also an acute need to act quickly to avoid and/or adapt to climate-related challenges already being felt.

However, the Global North should recognize Global South countries for the strides they have taken, particularly given that the Global North's historic and current emissions form the bulk of atmospheric GHG concentrations. Countries in the Global North should further acknowledge the deep historical economic inequities that contribute to the differentiated implementation of climate solutions. They must recommit to the 'common but differentiated responsibilities' principle formalized in the United Nations Framework Convention on Climate Change in 1992 and, while acknowledging existing progress, provide tangible financial support for further advancing climate solutions.

Climate change affects us all. Partnerships at local, regional and international scales are key to the successful implementation of climate solutions, and the strongest partnerships are those built on mutual respect and shared goals[25]. To achieve the ambitious 1.5 °C warming target, we will need all hands working together in an equitable way. Only through true partnership between the Global North and Global South, and shared recognition of advances made in countries around the world, can we ever hope to advance climate action. ❐

Chad Jonathan Frischmann[1]✉, Mamta Mehra[1,2], Jimena Alvarez[3], Emilia Jankowska[1], Heather Jones[1], Amrita Namasivayam[1] and Abdulmutalib Yussuff[4]

[1]*Project Drawdown, San Francisco, CA, USA.* [2]*Global Council for Science and the Environment, Washington, DC, USA.* [3]*Lancaster University Management School, Lancaster University, Lancaster, UK.* [4]*Department of Science, Technology, Engineering and Public Policy, University College London, London, UK.*

✉*e-mail: chad.drawdown@gmail.com*

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Author contributions

C.J.F., M.M. and H.J. conceived the idea for this Comment. M.M. led the project planning and coordination. C.J.F., M.M., J.A., E.J., H.J., A.N. and A.Y. contributed to literature search and writing, according to sector expertise. C.J.F. led the framing and editing of the manuscript. All authors contributed to revising the manuscript.

Competing interests

The authors declare no competing interests.

Check for updates

Emissions rebound from the COVID-19 pandemic

Global CO_2 emissions in 2021 were only 1% less than the record levels of 2019, driven by increases in power- and industry-related emissions from China and India and a return of the carbon intensity of electricity to pre-pandemic levels. Is this resumed growth in fossil energy, or a final fleeting surge before a long decline?

Steven J. Davis, Zhu Liu, Zhu Deng, Biqing Zhu, Piyu Ke, Taochun Sun, Rui Guo, Chaopeng Hong, Bo Zheng, Yilong Wang, Olivier Boucher, Pierre Gentine and Philippe Ciais

Four years after the Paris Agreement was adopted, global fossil-fuel emissions reached a record high of more than 35 Gt CO_2 in 2019 (ref. [1]). Widespread disruptions in human activity and energy use caused by the COVID-19 pandemic then led to an unprecedented 6% drop in 2020 emissions, to 33.3 Gt CO_2 (refs. [2,3]). In turn, this remarkable decrease in emissions led analysts to speculate about longer-term changes in the way that energy is generated and used worldwide, and — given persistently high growth rates of renewable energy and increasingly ambitious climate commitments — about whether 2019 could even have been the high-water mark of global emissions[4–6]. Specifically, analysts expect the long-term decline of fossil energy to begin when annual increases in renewables and other non-fossil sources of energy entirely meet new energy demand — a time that may be hastened by both pandemic-related decreases in energy demand (–4% in global energy demand in 2020 (ref. [7])) and stimulus-driven increases in the growth rate of renewable energy.

However, the latest estimates of the Carbon Monitor (an international collaboration that was initiated in 2020 to track global, regional and sectoral emissions in near real-time), based on assimilated activity data from major countries and sectors[8], reveal a strong rebound of emissions in 2021. Emissions between 1 January and 31 December 2021 were only 1% less than those of the same period in 2019 (Fig. 1). Global emissions in 2021 reached 34.9 ± 0.3 Gt CO_2 — a 4.8% increase on the year, which brought emissions just shy of 2019 levels. Our estimate is very similar to recent independent International Energy Agency

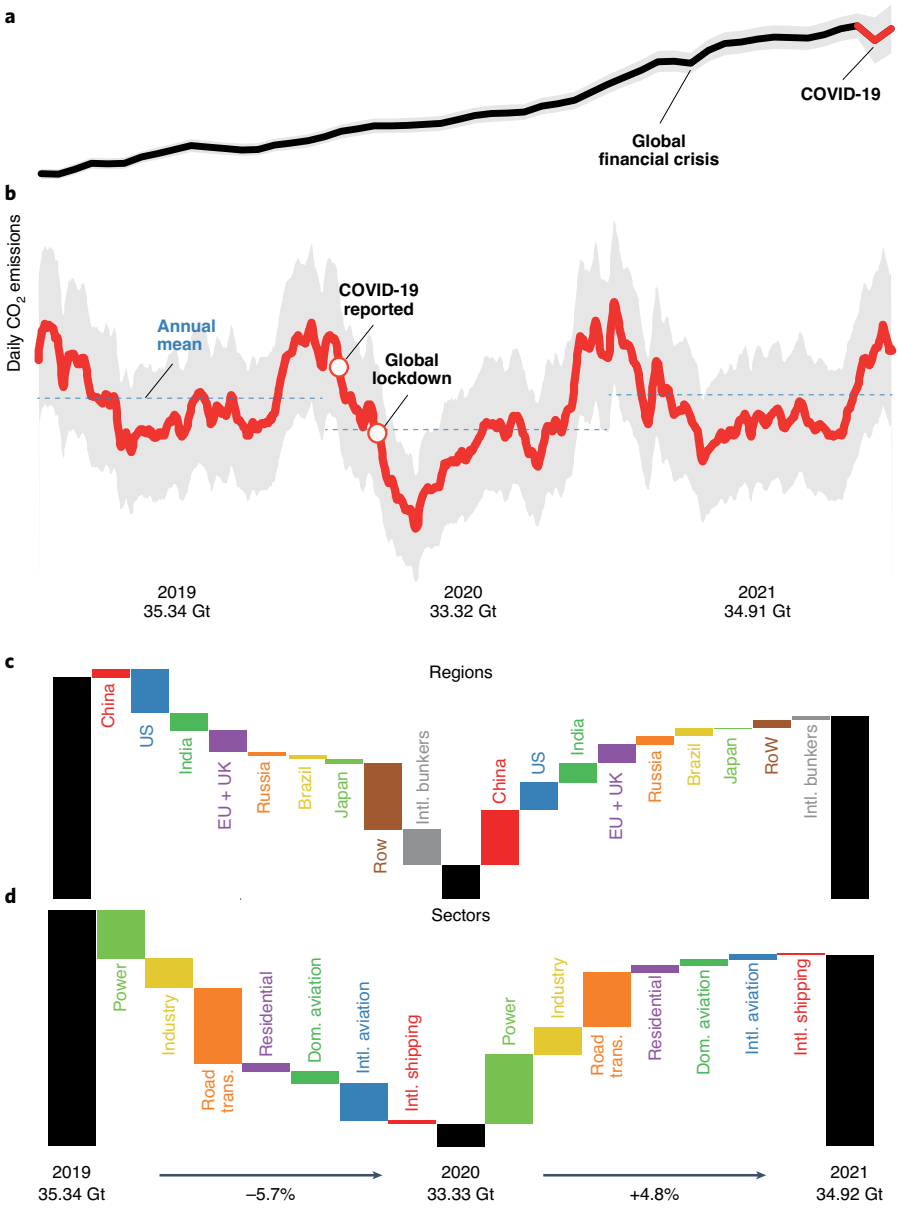

Fig. 1 | Trends in global CO_2 emissions. a, Long-term increases in global CO_2 emissions have been punctuated by decreases in some years related to global crises such as the COVID-19 pandemic. **b**–**d**, The pandemic-related decreases in emissions were greatest in mid-2020 and rebounded strongly in 2021 (**b**), although changes in emissions have varied across regions (**c**) and sectors (**d**). EU, European Union; RoW, rest of world.

projections of a 4.8% increase in 2021 (ref. [7]). These emissions are an integrated measure of the race between rebound and non-fossil sources of energy, and at a global level they suggest that energy demand is resurgent and outpacing efforts to 'build back better'.

Yet the patterns of emissions decrease and rebound for 2019–2020 have varied widely across regions and sectors (Fig. 1c,d). The emissions decrease in the United States was larger than in any other individual country (−9.5% in 2020), but the rebound has also been strong (+6.5% in 2021; blue bars). The combined reductions in 2020 emissions from smaller countries were also quite large (brown bars), but in contrast there has been little recovery in these countries' emissions in 2021. Meanwhile, in India, Russia and Brazil, 2021 emissions exceeded those in 2019 by 0.7%, 3.0% and 8.2%, respectively (dark green, orange and yellow bars), and in China annual emissions did not decrease at all, but grew by 0.9% in 2020 and increased by a further 5.7% in 2021 (red bars). These differences are noteworthy indicators of both the magnitude and persistence of pandemic-related disruptions in different regions. In particular, 2021 emissions would have probably exceeded 2019 emissions if not for the mostly low-income 'rest of world' countries that have not recovered from the pandemic.

Similarly, emissions from road transportation and aviation decreased substantially in 2020 (Fig. 1d; road transportation by −10.9% in orange, and domestic and international aviation by −30.8% and −56.0% in dark green and blue, respectively) and are on track to remain below 2019 levels in 2021 (although they have all rebounded somewhat as lockdowns have lifted around the world). Meanwhile, power- and industry-sector emissions recovered from substantial drops during 2020, with their emissions in 2021 1.5% greater and 0.2% less, respectively, than in 2019 (light green and yellow bars). Increases in power-related emissions relative to 2019 underscore the strong rebound of fossil energy within the sector most amenable to decarbonization.

Further analysing the changes in power-related emissions in major countries shows that the largest decreases in the second quarter of 2020 were driven by reductions in the carbon intensity of electricity, but that corresponding increases in carbon intensity also underlie increases in power-sector emissions in 2021 (Fig. 2). This suggests that the carbon intensity of the global power sector is highly sensitive to electricity demand at present — when demand declined, use of fossil fuels plummeted, but as demand has rebounded, fossil generators have just as quickly resumed operations. Moreover, despite gradual increases in the share of non-fossil electricity in major countries, the carbon intensity of electricity has increased markedly in late 2021 (Fig. 2c), reflecting a resurgence in coal-based generation as natural gas prices have recently risen[9].

Thus, the latest estimates cast doubt on the prospect that 2019 was the high point of global fossil-fuel emissions. Although solar and wind energy continue to grow much faster than fossil sources (for example, renewables accounted for 83% of new power capacity in 2020 (ref. [10]) and only China installed substantial new coal capacity[11]), overall energy use and emissions are recovering rapidly in many places, and some tallies show that more energy-related stimulus has gone to fossil fuels than to renewables[10]. Despite this, decades-long trends in non-fossil energy and large fluctuations in the carbon

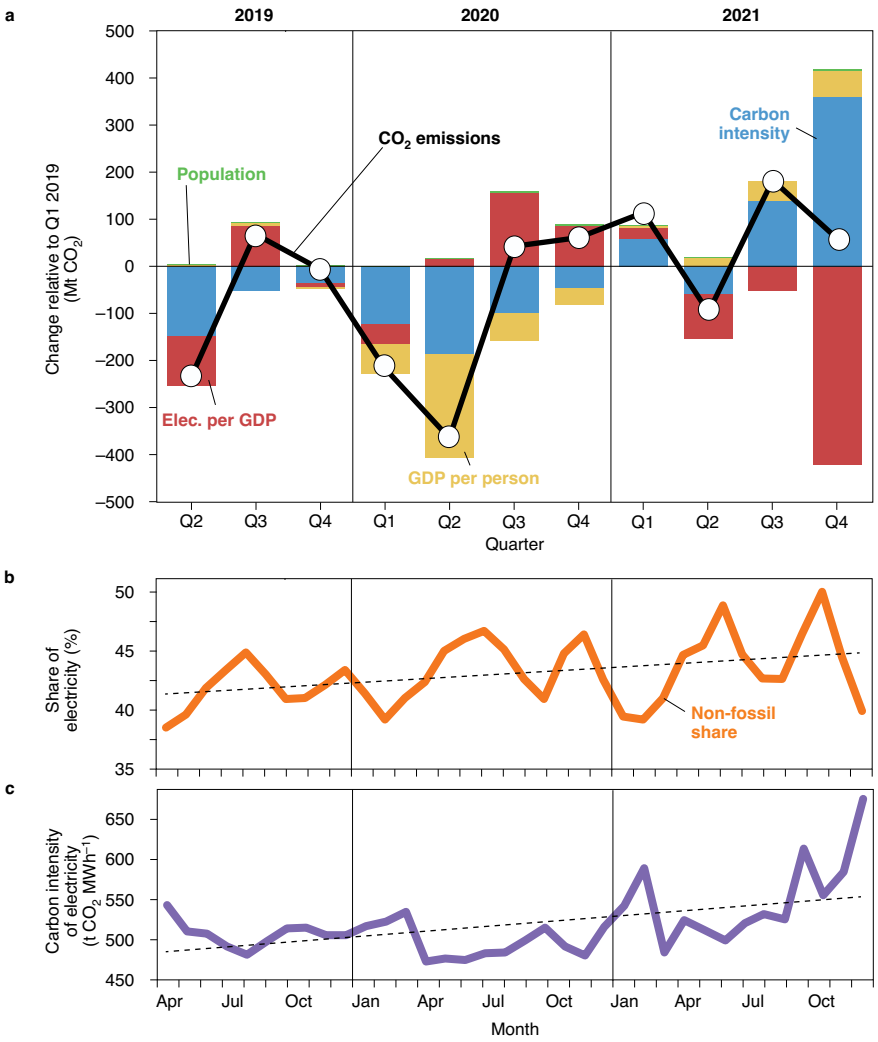

Fig. 2 | Decomposition of changes in power sector emissions. a, Changes in electricity-related CO_2 emissions from China, India, the EU, the United States, Japan, Brazil and Russia (**a**, black line) relative to the beginning of 2019 have most often been driven by changes in carbon intensity (CO_2 per unit electricity consumed; blue bars), with the largest decreases during the second quarter of 2020 and rebounds in 2021 also influenced by changes in economic activity (gross domestic product (GDP) per person; yellow bars). **b**,**c**, Although the share of non-fossil electricity has been gradually increasing over the period (**b**), the overall carbon intensity of electricity also increased in 2021, reflecting decreases in gas and oil electricity and increases in coal.

intensity of electricity during the pandemic indicate that the long dominance of fossil fuels is now precarious. When and how quickly the use of such fuels will decline, however, will depend on how successful countries are in moderating increases in energy demand, curtailing further growth of fossil energy[12], and accelerating growth of non-fossil energy sources. Although many of the mitigation scenarios recently produced by integrated assessment models, energy system models and industry groups project fossil emissions to increase for years to come[13,14], such models have routinely and systematically underestimated the falling costs and related growth of modern renewables such as solar photovoltaics[15,16] — and may be doing so again[17]. If so, as world leaders look to implement agreements from COP26, and as the latest IPCC reports are released, the most important task may be to remove barriers to the deployment of renewables. In any event, the coming year should reveal whether 2021 was a fleeting spike at the beginning of a long downward trend in emissions, or whether fossil-fuel emissions have more years of growing to do. ❐

Steven J. Davis[1,2]✉, Zhu Liu[3]✉, Zhu Deng[3], Biqing Zhu[3], Piyu Ke[3], Taochun Sun[3], Rui Guo[3], Chaopeng Hong[4], Bo Zheng[4], Yilong Wang[5], Olivier Boucher[6], Pierre Gentine[7] and Philippe Ciais[8]✉

[1]*Department of Earth System Science, University of California at Irvine, Irvine, CA, USA.* [2]*Department of Civil and Environmental Engineering, University of California at Irvine, Irvine, CA, USA.* [3]*Department of Earth System Science, Tsinghua University, Beijing, China.* [4]*Institute of Environment and Ecology, Shenzhen International Graduate School, Tsinghua University, Shenzhen, China.* [5]*Key Laboratory of Land Surface Pattern and Simulation, Institute of Geographical Sciences and Natural Resources Research, Chinese Academy of Sciences, Beijing, China.* [6]*Institut Pierre-Simon Laplace, Sorbonne Université–CNRS, Paris, France.* [7]*Department of Earth and Environmental Engineering, Columbia University, New York, NY, USA.* [8]*Laboratoire des Sciences du Climat et de l'Environnement, LSCE/IPSL, CEA–CNRS–UVSQ, Université Paris-Saclay, Gif-sur-Yvette, France.*

✉*e-mail: sjdavis@uci.edu; zhuliu@tsinghua.edu.cn; philippe.ciais@cea.fr*

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Competing interests

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