

LCSRN-09-2

Low Carbon Society Research 2009

Annual Report March 2010

International Research Network for Low Carbon Societies (LCS-RNet)
Secretariat



International Research Network For Low Carbon Societies (LCS-RNet)



Low-carbon society research: Activities of academic society/specialists/industries supporting policy and measures taken by individual countries (including governments, local governments, and local communities) to reduce the green house gas emission for stabilizing climate. As the focus is on mitigation efforts aimed to low carbon society, adaptationo measures are refered only when necessary.

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Summary

The trends of the world research for the establishment of a low-carbon society are summarized as follows:

1. Integration of efforts by policy-making communities and research communities in progress to establishing low-carbon societies

Responding to the international efforts for climate stabilization, the government of respective country in the world has shifted their policy toward low-carbon policies, though the expression of it is in a different way of a low-carbon society, a low-carbon economy and a green growth. Following this, developed countries such as European countries are calling up researchers to formulate their policies. In the North America, the notion of low-carbon society has not been fully accepted yet. The direction of policies has not been clear. On the other hands, Asian developing countries, in response to Green Growth and Nationally Appropriate Mitigation Actions (NAMA), have started to formulate their mitigation plan through intensified cooperation with the research world.
2. Approaches and issues of low-carbon society research

The knowledge required for those who are involved in policy making for the construction of a low-carbon society cuts across a wide range of areas. Major tasks include how to set the medium to long term targets, policies to achieve the target and thier impact ont the economy, effectiveness of technological development, how to let the people move toward a low-carbon society, and reconstruction of local communities/urban areas. The main concerns of policy makers in the developing countries include, in addition to those mentioned above, conservation of forests and soil, how to distribute funds, how to and in what manner identify a path leading to the low-carbon development while putting priority on economic development/poverty elimination.
3. Orchestration of the research:

To effectively support such policy as construction of low-carbon society which is urgent and requires integrated knowledge encompassing various areas, Center of Excellence:COE, etc. which cut across research areas are, in parallel with formulation of policies, being established. The UK, which is driving forward climate change strategy in a proactive manner, has established, as an administrative machinery, the Department of Energy and Climate Change. It also clarified the policy package by enacting an act to encourage a transition toward the low-carbon economy, established the Committee on Climate Change to formulate unified policies, and, responding to these initiatives, formulated a network to integrate such research institutions and universities for the purpose of promoting inter-disciplinary research on climate change so that the result can be reflected on the policies. In Japan, formation of permanent headquarter organisation has been delayed and researches are being carried out independently by individual ministry/agency. Although Japan Science and Technology Agency has recently begun taking initiatives for cross-sectional orchestration of the academic world, there still is a long way to go before it gets to the levels that are called for to taking a leading role towards the low carbon societies. In Asian developing countries, for example in Indonesia and Thailand, etc., COE is being established as well.
4. Added-value of international research network

The policy makers who attended the Bologna meeting in October 2009 were acutely aware of the importance of research exchange through international research network. Their opinions were that what is urgently needed for the policy makers now is accurate information; it is

very important to learn each other from the policies of others and their successes and failures; excellent opportunities should be provided to carry out an effective research by making it respond to the request from the policies; and more value should be added by carrying out those researches that have not been carried out by other international institutions, for example, research on long-term perspective, sociological analysis, and policies related to individual behavioural change (lifestyle). They expressed their expectation for timely outputs that can serve as a reference to the policy makers as well as necessity to expand the activities to G20 and outreach countries. The background for this seems to be the urgency in formulating policies toward a low-carbon society where little time afford to wait for accumulation of knowledge and policy examples in one country and the rationality of learning from each other's knowledge and experience among Annex I countries which have, to some extent, similar developmental stage, political system, and economic/social background.

5. Future direction of low-carbon society research:

For the establishment of effective low-carbon world, individual countries strongly feel the necessity of integrated research in support of the policies. In addition, the importance and the benefits of international cooperation were also recognized at the Bologna meeting. Furthermore, the developed countries have began to think that it is desirable to establish policy research bases in the developing countries as mitigation in the developing countries is essential for the future climate stabilization. Under such circumstances, it is necessary for the International Research Network for Low Carbon Societies to do more activities for identification and sharing of research themes required for the policy, promotion of exchange between policy and research as well as among researchers, and intensified research activities in the developing countries.

INTERNATIONAL RESEARCH NETWORK FOR LOW CARBON SOCIETIES (LCS-RNET)

Background

At their 2008 meeting in Kobe, G8 Environment Ministers recognised the need for countries to make the transition to low-carbon societies. This would contribute to the goal, discussed at the 2007 G8 Heiligendamm Summit, of halving global emissions of greenhouse gases by 2050. To make the transition, each country needs a clear vision of what a low-carbon society would look like and how the transition might be achieved. In Kobe, the G8 Environment Ministers strongly supported the establishment of an *International Research Network for Low Carbon Societies (LCS-RNet)* to help with developing these visions and pathways.

What are the objectives of LCS-RNet?

The objectives of the Network are:

- to promote information exchange and research cooperation relating to low-carbon societies;
- to promote understanding of low carbon societies through dialogue between researchers and various stakeholders including policy-makers, business and citizens;
- to share national and sub-national visions of low-carbon societies; and
- to contribute to international policy-making processes on climate change, including the G8, by communicating research outcomes and recommendations.

What is the focus of its activities?

Among the topics covered by LCS-RNet are: energy technologies and resources; finance, investment and the economics of a low carbon society; low carbon cities and infrastructure; mobility in a low carbon society; lifestyle and behaviour; the contribution of low carbon societies to sustainable development; low carbon society policies; low carbon society modelling; and the low carbon society research environment. A unique feature of LCS-RNet is that it addresses the social and human dimensions of the low carbon society as well as technology and economics.

How does it operate?

LCS-RNet has been established under the auspices of G8 governments but is operated by a group of leading research institutions. A Steering Group composed of representatives from participating research institutions guides the development of the network and plans its activities. Government representatives from the countries holding the current and succeeding G8 Presidencies participate in the Steering Group as observers. The Institute of Global Environmental Studies (IGES) based in Hayama Japan hosts the LCS-RNet Secretariat.

LCS-RNet strives to be policy relevant without being policy prescriptive and is independent of any government. Membership of the network does not imply any constraint on the activities of participating research organisations.

The key event in the LCS-RNet calendar is a two-day annual Researchers' Meeting to which all member organisations are invited. Other proposed activities include: a one week summer school for intensive study; promotion and support for stakeholder meetings in different national settings; and the development of tools and measures to facilitate stakeholder dialogue.

What are the outputs?

A key goal is to generate accessible outputs that will bridge the gap between the research community and policy-makers. LCS-RNet will communicate its activities and findings to G8 Environment Ministers Meeting, Major Economies Meeting on Energy Security and Climate Change, the UNFCCC and other international policy processes.

In addition to reports of the annual researchers meeting, the network will produce a newsletter and annual report.

Who is engaged with LCS-RNet?

Research institutions conducting activities that will help to form a vision of and make the transition to a low carbon society are eligible to participate in LCS-RNet. The following research institutions participated in the first Researchers Meeting in Trieste in April 2009:

Institute for Sustainable Development and International Relations (IDDRI), France
Environment and Energy Management Agency (ADEME), France
Wuppertal Institute for Climate Environment Energy (WI), Germany
Euro Mediterranean Centre for Climate Change (CMCC), Italy
National Agency for New Technologies, Energy, and the Environment (ENEA), Italy
Institute for Global Environmental Studies (IGES), Japan
National Institute for Environmental Studies (NIES), Japan
UK Energy Research Centre, UK, and
National Institute of Environmental Research (NIER), Korea, Republic of

LCS-RNet takes an inclusive approach to its membership and qualifying institutions from countries within and beyond the G8 are welcome to participate. The participation of Institutions from developing countries is particularly encouraged.

Where to find more information

For more information about LCS-RNet visit the website <http://www.lcs-rnet.org>.

Published by the Institute for Global Environmental Strategies (IGES) on behalf of the International Research Network for Low Carbon Societies (LCS-RNet)
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Referencing this report:

LCS-RNet 2010, Low-Carbon Society Research: 2009. Edited and written by the LCS-RNet Secretariat, Shuzo Nishioka, Wataru Machida, Kyoko Miwa, Takashi Otsuka, Takako Wakiyama. Published: IGES, Japan.

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LCS-RNet Secretariat
C/o Institute for Global Environmental Strategies (IGES)
2108-11, Kamiyamaguchi, Hayama, Kanagawa, Japan, 240-0115
<http://lcs-rnet.org>

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Printed in Japan

1. Integration of efforts by policy-making communities and research communities in progress to establishing low-carbon societies

Responding to the international efforts for climate stabilization, the government of respective country in the world has shifted their policy toward low-carbon policies, though the expression of it is in a different way of a low-carbon society, a low-carbon economy and a green growth. Following this, developed countries such as European countries are calling up researchers to formulate their policies. In the North America, the notion of low-carbon society has not been fully accepted yet. The direction of policies has not been clear. On the other hands, Asian developing countries, in response to Green Growth and Nationally Appropriate Mitigation Actions (NAMA), have started to formulate their mitigation plan through intensified cooperation with the research world.

For the purpose of organizing an international research network for low carbon societies (“Network”, hereafter), the current status of policy and research responses obtained through the hearing sessions with the policy makers in charge of the establishment of a low-carbon society and researchers involved in that is shown in Table 1. The following is the rough sketch of the situation.

Europe:

It has already hammered out a number of initiatives in relation to the reduction target and its realisation; and developed research and research organisation to support them. On the other hand, concern has been expressed about the current status of R&D budget coming from the governments of EU countries as the budge allocated to the research on climate change and low-carbon technology is leveling off (presented by CMCC at LCS-RNet Annual Meeting, 2009).

Germany:

It is one of the forerunners in terms of the discussion on long-term target. The country has already started discussion on energy and emission targets since 1990; and the Parliamentary Enquete Commission was considering the target of 80% reduction by 2050. By 1996, it seems that they have started to focus, in accordance with the EU policy, on energy initiatives and related researches. From around 2000, the Umweltbundesamt (“UBA”) or the Federal Environment Agency of Germany began studying a long-term energy scenario, etc. The shift to the renewable energies was strengthened from the early period, and in April 2000, the Renewable Energy Act was enforced where there were such ambitious targets as to make the ratio of renewable energy be 20% in total electricity consumption by 2020; and be more than 50% in total primary electricity consumption by 2050. Multiple research institutions have been conducting long-term energy scenario analysis. Although these policies have been put in place against the background of the trend toward discontinuation of atomic power generation in Germany as a consequence of Chernobyl, there is a possibility that these policies will be reviewed because of the result of federal parliamentary election in 2009 and the subsequent policy change by the new government. There are a number of background issues for this, including problems associated with the drastic shift to the renewable energies, the current situation where electricity is imported from France where there are many nuclear power plants, the fact that the electricity prices have increased by a large margin because of the FIT system applied to the renewable energies, and the pressure to achieve the emission reduction target. With regard to this, in 2009, Öko-Institut has, as requested by the UBA of Germany, conducted a research to calculate the total green house gas emission for all types of power generation.

France:

The same as other EU countries, the main focus of efforts to achieve the reduction target is on changeover to biomass energy and improvement on efficiency of building related energy saving measures. As is obvious from the fact that more than 70% of the R&D budget of the Ministry of Higher Education and Research (MESR) and that of ADEME which is an official agency of the Ministry of Ecology, Energy, Sustainable Development, and Management of Territory (MEEDDAT) and also a member of LCS-RNet is spent on energy related matters, they have been discussing about energy related policies since the 1990s. In 1995, the National Program for measures against global warming was formulated by International Negotiating Committee (INC) in an effort to achieve the action targets of the United Nations Framework Convention on Climate Change. In 2000, the prime minister summoned Interministerial Commission on the Climate Change (CIES) to adopt the National Program for Tackling Climate Change (PNLCC) submitted by the Interministerial Taskforce on Climate Change (MIES). In 2004, Climate Plan is published as a measure against global warming. In recent years, MEEDDAT was established in 2007 making it possible to coordinate between measures related to climate change/energy and policies related, in the broad sense, to domestic and overseas development. As for the carbon tax bill which has been proposed a number of times since the beginning of 2000, although there was a court decision again in 2009 to consider it as unconstitutional on the basis of the issue of fairness between sectors/enterprises, as the current government is very keen to introduce it, an amended bill was approved in a Cabinet meeting in January 2010.

Formulation of a roadmap through participatory approach, where researchers and stakeholders invited by the Council for Strategic Analysis (Conseil d'Analyse Stratégique, used to be "Committee for Plan (Commissariat au Plan)", have a series of dialogues, has been progressing since early days. The Grenelle Environment meeting (Grenelle Environnement) began in 2007. In order to consider the environmental problems throughout the entire society, participated by five stakeholders, the government, local governments, consumer groups, unions, and NGOs, this meeting, after setting such targets as ecology and sustainable national land development, formulates a roadmap. As much as three subcommittees out of six which commenced in 2007 potentially contain those elements that are associated with the low-carbon society, for example, "Measures against climate change and suppression of energy demand", "Adoption of sustainable production/consumption methods", and "Recommendation of environmental protection oriented development model favorable for employment and competitiveness". Recently, investment in sustainable development leveraged by a large quantity of government bond of about 100 billion euros was announced; out of it, 6 billion euros will be spent on support for cutting-edge environmental technologies. Priority areas include such low-carbon technologies as biomass energy, wind power, solar energy, geothermal power, ocean energy, bio fuel, automobile, zero-carbon via carbon capture and CCS, smart grid, energy storage and battery, improvement on building efficiency, biomass materials, and optimization of industrial processes, distribution and management.

Italy:

The Italian Ministry for the Environment and Land and Sea took initiative to establish Euro-Mediterranean Centre for Climate Change by integrating six climate change related research institutions as follows: Istituto Nazionale di Geofisica e Vulcanologia, Fondazione Eni Enrico Mattei (FEEM), Università degli Studi del Salento, Centro Italiano Ricerche Aerospaziali, Consorzio Venezia Ricerche, Università degli Studi del Sannio. The purpose of integration was to establish a more integrated research center where a variety of research projects can, while restricted to the Mediterranean area, supplement each other. The main area of research is the development of climate model and development of those models that are related to influence, adaptation and reduction. For example, at FEEM, they are conducting model analysis regarding influence of R&D, policies and carbon prices. The awareness of the Italian government that the cross-sectional

approach is important for low-carbon society research was the background for the establishment of LCS-RNet and the support for hosting the 2009 annual meeting. In 2009, Italy, as G8 presidency holder, led the way to Copenhagen by hosting a high-level forum for low-carbon technology.

The US:

As the US trying to achieve carbon reduction mainly by means of technological response/ technology development, the research framework at DOE/EPA is being developed. Such concept as “low-carbon society” has not been promoted in a clear-cut manner.

Although the US broke away from Kyoto Protocol in 2001 due to rather negative political attitude toward the measures to reduce GHG emission by the previous government which lasted for 8 years since 2001, it was expected that there would be a change of policy as the supreme court handed down a decision in 2007 that green house gas should be subject to the Clean Air Act. Starting from 2008, the process to adopt the cap and trade legislation, which aims to reduce the GHG by 14% (from 2005) by 2020 and 83% by 2050, has begun.

In 2009, the new president, in the State of the Union message, requested Congress to pass the cap and trade legislation as well as the Acceleration of Renewable Energy Production Bill, and in the Budget Message outline, to formulate an economy-wide emission reduction plan to reduce the green house gas emission by about 14% (from 2005) by 2020 and about 83% (from 2005) by 2050. In June of the same year, the House of Representatives passed the American Clean Energy and Security Act (Waxman-Markey Bill: establishes a cap & trade system for greenhouse gas emissions, establishes a renewable electricity standard, a low carbon fuel standard, and energy efficiency programs and standards for buildings, lighting, vehicles, etc. output-based allowance allocation mechanism). In September, the Senate Bill (to make the GHG emission decrease in 3 years time) was submitted. At the UNFCCC COP15 in December 2009, the US showed its enthusiasm by taking an active role in the establishment of a new framework.

Activities at state level are in progress particularly in the Western states. They include Regional Greenhouse Gas Initiative (RGGI), California Global Warming Solutions Act (AB32), Western Climate Initiative (WCI), and Midwestern Greenhouse Gas Accord (MGA). Northeastern states like Massachusetts, are also pioneering in the emission trade system.

With regard to the research based on low-carbon society approach, although it has been recognized that, in addition to the conventional technology scenario based research, social science based research is necessary, there have not been many examples of research actually carried out by researchers.

People not only in the environment area, but also in the science and technology area are getting interested in such approach as low-carbon society.

Canada:

Although Canada was actively engaged in formulation of countermeasures against a difficult background where the 2003 GHG emission was 24% higher than that of 1990, there was a strong opposition from the business world. As the trend shifted after the change of the government, in May 2007, Canada announced that it abandoned the implementation of Kyoto Protocol obligation. The amount of emission, after that, is basically in an upward trend due to the GHG emission in the process of refining of oil sand, which is an alternative fuel caused by the spike in oil prices. As the attitude of the central government is somewhat negative towards global warming issues, there has not been much progress in policy/research area. However, as Canada is a country of two-tiered structure, federal level and regional level, there is a possibility that some independent policies are pursued at regional level independent of those at federal level. There are active movements in relation to such stakeholder meetings as Round Table on the Environment and the Economy as well as the initiatives taken by the local government to share the emission trade market with the northern states of the US. The National Round Table on the Environment and the Economy (NRTEE) is an

approach to let the knowledge of business and research experts be reflected on the policy making where those reports that have been approved by the members of round table meeting appointed by the Minister for Environment are submitted to the parliament. The members get together regularly to carry out a range of activities such as research review, adoption of reports, and establishment of new themes. Reports that have been prepared like this include [Achieving 2050: A Carbon Pricing Policy for Canada](#) (2009) and its Technical Report, Getting to 2050 Canada's Transition to a Low-emission Future (2007). Among other researchers at university, there are those researchers who hold such perspective as making a reduction scenario while incorporating people's taste/preference when selecting technologies (for example: Professor John Nyboer, Simon Fraser University). However, there seems to be no collaboration, etc. among researchers. In addition, the Ministry of Environment itself, partly due to the federal system, does not have information concerning what sort of related researches are being conducted at various Canadian universities nor there seems to be a move toward orchestrated research cooperation.

- **Japan:**

As you can see from the fact that the Basic Law for Prevention of Global Warming is being discussed at the moment, the framework for low-carbon policy has not sufficiently been developed yet. The policy discussion started from around 2007. "Low-carbon society research" of the National Institute for Environmental Studies whose policy consideration began to move and which started from 2007 preceded other activities and supported the policy formulation. Following that, the Council for Science and Technology Policy and the Ministry of Economy, Trade and Industry started to formulate technology roadmaps. The Ministry of Education, Culture, Sports, Science and Technology launched Investigative Meeting for Research and Development Strategy for Achieving a Low-carbon Society from 2010 and established the JST Centre for Low Carbon Society Strategy in December 2009. A number of research organisations adopting low-carbon society as their slogan are being established in a variety of forms including those similar to COE at universities and so on. However, any cross-sectional research organisation which gives unified support as a whole to the policy has not formed yet. In this network, the National Institute for Environmental Studies is nominated as the core research institution for domestic coordination in Japan.

Developing countries in Asia:

Although these countries have not been very keen in taking a initiative to suppress the greenhouse gas emission, they are now willing to formulate a medium to long term mitigation plan as there is a mounting necessity, in the discussion process for the new international framework in preparation for Copenhagen, to formulate a GHG reduction measures using the funds from the developed countries for the NAMA, for example. In addition, in ASEAN countries, although it has not become a sort of policy which sets a direction for the overall policy, more and more countries started to include "green growth strategy" as one of the national targets. There has been a move toward establishment of COE among those research institutions such as university which, in response to that, have been cooperating with the government to set up a national plan.

China:

China has been systematically conducting research projects for the future establishment of low-carbon society from early days. In 2008, the Chinese Academy of Sciences published a report titled "China's Approach towards a Low Carbon Future". In 2009, the Energy Research Institute, National Development and Reform Commission published a scenario research titled "Chinese Road to Low Carbon Development for 2050" (started as a joint research with the National Institute for Environmental Studies of Japan). As a number of COEs adopting low-carbon as their slogan, including a few at Tsinghua University, are being established at universities all over China, there is no doubt that research base is being established in China. With regard to those research institutions

under the Ministry of Environment, CREAS has newly established a research group concerning low-carbon development; and another institution has established a center for research on low-carbon economy inviting a director from Europe. At Tsinghua University, a research institute which has been carrying out researches on nuclear energy established a low-carbon society research division, inputting as many as 40 young researchers including postdoctoral fellows, and becoming a member of ICLCS (of which the State University of New York at Stony Brook is playing a key role), an international research network mainly consisting of universities. As you can see above, the research on low-carbon development and low-carbon economy is becoming so popular that you can almost say that there are too many institutions of them.

India:

In June 2008, India announced its own National Action Plan to tackle global warming. The following eight items are specified: 1) Promotion of the use of natural energy such as solar power (100 MW PV/yr; 1,000 MW Thermal by 2017), 2) Improvement on energy efficiency (10,000 MW saving by 2012), 3) Sustainable environment, 4) Improvement on efficiency concerning the water use by 20%, 5) Preservation of Himalayan eco system, 6) “Green India” to increase the ratio of forest area from 23% to 33% by encouraging reforestation, 7) Strategic knowledge concerning the sustainable agriculture and climate change, 8) Save 10,000 Megawatt by 2012 by improving energy efficiency. According to the medium term target reported to the United Nations Framework Convention on Climate Change in January 2010, India is going to reduce the energy consumption per GDP by 20-25% from 2005. However, it is that emission from agriculture sector is excluded from the target.

The 2008 National Action Plan includes an item called “strategic knowledge for climate change”. Mr. Shukla et. al of the Indian Institute of Management Ahmedabad are carrying out scenario studies using a nationwide scenario based on integration model and city-by-city expanded snap shot model (ExSS).

Indonesia:

In Indonesia, following the President Yudhoyono’s announcement of the policy of 26% reduction of emission from the baseline (BAU) by 2020 in September 2009, the government-wide initiative to formulate the mitigation plan has begun with an intention of achieving the dual goal of climate change prevention and sustainable development of the society/economy. Already, the State Ministry of Environment (KLH) has published National Action Plan Addressing Climate Change (RAN-PI) and the 2nd National Communication; and the National Development Planning Agency (BAPPENAS) has published Climate Change Roadmap as well as Medium Term Development Plan 2010-2014 (RPJM). Mitigation targets involve the following seven main areas: energy, forestry, waste management, peat-lands, traffic, industry and agriculture (forestry: 13.3%, peat-lands: 9.5%, the remaining five sectors: 3.2%).

The Indonesian National Commission on Climate Change (NCCC) has prepared a strategic report regarding low-carbon economy development support in Jambi and Kalimantan region calculating the GHG reduction cost curve for Indonesia.

In the scenario/model analysis in 2007 National Action Plan Addressing Climate Change, the future path of the following four emissions are examined: 1) Implementation of the Presidential Decree to deal with the energy crisis (May 2005), 2) Nuclear power generation, 3) Geothermal power generation, and 4) CCS.

Indonesia is cooperating with Japan through climate change tackling program loan program. A number of universities are involved in this program loan in a variety of manners. In addition, the Arief Anshory Yusuf research group of Padjadjaran University is carrying out an analysis project in relation to three “E”, (Economy, Equity and Environment) using a general equilibrium model, INDONESIA-E3. Research in energy sector is being carried out at the Center for Research on

Energy Policy, Bandung Institute of Technology and research in forestry sector is being carried out at the Centre for Climate Risk and Opportunity Management, Bogor Agricultural University, while the results of these research projects being communicated to the policy makers.

Thailand:

It seems that there are regional targets as well, for example, the Bangkok area five-year plan: 15% reduction by 2012. The main pillars include improvement of traffic system, renewable energy, economic use of energy and economic use of energy concerning buildings, waste disposal, and expansion of forest. In Thailand, an environment energy consortium has been formed led by the government/Science Foundation. In addition, social science based research is being carried out focusing on “Sufficient Economy” i.e. the philosophy of “moderation” where doing too much should be avoided, and the importance of collaboration/cooperation/synergy in the community. However, we don’t have much information about research projects which would give basic support for the preparation of roadmap containing actual policy mix.

- As discussed above, integration of research corresponding to the policy is progressing among G8, G20 and outreach countries. However, as there are many situations, even in the developed countries, which could make the integration particularly difficult, reality is that effort to unify it is not necessarily being made. It would be probably appropriate to say that the developing countries are keen in accepting research projects from the developed countries in response to the formation of policies connected to foreign aid and trying to conduct researches for the low-carbon development.

Table 1. Progress of LCS policy and related research (next page)

Overall Country-by-country	Overall Country-by-country	Summary	Policy trend	Cooperation between policy and research	Trend of research world/orchestration	Important research theme
Overall Item-by-item	Rapidly moving	Rapidly moving	More international treaties are coming into the scene	Gradually being set up	Cross-sectional orchestration such as COE has been progressing	There are differences between the developing countries and the developed countries
Japan	Slightly behind	<p>07: "21st Century Environment Nation Strategy"</p> <p>08: "Action Plan for Achieving a Low-Carbon Society"</p> <p>09: "Basic Law for Promotion of Achieving a Low-Carbon Society" bill was submitted to the Diet (before the change of government)</p> <p>09: "Hatoyama Initiative"</p> <p>09: "The Ministry of Education, Culture, Sports, Science and Technology, Research and Development Strategy for Achieving a Low-Carbon Society"</p> <p>10: "Medium to Long term Roadmap plan"</p> <p>10: "Basic Law for Prevention of Global Warming" is scheduled to be submitted to the Diet</p>	<p>04: "Low-Carbon Society Scenarios toward 2050 Research Project" (NIES) started</p> <p>06: "Energy Technology Vision and Roadmap 2100" (Ministry of Economy, Trade and Industry)</p> <p>09: "Center for Low Carbon Society Strategy" was established (Japan Science and Technology Agency: JST)</p> <p>09: Japan Climate Leaders Partnership (Japan-CLP) (industry)</p>	<p>Increase of the number of COE at universities</p> <p>Integrated promotion budget for research of earth environment (S6) "Low-Carbon Society Scenarios toward 2050 Research Project" (commenced in 2004, NIES)</p> <p>"Energy Technology Vision and Roadmap 2100" (METI)</p> <p>"The Ministry of Education, Culture, Sports, Science and Technology, Research and Development Strategy for Achieving a Low-Carbon Society" (2009)</p> <p>Japan Science and Technology Agency (JST) established the Center for Low Carbon Society Strategy (2009)</p>	<p>Model based scenario research</p> <p>Renewable energy, nuclear power, carbon capture and storage technology (CCS), etc.</p> <p>Market mechanism based policies such as EU Emission Trade System (EU ETS), and Climate Change Levy</p>	
The UK	Leading the pack	<p>The industry, government and private sector are cooperating in sharing/managing all the knowledge and information related to research, policy and actual economic activities toward a low-carbon society</p>	<p>06: Stern Review</p> <p>07: Energy white paper (DTI) / MARKAL and MARKAL-MACRO model of UKERC</p> <p>PAS2050 standard / Carbon footprint (pilot project from 2007)</p> <p>Under the Climate Change Act, the Committee of Climate Change consisting of experts of science and economy was established. This committee conducted analysis on science/economy/society, prepare a report and give advice to the government.</p>	<p>02: Establishment of UKERC, etc. This is a center for renewable energy research and a consortium of 15 research institutes.</p> <p>For example, Tyndall Centre, one of its members, is involved in a range of researches including benefits of low-carbon society in terms of air quality and human health, governance of climate change, consumption, economic costs and roadmap of low-carbon initiative using E3MG/CIAS model</p>	<p>02: Establishment of UKERC, etc. This is a center for renewable energy research and a consortium of 15 research institutes.</p> <p>For example, Tyndall Centre, one of its members, is involved in a range of researches including benefits of low-carbon society in terms of air quality and human health, governance of climate change, consumption, economic costs and roadmap of low-carbon initiative using E3MG/CIAS model</p>	

	Overall Country-by-country	Summary	Policy trend	Cooperation between policy and research	Trend of research world/orchestration	Important research theme
Korea		Flag of green growth	<p>Korea, under Low Carbon Initiative, is implementing more advanced policies than Japan</p> <p>09: Promotion of Green New Deal for job creation</p> <p>09: Five year plan for green growth</p> <p>09: Basic Law for Low-Carbon Green Growth (scheduled to be enforced in April 2010)</p> <p>Green growth business includes the following six areas:</p> <p>(1) Mew/Renewable energy, (2) Carbon reducing energy, (3) High-level water treatment, (4) Application of LED, (5) Green transportation system, (6) Advanced green city</p>	<p>Urgent national task includes response to environmental resource crisis and creation of new growth engine.</p> <p>The Korean National Institute of Environmental Research (NIER) has developed a national scenario for the realisation of low-carbon society.</p>	<p>Research on Green growth by the Korean National Institute of Environmental Research (NIER) and the Korea Environment Institute (KEI)</p>	

Overall Country-by-country	Summary	Policy trend	Cooperation between policy and research	Trend of research world/orchestration	Important research theme
Italy		<p>The same as other EU member countries, the mainstay is the improvement of efficiency on energy and building. Fixed price purchase system (Feed-in-tariff) has been established in relation to solar energy and other forms of small-scale renewable energy power generation up to 1 MW.</p> <p>For example, 20 EUR cents/kWh for geothermal plant, 34 EUR cents/kWh for wave/tidal power generation, 22 EUR cents/kWh for water power generation; other modes of power generation include biomass and wind power</p>	<p>Established the Euro-Mediterranean Centre for Climate Change by integrating six climate change related research institutions. The purpose of integration is to establish a more integrated research center. The main area of research is climate model and development of those models that are related to influence, adaptation and reduction.</p>	<p>Six institutions, which became a part of CMCC, are carrying out, while taking advantage of their own specialties, research projects based on climate model and models related to impact, adoption and reduction. FEEM is carrying out model analysis regarding impact of R&D, policies and carbon prices.</p>	
Germany	<p>Research toward a low-carbon society is being conducted with the help of private sector in the form of commissioned research from the government to research institutions.</p>	<p>90: The Parliamentary Enquete Commission (50% MPs, 50% scientists) has already considered 80% reduction target by 2050.</p> <p>96: Policy to promote utilisation of renewable energy</p> <p>00: Decided to discontinue atomic power generation</p> <p>2002: Parliamentary Enquete Commission for renewable energy</p> <p>2004: Quantitative energy scenarios for Germany: -80% GHG by 2050, with DLR (German Aerospace Center), etc.</p> <p>2005: Long term energy scenarios for Germany (UBA)</p> <p>07: Meseberg Package (aim: 40% target) "Integrated Energy/Climate Program Outline"</p> <p>07: "Integrated Energy/Climate Program"</p> <p>08: "German Strategy for Adaptation to Climate Change"</p> <p>09: Revised "RE Law"</p>	<p>Since 1990, researches on energy and reduction targets have been conducted. More than one institution are conducting that research on 2050 energy scenario. The half of Parliamentary Enquete Commission members are invited scientists in 1990.</p> <p>Research on Integrated Energy/Climate Program by the German Federal Environment Agency (partly done by Fraunhofer ISI Institute)</p> <p>UBA's research commissioned to New Energy Research Institute (IfnE)</p> <p>"Expansion of renewable energy in the electricity sector" (to estimate the short/long term impact of the revised Renewable Energy Law which became effective from 2009)</p> <p>There is no research cooperation regarding LCS.</p> <p>Research on low-carbon city (Munich) by Wuppertal Climate Environment Energy Institute (WI)</p> <p>Scenario/Model analysis by Potsdam Institute for Climate Impact Research</p>	<p>There is no robust network among research institutes, or anything like that.</p>	

France	Overall Country-by-country	Cooperation with researchers and stakeholders is progressing through participatory approach	<p>Summary</p> <p>95: National Program for measures against global warming 00: Adoption of National Program for Tackling Climate Change (PNLCC) 04: Climate Plan as a measure against global warming 07: Establishment of the Ministry of Ecology, Energy, Sustainable Development, and Management of Territory Target of 75% reduction below 1990 levels by 2050 and minimum 20% reduction below current level by 2020 (target of EU) Carbon tax legislation has been submitted a number of times since the beginning of 2000. 09: Court decision to consider Carbon tax as unconstitutional Jan 2010: The amended bill was approved in a Cabinet meeting. Formulation of roadmap through participatory approach Approach where researchers and stakeholders have a series of discussions has been developed since early days. The Grenelle Environment meeting (Grenelle Environnement) which began in 2007 was participated by the government, local governments, consumer groups, unions, and NGOs. As much as three subcommittees out of six are related to the low-carbon society, for example, "Measures against climate change and suppression of energy demand".</p>	<p>Policy trend</p> <p>95: National Program for measures against global warming 00: Adoption of National Program for Tackling Climate Change (PNLCC) 04: Climate Plan as a measure against global warming 07: Establishment of the Ministry of Ecology, Energy, Sustainable Development, and Management of Territory Target of 75% reduction below 1990 levels by 2050 and minimum 20% reduction below current level by 2020 (target of EU) Carbon tax legislation has been submitted a number of times since the beginning of 2000. 09: Court decision to consider Carbon tax as unconstitutional Jan 2010: The amended bill was approved in a Cabinet meeting. Formulation of roadmap through participatory approach Approach where researchers and stakeholders have a series of discussions has been developed since early days. The Grenelle Environment meeting (Grenelle Environnement) which began in 2007 was participated by the government, local governments, consumer groups, unions, and NGOs. As much as three subcommittees out of six are related to the low-carbon society, for example, "Measures against climate change and suppression of energy demand".</p>	<p>Cooperation between policy and research</p> <p>The main focus of efforts to achieve the reduction target is on changeover to biomass energy and improvement on efficiency of building related energy saving measures. MIES (Interministerial Taskforce on Climate Change): Factor 4 scenario analysis of the target of 75% reduction below the 1990 levels by 2050 (IDDRI, ADEME) Recently, investment in sustainable development leveraged by a large quantity of government bond of about 10 billion euros was announced; out of that, 6 billion euros will be spent on support for cutting-edge environmental technologies. Priority areas include biomass energy, wind power, solar energy, geothermal power, ocean energy, bio fuel, automobile, zero-carbon via carbon capture and CCS, smart grid, energy storage and battery, improvement on building efficiency, biomass materials, and optimization of industrial processes, distribution and management.</p>	<p>Trend of research world/orchestration</p> <p>The French Environment and Energy Management Agency (ADEME), although it is not a research organisation in itself, is playing a central role, under MEDDAT and Ministry of Higher Education, in facilitating and coordinating research projects.</p>	<p>Important research theme</p> <p>Priority areas include biomass energy, wind power, solar energy, geothermal power, ocean energy, bio fuel, automobile, zero-carbon via carbon capture and CCS, smart grid, energy storage and battery, improvement on building efficiency, biomass materials, and optimization of industrial processes, distribution and management.</p>
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Korea		Flag of green growth	<p>Korea, under Low Carbon Initiative, is implementing more advanced policies than Japan</p> <p>09: Promotion of Green New Deal for job creation</p> <p>09: Five year plan for green growth</p> <p>09: Basic Law for Low-Carbon Green Growth (scheduled to be enforced in April 2010)</p> <p>Green growth business includes the following six areas:</p> <p>(1) Mew/Renewable energy, (2) Carbon reducing energy, (3) High-level water treatment, (4) Application of LED, (5) Green transportation system, (6) Advanced green city</p>	<p>Urgent national task includes response to environmental resource crisis and creation of new growth engine.</p> <p>The Korean National Institute of Environmental Research (NIER) has developed a national scenario for the realisation of low-carbon society.</p>	<p>Research on Green growth by the Korean National Institute of Environmental Research (NIER) and the Korea Environment Institute (KEI)</p>	

Overall Country-by-country	Summary	Policy trend	Cooperation between policy and research	Trend of research world/orchestration	Important research theme
Canada		<p>Two-tiered policy structure consisting of those at the federal level and those at the regional level</p> <p>Federal level: Response to the KP: (1) Ratification of the KP, "hurry up and wait", (2) Gave up implementation of the target, focus on post-2012 framework</p> <p>Regional level: Two kinds of dynamics: (1) Its own policies in the absence of those at the federal level, (2) Influence the federal government through common regional policies</p> <p>07: Turning the Corner Green Plan</p> <p>07: Regulatory Framework for Air Emissions which includes the use of emission trade system</p> <p>08: Detailed draft of emission trade system (Turning the Corner: Regulatory Framework for Industrial GHG Emissions). This was scheduled to be effective in January 2010, but postponed.</p> <p>However, the government is still expressing its commitment to 17% GHG reduction (below 2005 levels) by 2020</p> <p>The government is implementing the following policies/measures: Emission regulation (an offset system was established in 2008. In the future, this will be linked to the US cap and trade system), improvement of energy efficiency, increase of renewable energy, and promotion of technology development/dissemination.</p>	<p>06: Advice on a Long-term Strategy on Energy and Climate Change (NRTEE)</p> <p>Other NRTEE reports</p> <p>Getting to 2050: Canada's Transition to a Low-emission Future (2007)</p> <p>Achieving 2050: A Carbon Pricing Policy for Canada (2009)</p> <p>Natural Resources Canada (NRCan) has prepared five scenarios consisting of four scenarios representing those future images that do not include reduction target and the one that maintains the reduction ratio required to achieve the Kyoto targets.</p>	<p>Research papers presented at academic conferences are in themselves not many.</p> <p>People not only in the environment area, but also in the science and technology area are getting interested in such approach as low-carbon society</p>	

Overall Country-by-country	Summary	Policy trend	Cooperation between policy and research	Trend of research world/orchestration	Important research theme
China	Rapidly developing	<p>National Climate Change Programme by the government.</p> <p>06: An energy-saving /emission-reduction steering group was established under the prime minister.</p> <p>07: Energy-saving/Emission-reduction work plan; Energy-saving Law</p> <p>Monitoring will to be carried out by introducing the Energy Intensity per GDP system, etc.</p> <p>Differentiation of energy charge applied to the energy intensive industries.</p> <p>Low-carbon economy was mentioned in the 12th five year plan.</p>	<p>The notion of low-carbon economy was incorporated in the five year plan, making it an important part of the national policy. For this reason, many research institutes have raced to start LCE research. As a result, there are almost too many of them.</p> <p>NDRC Energy Research Institute presented a scenario</p> <p>Center for Climate Change and Environmental Policy (CCEP),</p> <p>Environmental Regulation Planning Academy, Ministry of Environmental Protection,</p> <p>Institute of Policy and Management, Chinese Academy of Science</p> <p>Tsinghua University: Institute of Nuclear and New Energy Technology,</p> <p>Institute of Energy, Environmental Economy, and Low-carbon Laboratory</p> <p>Institute of Policy and Management, Chinese Academy of Science: Report on low-carbon society research (Chinese sustainable development strategy report – searching for Chinese way of low-carbon society Future, Professor Wang Yi, used to work for CRAE, 2009)</p> <p>Social science based research is being carried out focusing on “Sufficient economy” i.e. the philosophy of “moderation” where doing too much should be avoided, and the importance of collaboration/cooperation/synergy in the community.</p>		<p>Research on LCE</p> <p>Co-benefits including environmental, social, economic solution other than GHG</p>
Thailand	Collaboration with social satisfaction society	<p>Bangkok area five year plan: 15% reduction by 2012</p> <p>The main focuses of attention include improvement of traffic system, renewable energy, economic use of energy and economic use of energy concerning buildings, waste disposal, and expansion of forest</p>			

Overall Country-by-country	Summary	Policy trend	Cooperation between policy and research	Trend of research world/orchestration	Important research theme
India		<p>08. Announced National Action Plan to tackle global warming. The following eight items have been specified: promotion of the use of natural energy such as solar power, improvement on energy efficiency, to increase the ratio of forest area from 23% to 33% by encouraging reforestation, and to improve energy efficiency.</p> <p>According to the medium term target in January 2010, India is going to reduce the energy consumption per GDP 20-25% below 2005 levels. However, it is that emission from agriculture sector is excluded from the target.</p>	<p>2008 Action Plan includes an item called “strategic knowledge for climate change”</p>	<p>Scenario study using a nationwide scenario based on integrated model and city-by-city expanded snap shot model (ExSS) and so on</p>	
Indonesia	<p>Movement in response to aid</p> <p>Regardless of what Indonesia says in the international negotiation, the government has started to take reduction initiatives</p>	<p>09. As the president announced a policy of 26% reduction of emission from the baseline (BAU) by 2020, this value was also reported as the voluntary reduction target in a report to the UNFCCC required by the Copenhagen agreement. National Action Plan Addressing Climate Change (RAN-PI) and the 2nd National Communication by the State Ministry of Environment (KLH) The Climate Change Roadmap and the Medium Term Development Plan 2010-2014 (RPJM) by the National Development Planning Agency (BAPPENAS)</p>	<p>At the dialogue between policy makers and researchers held by the LCS-RNet Secretariat in February 2010, some of the researchers who participated said that it was the first time for them to have such opportunity.</p>	<p>Research is being carried out by a group led by Arief Anshory Yusuf at Padjadjaran University (general equilibrium model analysis); in energy sector at the Center for Research on Energy Policy, Bandung Institute of Technology; and in forestry sector at the Centre for Climate Risk and Opportunity Management, Bogor Agricultural University, while the results of these research projects are communicated to the policy makers</p>	<p>The government has set the mitigation targets centering around the following seven areas: energy, forestry, waste management, peat-lands, traffic, industry and agriculture</p>

	Overall Country-by-country	Summary	Policy trend	Cooperation between policy and research	Trend of research world/orchestration	Important research theme
The US	Focus of the policy is on technology. The research world is also in a state of waiting for government's articulated direction and funding.		<p>April 01: Broke away from Kyoto Protocol</p> <p>07: The supreme court handed down the decision that green house gas should be subject to the Clean Air Act.</p> <p>Since 2008, Deliberation to reduce the GHG by 14% (from 2005) by 2020 and 83% by 2050 was done.</p> <p>09: The State of the Union message: requested Congress to pass the cap and trade legislation as well as the Acceleration of Renewable Energy Production Bill</p> <p>June 09: The House of Representatives passed the American Clean Energy and Security Act, Waxman-Markey Bill, cap & trade bill: reduction by 17% (from 2005) by 2020 and 83% (from 2005) by 2050</p> <p>September 09: The Senate Bill (to make the GHG emission decrease in 3 years time) was submitted.</p> <p>At the UNFCCC COP15 in December 2009, the US took an active role in the establishment of the new framework.</p> <p>Activities at state level: Regional Greenhouse Gas Initiative (RGGI), California Global Warming Solutions Act (AB32), Western Climate Initiative (WCI), and Midwestern Greenhouse Gas Accord (MGA)</p>	<p>Scenarios for a Clean Energy Future Report by DOE; Researchers of Argonne National Laboratory, Lawrence Berkeley National Laboratory, the National Renewable Energy Laboratory, Oak Ridge National Laboratory, and PNNL jointly evaluated the possibility of scenario/model analysis, R&D, public policy to promote clean energy and so on.</p> <p>The All Modular Industry Growth Assessment (AMIGA), a general equilibrium model, by Donald Hanson of Argonne National Laboratory and others showed, targeting the period up to 2050, BaU and three other scenarios plus respective scenarios of which climate change measures were factored in.</p> <p>09: EPA used two general equilibrium models, IGEM (Harvard Kennedy School) and ADAGE (RTI: International Sphere Institute) for evaluation/analysis of the impact of Waxman-Markey Bill</p> <p>09: The US Climate Action Partnership (USCAP) published a blueprint (industry/NGO)</p> <p>There is a tendency for research institutions to obtain funds from multiple numbers of government agencies to maintain impartiality. In addition, there are many cases where funding is coming from research fund organisations rather than government agencies.</p> <p>People not only in the environment area, but also in the science and technology area are getting interested in such approach as low-carbon society.</p>	<p>With regard to the research based on low-carbon society approach, although it has been recognized that, in addition to the conventional technology scenario based research, social science based research is necessary, there have not been many examples of research actually carried out by researchers. People not only in the environment area, but also in the science and technology area are getting interested in such approach as low-carbon society.</p>	

	Overall Country-by-country	Summary	Policy trend	Cooperation between policy and research	Trend of research world/orchestration	Important research theme
IEA UNEP		Trying		<p>In case of IEA/OECD, they carry out many researches in relation to renewable energy including bio fuel and efficiency improvement including building energy saving because their mission is to provide information and products required by the member countries (developed countries). Mining of oil They carry out those researches that help achieve the maximum use of fossil fuel available to use, for example, improvement on efficiency of refinery operation.</p> <p>There hasn't been perspective to connect energy saving to CO₂ reduction.</p>		

2. Approaches and issues of low-carbon society research

The knowledge required of the staff in charge of policy making for the construction of a low-carbon society cuts across a wide range of areas. Major tasks include how to set the medium to long term targets, policies to achieve the target and economic evaluation of them, effectiveness of technological development, how to let the people move toward a low-carbon society, and reconstruction of local communities/urban areas. The main concerns of the staff in charge of policy making in the developing countries include, in addition to those mentioned above, conservation of forests and soil, how to distribute aid funds, how to and in what manner identify a path leading to the low-carbon development while putting priority on economic development/poverty elimination.

2.1 Necessity for the integration of policies and research for low-carbon society research

The reason why low-carbon society research needs policy support through integrated research will be described in section 4 below. In this network, research approaches and issues were discussed mainly at annual research meetings with the participation of some staff in charge of policy making and stakeholders.

The reasons for adopting this method are based on the following characteristics of low-carbon society research:

Participatory approach: Although the creation of low-carbon societies is policy-driven, the responsive actions are carried out by stakeholders in each field. To ensure that research is effective in creating low-carbon societies, stakeholder participation is necessary for all the stages of identifying issues in the beginning, establishing a whole plan and formulating individual policies. Because the transition to low-carbon societies requires great and rapid changes, dialogues with the stakeholders are important from the early stages of the planning and implementation of the transition.

Place-based approach: The situation of policy makers and stakeholders differs among countries, regions, or development stages. Research that takes into account this difference (place-based science) is necessary for each stakeholder to put the research into action.

In this network, from the viewpoint described above, a world research meeting, a meeting between staff in charge of policy making and researchers, and dialogues among policy makers, stakeholders, and researchers were held in Bologna, Bogor and Yokohama, respectively this year, and distinguished suggestions were made at each of the meetings concerning the direction for the promotion of low-carbon research. In addition to these meetings, the Secretariat analyzed research issues concerning the creation of a low-carbon society (“12 Items Demanded by Policy Makers from Modelers”). Moreover, at the sectional meetings on daily life, industries, community development, and zero-emissions energy in the “Mid- and Long-Term Roadmap Review Conference” commissioned by the Ministry of the Environment of Japan, about 50 experts have examined what policies and research issues are necessary for achieving Japan’s mid-term targets, and some necessary research issues have been identified.

2.2 International research meeting in Bologna (reference: Toward the Realization of Low-Carbon Societies: Synthesis Report on the First Annual Meeting of LCS-RNet):

This was an annual meeting of LCS-RNet with the participation of 56 members of staff in charge of policy making, stakeholders, and researchers from advanced and developing countries throughout the world. In the two-day meeting, the following directions for policies and research were presented for the realization of low-carbon societies:

Summary of key messages

Long-term and mid-term targets

- ² World leaders aspire to bold targets for emissions reductions.
- ² Co-benefits will arise from setting appropriate country- and region-specific targets.
- ² Backcasting approaches can identify feasible and desirable pathways towards sustainable low-carbon societies.

Economic aspects of low carbon societies

- ² Co-ordination is needed between environmental goals and innovation policies.
- ² Sectoral and regional perspectives need to be taken into account.
- ² New financing paradigms will be required if developing countries' mitigation and adaptation needs are to be met.

The role of technology

- ² Radical technological change is crucial in reaching a low-carbon society.
- ² More investment in energy technology is needed.
- ² Technology will not deliver a low-carbon society on its own.
- ² Climate policies and R&D strategies must be synchronised.

Public policy and lifestyle change

- ² Public policy can lead the way to lifestyle change and a low-carbon society.
- ² Facilitating behaviour change is not easy, but can be accomplished.
- ² The most effective measures will be tailored to individual countries and localities.
- ² LCS lifestyles do not have to entail sacrifice.

Cross-cutting issues

- ² A persistent signal is needed to stimulate change across all sectors.
- ² Planning for land use change is essential.
- ² Cities provide an excellent opportunity to promote a low carbon society.
- ² Research that would allow developing countries to set their own targets and pathways is essential.
- ² Human resource development is needed as well as technology co-operation.
- ² We need to adapt to unavoidable climate change and remain alert to new scientific insights.

2.3 Dialogue between policy making staff and researchers in Bogor (reference: Synthesis Report of the Bogor Meeting): This was a meeting for dialogues between policy makers and researchers. A two-day workshop was held in Indonesia with the participation of 80 persons, with the result that developing countries made suggestions concerning policies and research issues for low-carbon development. What were especially highlighted at the meeting were efforts for low-carbon growth strategies, effective international cooperation and the use of funds, creation of cooperation systems between the central government, local governments and various sectors, and knowledge about appropriate technologies and good practices.

Key messages of Indonesia

from the Dialogue between policy makers and researchers:

Demands and roles of SLCD/GG researches from policy perspective

Low Carbon Development and Green Growth

- Low Carbon Development is a good opportunity to realise sustainable development.
- Fundamental change in people's mindset is necessary to promote development.
- Harmonised policies and coordination between central and local governments, as well as across sectors, are key.
- Networking between/across local, national, regional and global levels to promote low carbon development, such as LSC-RNet, is important

Collaboration between policy- and research communities

- Developing national and sectoral roadmaps is effective approach to identify a course of actions required.
- Dynamic modeling is an effective tool to understand how policies in different sectors affect with each other.
- Activating research network with better linkage with policy-makers is an immediate need for sustainable development led by the low carbon development.
- Multi-disciplinary approach in the formulation of research is called for to meet needs in policy-making.

Areas to focus for promoting low carbon development

- Forestry and peat land and Land-use Change followed by Energy sector are given priority.
- Sustainable forestry/land use and land use change policies must be put in place.
- Energy source must be diversified by promoting locally produced renewable energy. (particularly geothermal source and solar power).
- To promote renewable, impact on whole ecosystem must be understood.

Technologies as fundamental element in Green Growth

- Technology is fundamental element to draw positive emission scenarios while ensuring sustainable development.
- Identification and deployment and dissemination of readily available low-carbon technologies should be prioritized in short-term.
- Development of appropriate local technologies is important in long-term.

Mobilisation of available financing schemes

- Scaled-up financing from international source is fundamental to achieve Indonesian target.
- Available source includes national budget, finances from international sources including ODA and multilateral schemes, private sectors, and NGOs.
- Best utilisation of all available financial resources should be ensured.
- New institutional arrangement to ensure the efficient use of resource across sectors must be realized.
- Better coordination both vertically (national and local) and horizontally (across-sector) must be ensured.
- Clear signals to shift towards low carbon development, and diffusion of good practices, is essential

Life-style innovation for the sustainable low carbon development

- Traditional values and practices are rich in the tips for designing innovative lifestyle to enable low carbon development, while applicability to the modern context and different locality should be also carefully examined.
- Principles of traditional society, such as ‘sufficiency,’ ‘co-existence with nature,’ and ‘cooperation’ should be re-vitalized in the current development context.
- Local and indigenous technologies, methods, and wisdom should be fully utilized in promoting Green Growth especially in sectors such as agriculture, fishery and forestry.

Notice: participants’ review in progress (26 March 2010)

2.4 Stakeholders Meeting in Yokohama (reference: Report on Stakeholders Meeting in Yokohama): As a meeting of stakeholders in Japan, an open meeting was held mainly with the participation of researchers in housing, regional development, retailing, technical development, regional administration, finance, social planning and low-carbon societies. The discussion issues were Japan's vision of a low-carbon society, obstacles to be overcome for low-carbon development, and policy problems from an on-site perspective. Many problems were pointed out against the background of the situation Japan will face in the future – that is, a declining birthrate, an increasing number of elderly persons, increasing energy costs, and the reconstruction of communities. Moreover, challenges to be tackled by Japan were identified, such as taking leadership in the transition, establishing the foundations for the provision of human resources and funds, and government-community cooperation in social systems reform.

Six key findings from the Stakeholders Dialogue in Yokohama

- Overcoming barriers to Low-Carbon Societies -

It is time to act. Change is an opportunity.

Japan is now in the midst of major changes as it faces a decline in population, an aging society, increased global competition for its industries, issues of managing national finances, energy security, the restructuring of land use, and so forth. Efforts to shift from the current energy-intensive society towards a low-carbon one will guide us in a major transition to realising a better future. It is thus important to consider these substantial changes as a major opportunity and make every effort to deal with them in a positive manner.

It is time to discover, find and create new values.

When the conditions surrounding the society change, this sheds light on things that were not sufficiently valued in the past. Discovering things that we lost due to industrialisation, such as traditional social systems that have long been maintained in local communities, traditions, institutions, and values, will help us to create new values to live in a low-carbon society. Venture business created using “Trust” capital is a good example. If people consider a house as a service to use in accordance with the needs of each generation, not something to “possess”, this will help to establish houses as good long-lasting social capital together with their environment.

It is time to stop the compartmentalization of systems to make full use of the potential of each component in a harmonised way.

By internalising new values in economics, new industries or businesses will be created. Business people should be more positive in trying to develop new enterprises through joint ventures with different industries as well as through cooperation between cities and rural areas. By rediscovering the basic strength that was gradually established through tough experiences, such as pollution and economic recession, and by finding ways to establish new collaborative relationships amongst different industries, the Kawasaki coastal industrial zone has become rejuvenated as a new industrial area from its previous obstructive style. It is important for each government agency to give up its bureaucratic and compartmentalised policy-making style, and try to achieve the integration and harmonisation of policies. As an example, in housing policies it is necessary to implement comprehensive policy revisions such the abandonment of policies that encourage people to become private home owners, as well as to promote capacity-building for local carpenters to construct houses with low carbon emissions, to extend the average life of houses by promoting renovations, to revise building standards to eliminate basic obstacles to energy-efficient houses, etc. Business sectors should also give the authority for decision-making to the people working at the front line.

It is time to take risks and face challenges

In the midst of major social change, everyone must be ready to take risks to meet the challenges and build a new society. It is necessary to avoid adhering to the apparent current stability. It is encouraging to see more and more entrepreneurs who are willing to take risks. The financial sector could also apply methods of venture capital taking risks into account. The government must take up the role of providing safety nets for those who challenge these risks and guarantee opportunities to

start over again.

For policy-makers, it is time to give a clear signal of the need to shift to a low-carbon society and formulate policies with a long-term perspective that include safety nets, and then share this vision with the private sector.

It is time to espouse a clear vision as a nation of how to maintain a prosperous Japanese economy and of the kind of society we would like to pursue. The role of the government is to give a clear signal to indicate that we are in a transitional period, to propose strategies for the future and roadmaps toward achieving them. It is also important to involve the demand side on a global scale, and to support the identification and accumulation of intellectual property that is necessary for the technologies and systems required. Developed countries are putting individual technologies, systems technologies and planning, infrastructure, and finance together as whole systems to develop low-carbon societies or for urban planning and to sell these in the global market, mainly targeting developing countries. There is a huge potential for Japanese technologies if they are integrated into larger technological structures and systems, and this is the direction for Japan to go forward. Subsidies to overcome the initial barriers to making this shift towards a low-carbon society must be implemented within an appropriate time frame in ways that support social capital development and strengthen the capacity of industries over the long term. The role of the government is to raise the levels of the lowest standards. It would be better to leave it to competition within the private sector to then raise general levels to the highest standards.

It is time to trust the capacity of the private sector and make use of it

It is the private sector and individuals that will make the transition, and the government must trust their capacity. Japanese enterprises have sufficient potential to make changes. It is the private sector and individuals who will decide on, act on, and create the means to achieve a low-carbon society. It is important for them to demand what they require from each other. However, it is also important to make clear who will carry this out, and who are the objects of the changes. All stakeholders must be aware of their own responsibilities. Individuals and businesses must be aware of the mutual benefits and the importance of sharing them in order to design solutions in a rational way.

2.5 Policy makers' 12 questions (reference: Power Point with the same title)

Asia Energy Modeling Meeting (17 September 2009, Tsukuba, Japan) was held by National Institute for Environmental Studies (NIES) and Stanford University's Energy Modeling Forum (EMF) with about 30 participants from Japan, USA, Europe and other Asian countries. In discussion of the last session, titled future research themes, LCS-RNet was asked to provide inputs and Dr. Shuzo Nishioka, Secretary General of LCS-RNet presented on the relation between policies and researches in Japan. By reviewing the questions from policymakers through the working group for the 2020 (mid-term) target for emission reduction under the Aso Administration, and how researchers respond to them, the twelve frequently asked questions from policy makers to researchers were presented as follows:

- What will happen if there is no climate policy?
- How much reduction is necessary ultimately?
- How are reduction targets set for the world?
- What options are there for mid- and long-term reduction targets?
- How will the industrial structure change if domestic measures are taken?
- How much reduction is possible in each sector?
- Does land use have to be changed?
- How much does reduction cost?
- What policy means are there to achieve the targets?
- How much will they influence the state economy?
- Is it possible to win international competition?
- How can Japan contribute to the world?

3. Orchestration of the research: research promotion through domestic/ international cooperation

To effectively support such policy as construction of low-carbon society which is urgent and requires integrated knowledge encompassing a number of areas, Center of Excellence:COE, etc. which cut across research areas are, in parallel with formulation of policies, being established. The UK, which is driving forward climate change strategy in a proactive manner, has established, as an administrative machinery, the Department of Energy and Climate Change, clarified the policy package by enacting an act to encourage a transition toward the low-carbon economy, established the Committee on Climate Change to formulate unified policies, and, responding to these initiatives, formulated a network to integrate such research institutions as university for the purpose of promoting inter-disciplinary research on climate change so that the result can be reflected on the policies. In Japan, formation of permanent headquarter organisation has been delayed and researches are being carried out independently by individual ministry/agency. Although Japan Science and Technology Agency has recently begun taking initiatives for cross-sectional orchestration of the academic world, there still is a long way to go before it gets to the policy level. In Asian developing countries, for example in Indonesia and Thailand, etc., COE is being established as well.

3.1 Background to the need for integrated research and networks

Since the research institutes of many countries have already begun to carry out the research necessary for the creation of low-carbon societies, why is it necessary to create domestic or international networks of researchers? Because the purpose of a network is to promote the participants' sharing of information, joint addition of values, coordination, and supplementation, the network must facilitate the participants' achievements of targets through their cooperation. The following presents the background to the need for integrating and networking research for the creation of low-carbon societies:

- (1) Importance and urgency: Low-carbon societies represent a considerable transition from the highly energy-dependent societies developed so far. In addition, since the emissions of greenhouse gases should be made to peak during the next several decades so that these emissions are halved by the mid-21st century, it is urgently necessary to share intelligence.
- (2) Necessity of integrated knowledge: Because the transition to a low-carbon society has to occur in every field, knowledge in a wide range of fields is necessary and should be integrated effectively.
- (3) The maintenance of global public goods through international cooperation: Because the climate is one of the global public goods, free-riders should not be allowed.. To prevent this, it is effective to improve the level of intelligence among all the members. In addition, if all the members in the world share intelligence, it will become easier to cope with the problem.
- (4) Participatory approaches that ensure effectiveness: Activities for creating low-carbon societies are carried out by stakeholders and policy making staffs. The immediate use of the research results requires exchanges of these results from the point in time the issues emerge.
- (5) Confirmation of regional characteristics: Conditions for the creation of low-carbon societies differ among countries and regions. Networks will enable better understanding of the differences and make cooperation more effective.
- (6) Necessity for a new research approach: Because low-carbon society research, which has the clear goal of stabilizing the climate, applies Gibbons' Mode II research concept to a more global approach, it is necessary to jointly develop a new research concept, approach and method.

3.2 Characteristics of low-carbon society research

Low-carbon society research is important and urgent work that challenges the future at a critical crossroads for the human beings. This great challenge requires a research style (approach) that is different from the style so far. The creation of world networks will become a place for establishing a new research style through practice.

Fusion of natural, engineering, and social sciences for climate stabilization policies

When countries set reduction targets to realise a low-carbon society, consideration will be given to the temperature rise estimated from climate models and the damage caused by the rise, while consideration is given also to the impact of the control of greenhouse gases on industries. When countries make decisions, balancing the uncertainty of climate models, the irreversibility of the impacts, and the possibility and economic efficiency of measures, it is necessary to fuse climate science, regional environmental studies, engineering, industrial economics, and other studies. Only such a fusion of various sciences makes it possible to come up with political decisions about by how much emissions should be reduced.

Technologies in every field are necessary for the achievement of the targets, and the cooperation in science fields that supports them

Once targets are set, the potential of every technology should be tested to achieve the targets. Practical use of technologies requires the infrastructure for utilizing them based on the results of urban planning, regional planning, and traffic engineering. Moreover, the promotion of energy saving in houses and offices requires not only energy-saving technologies, but also tax and information systems that facilitate their promotion. It is also important to develop zero emissions technologies, such as those that greatly reduce greenhouse gases and those that make it possible to run cars using solar energy. At the same time, it is important also to manage research reasonably with limited funds by disseminating technologies already put into practice and existing technologies and by identifying low-carbon technologies that will become feasible in the near future and can be developed with some effort. It is helpful to use fiscal science, economics, business science, industrial policy studies, communications theories, and behavioural science analysis that facilitates human actions. To change the whole social system, it is necessary also to adopt policy studies concerning laws and customs as well as the ways of thinking of cultural studies and anthropology. In this way, it is essential to carry out cooperative research by mobilizing various kinds of intelligence.

Policy making by back-casting

The forecasting method has so far been used frequently to examine what policies and measures are effective in achieving targets and when they should be introduced. To eliminate the cause of later trouble, however, it is appropriate to use the back-casting method for making a plan to achieve reduction targets effectively by using all possible means. This new method sets targets first and then devises policies retroactively from the targets. Research and development with the use of such a new method is necessary for creating low-carbon societies.

Future scenarios chosen by the society: participatory approach

The transition to a low-carbon society is almost synonymous with how to create one's own country in the future. This means that each country is able to choose or visualize its own future. Therefore, a participatory approach – positive dialogues with citizens – is necessary not only during the process of choosing a future scenario and devising policies for the scenario, but also during the process of carrying out research on which such policies are based. To facilitate the development of the country in the 21st century, low-carbon research should proceed through a participatory approach. It is therefore important for researchers to continue dialogues with citizens, policy makers, and industries.

Importance of international cooperation

Climate stability requires the participation of all the countries in the reduction of greenhouse gases. It is especially essential to carry out joint research on methods for the promotion of effective cooperation between developing countries and advanced countries and the effective use of funds for cooperation so that developing countries which are likely to increase emissions greatly can develop into low-carbon societies.

3.3 Climate change policies and integrated research in the UK

The UK has been positively promoting climate change measures. The UK established the Department of Energy and Climate Change as an administrative organ, clarified a package of policies through the enactment of laws that facilitate the transition to a low-carbon economy, established a Committee on Climate Change for the formation of unified policies, and created a network of universities and other research institutes to promote cross-disciplinary research on climate change and to reflect the research results in the measures to be taken. (Mainly based on materials published by the UK Embassy in Japan)

Policies: The Stern Review published in October 2006 explained that if measures are not taken against climate change, the cost will rise to an unacceptable level, while the cost of climate change measures is estimated to be 1% of the annual GDP. Responding to findings of such research, in October 2008 the UK established the Department of Energy and Climate Change (DECC) as an agency that comprehensively coordinates the formulation of policies for two challenges; energy security and climate change. In November that year, the UK established a package of policies for controlling carbon emissions and facilitating the transition to a low-carbon economy, the Climate Change Act, the Energy Act, and the Planning Act which ensures the enforcement of the former two acts. The Climate Change Act 2008 is the world's first long-term and binding law for climate change policies and provides for the following: 1) legally binding numerical targets; 2) carbon budget (emissions caps on three agencies to be fixed every five years); 3) establishment of a Climate Change Committee; and 4) the UK Government's imposition of the obligation of emissions reporting on companies pursuant to the Companies Act by April 2012.

In June 2009, DECC published its Fifth National Communication, which was to be submitted to the UNFCCC. The Communication describes that the UK's emissions of greenhouse gases are expected to decrease by about 23% compared with the level in 1990. This rate of decrease is far greater than the target of 12.5% set in the Kyoto Protocol, indicating that the UK is heading towards a low-carbon society. Moreover, in July 2009, the UK published the UK Low Carbon Transition Plan, which lists the following targets to be achieved by 2020: green employment of 1.2 million people; reconstruction of 7 million houses; support for clean energy generation at more than 1.5 million households; a carbon reduction in power generation by 40%; reduction of gas imports by half; and the reduction of average emissions from cars by 40%. Before the publication of this strategy, in March 2009, the "Low Carbon Industrial Strategy: A Vision" was published as the industrial world's first paper to give stakeholders an explanation of the long-term view on low-carbon industrial strategies.

The UK's climate change policies have placed importance on the realization of greenhouse gas reductions using a highly cost-effective method for organisations. The UK has used market-based policies, such as the European Union Greenhouse Gas Emissions Trading System (EU ETS), the Climate Change Levy, the Climate Change Agreements, and the Carbon Reduction Commitment, in order to maintain the principle of sound competition and improve the business environment, while

1 <http://ukinjapan.fco.gov.uk/resources/ja/news/11700226/19081700/uk-kyoto-protocol-announcement-j>

dealing with climate change.²

In addition to the EU ETS, which started in 2005 for power stations and heavy industries, the three-year trial period of the Carbon Reduction Commitment (CRC) started in April 2010. CRC is an obligatory emissions trading system imposed on non-energy-concentrated businesses and the companies and associations belonging to the commercial and public sectors. CRC will be introduced in earnest after the trial period.

To cope with the decline in fossil fuel reserves, the UK has a choice between their replacement with an increasing volume of imported fuels or their replacement with low-carbon energy. Because the use of low-carbon energy is very important not only for climate change policies, but also for the UK's energy security and price guarantee, the UK considers that renewable energy, nuclear power, and carbon capture and storage (CCS) will play important roles in climate change policies. Concretely, the UK officially became a member of the International Renewable Energy Agency (IRENA) in June 2009 and published a report entitled "Energy Security: A national challenge in a changing world" in August 2009, in which the UK asserted that the transition to a low-carbon economy is important for energy security, along with climate change policies.

In the Low Carbon Industrial Strategy published on July 15, 2009, the UK Government has established Low Carbon Economic Areas (LCEAs), a plan to accelerate the growth of low-carbon industries and related technologies and industries in cooperation with the central and local governments and the Regional Development Agencies (RDAs), taking into consideration the geographical and industrial advantages of each domestic region.

Research: UKERC's research on the energy system model (ESM) has been carried out at Kings College London (KCL) and the University of Cambridge. The results of research on MARKAL and MARKAL-MACRO models were also in the UK Energy White Paper published in 2007 by the Department of Trade and Industry (DTI).

In its low-carbon society program, the Tyndall Centre, which carries out academic efforts for climate change research, has analyzed challenges concerning different climate stability levels and low-carbon roadmaps and has dealt with such themes as technology, behaviour, and control across a wide range of issues in space, time, and sectors. Concretely, research has been carried out on themes such as low-carbon society's benefits to atmospheric quality and human health, the control of climate change, consumption, the economic cost and roadmap for decarbonisation according to the E3MG/CIAS model, and the revision of REDD and CDM.

Spergen/FlexNet is a federation that is proceeding with research on low-carbon energy systems from the viewpoints of social science and technologies. Based on the UK Government's Low Carbon Transition Plan (LCTP), Spergen/FlexNet has analyzed what effects will arise when 40% of electricity is supplied by renewable energy in 2020 and what power systems will be necessary for achieving the Climate Change Committee's objectives – that is, an 80% reduction by 2050 and full decarbonisation by 2030.

The Carbon Vision Building Initiative is a four-year research project about how to reduce carbon

2 <http://ukinjapan.fco.gov.uk/ja/about-us/working-with-japan/energy-environment/low-carbon-economy/>

3 <http://ukinjapan.fco.gov.uk/ja/about-us/working-with-japan/energy-environment/low-carbon-uk/carbon-reduction-commitment/>

emissions in buildings. This project has been financed by the Carbon Trust and the Engineering and Physical Sciences Research Council (EPSRC). Carbon Vision has also financed other research fields, such as the industrial process.

Towards a Sustainable Energy Economy (TSEC) is a research program supported by EPSRC and others and has been carrying out cross-field research activities, including not only UKERC's activities but also Keeping the Nuclear Option Open (KNOO), Managing uncertainties, and carbon management and renewable.

In addition, E-On, an energy company, also has used a large amount of funds to proceed with various research projects through a partnership with EPSRC, including the transition to a low-carbon economy.

In the 1990s, William Rees in Canada and others, advocated a concept called "ecological footprint," which expresses the load of human activities on the environment considered as an area necessary for reproducing resources or purifying waste. The metaphor of ecological footprint was used for the carbon footprint, which expresses the footprint of the volume of emissions. The method is similar to the methodology of life cycle assessment (LCA). This method has been used all over the world in the context of "sustainable consumption" and the "visualization of CO₂." In the UK especially, the Carbon Trust established standards called PAS2050 jointly with the British Standards Institution, began a pilot project in 2007, put the world's first carbon footprint-indicating goods on the market, and had the carbon footprint displayed on about 75 items from 20 companies by 2008. This attempt has drawn attention as an example whereby a research method has influenced not only policies, but also the behaviour of producers and consumers. The Carbon Trust was established by the UK Government in 2001 as an independent company that facilitates the transition to a low-carbon economy in response to the climate change problem. Its mission is to accelerate the transition to a low-carbon economy through joint efforts with various organisations to reduce carbon emissions and develop commercial low-carbon technologies. The Carbon Trust is partly financed by a climate change tax and is managing support measures such as the provision of no-interest loans to small and midsize companies for the introduction of energy-saving equipment.

As described so far, it can be said that, in the UK industry, academia, and government have cooperated with each other to share and manage knowledge and information at all the levels of research, policies, and actual economic activities toward achieving a low-carbon society.

3.4 Policies and research in Japan

In Japan also, the "creation of a low-carbon society" and research on it have begun to be integrated.

Policies: In Japan, the Cabinet approved the "Action Plan for Achieving a Low-Carbon Society" in July 2008 as a concrete roadmap for the transition to a low-carbon society. After this, the Liberal Democratic Party's Global Warming Countermeasures Headquarters drafted the "Basic Law on Promotion of the Creation of a Low-Carbon Society" and submitted it to the Diet in July 2009. After the Democratic Party of Japan came into power in 2009, the new Government announced a policy of providing support for measures in developing countries to combat global warming as well as the "Hatoyama Initiative," which includes the MRV principle. Domestically, the Minister of the Environment, Sakihito Ozawa, published "draft mid- and long-term roadmaps" for measures against global warming in February 2010, which specifies mid- and long-term targets: a 25% reduction in the amount of greenhouse gases by 2020 and an 80% reduction by 2050 (compared with the level in 1990). Moreover, although agreement has still not been reached concerning issues such as the concrete direction of environmental taxes and emissions trading, the industrial world's profits, and

4 <http://pioneers.epsrc.ac.uk/exhibition/Interactivehome/Pages/Carbonvisionbuildings.aspx>

the treatment of nuclear power plants, the “Basic Bill to Prevent Global Warming” will be submitted to the Diet during this year’s session, which indicates that Japan has begun to move towards a low-carbon society.

Research: In Japan, as a forerunner of the consideration of policies for low-carbon society that begun around 2007, the National Institute for Environmental Studies began research under the “Low-Carbon Society 2050 Project” in 2004 to support the Government’s formulation of policies. In/after 2007, the Ministry of Economy, Trade and Industry published the “Energy Technology Vision and Roadmap 2100” concerning energy technologies essential for achieving the targets. In August 2009, the Ministry of Education, Culture, Sports, Science and Technology (MEXT) published the “R&D Strategies for the Creation of a Low-Carbon Society” and established a strategic headquarters. Utilizing its advantage in the fields of science, technology, and education, MEXT came out with integrated concepts of green innovation (efforts for a low-carbon society), brown innovation (revitalization of agriculture, forestry, and fisheries) and silver innovation (urban planning for an aged society). In December 2009, the Japan Science and Technology Agency (JST) inaugurated the Center for a Low Carbon Society Strategy, and universities have begun to establish research institutes for a low-carbon society in various forms, such as a “center of excellence.” Established comprehensive strategies and scenarios will be used for the Government’s efforts to create strategies for a low-carbon society. In addition, the National Institute for Environmental Studies, a member of LCS-Rnet, has been designated as a core research institute for domestic cooperation in Japan. To respond to these movements, it is necessary to create a network that covers the whole of Japan.

Business: In the industrial world, a “low-carbon society” is one of the important keywords in the light of how companies can contribute to the solution of the climate change problem as members of the society. The Japan Climate Leaders’ Partnership (Japan-CLP) is a network of companies that regard taking the leadership in the transition to a sustainable low-carbon society as their business chance and opportunity for the next stages of development (the members are AEON, SAP Japan, Obayashi Corporation, Tokio Marine & Nichido, Fujitsu, Bank of Tokyo, Mitsubishi UFJ, and Ricoh). For example, Ricoh has adopted the back-casting method. Although Ricoh has established a mid-term environmental action plan every three years, this caused delays in the development of technologies and Ricoh could not keep up with the rapid change in society and competition. To cope with this problem, in 2007 Ricoh established a mid-term action plan based on the long-term environmental targets for 2010 set up from the environmental vision for 2050. Such a plan is used only for in-house behavioural standards, and does not indicate the direction Japan that should take.

City: After Prime Minister Yasuo Fukuda made his policy address to the Diet in January 2008, Japan has been making efforts to promote low-carbon cities, including the “Environmental Model City,” a concrete measure specified in the “Plan to Improve Cities and Urban Life” approved by the Regional Revitalization Headquarters, and the Promotion Council for Low-Carbon Cities, which was inaugurated in December 2009 to create low-carbon cities and communities by carrying out excellent measures for environmental model cities throughout Japan and by disseminating Japan’s excellent measures to the world in cooperation with foreign cities that are positively addressing the creation of low-carbon societies. Tokyo Metropolitan Government starts its own Emission (cap and) Trading system from 2010, prior to the Central Government.

Research on the creation of low-carbon societies: The following are the main research activities.

- The National Institute for Environmental Studies presented a scenario of 70% reduction by 2050 in its “Low Carbon Society 2050 Project,” using an integrated model.
- In its “Asian Low-Carbon Society Study,” the National Institute for Environmental Studies expanded the above-mentioned integrated model to an integrated evaluation model for measures

against global warming in the Asia-Pacific Region.

- Kyoto University prepared a policy roadmap for self-governing bodies in its “Scenario and Model Studies on Low-Carbon Cities (Shiga and Kyoto).”
- The Research Institute for Innovative Technology for the Earth has researched environmental technologies and made economic evaluations for the 21st century in its “Dynamic New Earth 21 (DNE21) Model.”
- Osaka University presented its research results in the “Direction of Low-Carbon Cities: Environmental Innovations to Improve Sustainability.”
- The Institute for Global Environmental Strategies published “A New Development Pathway to Low-Carbon and Sustainable Asia and the Pacific.”
- In its “Ultra-Long-Term Energy Technology Vision,” the Institute of Energy Economics showed a roadmap until 2100 concerning energy technologies necessary for the creation of low-carbon society.
- The Center for Low Carbon Society Strategy of the Japan Science and Technology Agency (JST) is preparing R&D strategies for the creation of low-carbon societies on behalf of the Ministry of Education, Culture, Sports, Science and Technology.

4. Why international research network?: Added-value

(See: Summary Report of Responses to the Evaluation Questionnaire for Government Focal Points and Observers at the Bologna Annual Meeting.)

The policy makers who attended the Bologna meeting in October 2009 were acutely aware of the importance of research exchange through international research network. Their opinions were that what is urgently needed for the policy makers now is accurate information; it is very important to learn each other from the policies of others and their successes and failures; excellent opportunities should be provided to carry out an effective research by making it respond to the request from the policies; and more value should be added by carrying out those researches that have not been carried out by other international institutions, for example, research on long-term perspective, sociological analysis, and policies related to individual behavioural change (lifestyle). They expressed their expectation for timely outputs that can serve as a reference to the policy makers as well as necessity to expand the activities to G20 and outreach countries. The background for this seems to be the urgency in formulating policies toward a low-carbon society where little time afford to wait for accumulation of knowledge and policy examples in one country and the rationality of learning from each other's knowledge and experience among Annex I countries which have, to some extent, similar developmental stage, political system, and economic/social background.

Do the staff in charge of policy making really think that such a network is needed? This question was asked in a questionnaire that was presented to key participants in the 2009 Bologna Annual Meeting jointly by the Umweltbundesamt ("UBA"), or the Federal Environment Agency of Germany, which will host the 2010 Annual Meeting, and the LCS-RNet secretariat. In-depth responses were obtained from the government agencies of the U.K., Japan, Germany, and Italy (the government focal points). The main objectives of the questionnaire survey were to grasp the expectations of the participating governments more concretely and to reflect them in the 2010 Annual Meeting agenda and, more broadly, in future LCS-RNet activities. The very fact that this survey was conducted can be viewed as an indication of the strong interest the German government has in LCS-RNet. Created in 1974, UBA is the largest administrative body in Germany for environment matters. Its mandates include analysis, research, and development in the field of environment, and it also functions as a think tank to provide scientific support to environmental policies of the federal government.

4.1 Selection of research themes

Would you prefer the Network to focus on several particular aspects of Low- Carbon Society?

Yes: 3 No: 1

Comments attached to the affirmative responses included suggestions that duplication with other networks should be avoided, and (i) LCS-RNet should make differentiated efforts, and (ii) should choose one topic related to the themes for a project period of 1-2 years in view of the objectives and activities of LCS-RNet.

Suggested specific themes were: targets and trajectories; sustainable development; transformational pathways and political instruments to reach targets; technology, technology transfer, mitigation potentials, and energy efficiency approaches; green economy; economy & taxation; and behavioural change sociology.

With respect to theme selection, the importance of listening to the opinions of non-researchers was pointed out, by statements such as: that policy makers as well as researchers in the process of researches should participate in the theme selection process, and that dialogue and partnership with stakeholders are important.

Meanwhile, some expressed a concern that many other organisations are already engaged in

research programs on the themes of technology and the like and that focusing on some projects for each theme would not be the best option for LCS-RNet.

4.2 The need to develop a scenario

How important do you rate the development of a “2050 Scenario” for your country, and could the Network support you?

Important: 3

All agreed that it is “important.” Some respondents commented that many countries are now preparing 2050 scenarios, and accordingly, sharing of scientific knowledge among countries is all the more important. There was a more concrete suggestion that the G8 and the outreach countries share information as to how to promote energy shift. A respondent noted the importance of presenting policy makers with scientific guidance in line with IPCC works.

Countries are pressed with the unprecedented requirement to set 2050 reduction targets and identify policy pathways thereto. It is very important that countries cooperate by sharing each other’s knowledge and experiences in order to draw up workable and subsequently verifiable scenarios in a timely fashion with limited budgetary and human resources. Recognition of this challenging task and a strong sense of commitment to international cooperation are apparently reflected in the expectations expressed about the role of LCS-RNet through the responses to the questionnaire.

4.3 Style of LCS meetings

Should the Network meetings maintain an *informal* or a more *formal* character?

Informal: 3 Formal: 1

RNet in itself is a formal entity officially inaugurated under the G8 process. This question was directed to the format of RNet meetings---whether a more formal style is preferred or the current “casual” style should be kept. Those who favored the informal style added: that the network should time its meetings with the international negotiation timetable if it is to make inputs to international policy making processes, and that the informal format is preferable because the main purpose is to exchange ideas and information among researchers. Meanwhile a respondent who favoured the informal character added a certain degree of formality may be necessary only in aspects such as ceremonial sessions and openings with high politicians and business leaders in order to increase the international presence of the network.

One respondent who favored more formal meetings pointed out the necessity of an organisation’s constitution/charter including procedural rules, finances, and the organisational organs. It was suggested that the example of international collaborative partnership on energy efficiency might be of some reference because it is likewise launched under the G8 process and is hosted by a large international body, the International Energy Agency (IEA).

Participating research institutes generally agreed that LCS-RNet should be an informal forum in terms of not only activities but also organisational structure. The questionnaire survey revealed that the majority opinion of the government focal points was not different. It also revealed, however, that some believe strongly that the network should be transformed into a more formal organisation.

4.4 LCS-RNet and policies

Should the Network produce formal policy recommendations?

YES: 2 Maybe: 1 NO: 1

While the responses diverged somewhat, the affirmative answer that the Network should produce policy recommendations ranked first.

The responses confirmed that the Network’s recommendations should be relevant to policies but should not be prescriptive. A respondent stated that no more than strategic outlooks should be produced. Another wrote that recommendations should be made to G8/G20 on specified and

concrete themes.

4.5 Benefits of information exchange among industrialized countries

How important do you think policy learning between Annex I countries should be?

MOST IMPORTANT: 3 Somehow Important: 1

All respondents answered either “most important” or “somehow important.” Comments included: that policy learning and comparison of success and failure strategies of other countries are highly important, and that the Network should be expanded to non-Annex I G20 countries beyond Annex I countries. Some commented that Annex I countries in particular should learn from each other more in the aspects of long-term outlook, sociological analysis, and policies on change in individual behaviour (lifestyle), and that the added value of LCS-RNet would be increased by addressing those themes that have not been addressed by IEA or OECD.

The responses imply that there are still differences in knowledge among industrialized countries and policy makers are searching for effective methods to study and compare other countries’ experiences for possible reflection in their own policies. Policy decision-making directed toward a shift to low-carbon society requires a comprehensive review of numerous factors. The underlying thoughts behind these comments are believed to be: a sense of urgency in making low-carbon society policy decisions without waiting for its accumulation of one’s own national knowledge and policy experiences, as well as the genuine rationale for Annex I countries of similar development stages, political regimes, and socioeconomic backgrounds to learn from each other’s knowledge and experiences.

4.6 Connecting government focal points

The idea was brought up to found a government policy board to give input and address the Network with specific questions; what is your opinion on a government board?

Yes: 1

No: 1 No idea: 2

The apparent indecision indicates the importance the respondents place on scientific independence. Any such policy board would unlikely be able to give unified input, because policies vary from one country to another. A respondent commented that it is more important what policies the governments would formulate, taking into account LCS-RNet outputs.

Meanwhile, another respondent commented that interaction with any stakeholders (including government policy makers) should be welcomed.

4.7 Potential of LCS-RNet

How do you rate the potential of the Network?

High potential: 3

Middle: 1

The responses reflect the strong expectations placed upon the contributions of LCS-RNet. Concrete comments included: the need to produce policy relevant products in a timely manner, and the network of researchers providing knowledge for policy decision-making directed forward Factor 4 group. Some suggested participation in themes most needed by policy makers, but it would be difficult to restrict participating researchers on the basis of their academic specialization. While focusing is important, restricted membership would preclude exploration of new crosscutting research themes.

4.8 Expectations of the governments

What kind of input could the Network deliver for your Ministry?

Apart from the fundamental objective of knowledge sharing, some concrete suggestions were

obtained.

Regarding the scenario issue, recommending methodologies and tools for development of long-term pathways for countries was suggested. Regarding the policy issue, comparison of measures toward attainment of country objectives was requested. Another suggestion was impact evaluation of low-carbon society investment to the economy and assessment of the role of green economy for sustainable development. One specific suggested output was assessment of mitigation potential of innovative low-carbon technologies, but, as the responses to Questions 1 and 5 indicated, study in those areas would overlap with the work already being promoted by IEA or OECD and should preferably be avoided. A close examination would be in order, before LCS-RNet decides to go beyond information pooling and sharing, or considers how to differentiate itself from others.

One respondent wrote “dialogue and partnerships between officials and researchers.” This is indeed one of the three objectives of LCS-RNet, but dialogue and partnerships cannot be an output per se; they should rather be considered methodology.

4.9 Themes for the next LCS-RNet Annual Meeting

Which issues should the next annual conference cover?

Suggested topics varied including: low-carbon pathway, policies, green economy, behavioural change/demand reduction, energy, and technologies.

Perhaps reflecting the recession that has lingered since the 2008 worldwide credit crunch, respondents put green economy, economically beneficial climate policy, and other economy-related issues high on the list. Others added decarbonisation pathway and lifestyle change. Regarding scenarios, some suggested that the Network look into not just those to 2050 but also to 2100, while others proposed energy, technologies, consumer behaviour, demand reduction, and other specific issues related to 2050 scenarios.

And as projects extending over one to two years, respondents suggested: carbon tax and its impact on sustainable development in the field of economy & taxation; green growth on jobs and fair transition issues in the field of sociology; and deployment of low-carbon technologies to industrial and household applications in the field of technology.

4.10 Other matters of importance

Comments about the Second Annual Meeting included the following:

Most respondents were interested in enlargement of participating research institutes membership, especially those of developing countries (outreach countries and G20).

One respondent pointed to the need for dialogue between researchers/climate scientists and climate economists, writing “there is a problem of climate economists saying that it’s not going to be that bad, whereas climate scientists pray for catastrophe: as officials we need to get a clearer picture on the urgency of climate change.” This is indeed a candidly-expressed genuine expectation on the part of policy makers who are charged with the responsibility of designing the futures of their respective countries.

For governments that have their research institutes registered in the LCS-RNet, the most important question is what feedback is gained from the participation. The responses collected by the questionnaire survey will be taken into serious consideration when UBA, Wuppertal Institute (the research contact point for Germany), and the LCS-RNet secretariat prepare the agenda of this year’s Annual Meeting. In parallel, they will serve as a good reference for the steering committee in their drive toward generation of clearer and more beneficial outputs through the activities of the next few years.

5. Future direction of low-carbon society research

For the establishment of effective low-carbon world, individual countries strongly feel the necessity of integrated research in support of the policies. In addition, the importance and the benefits of international cooperation were also recognized at the Bologna meeting. Furthermore, the developed countries have began to think that it is desirable to establish policy research bases in the developing countries as mitigation in the developing countries is essential for the future climate stabilization. Under such circumstances, it is necessary for the International Research Network for Low Carbon Societies to do more activities for identification and sharing of research themes required for the policy, promotion of exchange between policy and research as well as among researchers, and intensified research activities in the developing countries.

The LCS-RNet secretariatis in the process of reconstructing the work plan for next year and beyond, based on the above-described background situation as well as the views expressed to the work of the Network grasped as a result of this year's work. The recent developments in the world climate policy scenes require the urgent establishment of research networks within a few years. The mission will be fulfilled if such networked activities become a standard among major institutes around the world. The general directions toward which future efforts should be headed are:

1. Promotion of further exchange among countries, between staff in charge of policy making and researchers, and among researchers;
2. Construction of research base particularly in developing countries that hold the key to successful global climate policies; and
3. Empowerment of research sector as to presenting its knowledge and findings to the policy making processes.

6. Considerations on basic indexes of low-carbon society and socioeconomic system

The LCS-RNet secretariat is engaged in a basic study that is needed to define the perspectives for review of low-carbon society works. A gist of findings during the year follows.

Summary of the paper:

Economy is represented by the index “GDP.” Low-carbon situation is represented by the GHG emissions. Insofar as the goal of low-carbon society is expressed in terms of economy or low carbon or both, neither the GDP nor GHG emissions, whether per capita or as a whole, can serve as the single universal index, because countries are all different in regard to population size, development stage, global technology efficiency, and efficiency of available technologies. If the low-carbon society is to possess certain socioeconomic driving force, and rather than to stay in equilibrium, keep moving on in pursuit of development and growth, the goal of such a society should be the enhancement of per capita GDP (feel rich-index) and the constraint factor should be the total GHG emissions with attention to climate stability. A low-carbon society moving forward in socioeconomic terms will seek, for example, to increase the per capita GDP of its economic members, and not total GDP, which simply measures the total size of its economic system. It is suggested that the current economic system that is structured to pursue growth of its total GDP would have to eventually be replaced by a new kind of socioeconomic system.

Wataru MACHIDA, Kyoko MIWA and Shuzo NISHIOKA

LCS-RNet Secretariat,
c/o Institute for Global Environmental Strategies (IGES),
2109-11, Kamiyamaguchi Hayama, Kanagawa, JAPAN, 240-0115
Fax: (81 46) 855 3808, E-mail: LCS-RNet@iges.or.jp

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1 The article , "Low Carbon Society embedding or embedded in Economy?; Speed of indicators or Direction against the constraint", was submitted and accepted to Journal of Renewable and Sustainable Energy, American Institute of Physics (forthcoming). The paper was abstracted to be included in this Annual Report.

1. INTRODUCTION: What is LCS and how to approach this in this paper

What is Low Carbon Society (LCS)? One of the definitions of LCS is that made in NIES (2006). A Low Carbon Society; 1) takes actions that are compatible with the principle of sustainable development, ensuring that the development needs of all groups within society are met; 2) makes an equitable contribution towards the global efforts to stabilize atmospheric concentrations of carbon dioxide and other green house gases at a level that will avoid dangerous climate change through deep cuts in global emissions; 3) demonstrates high levels of energy efficiency and uses low-carbon energy sources and production technologies, and 4) adopts patterns of consumption and behavior that are consistent with low levels of GHG emissions.

There can be several ways to interpret such definition into quantitative term, but in this paper, Low Carbon Society is described by using phase diagram with several numerical indicators from IPAT equation where environmental impact (I) is calculated from Population (P), Affluence (A) and Technology (T). In this manner, the goal, achieving LCS, is rather mechanically translated into objects and constraints; the three objects (i.e. GDP, GDP per capita and non-economic indicator such as happiness index) and the two different types of constraints (i.e. emission and emission per capita). Each choice on objects and constraints of LCS results in each different argument and logic.

2. PROBLEM DEFINITIONS and RESEARCH QUESTIONS

2.1. Problem Definition 1: Economy is not everything for Low Carbon Society

In Japan, the two scenarios toward Low Carbon Societies in 2050 were illustrated (Nishioka, 2008: NIES, 2008a: NIES 2008b); Scenario A as active, quick-changing, and technology oriented society and Scenario B as a calmer, slower, and nature oriented society. To connect the past, the present and the future, the historical data of GDP/capita, CO₂ emission/capita and population since 1950 and the results of the two future scenarios in 2050 are integrated in [Figure 1](#). The two questions are worth considering from this figure.

The first question is about whether the object of Low Carbon Society is GDP or GDP/capita. As in Stern Review and the Green Golden Rule (Chichilnisky, 1995), GDP rather than GDP/capita has been the main object for discounted utilitarianism which is widely used approach by economists. This tradition can go back to the underlying moral principle for legal and social reforms in the 18th century, proposed by Jeremy Bentham, *the greatest happiness for the greatest number*, where the happiness can be interpreted as GDP/capita and the number as population.

Meanwhile, in Millennium Development Goals (MDGs, United Nations (2008)), the indicators are more related to per capita; the economy of each individual rather than the aggregated national economy is the object. Human Development Index (HDI), as summary measure of human development, also adopts GDP per capita (UNDP, 2009)

Does Low Carbon Society have priority over GDP for the whole economy or over GDP per capita for each individual? The rationale to pursuit GDP per capita could be based on human development and happiness for each individual. Meanwhile, one rationale in the economic theories for setting GDP as object (to maximize) would be that our society behaves so within the current market system. And maximizing GDP and GDP per are not always consistent to each other.

The second question is about whether the main object of Low Carbon Society can be measured by economic indicators such as GDP and GDP/capita. In [Figure 1](#), Scenario A results in much higher GDP and GDP per capita than Scenario B, mainly because of the higher GDP growth rate. However it might be the case that a society might prefer Scenario B, regardless of its lower GDP and GDP per capita. For instance, Karl Polanyi, in

1 For history and academic discussion on IPAT equation, read Chertow (2001)

2 Data from Gapminder (2009)

3 Regarding the level of aggregation, Stern Review team (2007) wrote as follows;

“Much of the discussion of values in this note and in the literature takes place at a high level of aggregation. Thus it considers total world consumption or income or aggregate country level income. There is often little distinction between different kinds of goods or allocation of individuals’ income across different periods of their lives. And in much of the formal modelling the attention to within country distribution is very limited”.

his book, *The Great Transformation*, pointed out three general types of economic systems that existed before the society was embedded into free market economy: redistributive, reciprocity and householding. (Polanyi, 1944).

What are the indicators to properly illustrate Low Carbon Societies in addition to economic ones (i.e. total GDP and GDP/capita)? This has not been answered yet.

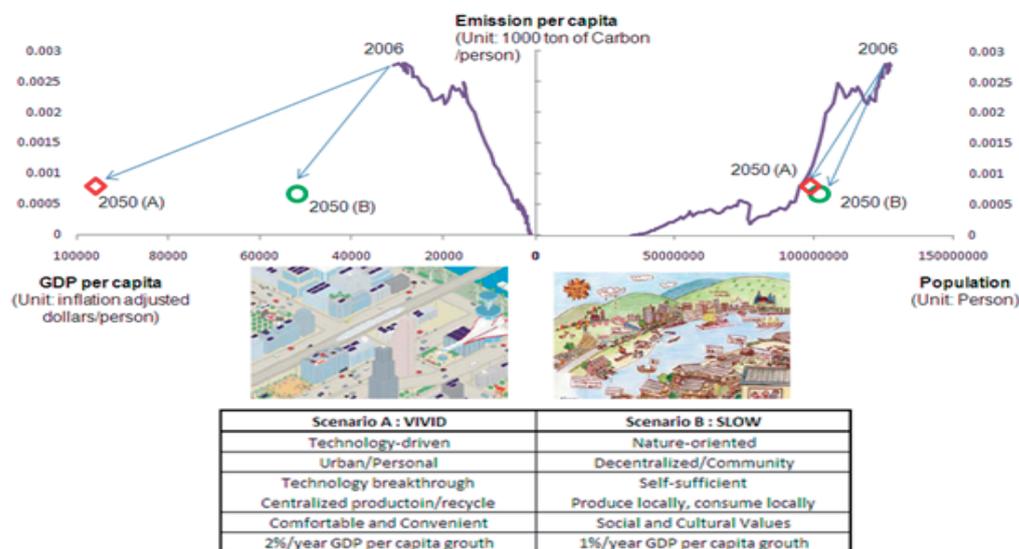


Figure 1. Historical path and future scenarios in Japan toward Low Carbon Societies in 2050

2.2. Problem Definition 2: Speed on the Constraint or Liberation from it?

Low Carbon Society would have a constraint on total GHG emissions. In numerical modeling, the optimal solution is often found on the constraint, especially when the objects and constraints are assumed to be in trade-off relation. For instance, if the limit of GHG emissions is 50 giga ton of CO2 equivalent, the optimal solution for the economic growth would be also when 50 giga ton is emitted. However, this depends on the assumptions. For instance, Figure 2 shows three paths (Business as Usual, Low Carbon Technology and Intensive Low Carbon Technology) and the constraint on emission, starting from $t = 0$ (A0, B0 and C0). On the path of BaU, the economy cannot grow after $t = 1$ (i.e. A1), since A2 is beyond the emission constraint. Thus, from A1, the economy has to make transition to the path with Low Carbon Technology. When $t = 2$, it can be in the same position of B1 (i.e. A2') or B3 (i.e. A2''). If the latter is the case it can be said that taking the path closer to the constraint is more optimal, because it is quicker to arrive at the same location. However, if the former is the case, taking the path away from the constraint is faster for the rapid growth of GDP. When $t = 1$, if the speed of GDP growth is what to be maximized, A1 is better than B1 and C1. However, for the later periods, C1 might be the best; the direction away from the constraint is important especially when transition into more low carbon technology takes some cost.

Regarding technology transfer, low carbon infrastructure, lock-in effect and technology leap-frog, it is often said that developing countries have more opportunities than the developed ones, since they have late-comer advantage as their society, economy and technology have not been locked in unsustainable ways. For instance, suppose that developing countries stands on A0 and developed countries in A1 in 2010. If the goal is to reach C6 and changing the directions between the three paths would take time and cost, then developing countries could move on C1 and reach C6 and even might reach the goal quicker than the developed countries. The important message here is that if developing countries take the same paths that developed ones had already passed, then they would also have to be running on the constraint. Also notice that if developed countries help developing ones to take the path of intensive low carbon technology, then developed countries can push the constrain from their own paths.

In addition to the issue of the cost of transition, the assumptions on objects and constraints determine if trade-off would appear or not. For instance, the slope in the upper-left of Figure 6, later discussed, shows the trade-off between total GDP and total emission, while the slope in Figure 7 represents the trade-off between GDP

4 GDP per capita in 2050 of Nishioka (2008) is converted into Purchasing Power Parity by the values in 2000 of Nishioka (2008) and Gapminder (2009).

per capita and Emission per capita. Thus, if the object is GDP per capita and the constraint is total emission, then the trade-off between them might not necessarily exist.

Will a Low Carbon Society be a society right on the threshold which does not violate the constraint, or a society liberated from such constraint? In this paper, the latter, the path to avoid the constraints, are further analyzed.

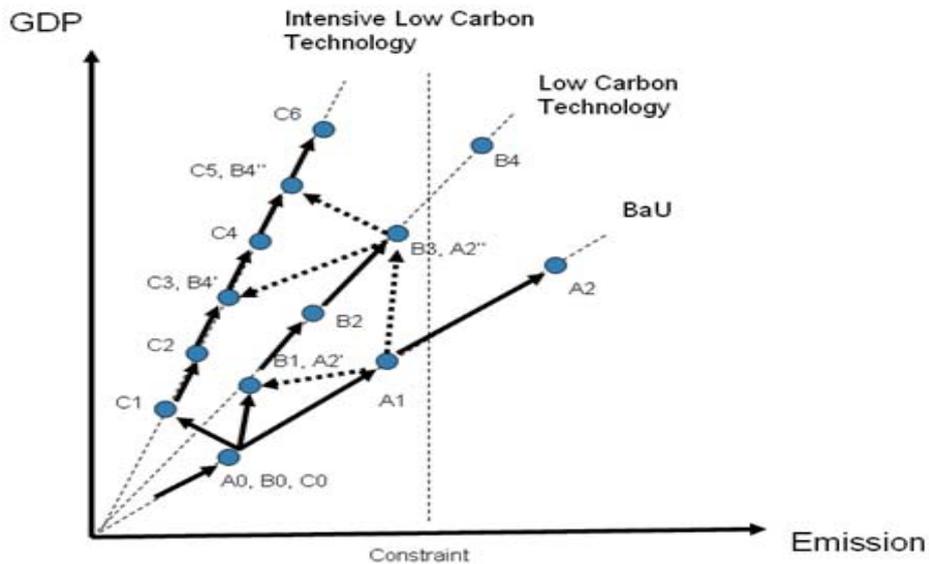


Figure 2. Paths and constraint

2.3. RESEARCH QUESTIONS

Considering these problem definitions, the following two research questions are derived.

Research Question 1: Starting from IPAT equation, what are the basic indicators, objects and constraints to shape the arguments of Low Carbon Societies?

Research Question 2: What are the historical paths of several countries and what can be said for their future paths toward Low Carbon Societies?

3. DATA and METHODOLOGIES

As for methodologies, the concept of IPAT equation is employed as the start of the argument by decomposing the emission (i.e. environmental impact) into each variable (i.e. population, affluence and technology) and has been developed into the use of phase diagram to geometrically analyze paths from the past to the future, while defining the object of the model (e.g. GDP, GDP per capita). IPAT variables are employed in this paper because each variable in IPAT equation is in scalar value so that several variables can be shown simultaneously in phase diagram and also because the equation is very similar to the structure of Input Output Analysis and Life Cycle Assessment (LCA), which model the material balance of economic system.

Most of the data are obtained from Gapminder (2009), such as GDP/capita (in Purchasing Power Parity), CO₂ emission per capita and population, since it has the consistent dataset covering many countries, many different types of economic, environmental and social indicators and long time series (e.g. from

5 For details about these similarities, see Heijungs (2001) and Heijungs and Suh(2002)

18th century for GDP/capita). Especially preparing the data for longer time scale is important, because time scale would define the nature of argument.

For instance, historical data on population is shown in [Figure 3](#) (with logarithmic scale).

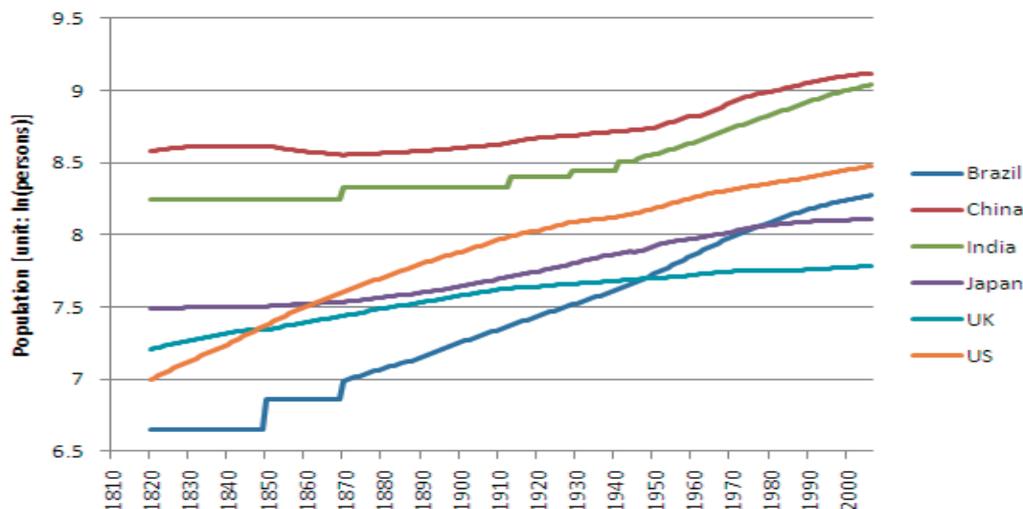


Figure 3 Historical Population

In the end of 20th century, the rates of population growth in China and India are higher than those of US, UK and Japan. However, if we consider the whole 19th and 20th centuries, this is not the case. For example, that of US is much higher than that of China. And those of China and UK are similar to each other. Notice that in logarithmic scale, the slope corresponds to growth rate (of population).

4. ARGUMENTS and RESULTS

4.1. IPAT equation and Basic Indicators for LCS

As IPAT equation has been chosen to derive basic indicators to be used in this paper, first this equation is explained in this section. IPAT equation is described as follows.

$$\text{total CO}_2 \text{ emission} = \text{Population} \times \text{Affluence} \times \text{Technology intensity}$$

$$= \text{population} \times \frac{\text{total GDP}}{\text{population}} \times \frac{\text{total CO}_2 \text{ emission}}{\text{total GDP}}$$

These indicators in IPAT equation correspond to main variables in economic models such as General Equilibrium.

In addition to these variables, land per capita would be important variable for considering Low Carbon Societies, partly because the visions of LCSs are strongly related to how they use lands as seen in the illustrations of two different scenarios in [Figure 1](#), and partly because land has been one of the principal elements among economists from the past, such as François Quesney who made *Tableau Économique* in 1759 and to the present such as ecological footprint. Also in LCS-RNet annual meeting in bologna in 2009, it was pointed out that terrestrial policy is one of the key issues to achieve low carbon society (LCS-RNet, 2009).

[Figure 4](#) shows territorial size of each country (unit: square kilometer) divided by population in arithmetical scale. Variation of quality of land (e.g. suitability for farming, living and extracting other natural resources) is not considered at all for simplification, but, solely from this figure, it could be possible to reason that the decrease of land/person is saturated in UK, India and Japan with current

6 For details and variations of IPAT equation, see Chertow (2001)

technology, China is getting close to it, while lands of Brazil and US have more capacity for population.

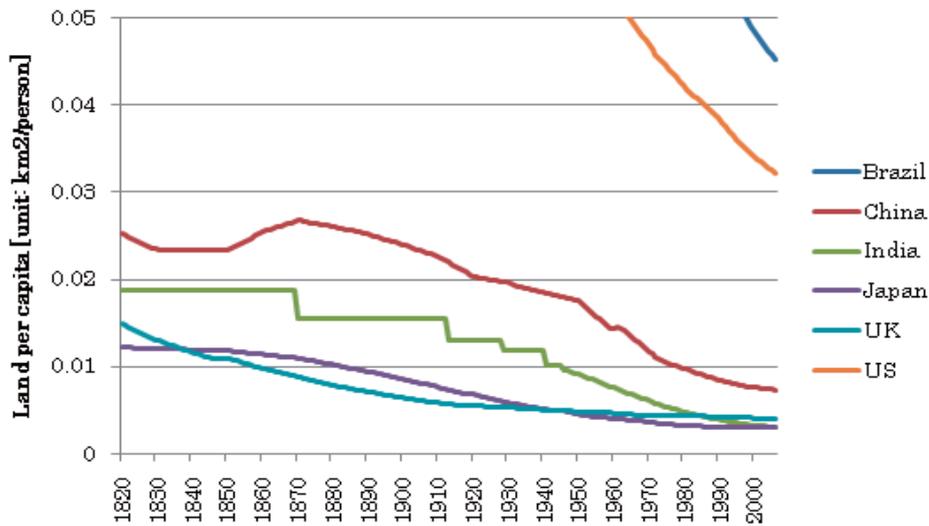


Figure 4. Historical Data of Land per capita

4.2. Framing Objects and Constraints

As already discussed in the first of problem definition, the three different kinds of objects are set for considering the paths for Low Carbon Societies; GDP, GDP per capita and indicators such as Human Development Index and Satisfaction with Life Index (named Social Indicators)..

As for the constraints, emission (e.g. unit: ton) and emission per capita are chosen. Indicator of land, square km per person, is important both as amenity (i.e. object) and constraint, but the further numerical analysis on land is out of the scope of this paper.

How can one choose between the constraints; total emission and emission per capita? If the carrying capacity of GHG absorption in the environment is the start of the logic, one would choose total emission as the constraint. If he starts from the logic that GDP per capita shall be the same for any individual thus one might say that the constraint on emission shall be also based on per capita and emission per capita would be proper. Meanwhile, this paper also will introduce a case where GDP per capita is the object while total emission is the constraint (Case C in Table 1, discussed later).

Base on these objects and constraints, the five different cases are analyzed as illustrated in Table 1.

Table 1. Five cases with different objects and constraints

	OBJECT	CONSTRAINT	Low Carbon TECH	OTHER VARIABLES
Case A	Total GDP	Total emission	Yes	Population
Case B	Total GDP	Emission per capita	Yes	Population
Case C	GDP per capita	Total emission	Yes	Population, Affluence
Case D	GDP per capita	Emission per capita	Yes	Population, Affluence
Case E	Social indicator	-	-	-

7 These social indicators are also affected positively by GDP/capita, for instance, since HDI consists of life expectancy index, education index and the value calculated from GDP per capita. Thus social indicators do not mean that they exclude economic ones but rather that economic indicators are embedded in social ones.

For Case E, the biographical path of population, affluence, technology and impact is not analyzed and discussed, but it is shown in Figure 5 that the correlation between GDP per capita and social indicators is not always clear (e.g. Japan) As shown in Figure 1, visions toward low carbon societies would not be depicted solely by economic indicators. While taking into account of the limitation of economic indicators to illustrate low carbon societies, Case A-D will be further analyzed in the following sections, by setting the objects of societies as GDP or GDP per capita.

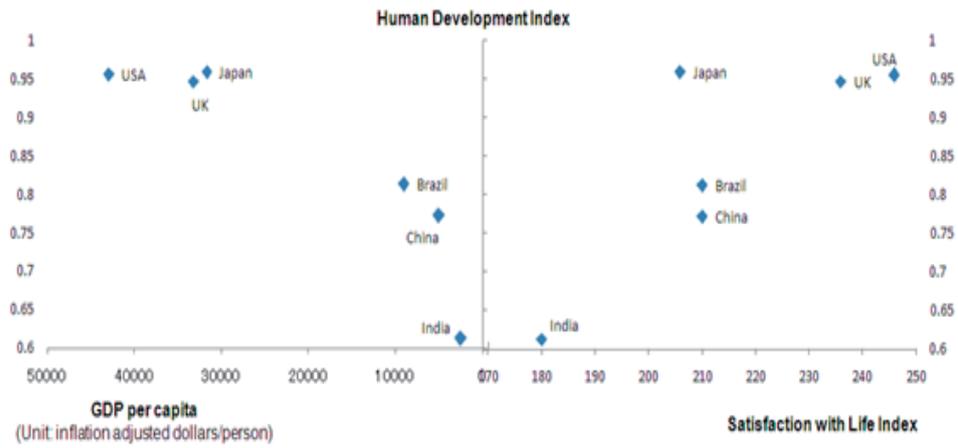


Figure 5. Correlation between GDP/capita and social indicators ⁸

4.3. Historical and Future Paths toward LCS

For an example, paths for China and USA are shown. First, Case A and B are analyzed and discussed in Figure 6.

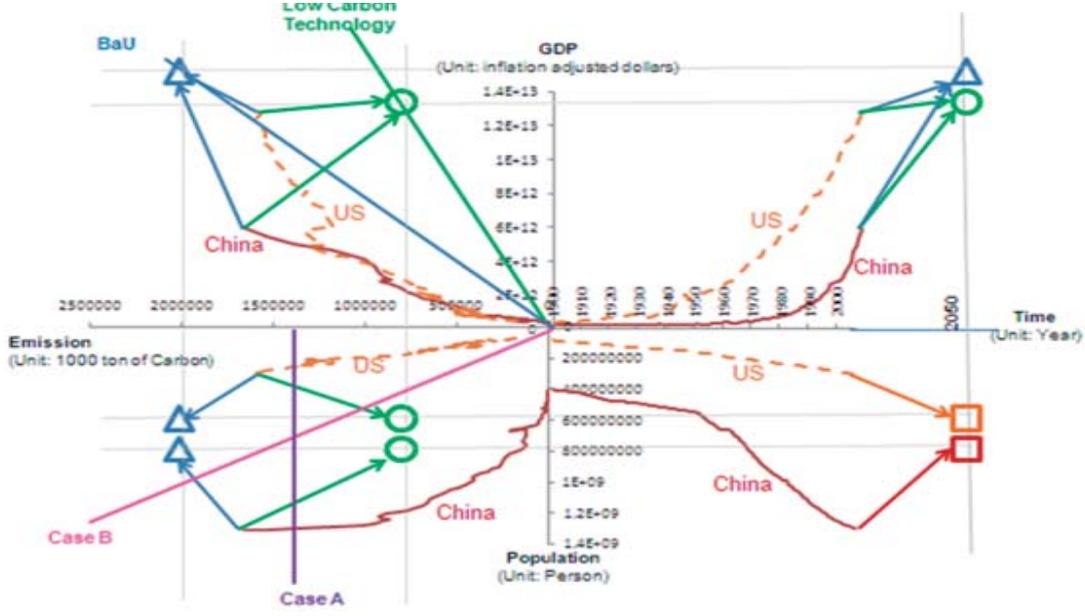


Figure 6. GDP is Object for society (Case A and B)

The path of each country is drawn for the past (1900-2006) and for the future (to 2050). Targets of GDP and population in 2050 are on the right side of the figure. The efficiency of technology is given by the slope in the

⁸ GDP per capita (PPP) comes from Gapminder (2009) for the year 2007, Human Development Index comes from UNDP (2009) for 2007, and Satisfaction with Life index from White (2007) for 2006.

upper left part. In the bottom left part of the figure, the constraint of total emission is parallel to y-axis (for Case A), while that of emission per capita is the slope (for Case B).

The behavior of this figure is based on the assumption that GDP and technology affect total emission, not population, since GDP itself is given exogenously regardless of population. This can be expressed by changing IPAT equation into $I = GDP * Technology$ because $Population * Affluence = GDP$.

This could lead to an unsustainable outcome for the constraint of emission per capita (Case B); if other things (e.g. GDP and technology) are the same, the more population, the less emission per capita. And more population enables more total GDP, emitting more emission.

For the constraint of total emission (Case A), when the target of GDP is set, technology is the only variable that can be adjustable to meet the object. From this logic, it can be said that Low Carbon Society can be achieved by Low Carbon Technology and the target of total GDP, not by other socio-economic elements such as population and affluence. The problem of this case is that the target, total GDP, cannot be continued to increase if technology development is saturated. Next, Case C and D are shown in [Figure 7](#).

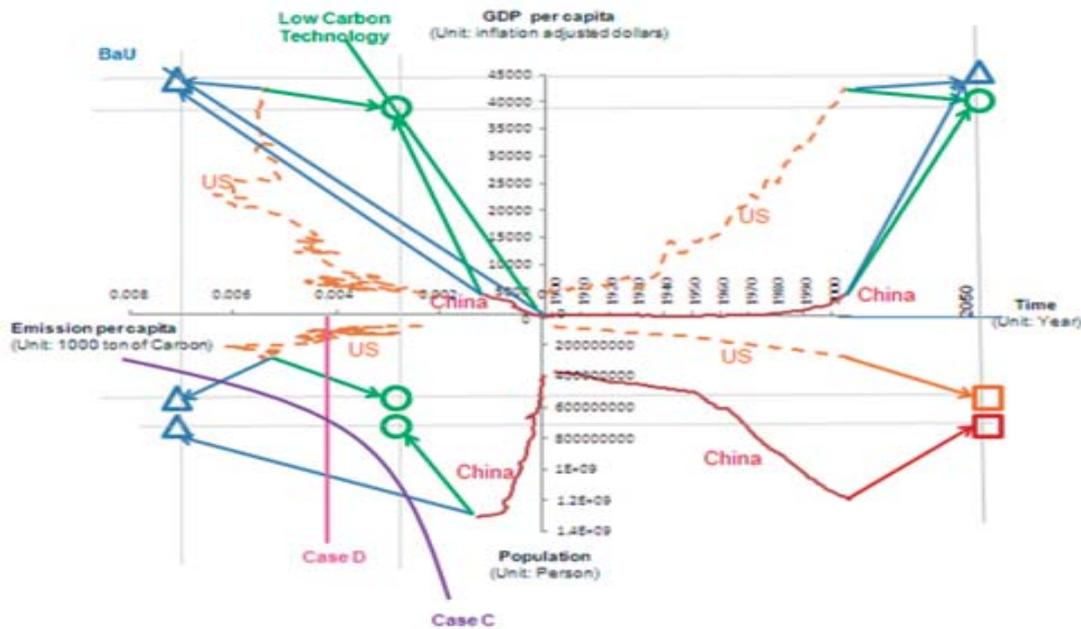


Figure 7. GDP per capita is Object (Case C and D)

Targets of GDP per capita and population in 2050 are on the right side of the figure. The efficiency of technology is given by the slope in the upper left part. In the bottom left part of the figure, the constraint of total emission is the curve ($A * P < constraint$) (for Case C), while that of emission per capita is parallel to y-axis (for Case D). When GDP per capita, not total GDP is set as target, the situation is different from case A and B. For the constraint of emission (Case C), not only technology but also population are the elements to be adjusted to achieve the target, affluence. Notice that perusing affluence does not necessarily go together with the growth of total GDP. For the constraint of emission per capita (Case D), only technology affects whether the constraint is satisfied or not. The problem of this case is the target, affluence, cannot be continuously increased because of the constraint.

The outcomes of the logics for these four cases are summarized in [Table 2](#).

It is important to notice that the strategies on population changes very widely based on the assumption on object and constraint. These results suggest that not only GDP and technology but also socio-economic indicators such as affluence and population shall be properly integrated in consistent visions and strategies toward Low Carbon Society.

From the view that the carrying capacity of the climate is well expressed in total emission which shall be the constraint, Case A and C are feasible, while Case B and D focus on the equity of responsibility.

From the assumption that economy behaves to maximize GDP regardless of visions toward low carbon societies, Case A and B are feasible, while Case C and D considers more on individual rather than the economy as a whole. GDP per capita can be also interpreted into the human rights to develop.

From the notion that trade-offs which might arise from the efficiency of technology shall be disappeared in objects and constraints, Case B and C are feasible, since population can be increased or decreased to get liberated from the constraint. Meanwhile, if one thinks that standing right on constraints are the mother of efforts,

development and progress, then Case A and D would be better.

From the logic that the carrying capacity of land is limited and less population is better, then Case B is not proper.

Thus, for instance, Case C satisfies the principles of the carrying capacity of the climate and land (i.e. total emission and land per capita have to be lower than certain threshold), human rights to develop (i.e. GDP per capita growth is not constrained), but not necessarily the nature of the free market to maximize GDP.

Table 2. Strategies of Technology and Population for each different object and constraint

	OBJECT	CONSTRAINT	Technology	Population
Case A	Total GDP	Total emission	More efficient	Not Affecting the Object
Case B	Total GDP	Emission per capita	More efficient	More Population
Case C	GDP per capita	Total emission	More efficient	Less Population
Case D	GDP per capita	Emission per capita	More efficient	Not Affecting the Object

5. CONCLUSION and DISCUSSION

Research questions have been answered as follows.

Research Question 1: Starting from IPAT equation, what are the basic indicators, objects and constraints to shape the arguments of Low Carbon Societies? Answer: as for the indicators, in addition to IPAT variables, another indicator, land per capita, is important for Low Carbon Society. For object, in addition to total GDP and GDP per capita, social indicators such as Human Development Index and Satisfaction with Life index are worth considering. For constraint, the rationale of constraint on emission (ton) and emission per capita (ton/capita) shall be given consistent logic between them, regarding the carrying capacity of climate and equity issue.

Research Question 2: What are the historical paths of several countries and what can be said for their future paths toward Low Carbon Societies? Answer: Not only GDP and technology but also socio-economic indicators such as affluence and population shall be properly integrated in consistent visions and strategies toward Low Carbon Society.

The four combination of the two objects (i.e. total GDP and GDP per capita) and constraints (i.e. total emission and emission per capita) are analyzed in phase diagram. For instance, the case of GDP per capita as object and total emission as constraint (Case C) satisfies the principles of the carrying capacity of the climate and land, human rights to develop, but not necessarily the nature of the free market to maximize GDP.

Also it is worth considering about if the optimal solution toward Low Carbon Society can be found on the constraint or away from such constraint. If changing the direction of the path with low carbon technology development takes time and cost, institutional arrangement would be additionally necessary in addition to market mechanism where optimal solutions are found on constraint.

The two problems were defined in this paper; 1) Economy is not everything for Low Carbon Society and 2) Speed on the Constraint or Liberation from it? These problem definitions were not solved fully in this paper. However, the research questions and answers lead to the starting point for the discussion on these problems. Especially, the case C where the object is GDP per capita, the constraint is total emission and the population is going to decrease is interesting setting for the future research, since this assumption does not seem to contradict to the one of the definitions of Low Carbon Society cited in the beginning of the paper. The challenge of such society would exist in how to balance between social object (i.e. GDP per capita), nature of market to maximize total GDP, environmental carrying capacity of the climate and land (i.e. total emission and square kilometer per capita) and human population.

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Appendix: List of reference materials

- 1) Synthesis Report of the Bologna Meeting
- 2) Synthesis Report of the Bogor Workshop
- 3) Report of the Stakeholders Dialogue in Yokohama
- 4) A Dozen Frequently Asked Questions from decision makers to modelers: Japan's case
- 5) "Low Carbon Society Research Network : Questionnaire for Government Focal Points and Observers" by the German government focal point
- 6) Machida, W., K. Miwa, S. Nishioka (2010) Basic Indicators of Low Carbon Societies and Socio - economic system

Reference Paper