IEEJ Energy Journal Special Issue December 2018

On Halving Global Greenhouse Gas (GHG) Emissions by 2050

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Currently most developed countries herald around 80% emission reductions by 2050 and this target derives from halving global GHG emissions by 2050.

This paper describes that the above 50% reduction target arose initially from the so-called "2℃ target (to keep temperature increase below 2℃ since pre-industrialization) ", states that this target has in fact originated from old information, and sets out that a reduction of 28% is sufficient based on the latest information. The paper then goes on to explain that the attainment of the 2℃ target is based on the unrealistic assumption of massive negative emissions (MNEs). Thereafter, the paper provides the latest information on the concept of "carbon budget", allowable cumulative CO_2 emissions to attain the target mentioned above, and on the vagueness of Global Mean Surface Temperature (GMST). Through discussion of these issues, this paper will demonstrate that there exist large uncertainties in many aspects of climate change, and the size of the reduction required to attain the emission reduction goals is fluid in nature. Based on the above, this paper proposes to set "net zero CO_2 emissions in a long run" as a shared actionable goal rather than sticking to the goal of reducing emissions by half by 2050 in order to achieve temperature target (of 2 degree).

The author briefly touches upon the most recent special report by the Intergovernmental Panel on Climate Change (IPCC) evaluating 1.5℃ goal in the text.

1. The Origin of the Target of Halving GHG Emissions by 2050

The target of halving GHG emissions by 2050 is actually based on the 2007 "Fourth Assessment Report" (AR4) of the IPCC.

Table 1 Size of Reduction in Emissions by 2050 for Attaining the 2℃ Target: IPCC Fourth Assessment Report

Category	CO_2 equivalent concentration (ppm)	Mean atmospheric temperature increase (from pre-industrial levels) (℃)	Size of reduction in CO_2 emissions by 2050 (from 2000 level)
I	445 ~ 490	**2.0** ~ 2.4	−85 ~ **−50**
II	490 ~ 535	2.4 ~ 2.8	—60 ~ —30

Source: Extract from the IPCC Fourth Assessment Report, WG3 Table SPM.5

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In AR4, it was stated that stabilizing temperatures within 2℃ (actually, 2.0~2.4℃) of pre-industrial levels would require a 50~85% reduction in CO_2 emissions by 2050 from the 2000 level (Table 1), with a reduction of 50% being proposed on the grounds that an 85% reduction would be excessively unrealistic.

However, at the IPCC's "Fifth Assessment Report" (AR5) of 2014, it was stated that in order to have a 66% or higher likelihood of attaining the 2℃ target, emissions would need to be reduced by 41~72% from the 2010 level by 2050.

Based on the same reasoning as that of AR4, this meant that the minimum size of the reduction required for attaining the 2℃ target now stood at 41%. Since global GHG emissions continually increased since the time of AR4, a 41% reduction from 2010 amounts to a 28% reduction from 2000 when using the same baseline year as that used in AR4. Why are the figures so different from 2007 to 2014, despite the fact that these are both IPCC reports?

The key to this difference lies in scenarios where there is large-scale temperature "overshooting" (in which temperatures exceed the 2℃ increase level temporarily before returning to 2℃) and an introduction of MNEs. Up until AR4, reports assumed a scenario in which temperatures would basically continue to rise and stabilize at a level at or below 2℃; in AR5, in view of continuous increases of GHG emissions, focus has shifted towards scenarios in which temperatures do indeed temporarily overshoot the 2℃ target. As a result, 2 degree target became achievable with less emissions reduction.

The key point here is that the target of halving global GHG emissions by 2050 is based on the old information (i.e. AR4).

According to the "IPCC Special Report on Global Warming of 1.5°C" which was made public immediately before the closing date for this paper, limiting the rise in atmospheric temperatures to within 1.5℃ of pre-industrial levels would require net CO_2 emissions to be reduced to zero by around 2050 to 2060. The report also points out that even if every country's pledge towards 2030 is fulfilled, temperature in 2100 would exceed 1.5°C. No major country offers much more stringent revised pledge at this moment. This simply shows how challenging the 1.5°C goal is.

2. Dependence of the 2°C Target on MNEs, and Its Feasibility

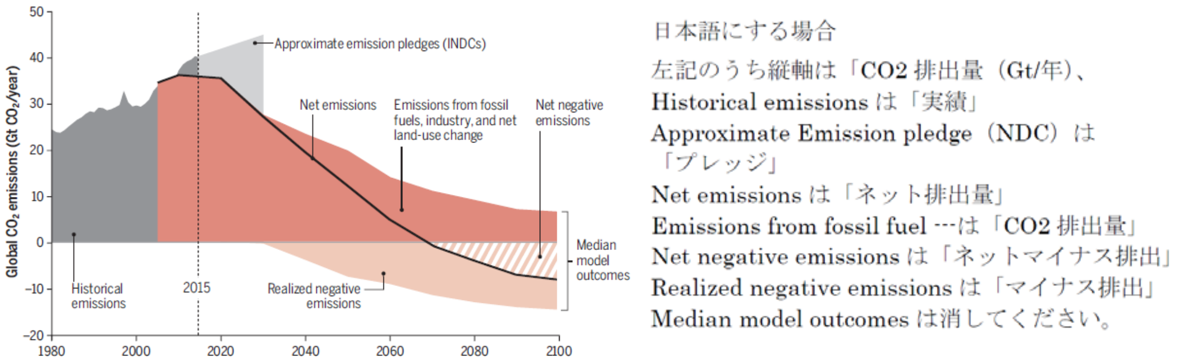
In addition to the above, most of the scenarios in AR5 for attaining the 2℃ target take MNEs as a prior assumption. Emissions could be reduced to zero through carbon capture and storage (CCS), but this does not actually result in negative emissions. Typical technologies used for bringing about negative emissions include bio-energy with carbon capture and storage (BECCS) which uses bioenergy combined with the capture and sequestration of CO_2 that is emitted, and afforestation/reforestation (AF/RF) in which CO_2 is absorbed through large-scale planting and replanting of forests. However, to take the United Nations Environment Programme (UNEP) report[1] as an example, attaining the 2℃ target would require negative emissions amounting to a

[1] UNEP (2017), "The Emissions Gap Report 2017, A UN Environment Synthesis Report," November 2017

cumulative total of 670 $GtCO_2$ (approximately 20 times the CO_2 emissions originating from energy use in 2015) by the year 2100.

To use a concrete image based on a different paper, even if efforts are made to bring about substantial reductions by 2100, this would still leave a fairly large level of emissions (~5-6Gt) remaining. However, if massive NE technology will be introduced, this could more than offset the remaining emissions by 2100, the level of net emissions could be brought down to minus ~8Gt (Fig. 1).

Fig. 1 The Relationship between the 2℃ Target and MNEs



Source: Anderson, K and Peters, G. (2016), “The trouble with negative emissions,” *Science* 354

The volume of cumulative negative emissions that would be required is generally found to be about the same across the literature, but the practical feasibility of attaining such massive NEs is considered to be extremely difficult. The main reasons are necessity of vast land area required and trade-offs with biodiversity and competition with food/water resources. Given this, the prospects for attaining the 2℃ target look bleak.

On the other hand, with not only Japan but the world as a whole experiencing frequent extreme weather events, recent literature has suggested that should atmospheric temperatures rise by more than 2℃, this will trigger further rises in temperature, resulting in a large-scale rise in sea levels to a degree beyond anything experienced by humanity[2]. The question of what we should do, given such a situation, is the challenge that now faces us. However, there are major uncertainties about various aspects in the climate change issue. These will be discussed in the following section.

3. Climate Change and Uncertainties (the carbon budget and global mean surface temperatures)

The concept of the “carbon budget” made its advent in AR5. The carbon budget concept focuses on the idea that a more-or-less linear relationship exists between cumulative CO_2 emissions and the rise in temperatures, with AR5 stating that cumulative CO_2 emissions need to be limited to

[2] Steffen, W. et al. (2018), “Trajectories of the Earth System in the Anthropocene,” *Proceedings of the National Academy of Sciences of the United States of America*, **115** 8252-8259

no more than 2900Gt (1Gt = 1 billion tons) in order to keep the rise in temperatures to no more than 2℃; however, with cumulative emissions reaching 1900Gt by 2011, no more than 1000Gt of leeway now remains. Should this be correct, it means that with global CO_2 emissions for 2015 (for example) standing around 33Gt, this remaining budget (that is, the volume of permitted emissions going forward) will be used up within around 30 years. However, papers disagreeing with such views have also appeared recently.

The reason for this lies in the different methods of measuring the global mean surface temperature (GMST). The first method (the model method) estimates GMST with near-surface air temperature over both land and sea based on its model calculations. The other method (the observational method) uses actual measured values for temperatures taken from observation points around the world, rather than models; this method estimate GMST as global weighted average of near surface air temperature over land, and sea surface (as opposed to near surface) temperatures over ocean. As sea surface temperatures are lower than near surface sea temperatures, it is inevitable that temperatures obtained via the observational method will be lower than those obtained via the model method. In reality, the carbon budget which was set out in AR5 as mentioned above is based on the model method; this makes current atmospheric temperatures somewhat higher in relative terms, resulting in a narrower leeway up to 2℃. This means that the future carbon budget for keeping temperature increases to no more than 2℃ is smaller. Against this, papers which make use of the observational method point out the underestimation of the AR5's carbon budget, leading to lively debates in academic circles[3]. The gap between the model method and the observation method produces a difference in temperature of 0.2℃[4]; assuming that temperatures are currently rising by 0.2℃ over a decade, this difference increases the length of the carbon budget by around 10 years. The main problem here is that the definition of GMST had been vague. Given this, the IPCC1.5℃ Special Report previously mentioned has defined GMST as global weighted average of near surface air temperature over land, and sea surface temperatures over ocean; unfortunately, however, since the model method is also recognized when calculating future predictions, this may cause some confusion in future.

This is one of the uncertainties which accompanies climate change, but a much greater uncertainty concerns climate sensitivity (the degree to which temperatures rise when the concentration of CO_2 doubles), the possible range of which currently covers a three-fold spread ranging from 1.5~4.5℃. For the sake of convenience, 3℃ is used for the purpose of calculations; however, should a level of 4.5℃ turn out to be the real level of climate sensitivity, attaining the 2℃ target will be a hopeless task even if MNEs are introduced, whereas this task should still be possible to attain if climate sensitivity turns out to be 1.5℃. Furthermore, the rate of reduction of global emissions required by 2050 in order to reach the 2℃ target will also vary greatly depending on the climate sensitivity.

Given such realities, our mission must be that of promoting further research aimed at reducing

3 Millar R.J. et al. (2017), "Emission budgets and pathways consistent with limiting warming to 1.5℃," Nature Geoscience **10** 741-747 is a typical example; however, other examples also exist.

4 Schurer A.P. et al. (2018) "Interpretations of the Paris climate target," Nature Geoscience **11** 220-222

these uncertainties, while making sure that we remain flexible in response to changes in knowledge in terms of our long-term targets.

4. Aiming toward Zero CO_2 Emissions in a Long Run

Meanwhile, CO_2 remains unattenuated in the atmosphere for hundreds or thousands of years. In other words, the emission of one ton of CO_2 certainly results in the atmospheric temperature rising by a certain amount. This means that temperatures will continue to rise. We must avoid this kind of scenario, and to do this we must realize net zero carbon emissions in a long run without large-scale NEs. Doing this will require efforts to develop zero-emission-oriented technologies in various domains including the electric power, transportation and industrial sectors in terms of energy supply, while on the demand side we will need to bring about a shift in people's lifestyles away from individual ownership and towards joint usage of items, and work to bring about energy efficiency using artificial intelligence (AI). In all of this, the decarbonization of the electric power generation sector in particular will be the key. This is because, although electrification will make progress across various domains going forward while the use of hydrogen also becomes increasingly proactive, we will not be able to achieve the target of net zero CO_2 emissions unless the electricity that is used is made carbon-free.

Writer's Profile

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Mr. Yamaguchi's previous position include Visiting Professor/Project Professor, University of Tokyo (2006–2015) and Professor of Economics, Keio University (1996-2004). Prior to this, he was Senior General Manager at Tokio Marine & Fire Insurance Co., Ltd. He served in numerous positions on committees and councils related Climate Change and Environmental issues such as a Lead Author of IPCC Working Group III.

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