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GLOBAL ENERGY GROWTH IS OUTPACING DECARBONIZATION

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Global Carbon Project

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Recent reports have highlighted the challenge of keeping global average temperatures well below 2°C and—even more so—1.5°C (IPCC 2018). Fossil-fuel burning and cement production release ~90% of all CO_2 emissions from human activities, with net deforestation releasing the remaining 10%. After a three-year hiatus with stable global emissions from 2014 to 2016 (Jackson et al. 2016, Le Quéré et al. 2018, IEA 2018), CO_2 emissions grew by 1.4% in 2017 and 2.1% in 2018 to 37 Gt (billion tonnes), and are expected to continue to grow in 2019 (updated from Le Quéré et al. 2018). Additional increases through 2019 and 2020 remain uncertain but appear likely because of persistent growth in oil and natural gas use and growth projected for the global economy. Coal use has slowed markedly in the last few years, potentially peaking, but its future trajectory remains uncertain.

Despite positive progress in ~20 countries whose economies have grown over the last decade and their emissions have declined, growth in energy use from fossil fuel sources is still outpacing the rise of low-carbon sources and activities (Le Quéré et al. 2019). A robust global economy, insufficient emission reductions in developed countries, and a need for increased energy use in developing countries where per capita emissions remain far below those of wealthier nations will continue to put upward pressure on CO_2 emissions. Peak emissions will occur when improvements in the CO_2 emitted per unit energy overcome the growth in global energy use, requiring fossil energy use to be replaced by rapidly low- or no-carbon technologies.

Climate change has arrived. Average global temperatures have already risen 1.1°C above pre-industrial levels and, at current rates of warming, are projected to reach 1.5°C within two decades (IPCC 2018). The Great Barrier Reef in Australia has lost half of its coral cover in its northern range, reflecting damage from two severe bleaching events since 2014 and cyclones (AIMS 2018). Extreme events, from hurricanes to heat-waves and wildfires, increasingly disrupt societies, including the loss of human lives. Changes in the intensity and frequency of climate extreme events and their impacts on ecosystems and society now have a discernible influence from climate change and its underlying warmer temperatures (Herring et al. 2018). Weather and climate disasters in the United States cost an estimated $306 billion in 2017, a hundred billion more than ever before (NOAA 2018). CO_2 emissions are responsible for most of the climate change that has occurred and will occur (e.g., Etminan et al. 2016, Huntingford and Mercado 2016) and emissions are rising again (Figueres et al. 2018). Fossil CO_2 emissions increased about 2% in 2018, the second year of growth after three previous years of relatively stable emissions (Jackson et al. 2017, Le Quéré et al. 2018a,b).

Current economic and energy trends suggest that industrial emissions will be at least as high in 2019 as they were for the record emissions observed in 2018. The International Monetary Fund projects Global Gross Domestic Product to grow by 3.2% in 2019, and if the global economy decarbonised at the same rate as in the last 10 years, that would still lead to an increase in global emissions. However, many uncertainties cloud predictions, including risks associated with a potential US-China trade-war, the extent to which the European Emissions Trading System (ETS) carbon price remains relatively high, and the unpredictability of Brexit, all of which could lead to rapid changes in global economic growth. Thus, while we expect global emissions to grow in 2019, we are uncertain how large that growth will be.

Emissions to date place us on a trajectory for warming that is currently well beyond 1.5°C and, potentially, 2°C (Figures 1, 2, and 3).

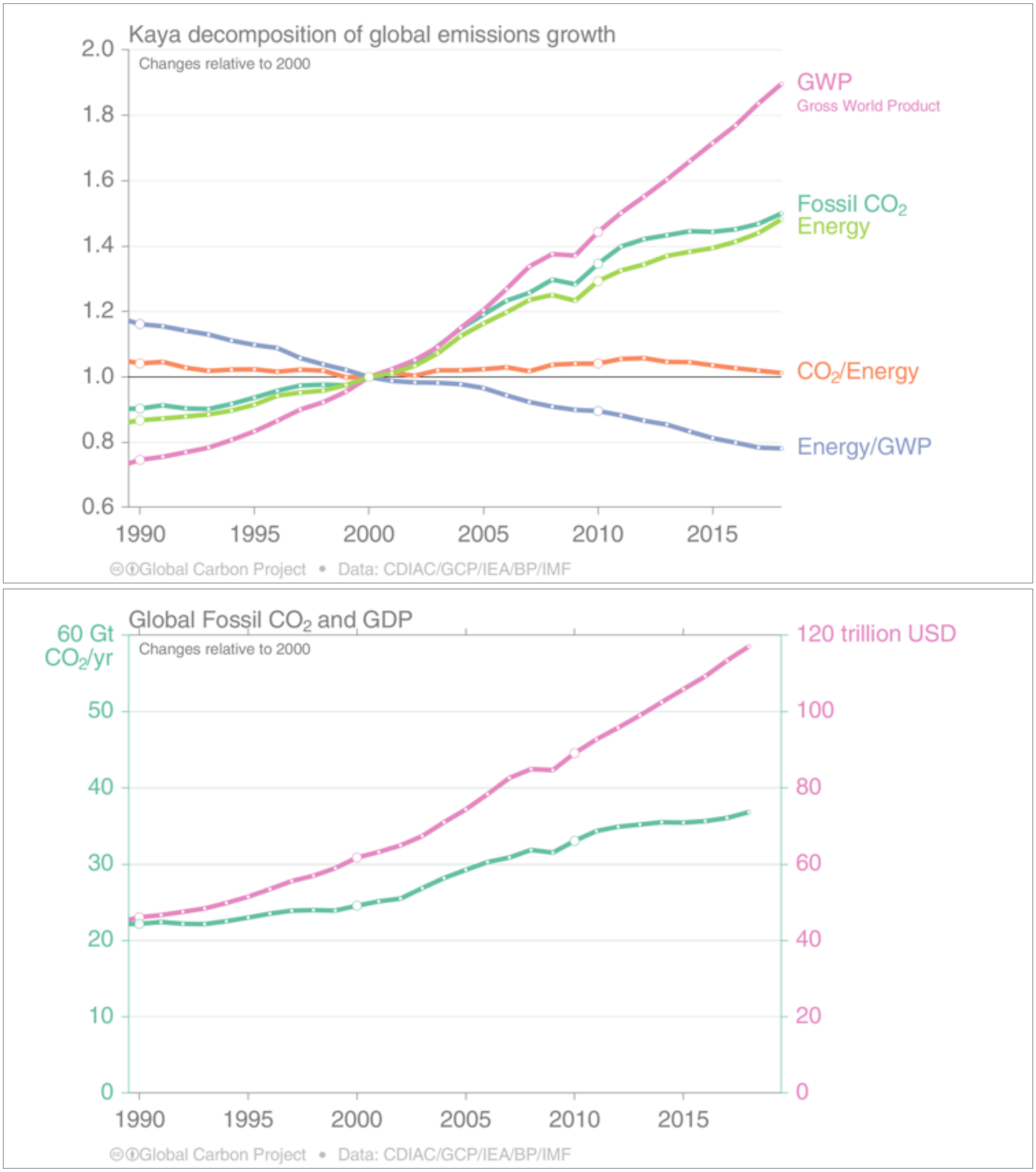

Figure 1 Bottom panel: Global CO2 emissions from fossil-fuel use and industry (green) and Gross World Product ($ US) expressed as purchasing power parity (red; World Bank 2019) since 1990. Upper panel: Relative to year 2000, Gross World Product, global CO2 emissions from fossil-fuel use and industry, global energy use (BP 2019), CO2 intensity of the energy system (global CO2 emissions from fossil-fuel use and industry divided by global energy use), and energy intensity of the global economy (global energy use divided by global GDP) from 1990-2018.

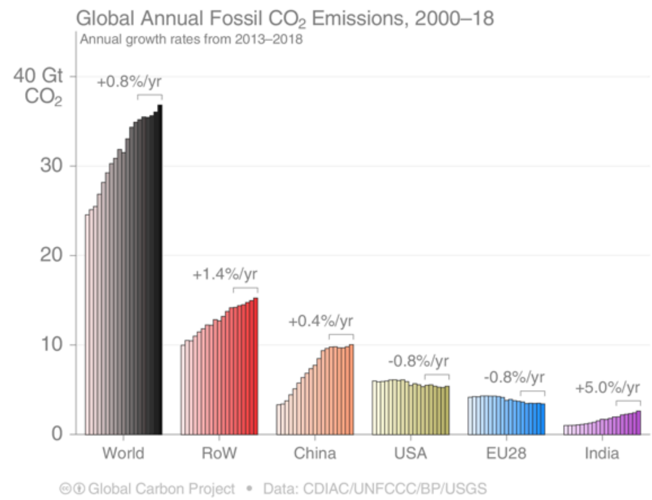

Figure 2 Fossil CO2 emissions, including cement production globally and for five regions (ROW= Rest of Word); brackets show average annual growth rate for 2013-2018.

The global growth in emissions in 2018 can be examined more closely through national trends. Changes in emissions (and estimated ranges) for 2018 compared to 2017 for major emitting countries and regions are (based on preliminary data): China +2.3%, the United States +2.8%, the European Union -2.1%, India +8.1%, and the Rest of the World +1.7%. Despite the return of rising emissions in 2018, positive developments can be found in at least 18 countries having significantly lower fossil CO2 emissions over the past decade without decreases in Gross Domestic Product (GDP): Aruba, Barbados, Czech Republic, Denmark, France, Greenland, Iceland, Ireland, Malta, Netherlands, Romania, Slovakia, Slovenia, Sweden, Switzerland, Trinidad and Tobago, United Kingdom, USA, and Uzbekistan (Le Quéré et al. 2019). These countries contribute 20% of CO2 emissions globally.

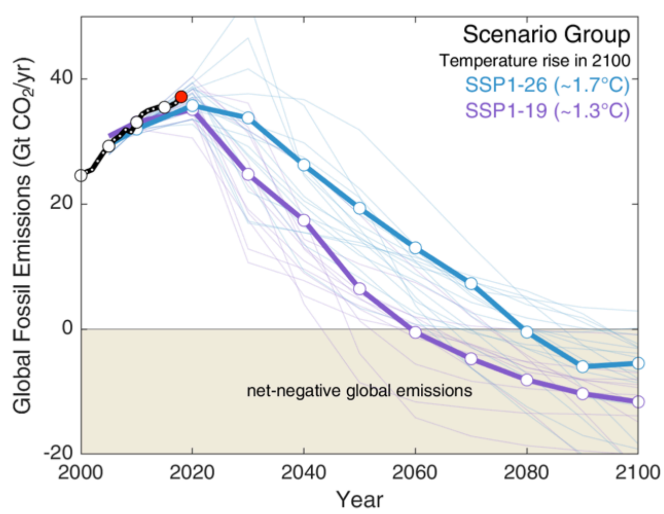

Figure 3 Historical fossil CO2 emissions (black, Le Quéré et al 2018b) compared to scenarios with a 66% probability of staying below 2°C in 2100 (thin blue lines, median temperature increase of 1.7°C; Riahi et al 2016) and below 1.5°C in 2100 (thin purple lines, median temperature of 1.3°C). The respective marker scenarios shown in bold are based on the Shared Socioeconomic Pathways (SSPs). Data: Riahi et al (2017), Rogelj et al (2018). Preliminary value for fossil CO2 emissions in 2018 is shown in red.

Different fossil fuels are contributing varying amounts to the observed increases in global and regional CO2 emissions. Natural gas use has grown the fastest of any fossil fuel at a rate of 2.6%/yr since 2013 (Figures 4, 5). Although natural gas is the cleanest of the fossil fuels, it is still a major source of the global increase in CO2 emissions and contributes to the growth in methane emissions. In countries such as the United States, some of this growth has come at the expense of coal as a fuel for electricity generation, reducing CO2 emissions as a result (Figure 5). In China natural gas use has grown at a rapid 9.4%/yr since 2013, both to supply new energy and to reduce air pollution from coal use. Natural gas use has grown in essentially every region of the world—and in many countries—over the past five years as energy consumption has increased.

Oil use has also grown steadily for many decades and, despite rapid increases in electric vehicles around the world, continues to increase in transportation. Oil consumption has grown 1.5%/yr on average globally since 2013 (Figure 4), with increases of ~5%/yr in China and India (Figure 5) contributing most to the global increase. More surprising has been the increased oil use of 1.3%/yr in the United States and 1.0%/yr in the European Union, where oil use was believed to have peaked some years ago (Figure 5). Despite improved fuel efficiency, these increases are driven by more air travel and vehicles and, in some countries, distance driven per vehicle. Vehicle numbers have grown ~4%/yr globally since 2012 (OICA 2017). Electric vehicle numbers doubled to 4 million between 2016 and 2018 but still represent only a tiny fraction of the billion or more of the light-duty fleet. Finally, air traffic is also using more fuel. Fuel consumption by commercial aircraft grew 27% over the last decade (Statista 2018). Passenger numbers and distance traveled both increased ~5%/yr over the same period, more than offsetting increases in aviation fuel efficiency (ICAO 2017).

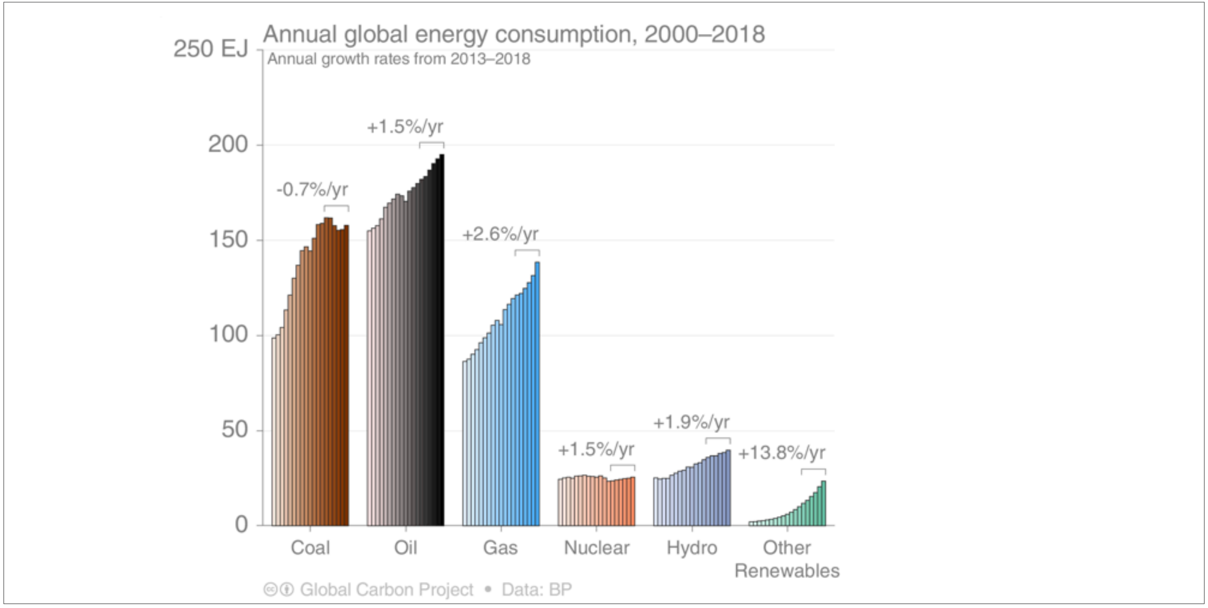

Figure 4 updated. Average annual energy consumption (EJ) by fuel source from 2000 to 2018 globally, with average annual growth shown from 2013 through 2018 (BP 2019).

Global coal consumption had either declined or been steady since 2013, but unexpectedly increased in 2018 (Figure 4). Global energy consumption from coal decreased from 162 billion GJ in 2013 to 158 billion GJ in 2018, a drop of 0.7% per year on average (BP 2019). Based on price and policy competition with natural gas and renewables, coal consumption in both Canada and the United States has dropped a substantial ~40% since 2005; in 2018 alone, ~15 MW of coal-fired capacity in the U.S. will close, a potential record. In the UK where the industrial revolution was born, coal use has declined rapidly in recent decades and could be phased out by 2025. In the E.U., wind, solar and other non-hydro renewables have grown so quickly that—at average rates of change over the past five years (Figure 5)—they are on pace to supply more primary energy than coal by 2021.

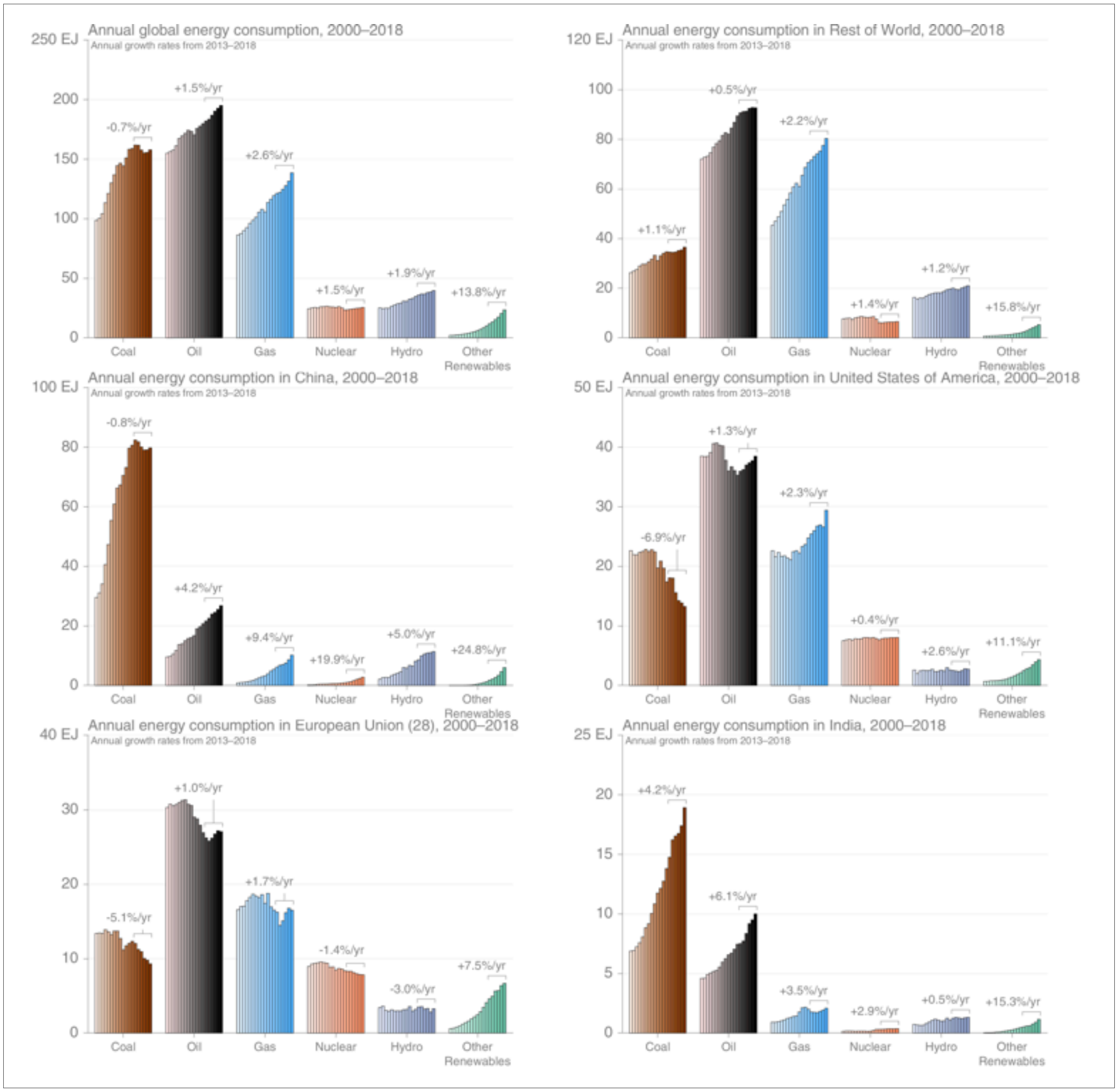

Figure 5. Average annual energy consumption (EJ) by fuel source from 2000 to 2018 globally (same as in Figure 4) and regionally, with average annual growth shown from 2013 through 2018 (BP 2019).

Steep decreases in coal use in places such as Canada, the U.S., and E.U. could eventually be outpaced by increased coal use elsewhere, particularly where energy poverty is prevalent (Hubacek et al. 2017). Increased coal consumption is occurring regionally in the Asia Pacific and Central/South America at rates of ~3%/yr over the past decade (BP 2019). Recent coal consumption in India grew at rates of 4.8% per year and now surpasses that of both the E.U. and the United States (Figure 5). Sustained growth at this rate would double India's coal consumption in less than two decades and generate more than a billion tonnes of additional CO2 emissions yearly.

In countries such as India where energy use and CO2 emissions are growing quickly, per capita statistics highlight inequities in global resource use (Figure 6). Energy use in the U.S. is ten-fold higher per capita than in India, where hundreds of millions of people still lack access to reliable electricity. It is five-times higher in the E.U. and, surprisingly, has increased for the last five years, reversing a decade-long trend of declining energy use and CO2 emissions (Figure 6).

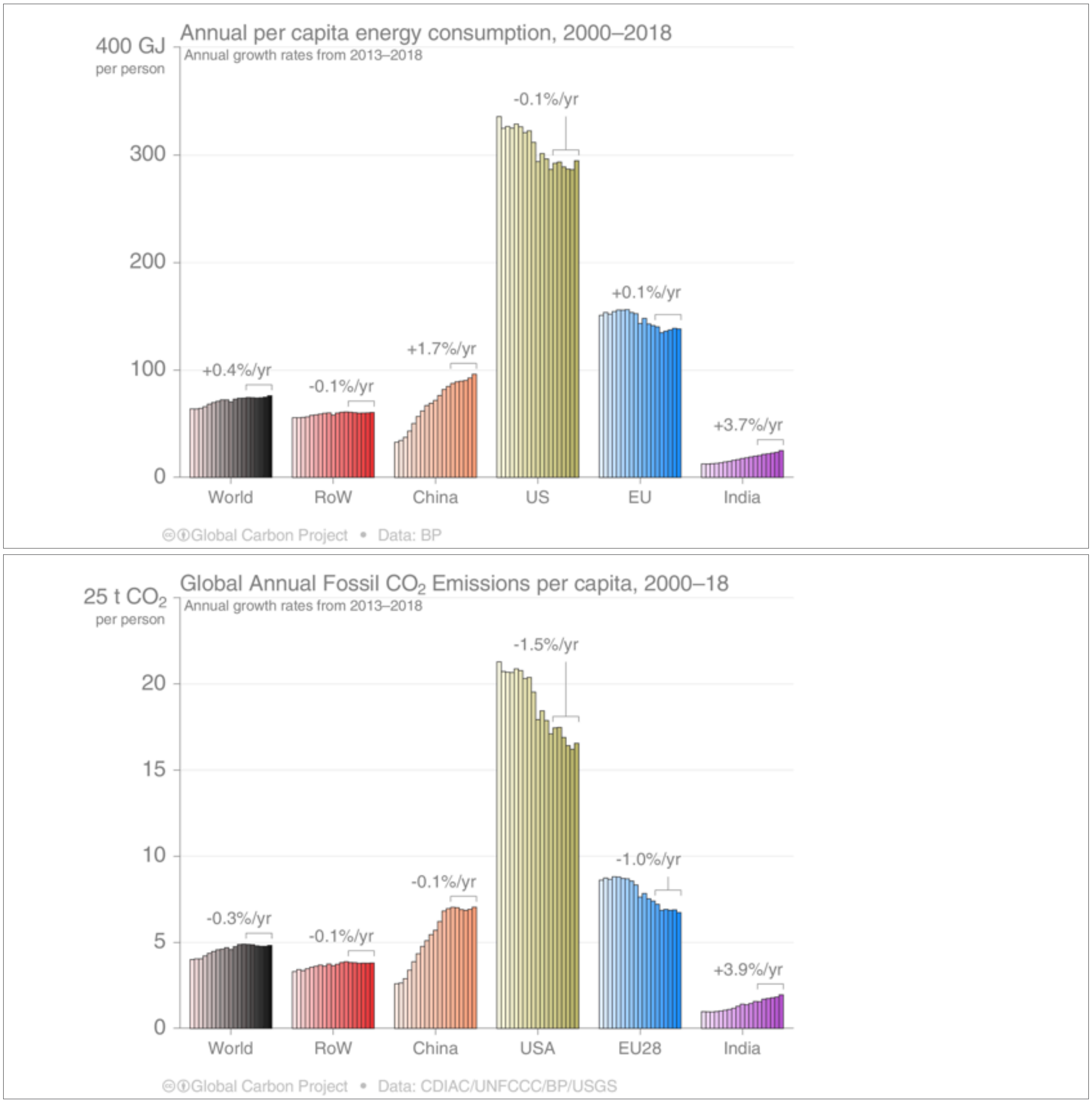

Figure 6. Per capita primary energy consumption (GJ per person) and CO2 emissions (Mg or tonnes CO2 per person) from 2000 to 2018, with average annual change shown from 2013 through 2018. RoW=Rest of World.

Increased CO2 emissions in 2018 are not attributable solely to relatively poorer nations where energy poverty remains a major concern (e.g., Casillas and Kammen 2010, González-Eguino 2015). The U.S. Energy Information Administration estimated that U.S. CO2 emissions grew 2.8% in 2018, but expects them to decline in 2019 (EIA 2019). A cold winter in the eastern half of the country increased heating demand compared to 2017, and a warm summer increased cooling demand. Oil use in the United States has also increased steadily for the last five years at an average rate of 1.3% per year (Figure 5; 2013-2018 average). Low oil prices have spurred both gasoline use and sales of light trucks in the United States; light trucks, which use a third more gasoline per mile on average than passenger cars (US DOT 2018), increased from half of new vehicles sales five years ago to two thirds today.

The biggest change in CO2 emissions in 2018 compared with 2017 was an increase in both energy consumption and CO_2 emissions in China, in stark contrast to relatively stable emissions since 2013 (Figure 5, and Liu et al. 2015, Guan et al. 2018). As a result, preliminary estimates show CO_2 emissions in China to grow by +2.3%in 2018 compared to 2017. The large growth of natural gas arises primarily from China's policy for climate change mitigation and air pollution control. The increase in China's energy consumption more broadly in 2018 is driven largely by growth in heavy manufacturing, with additional contributions from household use and the service sector. Iron, steel, aluminium and cement production, for example, all increased compared to 2017: +1.2% for iron production, +6.1% for steel, +4.2% for aluminium, and +1% for cement; thermal power generation increased 6.9% in the first three quarters of 2018, as well. Our estimated uncertainty range of China's 2018 emissions growth is large (i.e., 0.4% to 6.7%). This range reflects uncertainties in the evolution of China's economic growth and energy consumption in the last three months of 2018, as well as inherent uncertainties in preliminary monthly statistics. Near-term emission trends will depend on many factors, including the extent to which the Chinese government continues stimulating its economy and China's international balance of trade.

Whether CO_2 emissions will continue to rise in 2019 and beyond is unclear. As noted above, one positive sign is the number of countries where emissions are declining in the presence of economic growth, led by the E.U. and the United States. Such emission reductions are important but need to accelerate (Figures 4 and 5). Emission reductions in the E.U. have slowed in recent years (Le Quéré et al. 2018b; BP 2019), but declined 2.1% in 2018. Increased CO_2 emissions for the United States in 2018 arise both from weather this year (see above), a factor that is transient, and from sustained increases in oil use; continued reductions in the United States may also be at risk with changing political conditions and a potential withdrawal from the Paris Accord. China and India are experiencing a rapid expansion of non-fossil energy sources, but it is occurring with rapid growth in fossil energy sources in India, in particular. In the rest of the world, emissions are likely to continue to grow as developing countries strive for much needed economic growth and increasing energy use.

In summary, peak CO_2 emissions remain elusive, declining global emissions even more so. Short of a dramatic global economic downturn in the final quarter in 2019, global CO_2 emissions are likely to rise further. Projections in 2019 for growth in Gross Domestic Product are 3.2% (IMF 2019). However, projected economic growth of 6 to 8% for India and China and 2.5% in the United States (World Bank 2018) would almost certainly increase emissions over this year's value of 37 ± 1.8 Gt CO_2. A quarter century after the United Nations Framework Convention on Climate Change, we remain far from its signature goal to "stabilize greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system."

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