows superconductivity at a temperature of -196°C , the boiling point of nitrogen. The amount of current which can be transmitted by the superconductive wire is two hundred times of present commercial copper wire, and the loss of the electricity is half of present copper wire. Now, the superconductive electric power transmission cable is on the commercial use.

The first case of the of high temperature superconducting cable construction was successfully done at Albany City of New York state, by Sumitomo Electric Industries, Ltd, a Japanese corporation. The cable used was a bismuth group super conducting cable, which was developed by Sumitomo Electric Industries, Ltd. In the U.S., a plan of constructing superconducting cable network all over the U.S. by 2030 is under examination. The superconducting cable enabled the transmission of several GW at a distance of several hundred kilo meters almost without electricity loss.

In this chapter, we have described that, the electricity supply system in the future world can be formed with the cooperation of the countries, renewable energy technology and the world power network supported by new transmission technologies. We would like to emphasize two important points now.

First one is that it is time to conduct energy security, which was important part of the nation's sovereign authority, is achieved by regional cooperation. This community will expand in the future and cover the world. This means that the energy security will be achieved by the whole world. It will be the beginning of the world government.

Second is that it is time to start constructing social infrastructures, such as renewable energy generating plants and electricity transmission network, which requires huge investment, real quickly. Part of required capital will be produced by the world public company which manages fossil resources, which we will explain later.

In the next chapter, the utilization of biomass and the fixation of carbon dioxide will be

stated.

MEMO Is the nuclear power generation ecologically friendly?

The nuclear power generation was paid attention because it does not emit carbon dioxide at its power generating process. However, the nuclear power generation consumes much energy for its nuclear fuel before it is prepared to be used in the power generating process. In addition, the nuclear power generation uses much sea water as cooling water, which causes emission of carbon dioxide in the sea water to the atmosphere. For these reasons, the nuclear power generation cannot be evaluated as carbon dioxide free.

The most severe problem of the nuclear power generation is the safety of the operation and the processing problem of the high-level radioactivity waste. As for the processing method of the high-level radioactivity waste, which inevitably produced as burning dregs, several methods, such as vitrification, asphalt solidification and stratum disposition, were examined, however, each of them has some problems. The disposal of the radioactive waste to the ocean was banned by the London treaty of 1983. At present, about several hundred thousand drums are stored in the waste storage facilities. Except for new nuclear plants, every plant is forced to increase its storage facilities, because more than six hundred thousand drums are added every year in Japan

Chapter 6 The role of biomass for preventing global warming

Recently trials to use biomass for energy sources are vigorously conducted in many places of the world. In 2006, in the State of the Union message, President Bush published an idea that the U.S. reduces import of the oil from the Middle East by developing bioethanol technologies. On the other hand, EU published that it will increase ratio of biomass in its primary energy construction by three times by 2001, in its energy white book. This amount of biomass equals to ninety million tons of crude oil. Japan published in its “new energy introduction target” that it will largely increase the use of biomass.

When people hear these news, they will imagine biomass will play a very important role in the coming renewable energy society. However, biomass energy has fundamental weakness that it cannot grow more than a certain point because of its limited materials, which is different from other renewable energies, such as photovoltaic, wind power and hydro energy.

Biomass is living things and remain or excrement of living things. Almost all the biomass energy derives from the solar energy which plants fixated by photosynthesis using water and carbon dioxide. For this reason, the largest biomass derives from forests. In the history of human being, we always cut forests. When civilization collapsed, desert remained. The reason why the human being could flourish exceeding the limit of forest resources is that human came to maintain its civilization without cutting the forests because of the utilization of fossil fuels. For this reason, it is apparent that we cannot maintain our society with the limited amount of biomass energy when the use of fossil fuels becomes difficult.

Biomass has more important roles than the role of fuel in the society which has to tackle with global warming. First one is the role of protecting the biosphere, in other words, the role of animal foods and plants fertilizer. Second one is the role of material for carbon dioxide fixation in the ocean. The second role is derived from our authors' idea of fixating carbon dioxide in the ocean by using biomass. We regard biomass as a substance which contains carbon dioxide, and think that, by processing it to a substance fitting for ocean dumping, we can sequesterate carbon dioxide in the ocean with it. (Detail of this method will be explained later) When these two roles are given priorities, the amount of biomass used for generating energy comes to be limited. The biomass's energy use has the additional value of reducing carbon dioxide emission, only under the

condition that most of energy is made from the fossil resources. When the energy comes to be supplied by wind power or photovoltaic generation, the use of biomass energy which does not have cost competitiveness will decrease, because it loses the merit of reducing global warming effect.

In this chapter, we will describe how the utilization of biomass took place in the world. In the explanation, the limitation of the potential of biomass as an energy source will be made clear. After this explanation, the possibility of carbon dioxide fixation in the ocean by using biomass will be explained with the example of Japan, in addition to other methods for carbon sequestration which is now under investigation.

What does utilization of biomass mean?

Biomass is organic materials such as living things and their excrement. The fossil resources stored under the ground are derived from living creatures but are not included in biomass. Biomass was used as fuels and materials from the beginning of human history.

First, biomass is used as fuel for power generation. The energy efficiency of biomass is high, about 65 to 80%, when it is used in co-generation system which is conducted in Scandinavia and other countries. However, when biomass is used only for power generation, a small scale generator is used. For this reason, the energy efficiency comes to 10%. In addition, when domestic animal's excreta or sewage sludge is used, because of the high percentage of water content, vast amount of energy is wasted. Total energy efficiency of a thermal generation plant which uses fossil resources is close to 40%. This is why recently biomass is not used for simple combustion and steam turbine generation system. Many high efficiency power generation systems, which use gasification of biomass, metan fermentation and fuel cell technologies, are now under investigation.

In recent years, huge amount of biomass came to be used as bioethanol which was produced from corn in the U.S. and from sugar cane in Brazil.

Another alternative use for fossil resources is chemical industry use called bio refinery. In this bio refinery, corn is used for producing polylactic acid which is used for biodegradation plastic. In the U.S., Cargill, a grain major, and Dow-Jones made a joint venture company and started commercial production of polylactic acid. This company owns production equipment of one hundred forty thousand tons per year. In Japan, Toyota motors stated production of polylactic acid made from sweet potato produced in Indonesia.

Biomass utilization in Europe

Europe is a region where abundant wood biomass exists and regional heat supply plant was historically equipped. Utilization of biomass is advanced especially in Scandinavian countries. When the ratio of biomass energy in the primary energy is examined for each country, the ratio is distributed from low, such as 0.7% of England to high, such as 17.2% of Finland. This means that only limited number of countries vigorously utilize biomass. (F&T 6.1) The countries where large amount of biomass is used are countries with wide forest areas. For example, the production amount of timber per capita of Finland is fifty times of Japan, and that of Sweden is thirty four times of Japan. In these countries, the room of using remainder in the forest, which is by-products of timber, is quite large. The renewable energy white book of EU in 1997 stated that, it will use woody biomass of thirty million tons of crude oil and crops and biogas of sixty million tons of crude oil, in total, it will use biomass of ninety million tons of crude oil to increase the ratio of biomass in the primary energy three times, however, these numbers include the increase of the use in the areas where no former usage existed. For this reason, attainment of the plan is quite difficult. (T&F6.2)

Germany is aggressively introducing biodiesel produced by colza oil. The energy produced by biomass consists only 2% of primary energy in Germany, however, Germany is planning to increase it to 5.75% by 2010 and increase the sales of biodiesel from five hundred fifty thousand tons of 2002 to 1.79 million tons by 2010. EU is keeping certain percentage of acreage under cultivation (10% in Germany) as fallow to reduce amount of food production. The cole is cultivated in this fallow. The sales of biodiesel is increasing and it has become an example of success. However, to increase the production of biodiesel, it is necessary to import cate plant, such as sunflowers and soybeans from out side of EU, because the production of cole cannot be expected to increase.

England has made efforts to produce solid fuel energy crop because it has a special condition of lacking forest resources. The ratio of biomass energy in the primary energy was lowest in England in EU, however it is planning to attain half of the plan, that increases renewable energy ratio in the primary energy to 10%, by biomass. England is subsidizing to grow willow, poplar and Japanese pampas grass in fallow. England has failed in the project of gasification power generation plant of ten thousand kW, however, private companies own power generation plant of ten thousand kW which use fowl dung,

and power generation plant of thirty six thousand kW which use straw, and are operating them as commercial plants. However, these projects have little possibility of expanding because of limitation of raw materials.

Concerning woody biomass, which occupies largest part of present biomass utilization of EU, most of the by-products, such as black liquor and preparation rubbish, are utilized. In the future, remainder of the forest and waste wood will be the object of the utilization. In Germany, about 10 million tons of waste woods were discarded and they are now prohibited to be buried in the ground by the amendment of laws in 2005. For this reason, projects for biomass electricity generation, which utilize waste woods, are advanced in many places and the number of the projects comes up to 70. However, many projects are stopped because of the difficulty of acquiring enough waste woods.

As shown above, many biomass utilization are well on the way in EU and high targets are declared. However, because of the limitation of biomass amount, large increase of energy supply cannot be expected, and the attainment of “additional biomass utilization plan of 2010” seems to be difficult. The utilization of biomass will contribute to the regional economy of EU, but its ability as a measure for stopping global warming is small.

Biomass utilization in energy use in the U.S.

U.S. and Canada have made efforts to utilize biomass for their abundant forests resources. In their paper, pulp and lumber industry, process production from material wood to plywood and other downstream products is conducted in the factories. Even the bark remained is utilized as a fuel, this means complete utilization of woods has attained. Since 1978, learned from the experience of oil shock, biomass electricity generation was encouraged and 26% of power generation came to be generated by using biomass in Maine State where wide area of forests spread. However, the competitiveness of biomass power generation was lost because of liberalization of electric power. For this reason, the use of biomass is shifting from power generation to fuel use, like bioethanol, and material use.

In 1999, President Clinton promulgated the executive order for development and promotion of bio products and biomass energy. In the executive order a target of expanding the use of biomass to triple in these ten years. In the Bush's administration, this target was greatly decreased. The target of annual increase of biomass power generation and thermal utilization was reduced to 1.5%. On the other hand, for bio fuels,

the target of average annual increase in these thirty years is set to 15 %, and the production of 239 million tons of bio fuel in 2030 is planned. The official reason of these decisions is said that there is no necessity of generating power by biomass, which does not have cost competitiveness, in the U.S., where there are plenty of energy resources for power generation, such as coal, nuclear power, hydro power, and natural gas from Canada. On the other hand, the mixing of bioethanol to gasoline is said to have the effect of increasing energy security because it reduces the import of oil from abroad. Actually, strong lobbying of U.S. corn producers association for promoting bioethanol is said to be effective.

In the U.S. 9.68 million kl of bioethanol was produced from 23 million tons of corn in 2002. This 23 million tons is about 10% of the corn production in the U.S. and 1.4 times of Japanese corn import. For this reason, the production of bioethanol has become very important industry for corn producers and related industries people. However, the effect to the livestock industry and possibility of production increase of corn are considered, the increase of bioethanol production up to the administration's plan cannot be expected.

On the other hand, longtime controversy of whether the production of bioethanol from corn can truly reduce the emission of carbon dioxide exists. Doctor Pimental of Cornell University and Doctor Paztek of UC Berkeley published the result of LCA analysis, which says the net energy production of bioethanol is -29% in their collaboration book. There are many other researches which say similar result that the energy balance is minus. On the contrary, many researchers, such as researches of department of agriculture and ministry of energy say the energy balance is plus. Japanese industrial investigation committee reported that the energy balance is 1.1 which means that the energy which can be extracted from the bioethanol is a little bit larger than the energy used in the cultivation of corn and production of bioethanol from the corn. (This means that bioethanol is carbon dioxide free only in the relationship with Kyoto protocol) In either case, to grow corn and produce bioethanol to stop global warming is very ineffective, when the energy balance of photovoltaic power generation is 20 (The photovoltaic power generator produces twenty times of electricity, which was used in the production of the power generator.) The production of bioethanol from corn, will cause shortage of fodder and food, which gives large shock to livestock industries and spread famine in the world. When the global warming starts all over the world and the shortage of food production is worried about, the production of bioethanol from the corn should not be increase and cannot be increased.

On the other hand the production of bioethanol from sugarcane in Brazil has the energy

balance of more than 7, different from the case of corn. In this case, altering fossil fuel with this bioethanol made from sugar cane has the effect of preventing global warming. However, to produce bioethanol by cultivating sugar cane cutting the rain forest of Brazil cannot be recommended from many view point, such as preventing global warming and maintaining biodiversity.

In the U.S. projects to construct biorefinery, where diesel fuel and other biochemical products are produced from not only starch but also stalk and other residue of corn, are going on. A plan of producing 21million tons of biochemical mainly from polylactic acid polymer is published by Cargill-Dow. This biorefinery plan have similar problem with bioethanol, however, when the plant, which was incinerated before, is used, the adverse effects to the environment is not large.

Biomass utilization in energy use in Japan

In the “energy supply and demand outlook” of Japan, revised at the end of 2005 (F&T6.3), the ratio of new energy didn't change (3% in 2010 which is equal to 19.1million kl crude oil), but the contents were largely revised. The amount of solar heating was revised from 4.39 million kl to 0.9 million kl, which is a practical target, on the other hand, biomass thermal use increased from 0.67 million kl to 3.08 million kl (including 0.5 million kl of biomass fuel used in transportation sector) and waste thermal use increased from 0.14 million kl to 1.86 million kl. This plan relies 70% of total new energy on biomass group energy. From this point and the fact that total target of the new energy was set to 3%, strong will to stop the increase of the photovoltaic and wind power generation can be observed. Leaving the discussion of how to amend this Japanese political stance to later chapter, under this plan, large expansion of biomass and waste use is inevitable.

Japan has issued “Integrated Strategy for Biomass Nippon”, where biomass stock size and use of biomass in Japan are described. When this integrated strategy is seen critically, it does not show future vision of Japan, even though it covers all the discussion area. It is true that there is no history or equipments of thermal utilization of biomass in Japan, different from Europe. It is also true that there are no strategic plan or biomass resources in Japan, different from the U.S., where bioethanol is produced to reduce oil import and increase corn consumption. For these reasons Japan is thinking to enhance the power generating facility of old model waste incinerator for a while. Unless building super large waste incinerator, the thermal efficiency of biomass power generation is close to 20%, even though gasification and gas engine power generation

are conducted. When this plan is actualized, the incineration of recyclable waste may continue, which harm the effort to prevent global warming. For these reasons, Japanese plan for biomass utilization does not have much possibility to contribute to preventing global warming.

The invention of MACS

We have stated that the energy use of biomass does not have much importance as a method to prevent global warming, even though it produces some economical merit. On the other hand, when biomass can be sunk under the sea water in a form which is solvable to the sea water and fit the ecological system of the ocean, it can be used as a tool to fixate carbon dioxide in the sea water much easier than the former methods.

The system, which enabled the alternation of the biomass to a substance which fit for carbon fixation in the ocean, was invented. The system is called Multipurpose Material Conversion System (MACS), the main equipment of which is a material conversion machine based on hydro-thermal chemistry. This machine convert waste plastic, woods, sludge and other biomass to brown, good smell powder made of amino acid and oligo saccharide in a short time with small energy. This compound can be used as compost, fodder and fuel, but it also can be dumped into the ocean because it can easily sink under the water and does not consume oxygen when resolved by bacillus. For this reason, the possibility of carbon fixation under the sea by using this system was proposed.

Mr. Joji Takase, a specialist of hydro thermal chemistry of the institute for eco & economy system, developed the production process of MACS, where biomass is stirred one hour under the condition of 20 atmospheric pressure and 210 degrees Celsius. The dark brown color is caused by Maillard reaction (This reaction is also called as amino-carbonyl reaction; a condensation reaction caused by an acodensation reaction of amino group (-NH₂) to carbonyl carbon (-CO-))

This system was originally developed for composting of biomass and has high performance in this usage.

1. High processing capacity:

In usual composting process, it takes at least one month for complete composting and requires wide area, such as fermentation building, for this process. In case of MACS, the processing time is about one hour, which changes a little bit depending on the material.

2. The range of materials

MACS can convert plastics, woods, foods leftover and sludge (almost all biomass and waste plastics other than rubber) to the powders without assortment.

3. Safety of the process and product

The hydro thermal reaction proceed under the condition of 20 atmospheric pressure and 210 degrees Celsius, which is much lower than the usual industrial process, for this reason, the danger of the process is low. The reaction does not produce dangerous substances, such as dioxin, the danger does not exists for the products.

4. Utility of the product

The product of MACS can be used for organic fertilizer, fodder and food because of its low salinity, however, in case of demand shortage, it can be used as fuel.

(T&F 6.4 Utility of MACS)

(T&F 6.5 System flow of MACS)

The conditions of the MACS reactor, 20 atmospheric pressure and 210 degree, are conditions of the hot primitive earth surface, when the simple substances like carbon dioxide evolved to more complicated organism like amino acid. This may be the reason why the organisms are converted with minimum energy when they are put under these conditions with water, and why the products have no harmful effect to living things.

On the other hand, there are some reasons why MACS didn't spread soon. The reasons were as follows. First, MACS was used for sludge treatment, and the demand of the product was low only because it was made from sludge. Second, in Japan, reduction of volume is the primary requisite for waste disposal machine. MACS can reduce volume only to the half of the original sludge, this limitation harmed attractiveness of this machine as a waste disposal machine. However, MACS, which can convert the characteristics of organisms to a more easy to handle state, while keeping 80% of the carbon within the product, can work effectively when carbon fixation in the ocean is considered.

Current carbon capture and storage technology

To prevent the increase of carbon dioxide concentration in the atmosphere, many researches were conducted to investigate whether the capture and storage of the carbon dioxide emitted by the use of fossil fuel is possible or not, apart from the efforts to decrease energy consumption and convert the energy production system to reduce fossil fuel usage. Carbon dioxide from the emitted gas is separated and captured by using solvents, such as mono-ethanolamine. The power generation efficiency decreases by 30% to 40% for this operation, which cannot be avoided technologically. The storage place is considered to be underground or ocean. For the ocean sequestration, middle layer of the ocean and deep ocean pool are considered to be a place for storage and basic investigation is now going on. The experiments of middle layer storage, which were scheduled to be conducted on the offshore of Hawaii and Norway, were ceased, because of the criticism to the danger to the environment. The ground sequestration is on the validation phase, however, no commercial operation has started. For the cost of carbon sequestration, trial calculation is variously done. The published results are distributed from one 100 dollars per t-C to 333 dollars per t-C, and ground sequestration is more economical than ocean sequestration. The research of ocean sequestration was stopped in all the countries other than Japan, and the research for ground sequestration was continued in several countries. In Japan, NEDO and other research groups are investigating the possibility of carbon sequestration, however, carbon sequestration is an incomplete technology, which has no experience of long time storage. Even though it could sequester carbon dioxide for a while, when an accident of leakage from underground or ocean happens, dangerous suffocation event of carbon dioxide, which sometimes happens near the volcanoes, might occur at a much bigger scale. If carbon dioxide is diluted and discharged to the ocean, adverse effects on the ecosystem, such as extinction of some planktons might happen.

MEMO Melting coral and the shellfish by the rise of the carbon dioxide concentration.

Recently, a thesis was published by Nature, a scientific journal of England, which reports that ocean lives, which have shell of calcium carbonate, are now facing a threat of ocean acidification caused by increase of carbon dioxide concentration in the atmosphere. This thesis reported that if the emission of carbon dioxide continues in today's trend, the shell of the pteropoda, an important plankton which lives in Antarctic Ocean, begins to melt in 2050, and then melting of coral follows, and the shell of foraminifer and coccolithophorid begins to melt within 50 years since then, according to the forecast, with their own models, of thirteen laboratories, including Japanese

laboratory, in the world.

Oceanic carbon sequestration by MACS

As we have stated above, to discharge carbon dioxide directly to the ocean is difficult. However, the product of MACS, which is a harmless substance originally used for fertilizer, will not cause large destruction of the environment, on the contrary, it will grow planktons and fishes as nutrients. The product of MACS will be dissolved in the sea water at the middle layer of the ocean, where the concentration of organisms is high, and only a part of it will reach to the bottom of the ocean and is fixed there as methane hydrate by anaerobic degradation. In the investigation of the ocean where night soil was dumped, there was no piling up of night soil at the bottom of the ocean. Most of the product of MACS will be dissolved in the sea water and stay at the middle layer of the ocean as nutrients.

The anxiety, which occurs when we dump organism, such as the product of MACS, in the ocean, comes from our experience of environmental damage which was caused by red tide derived from coastal eutrophication. However, except for closed sea areas, such as Inland Sea and Tokyo Bay, almost all oceans, including off shore of Japan, are in the state of shortage of nutrients, such as phosphorus and nitrogen. Dr. Tetsuo Toyama, former president of Tokyo University of Fisheries, stated on the magazine of Marine & Waste Resources that oceanic manure is preferable if it is conducted selecting sea area for the increase of fishery.

The dumping of the MACS product to the ocean might be regulated by United Nations Convention on the law of the sea, London Convention, Protocol of 1996 on London Convention and Convention on Biological Diversity, etc. However, the sewage sludge is classified to the waste which and be sunk in the ocean, even though industrialized countries stopped ocean dumping of the sludge. We, authors, believe MACS product which has much smaller environmental impact is allowed to be dumped in the ocean under international laws. In the future, Japanese government should confirm that the carbon sequestration by MACS product is possible in COP

The potential of MACS

How much amount of carbon can MACS sequestrate in the ocean? The amount of carbon which can be sequestered in the ocean is determined by the amount of biomass to be used for carbon fixation, because the receipt power of ocean is almost infinite from the

view point of artificial carbon fixation. First, we will calculate the amount of carbon which can be used for carbon sequestration, by assuming that the wastes which is incinerated at present are processed by MACS.

1. Municipal waste

The amount of municipal wastes in 1997 was 51.2 million tons in Japan. Japan Environmental Sanitation Center published that the contents of moisture within them were 49.5% and, in the elemental compositions of wastes except moisture, the carbon content was 55.5%. The amount of municipal waste reduced to 50.59 million tons in 2004. When it is assumed that there was no change in the elemental composition of wastes, the carbon amount included in the wastes was about 14 million tons.

2. Industrial waste

The amount of sewage sludge was 190 million tons in 2003. When the content of moisture is assumed to be 84% and carbon content is assumed 60%, the amount of carbon contained was 18 million tons. In addition, the amount of animal's excreta is 90 million tons, and the amount of wood waste, waste plastic and waste oil is 15 million tons in total. The carbon content of these two groups is about 17 million tons. In total, about 35 million tons of carbon exists in industrial waste.

3. Unused biomass

As for unused biomass, the forest remainder, rice straw and rice husk are plenty in Japan. According to "[Integrated Strategy for Biomass Nippon](#)", the forest remainder, which was woods left in the forest, is 4 million tons, which is equal to 1.7 million tons of carbon, and the unused rice straw is 6.95 million tons a year and the unused rice husk is 0.74 million tons a year. In total, unused biomass which can be easily utilized in the near future comes up to several million tons of carbon a year.

4. Fossil fuel used for waste incineration.

The amount of carbon dioxide emitted from the fossil fuel used for waste incineration is 25 million tons a year. Assuming that the amount can be halved, 3.4 million carbon equal tons of fossil fuel can be reserved. In addition, by stopping the sludge incineration, the amount of nitrous oxide produced is reduced which benefit for preventing global warming.

5. Carbon dioxide emission from the process

out 20% of the carbon is lost in the process of MACS. The energy consumed in the process is about 2% of the treated amount. For the transportation of MACS product to the ocean, energy is consumed.

By adding the carbon amount of 1 to 4 and subtracting 5, it was made clear that by stopping the waste incineration and using MACS system, Japan can reduce carbon dioxide emission by about forty three million tons. This amount is about 12.6% of the Japanese total carbon dioxide emission. This means that Japan can easily observe Kyoto Protocol without using Kyoto mechanism by altering waste incineration to MACS treatment. In many Japanese forests, necessary thinning and cutting of the forests are not conducted, and much wood is rotting in the forests, whose volume is estimated to be more than 100 million tons. The above calculation does not include this amount, so it is supposed that the potential of the carbon fixation by MACS is much larger. If MACS is introduced in the countries such as the U.S., Brazil, and China, where several hundred million tons of biomass is incinerated in each country, the effect will be huge. As we have stated in Chapter 1, we believe carbon fixation of more than one billion crude oil tons in the ocean is possible by 2050.

At the last part of this chapter, we must state the economical prerequisite which enables MACS treatment.

Many people will suppose that by changing the waste treatment method from present incineration to the MACS, much damage will be caused on the companies of present waste disposal industry. However, we must remind that by introducing MACS, this industry acquires new social role of sequestering carbon dioxide, in addition to the present role of waste disposal. This means that the business chance of this industry will grow largely. However, to achieve this technological revolution without social conflict, the MACS technology should be opened to the public and every company should be given a chance to enter into this business, in addition, companies should be financed widely for the investment on the production equipment.

For the transportation of MACS product to the ocean, new system of distribution should be constructed. In the future, tankers which formerly were carrying oil and other fossil resources, will be remodeled and used for this carbon sequestration in the ocean.

The most important requisite is that a system which rewards the carbon sequestration properly should be formed. Under the Kyoto protocol regime and discussions, biomass is regarded to be carbon free and not to emit carbon when incinerated. When the existence of small companies and individuals who are utilizing biomass as energy source is

considered, it is quite difficult to change this assumption, but it is not contradictory to pay reward when a company sequesters carbon by using biomass. The problem is how each country can acquire fund to pay such rewards. The formation of world organization for managing fossil resources, which will be stated in the next chapter, will benefit for this object, too.

In this chapter, biomass energy was discussed separately from other renewable energy, and the conclusion is that energy efficiency of biomass is so low that it should be used for a material of carbon dioxide sequestration in the ocean or some objects other than energy source. Equipment for sequestering carbon dioxide, called MACS was introduced. At the last part of this chapter, we stated that for MACS system, in the same way as Bering Strait Dam and World Power Network, a system to produce large fund is required.

Through the arguments up to this section, the authors have stated that the global warming requires immediate correspondence, and that technological preparation is ready for the energy conversion and the carbon dioxide fixation in the ocean. The next step is to make clear what kind of political decisions or formation of the systems is necessitated to tackle with the global warming through such technologies. In this section, first, we will make clear, through the arguments at the drafting stage of Kyoto Protocol and the contents of the Kyoto Protocol, why the effective countermeasures have not been taken for the global warming. Then, we propose “United Nations Fossil Resources Managing Organization (UNFRO)”, our proposal for the post Kyoto Protocol regime, which has overcome the problems of the Kyoto Protocol regime.

International negotiation over the global warming

The recognition of the world for the global warming problem spread well at the first step. In 1985, a consensus of international scientific community was forged on the issue of climate change in Austria at the Villach Conference. This trend was followed by Toronto Conference held in Canada in June 1988, which led to the establishment of the Intergovernmental Panel on Climate Change (IPCC) in November 1988, which is made up of leading climate scientists from around the world. The United Nations General Assembly welcomed the establishment of IPCC and resolved to require to the United Nations Environment Program (UNEP) and the World Meteorological Organization (WMO) that examination for international treaty concerning climate change should be started as soon as possible by utilizing IPCC. In November 1989, a ministerial conference for air pollution and climate change was held in Noordwijk Netherland, for a high level discussion. Then, the United Nations Framework Convention on Climate Change (UNFCCC) was adopted at the Rio Earth Summit.

The United Nations Conference on Environment and Development (The Rio Earth Summit), held in Rio De Janeiro, was the largest scale environmental conference in human history. In this conference, one hundred eighty nations participated. In addition, from about one hundred nations, sovereigns or prime ministers attended. In this Rio Earth Summit, signs for the UNFCCC and the Convention on Biological Diversity started, and the Rio Declaration on Environment and Development, Agenda 21 and the Forest Principle Statement were adopted. UNFCCC was negotiated based on the United Nations framework and was managed by the United Nations secretariats. It was natural that UN functioned as a place to discuss the countermeasures for environmental problem, when the environmental problem came to be acknowledged as

a whole earth problem.

At the first Conference of the Parties of UNFCCC (COP1) held in Berlin Germany in March 1995, the essential principles in negotiating the Protocol was discussed. The sentences adopted in the conference are called Berlin Mandate. The important point of the mandate is that the emission target is set for only the industrialized countries and the countries with economics in transition. These countries' names are shown in Annex I. This point was strongly insisted by the industrializing countries. After that, the negotiations were held based on the Berlin Mandate and the principles were introduced in the Kyoto Protocol which was adopted at COP3 held in Kyoto in December 1997.

Standpoint of each country at the Kyoto Protocol negotiation

The standpoint of each country for the global warming problem was made clear in the negotiation process of UN for the Kyoto Protocol. In the UN negotiation process, more than two hundred countries are aligned in several negotiation groups. The groups' stand-points are internally arranged. For the Kyoto Protocol negotiation, three negotiation groups are formed. The first group consists of industrializing countries and is called G77+China. The second group is EU. The third group, which is called the Umbrella group, consists of industrialized countries other than EU, such as the U.S. Japan, and Canada. The composition and the outline of insistence of each group are as follows:

*EU In the latter half of 1990's, center-left parties took over the political power, and the green party participated in the coalition government in several major countries. This political situation of EU enabled them to correspond to the global warming problem positively. Several EU countries, such as Germany, Netherlands and Denmark, which are regarded as environment friendly nations, took the initiative of the negotiation for the Kyoto Protocol through the aggressive EU proposal, which requires fifteen percent reduction of greenhouse gas emission in 2010 from 1990. This proposal was based on the movement of the renewable energy introduction, which was symbolized in the renewable energy report stated in section five.

* G77+China The industrializing countries group consisted of the countries from different backgrounds. It included China and India, which had large greenhouse gas emission, oil producing countries and small islands countries. The insistence of the group can be summarized as follows: First, no arguments can be admitted which lead to the acceptance of emission target of the industrializing countries. Second, the industrialized nations have to reduce emissions aggressively. Third, the discussions to actualize capital and technology transfer should be solicited. For the first point, the

Berlin Mandate has already confirmed that point. The oil producing countries, such as Saudi Arabia regarded the countermeasures for the global warming as activities which reduce their oil sales earnings. They, by themselves, protested actively to the proposals, which might cause damages on the oil producing countries, apart from other industrializing countries.

* Umbrella group This group consists of Japan, the United States, Canada, Australia, Norway, New Zealand, Russia, Ukraine and Ice Land. The countries of this group don't have same standpoint, and thus this group cannot be said as a negotiation group. Each country in this group shows the understanding of the necessity of the countermeasures for the global warming, however, it tries to remove or lower the emission reduction target, which will cause damages for its economy. Especially, the U.S. senate assembly adopted the Byrd-Hagel Resolution by 95:0. This meant that even if the U.S. government agreed with the Kyoto Protocol, which forces emission reduction only to the industrialized countries, it will not be ratified.

By scrutinizing the insistences of each group, we can find out that only EU was in the position of positively introducing the emission reduction target. On the other hand, the countries which were strongly opposing in introducing the emission reduction target can be classified into three groups: One group is fossil resource producing countries. The second one is industrialized countries which have industries that depend heavily on fossil resources. The third one is the developing countries which seek for economic development depending heavily on fossil resources. This implies that the true problem which countries faced was whether each country could admit reduction of fossil resource use. Thus those countries whose industries suffer damages by reduction of fossil resources use showed strong opposition to the green house gas emission reduction. Even the industrialized countries, which recognized importance of the global warming problem, couldn't cooperate with the emission reduction. The negotiation was utterly difficult, however, the object to adopt a protocol with emission reduction targets, which was supposed to be difficult at first, was attained by the efforts of negotiators of Japan, EU, etc., though big problems were left in the content of the Protocol.

Outline of the Kyoto Protocol

At present, one hundred and eighty six countries participate in the Kyoto Protocol. The most important point of this Protocol is that thirty five countries, listed in Annex I of the Protocol, accepted legally binding caps on the emissions of greenhouse gases. The Annex I Parties consist of members of Organization for Economic Cooperation and

Development (OECD) and countries with economies in transition (EITs). Each country of the Annex I Parties sets the target of emission; the percentage they will reduce the emission of greenhouse gases in the year of 2008-2012 (first commitment period), from the base year of 1990. (Japan – 6%, the U.S. – 7%, EU – 8%, etc.) The costs for emission reduction will be high in the countries of a strict object, and will be low in the countries of a loose target. For this reason, the flexibility measures, called Kyoto mechanism, were introduced. In short, the Kyoto mechanisms are as follows:

*Emissions trading. Under emission trading system, a Party finding it relatively easy to meet its target may sell surplus emission credits to another Annex I Party finding it more difficult or expensive to stay under its own cap.

*Joint Implementation (JI) An Annex I Party may fund a specific project that reduces emission (or increases the uptake of green house gases in the forestry sector, etc.) in another Annex I Party, and credit those reductions against its own target through this mechanism..

*Clean Development Mechanism (CDM) This mechanism works in a similar way to Joint Implementation, but this time bringing in developing countries as hosts of mitigation projects. The CDM's institutional structure is more complex, including an Executive Board to supervise the system. Its monitoring procedures are also more stringent to guard against the generation of fictitious credits, given that developing countries do not have emission targets themselves and often lack the capacity required to accurately monitor their emissions. In addition to helping Annex I Parties meet their emission targets, the CDM aims to promote sustainable development in developing countries.

The Kyoto Protocol usually receives affirmative reputation, however, when its content is examined, it is apparent that it failed in controlling fossil fuel use or reducing GHGs emission. After all, the total GHGs emission amount of the world was not reduced from the level of 1990, because developing countries are not obliged to reduce emission, the number of countries which accepted emission cap was small, and EITs were given too generous emission caps. When the financial flow is examined, it is apparent that the Kyoto Protocol kept EITs and developing countries within its framework by economic incentives, such as too generous emission targets and CDM. (Figure and Table 7.1) Introduction of CDM system and the acceptance of generous emission targets increase financial flow from industrialized countries to these countries. On the other hand, failure of the adoption of the Protocol meant the collapse of the polite fiction that the

world is cooperating to stop the global warming. Japan wanted to avoid the latter situation by all means. For this reason, Japan accepted the conditions, which is apparently unfavorable to Japan, and contributed in passing the Kyoto Protocol to clarify the world will to tackle with the global warming.

The future of the Kyoto Protocol

The basic system of the Kyoto Protocol Regime is the individual legally binding caps on the emissions of the Annex I party, and the emission trading. In the real politics of the Kyoto Protocol, the defects of the system became apparent.

1. When some countries are exempted from the emission caps, or when too generous targets are set for some countries, the overall emission cannot be reduced.
2. The value of emission credits cannot be foreseen. The parties concerned cannot judge whether the emission reduction is advantageous or emission trading is advantageous.
3. The Annex I countries have to reduce domestic GHGs emission by their own responsibilities. In some cases, countries cannot observe the target by strong opposition within the countries. Some countries, like the U.S. and Australia, might withdraw from the Protocol.
4. It is quite difficult to agree on the emission cap of each country. In the process of Kyoto Protocol negotiation, multifarious arguments are conducted concerning the calculation of impartial reasonable target value. However, an agreement was not reached.
5. This system leads to short-term judgments and will not solicit investments in the technology or in the infrastructure.
6. This system cannot produce fund to be used for global infrastructures, such as the Bering Strait Dam and the global power network.

The No.4 problem, the difficulty of reaching an agreement on emission caps, is very serious. When the object of the system comes up to the halving of the total emission of the world, it is almost impossible to force each country to accept its emission cap. For this reason, it is impossible to keep the Kyoto Protocol type emission control system for a long period. In 2005, first Conference of the Parties after effectuation of the Kyoto Protocol (COP11) was held. The U.S. and Australia, which have withdrawn from the Kyoto Protocol participated in this conference. COP continues to be the negotiation place for the next framework for the emission reduction.

Proposal for the Post Kyoto Protocol other than international emission credit trading

Many methods are proposed for reducing GHGs emission other than the international emission credit trading. We will explain some of such proposals here.

1. Coordinated Carbon Tax : The carbon tax usually discussed are not global carbon tax levied by a central authority, with revenues collected in an international fund. So far, this type of carbon tax was not discussed because creating such powerful international institution that can levy and spend the money seemed to be impossible. The carbon tax usually discussed is a coordination of a series of taxes that each nation would apply through an international treaty. This coordinated carbon tax has three strong advantages.

First, a tax system is likely to be economically more efficient than “cap and trade”. In cases, such as global warming, where the key capital investments are long lived and costly to reverse, price system works well than quantity system. Greater certainty of cost makes it easier for firms to plan long term investment.

The second advantage of a tax system is that it could make the allocation of the commitments easier politically. In short, this means the allocation of commitments is the severest problem for quantity system

The third advantage of a coordinated tax system is said that it could eliminate the international financial flows that occur in a trading system. However, as is stated later, we, the authors think the financial flow is necessary in some reasons.

An architecture based on a coordinated carbon tax is not without problems.

First, a coordinated carbon tax is politically difficult to implement because it makes the cost of action transparent, and it potentially shift large revenues from emitters to the governments that apply the tax. Mindful of these facts, politically powerful stake holders may favor other instruments over the tax.

Second, monitoring and enforcement are extremely difficult in the carbon tax system. This is because countries could offset a tax on emissions with less visible compensatory policies that offer loopholes for energy- intensive and export- oriented firms that would be most adversely affected by the new carbon tax.

Third, it is said that the economical load grows in industrializing countries in coordinated carbon tax system. At present, industrializing countries deny sharing any burden for tackling with the global warming problem.

Following three methods are proposed by the research project of National Institute for Environmental Studies, Japan (NIES) and Institute for Global Environmental Strategies (IGES)

2. Carbon Credit Banking: This regime requires a legally-binding emission reduction target to be set for each country, including non-Annex I countries (under the current UN Framework Convention on Climate Change). In addition, a Carbon Credit Bank is to be established, and it introduces an international “safety-valve,” upper limit price for carbon allowance. Countries or private firms can invest in the bank to start projects similar to those under the Clean Development Mechanism. The bank could also offer money for adaptation to climate change.

3. Dual Track Approach: This regime also requires an emission target to be set for each country, but the targets are not necessarily legally-binding. After allocation of emissions, each country shall select one of two “commitment tracks.” Countries that choose Commitment Track A are requested to submit a list of PaMs that they pledge to implement. Countries that choose Commitment Track B are not required to submit PaM lists, but their emission targets are legally-binding, and they are expected to utilize emissions trading to help achieve their respective targets.

4. Technology + Compensation Funds: This regime does not require emission target. Under this scenario, it is likely that numerous bilateral or regional agreements on climate-related technology cooperation appear around the world. Participants in such agreements are requested to establish Compensation Funds. When it is estimated that the global emission is likely to shoot above a climatic limit, all the technology related agreements around the world are asked to pay a certain amount of money from their Compensation Funds to diffuse certain technologies to quickly reduce emissions. The Funds are also asked to contribute to adaptation activities

5. Government-led Policies and Measures (PaMs): In this “Government-led Policies and Measures” scenario, countries have little interest in emissions targets set country by country, as they assume that emissions trading will be a failure. Instead, countries become more interested in coordinating their climate policies and measures without using emissions trading. This option is supported by their industry sectors that call for maintaining a fair arena of international competitiveness. In the negotiations leading to

the 1997 Kyoto Protocol, the European Union also argued that the protocol should be organized around a menu of policies and measures. This method includes many qualitative proposals to mitigate climate change. No.6 to No.8 proposals are classified in this method.

6. Agreements on Standards on Energy efficiency, Carbon Efficiency or Technology:

This approach seeks coordination of various standards among industries around the world. It is considered to be the best way to maintain international competitiveness of industries, and at the same time give them incentives to aim for higher standards.

7. Sustainable Development Policies and Measures (SD-PAM): This approach was proposed mainly for developing countries, many of which find quantitative emission targets to be unacceptable – not only for political but also of technical reasons. In order to commit to and deal with emission targets, countries require good national inventory systems to know the amount of greenhouse gases they are emitting, but many developing countries lack adequate capability to collect such data. This approach urges countries to fully incorporate climate policy into their economic planning. From the perspective of energy conservation, many climate policies would be beneficial not only for the climate but also for the economy, especially from the point of energy saving.

8. Pledge and Review: This proposal was discussed in 1991 when the Framework Convention on Climate Change was in the initial stage of design. This vision would entail countries pledging packages of policies to address global warming; subsequent review would check whether commitments were being honored and identify needed adjustment.

As for the proposals of No.2 to No.8, we don't have enough space to state details of their merits and demerits. The common features of these seven proposals are the easiness to reach an international agreement and the uncertainty of environmental effectiveness. For this reason, when a very strict target, such as fifty percents reduction in 2050 from the year of 1990, is required, it is quite difficult to adopt one of these proposals alone.

In addition, all these proposals for the Post Kyoto Protocol have a common problem. These proposals don't pay much attention to the damages caused by the GHG's reduction. The Post Kyoto Protocol regime should minimize the damages in the fossil resources producing countries, industrializing countries and industrialized countries. If any one party's damage is not considered, global cooperation for the GHG's emission reduction is impossible. The UNFRO, which authors are proposing, is a regime for

which we paid much attention on reducing damages of each party. Then, before we explain about this system, we would like to list the general conditions which are required for the Post Kyoto Protocol regime.

The conditions required for the Post Kyoto Protocol

1. In order to reduce the emission of GHGs radically by 2050 without harming economical development, the emission scenario of A1T of the Special report on Emissions Scenarios (SRES) of IPCC, which assumes that the world changes energy source from the fossil energy to the renewable energy, and uses new technologies globally, should be used.
2. In order to use fossil resources more efficiently, fossil resources should be provided for the economic activities which produce largest economic value. To actualize this, the price of fossil resources will be increased to the level at which the emission level is decreased to the target. By the price increase, the request of the environmental economics, the internalization of external costs, is satisfied. Under the free trade regime, the price of fossil resources should increase globally at the same time and at the same level. For this reason, new regime has the ability of increasing fossil resources price globally.
3. If price increase of the fossil resources is the only method to decrease the carbon dioxide emission, the level of price increase could be very large. A report, which describes the effect of carbon tax introduction in Japan, says that, when the tax revenue is used to reduce GHGs emission, the effect will be increased by a factor of ten. For this reason, the fossil resources' price is increased in parallel with the subsidizing for renewable energies and for conservation of energies.
4. According to the forecasting models exhibited in the IPCC's Third Assessment Report, when the Kyoto Protocol comes into effect, the damages caused by the protocol amount to one tenth of the oil income for the oil exporting nations and regions. When GHG's reduction target comes up to fifty percents, the damages will be much larger. For this reason, these countries will not think the regime is impartial without receiving some compensation. Therefore, the fossil resources producing countries acquire a new industry or long term compensation in this regime.
5. The industrializing countries attain their progress through the establishment of the renewable energy infrastructure. In this process, international support will be done for the construction of the infrastructure.

6. If the strong emission regulation is enforced only to the industrialized countries, the leakage of industries to the industrializing countries will happen. This will not only make the attainment of the emission reduction target more difficult, but also grow the irritation of industrialized countries. For this reason, the disparity among the countries in application of the rule should be minimized.
7. If the common price, tax or penalty is applied to all countries, industrializing countries will repulse to the scheme by saying it is too burdensome to them. Other rules should be applied to the use of fossil resources in an area, such as cooking and heating of the housing, where application of world common rule is not proper, to help industrializing countries' people.
8. For the energy production industries, and for the industries which consume large amount of energy, industrial rearrangement is inevitable in industrialized countries.. To keep the global equity, a fund for industrial rearrangement in industrialized countries will be supplied by the regime.
9. To actualize the emission reduction of GHG's, each country's implementation and observance are necessary. Systematic monitoring system is required. It is much better, if the system in the regime doesn't require monitoring by utilizing global common economic system..
10. In many places of the world, the land will be lost by rising ocean surface. At the same time, the severe climate change will threaten lives of many countries' people. It is not proper to force the countries facing the disaster to handle the situations by themselves. The regime must ensure the existence and minimum lives of human beings.
11. The regime should be managed by minimum organization and cost.

The Post Kyoto Protocol Regime should satisfy the conditions stated above.

Now, we would like to check the principles of the UNFCCC at this point. The Principles of UNFCCC (Article 3) can be summarized as follows:

1. The Parties should protect the climate system, on the basis of equity and in accordance with their common but differentiated responsibilities and respective capabilities.
2. The specific needs and special circumstances of developing country Parties, especially those that are particularly vulnerable to the adverse effects of climate change, and of those Parties, especially developing country Parties, that would have to bear a disproportionate or abnormal burden under the convention, should be given full consideration.

3. Policies and measures to deal with climate change should be cost-effective so as to ensure global benefits at the lowest possible cost
4. The Parties have right to, and should, promote sustainable development.
5. The Parties should cooperate to promote a supportive and open international economic system that would lead to sustainable economic growth and development in all Parties

By mixing the principles of UNFCCC and more practical requisite stated above, the principles for the Post Kyoto Protocol Regime can be summarized as shown in F&T7.2

Figure and Table 7.2 The principles for Post Kyoto Protocol Regime

1. **Humanity:** Under this regime, great attention is paid to support the people who are vulnerable to the adverse effects of climate change or are bearing disproportionate or abnormal burden from this regime
2. **Equity:** Common and proportionate responsibility considering the respective climate circumstances and resource and industry conditions.
3. **Cost effectiveness:** Policies and measures to deal with climate change should be cost-effective. At the same time, recourses are used in the economic activities which can produce largest economic value.
4. **Commonality:** Rule differences among the nations are abolished or minimized.
5. **Penetration:** Minimized monitoring problem. Affect firms' activities directly.
6. **Minimum managing cost:** Can be managed by minimum organization and cost.
7. **Funding:** Creation of the fund which can be used for energy and industrial conversion, and for adaptation for the climate change.

The establishment of a Public Corporation for fossil resources management

It is apparent that the proposals we have explained above don't satisfy some of the principles shown in F&T 7.2. The emission amount allocation among the parties of "cap and trade" system should be based on an agreement on the definition of equity. However, it is quite difficult to determine "what is impartial" This is the reason why political decisions were made at the Kyoto Protocol. So, the "cap and trade" cannot satisfy the principle of equity. The "cap and trade" system cannot satisfy the principle of cost effectiveness, because the price of the emission credit cannot be foreseen. The "cap and trade system" doesn't satisfy the principle of penetration, because each party of the

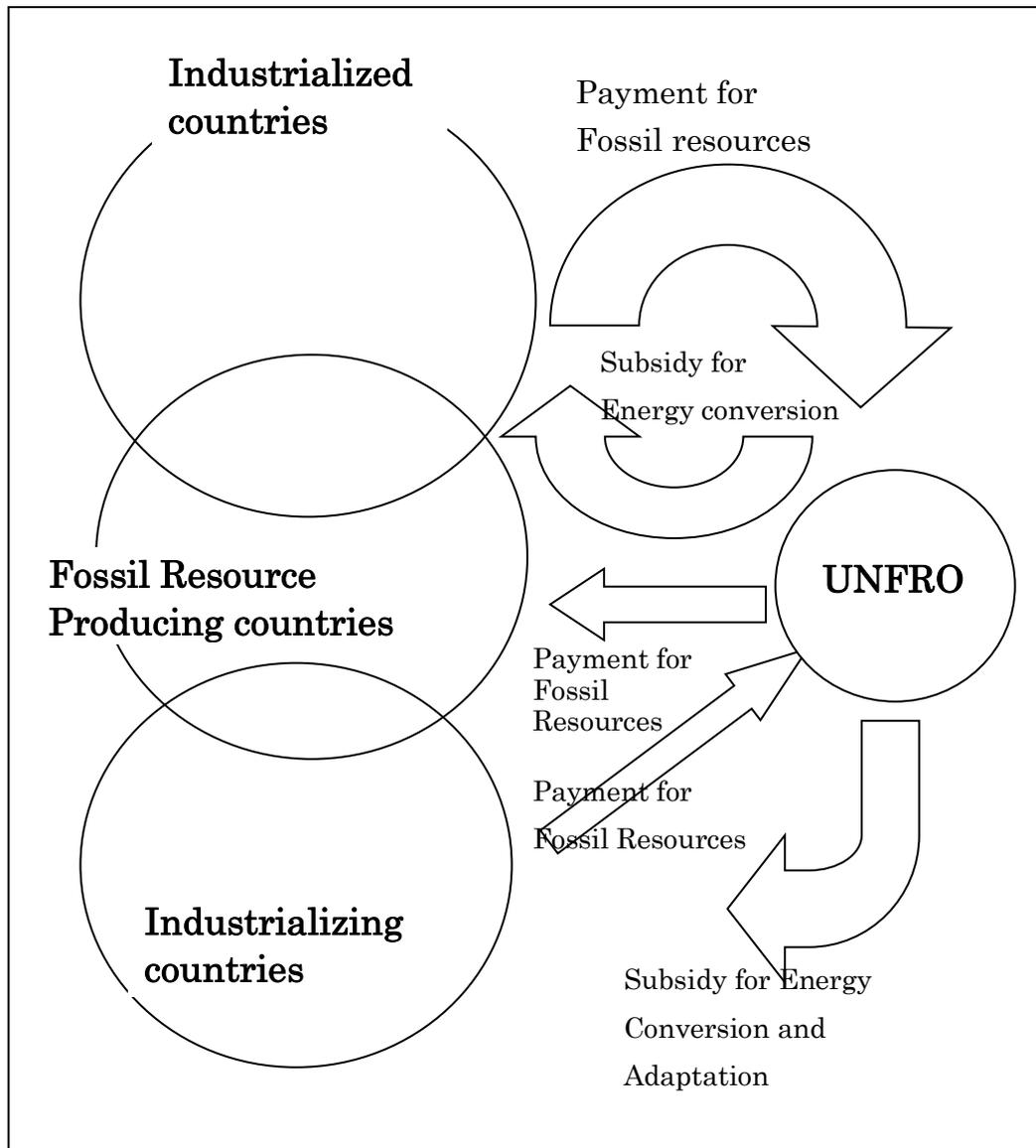
system should reduce the emission by their own measures. The “cap and trade” system does not create fund for international object, either. PaMs proposals don’t assure cost effectiveness of measures. At the same time, PaMs proposals don’t satisfy the principle of commonality, because they cannot force countries to participate in the regime. PaMs proposals don’t satisfy the principle of Penetration, because they require each country’s implementation. PaMs proposals don’t create fund for international object, either.

Authors are proposing a Public Corporation system as a Post Kyoto Protocol regime, which can satisfy all of the above principles. In short, this Public Corporation monopolizes world fossil resources. In this book, we call this system as the “United Nations Fossil Resources managing Organization (UNFRO).” The Function of this organization is shown in F&T7.3. This organization, in short, purchases the fossil resources from the countries producing fossil resources and sells them to the consuming countries at a monopolizing price. From the income of the organization, the organization pays purchasing price, and the profit of the operation is used globally for energy conversion, industry conversion and adaptation to the global warming . In addition, the rising price will reduce the emission of carbon dioxide globally. The monetary flow, which UNFRO brings about, is shown in F&T 7.4.

Figure and Table 7.3 Fundamental function of UNFRO

1. UNFRO purchases organizations concerning production and distribution of fossil resources, cooperating with resources producing countries, as long as they are necessary for the controlling of prices of fossil resources, under adequate price and conditions.
2. UNFRO controls the price of fossil fuel globally, under the supervision of UNFCCC, to manage gross fossil resources consumption
3. UNFRO supplies fossil resources at an appropriate price, lower than ordinary price, to sustain daily lives and societies of industrializing countries.
4. UNFRO supplies fund to the countries for the investment to reduce emission of GHG’s, such as converting energy and industry. UNFRO supplies fund to the countries for humanity sake, where the global warming causes damages.

F&T 7.4 International financial flow under UNFRO regime



The most important point of this system is to solve almost all difficult problems of impartialities by using the capital which is produced by monopolizing sales of fossil fuels. In short, the recovery of the economical damages, caused by reduction of GHG emission, is not negotiated in a conference of many countries which is managed by principle of equity, but is negotiated bilaterally between the countries and the UNFRO.

Concerning the relationship between UNFRO and fossil resource producing countries, UNFRO might take the form of acquisition of the fossil producing enterprises, or take the form of promising exclusive purchasing contracts with the fossil producing

enterprises. In both cases, the daily lives of fossil resource producing countries' people are not affected by the resource management of the UNFRO, because the daily operations are conducted by the former operating bodies. The fossil resources producing countries can cooperate with the UNFRO, because the future income of the countries is basically assured by this regime even if the volume of fossil resource sales declines in the future. The damage of the fossil resource producing countries, which is caused by the countermeasures for the global warming, will be recovered in the process of determining the conditions of sales between the countries or enterprises, and the UNFRO.

In the industrializing countries the increase of fossil resources price might be a burden to the lives of the people and to the economic development. First, the fossil resources, which were consumed in peoples' daily lives, such as cooking and heating, might be permitted to be used outside of the UNFRO system. Apart from these cases, any economic entity should not be permitted to conduct economic development depending too much on the fossil resources, even though this was not clearly pointed out in the UNFCCC. The industrializing countries should seek for an economic development based on the renewable energies. The economic damages caused by the increase of the fossil resources price will be recovered by the subsidy from the UNFRO, which is provided for the construction of infrastructures necessary for renewable energy society. The energy demand of the industrializing countries' people will be provided by the renewable energies.

The industrialized countries might feel the increasing fossil resources price burdensome. However, as is clearly stated in the UNFCCC, first, the industrialized countries should change their lifestyle and economic activities, because the global warming problems are caused by them. On the other hand, it is quite difficult for human beings to change their lifestyles. Then, an alternative for human beings is to speed up the electrification of their life style, including electrification of their vehicles, and supply the electricity by renewable energy. This is a method to reduce GHG emission while we can live under today's lifestyle. As we described in Chapter five, it is possible to generate abundant electricity by renewable energy source, and the capital produced by the UNFRO will be used for necessary infrastructures.

The industrialized countries have industries, which use fossil resources for raw materials or as inevitable fuels. As for these industries, high added-value industries, such as the chemical industries or the aviation industries, will keep on using fossil fuels, and low added-value industries have to conduct their business conversion. The former will provide fund for the UNFRO, and the latter will be subsidized for their business

conversion from UNFRO. However, it is impossible for the UNFRO to determine the allocation of subsidies. The UNFRO will allocate the money, which is the residue of the income deducted by the necessary expenditure and the fund for international use, to each member countries, according to the sales ratio to each country; and the government of each country will allocate the fund to the industries.

The countries, for which subsidies are provided, have to hand in the list of capital uses, because the government might subsidize for the industries, which consume large amount of fossil resources, to increase their international competitiveness. The annual submission of investment lists from the countries to the UNFRO is also necessary, because the prices of the fossil resources are determined by the amount of the capital necessary for the investment.

The consumers of the industrialized countries were affected by the price rise when they use fossil resources. However, the high fossil resources price is an adequate price reflecting the external diseconomy which was so far neglected. The renewable energies will be supplied to the consumers of the industrialized countries by the new energy industries at a market price, which will be lower than the current energy price.

Prerequisite for UNFRO

1. The fossil fuel price can be maintained at a high level.

Even though the price of fossil resources rises, the demand of fossil resources stays at a moderate level, which enables operation of UNFRO, because fossil resources are the low materials of chemical industry, which has a high value added, and fossil resources are used as fuels in the airlines industry where no alternative energy exists. The next point to think about is how to treat the alternative fuels of the fossil fuels, such as biomass ethanol. If no countermeasures are taken, as the price of fossil fuels rises, the demand for alternative fuels made from biomass increases and its production might expand rapidly. If this situation happens, the high price of the fossil fuels, which is required for reducing carbon dioxide emission, might not be maintained. At the same time, the production of biomass fuels also brings about the shortage of food supply, if it is conducted under a stringent food situation. Taxation for biomass fuels or some other countermeasures should be taken.

2. The capital to start the organization is provided

The World Bank and the International Bank for Reconstruction and Development, (IBRD) which is a part of the World Bank, is the largest financing institution, as an independent organization, which provide a capital for developments. IBRD supports

middle income countries to promote their sustainable developments, by providing financing and guaranteeing services. IBRD might be a suitable organization for UNFRO to rely on the financing to start up the operation. Member nations of UNFRO guarantee payments to IBRD and don't have to spend any money until UNFRO faces difficulty in paying back the money to IBRD. This method is the one which got a hint from current operation of IBRD. IBRD is managed by the funding from the market and contribution from the signatories. In this operation, each signatory pays only a part of the contribution until IBRD claims the balance. This method should be applied to UNFRO by IBRD.

3. The fossil resources producing countries accept long term divided payment.

When the fossil resources producing countries transfer property right of the resources to the UNFRO, the UNFRO pays for them by long term divided payment. The long term divided payment is necessary to control the amount of money in the financial market, at the same time, it is necessary because of the limited solvency of the UNFRO. When the fossil resources producing countries rejected transfer of the property right and decided to make a long term contract with the UNFRO to sell all of their products to the UNFRO, the problem of long term payment does not happen, and the sales price and amount are decided by the both parties according to the "market" conditions.

These three prerequisites are conditions to assure the profit of the UNFRO.

4. Existence of alternative energy

We believe this condition is satisfied. As we state in chapter X, the rising price of fossil resources and the constructions of infrastructures for renewable energy society, which were produced by the financial support of UNFRO, will produce renewable energy industry worldwide. The renewable energy will substitute the reduction of energy supply from the fossil fuels.

5. Formation of trust and cooperation to the UNFRO in each country

The price increase of the fossil fuel should be accepted by every firms and consumers of each country. The public opinion, that everybody should share the burden to stop the global warming, is hoped to be formed. At the same time, the recognition, that the control of fossil resources' price is inevitable and UNFRO is working for human common value and operated by human reason, is hoped to be generated.

The comparison of the UNFRO with other proposals for the Post Kyoto Protocol Regime

The result of the comparison, among “cap and trade” system, such as Kyoto Protocol, “PAM’s” system, in which countries adjust policies and measures, and the UNFRO, is shown in F&T 7.5. The difficulty to reach the agreement for introducing the system is largest in the UNFRO. However, if once the agreement is established, this system apparently has a strong power in reducing the emission of carbon dioxide.

When the UNFRO system is compared with other proposals for Post Kyoto Protocol Regime, several similarities can be observed.

The UNFRO and an international coordinated carbon tax system has similarity, when an international organization levies part of the carbon tax and redistribute it to the countries at a standard of equity for a supplementary measure. However, the UNFRO has superiority to the carbon tax system at the flexibility of collecting and distributing money. In addition, the UNFRO system can evade the allergy to the word of tax, this point is very important when the public opinion is concerned.

If the UNFRO consult the investment list of the energy and industry conversion, submitted from the member countries, at the allocation of the fund, the UNFRO system has similar effect of “Pledge and Review” on these investments. If the UNFRO contributes to using most efficient technologies in every country, the UNFRO can play a role like “PaMs.”

When the energy conversion has advanced, the UNFRO system has the characteristics of price mechanism, however, the effect of encouraging investment for technologies and projects plays greater role until then. At this point, the UNFRO shares philosophy with Technology Optimist.

In addition, at the introduction stage of the UNFRO, the “cap and trade” system can be used in parallel to reduce carbon dioxide emission more quickly.

As we have stated above, the UNFRO shares many merits with other proposals. This system would be refined in the process of designing details of the mechanism..

Figure and Table 7.5 The comparison of UNFRO and other systems

	“Cap and Trade” system	“Policies and Measures” system	UNFRO
Middle-term target	No.	No	Yes
Main reduction measure	Emission cap International emissions trading	Government-led policies and measures	Price of fossil resources Subsidy for energy conversion
Organization	UNFCCC	Treaty among many nations	UNFCCC UNFRO
Participation incentive	Emissions trading CDM	No	Subsidy for industry conversion and adaptation
Possibility of emission reduction	Medium	Low	High
Initial cost	Organization managing cost	No	Guarantee of member nations
Funds for adaptation	Industrialized countries’ responsibility	No	Profit from operation
Merits	<ul style="list-style-type: none"> * Apparent reduction amount target * No initial cost * Equity is considered 	<ul style="list-style-type: none"> * Easy to judge Achievement level * Equal conditions for each countries’ industry 	<ul style="list-style-type: none"> * Abundant fund * Equity is considered * Effect on corporation activities * No carbon leakage * Simple organization
Demerits	<ul style="list-style-type: none"> * Weak incentive for participation * Difficulty in deciding emission cap for each country * No effect on not-participating countries * Complex organization 	<ul style="list-style-type: none"> * No effect on Not-agreed on areas * No effect on Not-participating countries * Uncertainty in emission reduction * Uncertainty in Cost-effectiveness * Complex organization 	<ul style="list-style-type: none"> * Agreement of all fossil resources producing countries is necessary * Cooperation of financial market is required * Guarantee of all member countries is required * Public opinion * Renewable energy required

At the end of this chapter

So far, there are only two cases, in which super-state organ completely controls international public goods. One is the control of the development of the open sea abyssal floor. The other is the allocation of satellite position for the geosynchronous orbit. For this reason, the obstacle for the establishment of the UNFRO is larger than that for the “cap and trade” measure really established by the Kyoto Protocol. However, for all countries including Japan, it is time to start designing a public corporation to control fossil fuel price without hesitating over the project size, because the control system of international public goods already exists. Human beings can realize the technologies and systems, to tackle with the global warming problems, with abundant capital when this system starts to operate.