Climate Scenarios are Off Track

Roger Pielke Jr.*

A set of newly published papers indicates the scenarios of the future to 2100 on which much of climate research depends have already diverged from what has actually been unfolding in the real world (Burgess et al. 2020, Pielke and Ritchie, in press). Consequently, these scenarios – developed, collected and assessed by the Intergovernmental Panel on Climate Change (IPCC) -- offer a poor basis for projecting into the future policy-relevant variables, such as economic growth and carbon dioxide emissions. If scenarios are not updated, then the guidance provided to policy makers originating in research and assessment that rely on these scenario will be out-of-date and potentially misleading.

Burgess et al. (2020) perform the most rigorous evaluation to date of how key variables in climate scenarios compare with data from the real world (specifically, it focuses on the four factors of the Kaya Identity: population, economic growth, energy intensity of economic growth and carbon intensity of energy consumption). Burgess et al. (2020) also explore how these variables might evolve in the near-term to 2040, based on near-term energy outlooks, such as those of the International Energy Agency (e.g., IEA 2019).

Burgess et al. (2020) find that the most commonly-used scenarios in climate research have already departed significantly from the real world, and that this divergence is going to only get larger in coming decades. Fig. 1 below clearly shows this divergence. The figure shows carbon dioxide emissions from fossil fuels from 2005, when many scenarios begin, to 2045. The graph shows emissions trajectories projected by the most commonly used climate scenarios (with labels on the right vertical axis, see Burgess et al. 2020 for technical details and original sources). Actual emissions to date (dark blue curve) and those of near-term energy outlooks (labeled as EIA, BP and ExxonMobil) all can be found at the very low end of the scenario range, and far below the most commonly used scenarios.

An important reason for the lower-than-projected carbon dioxide emissions is that economic growth has been slower than expected across the scenarios, and rather than seeing coal use expand dramatically around the world, it has actually declined in some regions.

Fig. 2 below shows the difference between observations of the Kaya factors and the values found in the baseline scenarios of the IPCC Fifth Assessment Report Scenario Database (AR5).[1] The figure shows that most references scenarios of the IPCC AR5 overestimated both carbon dioxide growth and per capita GDP growth, and in most of the subregions of the IPCC (for details, see Burgess et al. 2020).

* Professor, Environmental Studies Program, University of Colorado Boulder, US / Distinguished Fellow, IEEJ

[1] https://tntcat.iiasa.ac.at/AR5DB/dsd?Action=htmlpage&page=about

Fig. 1 A Comparison of Energy-Related CO_2 Emissions Projected by Energy Outlooks. By IPCC AR5 Scenarios of Its Working Group 3, and SSP Baseline Scenarios. For Sources and Details, See Burgess et al. 2020

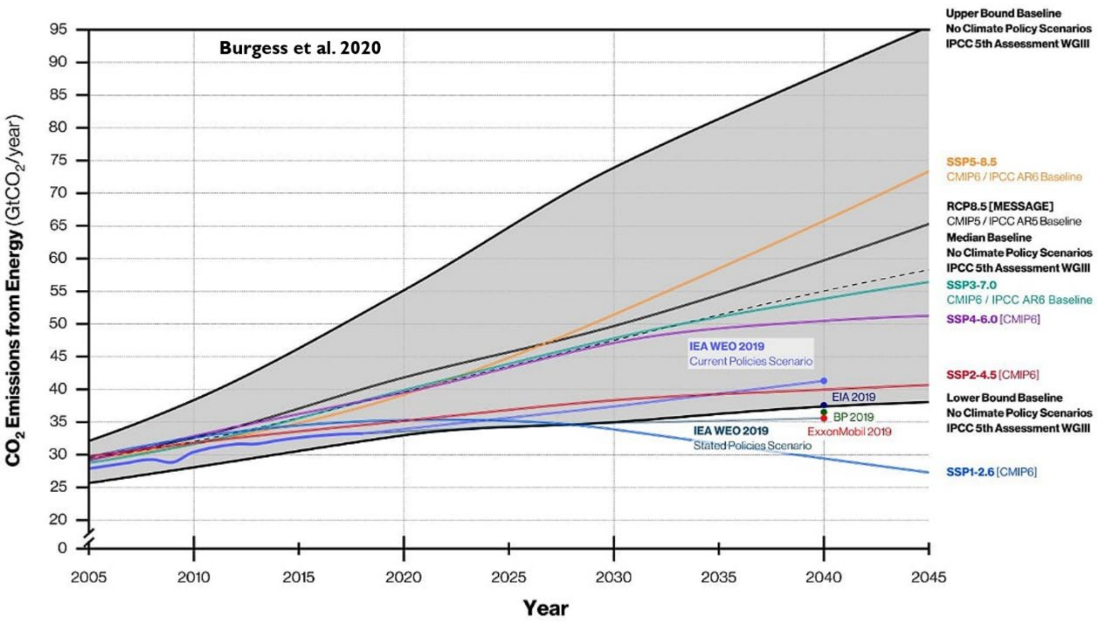
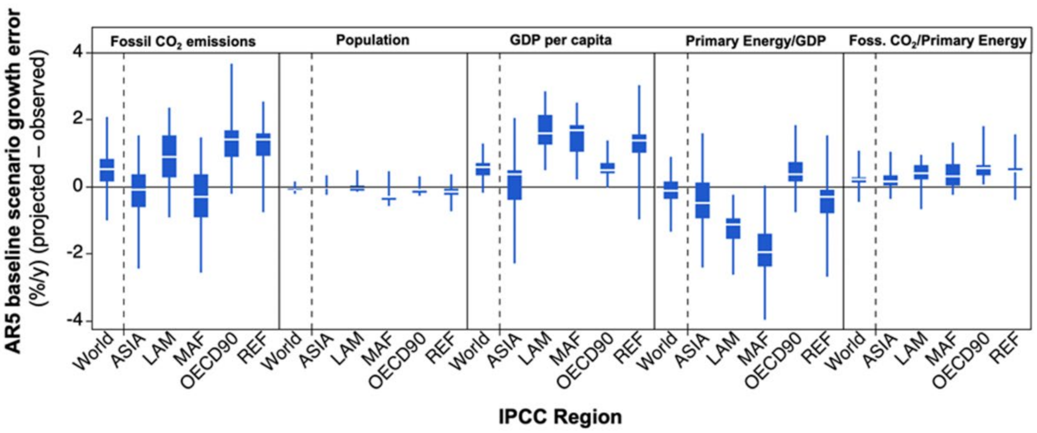


Fig. 2 IPCC Baseline Scenarios (2005-2020) Relative to Observations (2005-2017) (IEA 2019). Boxes Represent 25th-75th Percentiles (white dashes indicate medians). Lines above and below the Boxes Represent the Full (min-max) Range. From Burges et al. 2020



It is even conceivable, if not likely, that in 2019 the world has already passed peak carbon dioxide emissions. Crucially, the projections in Fig. 1 above are pre-Covid19, which means that actual emissions 2020 to 2045 will likely be even less than was projected in 2019 in the various short-term energy outlooks. As Hausfather and Peters (2020) write in *Nature*, the emissions scenario commonly used in research to represent a "business as usual" (or "baseline") trajectory into the future "becomes increasingly implausible with every passing year." Burgess et al. (2020) builds upon a growing literature indicating that commonly used climate scenarios are already well off track and will become increasingly off track e.g.,

A growing literature has begun to recognize the divergence of commonly used scenarios and the evolution of the real world (e.g., see Ritchie and Dowlatabadi 2018 as one of the first and most significant contributions to this literature). O'Neill et al. (2020) has also recognized that the real world and scenario architecture have drifted apart in the years since the scenarios were first developed. That is of course not surprising, as projecting the future is always challenging. Correspondingly, the authors, who include many developers of these scenarios, "recommend establishing a process for regular updates" to the scenarios and recommend that key variables in the scenarios "be updated now to be consistent with new historical data."

While it is excellent news that the broader community is beginning to realize that scenarios are increasingly outdated, voluminous amounts of research have been and continue to be produced based on the outdated scenarios (Pielke and Ritchie, in press). For instance, O'Neill et al. (2020) find that "many studies" use scenarios that are "unlikely." In fact, in their literature review such "unlikely" scenarios comprise more than 20% of all scenario applications in peer-reviewed publications from 2014 to 2019. O'Neill et al. (2020) also call for "re-examining the assumptions underlying" the high-end emissions scenarios that are favored in physical climate research, impact studies and economic and policy analyses. As a result of such high prevalence of such studies in the literature, they are also the most commonly cited within scientific assessments of the Intergovernmental Panel on Climate Change (Pielke and Ritchie 2020). O'Neill et al. (2020) find that the highest emission scenarios comprise about 30% of all applications in studies over the past five years, from a family of 35 different scenarios that they surveyed.

Evidence is now undeniable that the basis for a significant amount of research has become untethered from the real world. The issue now is what to do about it. Pielke and Ritchie (in press) recommend several options, beginning with the need for widespread recognition that scenarios have drifted away from real-world relevance. Pielke and Ritchie (in press) also recommend that the IPCC chose to either oversee scenario development or assess literature, but not both. In addition, policy relevance would be enhanced with a focus on near-term scenarios more closely aligned with real-world observations.

The challenges for climate research are significant. Pielke and Ritchie (in press) found almost 17,000 peer-reviewed articles have already been published (through early 2020) that use the now-outdated highest emissions scenario. That particular scenario is also by far the most commonly cited in recent climate assessments of the IPCC and the U.S. National Climate Assessment (Pielke and Ritchie, in press). And every day new studies are published using outdated scenarios.

The elevated role of scenarios across climate research means that there is a huge momentum behind their continued use. A research reset would be a massive endeavor and would require essentially writing off the policy, economic or other real-world relevance of thousands of studies, and perhaps even their scientific utility. There are of course reasons to use exploratory scenarios in modeling or theoretical studies, but such uses shouldn't be confused with practical relevance. Climate research finds itself at a crossroads and in need to address scenarios that are now off-track.

〈References〉

Hausfather, Z., & Peters, G. P. 2020. Emissions–the 'business as usual' story is misleading. *Nature.*

IEA (International Energy Agency) 2019. *CO2 Emissions from Fuel Combustion 2019 Highlights* (IEA). At: https://webstore.iea.org/co2-emissions-from-fuel-combustion-2019-highlights

O'Neill, B. C., Carter, T. R., Ebi, K., Harrison, P. A., Kemp-Benedict, E., Kok, K., Kriegler, E., Preston, B.L., Riahi, K., Sillmann, J. and van Ruijven, B. J. 2020. Achievements and needs for the climate change scenario framework. *Nature climate change*, 1-11.

Pielke, Jr., R. and J. Ritchie, in press. Distorting the view of our climate future: The misuse and abuse of climate pathways and scenarios, *Energy Research & Social Science.*

Ritchie, J., & Dowlatabadi, H. 2018. Defining climate change scenario characteristics with a phase space of cumulative primary energy and carbon intensity. *Environmental Research Letters*, *13*(2), 024012.

Writer's Profile

Roger Pielke Jr.
Professor Pielke founded and served as Director of the Center for Science and Technology Policy Research at the University of Colorado Boulder from 2001 to 2007 and from 2013 to 2016. He was a visiting scholar at Oxford University's Saïd Business School in the 2007-2008 academic year. His interests include understanding the use and misuse of science in areas such as the Covid-19 response, climate change, disaster mitigation, energy policy; and sports governance.