

Do the math

by Bill McKibben

A longer version originally appeared in **Rolling Stone** magazine, August, 2012

If the pictures of towering wildfires, devastating droughts and crippling hurricanes haven't convinced you, here are some hard numbers about climate change. May 2012 was the hottest month on record for the Northern Hemisphere – the 327th consecutive month in which the temperature of the entire globe exceeded the twentieth-century average, the odds of which occurring by simple chance were 3.7×10^{99} , a number considerably larger than the number of stars in the universe.



The June that followed broke or tied 3,215 high-temperature records across the United States, hot on the heels of America's warmest ever spring, which crushed the old record by so much that it represented the 'largest temperature departure from average of any season on record'. The same week, Saudi authorities reported that it had rained in Mecca despite a temperature of 109 degrees, the hottest downpour in the planet's history. In the autumn, a hurricane of unprecedented power slammed into the New York City region, causing tens of billions of dollars in damage. As the year ended, England announced it had suffered its wettest year ever recorded and Australia entered a hot spell that became so severe its weather service had to add two extra colors to its temperature maps.

Not that our leaders seem to notice. The meeting in Rio for the twentieth-anniversary reprise of a massive 1992 environmental summit accomplished nothing. Unlike George H. W. Bush, who flew in for the first conclave, Barack Obama didn't even attend. It was 'a ghost of the glad, confident meeting twenty years ago,' journalist George Monbiot wrote; no one paid it much attention, footsteps echoing through the halls 'once thronged by multitudes.' Since I wrote one of the first books for a general audience about global warming way back in 1989, and since I've spent the intervening decades working ineffectively to slow that warming, I can say with some confidence that we're losing the fight, badly and quickly – losing it because, most of all, we remain in denial about the peril that human civilization is in. When we think about global warming at all, the arguments tend to be

ideological, theological and economic. But to grasp the seriousness of our predicament, you just need to do a little math. Recently, an easy and powerful bit of arithmetical analysis first published by financial analysts in the UK has been making the rounds of environmental conferences and journals, but it hasn't yet broken through to the larger public. This analysis upends most of the conventional political thinking about climate change. And it allows us to understand our precarious – our almost-but-not-quite-finally hopeless – position with **three simple numbers**.

The first number: 2 ° Celsius

If the movie had ended in Hollywood fashion, the Copenhagen climate conference in 2009 would have marked the culmination of the global fight to slow changing climate. The world's nations had gathered in the December gloom of the Danish capital for what a leading climate economist, Sir Nicholas Stern, called the 'most important gathering since the Second World War, given what is at stake.' As Danish energy minister Connie Hedegaard, who presided over the conference, declared at the time: 'This is our chance. If we miss it, it could take years before we get a new and better one. If ever.'

In the event, of course, we missed it. Copenhagen failed spectacularly. Neither China nor the United States, which between them are responsible for 40 per cent of global carbon emissions, was prepared to offer dramatic concessions, and so the conference drifted aimlessly for two weeks until world leaders jetted in for the final day. Amid considerable chaos, President Obama took the lead in drafting a face-saving 'Copenhagen Accord' that fooled very few. Its purely voluntary agreements committed no one to anything, and even if countries signaled their intentions to cut carbon emissions, there was no enforcement mechanism.

The accord did contain one important number, however. In Paragraph 1, it formally recognized 'the scientific view that the increase in global temperature should be below two degrees Celsius'. And in the very next paragraph, it declared that 'we agree that deep cuts in global emissions are required ... so as to hold the increase in global temperature below two degrees Celsius.' By insisting on two degrees – about 3.6 degrees Fahrenheit – the accord ratified positions taken earlier in 2009 by the G8, and the so-called Major Economies Forum. It was as conventional as conventional wisdom gets. The number first gained prominence, in fact, at a 1995 climate conference chaired by Angela Merkel, then

the German minister of the environment and now the center-right chancellor of the nation. Some context: so far, we've raised the average temperature of the planet just under 0.8 degrees Celsius, and that has caused far more damage than most scientists expected. (A third of summer sea ice in the Arctic is gone, the oceans are thirty per cent more acidic, and since warm air holds more water vapor than cold, the atmosphere over the oceans is a shocking five per cent wetter, loading the dice for devastating floods.) Given those impacts, in fact, many scientists have come to think that two degrees is far too lenient a target. 'Any number much above one degree involves a gamble,' writes Kerry Emanuel of MIT, a leading authority on hurricanes, 'and the odds become less and less favorable as the temperature goes up.' Thomas Lovejoy, once the World Bank's chief biodiversity adviser, puts it like this: 'If we're seeing what we're seeing today at 0.8 degrees Celsius, two degrees is simply too much.'

Despite such well-founded misgivings, political realism bested scientific data, and the world settled on the two-degree target – indeed, it's fair to say that it's the only thing about climate change the world has settled on. All told, 167 countries responsible for more than 87 per cent of the world's carbon emissions have signed on to the Copenhagen Accord, endorsing the two-degree target. Only a few dozen countries have rejected it, including Kuwait, Nicaragua and Venezuela. Even the United Arab Emirates, which makes most of its money exporting oil and gas, signed on. The official position of planet Earth at the moment is that we can't raise the temperature more than two degrees Celsius – it's become the bottomest of bottom lines. Two degrees.

The second number: 565 gigatons

Scientists estimate that humans can pour roughly 565 more gigatons of carbon dioxide into the atmosphere by midcentury and still have some reasonable hope of staying below two degrees. ('Reasonable,' in this case, means four chances in five, or somewhat worse odds than playing Russian roulette with a six-shooter.) This number isn't exact, but few dispute that it's generally right. It was derived from one of the most sophisticated computer-simulation models that have been built by climate scientists around the world over the past few decades. And the number is being further confirmed by the latest climate-simulation models in advance of the next report by the Intergovernmental Panel on Climate Change (IPCC). 'Looking at them as they come in, they hardly differ at all,' says Tom Wigley, an Australian climatologist at the

National Center for Atmospheric Research. 'There's maybe forty models in the data set now, compared with twenty before. But so far the numbers are pretty much the same. We're just fine-tuning things. I don't think much has changed over the last decade.' William Collins, a senior climate scientist at the Lawrence Berkeley National Laboratory, agrees. 'I think the results of this round of simulations will be quite similar,' he says. 'We're not getting any free lunch from additional understanding of the climate system.'

We're not getting any free lunch from the world's economies, either. With only a single year's lull in 2009 at the height of the financial crisis, we've continued to pour record amounts of carbon into the atmosphere, year after year. The International Energy Agency's (IEA) latest figures showed that carbon dioxide emissions rose to 31.6 gigatons in 2011, up 3.2 per cent from the year before. America had a warm winter and converted more coal-fired power plants to natural gas, so its emissions fell slightly; China kept booming, so its carbon output (which recently surpassed the US) rose 9.3 per cent; the Japanese shut down their fleet of nukes post-Fukushima, so their emissions edged up 2.4 per cent. 'There have been efforts to use more renewable energy and improve energy efficiency,' said Corinne Le Quéré, who runs England's Tyndall Centre for Climate Change Research. 'But what this shows is that so far the effects have been marginal.' In fact, study after study predicts that carbon emissions will keep growing by roughly 3 per cent a year – and at that rate, we'll blow through our 565-gigatonne allowance in [thirteen] years, around the time today's preschoolers will be graduating from high school. 'The new data provide further evidence that the door to a two-degree trajectory is about to close,' said Fatih Birol, the IEA's chief economist. In fact, he continued, 'When I look at this data, the trend is perfectly in line with a temperature increase of about six degrees.' That's almost 11 degrees Fahrenheit, which would create a planet straight out of science fiction.

So, new data in hand, everyone at the Rio conference renewed their ritual calls for serious international action to move us back to a two-degree trajectory. The charade continued in November when the latest Conference of the Parties (COP) of the UN Framework Convention on Climate Change convened in Qatar. That was COP 18. COP 1 was held in Berlin in 1995, and since then the process has accomplished essentially nothing. Even scientists, who are notoriously reluctant to speak out, are slowly overcoming their natural preference to simply provide data. 'The

message has been consistent for close to thirty years now,' Collins says with a wry laugh, 'and we have the instrumentation and the computer power required to present the evidence in detail. If we choose to continue on our present course of action, it should be done with a full evaluation of the evidence the scientific community has presented.' He pauses, suddenly conscious of being on the record. 'I should say, a fuller evaluation of the evidence.'

So far, though, such calls have had little effect. We're in the same position we've been in for a quarter-century: scientific warning followed by political inaction. Among scientists speaking off the record, disgusted candor is the rule. One senior scientist told me, 'You know those new cigarette packs, where governments make them put a picture of someone with a hole in their throats? Gas pumps should have something like that.'

The third number: 2,795 gigatons

This number is the scariest of all – one that, for the first time, meshes the political and scientific dimensions of our dilemma. It was brought to wide attention first by the Carbon Tracker Initiative, a team of London financial analysts and environmentalists who published a report in an effort to educate investors about the possible risks that climate change poses to their stock portfolios. The number describes the amount of carbon already contained in the proven coal and oil and gas reserves of the fossil-fuel companies, and the countries (think Venezuela or Kuwait) that act like fossil-fuel companies. In short, it's the fossil fuel we're currently planning to burn. And the key point is that this new number – 2,795 – is higher than 565. Five times higher. The Carbon Tracker Initiative combed through proprietary databases to figure out how much oil, gas and coal the world's major energy companies hold in reserve. The numbers aren't perfect – they don't fully reflect the recent surge in unconventional energy sources like shale gas, and they don't accurately reflect coal reserves, which are subject to less stringent reporting requirements than oil and gas. But for the biggest companies, the figures are quite exact: If you burned everything in the inventories of Russia's Lukoil and America's ExxonMobil, for instance, which lead the list of oil and gas companies, each would release more than 40 gigatons of carbon dioxide into the atmosphere.

Which is exactly why this new number, 2,795 gigatons, is such a big deal. Think of two degrees Celsius as the legal drinking limit – equivalent to the 0.08 blood-

alcohol level below which you might get away with driving home. The 565 gigatons is how many drinks you could have and still stay below that limit – the six beers, say, you might consume in an evening. And the 2,795 gigatons? That's the three 12-packs the fossil-fuel industry has on the table, already opened and ready to pour.

We have five times as much oil and coal and gas on the books as climate scientists think is safe to burn. We'd have to keep 80 per cent of those reserves locked away underground to avoid that fate. Before we knew those numbers, our fate had been likely. Now, barring some massive intervention, it seems certain.

Yes, this coal and gas and oil is still technically in the soil. But it's already economically aboveground – it's figured into share prices, companies are borrowing money against it, nations are basing their budgets on the presumed returns from their patrimony. It explains why the big fossil-fuel companies have fought so hard to prevent the regulation of carbon dioxide – those reserves are their primary asset, the holding that gives their companies their value. It's why they've worked so hard these past years to figure out how to unlock the oil in Canada's tar sands, or how to drill miles beneath the sea, or how to frack the Appalachians.

If you told Exxon or Lukoil that, in order to avoid wrecking the climate, they couldn't pump out their reserves, the value of their companies would plummet. John Fullerton, a former managing director at JP Morgan who now runs the Capital Institute, calculates that at today's market value, those 2,795 gigatons of carbon emissions are worth about \$ 27 trillion. Which is to say, if you paid attention to the scientists and kept 80 per cent of it underground, you'd be writing off \$ 20 trillion in assets. The numbers aren't exact, of course, but that carbon bubble makes the housing bubble look small by comparison. It won't necessarily burst – we might well burn all that carbon, in which case investors will do fine. But if we do, the planet will crater. You can have a healthy fossil-fuel balance sheet, or a relatively healthy planet – but now that we know the numbers, it looks like you can't have both. Do the math: 2,795 is five times 565. That's how the story ends.

Published as the foreword to: **The Burning Question: We can't burn half the world's oil, coal and gas. So how do we quit?** Clark, Duncan; Berners-Lee, Mike. Kindle edition. © 2013

A Perfect Moral Storm

Stephen Gardiner's book, *The Perfect Moral Storm*, has three key chapters: **Chapter 1** describes a perfect moral storm. **Chapter 7** proposes a global test for contemporary institutions and the theories that guide them. **Chapter 9** uses an analogy to Jane Austen's *Sense and Sensibility* to help us see more clearly what is happening regarding climate economics. When he discusses a global test Gardiner uses the concepts, below to argue that the current institutional responses are **unreasonable**.

Storm Dimension	Description
Global	Affects all peoples. Solution requires cooperation of all peoples. The possibility that rich nations will take undue advantage of others is pronounced.
Inter-generational	Actions of the present generation affect future generations. We appear to be passing the buck (the cost) onto future generations.
Institutional	Our institutions and the theories under which they operate appear to be inadequate to the task.

How do we evaluate the response of an institution -- match the threat with the response?

Change	Description
Creeping Change	Slow and even change in small increments that is local in scope.
Methodical Change	Moderately paced and bounded change in medium increments that is national in scope.
Dramatic Change	Moderately-paced and bumpy change in large increments that is global in scope.
Spectacular Change	Fast and abrupt change in massive increments which is global in scope.

Landing	Description
Soft landing	Creeping change with significant but highly malleable, negative impacts.
Rough landing	Substantial change with major and moderately malleable, negative impacts.
Hard landing	Dramatic change with severe, and poorly malleable negative impacts.
Crash landing	Spectacular change with catastrophic negative impacts and no malleability.

Strategies	Implications
Prevention	Eliminates the effect.
Mitigation	Moderates the effect.
Acceptance	Ignores the effect.
Preparation	Moderates (Plan for evasive action when effect arises)
Coping	Moderates (Assume evasive action when effect arises)
Endurance	Full strength (Absorbs the costs)

Hypothesis	
Threat	There is a realistic threat of a harsh or crash landing.
Strategy	The current global situation is best described as manifesting a strategy of accept and endure.
Source	The accept-and-endure strategy is a product of the existing global system and institutions.
Sensible?	The nature of the threat makes the accept-and-endure strategy unreasonable .