Emission Scenarios & Recent Global Warming Projections

by Ross McKitrick

In the ongoing debates about the nature of the global warming threat there has been a lot of attention paid to some core scientific issues such as natural variability, the validity of climate models, the quality of atmospheric temperature data, the connection between climate and extreme weather, and so forth. One area that is receiving increasing attention is the socioeconomic modeling that underpins the emission projections that in turn gave rise to the famous warming projections of +1.4 to +5.8 degree C that have so alarmed policymakers. This article explains why the emission scenarios are almost certainly too high and ought to be revised as quickly as possible.

A back-of-the-envelope projection

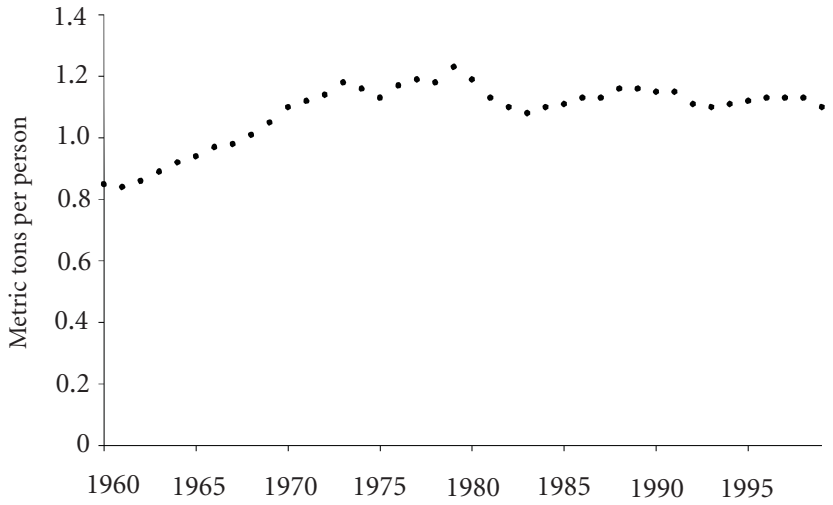
Figure 1 shows the globally-averaged per-person emissions of carbon dioxide in tonnes per capita (tC) since 1960. The average grew steadily from about 0.8 tC to 1.2 tC from 1960 to the early 1970s, and fell thereafter to about 1.15 tC. Since 1970, the average has been just below 1.14.

The steadiness of this average during the interval from 1970 to 1999 is quite striking since global per capita income grew during this period. The growth was not evenly felt, especially in developing regions. For instance, Brazil's per capita income rose 80 percent while Nigeria experienced no real growth at all. But in the developed countries there was a widespread increase in real per capita income: 60 percent in the US, 74 percent in the UK, 77 percent in Canada, 112 percent in Japan, etc. (Easterly and Sewadeh, 2001). Nonetheless, average carbon dioxide emissions per capita did not rise for the world as a whole.

So there is reason to believe that per capita CO_2 emissions are somewhat invariant to economic growth, at least at a globally-averaged level. We could likely rule out, for instance, the possibility that per capita emissions will exceed 2 tC in the next few decades.

Currently there are about 6.1 billion people in the world. The United Nations currently projects world population will reach about 9.3 billion persons by 2050 (UN, 2002). Population projections have tended to fall because fertility rates are dropping more quickly than demographers expected in the 1970s and '80s. But taking this projection as given, if CO_2 emissions per capita are 1.14 tC for the next 50 years, that would imply total global emissions of 10.6 billion tC by 2050. If emissions per capita range from 1.09 to 1.31 tC by

Figure 1: CO_2 Emissions in Tonnes Carbon Equivalent per Capita



Source: Marland *et al.* (2002).

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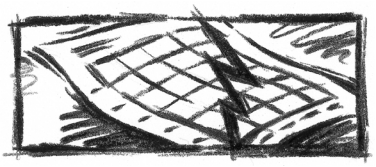


2050, the total emissions range will be 10.2 to 12.2 billion tC.

The official projections

For the purposes of the Third Assessment Report of the Intergovernmental Panel on Climate Change (IPCC, 2001), a set of emission scenarios were developed in the *Special Report on Emission Scenarios* or SRES (IPCC, 2000). The emission scenarios were developed based on the work of "storyline" teams that wrote scenarios about possible future states of the world as of 2100, then devised growth paths that would lead to those future outcomes. The scenarios thus developed were dated to begin at 1990 and run to 2100. Table 1 shows the range of emissions using UN population projections and a 1.1 to 1.3 assumed tC emissions per capita figure, compared with the emissions projected by the SRES group, at years 2020 and 2050.

The first column shows the central UN population projection in billions. The second column assumes per capita emissions of 1.1 tC to 1.3 tC and shows the implied range of emissions from fossil fuel use, in billions of tonnes. In 2020 these estimates are below 10 gigatonnes. The numbers from the 6 main SRES (called "Marker") scenarios range from 9.0 to 12.1 gigatonnes, implying per capita emissions will rise to between 1.2 and 1.6 tonnes per person. For the whole of the 1970 to 1999 period, emissions per person exceeded 1.2 tC only once, in 1979 (reaching 1.23). The SRES projects that by 2020 the average annual emissions per person will be, at a *minimum*, 1.2 tC from fossil fuel consumption.

By 2050, the SRES is projecting emissions per capita will be even higher, between 1.2 and 2.5 tonnes per person. This would require a sharp departure from what has been observed historically. If, however, the pattern over the previous decades persists, emissions will fall in the range of 10.3 to 12.1 gigatonnes.

Implications for climate forecasts

These sorts of calculations matter because the SRES emission scenarios were used as inputs for climate models in the recent Third Assessment Report of the IPCC. The famous conclusion from that report was the forecast increase in the "global temperature" from +1.4 to +5.8 degrees C.

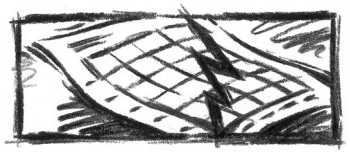
In *Taken by Storm* (Essex and McKitrick, 2002), we explain at length what is wrong with the notion of a "global temperature." To begin with, there is no such thing. There are, instead, statistical indexes constructed by averaging some highly processed temperature observations, but such indexes have no clear physical connection to climate. However, the important point here is that the low end of the emission scenarios is the only one that looks plausible, and its "warming" range is very small, about 0.1 degree C per decade. The attention to the IPCC report focused on the upper end of the warming forecast. It is obvious, though, that the emission figures are unrealistically high at the upper end. If the economic growth of the past three decades did not cause per capita emissions to rise at all, it is unlikely that growth over the next few decades could cause global per capita CO_2 emissions to suddenly double. It is not impossible, of course, but it would require quite a change in the way many economies function. If we rule out this doubling, much of the warming range presented in the Third Assessment Report is in doubt.

To the extent that we can evaluate them, the SRES Marker scenarios are known to be overstated already. For example, they assumed global coal consumption would rise between 4 and 31 percent over the 1990s, whereas actual consumption fell by over 10 percent during this period. The SRES scenarios predicted fossil fuel-based CO_2 emissions of 6.9 billion tonnes as of 2000. But observed emissions in 1999 were just under 6.5 billion tonnes (Marland *et al.,* 2002) and there has been no net emissions growth since 1996.

Note that the lowest of the SRES Marker scenarios implies 1.2 tC per person to be emitted as of 2050. Even this may be an exaggeration. In the summer of 2002, economist Dr. Ian Castles, former Chief Statistician for Australia and now a Fellow of Australian National University, wrote a letter to the Chairman of the Intergovernmental Panel on Climate Change, Dr. Rajendra K. Pachauri, raising some concerns about the SRES scenarios. Dr. Castles had looked at the SRES methodology and concluded that

Table 1: Comparison of Emission Scenarios using Relatively Steady per Capita Emissions versus SRES Projections

Year	UN Population Projection (billions)	Range of emissions assuming 1.1 to 1.3 tC per capita (billion tonnes carbon)	SRES Marker scenario projected range (billion tonnes carbon)	Implied per capita emissions under SRES range
2020	7.579	7.6-9.9	9.0-12.1	1.2-1.6
2050	9.322	10.3-12.1	11.2-23.1	1.2-2.5



the IPCC had made material errors in their projections. They had gone about the scenario constructions backwards. They had computed some ratios of developed country- to developing country-incomes as of 2100, then worked backwards to figure out what growth rates needed to be assumed between now and then in order to get there. These growth rates then determined the emission paths.

Unfortunately, the SRES team used cross-country comparisons based on market exchange rates rather than Purchasing Power Parity (PPP) rates. Exchange rates tend to amplify cross-country differences. For instance, the average income in Canada in 1998, converted to US dollars using market exchange rates, was about $19,600, compared to about $486 for Pakistan—a 40:1 ratio. But local prices in Pakistan are not as high as they are in the US, so income in US dollars would go further in Pakistan. On a PPP basis, income in Canada was only about 16 times that in Pakistan. Consequently, the amount of growth needed in Pakistan to converge towards Canadian real income (on a PPP basis) would be much lower than that implied using exchange rate-based comparisons.

Dr. David Henderson, former Chief Economist of the Organization of Economic Cooperation and Development also voiced concern over these exaggerated growth scenarios. In a letter to Pachauri in October 2002, he called upon the IPCC to review "the whole scenario exercise" since the famous warming forecasts are put into doubt if the underlying emission scenarios are wrong. In their correspondence with the IPCC, Castles and Henderson have focused on the B1 scenario, showing how the use of market exchange rates rather than PPP-based comparisons leads to untenable growth projections at rates more than double those observed historically. Yet the B1 scenario yields the lowest emissions path as of the end of the twenty-first century. If it is overstated, the whole body of conclusions in the Third Assessment Report are in doubt.

Another group of emissions forecasters are at the Massachusetts Institute of Technology in the MIT Joint Program on the Science and Policy of Global Change. A recent paper from this group and coauthors elsewhere (Webster *et al.*, 2002) projects a distribution of emission scenarios, with median emissions out to 2050 tracking the lowest of the IPCC SRES group. John Reilly of MIT's Joint Program commented recently (Corcoran, 2002) that the SRES exercise was "in my view, a kind of insult to science" and the method was "lunacy." He noted that the MIT lab refused a request from the SRES team to let their models be "tweaked" to support the IPCC scenarios.

Beyond 2050, anything can happen. Reilly and coauthors find in their models that if some current trends continue, then emissions could be in the range projected by the IPCC at the end of the century. By contrast, Chakravorty *et al.* (1997) have argued that market mechanisms must be better taken account of in these models, because technical substitution possibilities will drive fuel consumption. In particular, if fossil fuel prices follow what economists call the "Hotelling rule" (increasing, on average, at a rate equal to the real interest rate), and alternate energy sources like solar cells continue to decline in price at even half the observed historical rate, global fossil fuel use will drop to zero by the end of the century. They conclude that global warming is a short-run problem, and beyond a planning horizon of 100 years "the problem declines over time under any reasonable scenario of technological change."

Conclusions

There are clear problems with the SRES scenarios. IPCC Chairman Dr. Pachauri raised the matter at a meeting of the IPCC Bureau in December 2002, and has asked Castles to attend the next Bureau meeting in January to make a further presentation on the matter. For the sake of providing more reliable future projections, we ought to hope that the IPCC takes seriously the concerns being raised, and implements measures to correct the apparent exaggerations in the emission projections.

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