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Extreme scenarios

BY MARCEL CROK



The biggest news in the AR6 report is arguably that high-end scenarios like SSP5-8.5 and SSP3-7.0 are now believed to have low likelihood. That is extremely good news as it means that higher rates of warming in 2100 are thus viewed to be less likely than they were only a few years ago. Unfortunately, this news is deeply hidden in the report and few policy makers will see it. Worse, large parts of the report still emphasize these high-end scenarios. How did this happen?

IPCC reports are meant to be “policy relevant” and “policy neutral”.¹ Policy makers deal—by definition—with an uncertain future. No one can predict with any certainty what the climate is going to do 50 or 100 years from now. However, climate scientists have tools to explore what the climate might look like in the future. These tools are called scenarios and since the first IPCC report in 1990 scenarios have played an important role in climate policy.

In AR6 we find a table and a figure showing how global temperatures might develop under the five scenarios that were selected for the report. Here is figure SPM.8:

(a) Global surface temperature change relative to 1850–1900

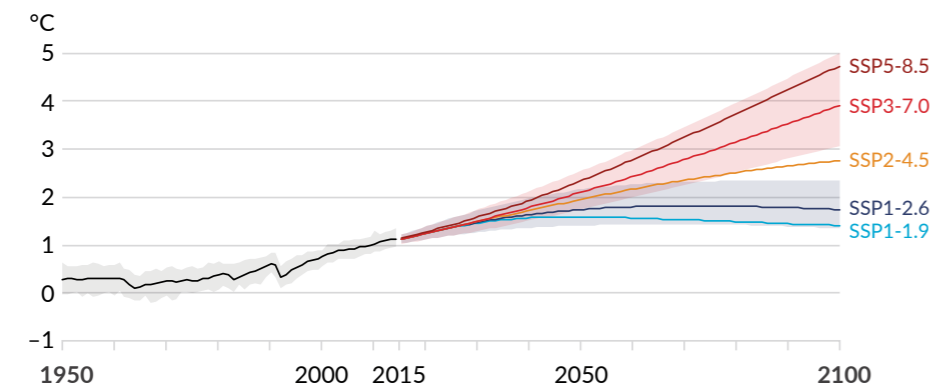


Figure 1: Global surface temperature change relative to 1850-1900 based on different scenarios. Very likely ranges are shown for SSP1-2.6 and SSP3-7.0. Source: AR6 figure SPM.8a.

Here we see that the two higher scenarios SSP3-7.0 and SSP5-8.5 reach 4 to 5°C of warming in 2100. That’s quite dramatic. Remember, the IPCC estimates that the world warmed around 1°C since 1850, in a period of 170 years. These scenarios suggest we will get another 3 to 4°C of warming in just the next 80 years. This is a nightmare scenario for those who take the Paris agreement that we should stay below 2°C, or preferably below 1.5°C, seriously.

Therefore, a really important question for policy makers is: how plausible are each of the scenarios that underlie the projections of future climate? Well, this might be a big surprise for you, but the IPCC doesn’t address this highly policy relevant question. In chapter 1 (page 238) it says: “In general, no likelihood is attached to the scenarios assessed in this Report.”

This is quite an admission and one that actually should have been put in the *Summary for Policy Makers* with a big disclaimer such as: “Note, this report makes extensive use of scenarios. However, the likelihood of these scenarios itself hasn’t been assessed!”

It becomes even stranger though. In the next paragraph on the same page there is this claim: “However, the likelihood of high emission scenarios such as RCP8.5 or SSP5-8.5 is considered low

in light of recent developments in the energy sector (Hausfather and Peters, 2020a², 2020b³).” The IPCC has just said the likelihood of its scenarios is not assessed in the report and now it says the likelihood of RCP8.5 and SSP5-8.5 is “low”. These statements are contradictory. How can you not assess the likelihood of the scenarios and then conclude that at least one scenario is low likelihood?

As we will see in this chapter the “low likelihood” of the IPCC extreme scenarios is quite an understatement. The RCP8.5 and the closely related SSP5-8.5 scenarios are – to use terminology of the IPCC itself – extremely implausible and it is more than correct for the IPCC to point this out. Again, this should have been pointed out prominently in the *Summary for Policy Makers* (SPM) with a disclaimer such as: “Note, the likelihood of the high emission scenarios RCP8.5 and SSP5-8.5 is regarded as low.” However, no such disclaimers were shown in the SPM and most of the policy makers who took the effort to read the SPM will not know the highest scenario has a “low likelihood” of coming true.

Baseline Scenario

Let’s take a step back and describe what scenarios are and see how the IPCC used them in the past. The process starts with generating ideas about socioeconomic developments: future population growth, economic growth, technological changes, land use changes. Scientists use so-called Integrated Assessment Models (IAMs) to integrate all these inputs and assumptions. These models can then be used to project greenhouse gas emissions over the course of the century. The output of these models are used by the climate modelling community to project climate changes.

In its first report in 1990 the IPCC used scenarios in the same way as Shell and other energy companies use them. In general, you will have a business-as-usual, or baseline, or reference scenario. That scenario is supposed to show what is likely to happen without climate policies. The other scenarios will have some assumed greenhouse gas emissions reduction. The difference between the baseline and policy scenarios will give an impression of the potential effect of policy changes on global temperature.

In 2000 it was time for the IPCC to update its scenarios. After long discussions it was decided that the new scenarios would be presented without any consideration of their likelihood. This is a spectacular change as it means that each scenario is presented as likely (or unlikely) as the other scenarios. There was no longer a baseline scenario. The advantage was scientists don’t have to go through the difficult process of determining how likely the scenarios are. The disadvantage though is that policy makers who are against strict climate regulations could use lower scenarios to claim things are not so bad and conclude no severe policies are necessary. Environmental NGOs were afraid this attitude would hamper active climate action.

So, in 2005 the process of making new scenarios started all over again. In hindsight this turned out to be a crucial moment. Scenario makers generally need a lot of time to generate new socioeconomic scenarios. However, the climate model community was very impatient and wanted to have the new scenarios as soon as possible. It decided, based on the extensive literature, that four so-called Representative Concentrations Pathways (RCPs) would be selected: one high scenario, one low and two in the middle. Two were put in the middle to prevent people from thinking the middle one was the most likely. These RCPs provide the greenhouse gas concentrations from 2005 until 2100. The climate model community could simply start using these new scenarios which were supposed to be ‘representative’ for different “families” of societal and energy system assumptions, and therefore used to project a small set of different climate futures.

¹ “IPCC reports are neutral, policy-relevant but not policy-prescriptive.” Source: www.ipcc.ch

² Z. Hausfather, G.P. Peters, Emissions – the ‘business as usual’ story is misleading, *Nature* 577 (7792) (2020) 618–620.

³ Hausfather, Z. and G.P. Peters, 2020b: RCP8.5 is a problematic scenario for near-term emissions. *Proceedings of the National Academy of Sciences*, 117(45), 27791–27792, doi:10.1073/pnas.2017124117

Meanwhile in parallel the scenario community would start working on the so-called Shared Socio-economic Pathways (SSP), i.e., how could the global population and economy develop to reach the levels of radiative forcing in the four RCPs? However, this process took ten years. So, in 2013, when the fifth IPCC report (AR5) came out, the four RCPs were used without knowing what the fictitious worlds behind the RCP's would look like, or if they were even plausible futures. Nevertheless, the IPCC decided to use the highest of its four scenarios, RCP8.5, as the reference or business-as-usual scenario. As it turned out, this was misleading and unfortunately this error continues today.

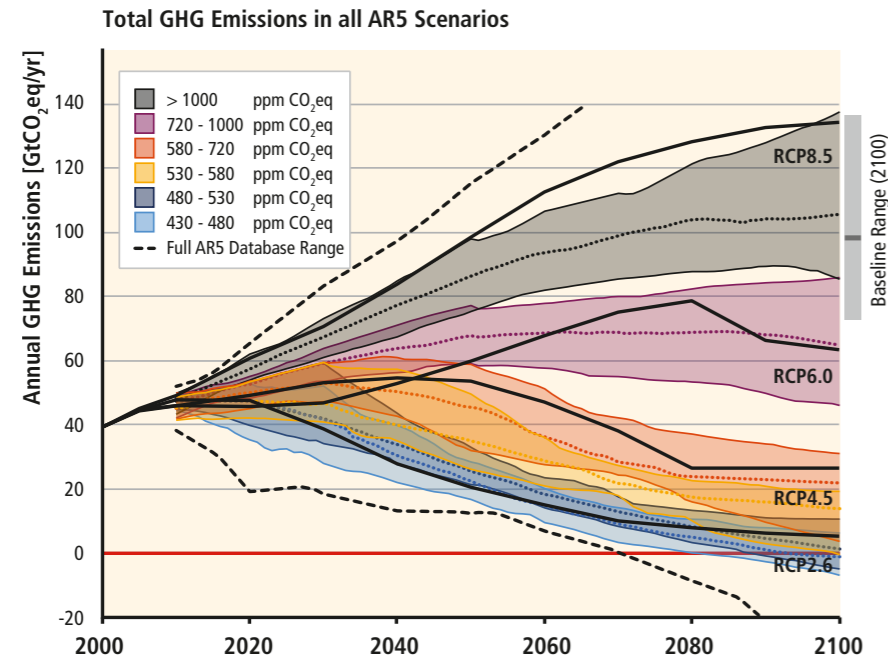


Figure 2: Annual greenhouse gas emissions in the recent past and projected for the future based on the four RCP scenarios. Note how in the top right RCP8.5 was called the baseline range. Source: WG3, AR5, p. 52.

RCP8.5 would quickly become the favourite scenario of the climate model community because it generates such a clear signal-to-noise ratio compared to the background of natural climate variability. In plain English: climate models produce spectacular (or if you like dramatic) results if you feed them with the RCP8.5 scenario. The 8.5 by the way doesn't refer to temperature⁴, but to the amount of climate forcing in 2100, i.e., 8.5 W/m². This is a huge amount of forcing⁵, AR6 estimates the total increase in forcing since preindustrial to be 2.72 W/m². This increase took place over the period 1750 to 2020.

It all sounds rather technical, so why should ordinary citizens be bothered with this? Well, hardly a day or week passes without a new scientific paper based on RCP8.5 reaching you through the media. Such papers often have a message of doom and gloom. If you read in your newspaper that something terrible is going to happen with the climate in 2100, it is a pretty safe bet that the underlying research is based on the implausible RCP8.5.

A famous example is how the 2018 National Climate Assessment (NCA) in the US was communicated to its citizens. Here is the CNN headline: "Climate change will shrink US economy and kill thousands, government report warns."⁶ The article said: "A new US government report delivers a dire warning about climate change and its devastating impacts, saying the economy could lose hundreds of billions of dollars – or, in the worst-case scenario, more than 10% of its GDP – by the end of the century." At least RCP8.5 is presented as a worst-case scenario—which it was not,

4 Sometimes people incorrectly think the 8.5 means 8.5°C of warming in 2100.
 5 Doubling the CO₂-concentration gives a theoretical forcing of around 3.7 W/m². So 8.5 W/m² is the equivalent of more than two doublings of the CO₂-concentration in the atmosphere. Since preindustrial the CO₂-concentration in the atmosphere has increased from 280 ppm to 415 ppm.
 6 <https://edition.cnn.com/2018/11/23/health/climate-change-report-bn/index.html>

as a worst case scenario also must be plausible—but in this case it was even worse: for the 10% estimate they used is an extreme upper limit of the already extreme RCP8.5 scenario. In that case Earth would warm a whopping 8°C in 2100. But even for RCP8.5 warming of 8°C is extreme. Normal warming rates for RCP8.5 are 4 or 5°C.

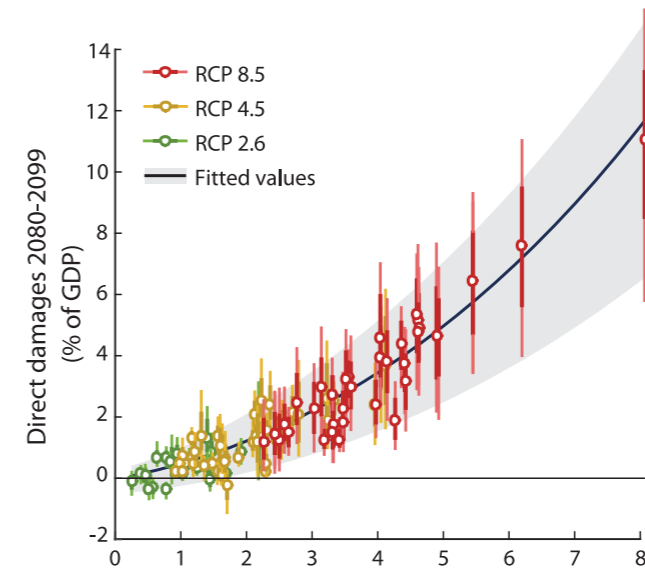


Figure 3: US GDP loss at the end of the century related to global warming rates.^{7,8}

The NCA is being disingenuous, the underlying study they used only showed GDP losses of 3 to 4% (see figure 3).

In The Netherlands something similar happened after the publication of AR6. The Dutch KNMI published a report (in Dutch⁹) in which it showed some relevant conclusions from AR6 for Dutch policy makers. The relevant headline at the national public news broadcaster NOS read: "KNMI adjusts expected sea level rise upward".¹⁰ It combined SSP5-8.5 with a very uncertain ice cap instability scenario to claim sea levels along the Dutch coast could rise by 1.2 meters in 2100 or even 2 meters. It was 18 centimetres in the past century with no sign of acceleration. Again, few news consumers (including Dutch policy makers) will realise what kind of assumptions are behind such grotesque predictions.

How Plausible are the Extreme Scenarios?

So how extreme is RCP8.5 and its more recent version SSP5-8.5? Well, just to give you an idea, to get there the world would need to start using six times more coal per capita than we use now. Or to translate it into coal power stations: currently there are around 6000 coal power stations in the world. RCP8.5 (and SSP5-8.5) implies humanity will add another 33,000 between now and 2100. What about the next scenario SSP3-7.0? That still implies the building of 17,000 new coal power plants. Again, highly implausible.

Countries like China and India are still building coal power stations, but western countries are closing them and replacing them with natural gas-powered stations. Globally coal consumption seems to be at a plateau for a decade or so.

7 Hsiang S, Kopp R, Jina A, Rising J, Delgado M, Mohan S, Rasmussen DJ, Muir-Wood R, Wilson P, Oppenheimer M, Larsen K, Houser T. Estimating economic damage from climate change in the United States. *Science*. 2017 Jun 30;356(6345):1362-1369. doi: 10.1126/science.aal4369. PMID: 28663496.
 8 <https://fabiusmaximus.com/2018/11/29/scary-but-fake-news-about-the-national-climate-assessment/>
 9 https://cdn.knmi.nl/knmi/asc/klimaatsignaal21/KNMI_Klimaatsignaal21.pdf
 10 KNMI adjusts expected sea level rise upwards

RCP-scenarios start in the year 2005 so there are now 15 years of real-world data to evaluate them. Such an evaluation is clearly something you might expect from the IPCC. After all it is highly policy relevant how their scenarios track with reality in order to know where we are going. However, apart from a short sentence about the likelihood, the IPCC said very little about the plausibility of its scenarios. It only referred to Hausfather and Peters 2020a and 2020b. These are indeed relevant pieces. One is a comment in *Nature*, the other is a reply to another paper in *PNAS*. They are not original peer reviewed works.

Several peer reviewed papers are available in the literature that deal with this issue. However, these papers were all ignored by the IPCC. A good starting point for this discussion is the 2017 paper “Why do climate change scenarios return to coal?” by Justin Ritchie.¹¹ The paper was very clear about RCP8.5 being an unlikely scenario because it assumes a return to coal. It said: “This paper argues SSP5-RCP8.5 is an exceptionally unlikely endpoint of future CO₂ forcing because it is biased by a return-to-coal hypothesis that distorts the future energy scenarios produced by IAMs [Integrated Assessment Models].” And elsewhere: “These four lines of evidence (i-iv) collectively indicate that RCP8.5 no longer offers a trajectory of 21st-century climate change with physically relevant information for continued emphasis in scientific studies or policy assessments.” This is a spicy remark, of course. Ritchie and his colleague specifically said RCP8.5 should no longer be used in policy assessments. That is, in IPCC reports. However, not only did IPCC ignore this paper, it also ignored the advice. Roger Pielke Jr, a well-known climate and policy scientist, in peer-reviewed papers, and summarized in his blog, documented how often RCP8.5 and SSP5-8.5 were mentioned in the AR6 report. The result is shown in the table below:

SCENARIO	MENTIONS	PCT of MENTIONS
SSP5-8.5 & RCP8.5	1359	41.5%
SSP1-2.6 & RCP2.6	733	22.4%
SSP2-4.5 & RCP4.5	571	17.4%
SSP3-7.0	378	11.5%
SSP1-1.9	200	6.1%
RCP6.0	32	1.0%

Figure 4: mentions of different scenarios in the AR6 report. Source: Roger Pielke Jr.

As you can see, of all the available scenarios, RCP8.5 and SSP5-8.5 are mentioned most. If you add the still extreme SSP3-7.0 scenario to it, then they are more than half of all scenario references in the report. Just to give some examples from the report:

- Under RCP2.6 and RCP8.5, respectively, glaciers are projected to lose 18% ± 13% and 36% ± 20% of their current mass over the 21st century (medium confidence). (77)
- Under RCP8.5/SSP5-8.5, it is likely that most land areas will experience further warming of at least 4°C compared to a 1995–2014 baseline by the end of the 21st century, and in some areas significantly more. (132)
- According to the SROCC, sea level rise in an extended RCP2.6 scenario would be limited to around 1 m in 2300 (low confidence) while multi-metre sea-level rise is projected under RCP8.5 by then (medium confidence). (188)

The reader gets the idea. All the scary messages from the report are based on RCP8.5 and SSP5-8.5. However, there is solid real-world evidence now, published in the peer reviewed literature that this scenario is not plausible. It is low likelihood according to IPCC, based on the implausible assumption of the explosive use of coal. It’s a scenario that you simply should not use to inform policy makers. However, in AR6 it’s the scenario that is used more than any other. How is this possible? Well, in a way it’s quite understandable. IPCC is supposed to review all the available literature that was published in the period leading to the publication of the report.¹² Bloomberg news

11 J. Ritchie, H. Dowlatabadi, Why do climate change scenarios return to coal? *Energy* 140 (2017) 1276–1291.

12 The deadline for literature for AR6 was 31 January 2021.

did a google scholar search for the use of different scenarios in the literature. The figure below summarizes their results:

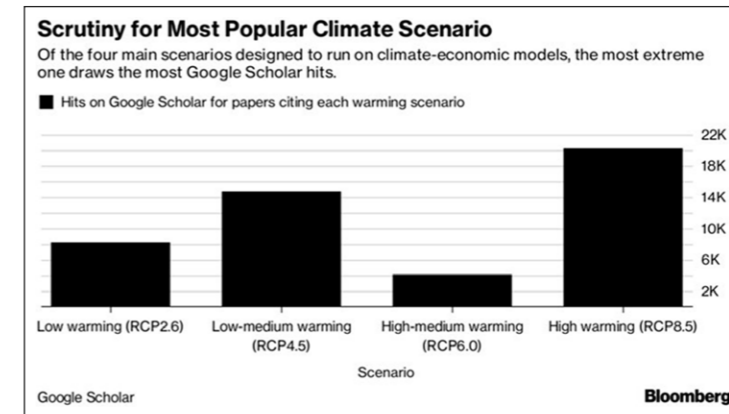


Figure 5: mentions in the literature of the different RCP scenarios.

RCP8.5 is not only the favourite scenario in AR6 but also in the literature. In this sense IPCC is simply doing its job, assessing and reviewing the literature. However, it’s still highly problematic since RCP8.5 is such an unrealistic scenario.

Scenario Reality Check

Another paper that was ‘missed’ by the IPCC was the 2020 paper “IPCC Baseline Scenarios Over-project CO₂ Emissions and Economic Growth” by amongst others Matthew Burgess, Justin Ritchie and Roger Pielke Jr.¹³ Title sounds pretty relevant for an IPCC assessment, doesn’t it? It showed this figure:

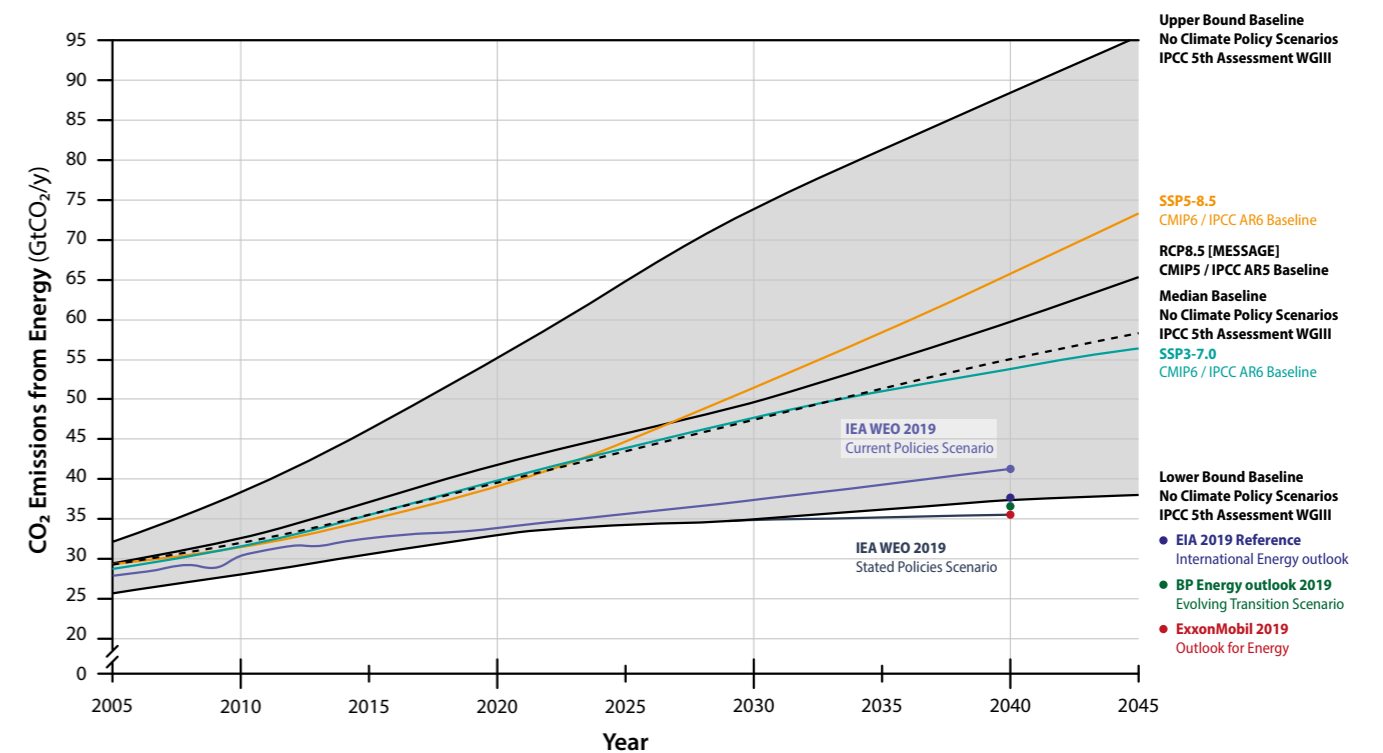


Figure 6: Past and future CO₂ emissions as projected by SSP3-7.0, RCP8.5 and SSP5-8.5 scenarios used by the IPCC. The coloured dots refer to several energy outlook scenarios of the International Energy Agency, the US Energy Information Administration, BP and ExxonMobil.

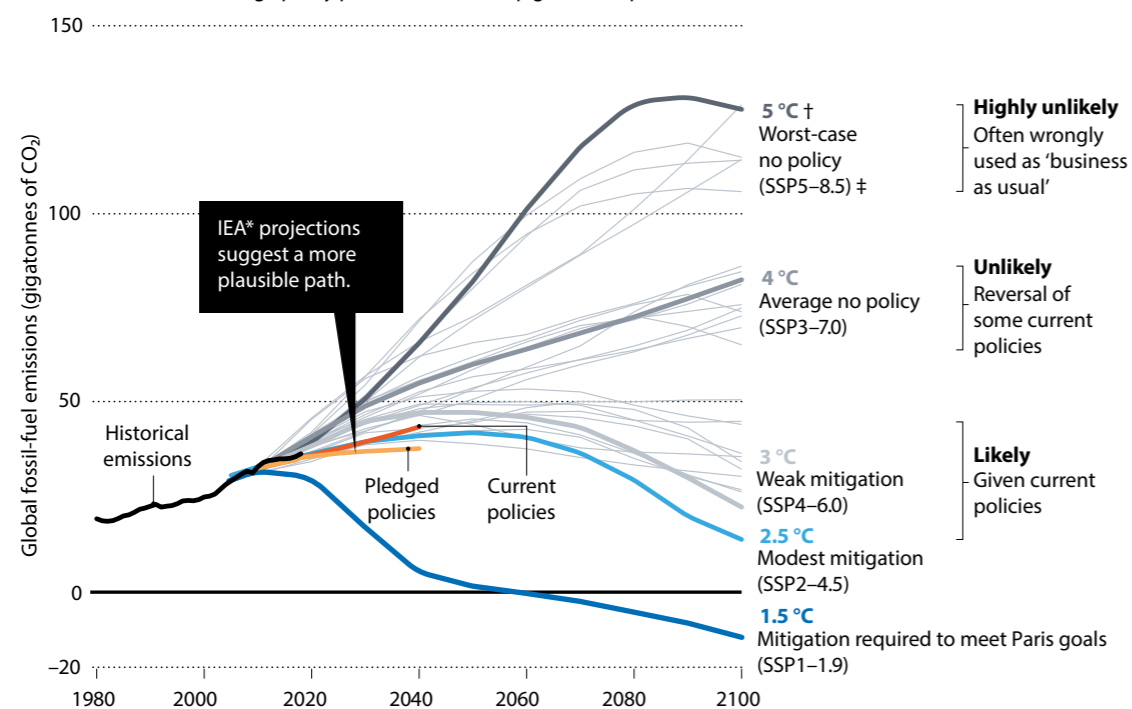
13 Matthew G. Burgess, Justin Ritchie, John Shapland, and Roger Pielke, Jr. IPCC Baseline Scenarios Over-project CO₂ Emissions and Economic Growth. *Environ. Res. Lett.*, 25 November, (2020), <https://doi.org/10.1088/1748-9326/abccd2>.

The real-world emissions follow the lower boundary of the grey area closely and move farther and farther away from the SSP3-7.0, RCP8.5, and SSP5-8.5 scenarios. Notice the huge range for the extreme IPCC climate policy scenarios. According to the five SSP's, without climate policies, emissions in 2045 can be slightly higher than they were in 2020 (the lower bound baseline) or much higher. The upper bound is around 80 gigatonnes of CO₂/year in 2045. The SSP3-7.0, RCP8.5 and SSP5-8.5 scenarios all imply huge increases in CO₂ emissions between now and 2045. Increases that are not expected by the International Energy Agency, the US Energy Information Administration, BP, or ExxonMobil.

The Hausfather and Peters comment in *Nature* had a somewhat similar figure, combining emissions with expected temperature:

POSSIBLE FUTURES

The Intergovernmental Panel on Climate Change (IPCC) uses scenarios called pathways to explore possible changes in future energy use, greenhouse-gas emissions and temperature. These depend on which policies are enacted, where and when. In the upcoming IPCC Sixth Assessment Report, the new pathways (SSPs) must not be misused as previous pathways (RCPs) were. Business-as-usual emissions are unlikely to result in the worst-case scenario. More-plausible trajectories make better baselines for the huge policy push needed to keep global temperature rise below 1.5 °C.



* The International Energy Agency (IEA) maps out different energy-policy and investment choices. Estimated emissions are shown for its Current Policies Scenario and for its Stated Policies Scenario (includes countries' current policy pledges and targets). To be comparable with scenarios for the Shared Socioeconomic Pathways (SSPs), IEA scenarios were modified to include constant non-fossil-fuel emissions from industry in 2018.
† Approximate global mean temperature rise by 2100 relative to pre-industrial levels.
‡ SSP5-8.5 replaces Representative Concentration Pathway (RCP) 8.5.

Figure 7: Different scenarios and their potential relation with global temperature. Source Hausfather and Peters 2020.

The Hausfather and Peters' figure makes it clear that SSP5-8.5 is "very unlikely and often wrongly used as business as usual". SSP3-7.0 is "unlikely" as it requires a reversal of current policies, i.e., policies that are already in place independent of climate pledges.

It would have been helpful if a figure like this would have made it into the AR6 report. How else would policy makers have noticed this? There is no disclaimer or warning in the *Summary for Policy Makers* (SPM). There is only a short sentence in Chapter 1 stating that RCP8.5 and SSP5-8.5 have "low likelihood".

How could this have happened? How is it possible that such an extreme scenario became so dominant in the literature and in both the AR5 and AR6 report? The discussion about that has only recently started. A long essay with the revealing title "How Climate Scenarios Lost Touch with Reality" was published in the summer of 2021 by Justin Ritchie and Roger Pielke Jr, after the dead-

line for AR6.¹⁴ It starts as follows: "A failure of self-correction in science has compromised climate science's ability to provide plausible views of our collective future."

One of the most striking sentences in the essay is this one:

"The continuing misuse of scenarios in climate research has become pervasive and consequential—so much so that we view it as one of the most significant failures of scientific integrity in the twenty-first century thus far. We need a course correction."

This is a harsh conclusion. They talk about the "misuse of scenarios" and blame the climate science community for not yet correcting an error that has slipped into the literature. Therefore, they call it a "failure of scientific integrity". In a much longer peer reviewed paper Pielke and Ritchie dive even deeper into this issue.¹⁵ This paper was available in 2020 although not yet officially published. Elsewhere in the report and in drafts the IPCC is not hesitant to use drafts of papers. But in this case they were not eager to fully discuss this issue in the report. The IPCC doesn't seem to be a big fan of the work of Roger Pielke Jr. Although Pielke Jr. has published authoritatively about scenarios, weather extremes, and about normalized damages due to disasters, AR6 only cited one of his papers, a rather old one from 2008. His more recent work is ignored. A recent report by the Global Warming Policy Foundation titled "The Hounding of Roger Pielke Jr" tries to explain where this attitude comes from.¹⁶ In short: it has to do with politics.¹⁷

Several prominent climate scientists reacted to the essay by Pielke and Ritchie.¹⁸ Chris Field (who has a long involvement with the IPCC) and Marcia McNutt (President of the National Academy of Sciences) rejected the criticism by Pielke and Ritchie. They wrote: "In particular, the high-emissions RCP8.5 scenario has long been described as a "business-as-usual" pathway with a continued emphasis on energy from fossil fuels with no climate policies in place. This remains 100% accurate, even if RCP8.5 does not appear to be the most likely high-emissions pathway."

They do admit that RCP8.5 is not the most likely pathway, but they still think it is right to call it a business-as-usual scenario.

Kate Marvel in her reply said: "I agree with Roger Pielke Jr. and Justin Ritchie's statement that we shouldn't call the high-emissions RCP8.5 scenario "business as usual," and they are right to call for the climate community to end this sloppy wording." However, she disagrees it is a matter of scientific integrity and emphasizes that AR6 doesn't call it that. "Neither the most recent Intergovernmental Panel of Climate Change report nor the National Climate Assessment claims RCP8.5 is "business as usual," but even an unrealistic scenario can yield interesting science if used appropriately."

Pielke and Ritchie in their long peer reviewed article "Distorting the view of our climate future: The misuse and abuse of climate pathways and scenarios" show that scenarios such as RCP8.5 have become so endemic in the literature that it is hard to get rid of them. They agree with Marvel that there can be reasons of academic interest to study such 'extreme' scenarios, i.e., to study how the climate could react to such extreme increases in greenhouse gas concentrations. However, such studies should not be highlighted in scientific assessments as if they are plausible pictures of the future that are relevant for policy makers.

14 Jr., Roger Pielke, and Justin Ritchie. "How Climate Scenarios Lost Touch With Reality." *Issues in Science and Technology* 37, no. 4 (Summer 2021): 74-83. <https://issues.org/climate-change-scenarios-lost-touch-reality-pielke-ritchie/>

15 Roger Pielke Jr. and Justin Ritchie, "Distorting the view of our climate future: The misuse and abuse of climate pathways and scenarios," *Energy Research & Social Science* 72 (2021): 101890.

16 <https://www.thegwfpf.org/content/uploads/2021/11/Laframboise-Pielke.pdf>

17 More about this in chapter 12 about disasters.

18 <https://issues.org/climate-scenarios-reality-pielke-jr-ritchie-forum/>

Most realistic scenario

At least climate scientists are beginning to openly acknowledge that RCP8.5 is not a realistic scenario. This raises the question, if RCP8.5 is not realistic which scenario is? Hausfather and Peters in their *Nature* comment (see figure 7) indicate that the weak to modest mitigation scenarios (SSP4-6.0 and RCP2-4.5) are currently in the likely range. This leads to warming of about 2.7°C in 2100, a number that is now frequently published as well.¹⁹

With a long and woolly sentence AR6 seems to agree with Hausfather and Peters:

“Studies that consider possible future emission trends in the absence of additional climate policies, such as the recent IEA 2020 World Energy Outlook ‘stated policy’ scenario (International Energy Agency, 2020), project approximately constant fossil and industrial CO₂ emissions out to 2070, approximately in line with the medium RCP4.5, RCP6.0 and SSP2-4.5 scenarios (Hausfather and Peters, 2020b) and the 2030 global emission levels that are pledged as part of the Nationally Determined Contributions (NDCs) under the Paris Agreement (Section 1.2.2; (Fawcett et al., 2015; Rogelj et al., 2016; UNFCCC, 2016; IPCC, 2018).”²⁰

Pielke, Ritchie and their colleague Matthew Burgess also looked into this issue: which of the scenarios is most likely and what would that imply for global temperatures?²¹ In their paper they conclude that another SSP scenario, SSP3.4, fits best with the observed emissions. Note, this suggests that the world is on track for an even lower global forcing in 2100 than the SSP2-4.5 or the SSP4-6.0 that were used in the AR6 report. This SSP3.4 scenario isn't even mentioned in the AR6 report.

The median warming connected to this SSP3.4 scenario is 2.2°C of warming in 2100, close to the target of the Paris agreement. So according to them this would be the most likely warming in 2100. Again, this is very good news. Again and again we hear messages about the coming climate apocalypse in the media. We hear complaints that the world isn't doing enough to fight climate change. However, in reality, while emissions are still high, the world has moved away from the higher emissions doom and gloom world into a more moderate middle of the road scenario, where things don't look so bleak.

The IPCC had all the data and the literature available and should have highlighted this good news. However, for whatever reason, they didn't. They make extensive use of a scenario that is completely out of touch with reality and highlight its results all over the report. No disclaimer was included in the *Summary for Policy Makers* warning policy makers of the situation. And week after week new publications appear using this extreme scenario to create screaming news headlines.

How to fix this unfortunate situation is not clear at the moment. If prominent leaders keep using this scenario and funding agencies keep funding research based on it, the use of this exaggerated scenario will continue for many years to come. Tighten your seatbelts.

19 “Earth will warm 2.7 degrees Celsius based on current pledges to cut emissions”, <https://www.sciencenews.org/article/climate-earth-warming-emissions-gap-pledges>

20 AR6, p. 239

21 Pielke, R., Jr, Burgess, M. G., & Ritchie, J. (2021, March 23). Most plausible 2005-2040 emissions scenarios project less than 2.5 degrees C of warming by 2100. <https://doi.org/10.31235/osf.io/m4fdu>