Climate change going beyond dangerous – Brutal numbers and tenuous hope

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Keith Kris

If we are not honest about the situation we will continue to do nothing substantive… sticking our head in the sand and, despite the science and data, convincing ourselves everything is going to be all right.

I have called this article 'Climate Change: going beyond dangerous', as in my view and that of many of my colleagues, we are now in the process of going beyond what has traditionally been defined as the threshold between acceptable and dangerous climate change.

The subtitle of the piece, 'Brutal numbers and tenuous hope', refers to the maths and the quantification underpinning the analysis. The numbers are brutal and hard to accept, begging fundamental questions about how we live our lives – they are not numbers we want to hear. Translating the analysis into repercussions for society, it is evident there is now only a tenuous hope of making the substantive mitigation necessary in the rapidly diminishing time frame available.

Given the grave situation we have (knowingly) got ourselves into, we need to be honest, direct and clear as to the implications of our analysis. Only if we strip away the rhetoric and naive technological optimism surrounding climate policy can we have some hope of responding appropriately to the scale of the challenges we face. If we are not honest about the situation we will continue to do nothing substantive. Instead we will carry on with the same ineffective policies we have pursued for the past two decades – what I refer to as 'cognitive dissonance' (an academic disguise for hypocrisy – sticking our head in the sand and, despite the science and data, convincing ourselves everything is going to be all right).

The evidence however, is that we have been heading in the wrong direction for years and, more disturbingly, the situation is worsening rather than improving. Since the 1992 Rio Earth Summit, where the climate convention was brokered, we have witnessed a rise in emissions

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year after year – not only that, but the rate of growth of emissions has also increased. If we are to turn this situation around we have first to acknowledge that despite numerous climate conferences, political soundbites and optimistic discussion of low-carbon technologies, we have abjectly failed to secure any control over emissions.

The void between rhetoric and reality

A prerequisite of responding to the climate challenge is exposing the void between the rhetoric and the reality around efforts to reduce emissions (mitigation). There is certainly plenty of discussion of mitigation, but seldom does it focus on the actual gap between the claims we make as individuals, companies, nations and a global community and what is actually happening in terms of absolute emissions. Buying a slightly more efficient car or improving the performance of supermarket refrigerators has nothing to do with solutions to climate change if we subsequently drive further or chill more of our food.

So what is climate change about? What are we responding to?

Internationally, there are a range of statements and declarations framing climate change and our agreed responses to it. First and foremost, the UN Framework Convention on Climate Change (1992) states in its Article 2 that:

> The ultimate objective of this Convention and any related legal instruments that the Conference of the Parties may adopt is to achieve… stabilization of greenhouse gas concentrations in the atmosphere at a level that would prevent dangerous anthropogenic interference with the climate system. Such a level should be achieved within a time frame sufficient to allow ecosystems to adapt naturally to climate change, to ensure that food production is not threatened and to enable economic development to proceed in a sustainable manner.

The more recent Copenhagen Accord (UNFCCC, 2010) states the goal as to 'hold the increase in global temperature below 2 degrees Celsius, and take action to meet this objective consistent with science and on the basis of equity' (it even recognises the need to consider strengthening the goal to 1.5°C). This is a very clear statement – reiterated in the Cancun Agreements (UNFCC 2011) – and an important backdrop against which to examine and quantify the scale of the policy challenge.

Looking to the EU, the European Commission (2007) reiterates the need to '…*ensure* that global average temperature increases *do not* exceed pre-industrial levels by more than 2°C' and states that we '*must* adopt the necessary domestic measures…' to ensure that this is the case. Likewise, the UK's Low Carbon Transition Plan (DECC, 2009) states that 'average global temperatures *must* rise no more than 2°C' (author's italics).

This language is not about accepting a 50:50 chance of keeping to 2°C. The Cancun Agreement, the EU and the UK, all categorically state that temperatures must rise no more than 2°C. Understanding the probability of staying below (or of exceeding) 2°C is pivotal to any informed discussion of mitigation – an absence of clarity on this issue risks confusion and inappropriate policies. As it is, policy-makers (along with many academics and climate specialists) repeatedly make statements, emphasising the importance of staying below 2°C whilst at the same time proposing policies that imply a very high chance of exceeding 2°C. It is from here that much of the void between climate rhetoric and actual mitigation policies emerges.

What does 2°C mean?

The framing of 2°C refers to the global mean surface temperature rise compared to the pre-industrial period. Since then, and due to the burning of fossil fuels, greenhouse gas concentrations in the atmosphere have continued to increase and temperatures have gradually risen.

A 2°C average rise may not sound too bad if you live in the UK, for example. However, the regional repercussions vary considerably. An average warming of 2°C might mean that temperatures at the poles rise by up to 6°C and parts of Africa experience considerably higher warming than many other regions (May, 2006). Furthermore, most of the planetary surface consists of oceans, and water has a high capacity for absorbing heat, so an average global rise of 2°C may correspond to an average land-based temperature rise of 3°C – triggering marked changes in temperature and precipitation patterns. The repercussions of an average 2°C warming reach deeper than we tend to imagine.

Why has a 2°C rise become the focal point of climate change discourse?

Over the past decades, many scientists have explored the various impacts associated with changes in global and regional temperatures. More recently these have been summarised and brought together to provide a succinct management and policy tool to help guide decision-making. The impacts have been summarised according to five different categories[1] with each category coloured along a continuum from white (acceptable) to red (dangerous)(Figure 1). Through a slow process of engagement between scientists, policy-makers, companies and civil society, 2°C has become established as a 'guard-rail' between acceptable and dangerous levels of climate change. While impacts resulting from temperature rises below 2° are not, on average, considered desirable either, it is widely, and often tacitly, assumed that they are somehow manageable and tolerable.

The first assessment of these impacts was made in the late 1990s and early 2000s (the left-hand graph). When the impacts were revisited in time for the Copenhagen climate summit in 2009, the scientific under-

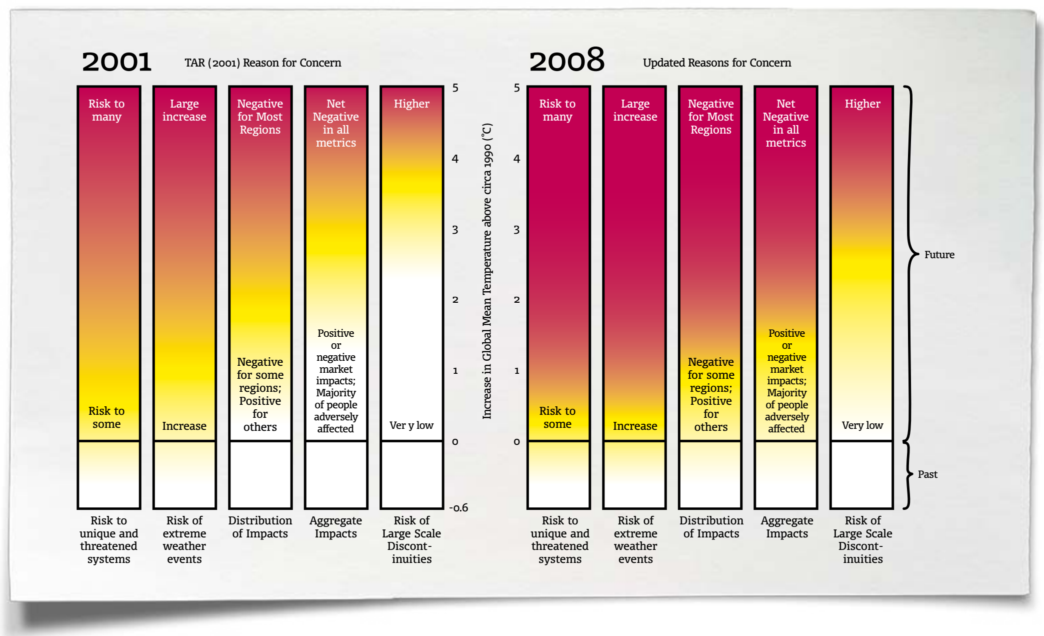

Figure 1: The impacts of 2°C are more serious than previously understood. More recent impact analysis suggests 2°C represents the threshold between dangerous and *extremely* dangerous, rather than between acceptable and dangerous climate change (Smith et al, 2009).

standing of global warming impacts had advanced, with all of the bars demonstrating greater impacts for any given increase in temperature. Not only do the impacts occur earlier than had been thought, but the set of impacts considered to be just about acceptable corresponds with much lower temperatures. The conclusion is clear. The impacts of 2°C are more serious than previously thought, and consequently the 2°C guard-rail lies in far more dangerous territory. If the logic of defining 2°C impacts as dangerous is to hold, the more recent impact analysis

1 Risks to unique and threatened systems, risks of extreme weather events, distribution of impacts, aggregate impacts and risks of large-scale discontinuities (i.e. 'tipping points').

suggests 2°C represents the threshold between dangerous and *extremely* dangerous, rather than between acceptable and dangerous climate change. Certainly, it could reasonably be argued that 1°C rather than 2°C should become the *de facto* appropriate target.

If one accepts the rationale of safeguarding against dangerous climate change it is difficult to argue against a 1°C goal from a scientific point of view. However, from a practical, political point of view, it is almost impossible to imagine us now stabilising at 1°C, given what we have emitted into the atmosphere already. Even if all emissions were immediately stopped, 1°C would likely be exceeded. In other words, 2°C, perhaps 1.5°C, poses a limit of what we could plausibly aim for. At the same time, we should bear in mind that we have consistently and abjectly failed to set a course that would ensure remaining below even 2°C.

What are the implications of 2° warming?

Daniel Silva

The problem with 2050 targets is that they conveniently give the illusion that we can carry on with what we are doing and pass the problem on to future generations.

Since the temperature goal of 2°C has significant political momentum behind it, let us turn to the question of what this entails, politically and socially. What degree of mitigation – what level of carbon reduction – is necessary to stay at or below a temperature rise of 2°C? Asking this question raises an associated question. How should a global carbon budget be distributed between Annex 1 (broadly OECD countries) and non-Annex 1 (broadly non-OECD) countries, between industrialised parts and the industrialising and less wealthy parts of the world? With respect to the first question, there are many long-term targets that sound ambitious. For example, the UK has committed to reductions of 80 per cent CO_2 equivalent by 2050. The EU has adopted a similar goal, while the 2007 UN climate negotiations in Bali concluded that cuts of 50 per cent in global emissions by 2050 are necessary. The problem with 2050 targets is that they conveniently give the illusion that we can carry on with what we are doing and pass the problem on to future generations. A 2050 goal is convenient for policy-makers, companies and the public alike – it does not interfere with decision-making, immediate business issues or how we live our lives. Indeed, the lure of long-term targets is considerable. Unfortunately, there is no basis in science for banking on the problem being solved through technology, by someone else, in the future; disturbingly, many scientists have used this inappropriate shorthand and continue to do so.

The CO_2 that we release into the atmosphere today will remain there for well over 100 years. Therefore, a target of cutting 2050 emissions by a given percentage does not directly correspond to how much the temperature will rise and whether we will avoid dangerous climate change or not. (Imagine, for example, continuously high emissions for decades followed by a sharp drop just in time to meet the 2050 target.) For long-lived gases such as CO_2 and many other greenhouse gases, *cumulative* emissions, the stock that builds up in the atmosphere, is the quantity that matters. Every day we turn the lights on, every time we drive a car we add to the accumulating stock of atmospheric CO_2. Our cumulative emissions – and our *carbon budget* – are pivotal to understanding temperature and climate change. This insight is fundamentally important; it exposes how inadequate it is to aim for long-term, gradual reductions to be delivered by future technology while highlighting the need for urgent and radical reductions that we need to bring about now. That is obviously much less attractive. Hence we shy away from addressing cumulative emissions. We much prefer to stick to long-term targets. They may prove meaningless with respect to global warming but they are tailored to cater for our cognitive dissonance. Bringing in the science reveals what we are not prepared to countenance – that we have to make changes to our lifestyles today.

What is the scale of the problem?

How, then, does a scientifically literate carbon budget approach change the scope of necessary mitigation?

To begin with, it is necessary to factor in the latest emissions data. It is clear that the situation is deteriorating, at a very fast rate. Figure 2 shows global emissions of CO_2. The graph rises in a dramatic way and the rise is connected to a wide range of phenomena, from the stuff we consume – the plasma screens we buy, how many cars and how far we drive, how many refrigerators we have – to the growth in population and so on. If any other species exhibited this same exponential pattern, we would know it was headed down a genetic cul-de-sac and faced a sticky end. The belief that it is possible to endlessly pursue such growth of everything and that the human species is somehow clever enough to defy the laws of science and physics betrays a certain arrogance in our collective imagination.

Over the last 100 years, CO_2 emissions have grown by about 2.7 per cent a year. Despite considerable discussions about climate change, particularly since the Earth Summit in Rio in 1992, emissions have gone up rather than down, as one might have expected. In fact, even the *rate* of increase has gone up. Between 2000 and 2007 the rate of increase was 3.5 per cent,

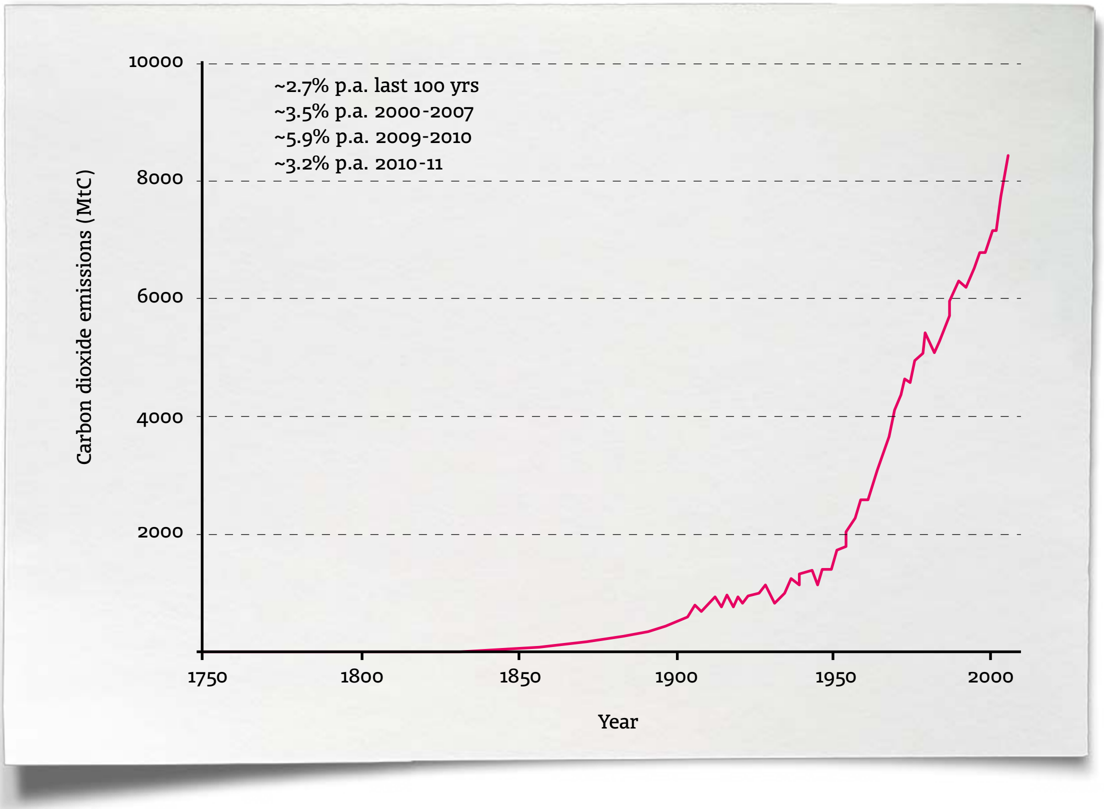

Figure 2: Not only are emissions growing, but also the rate of increase.

despite the considerable attention global warming had in this period.[2] In absolute terms this means vast increases, as the increase is exponential; that is, every year the growth rate is working on a larger number.

It is true that the economic crisis slowed emissions down, but less so than people generally believe, and only for a short period. The latest data reveal that for 2009-2010 emissions rose by 5.9 per cent, and for 2010-2011 by 3.2 per cent – despite the economic slowdown in many of the industrialised nations. Regaining ground that was lost in the recent economic downturn might account for part of the increase, but the underlying message is that we are more likely to see higher rates of increase as the industrialising parts of the world (non-Annex 1 countries) – particularly China and India, the producers of a large part of the goods consumed in the West – drive up emissions. Without radical and immediate mitigation, we are likely to see global emission increases of 3-5 per cent per year from 2012. We are fast heading in the wrong direction, accelerating towards the cliff rather than breaking and steering away from the edge.

2 Based on CDIAC data (Carbon Dioxide Information Analysis Center) http://cdiac.ornl.gov/

What are possible emission reduction pathways?

In light of our failure to reduce emissions, what does the science on cumulative emissions say about the mitigation efforts necessary now for 2°C.

Firstly, the earlier emissions peak the better. Generally, if emissions peak sooner, post-peak reductions need not be as drastic as for a later peak date. Coming off the peak will be the hard part, demanding continuously reducing emissions every single year while politicians and much of society are trying at the same time to foster economic growth.

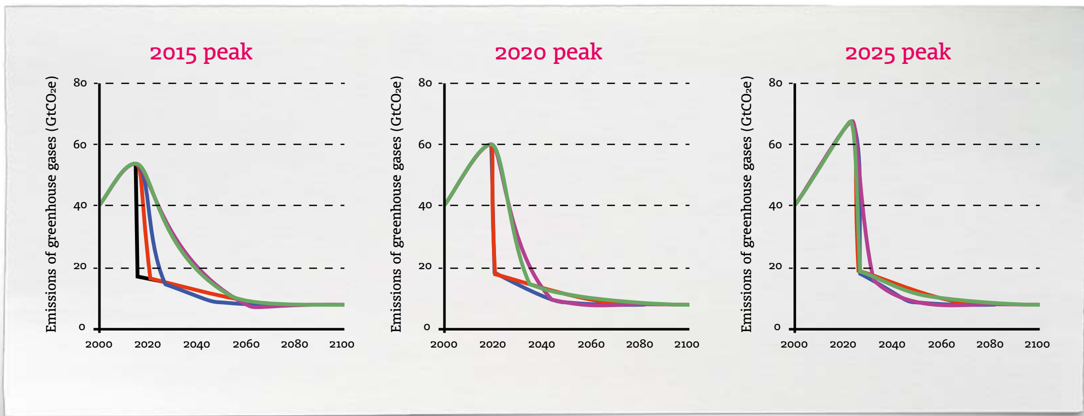

Figure 3: Possible emission reductions pathways based on different years of peaking. The scientific uncertainty about the exact correlation betweeen emissions levels and the resulting temperature increase is represented by the different coloured curves. Curves of the same colour correspond to the same cumulative emissions budget. (Anderson & Bows,2008)

The three graphs in Figure 3 visualise different pathways based on different peaking dates. It is important to note that emissions in all of the scenarios continue to increase before they reach a global peak in 2015, 2020 or 2025, respectively. There remains considerable scientific uncertainty about the relation between greenhouse gas emissions and resulting temperature increases, reflected in the set of different coloured curves in the graphs. But even the least demanding, most hopeful curves become horizontal and flatten out from around 2050. The reason is that emissions from all activities would have to be zero by then, with the exception of food production. Even allowing for efficiency improvements in agriculture it will not be possible to feed the world's population, projected to reach 9 billion by mid-century, without significant emission of greenhouse gases. Even if tractors run carbon free, the use of fertilisers and simply tilling the soil releases greenhouse gases into the atmosphere. These emissions absorb a substantial part of the 2°C budget, putting further pressure on the energy sector to reduce emissions immediately.

The key point is that curves of the same colour correspond to the same cumulative emissions budget. In the first graph, emissions peak in 2015, as assumed in the Stern report. Many consider it highly unlikely that global emissions can peak as soon as 2015. Emission curves in the second and third graph peak in 2020 and 2025, respectively. Because cumulative emissions are the same in all three graphs, the post-peak reductions are much steeper for a later peaking date. Furthermore, if emissions grow unchecked until the peaking date some cumulative emissions budgets are impossible to achieve, so the graph on the right contains fewer curves than the graph on the left.

A closer look at the 2020 graph reveals different estimations of what a 50:50 chance of avoiding exceeding 2°C warming would entail. The least demanding set of curves still require radical emission reductions of about 10 per cent year upon year from 2020 and continuing for around two decades. This is the scale of the challenge if we are to retain even a 50:50 chance of not exceeding the 2°C threshold – that is, to avoid what arguably constitutes *extremely dangerous* climate change.

This is not a promising outlook, and it looks even starker once unavoidable emissions from food production and deforestation emissions are subtracted to show the space left for energy-related emissions: subtracting them from the green and purple curves in Figure 4 yields the curves in Figure 5. Note that the curves in Figure 5 correspond to the same amount of cumulative emissions (the most optimistic case with respect to what is needed to avoid global warming in excess of 2°C) and only differ in their assumed deforestation scenario. Which-

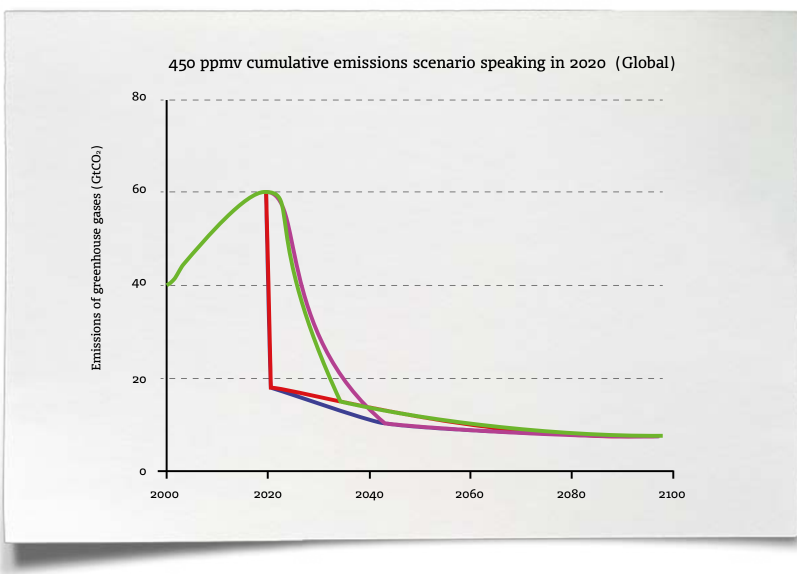

Figure 4: Even the least demanding set of curves still require radical emission reductions of about 10 per cent year upon year from 2020 and continuing for around two decades. (Anderson & Bows,2008)

ever of the two very optimistic deforestation scenarios is chosen, global energy-related CO_2 emissions have to decrease by 10–20 per cent per year, hitting zero between 2035 and 2045. Flying, driving, heating our homes, using our appliances, basically everything we do, would need to be zero carbon – and note, zero carbon means zero carbon. Carbon capture and storage could not, as we understand them today, get near to delivering this.

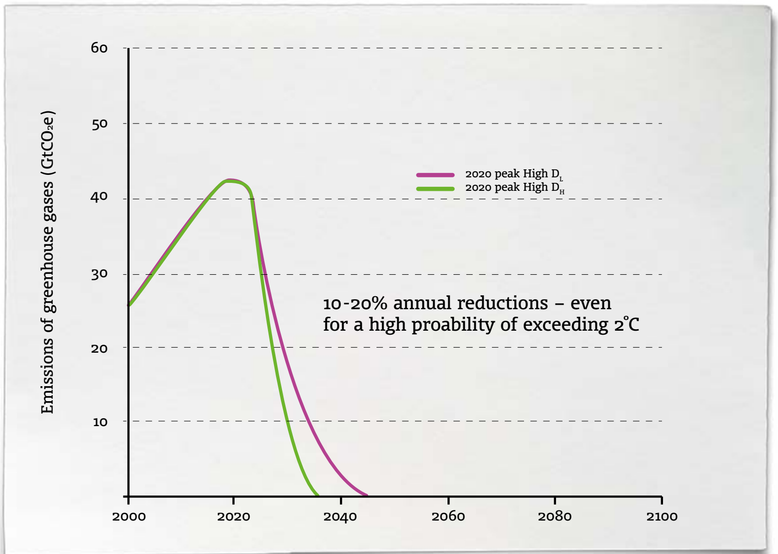

Figure 5. When taking unavoidable emissions from food production and deforestation emissions into consideration, global energy-related CO_2 emissions have to decrease by 10-20 per cent per year from a peak in 2020, hitting zero between 2035 and 2045.

Reduction rates of 10–20 per cent are unprecedented – there are no appropriate analogues for this level of mitigation. The Stern report (Stern, 2006) concludes that cuts in emissions greater than 1 per cent have historically been associated only with economic recession or upheaval. Although there was a considerable shift to gas-powered electricity in the UK and a massive increase in nuclear energy production in France, both countries saw only small emission reductions as their economies continued to grow. When factoring in emissions from international shipping and aviation, which are currently not included under the Kyoto Agreement, there was no meaningful reduction of emissions, only a temporary slowing of the rate of growth. The disastrous collapse of the Soviet Union triggered 5 per cent year-on-year emission reductions for about 10 years – a rate just half to a quarter of what is necessary to give us a 50:50 chance of achieving the 2°C goal (Anderson and Bows, 2008). In 2012, with emissions at a historically high level and with economic growth driving emissions still higher, we simply have no precedent for transforming our economies in line with our commitments to avoid dangerous (or even extremely dangerous) climate change.

Why does this sound different from the standard analyses?

Virtually all mainstream analyses assume that emissions will grow by only 1-2 per cent per year before peaking. In reality emissions are growing nearer to 3-5 per cent per year and are set to continue, with nothing in train to curtail this level of growth. The UK Committee on Climate Change (CCC) is just one of many organisations from across the climate change community that relies on such modelling assumptions for its policy recommendations.

Virtually all mainstream analyses also assume emissions will peak within the period 2010-2016 (with the occasional outlier at 2020). The Stern report specifies the year as 2015; the CCC's work is premised on a 2016 peak; and the recent report on adaptation and mitigation (ADAM) from the EU similarly assumes that emissions will peak in 2015 (Stern, 2006; CCC, 2008; Hulme et al., 2009). Studying the actual emissions globally, the question must be asked whether any of these assumptions of low growth rates and early peaking dates represent an adequate illustration of short-term reality. It is worth noting that a 2015/16 peak in global emissions implies that emissions from China and India peak by 2017/18; yet no analysts suggest this is, in any respects, either reasonable or equitable. In brief, almost all orthodox, low-carbon emission scenarios are premised on implicit assumptions about emission peaks for non-Annex 1 nations that few, if any, analysts considers appropriate.

Turning to post-peak emission reduction rates, our estimate of a required 10-20 per cent per annum reduction (from energy) is far more challenging than the estimates suggested in most other analyses, where rates are typically 2, 3 or 4 per cent per annum. As it stands, it is difficult not to conclude that the delusion of absurdly low emission growth and early peaks is maintained to facilitate post-peak reduction rates compatible with economic growth.

A more specific dividing line can be drawn between our analysis and that of Stern, the CCC and others, who suggest that large-scale supply-side technologies (new nuclear energy or coal with carbon capture and storage) will solve the problem. This begs the question of how possible and likely it is that supply-side technology could be put in place fast enough for emissions to come off the curve in time to avoid global warming of more than 2°C.

This is not to say that technology is unimportant. Quite the contrary, appropriate technologies are a prerequisite for achieving a low-carbon future – but they are not in and of themselves adequate or sufficiently timely. Reductions are needed urgently and large-scale technology cannot deliver under such temporal constraints.

Behavioural changes *could* bring about a faster transformation, as might some 'demand- side technologies', but there simply is no way of getting the supply-side technologies in place fast enough in the wealthier parts of the world. Sokolow's famous wedges could have worked if the process of change had been initiated earlier (that is, a much lower reduction rate would have been sufficient – a rate that a gradually increasing wedge, or wedges, of mitigation might have been able to deliver – see Figure 6).

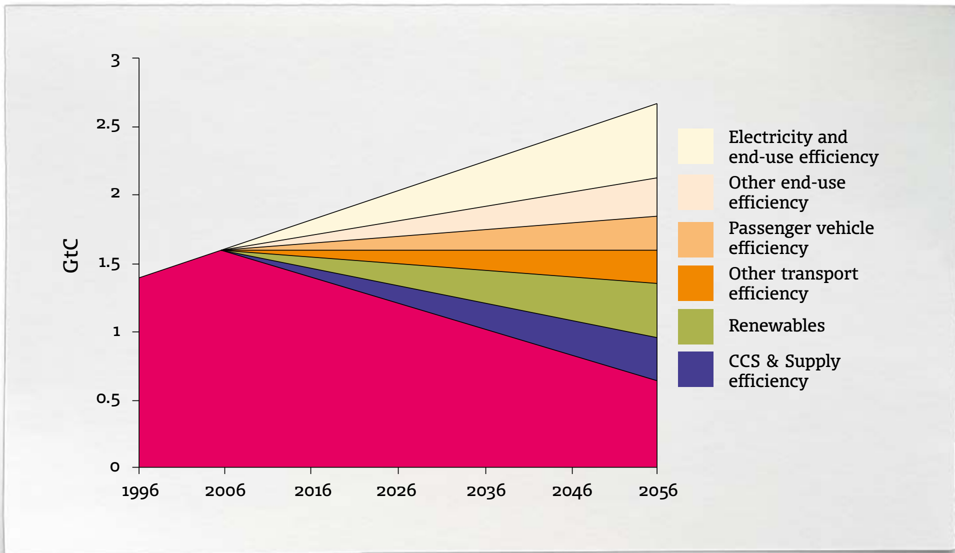

Figure 6: Sokolow's wedges – not enough and too late.

Where we are now, we need some wedges that are the other way around, with the broad side yielding substantial emission cuts almost immediately. Because we are addressing climate change at such a late stage we cannot solely rely on supply-side technology wedges, and wait for them to grow to a significant level.

The analysis offered in this article also challenges the standard economic – or, more precisely, the narrowly constrained financial – characterisation of the problem; we have left it so late to respond that net costs are now essentially meaningless. We live in a non-marginal world, where very large changes are already occurring, both in terms of impacts of a changing climate and of societal responses and stresses, whether in relation to mitigation or adaptation. These step-changes will only escalate as global warming proceeds. Conventional market economics is premised on understanding and making small (marginal) changes. But with

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With global warming, we are dealing with non-marginal, major changes occurring very rapidly.

climate change, we are not talking about small changes; we are dealing with a world of very large changes, outside the realm of standard market theory. In physics, Newtonian principles are deployed to understand how a car works, but in order to understand subatomic particles physicists turn to a different theoretical framing of the problem – quantum mechanics. By contrast, neoclassical (market) economists continue to propose marginal-based theories of small changes, regardless of the scale of the problem; this is not only academically disingenuous but also dangerously misleading. With global warming, we are dealing with non-marginal, major changes occurring very rapidly; a type of problem that market economics is ill-equipped to address.[3] That is not to say that costs, and particularly prices and market economics, cannot be helpful in dealing with niche aspects of climate change; but they are not helpful in addressing the overall challenge.

What would a 4°C world mean?

The current situation is highly precarious. It is easy to resign and claim that the necessary changes are impossible to achieve and that we are going to have to live with higher temperatures. For this reason, it is important to examine what these higher temperatures mean. Let us imagine a 4°C future, the level of warming we seem to be heading towards, if not more.

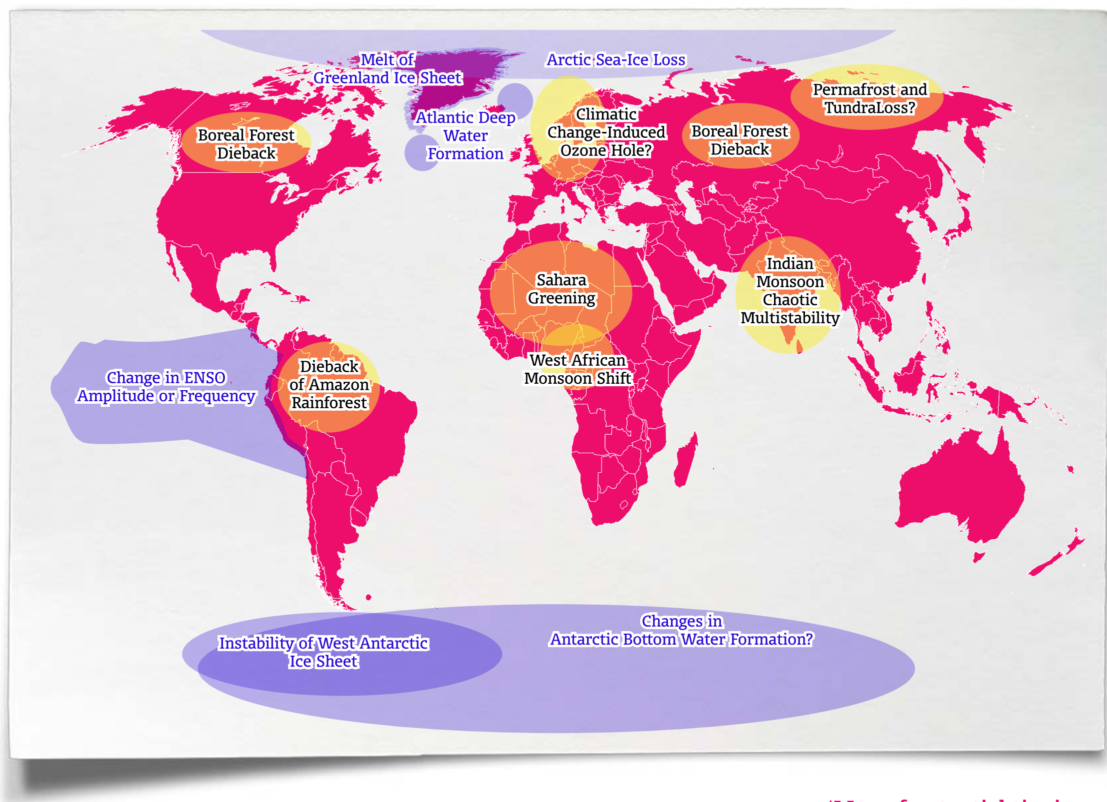
Let's look at a snapshot of a 4°C world. A *global* mean surface temperature rise of 4°C equates to around 5-6°C warming of global mean *land* surface temperature. According to the UK's Hadley Centre (Sanderson, 2011; New, 2011) a 4°C world would likely see the hottest days in China being 6-8°C warmer than the hottest days experienced in recent heat waves that China has struggled to cope with; Central Europe would see heat waves much like the one in 2003, but with 8°C on top of the highest temperatures; during New York's summer heat waves the warmest days would be around 10-12°C hotter – all as a consequence of an average global warming of around 4°C. As it is, our infrastructures and our way of living are not attuned to these temperatures, with the very real prospect of dire repercussions for many – particularly for vulnerable, communities.

3 Not only are immediate, substantive and system-wide investments in low-carbon infrastructure required but these also need to be accompanied by a rapid transition to low-carbon practices. At the same time, there are early signs that the impact and adaption facets of climate change are delivering non-marginal change – made all the more difficult by many of these changes being across national and cultural boundaries – boundaries where cost/benefit analysis and other market-valuation tools are inappropriate at best and divisive at worst.

At low latitudes, 4°C would result in reductions of around 30-40 per cent in the yields of important staple crops such as maize and rice, at the same time as the population heads towards 9 billion by 2050.

It is fair to say, based on many (and ongoing) discussions with climate change colleagues, that there is a widespread view that a 4°C future is incompatible with any reasonable characterisation of an organised, equitable and civilised global community. A 4°C future is also beyond what many people think we can reasonably adapt to. Besides the global society, such a future will also be devastating for many if not the majority of ecosystems.

Beyond this, and perhaps even more alarmingly, there is a possibility that a 4°C world would not be stable, and that it might lead to a range of 'natural' feedbacks, pushing the temperatures still higher (Lenton, 2008).



'Map of potential tipping elements in the climate system (based on Lenton, 2008)'.

A fair deal for non-Annex 1 countries – what's left for Annex 1?

Across the global community we continue to strive for economic growth. But this needs to be balanced with a limited and rapidly shrinking emissions cake; a cake that needs to be divided between the industrialising (non-Annex 1) and industrialised (Annex 1) nations.

My colleague Alice Bows (Sustainable Consumption Institute, University of Manchester) and I have analysed how far it is possible to push non-Annex 1 countries in terms of their emissions, and then see what is left for the Annex 1. Underlying the analysis as presented here, is a global emissions budget corresponding to a 40 per cent likelihood of exceeding 2°C (i.e. not a very ambitious scenario in relation to the risks involved). Figure 7 shows an emissions trajectory for non-Annex 1 countries over the 21st century. Emissions grow (with a tiny dip at the economic downturn in 2008) to a peak in 2025, at a growth rate of 3.5 per cent per annum, much lower than the 6-8 per cent growth in emissions that we are actually seeing in China, for example. Following the peak in 2025, emissions decrease at 7 per cent every year, twice the rate that the Stern review and most economist's claim is the limit within a growing economy. So we are already positing a very challenging curve for the non-Annex 1 nations.

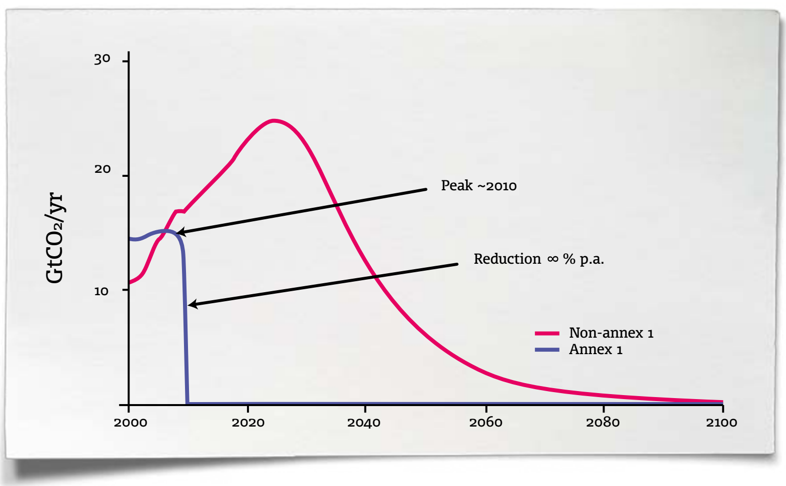


Figure 7: Even with a very challenging emission reduction trajectory for non-Annex 1 countries there are literally no emissions left for Annex 1 countries (Anderson & Bows, 2011)

What then is left for Annex 1 countries in this scenario? The blue curve illustrates the blunt reality: in 2010 Annex 1 countries had no emissions left. This means that we would have to switch the lights off today; in fact, we should have switched them off yesterday. It means we could not have taken the car home from work yesterday, and will be stuck in the office tonight. When we do get home – stepping off our bicycle – we should cancel our flight to the south of France, which is the last thing we do on the laptop before the battery runs out – or try to do, because we fail as the internet is down. There is literally no emissions space left for those of us in the Annex 1 parts of the world, in order to have a roughly 50:50 chance of staying below 2°C temperature rise; of avoiding *extremely* dangerous climate change.

This is a challenging situation, to say the least. But even this non-Annex 1 pathway may be too optimistic. To better understand the reality of current emissions, it is vital to pay careful attention to emissions from China and India, in particular. There is often a naivety underlying the dominant Western ways of analysing these issues.

China's annual fossil fuel emissions are about 7.5 gigatonnes of CO_2, around a quarter of the global total. The Chinese GDP growth rate has a 10-year trend of about 10.5 per cent per annum.[4] Some economists believe this growth rate cannot be sustained much longer, but they have said so for a long time, while the rate has still been achieved. China has been very successful in maintaining strong and sustained economic growth, and it is certainly not planning to bring it to a halt just now. India's emissions are about the same size as Japan's (about 6 per cent of the global total each), having grown at about 7.5 per cent per annum over the past decade. The rate of growth of emissions is lower than China's, but still significant.

The question is if and how long this can continue. Shanghai and Beijing have a similar GDP per capita as the average OECD country. However, there are 200 million people in China who earn less than US$1.25 per day and about 250 million people who earn between US$10 and US$20 a day. There is thus a large, untapped reservoir of people to sustain China, potentially, as a major industrial powerhouse, with substantial economic and emissions growth, for many years to come.

The Chinese GDP per capita measured in the market exchange rate (which is not a perfect measure but acceptable for these purposes) is about 5 per cent of the OECD average. Although citizens of Shanghai and Beijing (which have a combined population of about two thirds of that of the UK) are on average as wealthy as the average UK citizen, the average Chinese person has only about 5 per cent of the income of the average person living in one of the OECD countries. India's income per capita is even lower, around 2 per cent of the OECD average and just over a third of China's. All this suggests that there is considerable potential for continued economic growth in these countries. The emissions likely to accompany this growth could see us going well beyond what is currently accounted for in either our or the standard emission scenarios.

4 Based on CDIAC data (Carbon Dioxide Information Analysis Center) http://cdiac.ornl.gov/

Assuming China meets its 12th five-year plan along with its other promises to reduce its emissions intensity, it is likely to account for about one-half of the world's CO_2 emissions by the early 2020s. If these growth rates were to continue, by 2030 China alone would emit as much as the rest of the world today.

Most of the low carbon integrated assessment models informing governments around the world have emission peaks between 2005 and 2016. However, away from the headlines and microphones, few, if any, of those working on climate change consider these early peaks or accompanying low-emissions growth as either viable or appropriate.

Are these assumptions reasonable? Many Chinese scholars expect the emissions to peak in 2030 and then probably plateau. The minimum growth rate of emissions to peak is often assumed to lie between 5 per cent and 7 per cent, much higher than in current models that assume just 1-2 per cent growth to a very early peak. There is a large discrepancy between the numbers in Western models and scenarios, and those considered appropriate by many Chinese academics; and it may seem plausible that Chinese experts have a more robust understanding of China's actual emissions.

The situation looks similar for India. Assuming India will follow a pathway that is comparable to China's, its emissions will be about 3.5Gt by 2020 and could amount to 7Gt by 2030. Many Indian experts on climate change suggest that energy-related emissions will peak after 2030, again in stark contrast to the numbers in the established Western models. All of this, then, has serious implications for mitigation and adaptation analysis and subsequentially policy, globally and for all nations around the globe.

Putting these numbers together results in a world that looks completely different from the one that the Committee on Climate Change envisages, where emissions from China and India are assumed to peak by around 2017. Most of the low carbon integrated assessment models informing governments around the world have emission peaks between 2005 and 2016. However, away from the headlines and microphones, few, if any, of those working on climate change consider these early peaks or accompanying low-emissions growth as either viable or appropriate.

2°C – a political and scientific creed?

I would argue that the 2°C target is underpinned by what may be termed a political and scientific creed rather than by an updated consideration of the climate science. The prevailing orthodoxy that informs policy-makers is couched in a 'can-do' language, far removed from the reality we are facing. There are many examples:

> 'It is possible to restrict warming to 2°C or less…
> with at least a 50% probability.'
>
> The AVOID programme (AVOID, 2009)

> '[For 2°C it is necessary that] the UK cut emissions by at least 80%...by 2050. The good news is that reductions of that size are possible without sacrificing the benefits of economic growth and rising prosperity.'
>
> UK Committee on Climate Change (CCC, 2008: p.xiii&7)

> '…a low stabilisation target of 400 ppm CO_2e can be achieved at moderate cost…with… a high likelihood of achieving this goal.'
>
> *Adaptation and mitigation strategies: supporting European climate policy (ADAM) report* (Hulme et al., 2009: p.19)

But using the same science, very different conclusions can be drawn, as I have pointed out in a paper co-written with Alice Bows. As a contrast, we state:

> '…it is difficult to envisage anything other than a planned economic recession being compatible with stabilisation at or below 650 ppm CO_2e.' [i.e. ~4°C]
>
> (Anderson and Bows, 2008)

In a more recent paper we conclude:

> '…the 2015-16 global peaking date (CCC, Stern & ADAM) implies…a period of prolonged austerity for Annex 1 nations and a rapid transition away from existing development patterns within non-Annex 1 nations.'
>
> (Anderson and Bows, 2011)

These are radically different interpretations of the same science. In summary, the 'established' models differ from ours in terms of:

» The understanding of/accounting for historical emissions. These have sometimes been mistaken or, worse, possibly massaged, to provide acceptable data and trends for the more orthodox analyses.[5]

» Short-term emission growth is seriously downplayed within virtually every single low-carbon model.

5 Factoring 20th century emissions from Annex 1 nations into calculations of the 'fair' emission space available for Annex 1 in the 21st century would leave Annex 1 nations already in 'emission debt'. Whilst such an outcome may have [some] moral legitimacy, it evidently would not provide for a politically consensual framing of emission apportionment. However, the implications of including 20th century emissions and the concept of emission debt may guide the scope and scale of climate-related financial transfers (arguably as reparation) between Annex 1 and non-Annex 1 nations.

- The choice of peak year is Machiavellian at worst, but even at best, the idea that the peak will take place as early as projected is dangerously misleading.
- The assumed reduction rates are dictated by economists, and this is pivotal to why the early years of these analyses are unrealistic.
- The emission floors – that is to say, the emissions from food – are poorly understood, although some analyses, such as the UK Committee on Climate Change, deserve credit for seeking to embed this dimension in their work.
- Deploying geoengineering schemes to reduce carbon emissions is assumed to play a role. It may be that some of these technologies end up being viable options in the future, but to embed them in almost all low-carbon analyses is unacceptable. At the moment these are at the fringe of our understanding and very risky and speculative, at best. It's unreasonable and irresponsible to have these as ubiquitous and unquestioned in our carbon models.
- The split between Annex 1 and non-Annex 1 countries, between the industrialised and the industrialising world, is neglected or hidden in many analyses.
- There are many optimistic assumptions about 'big' technologies coming forward. Originally trained as a mechanical engineer, I see engineering as a solution to a number of issues, but I also recognise that we cannot deploy large-scale technological schemes fast enough, and that large-scale technological schemes are always associated with social, cultural and ecological realities on the ground that necessarily take considerable time to deal with in a fair and sustainable manner.

Lastly, the linear understanding of the problems held by many – for example, the idea that 4°C means a doubling of the impacts of 2°C, and that if we do not act now, it is ok because we can do so in the future – is scientifically unfounded. This does not work with a complex, dynamic system such as the climate system. Global warming is a cumulative problem – if we do not act now, we are committing the future to certain levels of climate change.

Before despairing

It is imperative not to be dissuaded from purposeful and effective action by a mood of pointless despair. There are many things we can do to attempt to keep to around 2°C, and if this is not possible in the end, then we can at least move in the right direction.

Fernando Weberich

Admittedly, all of this may seem very bleak. But it is imperative not to be dissuaded from purposeful and effective action by a mood of pointless despair. There are many things we can do to attempt to keep to around 2°C, and if this is not possible in the end, then we can at least move in the right direction. What I truly want to convey in this article is that we *can* act. So, let us conclude with some pointers of where real change may come from – of the opportunities to initiate early and substantive levels of emission reduction.

In summary, following our previous analysis, science tells us that for an outside chance of 2°C Annex 1 countries need to reach emission reductions of the order of about 40 per cent by 2015, 70 per cent by 2020, and over 90 per cent by 2030, with similar reductions globally with a lag of a decade or two – a disturbingly short time frame. These numbers are strikingly different from the sort of numbers we traditionally see. The typical response is: 'That is impossible'. In response, we need to ask: Is living with a 4°C global temperature rise by 2050 or 2070 less impossible?

Many people believe that we cannot reduce emissions at these rates, but it is crucial to stress the fact that we almost certainly are unable to adapt to the temperature increases that are likely if we do not cut our emissions drastically. There is no easy way out of this predicament, and we should not pretend that we are awash with win-win or green growth opportunities. Ours is now a world of very difficult futures, and the sooner we acknowledge this, the sooner we can seriously address the challenges we face.

So what can we do?

First, let us consider the question of equity before, second, turning to technology.

Equity

There are presently 7 billion people on the planet. But how many of these people need to make a substantial change in terms of their emissions of CO_2 and other greenhouse gases?

Consider Pareto's 80-20 rule, which states that 80 per cent of something relates to 20 per cent of those involved – a surprisingly useful and robust rule of thumb. Applied to climate change this would mean that 80 per cent of emissions derive from roughly 20 per cent of the population. This relationship holds fairly well within different nations as well as globally. What if we then look at the 20 per cent group and apply Pareto to them

– and then repeat the process again? What we find is that about 50 per cent of the world's emissions come from about 1 per cent of the world population. Admittedly, this is a very rough calculus; it could just as well be 2 or 3 per cent of the global population responsible for 40 per cent of the emissions or 1 per cent for 60 per cent, but it provides a broad guideline.

There need to be policies tailored to reduce the emissions of the 1 per cent, 2 per cent – or even 10 per cent – who are emitting significantly and disproportionately, rather than universal approaches that impact all 7 billion of the population – 80 to 90 per cent of whom are already very low emitters.

Certainly, the bulk of the emissions come from a small percentage of the world's 7 billion people. Yet, in the West, one often hears statements such as 'Oh yes, but the Chinese! They are becoming rich. Everyone wants a fridge and a car…'. It is true that people want these things. But by the time the mode person (not the mean) – that is, the 'normal' person – in China has obtained a car or a fridge, a low-carbon energy system would already have to be in place. It will take China 20 or 30 years, even at 10 per cent annual growth rates, to get its mode population to that level. This means that the poor cannot move fast enough to really affect the basics of this maths. We know who the main emitters, the 'few per cent', are. Large proportions of those residing in OECD countries. Anyone who gets on a plane once a year. Most academics. In the UK anyone earning towards £30,000 pounds, or perhaps less than that, would be within the 'few per cent'.

The question is: Are we, the wealthy 'few per cent' – principally, the Annex 1 countries of the world (but also about 200-300 million Chinese are, for example, in the same group) – sufficiently concerned to pass the necessary legislation and make substantial personal sacrifices and changes to our lifestyles now in order to help the rest of the population and future generations? Since we know who needs to change, policies must be aimed specifically at these people. This requires vast political mobilisation, but it also offers hope. There need to be policies tailored to reduce the emissions of the 1 per cent, 2 per cent – or even 10 per cent – who are emitting significantly and disproportionately, rather than universal approaches that impact all 7 billion of the population – 80 to 90 per cent of whom are already very low emitters.

Technology

Some of the necessary policies need to deal with technological change. There are many examples of what could be done.

Consider the electricity system. To light a traditional light bulb in a fossil fuel-driven electricity system, one needs a transmission network with pylons and wires as a way to deliver the power, a power station to generate the electricity, and people in Columbia or Australia to dig out the coal, or workers in Russia to extract the gas from the ground. Then, the fuels must be exported all the way to the power stations. This means that the energy we need for the light bulb requires much more energy at the source. A normal incandescent light bulb, which is in itself fairly inefficient, will need about 50 units of energy to produce a desired 10 units. About 6–8 per cent of the energy will be lost in transmission and distribution, the power station will be running at somewhere between 35 and 45 per cent efficiency, and there will be about 10 per cent loss in getting the fuel out of the ground, transporting it on a train, taking it to a port, bringing it across the sea, putting it onto another train and delivering it to the power station. All this needs to be done every day of the week for the 40-year life span of the power station. This demonstrates there are huge demand-side opportunities across almost all consumer goods, from cars to refrigerators.

Demand-side opportunities dwarf supply-side opportunities, and we can change demand in the very short term. Toasters have a one-to-two year life span, cars only about eight years in reality. Refrigerators and white goods about three-to-eight years. Real change could be brought about very rapidly through a stringent regulatory framework setting minimum standards.

Consider car efficiency. The average car in the UK emits about 175 g of CO_2 per kilometre. A new car emits on average about 144 g/km. In 2015, the EU plans to introduce legislation requiring 130 g/km as a fleet average (SMMT, 2011). This means the wealthy will be able to drive highly emitting prestige cars as long as the car manufacturers also sell some more efficient cars. In 2008, however, BMW introduced a 3-series 160 horsepower diesel engine. It is a strong, sporty car with a sophisticated diesel engine, but it only emits 109 g/km. Less exclusive cars such as VWs and Skodas were already available with 85–99 g/km. In 1998 Audi had a diesel car that only emitted 75 g/km. It could still travel faster than the motorway speed limits and it did everything a normal car does. With 80–90 per cent of all the vehicle kilometres in the UK (and similar across the EU) covered by cars eight years or younger, existing standard diesel engine technology, tweaked for performance in terms of efficiency rather than in terms of speed, could deliver a 50 per cent reduction of emissions from cars by the early 2020s, assuming the overall distance driven remains unchanged (it is currently stable in the UK). On top of this we could add new technologies, such as hybrids and electric cars. If we then reverse the recent trends in occupancy and have more people travelling together, we could probably see something like a 70 per cent reduction in emissions from cars by early next decade.

What is remarkable about this example is that it does not factor in a big shift to public transport (which is an essential part of the solution); we could still drive as much as we do today. Nor does it factor in a switch to electric cars, which would help the situation even more. It simply means decent legislation driving the penetration of existing technologies. There is huge potential, whether for cars or refrigerators, across the board, to make radical adjustments with appropriate legislation to bring emissions down in line with what is necessary.

In this sense, there is cause for optimism. Yet we need to bear in mind the reality of current emission projections. If we are broadly right on the science on cumulative emissions and temperature, if the developing parts of the world can peak emissions by 2025 to 2030, if there are rapid reductions in emissions from deforestation, if we can halve emissions from food production (currently they are going up, not down), if we do not trigger discontinuities (or 'tipping points'), and if we achieve the reduction rates that the Stern report, the Committee on Climate Change and the International Energy Agency maintain are compatible with economic growth – if all of this happens, a 2°C stabilisation is still unlikely. We need to go beyond this.

The current political and economic framework, however, seems to make this impossible. But, it is not *absolutely* impossible. If the 'few per cent' of the population responsible for the bulk of global emissions are prepared to make the necessary changes in behavioural and consumption patterns, coupled with the technical adjustments we can make now and the implementation of new technologies (such as low carbon energy supplies), there is still an outside possibility of keeping to 2°C. This is a very positive message. We have the agency to avoid the worst excesses of climate change if we are prepared to make changes now. If we are not, we are heading towards 4°C or more, which could happen as early as 2050. At the end of 2011, the International Energy Agency concluded that there could be 3.5°C warming even by 2035 (IEA, 2011). We are no longer talking about the end of the century, but about the lifetime of most people on the planet today. And again, 4°C is unlikely to represent a stable condition, and global warming may in fact reach much higher levels.

Where, then, does this leave us? In 2005, Tyndall Centre colleagues and I coined an expression that we judged provided a responsible framing of the climate challenge: *'To mitigate for 2°C and to plan for 4°C'*. But, as my colleague Alice Bows recently observed, we are in effect doing the opposite: mitigating for 4°C (by doing almost nothing to reduce emissions), while only preparing for 2°C. This is the worst kind of scenario. Benevolent rhetoric aside, we are racing headlong and consciously toward a dire future; where the first to be impacted will be those who have played no part in causing it.

As I have sought to emphasise, this analysis should not be taken as a message of futility. It is intended as a wake-up call, as we have lulled ourselves to sleep, still wearing our rose-tinted spectacles. Real hope, if it is to rise at all, will do so from an honest assessment of the scale of the challenge. It is, admittedly, very uncomfortable: the numbers are brutal and the hope is tenuous – but it still exists. Brazilian philosopher and politician Robert Unger captured the essence of our challenge when he observed: 'At every level the greatest obstacle to transforming the world is that we lack the clarity and the imagination that it could be different.'

The one thing we know about the future with climate change is that it will be different. If we do nothing, we will be hit by devastating impacts and unmanageable adaptation needs. If we choose to mitigate to avoid the worst, the mitigation will have to be very significant. The future is almost beyond what we can imagine, what we have ever seen before. Therefore, our role now is to think differently, to achieve greater clarity, to foster a greater imagination and to no longer keep saying that it is impossible. We must make the impossible possible.

There is real hope, but that hope reduces significantly each day.

The one thing we know about the future with climate change is that it will be different. If we do nothing, we will be hit by devastating impacts and unmanageable adaptation needs. If we choose to mitigate to avoid the worst, the mitigation will have to be very significant.

Kris Rande

References

Anderson, K. and A. Bows (2008), 'Reframing the climate change challenge in light of post-2000 emission trends', *Philosophical Transactions A of the Royal Society*, No. 366, pp. 3863-3882.

Anderson, K. and A. Bows (2011), 'Beyond 'dangerous' climate change: emission scenarios for a new world', *Philosophical Transactions A of the Royal Society*, No. 369, pp. 20-44.

AVOID (2009), *Can we limit warming to 2°C?* http://www.metoffice.gov.uk/media/pdf/9/8/avoid2.pdf

CCC (2008) *Building a low-carbon economy – the UK's contribution to tackling climate change*, Norwich, UK: The Stationery Office.

European Commission (2007), *Limiting global climate change to 2 degrees Celsius: the way ahead for 2020 and beyond*, Brussels, Belgium.

European Commission/DECC (2009), *The UK low carbon transition plan: national strategy for climate and energy*, London, UK: Department of Energy and Climate Change.

Hulme, M., H. Neufeldt, H. Colyer, H. and A. Ritchie (eds) (2009) *Adaptation and mitigation strategies: Supporting European climate policy*, Norwich, UK: University of East Anglia.

IEA (International Energy Agency) (2011), *World Energy Outlook 2011*. https://www.iea.org/publications/worldenergyoutlook/publications/weo-2011/

Lenton, T. et al. (2008), 'Tipping elements in the Earth's climate system', *PNAS*, Vol 16, No. 6. http://www.pnas.org/content/105/6/1786.full.pdf+html?sid=96145615-d450-4239-8ac8-aff5a334a896

May, Wilhelm (2006), *Towards a global '2 degree C-stabilization' scenario: estimates of the allowable greenhouse gas concentrations and the associated climatic changes*. Report for the Danish Meteorological Institute. http://www.dmi.dk/dmi/dkc06-03

Mark New, Diana Liverman, Heike Schroder and Kevin Anderson (2011), 'Four degrees and beyond: the potential for a global temperature increase of four degrees and its implications', *Philosophical Transactions A of the Royal Society*, 13 January.

M. G. Sanderson, D. L. Hemming and R. A. Betts (2011),'Regional temperature and precipitation changes under high-end (·4°C) global warming', *Philosophical Transactions A of the Royal Society*, 13 January.

Smith, J. B. et al. (2009), 'Assessing dangerous climate change through an update of the Intergovernmental Panel on Climate Change (IPCC) "reasons for concern"', *PNAS*, 26 February. http://www.pnas.org/content/early/2009/02/25/0812355106.full.pdf+html

SMMT (Society of Motor Manufacturers and Traders) (2011), *New Car CO_2 Report 2011*.

Stern, N. (2006), *Stern review on the economics of climate change*, Cambridge, UK: Her Majesty's Treasury, Cambridge University Press.

UNFCCC (1992), *United Nations Framework Convention on Climate Change*, United Nations. http://unfccc.int/resource/docs/convkp/conveng.pdf

UNFCCC (2010), *Report of the Conference of the Parties on its fifteenth session, held in Copenhagen from 7-19 December 2009*. http://unfccc.int/resource/docs/2009/cop15/eng/11a01.pdf

UNFCCC (2011), *The Cancun Agreements* http://unfccc.int/meetings/cancun_nov_2010/items/6005.php