Emissions – the "business as usual" story is misleading
Stop using the worst case scenario as the most likely outcome -- more realistic baselines make for better policy, argue Zeke Hausfather and Glen Peters

Over a decade ago, climate scientists and energy modelers made a choice with unintended consequences hotly debated today. With the Intergovernmental Panel on Climate Change (IPCC) Sixth Assessment Report (AR6) moving into its final stages through 2020, there is a rare opportunity to shift focus towards future scenarios that reflect a more realistic progression of policy, technology, and society.

In the lead up to the 2013 IPCC Fifth Assessment Report (AR5) the researchers developed four scenarios for what might happen to greenhouse gas emissions and climate warming by 2100. They gave these scenarios a catchy title: representative concentration pathways (RCPs).[1] One describes a world where global warming is kept well-below 2°C (as nations later pledged to do under the Paris climate agreement in 2015); it is called RCP2.6. Another paints a dystopian future that is fossil-fuel intensive and without climate mitigation policy, leading to nearly 5°C warming relative to preindustrial temperatures by the end of the century.[2,3] That one is named RCP8.5.

RCP8.5 was intended to explore an unlikely high-risk future.[2] But it has been widely used – by some experts, policy makers, the media – as something else entirely: as a likely 'business as usual' outcome. Indeed, a sizable portion of the literature on climate impacts refers to RCP8.5 as business as usual, implying that it is probable in the absence of stringent climate mitigation. The media then amplifies this message without communicating the nuances. This results in further confusion regarding likely emissions outcomes, as many climate researchers are not familiar with the details of these scenarios in the energy modeling literature.

This is particularly problematic when this worst case scenario is contrasted with the most optimistic scenario, especially in high-profile scholarly work such as the IPCC 5th assessment report and the recently published IPCC special report on the impact of climate change on the ocean and cryosphere.[4] The focus becomes the extremes, rather than the multitude of more likely pathways in between.

Happily – and that's a word we rarely get to use – the world envisioned in RCP8.5 is one that in our view becomes increasingly implausible with every passing year.[5] Emission pathways to get to RCP8.5 generally require an unprecedented five-fold increase in coal use by the end of the century, an amount larger than some estimates of recoverable reserves.[6] Global coal use may have peaked in 2013, and while future increases are possible, many energy forecasts expect it to flatline over the next few decades.[7] Falling costs of cleaner energy sources is a trend unlikely to reverse, even without new climate policies.[7]

Assessment of current policies suggest the world is on-course for around 3°C of warming above pre-industrial levels by the end of the century – still a potentially catastrophic outcome, but a long way from 5°C.[7,8] We should not settle for 3°C, nor should we dismiss progress.

Some researchers argue that RCP8.5 may be more likely than originally envisioned, because some important feedback effects could potentially be much larger than estimated by current climate models, such as the release of greenhouse gases from thawing permafrost.[9,10] They point out that current emissions are in line with such a worst case scenario,[11] though, in our view recent developments suggest current emissions are more in line with the median scenarios.[7] These critics are, we contend, looking at the extremes, as if all the dice are loaded to bad outcomes.

Asking "what's the worst that could happen?" is a useful exercise. It flags potential risks that emerge only at the extremes. RCP8.5 is also a useful scenario to benchmark climate models over an extended period of time by keeping future scenarios consistent. Perhaps it is for these reasons that the climate modelling community suggested RCP8.5 "should be considered the highest priority".[12] This prioritization of RCP8.5 means that it is likely to attract more model runs and thus be the scenario that exhibits the most robust statistics. Scientifically, it would then be very tempting to disproportionately highlight RCP8.5 in the IPCC Sixth Assessment Report. This is a trap we believe should be avoided. Now that the genie is out of the bottle, and more understand the unlikely nature of RCP8.5, the risks to scientific credibility for an unwarranted focus on RCP8.5 will be immense.

We must all – from physical scientists and climate impact modelers to communicators and policy makers – stop presenting the worst-case scenario as the most likely one. Overstating the likelihood of extreme climate impacts can make mitigation seem harder than it actually is. This risks further politicising climate policy by highlighting worst-case outcomes, and may lead to defeatism because the problem is perceived as out of control and unsolvable. Most pressingly, it may lead to poor planning: a more realistic range of baseline scenarios will strengthen the assessment of climate risk.

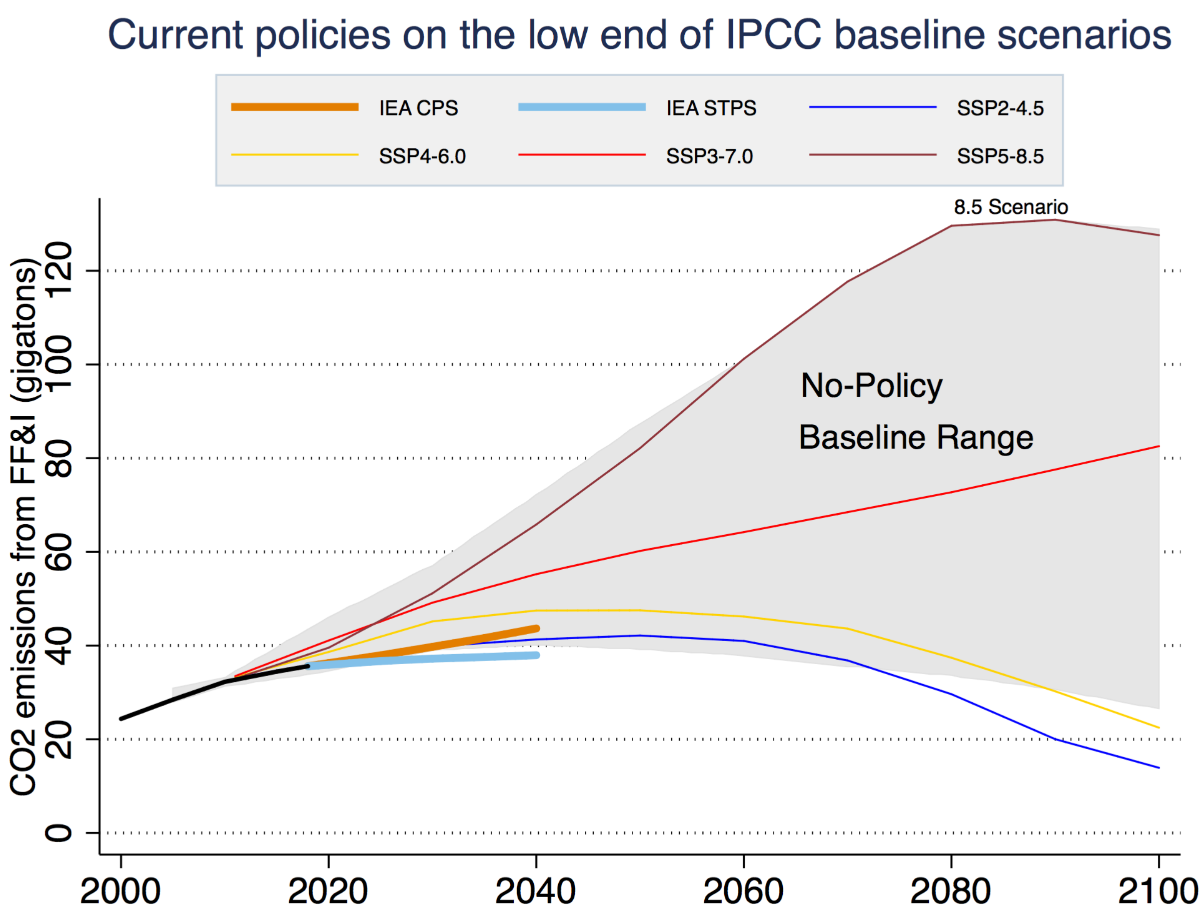
This admission does not make climate action less urgent. The need to limit warming to well below 2°C, as is clear from the IPCC's 2018 Special Report, does not depend on having a 5°C counterpoint.

Assess realistically

The plethora of different future emissions scenarios poses a challenge to users of climate data – from policymakers to investors.[13] Over 1200 mitigation scenarios were assessed in the IPCC 5th assessment report on climate mitigation in 2014. Another 400 scenarios were assessed in the recent Special Report on 1.5°C. Most of these assume a baseline with no climate policy while considering a range of different socioeconomic developments. In our experience in working with scenario users this proliferation leads to more confusion than clarity, particularly in the absence of any guidance on their relative likelihood.

Other organisations present relatively few scenarios. The International Energy Agency (IEA) now presents three main ones. Their Current Policies scenario indicates where emissions may go with things as they stand. Their Stated Policies Scenario includes both current policies and and what countries have promised to do under the Paris Climate deal. The IEA's Sustainable Development Scenario reflects emissions in a world already aligned with the goals of the Paris Agreement.[7] The UNEP Emissions Gap Report also takes a simple approach, comparing countries' pledges to reduce emissions with global pathways that limit warming to well below 2.0°C.[14]

These influential reports do not focus on worst-case outcomes. They plot the gulf between where the world is heading and where it has agreed it should go.



Caption: Annual CO2 emissions from fossil fuel and industry (FF&I) in 2019 IEA Current Policies (CPS) and Stated Policies (STPS) scenarios[7] compared to the range of baseline scenarios examined in the SSP Database,[19] as well as a subset of the baseline and mitigation scenarios chosen for use in the upcoming IPCC AR6 report.[12]

< Ok to add temperature ranges on second y axis? >

For those that have to make real-life decisions, the choice of scenario becomes important.[13,15] Adapting to an extreme RCP8.5 scenario with around 5°C warming in 2100 may lead to wrong and costly choices. Most users of climate scenarios care more about the world that is, rather than the world that might have been if global emissions had not flattened over the past decade. Users focused on mitigation are keen to capitalize on emerging opportunities such as cheap renewables, or avoid overinvesting in stranded assets in dying industries. For example, they want to know if the rapid cost declines in renewables may make investments in fossil fuels high risk. A RCP8.5 baseline renders these applications useless, as it implies that recent climate policies and technological progress are halted or even reversed.

For policy makers, mitigation policies referenced on the assumptions underlying high-emission baseline scenarios like RCP8.5 will seem exorbitant, as they do not incorporate the plummeting cost of many low carbon technologies over the past decade. The marginal investments to move from a 3°C world to 2°C world will be much less than the costs of moving from a 5°C world to a 2°C world. A narrative of progress and opportunity can make the Paris targets seem feasible, as opposed to being seemingly impossible.

Toward risk-based scenarios

Those tasked with taking climate action based on information from model scenarios are increasingly calling for a different, more risk-based approach to help with adaptation and mitigation.[13] This risk-based approach accounts for the relatively likelihood of different outcomes. Controversially, it requires researchers to assign probabilities to scenarios.[15]

Critics don't want to do this, as many see assigning probabilities to scenarios as necessarily arbitrary. But when specialists refuse to assign probabilities, users often do so themselves, and they may do this poorly as most do not have a deep understanding of assumptions underpinning these scenarios.

Initially, the probabilities do not need to be elaborate, and could even only amount to simply identifying the most likely scenario resulting from current energy system trends and policies. Currently, scenarios are selected based on their climate outcomes in 2100, not their likelihoods. More complex probabilistic approaches would require modelers to work differently[16]. For example they should forge new alliances with social sciences[17] and involve policy makers, investors and industry.[13]

This will be years of work. Meanwhile there are three concrete steps that should be taken in the next year in the lead-up to the IPCC AR6 to set the climate community on the right road. The latest generation of climate models has just come out, and now is the time many researchers are selecting which future emission scenarios to use in studies.

First, the new generation of emission scenarios (see box) has a much more nuanced approach to baseline scenarios, and IPCC authors can highlight a range of no-new-policy outcomes.[18,19] The space between high-end and low-end scenarios should be more deeply explored in the IPCC AR6, so that the climate impacts we are likely to experience can be more clearly communicated.[20] For example, according to many studies we are heading for a 3°C world, and it would be prudent to more clearly outline the climate impacts for 3°C in addition to those at 5°C.

Second, scientists should recognise that different users need different tools. In the context of IPCC AR6, this may mean that different working groups (science, impacts, and mitigation) highlight different scenarios in their analysis and communication. The final IPCC Synthesis Report may then integrate the different risk perspectives.

Finally, we suggest that climate impact studies undertaken using climate models developed for the IPCC AR6 should include scenarios that reflect more plausible baseline outcomes, such as SSP2-4.5, SSP4-6.0 and SSP3-7.0. When RCP8.5 or its successor SSP5-8.5 are deployed they should be clearly labelled as unlikely worst-cases rather than business as usual.

Box HEAD: Parting of the pathways
BOX strap: The 2021 IPCC report will compare different types of trajectory to those weighed in the 2015 report.

The Representative Concentration Pathways (RCPs) are a set of four possible end-of-century climate states.[1] The RCPs lack any consistent set of socioeconomic assumptions driving future emissions, and are simply intended to reflect different potential climate outcomes.[3] They include RCP2.6, RCP4.5, RCP6.0, and RCP8.5, with the number reflecting the additional radiative forcing in the year 2100, relative to preindustrial times. Radiative forcing (in watts per meter squared) measures the combined effect of greenhouse gas emissions and other factors such as atmospheric aerosol on climate warming. Current radiative forcing relative to preindustrial is around 2.5 watts per meter squared.

The Shared Socioeconomic Pathways (SSPs) are five different socioeconomic and technological trajectories that the world could follow during the 21st century.[19] Each of the SSPs has a baseline scenario where no climate policies are enacted after 2010 – resulting in between 3°C and 5°C warming above pre-industrial levels by 2100. In addition, the SSPs can be linked to climate policies to generate different end of century outcomes (analogous to RCPs) with radiative forcing of 1.9, 2.6, 3.4, 4.5, 6.0, 7.0, or 8.5 Watts per square meter in 2100. A subset of the SSP models have been selected for the upcoming 2021 IPCC AR6.[12], and will function like the RCPs in the prior IPCC AR5 report.

References

1) Moss, R. H., Edmonds, J. A., Hibbard, K. A., Manning, M. R., Rose, S. K., van Vuuren, D. P., … Wilbanks, T. J. (2010). The next generation of scenarios for climate change research and assessment. *Nature*, *463*(7282), 747–756. https://doi.org/10.1038/nature08823
2) Riahi, K., Rao, S., Krey, V., Cho, C., Chirkov, V., Fischer, G., … Rafaj, P. (2011). RCP 8.5—A scenario of comparatively high greenhouse gas emissions. Climatic Change, 109(1), 33. https://doi.org/10.1007/s10584-011-0149-y

3) van Vuuren, D. P., Edmonds, J., Kainuma, M., Riahi, K., Thomson, A., Hibbard, K., … Rose, S. K. (2011). The representative concentration pathways: an overview. Climatic Change, 109(1), 5. https://doi.org/10.1007/s10584-011-0148-z
4) IPCC (2019). IPCC Special Report on the Ocean and Cryosphere in a Changing Climate [H.-O. Pörtner, D.C. Roberts, V. Masson-Delmotte, P. Zhai, M. Tignor, E. Poloczanska, K. Mintenbeck, A. Alegría, M. Nicolai, A. Okem, J. Petzold, B. Rama, N.M. Weyer (eds.)]. In press.
5) Ho, E., Budescu, D. V, Bosetti, V., van Vuuren, D. P., & Keller, K. (2019). Not all carbon dioxide emission scenarios are equally likely: a subjective expert assessment. Climatic Change, 155(4), 545–561. https://doi.org/10.1007/s10584-019-02500-y
6) Ritchie, J., & Dowlatabadi, H. (2017). The 1000 GtC coal question: Are cases of vastly expanded future coal combustion still plausible? Energy Economics, 65, 16–31. https://doi.org/https://doi.org/10.1016/j.eneco.2017.04.015
7) IEA (2019). World Energy Outlook 2019, IEA, Paris, https://doi.org/10.1787/weo-2018-en.
8) Rogelj, J., den Elzen, M., Höhne, N., Fransen, T., Fekete, H., Winkler, H., … Meinshausen, M. (2016). Paris Agreement climate proposals need a boost to keep warming well below 2 °C. Nature, 534, 631. Retrieved from https://doi.org/10.1038/nature18307
9) Friedlingstein, P., Meinshausen, M., Arora, V. K., Jones, C. D., Anav, A., Liddicoat, S. K., & Knutti, R. (2013). Uncertainties in CMIP5 Climate Projections due to Carbon Cycle Feedbacks. Journal of Climate, 27(2), 511–526. https://doi.org/10.1175/JCLI-D-12-00579.1
10) Lenton, T., Rockström, J., Gaffney, O., Rahmstorf, S., Richardson, K., Steffen, W., & Shellenhuber, H. J. (2019). Climate tipping points - too risky to bet against. Nature, 575, 592–595.
11) Peters, G. P., Andrew, R. M., Boden, T., Canadell, J. G., Ciais, P., Le Quéré, C., … Wilson, C. (2013). The challenge to keep global warming below 2 °C. Nature Climate Change, 3(1), 4–6. https://doi.org/10.1038/nclimate1783
12) O’Neill, B. C., Tebaldi, C., van Vuuren, D. P., Eyring, V., Friedlingstein, P., Hurtt, G., … Sanderson, B. M. (2016). The Scenario Model Intercomparison Project (ScenarioMIP) for CMIP6. *Geosci. Model Dev.*, *9*(9), 3461–3482. https://doi.org/10.5194/gmd-9-3461-2016
13) Weber, C., McCollum, D. L., Edmonds, J., Faria, P., Pyanet, A., Rogelj, J., … Kriegler, E. (2018). Mitigation scenarios must cater to new users. Nature Climate Change, 8(10), 845–848. https://doi.org/10.1038/s41558-018-0293-8
14) UN Environment (2019), Emissions Gap Report 2019, UN, New York, https://doi.org/10.18356/08bd6547-en.
15) King, D., Schrag, D., Dadi, Z., Ye, Q., and Ghosh, A. (2015). Climate Change: A Risk Assessment. Centre for Science and Policy, University of Cambridge.
16) Morgan, M. G., & Keith, D. W. (2008). Improving the way we think about projecting future energy use and emissions of carbon dioxide. Climatic Change, 90(3), 189–215. https://doi.org/10.1007/s10584-008-9458-1
17) Tàbara, J. D., St. Clair, A. L., & Hermansen, E. A. T. (2017). Transforming communication and knowledge production processes to address high-end climate change.

Environmental Science & Policy, 70, 31–37.
https://doi.org/https://doi.org/10.1016/j.envsci.2017.01.004
18) The CMIP6 landscape. (2019). Nature Climate Change, 9(10), 727.
https://doi.org/10.1038/s41558-019-0599-1
19) Riahi, K., van Vuuren, D. P., Kriegler, E., Edmonds, J., O'Neill, B. C., Fujimori, S., … Tavoni, M. (2017). The Shared Socioeconomic Pathways and their energy, land use, and greenhouse gas emissions implications: An overview. Global Environmental Change, 42, 153–168.
20) van Ruijven, B. J. (2016). Mind the gap – the case for medium level emission scenarios. Climatic Change, 138(3), 361–367. https://doi.org/10.1007/s10584-016-1744-8