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The 2 °C Global Temperature Target and the Evolution of the Long-Term Goal of Addressing Climate Change—From the United Nations Framework Convention on Climate Change to the Paris Agreement

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ABSTRACT

The Paris Agreement proposed to keep the increase in global average temperature to well below 2 °C above pre-industrial levels and to pursue efforts to limit the temperature increase to 1.5 °C above pre-industrial levels. It was thus the first international treaty to endow the 2 °C global temperature target with legal effect. The qualitative expression of the ultimate objective in Article 2 of the United Nations Framework Convention on Climate Change (UNFCCC) has now evolved into the numerical temperature rise target in Article 2 of the Paris Agreement. Starting with the Second Assessment Report (SAR) of the Intergovernmental Panel on Climate Change (IPCC), an important task for subsequent assessments has been to provide scientific information to help determine the quantified long-term goal for UNFCCC negotiation. However, due to involvement in the value judgment within the scope of non-scientific assessment, the IPCC has never scientifically affirmed the unacceptable extent of global temperature rise. The setting of the long-term goal for addressing climate change has been a long process, and the 2 °C global temperature target is the political consensus on the basis of scientific assessment. This article analyzes the evolution of the long-term global goal for addressing climate change and its impact on scientific assessment, negotiation processes, and global low-carbon development, from aspects of the origin of the target, the series of assessments carried out by the IPCC focusing on Article 2 of the UNFCCC, and the promotion of the global temperature goal at the political level.

1. Introduction

The ultimate objective determined by the United Nations Framework Convention on Climate Change (UNFCCC) is to achieve "stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time-frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner" [1]. As a framework convention, this expression only fixes the requirements of the stabilization of the concentration of greenhouse gases in the atmosphere in a qualitative manner, and does not define the quantitative level of concentration for avoiding "dangerous anthropogenic interference with the climate system." How to define a quantified long-term global goal to address climate change is one of the core issues for subsequent scientific assessment and international climate negotiation.

Previous Intergovernmental Panel on Climate Change (IPCC) assessment reports have made assessments of rising temperature and possible risks in the climate system under various emission scenarios. However, due to uncertainties in the science of climate change, limits in scientific cognition and development, the time lag and spatial difference between emissions and their consequences, and

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necessary value judgment other than scientific assessment for defining danger levels, the IPCC has never scientifically affirmed the indices that indicate "dangerous anthropogenic interference with the climate system," and thus cannot define the unacceptable extent of global temperature rise based purely on science.

Scientific research into the 2 °C temperature rise started a long time ago; however, the 2 °C global temperature target was not considered as the action goal until the decision of the Council of the European Union (EU) conference in 1996 [2]. After the Copenhagen Climate Change Conference in 2009 and the Cancún Climate Change Conference in 2010, limiting the global temperature rise to below 2 °C above pre-industrial levels became the consensus of the international community. In 2008–2014, the IPCC's Fifth Assessment Report (AR5) made a comprehensive assessment of the climate system change, risks, emission budget, and mitigation pathway choice of 2 °C global warming on the basis of the research results available. After scientific assessment and a series of political pushes, one of the three goals reached at the 2015 Paris Climate Change Conference was stated as "Holding the increase in the global average temperature to well below 2 °C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5 °C above pre-industrial levels" [3]. Thus, the long-term goal of addressing climate change has evolved from a qualitative expression of stabilizing the greenhouse gas concentration in the atmosphere, in Article 2 of the UNFCCC, to a global temperature target with specific value, in Article 2 of the Paris Agreement.

This article analyzes the evolution of the long-term goal for addressing climate change, and the related impact on future scientific assessments, negotiation processes, and global low-carbon development, from the aspects of the origin of the 2 °C global temperature target, the related IPCC conclusion for Article 2 of the UNFCCC, and the promotion of the global temperature goal at the political level.

2. Early scientific research related to the 2 °C target

Studies regarding the 2 °C temperature rise can be traced back to the 1970s, when an explorative study was carried out in the European natural and social sciences to push decisions related to climate change. According to the overview given by Randalls [4] on the history of the EU's temperature control goal, the proposal for the global temperature control goal was very strongly related to the scientific study of climate sensitivity. Equilibrium climate sensitivity (ECS) quantifies the response of the climate system to constant radiative forces on multi-century timescales. It is defined as the change in the global mean near-surface air temperature at equilibrium that is caused by a doubling of the atmospheric carbon dioxide (CO_2) concentration [5]. If the ECS is 2 °C, then the doubling of the CO_2 concentration (generally taken as 550 ppm) will result in a global average temperature rise of 2 °C [6]. In 1967, Manabe and Wetherald [7] used a heat balance model and estimated a temperature response of approximately 2 °C to doubling CO_2 concentrations; in subsequent climate change science, and particularly in the estimation of the climate system model, the doubling of CO_2 has been taken as the core scenario for calculation. Initially, the ECS value was estimated by experts, and in the subsequent IPCC's First to Third Assessment Reports, it was taken as 1.5–4.5 °C. In the IPCC's Fourth Assessment Report, ECS was determined as 2.0–4.5 °C [8]. However, on the basis of many subsequent studies, the IPCC's Fifth Assessment Report (AR5) made an elaborate analysis of this issue, considering it to be 1.5–4.5 °C, that is, extremely unlikely to be less than 1 °C and very unlikely to be greater than 6 °C [5]. With respect to mitigation, countermeasures and actions to address climate change involve a series of estimations and policy analyses on social and economic costs. In 1977, Nordhaus [9] made an explorative cost-benefit analysis of climate change using the CO_2 concentration-doubling scenario; subsequent cost-benefit analyses of addressing climate change began to take the doubling of CO_2 or the 2 °C scenario as the starting point of exploration, reaching many research conclusions [10].

In the 1980s, before the IPCC's First Assessment Report (FAR) was released, climate change studies mostly focused on the relationship between increased anthropogenic greenhouse gas emission and greenhouse gas concentration in the atmosphere, and the global average temperature, calling attention to possible threats from anthropogenic factors. However, there was insufficient basis to determine the indices that should be chosen and the specific figure that would be used as the global ultimate objective in addressing climate change. In addition, since addressing climate change involves complex fields, discussion at the political or policy level tends to give a relatively prudent expression of proposed reductions of greenhouse gas emissions, and to wait for further scientific research results [4]. At that time, some scholars proposed a study of the threshold value of climate change from wider perspectives, in order to determine the level at which climate change can be accepted or avoided; that is, they hoped to make a systematic assessment of various risks that may result from climate change, instead of paying attention only to carbon emission [11].

3. IPCC's First and Second Assessment Reports and decision of the European Council

In 1990, the IPCC released its FAR. Based on the progress of study in that period, the FAR pointed out that the emissions from human activities resulted in an obvious increase of the concentration of greenhouse gases in the atmosphere, aggravated the greenhouse effect, and caused the global near-surface air temperature to rise, thus inciting the international community to immediately effect political progress and discuss how to take action to deal with global climate change. In this report, the assessment was made under the "business-as-usual" emissions scenario (Scenario A), along with other scenarios with progressively increasing levels of the controls (Scenarios B, C, and D); these scenarios held that in around 2025, 2040, 2050, and 2100, respectively, the equivalent CO_2 would be two times that of pre-industrial-revolution levels, and the global average temperature would rise by 0.1–0.3 °C per decade. In order for the concentration to remain stable at the level of that period (1990), it would be necessary to immediately reduce the anthropogenic emission of greenhouse gases (mainly CO_2) by 60%, and reduce methane by 15%–20% [12]. The IPCC's FAR placed emphasis on the rising temperature effect due to the anthropogenic emission of greenhouse gases; the scientific basis was insufficient at that time to formulate suggestions for a specific goal. Considering that addressing climate change involves wide and complex fields, the UNFCCC was formed under the encouragement of the FAR, and established the qualitative expression of the ultimate objective.

As an important scientific support for the UNFCCC's negotiation process, the IPCC included an examination of approaches to the realization of Article 2 of the UNFCCC in the Second Assessment Report following a resolution of the Executive Council of the World Meteorological Organization. In addition, the IPCC specifically formulated a synthesis report to present information on the scientific and technical issues related to interpreting Article 2 of the UNFCCC [13]. In fact, since the IPCC's Second Assessment Report (SAR), providing scientific information to assist the quantification of the long-term goal for the UNFCCC's negotiation has been an important task in the IPCC's scientific assessments. According to the SAR published in 1996, the scientific, technical, economic, and social science literature does suggest ways to move toward the ultimate objective of the UNFCCC, but uncertainties remain for the judgment of what constitutes dangerous anthropogenic interference with the climate system and what needs to be done to prevent such