Andasol solar power station in Spain. Prices of large-scale solar PV fell by 90 percent between 2009 and 2019.

A wind farm in Xinjiang, China. In 2020 wind, solar, and other renewables were about 62 percent cheaper than the least expensive new fossil fuels.

differences across localities, states, and nations mean that global bargaining over the future of the climate commons will require that these very different circumstances and challenges be reflected in any negotiations over a path forward.

Rapid Reductions in the Cost of Renewable Energy

The End of the Hydrocarbon Epoch: How Soon?

The industrial age, beginning with the use of steam engines in eighteenth-century North America and Europe, was driven by the conversion of fossil fuels (coal, oil, and natural gas) and biomass (wood) into energy. These hydrocarbon energy sources are now recognized as a major reason for increasing concentrations of CO_2 in the earth's atmosphere. There are other sources as well, such as the burning of forest and peat lands, especially in Asia, and the conversion of rainforest to pasture and cropland, especially in Latin America.

In the latter part of the twentieth century, recognition of these effects, as well as wide swings in the price of hydrocarbon fuels, spurred innovation in renewable energy sources, especially wind power and solar photovoltaic (PV) technologies. These renewable energy sources do not release GHGs. However, nearly all observers until the second decade of the twenty-first century did not expect them to replace fossil fuels soon. Continuing discoveries of oil and natural gas, as in Canada's Alberta tar sands, as well as new "fracking" technologies for underground gas, kept oil and gas prices relatively low. The widespread substitution of renewable energy appeared expensive and far off.

The Renewables Surprise

The rate of adoption of wind and solar technologies, driven in part by government subsidies, has surprised many. Prices of large-scale solar PV fell by 90 percent between 2009 and 2019, according to the U.N. Human Development Report, so that they now cost about a tenth or less of what they did in 2010. Lithium-ion batteries powering electric vehicles and other motors are 97 percent cheaper than in 1991. The projected annual cost decline between 2010 and 2020 for solar was 2.6 percent; the actual decline was 15 percent, more than five times faster than expected.[53]

This trend is continuing. In 2022, the International Energy Agency (IEA) noted that growth in renewables was much greater than expected, due in large part to government support in China, the European Union (EU), and Latin America. Economists largely failed to understand the forces driving these trends. As one group observed, these policies were implemented despite, not because of, the then-prevailing economic analysis and advice.[54]

The Cost Race

Although government policies have driven the adoption of renewable fuels to a significant extent, at its base the race to replace fossil fuels will be driven by comparative costs. The World Economic Forum, citing the International Renewable Energy Agency (IRENA), found in 2020 that wind, solar, and other renewables were about two-thirds (62 percent) cheaper than the least expensive new fossil fuels.[55]

These cost reductions make it feasible to reduce the