“The Mid- to Long-Term Global Vision for Challenges against Global Warming”

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<Keynote Speech>

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“New Emission Scenarios for Targeted Temperature Rise”

Thank you for kind introduction. I am honored to be invited to give a talk at such an important symposium. I would like to thank the organizers, President Fukui and also professor Yuhara.
Similarly to the previous speaker Professor Sir Brian Hoskins I have worked mostly in meteorological research. Around 20 years ago I came to consider that the global warming would become a serious issue and then started studies of future climate change due to global warming by use of climate models, collaborating with younger colleagues.
Currently I am working as a researcher in the Japan Agency for Marine-Earth Science and Technology (JAMSTEC), and serve as the program coordinator for the Innovative Program of Climate Change Projection for the 21^{st} Century, which is a national program supported by the Ministry of Education, Culture, Sports, Science and Technology (MEXT).

Being a senior researcher in the field of the climate research, recently I have increasing opportunities to talk to people outside academic community on the global warming issue. As one of such activities, together with Prof. Maruyama and Mr. Tsutsui from the Central Research Institute of Electric Power Industry (CRIEPI), I began to conduct a research on a global warming scenarios directly related societal issues, which is a new field to me.

I learned from the presentation of Sir Brian Hoskins that his research is very similar to what we are doing. In a sense, it might be said that a small research group here in Japan is challenging the same big issue. In the UKCCC a number of authoritative experts get together to discuss the issue for the sake of their government, while in Japan our three-person-group is engaged in the same kind of issue.

Today, I would like to report the latest results of our research concerning a specific issue rather than an overview of research results of a large national project. I understand that the objective of this symposium is to clarify the scientific basis of the GHGs reduction plan now under discussion, and to search for a GHGs reduction strategy that can be shared globally. Therefore I think our research is very suited for this objective. So, I would like to take this opportunity to show you our research results; perhaps I will go into some more details than other presentations.

The currently discussed GHGs reduction strategy is to limit the global mean atmospheric temperature rise within 2 degrees for preventing dangerous climate change. For this purpose, it is said that the global GHGs emissions should be reduced down to 50% of the present level by 2050. This target was first raised by the European Union in 1990s. From then on, it has been included in the G8 Summit declaration in 2007 and 2008 (slide 4).

In the political documents, the words of “present” and “the GHGs” are used without clear definition, but we need to identify what they mean for scientific discussion. Referring to the IPCC report, “present” indicates the year of 2000, and “the GHGs” means CO2 which were mentioned in the Fourth IPCC Assessment Report of the Third Working Group. Therefore our following discussion is based on these definitions.

As to “2 degrees”, how much precise is it? Just like Sir Brian Hoskins mentioned, “2 degrees” is not clearly defined anywhere. In the IPCC WGII AR4, it was stated that many serious problems would occur if the global mean temperature rose to a level more than 2 to 3 degrees compared with the 20 years’ average of 1980 to 1999. However, the global mean temperature in 1990 had already risen by 0.5 degrees from the pre-industrial level. Therefore what was said in the IPCC WGII report implies that a temperature rise of more than 2.5 degrees to 3.5 degrees from pre-industrial level might be dangerous.

Please keep in mind that there’s such a range of uncertainty in the temperature rise limit, though we will not discuss it now. Instead, let’s set the limitation for temperature rise to 2 degrees, while keeping some range of allowance in mind, and continue our discussion on the scientific basis for the necessary emissions reduction.

We climate scientists have been working for the scientific basis of the climate change issues. I think even in political, economical and many other discussions in society, it is also necessary to show the scientific background clearly for climate change mitigation strategy. However, there is a problem concerning the structure of IPCC. As shown in Slide5, the IPCC is divided into the Working Groups I, II, III. The Working Group I carries out climate research and make future projection, but the issues such as what kind of impact will be caused by that, how to respond against the impact, and how to mitigate the climate change if its impact is very large, are examined by other Working Groups. Since the assessment is carried out under such a structure, the climate science at the starting point doesn't connect directly with the discussion of the mitigation strategy.

Mr. Fukui had listened to various opinions and views in the mid-term target advisory committee of the government in Japan. However at that time, there were a lot of discussions from the view point of technology and social system for reducing emissions, but the relation between the climate science and the mitigation strategy or requirement for emissions reduction did not come into view so much. It remained obscure why such reduction is needed or whether such reduction is absolutely needed or not. Thus, one of the purposes of today's symposium is to clarify the relationship between the climate science and the mitigation strategy.

Slide5 shows the flow from the climate change science to the mitigation strategy. The full climate model referred here is such mode those are used for climate change projection research. It needs one or two years with very large-scale computer to make projections on what will come in the future due to the CO2 emissions. But that's not so easy. Therefore, a short cut way using a simplified model is usually used to link climate change to the future scenario analysis. Sir Brian Hoskins introduced that they used a simplified model named MAGIC in UKCCC. Our model is slightly different, but similar. It is a very simplified model which makes a linkage between the GHGs emission and the temperature rise. My collaborator, Dr. Tsutsui, is an expert on this issue.

The outline of my presentation is described in Slide 6.
"Stabilization" is a key word now in discussing the Global warming mitigation.
However, similar to Sir Brian Hoskins, I also doubt the conventional "Stabilization" in some aspects. Therefore, we proposed a new concept of stabilization by introducing an idea of zero emission (the emission is almost zero) to replace or add to the conventional stabilization.

Sir Brian Hoskins showed us a UKCCC emission scenario called "2016-3%-Low", which means to cut down the CO2 emission by 3% annually starting 2016, until the CO2 emissions is reduced to zero.
We will adopt the idea, examine various aspects what the zero emission implies, and discuss the differences in CO2 concentration and climate change between the cases based on the conventional stabilization and zero emission scenarios.
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And next, since the current idea of the 50% reduction by 2050 is based on the concept of the conventional stabilization, I would like to re-examine this scientific basis in detail. I am sorry that this part will be technical and a bit more complicated.

Finally, I will propose a workable scenario of global warming mitigation based on the zero emission. It is called Z650. Its detail, especially its socioeconomic implications will be explained by the next speaker, Professor Maruyama.

<Reexamination of traditional “stabilization” concept>

First is the reexamination of the conventional stabilization concept. Slide8 shows a graph in the IPCC TAR Synthesis Report, which illustrates the concept of stabilization very clearly. The purple line indicates the CO2 concentration. As shown on the horizontal axis, this figure is for the 1000 years from now. The CO2 concentration will increase rapidly during the first 100 to 200 years, then maintain a relatively stable level. This is the reason why it is called stabilization. Currently CO2 concentration is increasing, but before the industrialization, it was very constant in the natural world. The concept of the stabilization intends to make it constant again in the future.

The brown line shows the amount of the CO2 emissions corresponding to this scenario. The current increasing trend will continue until around 2020, and then the CO2 emissions will begin to decrease through various efforts. The decreasing will be very rapid within a certain period, but then the rate of decrease slows down. Finally, there will be a near constant small amount of CO2 emissions in the future. For a long time I have insisted that there is a problem here.

In this graph, the blue line stands for the sea level rise due to thermal expansion and the blue dotted line stands for the sea level rise due to ice sheet melting. The sea level will continue to rise even though the CO2 concentration and the temperature have been stabilized. This is a very important point that this graph of IPCC TAR Synthesis Report indicates.

Let me repeat the most important point, that the sea level is to keep rising even if the concentration and the temperatures are stabilized. The reason is that the air temperature is a little higher than the past. Because the air temperature is higher than the pre-industrial era, a large amount of seawater gradually expand due to thermal expansion effect until the whole volume of the sea water down to the bottom gets warmer, thereby the sea level will rise. Also, part of the ice sheets that keep their volumes under the temperature in preindustrial era will begin to melt, therefore the sea level will continue to rise. I think this is a very serious problem which is depicted by this diagram.

Slide9 summarizes the same viewpoints I have just mentioned, in addition another point that 65-70% of the final temperature rise will occur at the beginning of stabilization is also remarked, which is described in the IPCC 4th assessment report.

Slide 10 shows the correspondence between stabilization scenarios and CO2 emissions. The upper panel shows CO2 concentration pathways at selected stabilization levels and the lower panel shows CO2 emissions corresponding to each stabilization pathways. This figure is taken from the IPCC WGI AR4, but it was originally included in the Third Assessment Report (TAR). Thus such calculations to relate CO2 concentration stabilization pathways with corresponding CO2 emissions have been made and discussed in the past. In such studies the calculation was made by using simplified model. In this talk we will show some results of our study on the same concentration-emission relations but for scenarios different from “stabilization”.

Before going to our results by use of a simplified model, I will show some simulation results of a full earth system model, which is developed by a research group of JAMSTEC since 2002. The model includes not only the physical aspect of the global environment, but also the chemical carbon cycle as slide11 shows.

Slide12 shows a recent simulation results of the model. It indicates a CO2 emission pathway towards the 450ppm stabilization from current concentration level. Though it is just an example, it suggests that almost the same results were simulated by the complex full model compared with the simplified model shown in the slide10. Therefore, we are going to use the simplified model afterwards.

One problem that puzzles us in the upper right graph is that a small amount of emissions will continue even after the stabilization. The lower left graph shows the ecological absorption on land, and the lower right one shows the absorption by ocean. The ocean will continue to absorb CO2 even in the case that CO2 concentration is constant after stabilization, though one may suppose that the absorption would stop. The slide13 shows the reason. The CO2 coming from the atmosphere will fill up the orange area of the ocean in a short period. The top layer mixing is due to the ocean circulation driven by winds and penetrates down to several hundred meters. It will take around 20 years to mix the layer of this depth. Therefore, in the depth of several hundred meters, currently the CO_2 concentration is above about 350 PPM, which is the concentration in the atmosphere of the year of 1990 (20years ago). But things are different in the deep ocean layer, which is controlled by the deep ocean circulation.

The high salinity water generated by the cooling in the south and north polar regions sinks downward into the deep ocean. Driven by this mechanism, the sea water overlying those cold waters goes upward very slowly in all of the ocean areas. Because that the process takes a time span of about 1000 years, the deep ocean water has not yet experienced to contact with the atmosphere after the industrialization. The sea water in these deep levels sank from the surface 1000 years ago, when the Tale of Genji was written in Japan; it was the Song Dynasty in China; or it was before Norman Conquest in England. Therefore, the ocean will work to decrease the CO2 concentration towards near 280ppm of pre-industrial level by absorbing the excess concentration, even though the surface concentration has increased to 350 or even to 450ppm in the future. This process is responsible to generate the right bottom graph in the slide 12.

So, even after stabilization, the ocean will continue to absorb. We do have such a mechanism in nature. However, should we rely on this, and continue emissions of CO2 indefinitely? That is stated on slide15. As I have shown you in the graph of slide12, in the stabilization strategy once you reduce the emission drastically, why do you stop your effort after a while? That’s my question. Once emissions go down to about 10% to 20% of the peak, you’re not going to continue your efforts to reduce further. Why do you continue to emit a very small amount over many centuries? It is very strange.

Well, the keeping of CO2 emission is not based on concrete grounds as emissions strategy or requirement. That is merely due to the inverse calculations. It is decided beforehand to stabilize at a constant concentration level and then CO2 emissions are estimated to meet the constant concentration backward. Then, such a curve comes out.

In the natural world, the sea water absorbs CO2 little by little even the concentration is constant at a stabilization level, because there is a vast amount of sea water in the deep ocean that was in contact with old air some 1,000 years ago and doesn't know the Industrial Revolution , as I explained previously. And if we want to keep the atmospheric CO2 concentration at a prescribed constant level, we need to continue to emit CO2. Thus “stabilization” implies that in order to maintain the concentration at a higher level than pre-industrialization age, we continue to emit. So, it sounds strange, doesn’t it?

In contrast to this, we have an idea as follows as summarized in slide 16.

The emission reduction shall not be slowed down. We will continue to reduce emissions so that it will be lowered to a level sufficiently below the level of natural uptake, that's about 10% or 20% of the current emissions. This can be regarded as practically zero emission. In this case the CO2 concentration will once go up, but then it will come down to approach its final equilibrium. In a similar fashion, the temperature will go up but then it will start to decline at a certain point.

In Sir Brian Hoskins's diagram, the 2016 3%low scenario, the temperature is also going down. You might worry that there's going to be a cooling effect on the globe rather than global warming. But there is no problem. Because, when CO2 concentration decrease by the natural absorbing and the temperature declines corresponding to this, the declining rates are very slow as the same level as changes which take place in the natural world.

In comparison to 2 or 3 degrees which is currently discussed, the temperature rise in the zero emission case is finally going to approach much lower levels; say the final concentration 370 PPM and the final temperature rise 1.3 degrees. Therefore, if we can attain zero emissions, it works very well, so that's what we have tried to examine this possibility in our research.

<Calculation by simplified model>

In Sir Brian Hoskins' talk, UKCCC used a simple model called MAGIC, while the model we used is NICCS, Nonlinear Impulse Response Model of the Coupled Carbon Cycle-Climate System. This was first developed by Max Planck Institute in Germany and was improved Dr. Tsutsui. (Slide18)

First, we will introduce one of our scenarios which assumed zero emission. It is represented in the bold line in Slide19 as Z650. The upper left graph (a) shows the amount of CO2 emissions. There are various proposals as to the amount of CO2 emissions scenarios including UKCCC's. So referring to those we have produced our new scenarios Z650.

The peak of Z650 will occur in 2020, and the amount of emissions is 11 Gt (Gigaton) carbon at that time. Sir Hoskins used Gt CO2 as the unit of emissions, so amounts expressed in his unit must be 11 over 3 times of our amount. Therefore the equivalent amount is 40 Gt CO2, and this is the peak. After that, by 2040 it's going to be 8 Gt carbon, and in 2070 4 Gt carbon, and in 2100 2 Gt carbon. So, every 30 years, it will be reduced by half. This corresponds to a reduction of about 1.5% or 2% per year, and this almost coincides with the scenario of UKCCC 2016 2% low.

Based on this emissions path, by use of NICCS, we have calculated the CO2 concentration (b) of slide19, the global mean temperature rise (c), the sea level rise (d) until 2200. Slide19 also shows the scenario which stabilizes CO2 concentration by 450ppm with the dashed line.

Furthermore, the long-term characteristics of the two scenarios, Z650 and E450 are shown in Slide20. The graph of the lower side in Slide20 shows the stabilization of the CO2 concentration by 450ppm. In this case the CO2 concentration after stabilization is fixed by definition, and this level of the CO2 concentration will continue indefinitely. This is the conventional concept of stabilization at 450ppm. On the other hand, the graph of the upper side in Slide20 shows that the emissions of CO2 will be reduced down to zero in the middle of the next century. And as a result, the concentration will once overshoot exceeding 450ppm to go up to 480ppm at one time, but afterwards will be reduced down to 370ppm at 3000, that is lower than the current level.

I forgot to say that, in the mean time the comparison between the two, we are only considering CO2; other GHGs or aerosol effects were not taken into account. We will treat them later on as a more realistic case.

The peak of the global mean temperature rise under the scenario of Z650 is about 1.8 degrees and CO2 concentration also reaches its peak at one time.
However, after the peak, since the emissions go down to zero, CO2 concentration goes down as expected, and the global mean temperature also goes down.
Well I said E and Z, Z stands for zero emission and E stands for emission keeping stabilization. 650 stands for the total emissions of CO2 in the 21st century in terms of carbon amount, that means 650 Gt carbon.

In the E450 case, the temperature continues to rise and by 3000 it reaches 2 degrees higher than the pre-industrial era. The sea level rise, though only the thermal expansion is taken into account, will keep rising. Next, we shall examine Z650 case where 650 stands for total CO2 emissions in the 21st century in terms of Gt carbon or 2,300 Gt of CO2. And as for the total amount of the emissions that the human emitted until present since the time of the Industrial Revolution, they are about 350 Gt carbon. Therefore, regarding the total emissions until the end of the 21st century, it's going to be about 1,000 Gt carbon in the case of Z650.

As mentioned already, in the case of zero emission, the temperature will once go up, but then start to decline to reach about 1.3 degrees rise at 3000. The concentration will also decline down to 370ppm. In the other case of emission keeping scenario, following the conventional stabilization concept, the concentration will be kept constant, because the emissions is maintained. Temperature continuously rises gradually approaching the equilibrium value which is slightly above 2 degrees. The comparison between the two scenarios is very clear. If we continue to work on CO2 emission reductions and if we make it zero in mid 21st century, the temperature will go up for a while but then it will turn to decline, and may reach the safety level of the temperature. The slide21 summarizes the results of comparison between E450 and Z650.

<Re-examination of the current emissions reduction strategy “50% reduction by 2050”>

Now, we shall reconsider the current emission reduction strategy of 50% by 2050 (slide22). Slide23 shows a table in the IPCC WG III AR4 (2007) which seems to be the grounds for the emission reduction strategy of 50% reduction by 2050. In the table, Category I Scenario, which represents a group of 6 scenarios with the least amount of emissions, seems to correspond to this advocated strategy.

Now, we have just seen that in the case of the scenario for zero emission, it is allowed to emit more CO2 in the 21st century compared with the conventional stabilization scenario. Namely, the total emission in the 21st century of E450 was about 100 Gt carbon less than the amount of zero emission’s scenario. Since in the E450 case lot of CO2 emissions will occur in the future after 2100, by the accumulation of a little emission, it brings about a high gross emissions. On the other hand, within the 21st century the amount of emission for E450 is smaller than zero emission’s scenario.

Since we know the above contrasting features of the two stabilization types and the reduction by 50% in 2050 sounds like a very tough target, therefore we thought if there is an attainable prospect of zero emission by 2150, so far in the 21st century, the more emission would be allowed under the same temperature rise constraint. Then, we have checked it. (Slide24)

In order to check this, like in the case of UKCCC’s, we need to consider other GHGs like methane, nitrous oxide as well as CO2. At the same time, we need to consider the cooling effect by aerosol (slide25). If we explain details, it’s going to be quite complicated so that I would like to skip. However, there is one important point. In order to compare these two, the traditional stabilization and the zero emission stabilization, we need to compare them based upon the same sets of conditions regarding effects of other GHGs and aerosols. As to E450, it should be reduced by including the additional radiative effects from other gases, and then the effective total concentration should be 450PPM CO2 equivalent at the stabilization. As to Z650, since we have considered only CO2, it should be adjusted to the total emissions by including other GHGs (slide26).

As the common data to be used by various studies in the world, Integrated Assessment Modeling Consortium (IAMC) recently published several GHGs emissions scenarios for the IPCC 5th report which will be reported in the future. Slide27 shows some of the CO2 emissions pathways in the report of IAMC together with the pathway of Z650. One of the pathways in IAMC's report, RCP2.6, corresponds to the concentration of 450ppm including all GHGs at 2100, in a word this is the scenario of 450ppm stabilization emissions pathway to meet the 2 degrees temperature rise. Therefore, as the representative of scenarios which include the effects from other GHGs and become stabilized at 450ppm CO2 equivalent, it is natural to adopt RCP2.6.

Looking at the curve of RCP2.6 in Slide27, we see that the current emission amount is 8.5 Gt carbon per year, and for a decade or so the emissions will increase a little bit, but afterwards the emissions will be drastically reduced to be quite close to zero at 2100. Slide27 also shows the curve of RCP3-PD, which is similar kind of data as RCP2.6. The emissions of RCP3-PD become negative at 2100. Recently more focus is placed on this RCP3, but it seems a little bit strange. Therefore, we adopt RCP2.6 as the counterpart of the comparison.

Z520 in Slide28 was produced by us as a representative of zero-emission scenario for the comparison. Based on Z650, it is one of family scenarios modified by the method of trial and error. The total emissions of Z520 in the 21st century are 520 Gt carbon. And this amount is almost the same as the amount of 2016 3% low, which Sir Hoskins showed as the conclusion of the most desirable emission scenarios.

I am going to go into details from now on comparing Z520 which is the new scenario of zero emission type and RCP2.6 which is the conventional stabilization scenario. Actually incorporating the effects of other gases we had a difficulty and as a result, we derived two modified versions RCP2.6 mod A and RCP2.6 mod B. Actually the emission paths of other gases, which are included in the original RCP2.6 scenario, match the emission path of CO2. However, in order to study under the same condition as Z520, if we try to include the new paths of other gases which we have produced from the basically same considerations, the result looks quite odd. So we modified the original CO2 emission pathway of RCP2.6 to become smooth after incorporating other gases effects with the conditions:

A. total radiative effect becomes 450ppm CO_2 eq. by 2100 or

B. CO_2 emissions be close to the original RCP2.6, even though the total effects cannot reach 450ppm CO_2 eq. by 2100 but delays. These two modified pathways are designated as mod A and mod B.

Comparing the two (Z520 and RCP2.6), under the same condition including other gases, I would like to show you what the result looks like (slide30).

In Slide31, the solid line stands for the scenario of zero emission, the dashed line, and dot-dashed line stand for two modified RCP2.6 scenarios, mod A and mod B, respectively. When you look at RCP2.6s, though they are intended to be stabilization pathways, there are little peaks. If we consider the actual situation, the total effective concentration of CO_2 and other gases is already about 420ppm at present, and since we might not be able to change the pace of emission soon, there's no choice but to overshoot. However, as Slide31 shows, in the end of the 21st century in this scenario the concentration is stabilized at the level of 400ppm for CO_2 alone.

As Slide32 shows, when we include the effect of other gases, the concentration level is 450ppm CO_2 equivalent, and this level will continue. Unless we meet this, we can't attain the 2 degrees temperature limit. On the other hand, in the case of Z520, the concentration level once goes up to a higher level higher than 510ppm CO_2 equivalent at the peak, but afterwards it goes down to a lower level. And at 2300, it is at a lower level than RCP2.6.

As Slide33 shows, as for the temperature, naturally we can see that the temperature of Z520 is going up close to 2 degrees rise but it goes down thereafter. In line with the zero emission characteristics, it goes down and down, so that it reaches a level between 2 and 1 degree rise. The concentration also goes down to the level which is lower than the present day level.

As for RCP2.6, the temperature will continue to rise in the far future approaching 2℃, but within 200-300 years it will continue to be under 2 degrees rise. So, this is another characteristics arising from the limitation of stabilization. Slide34 shows the summary for the comparison between Z520 and RCP 2.6.

Thus we could confirm our expectation that under the zero-emisssion stabilization pathways more CO_2 emissions are allowable in the 21st century compared with conventional stabilizations. Specifically under the zero emission, we thought more than 50%, like 60% of the year 2000 emissions were permissible at 2050. (Slide35) However, at 2050, it is only up to

54%, even in the zero emission scenario like Z520. And a strange point is that the amount of the emissions for RCP2.6 is only at 33% of the year 2000 emissions at 2050. That means 67% reduction. (Slide36)

This fact was, however, obvious from beginning by inspecting the RCP2.6 in the slide27. We have adopted this as a representative of Category I, because the target stabilization level is 450ppm. By our careful inspection, we found out that the emission paths of IPCC WGIII Category I were not realistic. As seen from Slide37 the amount of CO2 emissions of RCP2.6 is originally above those of IPCC Category I in the first 20-30 years from 2000. At present emissions of CO2 are rapidly increasing, and this fact is incorporated in the new scenario RCP2.6. Therefore, from a consideration that the concentration at a certain time is nearly determined by the cumulative past emissions, the emission path of RCP2.6 has to be under the path of Category I at 2050. Both of RCP2.6 and Category I are the stabilization scenarios at 450ppm equivalent CO2 concentration, but the paths of Category I do not reflect influence of the real fact that currently the emissions already increased by about 20% from 2000.

The concept of 50% reduction by 2050 was supposed to be based on the scenarios in the IPCC AR4. However, they did not reflect the current situation as the amount of emissions. Therefore, if we reflect the current increasing situation, it is not enough to reduce the amount of the emission by 50% at 2050. In short, the currently advocated emissions reduction strategy has not sound scientific backgrounds.

As described in Slide35, at first we expected that the scenario of zero emission would allow more emissions than the amount of 50% reduction at 2050, but actually it was not so. The reason can be understood from foregoing discussion. Namely, if we reflect the current realistic condition correctly, the reduction rate at 2050 for the conventional stabilization scenario should be more than 60% leaving near 30% of the 2000 emission as allowable. Fortunately we have the idea of zero emission, and if we adopt it, it is possible to say that attaining 50% reduction at 2050 ensures the 2 degrees rise limit under the condition that the emissions go to zero in the 22nd century. Thus the widely advocated mitigation strategy could be survived by including zero emission. And this conclusion is mentioned in Slide38.

<Zero emission scenario Z650 for application to practice>

Now I'd like to pass on to Prof. Maruyama, but just let me introduce the scenario of Z650. I initially took up this Z650 pathway for a comparison of the conventional stabilization scenario and the zero-emission stabilization, but now I would discuss this Z650 scenario more carefully as a practicable and significant scenario of CO2 emissions.

In the case of Z650, if we include the effects of other gases, the temperature increases higher than 2 degrees. However, it differs from the 2 degrees in the case of conventional stabilization. In the case of the conventional stabilization, the target level (2 degrees high) temperature continues forever. And if so, in the view point of several hundreds and thousands of years, for instance, the melt of the ice sheet of Greenland will advance with elapse of time under 2 degrees high temperature than the preindustrial level.

On the other hand, the temperature rise exceeds 2 degrees in the Z650 case but it is only for a certain limited period of time and after several centuries the temperature goes down sufficiently below 2 degree, it is likely to be permitted.
In Slide40, this kind of the idea is mentioned, and as a matter of fact, the scenario of Z650 was originally designed based on this idea.

Slide41 shows the result of the calculation for the pathway of Z650, which includes other gases effects. As the graph shows, the temperature rise is a little over 2 degrees, but afterwards it goes down. Though the risk level of global warming is not necessarily clear, the dangerous level was supposed to be decided as 2 degree rise on the assumption that this level temperature continues through all eternity. Then a 2.2-2.3 degrees rise which is a little over 2 degrees but only for a limited period, 100 ~ 200 years, it may be allowable (Slide41 graph d).

Based on this scenario, since the total amount of the emission in the 21st century is about 650 Gt carbon we may have a large capacity to accommodate needs of newly developed and developing countries. Thus there is a socially and economically significant meaning to discuss feasibility of this proposed scenario as a "globally shared target", the objective of this Symposium. This will be further discussed by Prof. Maruyama.

Thank you for your attention.