Z650

November, 2011

CIGS Symposium on

Globally Sharable CO_2 Reduction Target against Global Warming

- 2011/9/16 brief report-

CIGS キヤノングローバル戦略研究所
The Canon Institute for Global Studies

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本シンポジウムの総括 Summary of the symposium
共有された認識 Common understanding

地球温暖化抑制に関する国際的な合意が見通せない現状を踏まえて、我々専門家と実務者が危機感を持って集まり、新たな気候変動の科学的知見と其の示唆、新たな温室効果ガスの排出シナリオと其の実現のための新たな国際協力メカニズムの構築について議論し、次の共通認識を持つに至った。

Considering the absence of clear vision on international agreement to combat global warming, we, specialists and persons in charge, came together with a sense of crisis. Through discussions on the new scientific knowledge on climate change and its suggestion, the new scenario of greenhouse gases emissions and the new international mechanism for realizing the scenario, we have reached the following common understandings.

１． 気候変動の科学に基づいて、オーバーシュートシナリオを考慮した、実現可能な温室効果ガスの排出シナリオを支持する。

To support the feasible scenario of greenhouse gas emissions on the basis of the climate change science while taking into account over shoot scenario.

２． エネルギー起源の二酸化炭素の排出シナリオのもとで世界全体の最適化（コストミニマム）により、長期エネルギービジョンと排出分担を追求し、投資とメリットがバランスするエネルギービジョンの提案を歓迎する。

To pursue the long-term global energy vision by the global optimization of mitigation costs of carbon dioxide under the energy related low carbon dioxide emission scenario. To welcome the vision that is balanced between additional investments and fuel saving benefits.

３． オープンでフェアかつ効率的な仕組みによって低炭素技術の普及を国際協力により進める。温暖化を抑制し、経済成長と両立するエネルギービジョンの実現につとめることを共有する。

To promote the deployment of low carbon technologies through international cooperation based on an open, fair and efficient international mechanism. To share the will of realizing the energy vision in which economic growth and global warming control would co-exist.

４． 国際的な討議の場を通して、世界で共有できるビジョンとして受け入れられることが望ましい。

The vision is to be shared through international discussions.

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Preface

The Canon Institute for Global Studies organized its first global warming symposium in October 2009. We wanted to hold this second conference earlier but various developments including the March 2011 great earthquake and tsunami have delayed the convening of this conference.

Although there was some progress at COP15 in 2009 and COP16 in Cancun 2010, it was not significant. COP17 will be held in Durban South Africa at the end of the year. While the world is hoping for more substantive progress, various interests will clash as in any political discussion. However, there needs to be a common scientific base of knowledge shared by all of the participating countries concerned. We believe that a shared scientific understanding would lay the foundation for substantial progress.

Turning to the issues that Japan faces towards 2020, Taro Aso committed to a 15% emissions reduction by 2020 when he was the Prime Minister. A working group was formed to review scientific as well as socioeconomic factors and provide a scientific basis for this target. Professor Yoichi Kaya played a key role in that process. After the DPJ, Democratic Party of Japan came to power, they committed to 25% reduction from 1990 levels that was not necessarily fully based on science. The important thing is to have solid science-based commitments otherwise there won’t be confidence in the feasibility or the reliability of the commitment.

Keeping this in mind, during this symposium we would like to look at what could happen at COP17 later this year. We hope that we will be able to contribute scientific information that could help decision makers there. Various long-term scenarios for reducing greenhouse gas emissions and the best energy mix scenarios for energy strategies to achieve these reductions will be reviewed. We hope to be able to reach a shared understanding and consensus on the science and scenarios.

The situation for nuclear power after the Fukushima accident last spring has become more difficult. Cost is key factor when various energy sources are compared in developing the energy mix. The accident has clearly shown that the cost characteristics are among various extremely difficult issues. We would appreciate consideration of the issues and future role for nuclear power in addressing the global warming issue.

We were pleased to have this group of outstanding specialists consider these issues from a range of viewpoints in a free and open discussion.

Toshihiko FUKUI

Program

Opening (10:00-10:15)

Toshihiko FUKUI, President, CIGS

Session 1: "Need for a globally sharable CO_2 reduction target" (10:15-12:15)

1) "Timescales and Processes in Climate Change: Transience, Persistence, Irreversibility, and the Surprising Roles of Different Greenhouse Gases"

Dr. Susan Solomon, Adjunct Professor, University of Colorado, Boulder, US

2) "Stabilization of the CO_2 concentration via overshoot followed by zero-emissions - Possibility of new emission pathway to stable climate -"

Dr. Taroh Matsno, Principal Scientist,
Japan Agency for Marine-Earth Science and Technology (JAMSTEC)

3) Discussion

Session 2: "A Globally Sharable Vision against Global Warming" (13:30-14:40)

1) "A Globally Sharable Vision against Global Warming"

Dr. Carlo Carraro, President, University of Venice, Italy

2) "Proposal from CIGS"

Dr. Tetsuo YUHARA, Research Director, CIGS, Japan

Session 3: Discussion (14:50-16:55)

Moderator: Masakazu Toyoda, Chairman and CEO,
The Institute of Energy Economics, Japan

Main Discussants:

- Mr. William C. Ramsay, Senior Fellow, the French Institute of International Relations, France
- Mr. Dadi Zhou, Former Director-General, Energy Research Institute, National Development and Reform Commission, China
- Prof. Yasumasa Fujii, Professor, Dep. of Nuclear Engineering and Management, Graduate School of Engineering, the University of Tokyo, Japan

Session 4: Summary and wrap up (16:55-17:30)

Dr. Tetsuo YUHARA, Research Director, CIGS, Japan

Closing

Toshihiko FUKUI, President, CIGS

Executive Summary

As a new international agreement to control global warming appears to be unlikely, the Canon Institute for Global Studies convened an international symposium with participants including experienced climate change researchers from the academic community, specialists in global warming countermeasures and energy policy as well as working level experts with experience in building social consensus. The technical and economic feasibility of a new scenario for greenhouse gas emissions and approaches for a new international mechanism to implement the scenario were discussed and a sharable vision was considered.

Session 1: Need for a long-term comprehensive approach to global warming- Message from Climate Science

Dr. Susan Solomon, Adjunct Professor, University of Colorado, Boulder and former Co-Chair of IPCC WG 1 presented the science for long-term processes for climate change caused by anthropogenic emissions of greenhouse gases. Dr. Taroh Matsuno, Professor Emeritus, University of Tokyo and Principal Scientist, Japan Agency for Marine-Earth Science and Technology (JAMSTEC) proposed a new scenario for CO_2 emissions based on recent research results.

Dr. Susan Solomon began her presentation "Timescales and Processes in Climate Change: Transience, Persistence, Irreversibility, and the Surprising Roles of Different Greenhouse Gases" by discussing the evidence for global warming and the large role played by anthropogenic emissions of carbon dioxide. Analysis of the climate change process for a IPCC greenhouse gas stabilization scenario showed that the transient response while concentrations were rising would be only about half of the equilibrium temperature rise. Temperature rise would continue even after the stabilization concentration was reached and the possibility of an overshoot scenario[1] was noted. However, the natural carbon cycle process is slow and unless drastic reductions in emissions are expected, she commented that overshoot should be considered very cautiously. A new framework for considering carbon dioxide emission control to mitigate climate change, cumulative carbon emissions, was introduced. It was stressed that cumulative carbon emissions controls the global climate system in the long term. New research results were introduced showing that if the cumulative emissions during the 21st century were the same and near zero emissions were achieved by 2100, the temperature rise would be the same even if the emissions pathways differed. Finally, the need for low carbon technologies to reconcile economic growth

[1] A scenario where large short-term emissions of CO2 result in temporarily exceeding the targets for atmospheric CO2 concentration and temperature. After this, emissions are reduced to a level below the absorption capacity of the earth and the concentration and temperature rise gradually decrease.

with controlling climate change.

Dr. Taroh Matsuno began his presentation "Stabilization of CO_2 Concentration Via Overshoot Followed by Zero-Emissions – Possibility of New Emission Pathways to Stable Climate –" by reconsidering the traditional stabilization concept from a long-term perspective on climate change. He identified the issue in the traditional stabilization concept where after drastic reductions in CO_2 emissions, continuing anthropogenic CO_2 emissions would maintain relatively high atmospheric CO_2 concentrations and temperature. In contrast, he proposed a new "zero emission stabilization" concept where anthropogenic CO_2 emissions in the near future would be reduced below the world's natural absorption capability (zero emission). Furthermore, this new concept, the overshoot scenario and cumulative emissions control were combined to proposed a more practical CO_2 emissions pathway, the Z650 scenario. In this scenario, the cumulative emissions for the 21st century are set at 650 GtC and it is assumed that zero emission is achieved by the mid 22nd century. Simulation using a simplified climate model showed that in the Z650 scenario, after the atmospheric greenhouse gas concentration reached about 530 ppm, it gradually declined until it stabilized at 410 ppm. Temperature rise reached 2.3°C and then gradually declined to about a 1.7°C rise. It was also reported that melting of Greenland ice sheet, sea level rise, etc. were about the same as for the IPCC 450 ppm stabilization scenario. As more CO_2 emissions could be allowed through 2050, this would be highly feasible from a socio-economic standpoint.

Session 2: A Globally Sharable Vision against Global Warming

Dr. Carlo Carraro, President and Professor of Environmental Economics, Ca' Foscari University of Venice, Vice Chair of IPCC Working Group 3 and Dr. Tetsuo Yuhara, Research Director of the Canon Institute of Global Studies and Project Professor, Tokyo University proposed a globally sharable vision for controlling global warming.

Dr. Carlo Carraro in his presentation "A Globally Sharable Vision against Global Warming" presented policy options to address the international political target of 2°C [2] based on the 450 ppm target based on analysis of feasibility and necessary conditions. Currently atmospheric GHG levels are about 430 ppm CO_2 -eq and it has been reported would reach 450 ppm within six years regardless of agreements at COP17. If atmospheric levels reach 550 ppm, it has been reported that technology for removing CO_2 from the atmosphere would be necessary to maintain the 2°C target. Based on this background, three policy options were presented. Option 1 was for all major emitting countries to cooperate to implement action to reduce emissions to control atmospheric

[2] Global average temperature rise over the pre industrial revolution level should be limited to less than 2°C.

CO_2 levels below 450 ppm. However, the lack of international agreement, the difficult of changing the energy system mix, lack of essential technologies and other problems meant that the feasibility was low and the negative economic impact was assessed. Option 2 was to promote technically and economically desirable emissions and allow atmospheric GHG levels to overshoot to 550 ppm and then reduce levels below 450 ppm by large scale use of negative emission technologies. However, recent calculations show that the required arable land for the main negative emission technology, biomass CCS, would be greater than 50% of the world' arable land in 2050 and increase to two thirds in 2100. Given the limits to increases in agricultural productivity, the feasibility was judged to be low. Option 3 proposes the gradually adoption of adaptation measures as the effects of climate change cannot be prevented with mitigation measures. The above shows that achieving the 2°C target and 450 ppm target will be extremely difficult. Finally, he discussed the need for rapid reduction action, large-scale investment in the energy sector, development and diffusion of low carbon technologies and steady promotion of adaptation measures to address global warming.

Dr. Tetsuo Yuhara presentation "Zero-Emission Scenario: Energy portfolio, Emission Pathways and Costs based on Global Optimization" reported research results from The Canon Institute for Global Studies Energy Research Working Group. The Z650 scenario based on climate science proposed by Dr. Taroh Matsuno was reintroduced as a global sharable vision against global warming. Focusing on the CO_2 emissions from energy that accounts for most of the anthropogenic greenhouse gas emissions, global optimization scenarios were considered using an energy model and feasible technologies were shown. Industrialized countries will maintain primary energy consumption level while the energy mix shifts from primarily fossil fuel to primarily renewable energy. The continuing large growth in primary energy supply for developing countries will be provided mainly by renewable energy and nuclear. This will result in the proportions for fossil, nuclear and renewable in the global primary energy mix shifting from 7:1:2 in 2030 to 5:2:3 in 2050 and to 3:2:5 in 2100 showing the shift to low carbon technologies. If the global optimal energy vision can be achieved, the ratio of CO_2 emissions from energy in 2030 relative to 2005 for the world, industrialized countries and developing countries would be 1.2, 0.95 and 1.54 times respectively and in 2050 would become 0.75, 0.48 and 1.12 times. As a result, differences in the per capita and per unit GDP emissions between industrialized and developed nations would be greatly reduced by 2050, indicating a balance between regions. Comparison of implementation of the low carbon vision to a scenario without limits on CO_2 emissions, showed that both industrialized and developing countries would be able to cover the cost of additional investments to reduce fossil fuel consumption by the energy conservation benefits, thus showing the vision's economic rationality. Furthermore, the results of case studies considering constraints on availability of nuclear power and carbon capture and storage (CCS) technology supported the necessity of the technologies. With regards to nuclear safety, the analysis and technical perspectives of experts on the Fukushima Daiichi Nuclear Power Station accident was introduced. Finally, in order to achieve the low carbon vision developed by the global energy system optimization, along with the efforts by industrial and developing countries based on their capabilities, international cooperation will be indispensable for development and diffusion of low carbon technologies. Key technologies will be clean high efficiency fossil fuel generation, nuclear power and fuel cycle, renewable energy power generation and stabilization, energy conservation and CCS. In order to promote international cooperation, the requirements for additionality in the current CDM need to be eliminated and complex restrictions and procedures need simplified. Also, speculation in the carbon market needs to be eliminated. Bilateral offset mechanisms should play a central role and building a transparent, fair and efficient international cooperation mechanisms will be desirable.

Session 3: Overall Assessment

After the presentations, Mr. William Ramsay, Senior Fellow, Director of the IFRI (Institut Francais des Relations Internationales) Energy Program, France, Mr. Dadi Zhou, Director general (emeritus) Energy Research Institute (ERI) of the National Development and Reform Commission, China, Professor Yasumasu Fujii of Tokyo University and Mr. Masakazu Toyoda, Chairman and CEO The Institute of Energy Economics, Japan expressed their approval in principle for the scientific, technological feasibility, economy and fairness basis of the global warming control approach being considered and made the following comments.

William Ramsey, based on EU global warming measures and the energy policy situation, stressed the importance of reflecting scientific knowledge in policies.

Dadi Zhou introduced China's energy policy and action toward low carbon and comment that rapid action at the same time as scientific deliberation was required.

Yasumasu Fujii noted that the introduction of large amounts of unstable renewable energy would need to be carefully considered in energy modeling and stressed the importance of linkage with economic models.

Masakazu Toyoda discusses issues for Japan's energy policy after the Fukushima Daiichi Nuclear Power Station accident and commented that it was important for the themes of this symposium to be addressed in international discussions.

Session 4: Discussion

The four speakers, 4 commenters and other participants including Dr. Kaya Yoichi, Senior Vice President, Research Institute of Innovative Technology for the Earth, Mr. Kazuhiko Hombu, Project Professor, University of Tokyo, Dr. Seta Emori, Head Climate Risk Assessment Section, National Institute for Environmental Studies, Dr. Hiroshi Ujita, Professor, Mr. Ryozo Hayashi, Director/Special Advisor CIGS, Mr. Kazumasa Kusaka, Advisor CIGS and Mr. Akihiro Sawa, Research Organizer CIGS discussed (1) the role and issues for using nuclear power and (2) science and international negotiations for controlling climate change.

Although the Fukushima Daiichi Nuclear Power Station accident is impacting nuclear policy worldwide, nuclear power is indispensable for addressing global warming and energy security. Based on the assumption of securing the highest possible level of technological safety, understanding the impact of the accident, communication and information disclosure will be vital for building public acceptance and trust.

Within the IPCC, there are almost no opportunities to discuss the linkages between science and policy. It was stressed that opportunities for cross cutting interdisciplinary discussions were necessary for future international deliberations.

Synthesis

The specialists and working level experts participating in this symposium came together with a sense of crisis due to the absence of a clear common vision for international agreement on combating global warming. Discussions of new scientific knowledge on climate change, its implications, the proposed new scenario for greenhouse gas emission scenario and the proposed new international mechanisms for implementing this scenario have resulted in the following common understandings.

- Support for feasible greenhouse gas emission scenarios based on climate change science while taking the overshoot scenario into account.
- Need to pursue a long-term global energy vision based on global optimization of the mitigation cost for energy related carbon dioxide emissions for a low carbon dioxide emission scenario and to welcome an energy vision balanced between required additional investments and fuel saving benefits.
- Promotion of deployment of low carbon technologies through international cooperation based on open, fair and efficient international mechanisms and working to implement an energy vision in which economic growth and global warming control co-exist.
- Sharing the vision through international discussions.

Contributors

Overseas

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Ms. Yuriko Aoyanagi	Research Fellow, CIGS

Presentations

Timescales and Processes in Climate Change Transience, Persistence, Irreversibility, and the Surprising Roles of Various Greenhouse Gases

Susan Solomon

University of Colorado, Boulder, US

Introduction - Overview of the Climate Change Issue

The key issue is how reversible are our choices about carbon dioxide emissions in particular among greenhouse gases and how does that affect the way we think about possible emission reduction choices.

The last ten-years have been the warmest decade since at least the late 1800s. It's about three quarters of a degree Celsius warmer, globally averaged, that it was in the late 1800s. If data is averaged around the world, there was a very rapid warming in the early part of the 20th century, followed by a slight stalling of the warming probably associated with the haze and pollution from Japan, Europe and the United States. As we cleaned up our pollution, the temperatures have warmed dramatically since about the late 1970s.

Examining carbon dioxide measurements for the past 10,000 years from ice core data shows almost 10,000 years of every stable amounts of carbon dioxide followed by the very rapid rise as the industrial development began at the turn of the 20th century. There is now about one third more carbon dioxide in the atmosphere than for the 10,000 years prior to industrial development.

This is what is forcing climate to change. When a gas like carbon dioxide that absorbs infrared energy is introduced, the planet has no choice but to get hotter. The concentrations that we see today are actually higher than we've had in at least 800,000 years from ice core data.

What will happen to the planet if the increase in carbon dioxide is allowed to increase? Results of modeling studies show that temperatures over North America or Asia will be substantially warmer than the variability observed during the 20th century. What about time scales of hundreds if not thousands of years?

EMIC (Earth Models of Intermediate Complexity) are low-resolution models similar to past GCM (Global Circulation Models) that can be run for hundreds if not thousands of years. It may be possible to include more of the interactive process that is difficult to include in detailed high resolution models.

Transience, Persistence, and Irreversibility

The Fourth Assessment Report included a climate stabilization experiment based on a comparison of 8 studies using EMICs running with the same amount of carbon dioxide that increased and then was held constant for about 900 years. Temperature increases while carbon dioxide increases and then remains on an increasing slope for many hundreds of years. Although the increase is slight it continues for a long time and sea level rise continues well beyond the 900 year time scale.

Radiative forcing of the climate system increases when CO_2 increases. A transient climate response will occur during that time. If forcing is stabilized, it would take many hundreds of years to reach a quasi equilibrium and an almost-equilibrium climate response (Figure 1). If the preindustrial carbon dioxide level is doubled, the transient response while the concentrations are increasing is about 1.5 degrees at the time of doubling and the long run response is about 3 degrees. The warming in the long run is about double that of the transient response.

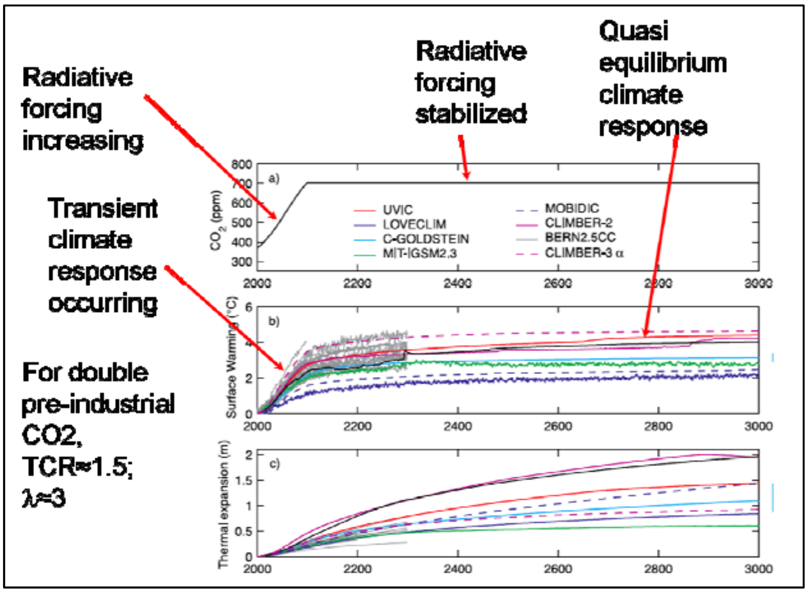

Figure 1 Radiative forcing and climate response

If emissions were to stop completely, could the world return to a natural state? Although you might imagine that it would, it actually would not. An example from AR4 using the same models run with CO_2 increasing up to a certain point and an arbitrary stop in emissions. CO_2 levels did decrease, but did not return to the starting level even after 900 years. That's a fundamental property of the oceans and it's clearly true in all of these models.

The slow response of atmospheric CO_2 levels to termination of emissions is partly due to the fact that CO_2 participates in a cycle. Some of the CO_2 goes into vegetation or the surface ocean.

The long term sink is the deep ocean and it takes a very long time for water to sink down there. There is no single carbon dioxide lifetime. Some is removed in the first ten years, some more in the first hundred years and then it slows down and gets slower and slower as these sinks saturate. It actually takes many tens of thousands of years to remove the carbon we put into the atmosphere in the natural cycle.

What this means if we were to run out of fossil fuels, we continued to emit for the coming century and then stop, the warming will last for a thousand years and we will have locked in sea level rise due to thermal expansion. To this would be added the sea level rise as ice sheets melt that would be more difficult to calculate. The key point is that sea level will continue to rise and it's irreversibly linked to whatever peak value of CO_2 reached in the current century. What this means is that we are close to making the decision as to whether or not the low-lying countries are going to be eliminated. If we don't come up with some sort of geo-engineering solution, it will be an irreversible decision.

U.S. National Academy of Sciences Climate Stabilization Targets Report

This report attempts to describe how quantitative we could be about how much difference the point chosen to stabilize greenhouses, especially carbon dioxide, would make. One of things realized early in this work was that warming should used as the framework for analyzing climate impacts. One example of the advantages of using this approach is illustrated by Arctic sea ice. The results for Arctic sea ice from various models are much more compact when plotted versus temperature than when plotted versus time. Similarly, predictions of wildfire in western North America based on a relationship with temperature correspond closely with observed wildfire area.

Evaluation of the impact of global food production per degree of warming shows that some crops are more sensitive. U.S. and African corn was one of the most sensitive crops with a 10 to 20% decrease per degree of warming depending upon the model. Warming levels of 2 or 3 degrees could mean decrease in yield of African corn, Indian wheat and American corn of about 50% in the absence of adaptation measures. Given the anticipated irreversibility of climate change, these impacts would continue for hundreds of years.

Turning to the issue of extreme hot summers and global warming, the data for Europe shows that the warming trend especially as reflected in lack of cold European summers that were frequently experienced in the past. A shift in the distribution of temperatures has a much larger relative effect at the extremes and by 2050, Europe is likely to have many more summers like 2003 and 2010. This applies not only to Europe and by the time we reach 3 degrees of total warming, it is expected that almost every future summer would be as hot or hotter than the hottest in the past 20 years. , it cannot be broadly stated that all extreme types of climate event will increase. However, hot summer seasons are increasing and will continue to increase. Careful analysis is necessary for each type of extreme.

Cumulative Carbon

Cumulative carbon is a new way of looking at some of these issues. Each added ton of carbon produces a nearly constant increment in warming that will be there for those thousand years. If 200 or 500 or 2000 gigatons of carbon are emitted globally, the amount of added warming per ton is almost the same. That turns out to be a very interesting as it means that the future trajectory of emission doesn't really matter (Figure 2).

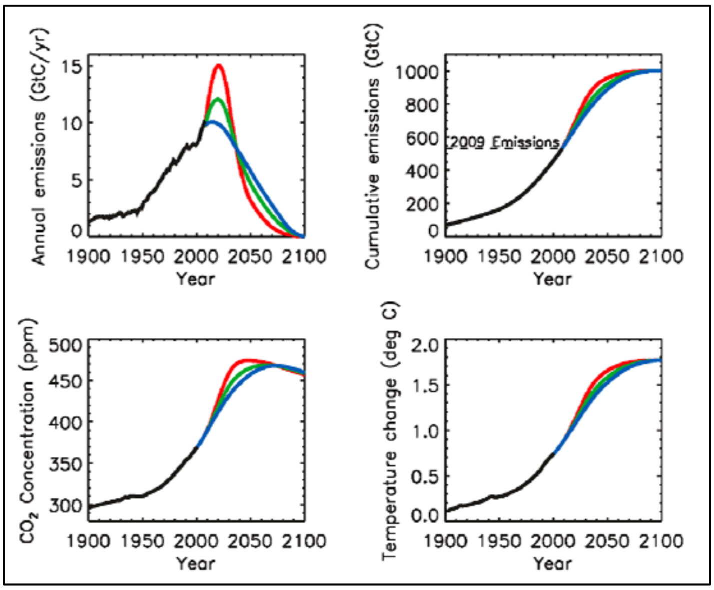

Figure 2 Cumulative carbon and stabilization

Conclusions

Climate changes from CO_2 emissions should be expected to be nearly irreversible for at least 1000 years. This is mainly linked to ocean heat uptake.

Climate change impacts would affect rainfall, wildfire, extreme seasons, etc., i.e., people and ecosystems for a long time.

If we wait to observe problems, longer-term impacts would be twice as large as those observed along the way unless CO_2 emissions are phased out by 90~100 percents or management with short-term GHG occurs.

Cumulative carbon emissions will control the planet's long-term future climate. Carbon already emitted has probably taken us most of the way to 2°C warming and only about 1 billion people have enjoyed the development associated with those emissions. There is a great need for low-carbon energy to reduce climate risk while fostering development.

Stabilization of CO_2 Concentration via Overshoot Followed by Zero-Emissions

– Possibility of New Emission Pathways to Stable Climate –

Taroh Matsuno

Japan Agency for Marine-Earth Science and Technology, Japan

Introduction

The presentation by Dr. Solomon reviewed global warming, its impacts and stabilization. She referred to various timescales and emphasized that the impacts would continue over a very long timescale and therefore be irreversible. Her presentation laid out the background for this presentation of the proposal for stabilization of CO_2 concentration via overshoot followed by zero-emissions and the possibility of a new emission pathway to stable climate. At the first CIGS symposium in October 2009, we discussed this concept in the context of the sharable energy vision. Dr. Yuhara and Dr. Duan of the CIGS have analyzed the concept from an energy-engineering standpoint. This presentation focuses on the earth science aspects of this concept.

Traditional Stabilization Concept

Stabilization scenarios and zero-emissions in stabilization scenarios were reconsidered starting with comparison of the existing scenarios and the new scenario. The initial comparison considers CO_2 only and some results of analysis including other GHG gases are also introduced.

The concept of stabilization goes back to the UNFCCC adopted at Rio in 1992. The Convention includes the ultimate objective of stabilizing GHG concentrations in the atmosphere. However, stabilization is not clearly defined in the Convention. Atmospheric CO_2 levels have risen due anthropogenic CO_2 emissions and the usual view of stabilization is that this should be controlled. CO_2 emissions are expected to increase, peak and then decline. Without that emission levels could not be stabilized. However, the assumption is that there will be 80% or 90% reduction in emissions. This means that 20% or 10% of emissions continuing over the long run after stabilization. This would mean that temperature would continue to rise, sea level rise due to thermal expansion and melting of ice sheets, etc. would continue as was discussed in the IPCC Third Assessment Report and would lead to a pessimistic outlook about the future. The new proposed scenario challenges these assumptions and concepts.

Our starting point is some naïve questions about the traditional stabilization concept. First, why would the world (human society) stop or slow down reductions in emissions after achieving drastic reductions? Also, why is it assumed that a small but significant amount (10~20% of peak emissions) will continue over many centuries? These continuing emissions are merely a consequence of “stabilization = constant concentration” or the “Emissions keeping stabilization”. This results in anthropogenic emissions maintaining the higher concentration/temperature in opposition to natural recovery effects.

In contrast the new “Zero-emission stabilization” concept assumes that emissions will continue to be reduced without “slowing down”. This means that emissions can be reduced to levels lower than natural uptake at the originally intended stabilized state. Thus, elevated CO_2 concentration will decline towards final equilibrium. Rate of temperature rise will decrease and might decline. The final state (after about a millennium) is a stable stationary state similar to the pre-industrial era but with higher CO_2 concentration and temperature.

Comparison of Two Stabilizations (CO_2 only)

A simplified carbon cycle/climate model SEEPLUS developed by Dr. Tsutsui of CRIEPI based on the Max Planck Institutes Nonlinear Impulse Response Model of the Coupled Carbon Climate System (NICCS) was used to model the E450 emission keeping stabilization and Z650 Zero Emission stabilization with CO_2 only. E450 scenario stabilizes atmospheric levels at 450 ppm while the Z650 scenario assumes total carbon emissions of 650 gigatons during the 21^{st} century and achievement of Zero Emissions in the second half of the 22nd Century. While the Z650 scenario during the 21st century has higher total CO_2 emissions, peak CO_2 levels (480 ppm vs 450 ppm) and global mean temperature rise, the modeling results show that the Z650 scenario will have lower CO_2 concentrations and global mean temperature rise by the second half of the 22nd Century compared to the E450 scenario as shown in Figures 1 and 2. These results show that the Z650 scenario might allow more emissions in the near term compared to the E450 scenario as long as Zero-emissions are achieved. Thus, these results show that there may be emission pathways of the Z-stabilization type that will allow emissions at levels greater than 50% reduction in 2050 while achieving the 2°C target.

Comparison of Z650 and RCP 2.6

If the emissions pathway for the Z650 scenario is compared with the E-stabilization RCP 2.6 and RCP 4.5, Z650 fills the gaps between those two scenarios (Figure 3).

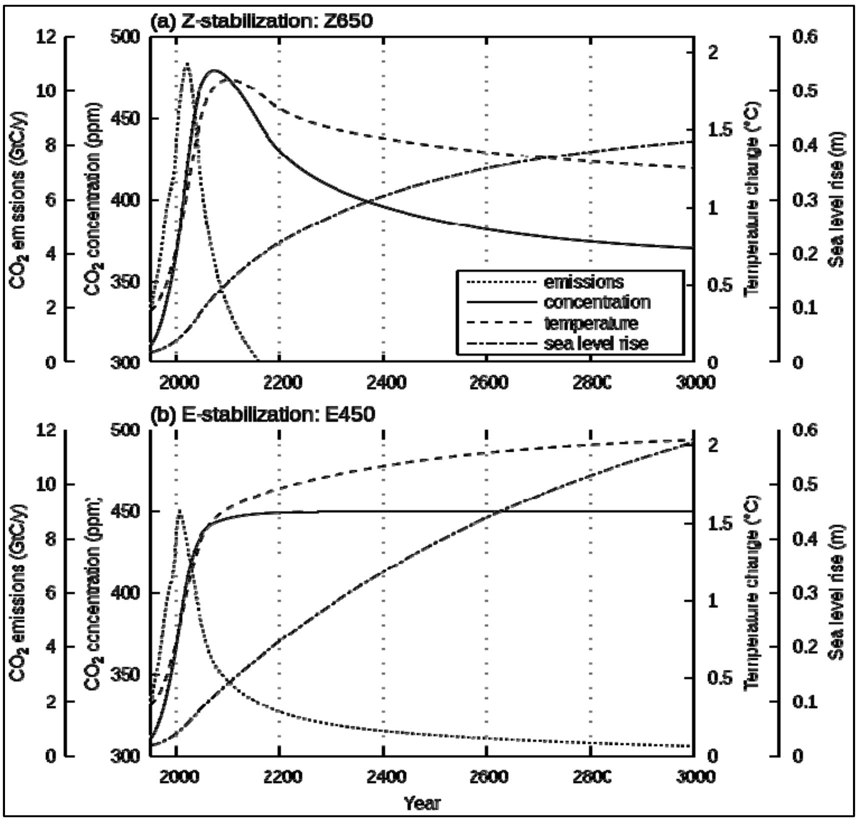

Figure 1 Long-term characteristic of Z650 and E450

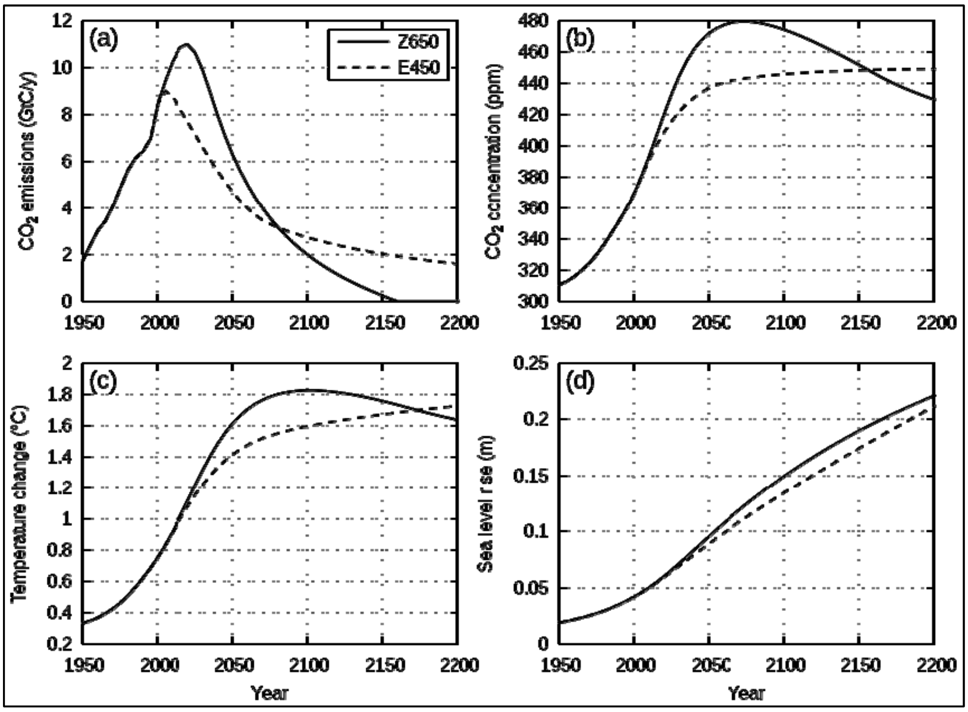

Figure 2 Comparison between Z650 and E450 during short to mid term

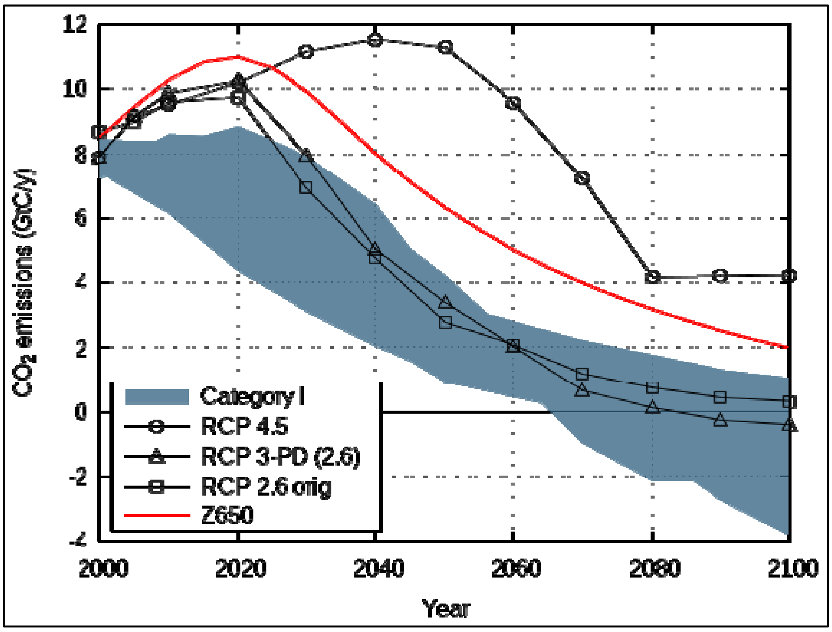

Figure 3 CO_2 emission pathways: RCPs and Z650

Summary and Challenges

The appropriateness of the traditional equilibrium approach to stabilization (E-stabilization) for setting targets or measuring climate change mitigation was questioned. Zero-emission stabilization (Z-stabilization) is posed as an alternative. Z-stabilization assumes that CO_2 emissions are reduced to zero and the atmospheric concentration and temperature begin to decline towards final equilibrium status beyond the 21st century. This decline means that sea level rise and the melting of the Greenland icecap should be kept within acceptable limits. In contrast, compared to E-stabilization, despite higher emissions during the 21st century, maximum temperatures occur for a limited period and the upper limit for temperature might be relaxed slightly. The higher total emissions allowed during the 21st century by the Z650 stabilization pathway may provide a better fit with socio-economic needs of developing nations than E-stabilization pathways.

Challenges related to the Z-stabilization and E-stabilization pathways include the long-term outlook over centuries and millennia for climate, sea level and global environment (both transient pathways) and final equilibrated states. The impacts of forced natural climate variabilities including solar radiation, volcanic activity, etc. need to be taken into account. Finally, the feasibility of zero-emissions must be considered in more detail including the essential uses for fossil fuel and control of other GHG emissions.

A Globally Sharable Vision against Global Warming

Carlo Carraro
University of Venice, Italy

Introduction

The scientific papers focused on the physical side of the problem and introduced possible emission paths that could stabilize concentrations or temperature at the desirable level with taking into account economic implications, constraints and incentives necessary to achieve that type of objective. This paper addresses the economic dimensions by identifying the implications in terms of investment, in terms of cost, in terms of policy decision and for achieving a climate stabilization target.

Current Situation

The situation is not good from a policy standpoint. Although agreements were reached in Copenhagen and Cancun, there content is not substantial. The Kyoto Protocol that will expire in 2012 was not very ambitious and not very effective in reducing emissions. Although world leaders have agreement to stabilize emissions in a way that temperature is not going to increase more than 2 degrees, this target is more a political objective to induce behaviors, investments and changes in strategy in most economic sectors rather than a sound objective that is based on careful analysis on the physical and economic sides.

The prospects for future agreements are not good. It is difficult to expect a global agreement, certainly not in Durban, probably not in this decade. But this is not necessarily a negative conclusion because this keeps the door open for domestic policies and measures that can be effective if well designed and coordinated across countries.

Is the 2 °C target feasible?

The present level of GHG concentration is 430ppm CO_2-eq (390ppm CO_2 only), well above the level necessary to make a temperature increase above 2 °C unlikely. 450ppm CO_2-eq will be reached within six years, whatever world leaders decided in Cancun or will decide in Durban. If 550ppm CO_2-eq is reached, there is little chance to stay below 2 °C unless technologies to reduce the stock of emissions are developed.

Policy Options

For purposes of discussion, three main policy options are identified.

The first mitigation policy is to reduce (the flow of) emissions soon and cooperatively by agreement among all major emitting countries. Reality tells us this is very difficult as there is no international agreement and action is delayed in all countries. Stabilization through reduction of flow emissions would require a drastic and rapid change in the energy mix. The required investments to achieve these objectives are very large. In addition, some crucial technologies, in particular, nuclear power and CCS are not available and will not be available as much as desirable.

The second mitigation policy is to delay in emission reductions and to have negative emissions or reduction of the stock of emissions. This would allow some overshooting but then to achieve 450 ppm and the 2 degree target, most models predict that negative emissions are necessary later (Figure 1). This scenario implies that reduction of emissions stock is feasible. There is doubt that the technology for large scale carbon dioxide removal will be available. The most promising options are terrestrial biological approaches including land use and afforestation, bio-energy with CCS, biomass and biochar. However, it appears that these are unlikely to achieve the necessary scale. For example, it has been estimated that a 1000 million hectares would be required for biofuel production. Current the total amount of land developed to crops is 1500 million hectare. The impact of biofuel development will have important implications on prices, especially food prices.

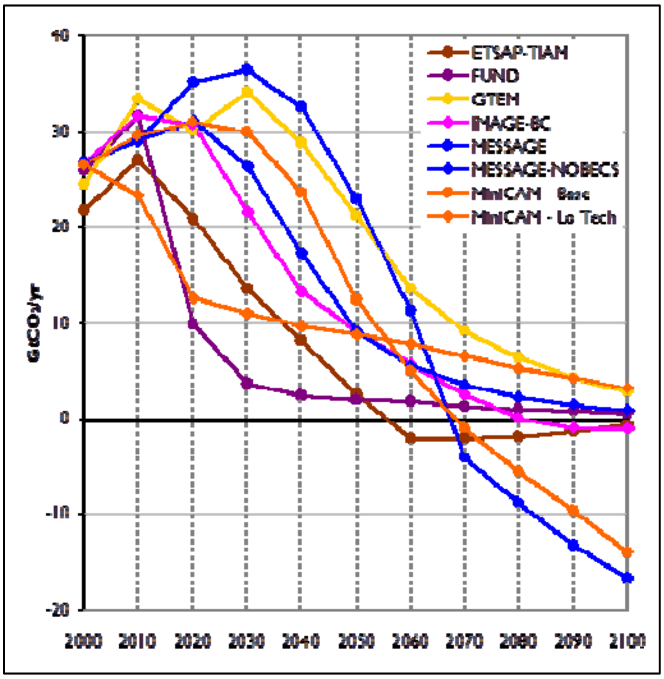

Figure 1 CO_2 emission pathway of overshooting concentration

The third policy option is to adaptation to climate change by investing in infrastructures and measures to adapt to climate change. As is it is not probable to stay below 2 degrees, even above 2 degrees there is climate change that can be dealt with through adaptation. As the impacts of climate change are very uneven, developing countries in particular are much more vulnerable and need more resources to adapt to climate change. Even if mitigation policy is effective, some adaptation will be necessary. The investments required by developed countries are small compared to those required by developing country (Figure 2). Thus, resources to adapt to climate are mostly needed in developing countries and those countries are unlikely to have resources. Whatever, the approach, transfer of resources from developed countries to developing countries will be required.

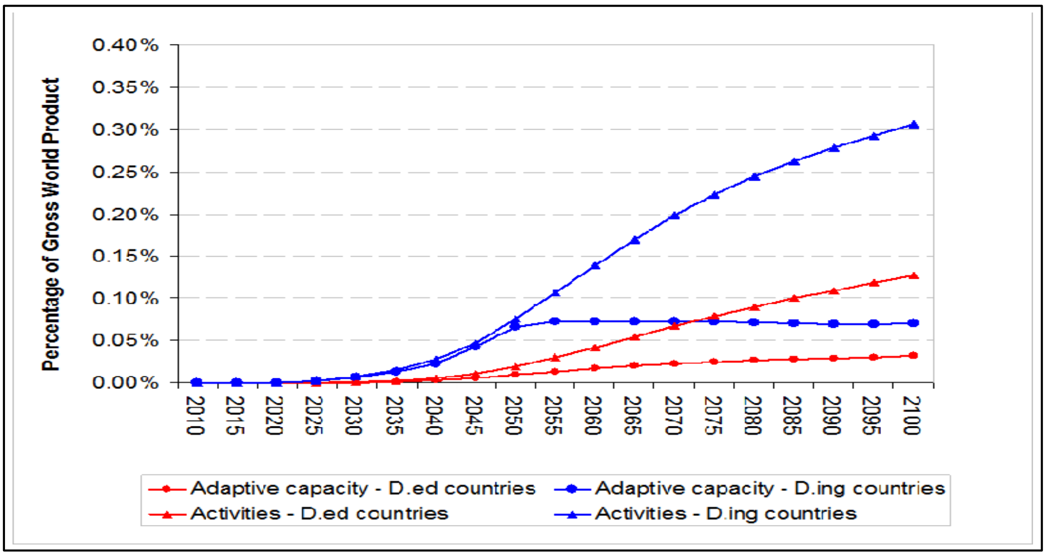

Figure 2 Regional adaptation: necessary activity vs. capacity

Cost, benefits and investments

The consensus presented in the fourth IPCC assessment report was that cost of controlling emissions would be about 1% of global GDP with very uneven distribution. However, the costs are higher if action is delayed, if participation is incomplete and technology development and diffusion is limited. The benefits are very uncertain but are likely to be larger than 1%. However, the problem is investments, the resources necessary to drive the change. The necessary investments in the short run are very large and the economic downturn has exacerbated the problem.

Estimates of the necessary investments are as follows:

The IEA estimated that the required investments in the energy sector to stabilize GHG concentrations at 450ppm CO_2-eq would be $430 billion per year. The IIED estimated that $175 billion per year would be required for adaptation. It has been estimated $50 billion would have to be invested in energy R&D. This is a total of about $650 billion per year. The necessary investment in energy R&D is equivalent to .08% of global GDP. This is large compared to current investment level in energy R&D of .02% of global GDP. However, in the 1980s, investments in energy R&D were higher than 0.08%. It was feasible 20 years ago and it can be feasible in the future even if the amount of resources is large.

The conclusion on investments is that higher investments are required for the new energy mix for the low carbon world. However, these investments would be for technologies that are not well know, very complex and risky technologies for renewables, nuclear power and CCS. Investors do not like to move into risky investments unless the potential return on investment is high. However, the driving policies are lacking and prices in the carbon market are not high enough to drive investments.

Policy Scenario

A mild international policy as soon as possible: Ambitious emission reductions in the short run consistent with the 2 degree target or 450 ppm are not feasible. Thus, a policy consistent with a less ambitious policy, 550 ppm or 600 ppm, is necessary. A policy is necessary because price signals are crucial in order to drive investments in the right direction.

Development of technologies for negative emissions (innovation, land use, afforestation, bioenergy, CCS) and reducing future mitigation costs. Large innovation effort in the energy sector shifting investments from fossil fuel to other energy technologies. Innovations in agriculture, energy, transport, urban planning (green cities). There are many innovations that are necessary in order to drive our societies to a low carbon.

Slowly increasing investments in adaptation, particularly in developing countries is necessary. This should take into account that investments in adaptation are also investments for economic development, a win-win strategy that could be implemented in developing countries.

The policy scenario is a progressive climate policy which is slow but effective for all possible paths for reducing the flow of emissions, reducing the stock of emissions, adapting to climate change and are implemented at the same time.

Zero-Emission Scenario: Energy portfolio, Emission Pathways and Costs based on Global Optimization

Tetsuo Yuhara

The Canon Institute for Global Studies, Japan

Introduction

The presentations by Dr. Solomon and Dr. Matsuno presented the scientific background for this report on the results of the CIGS Energy Research Working Group evaluation of technically feasible solutions for collaboration between developed and developing nations. The focus of the evaluation was on total emissions as well as emissions curves for energy related CO_2 based on Dr. Matsuno's report. Within these constraints, global optimization was conducted for cost minimization and the resulting energy portfolio and required investments were developed based on this optimization. The addition emission reduction costs for the energy portfolio and the resulting energy conservation merits will be discussed. Approaches for enhanced international cooperation on the global energy portfolio are discussed.

Fukushima Daiichi Nuclear Power Station Accident

Nuclear power has been expected to play a key role in addressing climate change challenges. However, the accident at the Fukushima Daiichi Nuclear Power Station has impacted these expectations. The working group has reviewed these issue and some of the conclusions of this review are as follows:

- The causes of the Fukushima Daiichi nuclear accident are straight forward and can be addressed.
- Most of nuclear power stations in operation in Japan are Generation III with improved safety features compared to the affected reactors. New reactors world-wide will be Generation III+ with passive safety that imparts high resistance core meltdown and greatly improved safety.
- Although nuclear power will have to be reconsidered including the possibility of phase out, it was concluded that nuclear power is indispensable along with renewable energy in addressing climate change.

Global Emission Pathway

The overshoot scenario is related to the issue of how long fossil fuel can continue to be used. Either fossil energy resources will be exhausted 150 to 200 years in the future or the zero-emission era might result in not being able to use fossil fuels from the middle of the next century. Dr. Matsuno's report discussed the Z650 scenario that assumes emission of 650 gigatons of carbon during the 21st century and achievement of zero emission around 2150. The pathway assumes peak emissions of 11 Gigatons carbon in 2020 with annual reduction of 2% per year through 2100 with achievement of zero emission by the mid 22nd century. The impact of the optimal energy portfolio on the Z650 pathway was analyzed. Although the optimal energy portfolio resulted in lower emissions during the early and late stages with higher emissions in the middle stages, the results of modeling indicated that there would not be large impacts.

Energy Related Carbon Emissions

The energy related portion of CO_2 emissions were modeled using the GRAPE (Global Relationship Assessment to Protect the Environment) model based on inputs including final demand by sector, CO_2 emission constraints, energy cost, capital and transport cost. The effects on primary energy, electric power portfolio and the transport sector are the outputs. Three scenarios were analyzed BAU (business as usual), REF (Reference where energy conservation and efficiency technologies are used with no CO_2 cap) and Z650 which assumes a cap on CO_2 emissions.

The results for total primary energy for 2030 and 2050 are not that different for the Ref scenario and Z650. However, the decline in proportion of fossil fuel is greater for Z650 and the increase in the ratio of nuclear and renewable energy is greater for Z650 (Figure 1). If industrialized and developing countries are compared, in contrast to the almost constant Total Primary Energy for industrialized countries, gradually declining ratio of fossil and increasing ratio of renewable energy through 2100, Total Primary Energy increases for developing countries, fossil fuel consumption peaks in 2040 and both nuclear and renewable energy increase greatly (Figure 2).

The results for Global Power Generation trends for Z650 show that hydropower and biomass will play a major role among renewables with wind power gradually rising through 2050. From 2050 onwards, solar energy will become more prominent reflecting cost and the use of global cost minimum optimization. Nuclear power is projected to grow for 810 GWe in 2030 to 1800 GWe.

Based on the global CO_2 emissions for Z650 reported by Dr. Matsuno, the CO_2 emissions for industrialized countries peak in 2010 and emissions in 2050 will be reduced by 50% compared to 2005 levels. Emissions by developing countries will peak in 2030 at 1.6 times 2005 emissions and decline to 1.1 times 2005 emissions.

From the standpoint of regional equity, per capita emissions in the industrialized nations will approach that of the developing nations by 2100 and the CO_2 emissions per GDP of the developing nations will approach that of the industrialized nations (Figure 3). The results for industrialized nations show that CO_2 emissions per capita and CO_2 emissions per GDP will converge around 2050. Global emissions in 2030 will be 1.6 times that of 1990 (1.2 times that of 2005) and will be about 1990 levels. Compared to the REF scenario without CO_2 constraint, the ratio for global emissions in 2030 for Z650 is 0.82. For industrialized nation the ratio is similar at 0.89. For 2050, the ratio to the REF scenario for industrialized nations of 0.48 is similar to the global ratio of 0.46 (Table 1). As the reduction potential is higher for developing nations, the effect is larger.

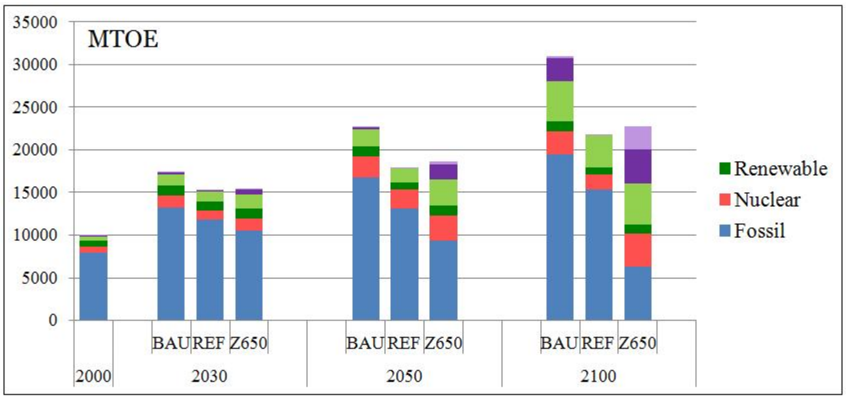

Figure 1 Simulated total primary energy of the three scenarios

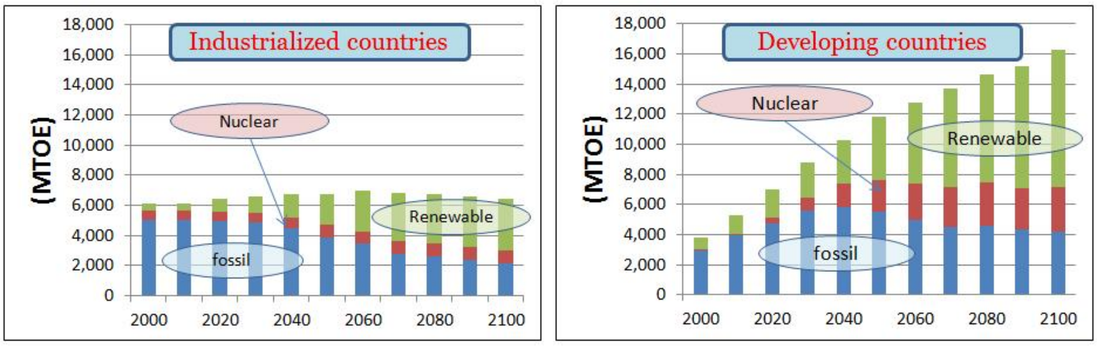

Figure 2 Simulated regional total primary energy of the Z650

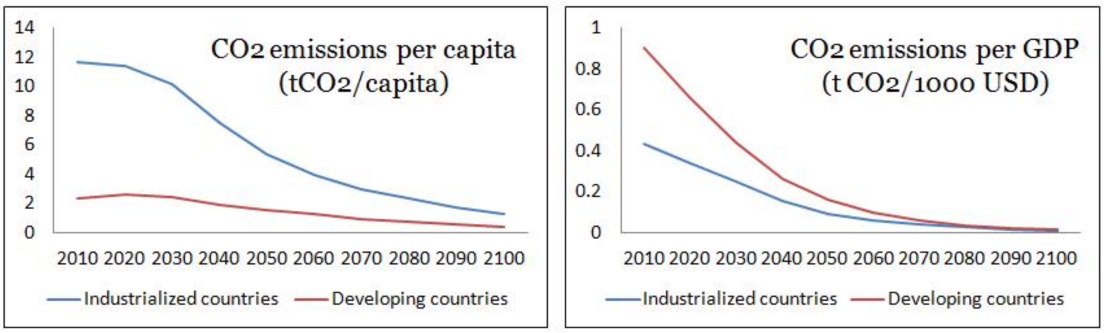

Figure 3 Two CO_2 emission index based on simulation of Z650

Table 1 Global and regional emissions in major industrialized and developing countries

Region	CO_2 emissions					
	2030			2050		
	Ratio to 1990 levels	Ratio to 2005 levels	Ratio to REF of 2030	Ratio to 1990 levels	Ratio to 2005 levels	Ratio to REF of 2050
World	1.60	1.20	0.82	1.00	0.75	0.46
Industrialized countries	1.05	0.95	0.89	0.53	0.48	0.48
USA	1.16	0.96	0.90	0.57	0.47	0.47
EU15	0.89	0.86	0.91	0.46	0.45	0.53
Japan	0.93	0.79	0.90	0.55	0.47	0.66
Developing countries	2.82	1.54	0.77	2.05	1.12	0.45
China	2.77	1.48	0.74	1.53	0.82	0.37
India	3.42	1.91	0.72	2.83	1.57	0.37
ASEAN	3.74	1.64	0.80	3.41	1.50	0.57

Technological and Economic Perspective

The results of the analysis showed that additional investment of $7 trillion by developing nations over 40 years would be required to achieve the Z650 scenario compared to the reference scenario. However, in addition to the reduction in CO_2 emissions, the benefits from reduction of fuel consumption would be $9 trillion. For the advanced countries, the additional investment would be $4 trillion and the benefit would be $5 trillion (Figure 4). Thus, in this case there would be a good balance between benefit and investment from the optimal energy mix. This assumes the technologies to be used by 2050 are those technologies that currently appear to be feasible and are expected to be widely deployed by 2030.

Sub-scenario analyses of the impacts of NuPO (nuclear phase-out) with no new nuclear power plants being constructed after 2020 and NoCCS (No carbon capture). Phase-out of nuclear power would result in replacement with fossil with CCS and renewable energy with battery storage. For NuPO, compared to the Z650 scenario, global total additional investment through 2050 would increase from $11 trillion to $17 trillion while benefits from fuel saving would decline from $14 trillion to $9 trillion. For NoCCS, the global additional investment through 2050 would increase to $24 trillion and fuel savings to $17 trillion. Marginal abatement cost would increase from $193/ton in 2050 to $298/ton for NuPO and $302/ton for NoCCS. Thus the control costs would rise significantly under both sub-scenarios (Figure 5).

Global Vision vs. National Plans

This analysis shows that there is a significant gap between REF scenario that can addressed through domestic effort and the Z650 scenario for developing countries. Cumulative reductions of 248 GtC would require additional investments of $7 trillion with benefits from fuel saving of $9 trillion.

To eliminate this gap, low carbon technology deployment schemes and financial schemes to cover the additional investments are required. This target is an order of magnitude larger than the current Kyoto Protocol CDM (360 Mt CO_2 /year) and it would be difficult for the current CDM mechanism to address this. Also, the requirement under the current CDM for “additionality” means that it is difficult for business to develop.

An enhanced international mechanism that meets these requirements will have to be developed that incorporates the Z650 target in the framework to promote low carbon technology transfer. Developing countries should receive financing while industrialized countries would provide financing and technology while receiving offsets. The carbon offsets can be bought and sold and compensation provided for technology and intellectual property to provide incentives for development of low carbon technology. The internationally open MRV system to certify emissions reductions should to provide a transparent certification mechanism to ensure that incentives are not lost (Figure 6).

The results of analysis of CO_2 reductions by sector show that energy conservation and renewable energy play an important role during the whole 2010-2050 period while nuclear, CCS and transport technologies will play an increasing role in later stages (Figure 7). Necessary innovative technologies that were indentified were 1) high efficiency fossil fuel power generation, 2) nuclear energy and spent fuel recycling systems, 3) renewable energy and storage systems, 4) Energy conservation systems and 5) Carbon capture and storage.

Summary

- Z650 Scenario is proposed as a shared global emission pathway based on scientific analysis.
- Global energy system optimization suggests a regionally equitable low carbon vision to achieve the Z650 scenario. In 2050 the energy related CO_2 emissions of the world, industrialized nations and developing countries would be 0.75, 0.48 and 1.12 compared to 2005 levels.
- The low carbon vision is technologically feasible and economically rational. The benefits of fuel savings would cover the cost of additional investments.

- A significant gap between current national mitigation plans and the low carbon vision is projected for developing countries. Large scale national cooperation for promoting deployment of low carbon technology will be necessary.
- The current CDM system is inadequate to achieve the global low carbon vision. An enhanced technology oriented mechanism based on a bilateral offset scheme is proposed.

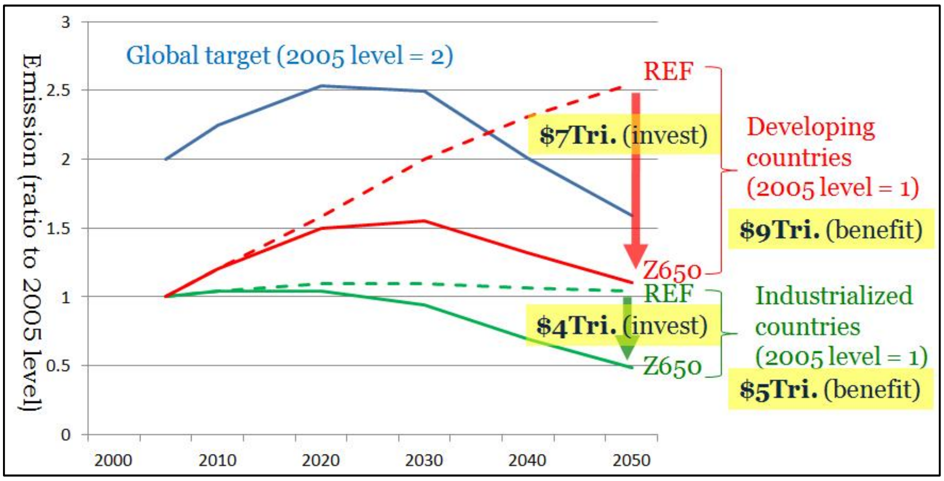

Figure 4 Image of CO_2 emission reductions in industrialized and developing countries

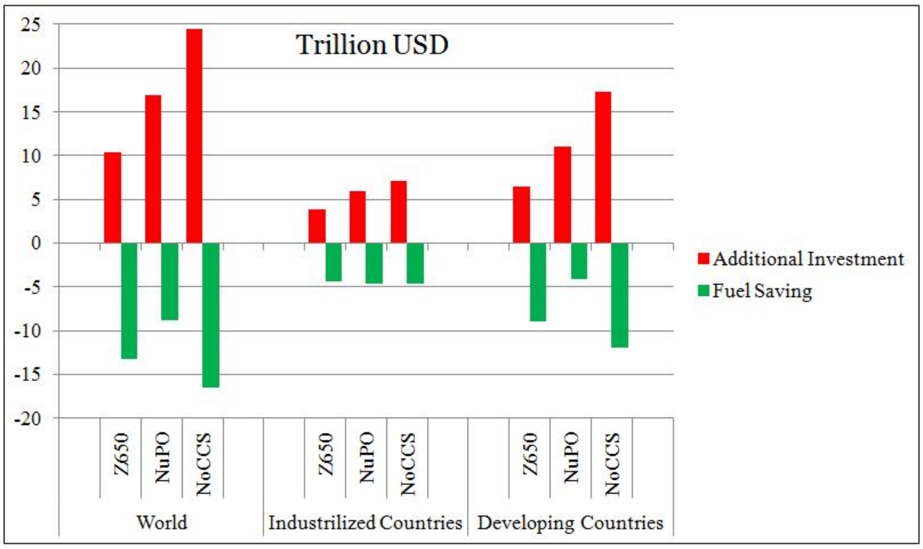

Figure 5 Cost-benefit comparisons of different scenarios based on simulation

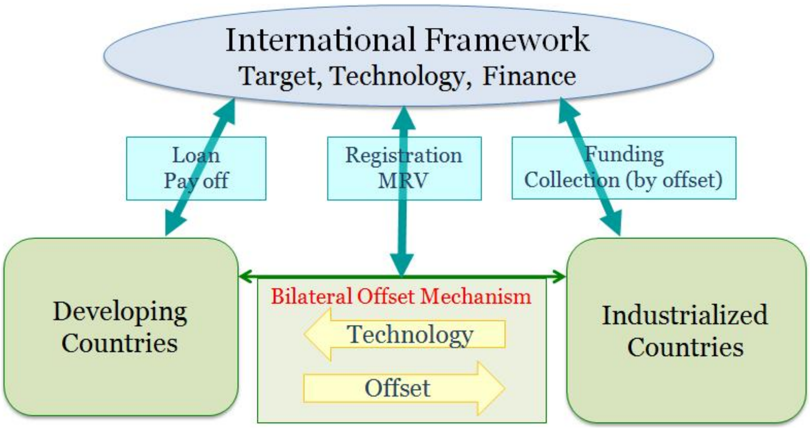

Figure 6 Image of proposed international cooperation scheme

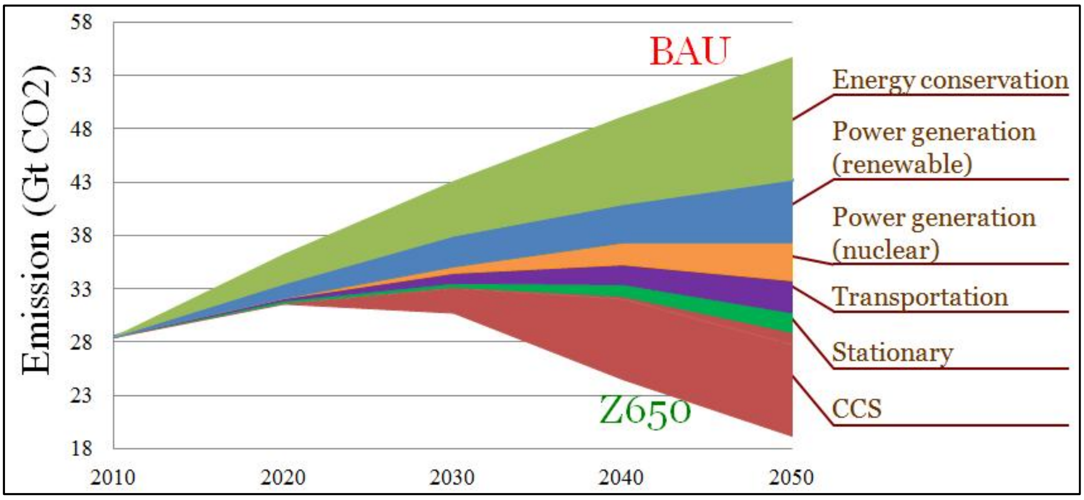

Figure 7 Contributions of each sector to CO_2 emission reduction based on simulations

Panel Discussion

Moderator

Masakazu Toyoda, the Institute of Energy Economics

Main Panelists

William C. Ramsay, Institut Francais des Relations Internationales, France

Dadi Zhou, Energy Research Institute, National Development and Reform Commission, China

Yasumasa Fujii, the University of Tokyo

Carlo Carraro, Ca' Foscari University of Venice, France

Taroh Matsuno, Japan Agency for Marine-Earth Science and Technology

Susan Solomon, University of Colorado, Boulder, US

Discussants

Yoichi Kaya, Research Institute of Innovative Technology for the Earth

Kazuhiko Hombu, the University of Tokyo

Seta Emori, National Institute for Environmental Studies

Hiroshi Ujita, Tokyo Institute of Technology

Ryozo Hayashi, CIGS

Kazumasa Kusaka, CIGS

Akihiro Sawa, CIGS

Introduction

Brief presentations were made by Mr. Ramsay, Mr. Zhou, Professor Fujii and Mr. Toyoda to provide additional background information prior to starting the main panel discussion.

William Ramsay provided an overview of the European experience in dealing with climate change, the challenge of reducing emissions and achieving the required energy mix. The European Union is a loose federation of 27 states and each has their own government and energy policies. Directive including ones related to regulatory, roadmaps for investment and infrastructure, efficiency and external energy policies have been issued that are designed to drive a coherent European energy policy. However, the question is how these are translated into real legislation, real policies and real practices in the market place. The main focus is on the power sector. However, the markets are not converging and still have different rate structure, regulatory programs and poorly integrated grids. The European policy statement set of 80% dependence on renewables with a heavy reliance on offshore and imports of renewable energy. The differing approaches by Germany, Italy, Spain and France were discussed. The rapid penetration was raised as an example. "Gas is being the fuel of no choice." If nuclear and coal can't be used, renewables are not coming fast enough and CCS has not been demonstrated, gas is the only remaining choice. It's a tough fight in Europe to meet the kinds of challenges that are being outlined here already where we've got targets in mind that we have thought, in the past, were visible. We're looking at more difficult targets and politically more risky targets.

Dadi Zhou provided an overview of the growth in energy consumption, the role of coal and policies to address energy efficiency and the low carbon society. Policies have been announced to drive energy conservation and emissions reduction including economic measure with a target of 40% reduction in energy intensity [per unit GDP]. The roles of natural gas, hydropower and nuclear will be greatly expanded. Hydropower capacity is planned to grow from 210 GW to 400 GW while nuclear power has been proposed to grow to 400 GW by 2050. China plans to build more nuclear plants despite Fukushima. By 2020, 150 to 200 GW of wind power and 20 to 50 GW SPV. One desire is to reduce the proportion of coal from the current 70% to 30%.

Yasumasa Fujii discussed the uncertainty regarding nuclear power which means that PV and wind will probably play a greater role. Previously it had assumed that these renewable sources would account for about 15% of power generation. However, PV and wind may supply 20 to 30% of total grid power supply. Current energy models may not be ready to address the large inflow of intermittent energy sources. Technological options to cope with output fluctuation of PV and wind power include compensation by energy storage, compensation by fossil fuel fired power plant and control of PV output by smart grid technology. This would require models with very fine temporal resolution. Another issue is that minimization of total energy system cost does not necessarily lead to the optimal strategy for society as a whole.

Masakazu Toyoda reviewed the outlines of the Basic Energy Plan for Japan compiled in 2010. This includes increasing the share of zero-emission power sources from 34% to 70% with nuclear power providing 50% of electric power generation in 2030. He noted that renewables accounting for 20% of total generation and even if this were increased to 30% of total generation, it would not replace nuclear. More fossil fuel would have to be used to fill the gap. His personal conclusion was that further energy conservation and energy efficiency to reduce power usage, use renewables as much as possible, fossil fuel should be as clean as possible and safer nuclear power is needed. He stated that he believed that at least 25% nuclear would be required to make this equation work.

He then turned to the relationship between climate negotiations and science. He noted that there are three options for the negotiations. First is extension of the Kyoto Protocol. Japan has rejected this as China, US and other major emitters are not included. Second, is continuing negotiations for a legal framework involving every major country and the third is to the accept the COP decision based on the Copenhagen Accord which results in less ambitious targets being the basis. His personal position is that the third approach, probably close to Dr. Carraro's position, should be taken. This would mean that the scenario would be somewhere between Category II and III through. However, given that the Category I scenarios are the current recommendation, it will be difficult to make progress in the negotiations. He asked the panelists to address the issue of the IPCC's recommended scenario and how this should be connected to negotiations.

Discussion

Mr. Toyoda, the moderator, introduced the two topics for the panel discussion, 1) Nuclear power, lessons from Fukushima including the challenges of nuclear safety and 2) climate change, negotiation, and science.

1) Nuclear Power

The moderator briefly reviewed the presentations at the start of the panel discussion discussed policy direction in Germany to phase out nuclear, the decision by China to continue its nuclear development plan, the implications for grid management if nuclear power were replaced by renewables and the need for safer nuclear power.

He posed the questions for the first topic, (1) Can we afford to abandon the nuclear option? (2) Will nuclear power be accepted even if we can ensure safety?

Impact of Fukushima and Safety

Prior to Fukushima that the Italian government had reached agreement with the French government for construction of 4 nuclear reactors. The reasons for this were that Italy was and is unable to meet the European level reduction targets. The construction of the plants was an alternative to buying permits on the European market. The second reason was the energy security issue especially for gas. However, the reaction to the Fukushima accident has stopped this.

One panelist commented on the low relative risk of nuclear power compared with alternatives. Another panelist responded was important to differentiate between occupation risks and public risk. It is important to understand how the public perceives risk.

A panelist with a background in nuclear safety regulation stated that nuclear power would be needed for some time. However, the issue will be measurement metrics of safety? That is how safe is safe enough? Also, Fukushima has shown us that location based safety analysis to calculate how safe is safe enough needs to be established.

The issue of the long-term effects of the wide areas that have low-level contamination need to be considered.

There is a wide range of estimates of health effects and cost for dealing with low level contamination. Also, there is the issue whether the public would be more concerned about nuclear accidents or the implications of more CO_2 emissions and global warming.

It was noted that about 20 new countries that are looking or have announced their intention to adopt nuclear power. Reactor suppliers would have to be very careful in evaluating the quality of the institutions in those countries before delivering a nuclear reactor. Is the country ready to manage a nuclear reactor? Does it have the safety authorities? Does it have a culture of safety? Because another accident in some country is going to be viewed as an accident everywhere.

Other panelists noted potential issues for nuclear power in developing countries of political and military security and terrorism.

The issue of trust in the safety of nuclear power. It was stressed that we have major communications problem as Fukushima demonstrated.

It was noted that the French have a very careful policy towards local communities including information and subsidies. Another more recent policy is siting of important power plants near the country's borders as much energy is sold to other countries.

Need and Role for Nuclear

The opinion was stated that a reasonable and safe stabilization level could not be achieved without nuclear power. While Europe could afford not to have nuclear plants and replace nuclear with renewable energies, it was not feasible at the world level. These power plants are, in particular, necessary in developing countries more than in developed countries because they need much more energy than developed countries and because they cannot afford to pay higher price energy that developed countries can pay, in particular renewable energy that the developed countries can certainly afford.

Another panelist stated that it would be difficult to imagine a sustainable mix without nuclear in it. It was noted that while several of the participants have stated that developing countries would need nuclear power. However most nuclear reactors are in developed countries. The problem is not that nuclear power will be used by developing countries but how nuclear power will be replaced in developed countries.

The issue of what could substitute for nuclear was addressed. If the low carbon society is not an issue, fossil fuel is the answer and is the solution for the current Japanese situation. He stressed that renewable energies would not be a substitute for nuclear power or fossil fuel without adequate backup storage and that several tens of percent of total demand could not be covered by renewable energies.

The scenario of nuclear being an interim solution was criticized and it was stressed that nuclear was needed over the long term. However, once through approach for use of nuclear fuel for light water reactors means that available uranium resources are limited without reprocessing to the same time frame as oil.

2) Climate Change, Negotiations and Science

The moderator set the stage for the second part of the discussions. He noted that Dr. Matsuno and Dr. Solomon mentioned that it would be desirable to consider scenarios other than Category I scenarios. Also, whether the emerging consensus based on the Cancun agreements and the Copenhagen Accord would meet the requirements of the scenarios explained by Dr. Solomon and Dr. Matsuno. He noted that we may be moving towards the progressive climate approached described by Dr. Carraro. Also, that while the IPCC doesn't make decisions, it does have the role of providing scenarios for the politicians to adopt and build action plans.

IPCC and Climate Science

It was reiterated that the zero-emission stabilization offered the opportunity to accommodate the needs of developing countries in the mid-term and still achieve stabilization at lower levels than the traditional approach to stabilization. The issue of the zero emission stabilization approach had been raised at the IPCC but it was not accepted.

The constraints that the IPCC operates under were stressed. If the IPCC began to create the science, it would be very different from its current role of assessing published research.

In order to be considered, it was stressed that ideas like Dr. Matsuno's need to be published.

Risk issues related to proposed measures such as biomass power generation with CCS were noted. There are uncertainties related to impacts on ecosystem of these approaches. It was stressed that it was necessary to tentatively agree that 2 degrees should be the basis of the discussion and then assess whether the approach that Dr. Matsuno is advocating makes sense or not. In that assessment, it is necessary to keep in mind the many uncertainties and work to address those uncertainties needs to be continued.

In response to a question by moderator regarding dialog between working groups, a panelist responded that cross-cutting groups have been established to deal with interdisciplinary issues by the IPCC and that this would help produce a better Fifth Assessment Report.

Negotiations

The issue of the Framework Convention and the definition of stabilization in Article 2 were noted in relation to the overshoot scenario. Proper explanation would be required to avoid the need to rewrite the convention.

There are many aspects of what would be called technology development, negotiation, and science that would have to work together in a different way than what IPCC does. This probably not a job for IPCC as it goes too far outside of its existing frameworks.

Given that the negotiating situation with impending end of the Kyoto protocol might not immediately result in a framework for reducing CO_2 emissions, it was noted the overshoot scenario provides a pathway for that to that to happen and still have the possibility to return to intended levels. Also, he felt that there was too much emphasis on mitigation. He noted that adaptation would be very important with mitigation and more effort was required to assessing the cost associated with adaptation.

The moderator summarized in closing that counter measures for low dose radiation were required for obtaining public support for nuclear power. He also commented on the need to change the current perception of the IPCC and an integrating group should be formed. Also, dialog between scientists and politicians might be desirable.

Closing Comments

Tetsuo Yuhara

There were a number of points presented that were quite encouraging. As we approach COP17, how can we having a common understanding. The main theme of the symposium was developing a proposal. The overshoot followed by zero emission scenario has helped to deepen our understanding and was supported by most of the participants. It is an approach that shows a way forward.

Although there was a general consensus among the panelist that nuclear power was necessary, especially for the developing countries. However, consensus at the political level and by the people at the national level will be required to promote nuclear. Also, another key step is to have a clear understanding of low dose effects.

Dr. Carraro and I emphasized the importance of science in developing innovative technologies, assessing the feasibility of the technologies and the economic assessment of technologies. I believe that a common understanding regarding this approach was developed. We also developed a consensus of the need for interdisciplinary discussions like the ones we had at this symposium for the IPCC in developing its consolidated report. However, even with the common understandings developed during the course of our discussions, there will be many difficulties in having this incorporated into policies.

However, I believe that as we continue our research and discussions with you, our shared understanding will eventually be broadly accepted.

Finally, I would like to express the appreciation of the organizers to the participants. And we will convene a symposium to follow-up on the issues discussed at this symposium prior to COP18.

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