"Research Project on Establishing of Methodology to Evaluate Middle to Long term Environmental Policy Options toward Low Carbon Society in Japan (Japan Low Carbon Society Scenarios toward 2050)" (FY2004-2008)

The first great step to prevent global warming was taken by Kyoto Protocol which came into effect on Feb.16, 2005. But it is necessary to reduce GHG (Greenhouse gases) emissions drastically to stabilize climate change. Japan is also required to assess its long-term global warming policy. A large part of social infrastructure is likely to be replaced by 2050. It would be possible to propose concrete policy packages including institutional change, technology development, and lifestyle change toward low carbon society.

This project focuses on the following issues: 1) long-term scenario development study to integrate environmental options consistently using simulation models, 2) long-term GHG reduction target setting considering effectiveness and validity, and 3) assessment of environmental options considering future socio-economic conditions in a) urban system, b) information technology (IT) society, c) transportation system, and d) industrial change. We have the above 6 sub projects consisting of research experts in those areas and develop social and technically consistent middle and long-term global warming policy. To show probable paths toward a low carbon society in Japan which is compatible with economic development, would enhance public interest and lead to social and lifestyle changes. We propose to offer the latest research findings.

We have simulated the required GHG reduction for Japan. We have investigated the scenarios toward 2050 with back-casting method. The desired Japan 2050 future images with 60-80% GHG reduction will be set and the path considering economic impact, technological possibility, institutional and lifestyle change will be simulated objectively and consistently.

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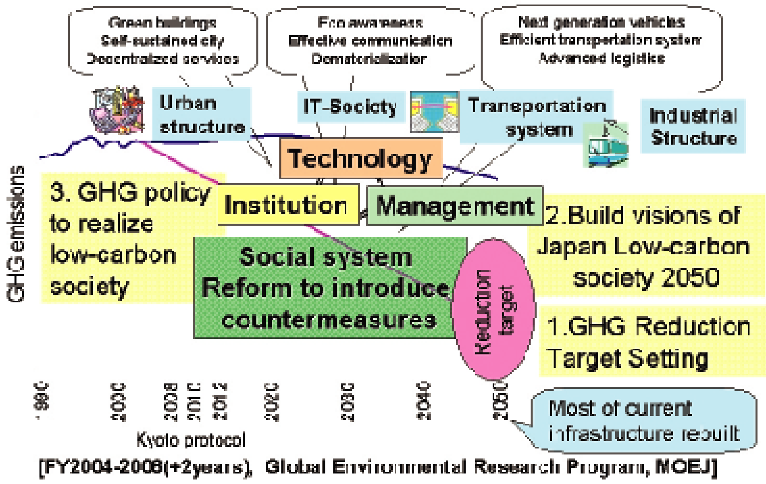

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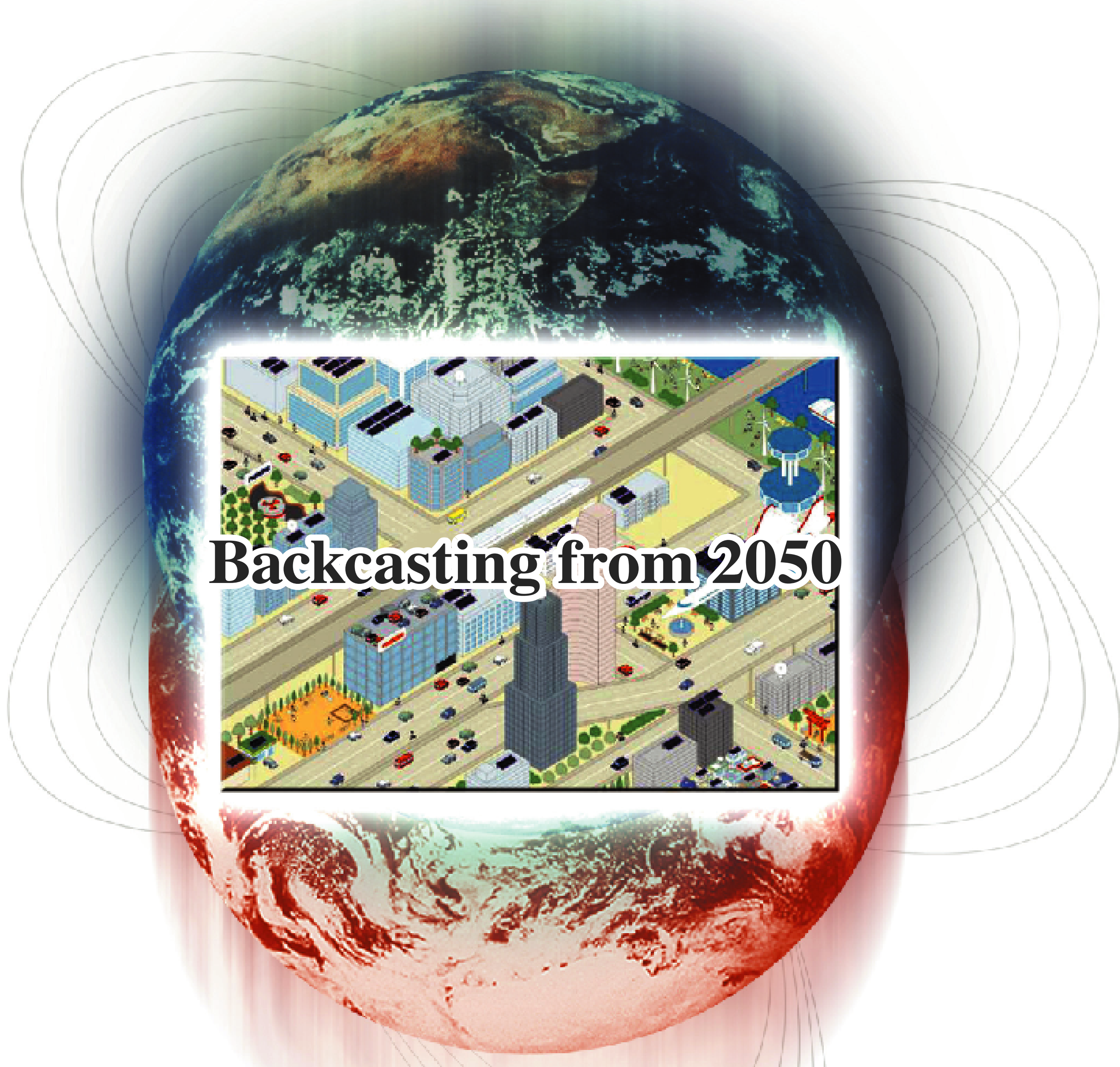
Global Environment Research Fund



Japan Low Carbon Society Scenarios Toward 2050

Research Project on "Establishing of Methodology to Evaluate Middle to Long term Environmental Policy Options toward Low Carbon Society in Japan" (FY2004-2008) sponsored by Strategic Research Development Project, Global Environment Research Fund, Ministry of the Environment, Japan

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Japan Low Carbon Society 2050

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Developing Scenarios of Japan Low Carbon Society toward 2050

Scenario Team

Junichi Fujino (NIES)

1. Why we need Low Carbon Society?

The first great step to prevent global warming was taken by Kyoto Protocol which came into effect on Feb.16, 2005. The ultimate objective of UNFCCC is to stabilize GHG (Greenhouse gases) concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. The appropriate level however needs to be determined.

The Central Environment Council (advisory committee for Ministry of Environment, Japan) proposed that it is important to steadily collect, consider and examine the information on long-term objectives of limiting the temperature rise to 2℃. According to our latest model calculations, in order that global mean temperature does not to exceed 2℃ from the pre-industrial level, global GHG reduction target needs to be about 50% of 1990 level in 2050 and 75 in 2100. For per capita emission in 2050 to be same in the world, Japan will be need to reduce around 80% emissions compared to the 1990 level. However these numbers include certain amount of uncertainty arising from climate mechanism, global warming impact. a large amount of reduction is required considering balance of sinks and sources of GHG. This implies that reduction rate for Japan would be more than 50%, which is between 60-80%.

2. How to depict Japan Low Carbon Society?

CO_2 emissions can be disaggregated with based on the following equation referred to as the Kaya identity:

$$CO_2 = (CO_2/E) \times (E/GDP) \times GDP \quad (1)$$

CO_2: CO_2 emissions, E: Primary energy, GDP: Gross Domestic Production

(CO_2/E) is "carbon intensity" and improves if the share of renewables and nuclear increases. (E/GDP) is "energy intensity" and improves if less energy is used to generate the same amount of GDP. Historically high improvement rate of carbon intensity is 0.5-1% and that of energy intensity is 1-1.5%. When we assume GDP growth rate will be constant at 1%/year toward 2050, CO_2 reduction rate will be 40% at most in 2050. If we set CO_2 reduction target as 60-80%, CO_2 emissions should be reduced by 2-3%/year. This means that "forecasting" method which considers future image as extension of current countermeasures is not likely suit low carbon society scenario development. Thus we examine the "backcasting" method, which develops first a favorable low carbon society and then discusses the method to achieve it (Fig.1).

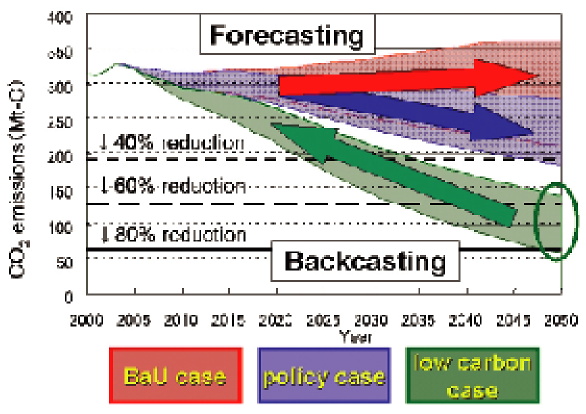

Fig.1 Path toward low carbon society

3. Japan 70% reduction scenarios in 2050

A large part of social infrastructure is likely to be replaced by 2050. We examined the case where 70% of CO_2 emissions will be reduced compared to 1990 levels.

We assume that population will become 100.6 million in 2050 according to existing estimations and per capita GDP growth rate will be constant at 2% till 2050. Sector-wise energy demand is estimated using macro-economic factors (population, GDP, historical productions, etc) and we assume that basic materials industry will produce the amount required to satisfy domestic demand.

Final energy demand in 2050 is likely to be the same as that in 2000 because of population decrease and autonomous energy intensity improvement. If we assume top-to-bottom energy demand countermeasures such as insulation, modal shift, high efficiency vehicles, clean product technology, and others, energy demand in 2050 will reduce by 35% (Fig.2). In residential sector there is possibility to reduce around 60% energy demand by 2050 (Fig.3).

We assume 3 scenarios for energy supply to satisfy final energy demand; case1: hydrogen (for fuel cell vehicles and stationary fuel cell) is produced from natural gas with carbon capture storage, and 50% of electricity is generated by nuclear, case2: hydrogen is generated by wind and biomass (around 50Mtoe biomass import), no new nuclear plant will be build after 2010, case3: no hydrogen and nuclear phase-out, biomass will be imported in a large amounts (around 100Mtoe) (Fig.4). PV and solar heating system will be a key player in the residential sector in 2050 (Fig.5).

We have developed detailed models (population, macro economy, sector-wise demand and supply, energy balance, and computer general equilibrium) to find the consistent and feasible pathway towards achieving the low carbon society.

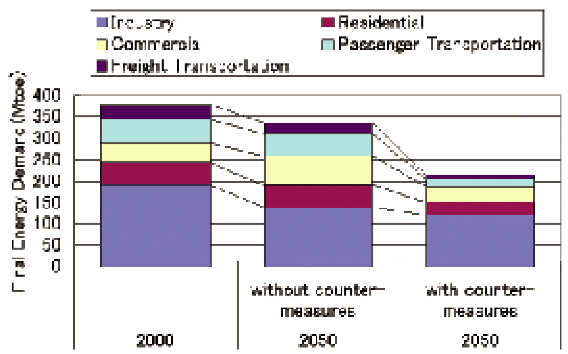

Fig.2 Energy demand side countermeasures

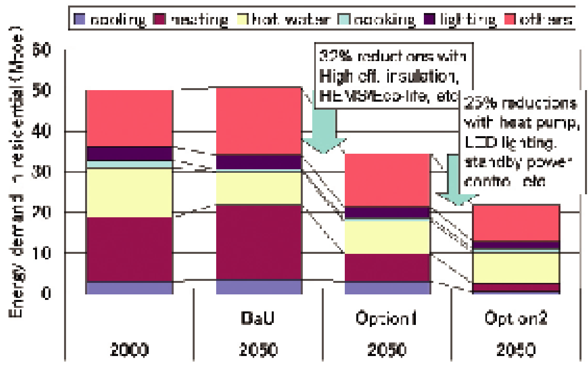

Fig.3 Energy demand in residential sector

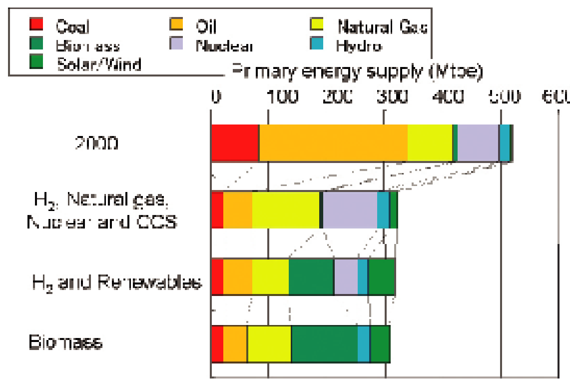

Fig.4 Energy supply side countermeasures

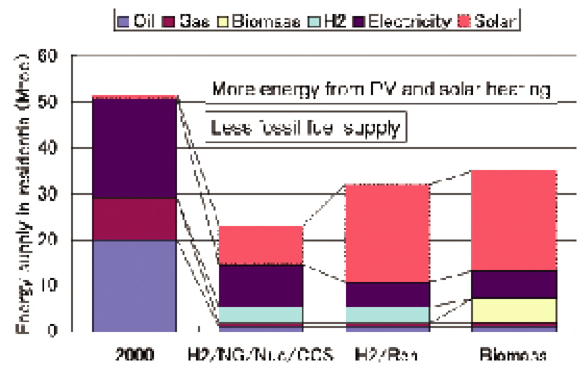

Fig.5 Energy supply in residential sector

What will be the level of Japan's GHGs reductions in 2050?

Criteria / Target-setting Team

Norichika Kanie (TIT)

1. Introduction

The long-term challenge the human society faces in tackling climate change is enormous. A number of reports and institutions from various countries, mainly in Europe, have identified in recent years the seriousness of the challenge by providing medium to long-term targets for climate change policy. A few examples are: CO_2 reduction by 60% in 2050 and 80% in 2100 for UK; 80% in 2050 for Germany and 75% in 2050 for France. The mission of the Team is to identify the extent of challenges we are facing in Japan, and to evaluate the robustness of the scenarios to overcome the challenge, using various criteria.

2. The Mission of the Criteria Team

More concretely speaking, the mission of the team is three fold.

1) To provide a GHGs reduction target for Japan in 2050

2) To investigate into policy processes through which target is set

3) To evaluate the scenario in terms of various criteria (e.g. international and national political feasibility)

Our emphasis so far has been on the mission 1), but we are also planning to move on to the missions 2) and 3) in the coming years.

3. Getting a Global Emissions Path: Developing AIM/Impact[Policy]

Our approach to derive a GHGs reduction target for Japan begins with a global emissions path. As the climate change is a global problem, we first identify the degree of global challenge (common responsibility), and then differentiate the responsibilities taking various criteria into account.

For calculation of global emissions path, we have been developing a dynamic optimization model called AIM/Impact[Policy] to simultaneously predict long-term economic activities and climate changes. The model is a nonlinear optimization model simulating the optimum developmental process in global economy, and provides a framework for quantitatively assessing various climate change policies. The model consolidates the world in a single region, and consists of four basic modules (economic/energy module, greenhouse gas emissions module, climate module, and sea level rise module). The baseline year for the analysis is 1990, and calculations are done for every 10 years until 2200. The major driving forces in the model are population and advances in technology, assuming the representation of four scenarios given in the IPCC/SRES. Our calculation suggests that GHG stabilization needs to be 475ppm in order to limit the increase of global mean temperature below 2 degree. This requires the global GHGs reduction of approx. 50% in 2050 (from 1990 level) (Fig.1).

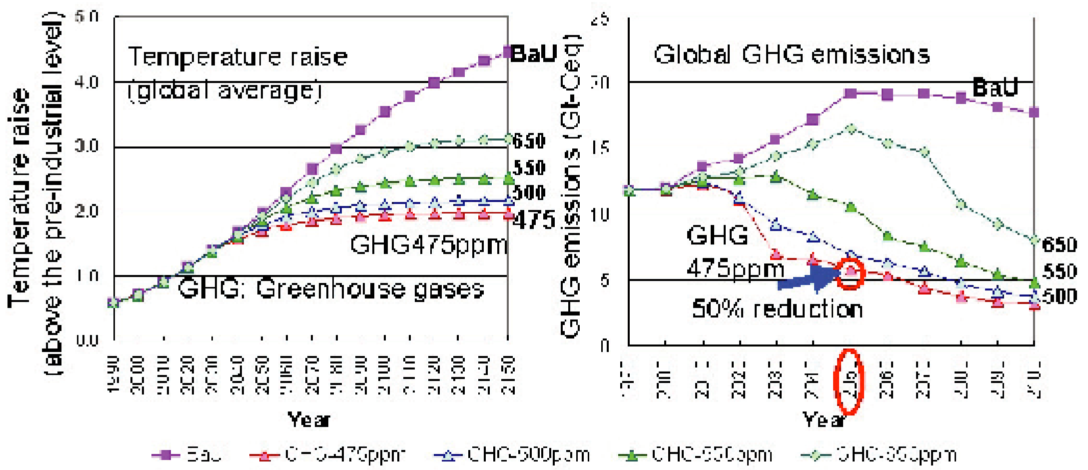

Fig.1 Temperature raise and GHG emissions for stabilization

4. From Global to National: Scenario Planning Approach to Differentiation

Differentiating responsibilities to reduce global GHGs depends to a great extent on international relations at the time. This reality has made us use a scenario planning approach to international relations towards 2050 under which differentiation regimes work. In other words, we construct feasible differentiation schemes in a given scenario, and quantify relevant parameters in each scheme. In this way we may arrive at a robust range of GHGs reduction levels in 2050 (Fig.2).

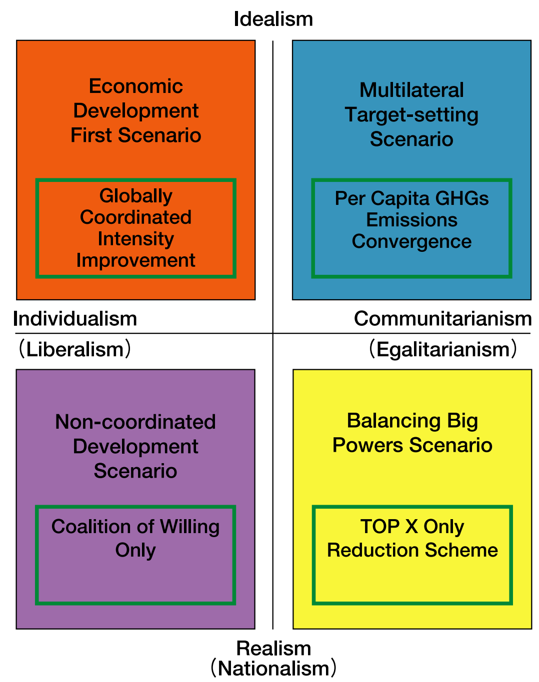

Fig.2 International relations towards 2050

Our preliminary calculation result suggests that the range of Japan's reduction amount in 2050 will likely be between 60% (in the lowest case, taking various uncertainties into consideration) and 90% or more from 1990 level in order to achieve 475ppm stabilization level (Fig.3). In case of 475ppm, for example, Japan's reductions in 2050 from '90 level are -79% for Multilateral Target Scenario, -88% for Economic Development First Scenario, but other scenarios do not allow reaching the target. For 550ppm -63% for Multilateral Target Scenario, -81% for Economic Development First Scenario, but chances to limit the global mean temperature below "2 degree" would be less than the case of 475ppm.

5. Further Steps Ahead

Considering various uncertainties (political, economical, impact, scientific, etc.), ultimately a target setting is a matter of political decision and value judgment. We have acknowledged the necessity to deal with the process through which a target is set in a socially acceptable manner.

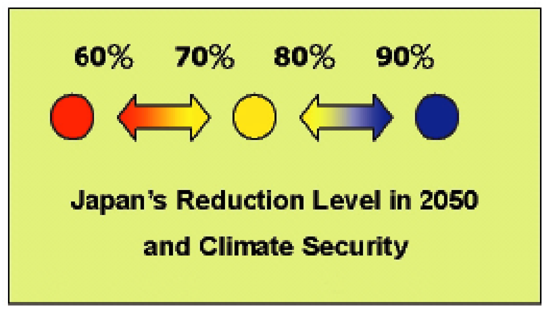

Fig.3 Range of Japan's reduction

EcoDesign for a Networked Society

ICT based society team

Jun Fujimoto (UT)

1. From symptomatic treatment to a causal approach

Industry strives to manufacture highly functional goods cost-effectively and in large quantities. Consumers then purchase a comfortable lifestyle supported by large resource consumption. Against this background, symptomatic treatment of the individual conditions of environmental problems would not produce any demonstrable results with respect to either the environment or the economy. We should instead take a causal approach and reform industrial activities and lifestyles, which are the root cause of the problem, by transforming them into new activities and lifestyles whose environmental loads are smaller.

The development and diffusion of information and communication technologies (ICT) has ushered benefits in all aspects of society. In industry, we have achieved efficiency improvements in materials supply, physical distribution, and office work, accompanied with globalization of business. In daily life, we have obtained many benefits from novel approaches to communication with other people, information acquisition for hobbies and entertainment, and purchase of commodities. These changes are expected to accelerate with increasing communication capacity and simplified access to networks in the future. Great structural changes in society will occur, signifying an ICT revolution.

As the consumption of resources depends on the social structure, the ICT revolution will provide significant opportunities to influence the environmental load of society. As we are moving toward an ICT revolution, building environmental consciousness will contribute to the causal treatment of environmental problems, which will in turn reform industrial activities and lifestyles through more sustainable approaches. This is our research perspective.

2. Environmental influence of ICT

With regard to the environmental influence of ICT, we can see both the positive and negative sides. The negative impact (increase in environmental load) results from increases in resource and energy consumption, and in the amount of waste generated from the increase in ICT equipment. In addition, the money and time gained through greater efficiency of an ICT society leads to excessive economic activity, which results in additional increase in resource and energy consumption (the rebound effect).

In contrast, the positive impact of ICT diffusion is due to a reduction in resource and energy consumption through "dematerialization" and "efficiency improvement". Dematerialization means the replacement of conventional materials and human mobility, which were once needed to carry information, with electrons. For example, electronic newspapers and books, and the delivery of music through the internet render paper and plastic discs useless. TV meetings and internet shopping make human movement unnecessary. Efficiency improvement means avoiding the waste of resources and energy by achieving better communication and coordination among individual components of the system, such as human, organization, equipment and so forth. For example, Supply Chain Management system (SCM) attempts to avoid the waste of materials, parts, and products related to manufacturing and logistics, by means of adequate communication between the demand-side and individual manufacturing and operating divisions. Home Energy Management System (HEMS) reduces unnecessary activities of home appliances such as air conditioners and lighting devices through communication of ambient environment characteristics, for instance presence or absence of humans, to the appliance controller. Eco-Drive systems lead drivers to consume less energy when driving. This is achieved by informing the driver of energy consumption conditions and methods of driving.

Furthermore, ICT distribution causes changes in the industrial mix (i.e., the growth of low-energy consumption industries). This would lead to reducing energy consumption in the industrial sector of Japan.

In addition, ICT enables people to get a concrete image of environmental problems from various points of view. Normally we are not aware of the relation between daily actions in our life and the environmental impact, and the actual condition of environmental problems. ICT will be able to give us a true sense of the reality of environmental problems. This would induce people to an environmentally conscious life.

3. How much CO_2 can be reduced due to ICT

It is difficult to quantitatively estimate the CO_2 reduction due to ICT. The reason for this is that the effect of ICT is indirect and dispersed (for instance, spread over production, distribution, and sales activities across various industries). However several research institutions have estimated CO_2 reduction effect in 2010 to be in the range of 2-3% of Japan's CO_2 total emission. This research project too estimated the reduction effect in 2010 in the last fiscal year. The results were as follows.

By introducing systems like HEMS it would be possible to reduce CO_2 by 15-20 million tons in the commercial and domestic sectors.

By encouraging the use of public transportation systems it would be possible to reduce CO_2 by 10million tons in the transportation sector.

And finally, by introducing SCM systems it would be possible to reduce CO_2 by 47 million tons in the industrial sector.

In addition to these reduction effects, we considered the negative impact and then estimated the net reduction to be about 5 % of Japan's total emission. However if we take into account the changes in industrial structure caused by ICT, the level of CO_2 reduction could increase to about 10%.

The above argument is based on ICT used in conventional social systems. However if ICT creates new social systems, the level of CO_2 may be further reduced.

4. Toward a low carbon-society utilizing ICT

It is difficult to imagine an ICT society in 2050 because of the rapid progress of ICT. However by understanding the desires of people regarding future society, it is possible to imagine a scenario of how advanced ICT can be utilized in such a society. And so we can imagine how ICT is to be developed and utilized towards realizing man's wishes and desires. To facilitate this understanding, 1000 citizens were surveyed on 11 categories like eating-style, working-style, and living-style in 2050. In addition, information on possible future life style was gathered by examining SF-films and animation, and consulting over ten well-known persons and two research groups. These ideas were then brainstormed in order to construct an image of a future-desired ICT society. At present, we are in the process of examining the extent to which it would be possible to reduce CO_2 while maintaining such a desired-society (Fig.1).

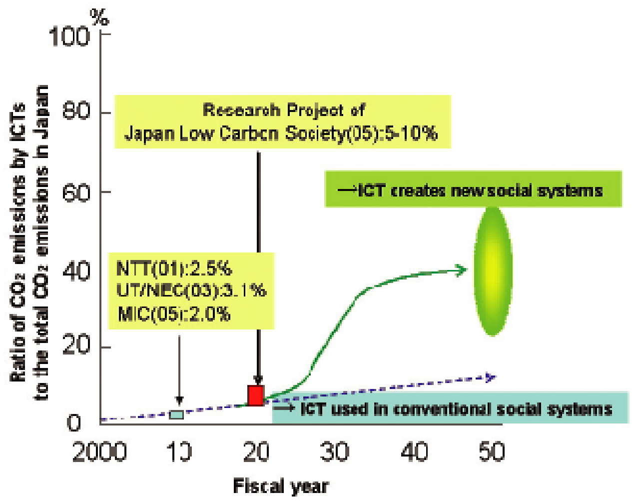

Fig.1 Estimation of CO_2 reduction due to ICT

Future CO_2 emission and its reduction in urban area in Japan

Urban system team

Keisuke Hanaki (UT)

1. Countermeasure for urban CO_2 emission

Household, commercial & service and transportation sectors are growing contributors to Japanese CO_2 emission. Various countermeasures are possible to control this. However, their effectiveness very much depends on structure, population density and economic activity. Interactions between the urban factor and countermeasures are discussed.

(1) CO_2 from energy sector
Change of demand for the electric power in the city changes the fuel source composition of the electric power company. Since fuel source differs depending upon the season and time of the day, change of electric power demand of home and business sectors lead to changes in the fuel source of power.

(2) CO_2 emission reduction in building sector
Energy saving in the operation of residential and commercial buildings and reducing induced loading in construction are measures for the building sector. Improvement of insulation and introduction of energy-saving equipment are important measures for residential buildings. Long-life building and the use of ecological materials are important for commercial buildings. As the life time of building is generally long, urban planning and social change will influence the building sector.

(3) District heating system
District heating system and cogeneration are established technologies. But their introductions depend on the use and density of buildings in the project area. High density areas and a mixture of residential, office building and hotel or hospital are favorable. Quantitative evaluation of the effectiveness on the basis of actual building utilization is necessary. Use of waste heat from solid waste incineration plant or sewage can also increase the reduction of CO_2 emission.

(4) Photovoltaic cell
The photovoltaic cell is installed on the building roof in the city. Independent houses can provide more space per person for photovoltaic cell than apartment houses. Photovoltaic cell is suitable for low density areas whereas the district heating is suitable for high density areas.

(5) Transportation sector
In the transport sector, there is a measure such as modal shift to the railroad and introduction of the hybrid car and the fuel cell powered vehicle. Also residence and working place are far apart. Commutation distances can be reduced through relocating of residential and work places.

3. Necessity of integration analysis

When various measures to reduce CO_2 emission are introduced to the urban area together, their effects are not simple. Effect of each measure depends on scale of the city, density, urban activity, geographical characteristics and climate. In addition, there is the effect of interaction among measures. For example district heating system is suitable for high density commercial area in general. CO_2 reduction becomes large when office and residence are located together in the same district. Use of urban recovery heat can further increase the effect of CO_2 reduction.
Photovoltaic cell is not a very effective option for such areas, while it is suitable for residential areas with low density.
Interaction between electricity demand and supply is one of the most important key factors in CO_2 reduction. Electricity is generated through various energy sources including nuclear, hydro and fossil fuel. CO_2 emission intensity significantly varies among them.
In order to analyze the effect for this kind of a city, integrated analysis is effective. Figure 1 shows the procedure of the integrated analysis. The analysis starts with using geographical information system on location and activity of the building inside the city today. Building energy use, installation of photovoltaic cell and others are assumed based on this data. Interaction between electricity demand reduction and power grid is also considered.

4. Urban area in the era of population decrease

Japan's population would soon start to decrease. This is a fundamental problem in the current society in which high quality of life and high activity of society are to be achieved. Generally, population decrease in large city is not significant, but it is estimated that at the small-to-medium-sized city the decrease ratio is high. Scale and density of the city are key factors in introduction of the public transport system that would reduce CO_2 emissions.
As for residences, the living floor space per person increases. This increases CO_2 emissions in the household sector.
In future, with the population declining, the transformation of large city to compact cities is desirable. Large cities may be redesigned to small and compact cities with reasonably high density. Public transportation is effective within such cities. Human and material flow among these cities is not very high.
The year of 2050 is not very far when considering the need for shifts in urban structures. Steps towards achieving sustainable cities thus need to be taken soon.

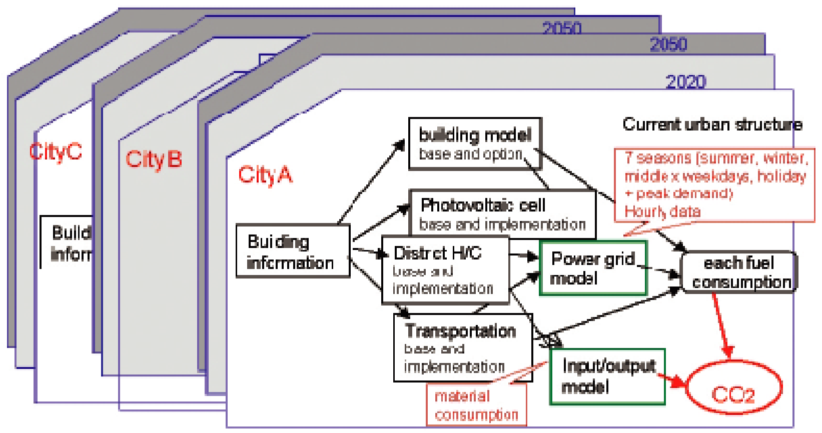

Fig. 1. Integrated analysis of CO_2 emission in urban area.

Long-term CO_2 reduction strategy of transport sector

Transportation system team

Yuichi Moriguchi (NIES)

1. Environmentally Sustainable Transport scenarios

In this project, the EST (Environmentally Sustainable Transport) scenarios are developed which achieve CO_2 reduction targets for both 2020 and 2050 through a combination of technological measures and demand management measures.

The EST 2020 scenario depends mainly on technological innovations, as there is less feasibility of drastic demand change in the short term (Fig. 1). The traffic demands are based on the estimation by the Ministry of Land, Infrastructure and Transport, and revised estimations corresponding to the socio-economic trend provided by the Scenario Team. The lead-time taken for changes in both the production capacity and the purchase behavior is taken into consideration.

The EST 2050 scenario is to be developed by back-casting approach. The amount of necessary reduction is the gap between the emission of BAU case and EST target. To achieve the target, the reduction by demand change should cover the rest of the reduction amount that can be achieved by technological innovation.

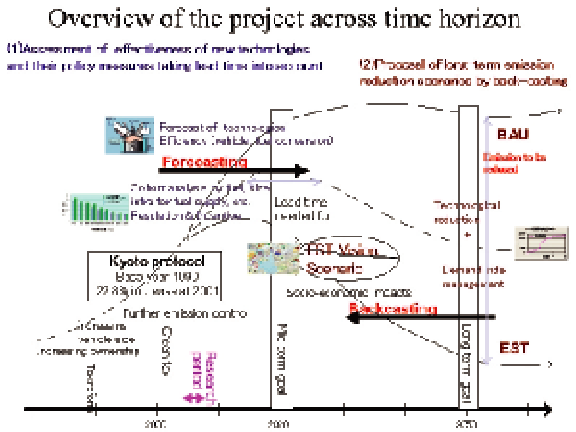

Fig.1 Approach of the EST study

2. Outline of the EST 2020 scenario

The points of the assessment are;

1) To apply the "well to wheel" approach to compare the fuel consumption and CO_2 emissions among various combinations of power trains and primary energy sources (Fig. 2).

2) To classify the passenger cars by size and classify the Heavy-Duty-Vehicles by load-capacity.

3) To consider the lead-time for spreading high efficiency vehicles, especially, the lead-time for provision of vehicle production capacities and infrastructures for alternative fuel supply.

4) To consider the strategies to build refueling stations for alternative fuel vehicles.

Conditions prevailing in 2020 BAU scenario are as follows.

1) Fuel consumption of hybrid vehicles is 40% less compared to current conventional gasoline vehicles.

2) 20% of passenger cars and 10% of LDVs are substituted by hybrid vehicles.

3) Fuel consumption of conventional vehicles improves by 10%.

4) Traffic volume of passenger cars increase by 66% from 1990 (+15% of 2002), and those of LDVs and HDVs decrease by 5% from 1990 level.

5) Efficiency of air, rail and ship transport improves by 5% and traffic volume of air increases by 20%.

Under these conditions, CO_2 emissions from transport sector increase by 18% compared with 1990's (-2% of 2002's).

Although FCEV is expected to contribute drastic CO_2 reduction, there are significant problems to be solved; durability of FC, cost of FCEV and the way to produce and supply hydrogen. Therefore, wide spread of HVs is thought to be the most feasible and effective measure in 2020.

Conditions of EST 2020 (HEV) scenario in comparison with BAU are as follows

1) 83% of passenger cars and 50% of LDVs are substituted by hybrid vehicles. 83% of Light passenger cars are substituted by battery EVs

2) Gasoline Engine Vehicles achieve 20% efficiency improvements through technological innovations and fuel-efficient driving.

Under these conditions, CO_2 emissions from the transport sector are almost equivalent to 1990 (-18% of 2002) level.

Conditions of EST 2020 (HEV & TDM) scenario in comparison with EST 2020 (HEV) are as follows;

1) 20% of traffic volume of passenger cars and 10% of traffic volume of LDVs decrease.

2) CO_2 emissions of vehicles increase -14% of 1990's (28% of 2002's).

It shows that the quick and rapid increase of the HEV production capacity is critical to reduce CO_2 emissions in 2020. Also demand management is required to achieve approximately 15% reduction over 1990 level (Fig.3).

CO_2 reduction with traffic demand management will be assessed by aggregating regional CO_2 reduction data (Fig.4).

We have just launched examples for achieving the vision of EST 2050 scenarios (cover page).

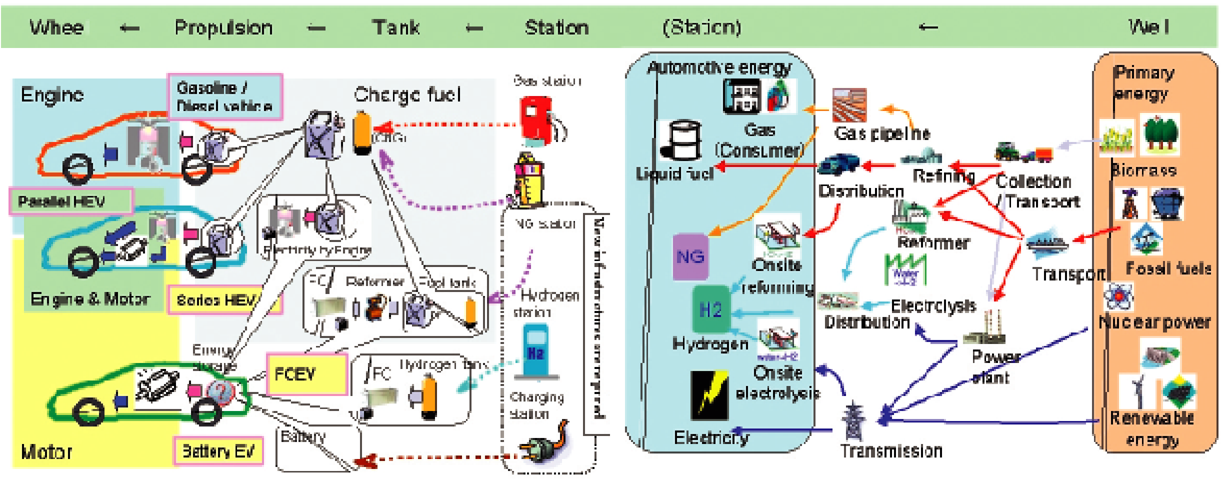

Fig.2 Flow of well to wheel

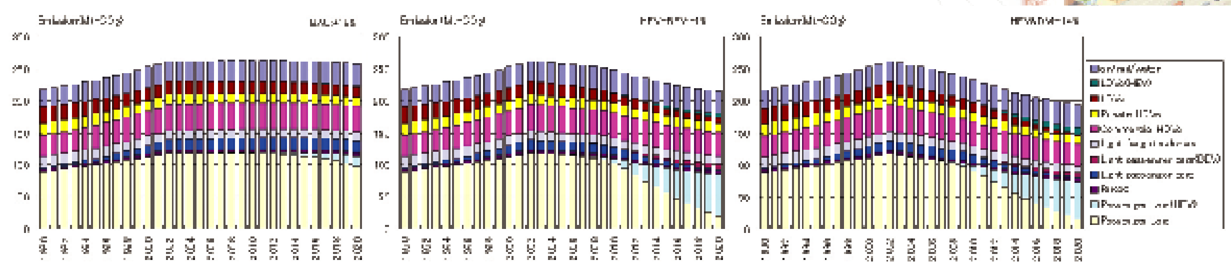

Fig.3 Transport CO_2 emissions of BAU, HEV case and HEV&TDM case

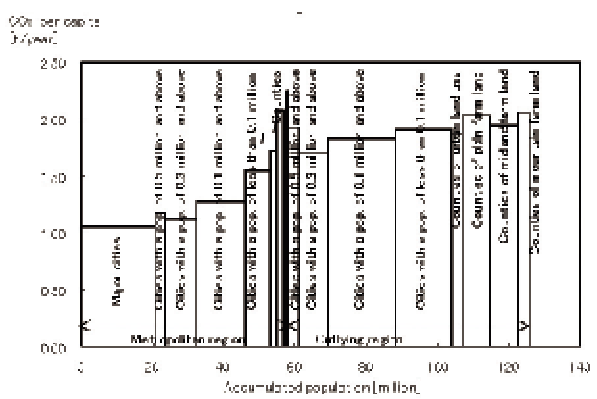

Fig.4 Estimated automotive CO_2 emissions by different regions in Japan