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GUEST EDITORIAL

Towards a robust and equitable global low carbon transition

The Conference of the Parties of the UNFCCC (COP28) to be held in Dubai (30 November–12 December 2023) is unlike any other, where the first global stocktake of progress towards goals of the Paris Agreement will be undertaken. Article 14 of the Paris Agreement requires a stocktake every five years 'considering mitigation, adaptation and the means of implementation and support, and in the light of equity and the best available science'. Calls for enhanced mitigation will likely emerge from the stocktake, which is timed two years prior to the next round of Nationally Determined Contributions (NDCs) to be made by the parties in 2024–25. The goal is '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, recognizing that this would significantly reduce the risks and impacts of climate change' (Paris Agreement, 2015).

The latest Emissions Gap Report (UNEP, 2022) conveys inadequate global progress towards this goal. At COP26, countries were called to strengthen their 2030 targets by the end of 2022, but enhanced ambition has been marginal. Given the gap between NDCs and the measures to implement them, current policies are projected to increase emissions rather than stabilize them. Global warming is directly liked to cumulative emissions of carbon dioxide across the world, with net-zero emissions central to stabilizing it. The overriding variable for mitigation of global warming is the total area under the annual carbon dioxide emissions curve, i.e. cumulative carbon dioxide emissions, which cannot be bounded unless global emissions decline. Pathways to limit global warming to 2°C and 1.5°C are estimated to require 30–45% lower global emissions in 2030, compared to current policy projections.

Climate tipping points are estimated to become increasingly likely once global warming exceeds 1.5°C. As the Earth system science has advanced, tipping elements have been shown to be more vulnerable than previously understood. Although the thresholds at which tipping will occur are uncertain, the crossing of 1.5°C can trigger multiple large changes from ice-sheet melting to slowdown of the overturning circulation of the North Atlantic Ocean (AMOC). Observational and field studies have revised upwards estimates of vulnerability of ice sheets to ocean warming. AMOC slowdown can have rapid impacts on the atmospheric circulation, including monsoons. Studies of climate policy in the face of uncertain tipping points indicate that their possibility requires enhanced mitigation to avoid crossing these thresholds and thereby lower the risk of larger climate change damages. Many such tipping points involve irreversible changes in the climate system, often requiring centuries to millennia to reverse, owing to the presence of hysteresis. Thus, climate tipping points are usually framed as changes to be avoided, elevating the urgency of mitigation towards net-zero emissions of greenhouse gases (GHGs).

Current policies have put the world on track for about 2.8°C of warming over the 21st century. A global emissions peak is required to occur no later than 2025 in plausible scenarios that limit warming to 1.5°C. Although a 2025 target for peak emissions seems unlikely to be reached, accelerating progress towards decreasing global emissions will be an important part of discussions at COP28.

The success of a global low-carbon transition in the near term depends substantially on the rate of decarbonization in developed countries having a large annual fossil-fuel emissions base. Even countries that have stabilized or lowered their emissions continue to have much higher per capita GHG emissions than the world average. Rapid and accelerated decarbonization in high-emitting countries would have the largest near-term collective impact on cumulative emissions. Most developed countries have targeted net zero by 2050, to achieve global net zero by mid-century. Recent analysis suggests that this requires ending new investments in oil, gas and coal starting this year (IEA, 2023). Backtracking by developed countries, through delaying or reversing policy measures or through new investments in fossil fuels, is inconsistent with the widespread enhanced progress required in the present decade to anchor net-zero ambitions.

India's NDCs have undergone revisions towards increased ambition. From the first NDCs aiming at reducing emissions intensity of the economy by 33–35% compared to 2005 levels by 2030, the goal is now 45%. For renewable energy in 2030, the goal is now 50% installed capacity by 2030, with targeted generation of over 40% through renewable purchase obligations. Considering the large expansion of renewable energy in the past decade, mainly from solar and wind, these goals can be met. Reversing the trend of increasing global emissions within this decade requires lowering emissions in the developed countries, together with limiting emissions in developing countries through sustained emissions intensity reductions as they expand energy services. Emissions intensity of GDP in India has been

reducing at a higher rate in recent years, mainly from renewable energy expansion. As the third largest GHG emitter in the world, with a rising share of world emissions, the country's near-term choices will be significant. However, India's contribution to world annual emissions remains small, and the wider role for the country's mitigation in this decade can be as a catalyst for global action and finance for accelerating collective action.

In the longer term, India's actions can play an important direct role in avoiding large cumulative emissions. Following COP26, India committed to a net-zero goal by 2070. Given its growing annual emissions, reaching net-zero in about 50 years does not circumscribe its cumulative emissions. The country's historic contribution to cumulative emissions is disproportionately small compared to its population, but a 2070 net-zero timeframe may lead to the possibility of large future emissions unless the peak is curbed. Avoiding large cumulative emissions in the future depends on near-term low-carbon choices that can facilitate locking into a sustainable and low-carbon emissions pathway for India. This will require early cross-sectoral transformations.

Historically, Indian negotiators have played a critical role in global framing of equity across nations and enshrining the principle of common but differentiated responsibilities in UNFCCC. Simultaneously, the country recognizes the urgency of global climate action, as a state party to the Paris Agreement. The enhanced ambition embodied in this Agreement followed a large body of science showing that 'dangerous anthropogenic interference' can occur at lower levels of warming than previously recognized. As a tropical nation facing limits to adaptation, India faces large damages from unabated global warming.

Damage costs of global warming are mainly driven by higher temperatures, with growing evidence of higher loss and damages from climate change at warmer baseline climates. Warm countries such as India experience large social costs of carbon, making mitigation to avoid carbon emissions prudent. In this context, building new coal plants is not economically justified. Large expansions of wind and solar energy are important for providing India's citizens sustainable development and decent living, and lowering air pollution-related health and mortality impacts. While existing fossil-powered plants might have to play an ongoing role to balance demand in the steadily decarbonizing electricity grid, early retirement of fossil-fuels infrastructure may be important to gain expertise in low-carbon energy and signal commitment towards a rapid transition as part of the mutual concessions of international climate diplomacy.

Low-carbon energy transitions face important challenges in India. Large-scale energy storage has not been tested for the widespread weather conditions prevalent, has never been implemented at the grid scale, is expensive and yields diminishing benefits towards grid balancing without concomitantly large renewable capacity. India has abundant and widespread solar energy. Solar power is not produced at night, during which large-scale wind energy and storage are required for meeting the energy demand. However, wind energy is seasonal and highly intermittent, requiring overcapacity to balance demand in the context of weather variability. India's low-carbon transition will require large amounts of financing to build a low-carbon energy system and supporting infrastructure in an uncertain global monetary environment with high interest costs. External funds will have to be supplemented by long-term debt financing and shared across sectors.

Climate tipping points present a further predicament for developing countries such as India that are moving to decarbonize their energy systems. Low-carbon energy will be dominated by wind and solar that are highly weather-dependent, and whose resource distributions are vulnerable to climate change. Climate modelling studies have shown that monsoon wind changes can alter distribution of wind energy and that cloudiness increases in a warmer climate can reduce solar energy potential in the country. Moreover, the climate and weather effects of triggering many important Earth system tipping elements on the atmospheric distribution of wind energy and cloudiness, central to the operation of low-carbon infrastructure, are poorly understood. This adds uncertainties to capacity utilization of low-carbon infrastructure. The alternative, to delay decarbonization, is not an option, as the same countries face large costs of unabated warming with intrinsic limits to adaptation. Given the uncertainties in effects of crossing tipping elements that are becoming increasingly likely, low-carbon transitions around the world must not only seek to limit the magnitude of global warming, but must also be planned while considering the possibility of changes in weather and climate. This requires a wide-ranging and collaborative effort between climate science and energy planning, and puts additional pressure on international climate finance.

Presently, it is unclear how the global finance gap will be bridged, with the amount committed (US$ 100 billion annually) being much lower than requirements of developing countries towards mitigation and adaptation (estimated US$ 2.4 trillion annually) by 2030. Additionally, low-carbon investments must consider further sources of uncertainty from large climate change. When developing countries undertake renewable energy investments, in the face of uncertainty about future weather and climate, offsetting economic risks to low-carbon infrastructure can be an important goal of international finance. Developing infrastructure designed to mitigate the impacts of such risks (e.g. long-range electricity transmission and grid-scale energy storage) might be especially suited to such finance.

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