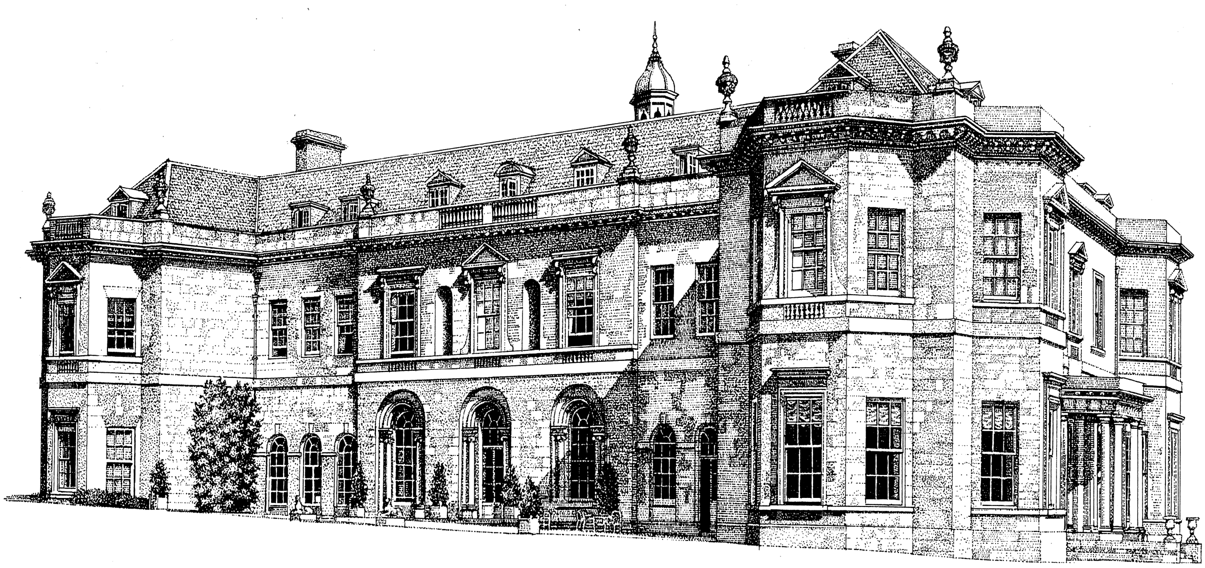
The Hartwell Paper

A new direction for climate policy after the crash of 2009



Hartwell House, Buckinghamshire, where the co-authors conceived this paper, 2-4 February 2010

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Preface

This paper arises from a meeting convened by the LSE in February 2010 to consider the implications of developments in climate policy in late 2009.

The Hartwell meeting was a private meeting, held under the Chatham House Rule. It included participants from various disciplines in the sciences and humanities, from academic and other walks of life and from around the world. The resulting *Hartwell Paper* is the third in a series to have been co-published in a collaboration between London and Oxford. In 2007, Professor Steve Rayner and I published *The Wrong Trousers: Radically Rethinking Climate Policy,* and an associated summary of some of the main arguments in *Nature* ('Time to ditch Kyoto', 449, 25 October). This was followed in July 2009, with a larger circle of co-authorship, by 'How to get climate policy back on course'. That circle has changed and expanded further for the present work.

The Mackinder Programme at the LSE exists to delve into the deeper driving forces of events, which may, like a volcano, produce sudden eruptions but which are different from and more than the accumulated visible clouds of smoke and ash. It is concerned with the magma and the tectonic plates – the geopolitics, including especially the many cultural dimensions – of events. Accordingly, the purpose of the Hartwell meeting was to take a long view of all the aspects of the crisis which enveloped global climate policy during the winter of 2009/10. Many of us were not surprised that climate diplomacy had crashed: we had been predicting this for some time. Other aspects were less expected. Therefore, in early February 2010 we sought to discover to what degree we shared an understanding of what had gone on and why; but especially, we sought in discussion and concretely in this paper, to look forward and to recommend productive courses of action.

The School is grateful for financial support from the Japan Iron and Steel Federation and the Japan Automobile Manufacturers Association, the Nathan Cummings Foundation (NCF), New York and the Fondation Hoffmann, Geneva which made this meeting and project possible. We have a special debt to Peter Teague, Program Director at NCF, for his advice and help. None of the funders necessarily endorses any or all of the resulting paper, of course. As convenor, I am grateful to colleagues in the Research Project & Development Division and in the Office of Development & Alumni Relations at LSE who nimbly and efficiently helped to put together and to manage the support for this work.

I am also extremely grateful to my colleague Johanna Möhring, Visiting Fellow in the Mackinder Programme, and to Dalibor Rohac, Weidenfeld Scholar at the University of Oxford, for assisting me in the conduct of the Hartwell meeting. Michael Denton and the staff at Hartwell House deserve our thanks for providing us with peaceful surroundings in which to meet and for ensuring that the conference-calling all worked faultlessly to enable us to include in the discussions Indian and Chinese colleagues who were not able to be present in person. Finally, I wish to express my thanks to all co-authors for their collegial and intensive engagement.

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Executive Summary

Climate policy, as it has been understood and practised by many governments of the world under the Kyoto Protocol approach, has failed to produce any discernable real world reductions in emissions of greenhouse gases in fifteen years. The underlying reason for this is that the UNFCCC/Kyoto model was structurally flawed and doomed to fail because it systematically misunderstood the nature of climate change as a policy issue between 1985 and 2009. However, the currently dominant approach has acquired immense political momentum because of the quantities of political capital sunk into it. But in any case the UNFCCC/Kyoto model of climate policy cannot continue because it crashed in late 2009. The Hartwell Paper sets and reviews this context; but doing so is not its sole or primary purpose.

The crash of 2009 presents an immense opportunity to set climate policy free to fly at last. The principal motivation and purpose of this Paper is to explain and to advance this opportunity. To do so involves understanding and accepting a startling proposition. It is now plain that it is not possible to have a 'climate policy' that has emissions reductions as the all encompassing goal. However, there are many other reasons why the decarbonisation of the global economy is highly desirable. Therefore, the Paper advocates a radical reframing – an inverting – of approach: accepting that decarbonisation will only be achieved successfully as a benefit contingent upon other goals which are politically attractive and relentlessly pragmatic.

The Paper therefore proposes that the organising principle of our effort should be the raising up of human dignity *via* three overarching objectives: ensuring energy access for all; ensuring that we develop in a manner that does not undermine the essential functioning of the Earth system; ensuring that our societies are adequately equipped to withstand the risks and dangers that come from all the vagaries of climate, whatever their cause may be.

It explains radical and practical ways to reduce non-CO2 human forcing of climate. It argues that improved climate risk management is a valid policy goal, and is not simply congruent with carbon policy. It explains the political prerequisite of energy efficiency strategies as a first step and documents how this can achieve real emissions reductions. But, above all, it emphasises the primacy of accelerating decarbonisation of energy supply. This calls for very substantially increased investment in innovation in non-carbon energy sources in order to diversify energy supply technologies. The ultimate goal of doing this is to develop non-carbon energy supplies at unsubsidised costs less than those using fossil fuels. The Hartwell Paper advocates funding this work by low hypothecated (dedicated) carbon taxes. It opens discussion on how to channel such money productively.

To reframe the climate issue around matters of human dignity is not just noble or necessary. It is also likely to be more effective than the approach of framing around human sinfulness –which has failed and will continue to fail.

The Hartwell Paper follows the advice that a good crisis should not be wasted

Part I: From 'How to get climate policy back on course' to 'The Hartwell paper'

One year ago, few would have guessed that by the spring of 2010 climate policy would be in such public disarray. Two watersheds were crossed during the last months of 2009, one political and one scientific. The narratives and assumptions upon which major Organization for Economic Cooperation and Development (OECD) governments had relied until that moment in shaping and pushing international climate policy towards becoming global climate policy have been undermined. The course that climate policy has been pursuing for more than a decade is no longer sustainable – climate policy must find a new way forward. And that presents us with an immense opportunity to set climate policy free to fly at last. The principal motivation and purpose of this paper is to explain and to advance this opportunity.

The first watershed is to be found within intergovernmental and international diplomacy. It was crossed on 18th December, a day which marked the confusing and disjointed ending to the climate conference in Copenhagen. The Accord which emerged from that meeting holds an uncertain status and it is not clear what the commitments under it might signify. Not only had no agreements of any consequence been reached, but the very process of multilateral diplomacy through large set-piece conferences had been called into question. So too was the leading role in global climate policy previously assumed by Europe. China, India, Brazil and South Africa in particular took initiative and expressed different views from those of the previous ruling consensus.[1] Yvo de Boer, the long-serving chairman of the United Nations Framework Convention on Climate Change (UNFCCC), who had guided the process through meeting after increasingly inconclusive meeting in recent years, has since announced his resignation and future plans to work in the private sector.

The second watershed is to be found within the science of climate change. It was crossed on 17th November. The climate science community has experienced an accelerated erosion of public trust following the posting on that date of more than a 1,000 emails from the University of East Anglia Climatic Research Unit.[2] These emails, whose authenticity is not denied, suggested that scientists may have been acting outside publicly understood norms of science in their efforts to bolster their own views and to discredit the views of those with whom they disagreed.[3] Not long after this, and partly as a consequence of the questions of trust thus raised, the Intergovernmental Panel on Climate Change (IPCC), which many governments had represented to their subjects or citizens as an impeccable "Gold Standard" validating their policies, also came under increased (and continuing) scrutiny as a consequence of errors and sloppiness, many of longer standing, but highlighted specifically in its 2007 Fourth Assessment Report. Universities, governments and the United Nations are all now conducting inquiries into many aspects of climate science and the conduct of climate scientists and science bureaucrats. In short, the legitimacy of the institutions of climate policy and science are no longer assured.

In fairness it must be said that the task at Copenhagen was intractable because in the years since the promulgation of the "Kyoto Protocol" in 1997 so many issues troubling the world have been woven into the tangled knot called 'climate change politics': the loss of biodiversity, the gross inequity in patterns of development, degradation of tropical forests, trade restrictions, violation of the rights of indigenous peoples, intellectual property rights. The list seemed to grow by the month. Copenhagen has shown us the limits of what can be achieved on climate change through centralising and hyperbolic multilateralism. Climate change – least of all the version of climate change we have chosen to construct – cannot be addressed through any single, governing, coherent and enforceable thing called 'climate policy'.[4]

In July 2009, a group of scholars from institutions in Asia, Europe and North America, including a number of the present co-authors, collaborated on a paper entitled 'How to get climate policy back on course'. It explained why the "Kyoto" approach, in development since the Rio "Earth Summit" of 1992, had failed and was doomed to fail. It recommended an alternative approach centred on direct steps to accelerate decarbonisation of the global economy.[5] The July paper also hinted at a much deeper fatal flaw in the dominant framing for climate policy:

> The … problem is epistemological. It is a characteristic of open systems of high complexity and with many ill-understood feed-back effects, such as the global climate classically is, that there are no self-declaring indicators which tell the policy maker when enough knowledge has been accumulated to make it sensible to move into action. Nor, it might be argued, can a policy-maker ever possess the type of knowledge – distributed, fragmented, private; and certainly not in sufficient coherence or quantity – to make accurate 'top down' directions. Hence, the frequency of failure and of unintended consequences.[6]

Without a fundamental re-framing of the issue, new mandates will not be granted for any fresh courses of action, even good ones. So, to rebuild climate policy and to restore trust in expert organisations, the framing must change and change radically.

The authors of this paper are an eclectic group of academics, analysts and energy policy advocates without any common political or professional affiliation. We are citizens from a small number of OECD countries – UK, USA, Germany, Japan, Finland, Canada – each of us working through heterogeneous sets of scholarly, scientific, academic, industrial and policy networks. We share a common concern that the current framing of climate change and climate policy has 'boxed us in'. The previous "Kyoto" model has dangerously narrowed our option space for thinking seriously and realistically about energy and environmental policies. We wish to contribute to a new pragmatism in the policy discourse surrounding climate change. To this end, we gathered at Hartwell House in Buckinghamshire in February 2010 and this paper is the fruit of our work.[7]

We begin by observing what was once controversial but which now seems inescapable: for progress to occur on climate policy, we must reframe the issue in a fundamental way: not simply in various procedural details. We must describe a different comprehensive approach for climate policy. To that end this paper proceeds as follows:

In Part II(A), we first re-focus and state our goals. Then in II(B) we sketch the way in which the 'climate politics' issue has been framed in the period 1985-2009. Starting narrowly from hypotheses about global warming and climate change as presented to policy makers in the 1980s, the politics of these issues grew luxuriantly and began to do very different sorts of work – for economists, for theologians, for activists and for politicians of different stripes, arrayed on every side of the issue.[8] Part II(C) explains why it is in vain to hope that science will be capable of telling us what to do. Instead, we offer a modest and practical way to think about science in relation to Earth systems. We seek to anchor our policy proposals with the three dimensions of this radical re-framing.

Part III, the final part of the paper, updates and details what we believe to be essential policy drivers to go forward from 2010. We recognise the immense complexity of the systems under examination. Indeed, we explain the special nature of that complexity in Part II(C). Our strategy and our proposed sequence of actions are shaped principally by that understanding of complexity. Therefore, the practical recommended actions in Part III move from the relatively most immediate and easily productive to the more complicated and long term. In this paper, we discuss but do not dwell on the issue of adaptation.

To date, climate policy has focused on carbon dioxide primarily, and even to the exclusion of other human influences on the climate system. We believe this path to have been unwise, even if in retrospect the approach was understandable, for reasons of gaining political traction.[9] We think that there is encouraging evidence to suggest that early action on a wider range of human influences on climate could be more swiftly productive. We review that evidence and make that case in Part III(A). In Part III(B), first we review the case for energy efficiency as a means to accelerate decarbonisation of the global economy. Energy efficiency is well worth doing for many reasons, but it has mainly short-term benefits for emissions reduction, and its potential is limited in the face of the current global growth rate. But efficiency gains give political traction by creating a sense both of benefits and of progress; and without traction, we are left as we are now, simply spinning our wheels. So that is why it comes next. Through a case study of the best documented example, we illustrate what best practice can achieve. The third step with respect to the accelerated decarbonisation of the global economy is the most indispensible but also the most arduous. We therefore present in the second part of Part III(B) what we called in our previous paper the "Kaya Direct" approach to accelerated decarbonisation. In so doing, we do not propose a grand and comprehensive governance regime to replace the failed regime. We are aware that in a complex world, the solutions we propose are not practically perfect but rather clumsy: that is our intent and we build this awareness into our approach.[10]

Finally, there is the question of money. Our proposals in Part III (C) for innovation to achieve accelerated decarbonisation require additional funding from somewhere, by someone. We agree with others that the huge efforts that have been invested in elaborating complex top-down regulatory regimes, and in particular the ambitions for regional – let alone global – "Cap & Trade" regimes to regulate carbon by price, can be now seen to have been barren in their stated aims although profitable for some in unexpected and unwelcome ways.[11]

If one seeks long-lasting impact, the best line of approach may not be head-on. "Lose the object and draw nigh obliquely" is a dictum attributed to the famous eighteenth century English landscape gardener Lancelot "Capability" Brown.[12] Brown's designs framed the stately home at the entrance, but only briefly. After allowing the visitor a glimpse of his destination, the driveway would veer away to pass circuitously and delightfully through woodland vistas, through broad meadows with carefully staged *aperçus* of waterfalls and temples, across imposing bridges spanning dammed streams and lakes, before delivering the visitor in a relaxed and amused frame of mind, unexpectedly, right in front of the house. That displays a subtle skill which has manifest political value: the capacity to deliver an ambitious objective harmoniously. "Capability" Brown might be a useful tutor for designers of climate policies.[13] His advice would be to approach the object of emissions reduction via other goals, riding with other constituencies and gathering other benefits.

Throughout this paper we are critical of the way in which the carbon issue has been overloaded with the baggage of other framings and agendas. The oblique approach which we advocate may appear at first glance to be no different because it adopts multiple framings and agendas as well. But that would be a mistake. Currently, all the framings and agendas are mobilised to advance the one core goal of decarbonising the energy system via the UNFCCC/Kyoto process. Our approach is actually the opposite: multiple framings and agendas are pursued in their own right, and according to their own logics and along their own appropriate paths. Decarbonisation is a contingent benefit, not an encompassing one. This is a radical difference: indeed, an inversion.

In our opinion, the experience of the recent failure of the frontal assault on climate policy – the implausibly straight driveway from the present to a magically decarbonised future – suggests that a more indirect yet encompassing approach via the attainment of different objectives which bring contingent benefits is, indeed, the only one that is likely to be materially (in contrast to rhetorically) successful. As 'How to get climate policy back on course' already documented, despite being the dominant policy for many years, there is no evidence that, despite vast investment of time, effort and money, the "Kyoto" type approach has produced any discernable acceleration of decarbonisation whatsoever: not anywhere; not in any region.[14]

Therefore, in our view, the organising principle of our effort should be the raising up of human dignity and in that pursuit, our re-framed primary goals should be three:

1) to ensure that the basic needs, especially the energy demands, of the world's growing population are adequately met. 'Adequacy' means energy that is simultaneously accessible, secure and low-cost.

2) to ensure that we develop in a manner that does not undermine the essential functioning of the Earth system, in recent years most commonly reflected in concerns about accumulating carbon dioxide (CO_2) in the atmosphere, but certainly not limited to that factor alone;

3) to ensure that our societies are adequately equipped to withstand the risks and dangers that come from all the vagaries of climate, whatever may be their cause.

These primary goals are articulated with the goal of emissions reduction via "Capability" Brown's dictum.

Part II: Radical Re-framing

On hearing of the death of the hitherto indestructible French diplomat Talleyrand, who had managed to switch allegiance successfully from Napoleon to the Bourbon restoration, Count Metternich of Austria is reputed to have asked suspiciously, "I wonder what he meant by that?"

Apocryphal or not, the anecdote simply applies the correct question to ask of any diplomatic action. It is correct because it forces us to check for any hidden agenda or, in the language of social theory, to check for and to identify the framing of a statement or policy. The more highly charged the issue, the more likely that there will be multiple framings, or multiple agendas hiding behind one framing. In the case of climate change, one of the co-authors in this paper first made this essential point more than a decade ago and Mike Hulme has most recently provided an extended discussion of its multiple framings.[15]

What might an alternative strategic approach to meeting these three primary goals look like in practice? It should be *politically attractive*, meaning an approach which allows us to take a few small steps which offer rapid and demonstrable pay-back, thus helping to sustain the effort. It should be *politically inclusive*, meaning an approach which is pluralist in instinct. And it should be *relentlessly pragmatic*, meaning an approach which prizes progress that can be measured in the short as well as long terms. In stating these goals we assume a radically different framing of what the idea of anthropogenic climate change means for an early twenty-first century world and what that, in turn, means for practical politics.

The first step is *to recognise that energy policy and climate policy are not the same thing.* Although they are intimately related, neither can satisfactorily be reduced to the other. Energy policy should focus on securing reliable and sustainable low-cost supply, and, as a matter of human dignity, attend directly to the development demands from the world's poorest people, especially their present lack of clean, reliable and affordable energy. One important reason that more than 1.5 billion people presently lack access to electricity is that energy simply costs too much. Obviously, if energy were free, then its provision would be simple. Even if such access could be supplied from fossil fuels – which is plausible but also debatable - this demand for access to energy, for reasons of cost and security *should* not be satisfied by locking in long-term dependence on fossil fuels.[16]

Providing the world with massive amounts of new energy supply to meet expected growth in demand, while simultaneously vigorously increasing access to energy for people currently without it, will therefore require diversification of supply. Diversification beyond fossil fuels necessarily implies an accelerated pace of decarbonisation. Such diversification ought to be a leading incentive to decarbonise future energy supplies.

We then need to separate the policy frameworks and interventions for attending to short-lived versus long-lived climate forcing agents. There is no obvious logical reason, for example, for connecting policies for reducing emissions of methane with those for reducing the emissions of halocarbons. The physical properties, sources and policy levers of short-lived forcing agents – black soot, aerosols, methane and tropospheric ozone – are quite different from those of long-lived forcing agents – carbon dioxide, halocarbons, nitrous oxide. In Part III below, where we set out our policy priorities, we argue that early action on non-CO_2 forcing agents should be part of a radically different and radically realistic response to our goals.

And thirdly, with the failure of the UNFCCC process to fulfil the function, we need to stimulate new thinking for enabling societies better to manage climate risks. All societies are ill-adapted to climate to some degree. In other words, climate extremes and variability imposes costs on all societies (as well, of course, as generating benefits). It is, therefore, important to evolve technologies, institutions and management practices which address the avoidable costs and damages wrought by climate, even more so to build this adaptive capacity whilst climate and society – and consequential risks – both change. These initiatives and the sharing of good adaptation practice make sense irrespective of views on the degree to which climate risks are being changed by human activities or how quickly they are changing. Adaptation policies should be untethered from those focused on decarbonisation.

These three strategic goals need not – indeed must not – be stitched together into one single impossible policy package, where connections between ends and means become inextricably intertwined. When connections between ends and means become obscured, policy discussions are too easily hijacked by diversionary disputes, such as the argument about whether or not the science behind preventing a two degree global temperature target – or indeed any comparable global target – is sound. Similarly, the degeneration of debate at Copenhagen from windy rhetoric about planetary emergency into hard anger from many NGOs and 'global southern' states was revealing. When the large, rich states refused to agree to the cash transfers that were being demanded, it displayed how different interests and agendas were concealed within utopian talk of global and universal solutions.

A: Our three over-arching goals

1) *Ensuring energy access for all*

In his forthcoming book, *The Climate Fix,* Roger Pielke Jr argues that a commitment to fulfilling all three of the objectives of energy access, security of supply and lower cost together, implies necessarily a requirement to diversify energy supply beyond fossil fuels. Diversification in turn necessarily means accelerated decarbonisation. Prospects for diversification will be greatly enhanced if alternatives to fossil fuels at lowere costs can be developed. Google has advocated this in its RE<C ('renewable energy at a cost less than coal') initiative and Bill Gates has also recently called for major investment in R&D to make low-carbon power, including nuclear power, cheaper than coal.[17] Achieving such a goal will necessarily involve a level of effort, in both time and money, comparable to that which nations typically invest to ensure public health or protect national security.

The need for energy supply diversification is perhaps best understood in terms of ensuring energy access. Present estimates suggest that about 1.5 billion worldwide people lack access to electricity. Many scenarios for the 'successful' implementation of mitigation policies leave what we believe to be an unacceptable number of people literally in the dark. For instance, the International Energy Authority's (IEA) 2009 450 Scenario to 2030 has global emissions on a trajectory to stabilisation at 450 ppm carbon dioxide; yet 1.3 billion people worldwide remain without access to electricity. For energy-poor countries with large populations, such scenarios inescapably paint a picture of rich countries who value limiting emissions over economic development elsewhere in the world. India, for example, has long made it plain that it will not find attractive any climate-related strategy which does not grapple with fundamental issues of inequity.[18] We believe that leaving more than a billion people without access to electricity by 2030 would represent policy failure. If energy access is to be expanded to include a majority of those without access today, while meeting expected growth in global energy demand in the rest of the world, the costs of energy will necessarily have to come down. The higher quality fossil fuels are in already tight markets. If the attempt is made to satisfy this new demand from these initially, as would be probable, the opposite is more likely to occur. Costs would rise. Alternatives to fossil fuels will therefore have to become cheaper. For this to happen, innovation is required.[19]

2) Ensuring viable environments protected from various forcings

Most existing climate policies work with the idea of co-benefits on the assumption that the primary rationale for policy implementation is to reduce the human impact on climate and that any co-benefits derived from such policy are secondary – desirable features, but not central to the policy imperative. Following the advice of "Capability" Brown, we argue that this logic needs to be inverted, so as to provide near-term, concrete, politically attractive benefits for near-term investments. Thus, the primary rationale for the policy goals articulated below is to improve the quality of human life – through securing public benefits in developed and developing countries and through managing the multi-faceted natural asset of tropical forests. That each of these policy goals has co-benefits for reducing the scale of human forcing of the climate system should be regarded as a desirable, but not central, co-benefit.

Eradicate emissions of black carbon[20] Black carbon (or soot) is a public health hazard. Around 1.8 million people die every year from exposure to black carbon through indoor fires. Black carbon also warms the atmosphere at regional and global scales, contributing between 5 and 10% of the total human forcing of the climate system, with particular implication for Arctic ice loss. According to conservative estimates, one ton of black carbon causes about 600 times the warming of one ton of carbon dioxide over a period of 100 years. It is feasible nearly to eradicate emissions of black carbon through targeted and enforced regulation.[21] The environmental pay-back here is relatively quick, with huge public health benefits, especially for the poorest in developing countries. We discuss this approach further in Part III.

Reduce tropospheric ozone Poor air quality in urban environments is exacerbated by emissions of carbon monoxide, nitrogen oxides, methane and other volatile organic compounds. In the troposphere, these gases react to form ozone, which is toxic to humans and to plants including crops. Such ozone has been estimated to induce between $14-26 billion of crop damage annually. Tropospheric ozone contributes between 5 and 10% of the total human forcing of the climate system. Rigorous implementation of air pollution regulations, together with a move towards more efficient urban transportation systems, could more than halve these emissions of ozone precursor gases. Human health in both developed and developing nations would be improved and crop damage would be reduced. A co-benefit is that human forcing of the climate would also be reduced.[22]

Work towards effective protection of tropical forests[23] Tropical forests are a key asset for humanity's future, not merely because of their carbon store, but also because of their husbandry of biodiversity, their timber and non-timber products and their wider livelihood functions for indigenous peoples. Rather than seeking to lock tropical forest management into an all-embracing climate convention, and thus get snarled up in the complexities of reducing industrial carbon emissions, forests should be managed in ways which recognise the integrated value of these ecosystems. Issues of deforestation should be de-coupled from the Framework Convention on Climate Change (FCCC).

3) *Ensuring that societies can live and cope with climate risk ('adaptation')*

It would be possible to write human history as the history of its emancipation from natural variability and change. Significant populations of humans now live in all climatic zones of the world. Technological innovations (e.g. air conditioning, building design, crop varieties) and cultural innovations (e.g. patterns of socialising, diet) that at times evolved quickly or at other times more slowly represent capacities adaptive to a range of climatic conditions. Cultural change has opened more of the world to human habitation.

But what made adaptation effective in the course of human history was the relative stability of climatic conditions which much of the time, although not always, were variable within certain expected boundaries. In historical times, strong deviations from the experienced norms of climate, for example, bitter hard winters of the sixteenth to eighteenth centuries, taxed the capacity of European societies to live with extreme climatic conditions. Breughel's paintings of frost fairs are examples of this. Modern climatic range conditions represent both a promise as well as a challenge to adaptation. Yet, adaptation has consistently been the poor and derided cousin of emissions reduction in the history of the climate regime.[24] Adaptation aims at prevention of loss (and exploitation of opportunity). It is therefore an active response to risk, once recognised. [25]

Adaptation and mitigation are not trade-offs, but complementary strategies. The category of the risks best managed by adaptation is certainly much larger than that assumed under the "Kyoto" approach, which (falsely) presented adaptation as a cost of failed mitigation, and thus something to be avoided. Since the Kyoto road effectively ended in Copenhagen, it is time to activate adaptation strategies with much greater vigour. Adaptation is significantly a development challenge. As with mitigation, it must be pursued along many avenues and at many scales as has been extensively argued elsewhere. In this paper, however, we are focusing our recommendations on energy and decarbonisation. That should not be interpreted as an indication of lesser priority, but of economy of effort; indeed, several of this paper's authors have long devoted and continue to devote particular effort to advancing adaptation policies, which are therefore promoted in detail elsewhere.[26]

B: How climate change was systematically misunderstood 1985-2009, and some consequences arising

The "Kyoto" approach was constructed by quick borrowing from past practice, with other treaty regimes dealing with ozone, sulphur emissions and nuclear bombs. It was not unreasonable that hard-pressed officials at the Rio "Earth Summit" in 1992 looked for examples of treaties that had worked – the Montreal Protocol, the START Treaties, the internal US sulphur emission reduction regime – from which to bolt together the skeleton of the radical new attempt to regulate the climate that their political masters had decided they must do. Nor was it novel for them to do so: incremental adaption from past successes is what is usually done by diplomats in such circumstances.

The task was fitted into what Nordhaus and Shellenberger called a 'pollution paradigm'. But, in this case, the analogies were structurally unsound.[27] While superficially plausible, they are not applicable in the ways that the drafters assumed because these were all 'tame' problems (complicated, but with defined and achievable end-states), whereas climate change is 'wicked' (comprising open, complex and imperfectly understood systems). Originally described by Rittel and Webber in the context of urban planning, 'wicked' problems are issues that are often formulated as if they are susceptible to solutions when in fact they are not.[28] Technical knowledge was taken as sufficient basis from which to derive Kyoto's policy, whereas 'wicked' problems demand profound understanding of their integration in social systems, their irreducibly complexity and intractable nature. We elaborate this vital contrast below.

The consequence of this misunderstanding was that there was a fundamental framing error, and *climate change was represented as a conventional environmental 'problem' that is capable of being 'solved'.* It is neither of these.

Climate change emerged as a policy issue in the aftermath of the fall of the Berlin Wall. Despite a few cautionary voices[29], the idea soon became established that climate change represented a global threat that required a coordinated global solution. In *The Wrong Trousers*, Prins and Rayner identified the misleading analogies with other international and environmental issues that shaped the FCCC and the Kyoto architecture. In particular, the concept of epistemic community[30] circulating in policy circles reinforced the idea that a common diagnosis of the 'climate problem' was required to move policy forward. This view was reinforced by the prominent roles played, for example, by the scientific Ozone Trends Panel in the formation of the ozone regime and of the role of science in shaping the Med Plan to 'save the Mediterranean', neither of which were 'wicked' problems.

Rather than being a discrete problem to be solved, climate change is better understood as a persistent condition that must be coped with and can only be partially managed more – or less – well.[31] It is just one part of a larger complex of such conditions encompassing population, technology, wealth disparities, resource use, etc. Hence it is not straightforwardly an 'environmental' problem either. It is axiomatically as much an energy problem, an economic development problem or a land-use problem, and may be better approached through these avenues than as a problem of managing the behaviour of the Earth's climate by changing the way that humans use energy. That is reflected in the radical reframing which we employ for this paper.

What makes a problem 'wicked' is the impossibility of giving it a definitive formulation: the information needed to understand the problem is dependent upon one's idea for solving it. Furthermore, wicked problems lack a stopping rule: we cannot know whether we have a sufficient understanding to stop searching for more understanding. There is no end to causal chains in interacting open systems of which the climate is the world's prime example. So, every wicked problem can be considered as a symptom of another problem.[32]

That is frustrating for politicians. So policy makers frequently respond to wicked problems by declaring 'war' on them, to beat them into submission and then move on. Indeed, almost any 'declaration of war' that is metaphorical rather than literal is a reliable sign that the subject in question is 'wicked'. So, we have the war on cancer, the war on poverty, the war on drugs, the war on terror and now the war on climate change.

The public is often initially stirred by such declarations of war; but, as wicked problems demonstrate their intractability, the public soon grows weary of them. Recent polls suggest that public opinion in many developed nations is losing its previously intense preoccupation with climate issues as it becomes increasingly apparent that it is no more a problem to be 'solved' than is poverty, and as attention focuses on what people feel to be more pressing issues, like the economy.[33]

C: Misunderstanding the nature of the science of Earth systems

A second misunderstanding has developed in parallel with that of the misapplied analogies from other treaty situations. In its way, it is as profound and as widely shared a 'mis-framing' and it concerns the popular view of science as projected by users of scientific information and by those producers of primary science on climate issues who have chosen also to act as advocates and activists. They employ a 'deficit model' of science. The expert scientist pours knowledge into the ignorant and passive heads of the public and their representatives. Their deficit is remedied. They trust the expert's superior knowledge and qualifications and the scientist then leverages that power to instruct further the ignorant public and to delineate the correct actions to remedy the situation which the expert has described.

Hulme documents the special role of this sort that was played by the Met Office's "Dangerous Climate Change" conference of 2005, held at the behest of Prime Minister Blair's office ahead of the Gleneagles G-8 summit, and the associated role of the then Chief Scientific Adviser to HM Government.[34] The same model was endlessly repeated in the pre 17th November 2009 assertions of the unimpeachability of the International Panel on Climate Change (IPCC), usually citing percentages of agreement or numbers of scientists agreeing. Journalists placed implicit and in retrospect excessive trust in such deficit-model statements. Their sense of betrayal, to be detected among many observers of the climate debate after the 17th November watershed, perhaps explains the ferocity with which the climate science community is being investigated by the media now.

In fact, there is another sort of insight about the popular model of science that is important. This is the way in which the role of value judgements can be unhelpfully obscured. In his 2007 book on science policy, Roger Pielke Jr presents the issue in the following way. He notes that the prediction of an imminent tornado is judged to be a sufficient basis for action without reference to other criteria. It is solely an issue of trust in the authoritativeness of the source. This trust results not because values are not present, but rather simply because the value issues are *not in dispute*: no one wants to die because of being in the path of a tornado that everyone agrees is heading in their direction. In contrast, a person's position on the question of abortion may be informed by medical expert knowledge, but it is well understood that religious and other views may play a greater a role in how people think about the issue. The consequence of the misunderstanding of science by the 'deficit' model, Pielke suggests, is that climate change policy, which with its multiple framings is more similar to peoples' views on abortion, has been commonly presented as if it were akin to the value-consensus context of the tornado prediction. In turn, this error has led to the common and flawed assumption that *the solutions to climate change should be 'science driven' as if a shared understanding of science will lead to a political consensus.*[35] Rather, as we have seen, the diverse political framings reveal themselves in alternative views of science. The consequence is that debates about climate politics are then waged in the guise of debates about science, to the detriment of both.

Yet, as we have striven to make clear, 'climate change' is not a single problem amenable to a single understanding or a single solution path. Climate change was brought to the attention of policy-makers by scientists. From the outset, these scientists also brought their preferred solutions to the table in US Congressional hearings and other policy forums, all bundled. The proposition that 'science' somehow dictated particular policy responses, encouraged – indeed instructed – those who found those particular strategies unattractive to argue about the science.[36] So, a distinctive characteristic of the climate change debate has been of scientists claiming with the authority of their position that their results dictated particular policies; of policy makers claiming that their preferred choices were dictated by science, and both acting as if 'science' and 'policy' were simply and rigidly linked as if it were a matter of escaping from the path of an oncoming tornado.

Elected decision-makers would like to know how climate change will affect specific political jurisdictions, and, more importantly, what types of interventions will make a difference, over what time scales, at what costs, and to whose benefit– and whose detriment. But, when it comes to questions like these, political beliefs act like magnets, selecting, and interpreting the science as it is aligned by their force fields. In the case of climate modelling, which has been prominent in the public debate, the many and varied 'projective' scenarios (that is, explorations of plausible futures using computer models conditioned on a large number of assumptions and simplifications) are sufficient to undergird just about any view of the future that one prefers.[37] But the 'projective' models they produce have frequently been conflated implicitly and sometimes wilfully with what politicians really want, namely 'predictive' scenarios: that is, precise forecasts of the future.

Politics is not about maximising rationality. It is about finding compromises that enough people can tolerate to allow society to take steps in the right direction. So, contrary to all our modern instincts, political progress on climate change simply *cannot* be solved by injecting more scientific information into politics. More information does not automatically reduce uncertainty and increase public confidence, which is the common politicians' assumption. But, in consequence of that assumption being present and potent in this (or any) politically hot field, there is a constant temptation for experts to overstate and to oversimplify: something that is plainly revealed in the recent history of climate issues.[38] But this is a recipe for political disappointment, as the 2010 Gallup poll cited at fn 33 documented. It shows a trend setting in of increasing erosion of public trust in the assertions of climate scientists, although, interestingly, to date this has not translated into an equivalent disenchantment with taking practical action.[39]

More fundamentally than in the realm of politics, over-stating confidence about what is known is much more likely to lead us astray in basic research than admitting ignorance. It locks us into rigid agenda and framings such as the one that gave us the dead end of Kyoto, rather than leaving open multiple, even competing options, that allow for learning and adaptability in moving understanding forward. This dynamic tension has always been the motor force in scientific revolutions.[40]

Within hotly contested debates and in the study of wicked and complex open-system issues, in fact the most useful knowledge is of that different sort. It pertains to what we know that we do *not* know, or to where there remains much doubt or disagreement. Then we can consider *why* we don't know or have doubts. That knowledge will help us to grade our certainty, to sensitise us to the significance of the unexpected and to make connections that others do not see: for example, Professor Dame Jocelyn Bell Burnell as a graduate student at Cambridge in December 1967 spotting the radio signals which led to discovery of pulsars, or James Lovelock looking for signs of life on Mars which led him to the Gaia hypothesis of a self-regulating, life-supporting atmosphere on Earth. In that way we can make credible progress.[41]

But we should never overlook the inherent unknowability of the future behaviour of climate-change drivers ranging from population growth to economic performance to technological innovation. They introduce irresolvable uncertainty independent of how well the basic science of climate is understood. In sum, in our understanding, we invert the conventional wisdom on the relationship between scientific knowledge and politics which has informed the FCCC/Kyoto approach. Awareness of the indeterminate and the unknown has profound political as well as research methodological *value* because it releases the power of systematic doubt. Value disputes that are hidden behind positivist scientific claims and counterclaims may thus be brought more clearly into the sunlight of democratic deliberation. Until that happens, the political system will remain in gridlock, and everyone will be convinced that they have certainty and truth on their side

Part III: A Radical Departure from Business-As-Usual in Climate Policy

The crossing of two thresholds in late 2009 was documented in Part I. Crossing those thresholds made unavoidable the difficulties which had already arisen from longer established errors in the understanding and application of diplomatic process and of scientific knowledge about 'wicked' problems. These were explained in Part II. So far, this paper has sought to provide as clear an account as we collectively can give of where the world stands in 2010 in face of a nexus of issues comprising climate change; humanity's knowledge of Earth's biophysical systems (and especially our swiftly increasing knowledge of our ignorance of their mysteries); and extensive governmental and intergovernmental political and economic interventions in this field since 1992 (and especially since 2005/6). Finally, this nexus threatens continuing erosion of public trust in expert institutions whose integrity is necessary if we are to manage more rather than less effectively.

We believe that we should begin with the actions that can command the broadest assent and achieve the quickest results. Once there are some palpable achievements to show, we believe that a constituency of public trust may be rebuilt and that a constituency of public permission may grow. These are the indispensible prerequisites for harder tasks. Our goal is broad-based support for radical acceleration in decarbonisation of the global energy economy. We believe that an indirect approach, which pulls on the twin levers of reducing the energy intensity of economies and the carbon intensity of energy, is more likely to win public assent than a frontal assault upon carbon emissions, especially one coming soon after the recent turbulences. This is because there are many potential constituencies for, and beneficiaries of such efforts, independent of the politics of climate change

For the avoidance of misunderstanding, two points must be spelt out. First, we do not mean that all or any action on the most ambitious goal of radical decarbonisation is postponed until previous steps – such as efficiency improvements – are successfully underway, let alone complete. As we make clear below, we think that the research, development, demonstration and deployment (RDD&D) phase of radical decarbonisation, funded by a low carbon tax, could and should start at once. But the sequencing of steps is consciously informed by the lessons of recent failures, which we seek by all means to avoid.

Secondly, to advocate this different pathway does not imply that we think that there is inadequate or weak scientific evidence to support the case for decarbonisation. However, as we have been at pains to explain, we do not view the scientific evidence in the way that it has been mainly presented to the public by issue advocates. As *The Economist* wrote in its special survey of climate science on 20th March 2010, “Action on climate is justified, not because the science is certain, but precisely because it is not.”[42] Its view is close to ours. Our position is that action is justified on a whole range of issues often subsumed by the climate change framing. Many of these issues can stand on their own irrespective of the state of climate science. In the process of tackling them, we can diffuse obliquely some of the climate forcings – while creating the experience of positive feedbacks from action. So, it is not just that science does not dictate climate policy; it is that climate policy alone does not dictate environmental or development or energy policies.

Since views of ‘what the science says’ have become matters that can be easily misrepresented, sometimes intentionally in the hyper-politicised climate debate, for the avoidance of misunderstanding, our view of the present status of climate science, in minimalist terms, is as follows.

The sharp increase in concentrations of CO_2 in the atmosphere from the pre-industrial level of around 280 ppm to 389 ppm today, and rising in recent times at just under 2 ppm per year, is one of the firmest data tracks which we possess. It is also the least controversial graph in the current debate; and the rise which it documents is unprecedented in the last 10,000 years.[43] But how this clear CO_2 trend relates to global temperature and distributed weather extremes is much cloudier.[44] How rising CO_2 levels – and other human forcings – may relate to prospective climate change is, by extension, a further articulation of theory, data and modeling of the most mysterious of complex systems on Earth. These efforts too have become controversial.[45] But what is certain is that such projections are uncertain.

We have already deplored the side-lining of non-CO_2 forcing agents from the previous climate policy regime for non-scientific reasons, and will shortly return some of them to the front line of future action. But in our view, the Mauna Loa CO_2 trend line *alone* justifies action to abate its rate of rise, even if – and, in fact, particularly because – we do not know for certain what its causal effects are or may be. We share the common view that it would be prudent to accelerate the historical trend of reducing the carbon intensity of our economies, which has been a by-product of innovation since the late eighteenth century[46]. However, we do not recommend doing so by processes that injure economic growth, which we think – and the history of climate policy demonstrates – is politically impossible with informed democratic consent.

A: Returning the relegated non-CO_2 'forcers' to front line service

We observed earlier that the human influences on the global climate system are not limited to the input of CO_2, but involve a range of other climate forcing agents that operate in broader environmental contexts. But, for reasons of convenience in framing policy, not for scientific reasons, they have been over-looked. Since action on these non CO_2 'forcers' may have quicker impact and large, immediate primary benefits, we would give them priority, now. In contrast to long and arduous tasks, these can be 'quick hits'. They achieve widely subscribed practical effects and they can thereby help to re-build public confidence.

The majority of these other forcings, specifically black carbon (soot) and other aerosols, reactive nitrogen, tropospheric ozone and methane, are prime ingredients of air pollution. The somatic health benefits of reducing air pollution are well-known and welcomed. National clean air legislation to enforce it has been well demonstrated in many jurisdictions, particularly since the iconic British Clean Air Act 1956 (passed in response to the Great

London Smog of 1952)[47]. Among their climatic effects these other forcing agents have a role in altering atmospheric and ocean circulation features away from what they would be in the natural climate system. They have additional climate effects though solar heating of the boundary layer that leads to the evaporation of clouds and changes in snow and ice albedo: black soot falling on white snow and ice increases the absorption of heat and may hasten melting. [48] In fact, as 'How to get climate policy back on course' already suggested, reporting new work, black soot may help to explain the recent Arctic ice melt more convincingly than anything else. Black carbon may have contributed up to 50% to the recently observed warming in the Arctic.[49]

Most fine aerosol particles, including sulfate, nitrate, and carbon, scatter solar radiation back to space and lead to cooling. However, black carbon that emanates from diesel engines, inefficient cooking stoves, forest fires and the like, absorbs solar radiation and warms the atmosphere. Because of these feedback processes and its characteristics in the atmosphere, black carbon is considered in many studies to be the second most important anthropogenic component of global warming after carbon dioxide.[50] Black carbon has received attention only recently and its effects have not yet been taken properly into account in the IPCC reports.[51]

Shine and Sturges estimated that 40% of the heat trapped by anthropogenic greenhouse gases (GHGs) in the Earth's atmosphere is due to gases other than CO_2. [52] In a recent study, Bera *et al*. analysed more than a dozen molecules involved in global warming to find out which chemical and physical properties are most important in determining their inherent radiative efficiency, and thus possess the largest potential to contribute to global warming.[53] They found that molecules containing several fluorine atoms tend to be strong GHGs, compared to molecules containing chlorine and/or hydrogen. For instance, some hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs), which are continually utilised in various industries, were shown to be extremely efficient greenhouse gases as they absorb in the atmospheric infrared window and in some cases have atmospheric lifetimes estimated at thousands of years. The study concluded that some PFCs and HFCs display the characteristics to impact global temperatures significantly more than CO_2 in terms both of short-term and long-term effects. This being so, they can be immediately acted on under the successful Montreal Protocol.[54] Some of the most effective HFCs have global warming potentials that are thousands of times that of CO_2. For example, over a 100 year period, nitrogen trifluoride has a global warming potential 17,200 times that of CO_2.

The importance of land use change to emissions of GHGs is well established, with approximately one-third of anthropogenic CO_2 emissions since 1850 attributed to land use activities.[55] However, a growing body of evidence suggests that land use is playing a significant role in ongoing climate change through a set of biogeochemical mechanisms independent of the radiative effects of GHG emissions, the influences being most pronounced at the scale of urbanised regions.[56] For example, the recent work by Stone suggests that alterations in surface fluxes of moisture and energy resulting from land use activities may contribute to regional scale climate phenomena more directly than associated changes in emissions. Most, if not all, of these human influences on regional and global climate will continue to be of concern during the coming decades. Moreover, rapidly expanding urban populations are increasingly vulnerable to rates of warming exceeding that of the planet as a whole.

In light of this evidence, a more comprehensive and, ultimately, effective climate change mitigation effort must respond both to the atmospheric and land surface drivers of warming. Firstly, we need separate policy frameworks and interventions for short-lived and long-lived climate forcing agents. The physical properties, sources and policy levers of short-lived forcing agents – black soot, aerosols, methane and tropospheric ozone – are quite different from those for long-lived forcing agents – carbon dioxide, halocarbons, nitrous oxide. More attention should be paid to designing better materials that have minimal absorption capabilities in the atmospheric window, or shorter atmospheric lifetimes.

Secondly, mitigating some degree of the human influence on climate could be achieved through land use policies. At the scale of regions, this could mean avoiding deforestation to hold the potential to restore moisture and energy balances, whereas in urban environments enhanced tree protection, for example, should be recognised as a form of climate change mitigation.

Finally, current mitigation strategies assume reductions in the atmospheric concentration of GHGs (typically expressed in units of carbon dioxide equivalents as part of the standardisation on this metric) and enhancements of sinks to be the sole mechanisms through which ongoing changes in climate can be slowed or arrested.[57] However, broadening the range of management strategies beyond those conventionally defined as 'mitigation' would have other benefits, for human health, agricultural productivity, and environmental quality, which, together with their climate change relevance, justify the actions needed to achieve the alternative scenario.[58]

B: Ensuring that the best is not the enemy of the good in a complex world

For decades and longer, energy experts have debated the potential for efficiency gains to reduce overall energy use, and more recently its potential role in decarbonising economic activity. Since at least 1980, reductions in the energy intensity of gross domestic product (GDP) have been the primary factor responsible for the decarbonisation of the global economy. However, both energy use and carbon emissions have continued to rise despite the consistent and longstanding decline in the energy intensity of the global economy. As such, we believe that continued and even accelerated rates of global energy intensity decline will not be sufficient to accelerate decarbonisation in the future. The most significant reason for this view is the assumption of greatly increasing energy demand in coming decades which is to be found stated across virtually all energy scenarios of international energy agencies and major energy companies. Many such scenarios do not envisage a dramatic expansion of energy access to the 1.5 billion people presently lacking reliable access, as we do here. So, our ambition lies on top of the already formidable conventional assumptions. Future rates of energy intensity decline will affect how much new energy is ultimately needed, but it will not alter the fact that much more energy is needed. In a context of increasing energy demand, the simple mathematics of carbon dioxide emissions indicate that decarbonisation of energy supply should take the lead as the primary factor responsible for future decarbonisation of economic activity.

Therefore, in this part of the paper, we offer no resolution to the long-standing and on-going debates about the relative role of efficiency in future energy demand. Nor do we feel that our case requires us to do so. In many, if not most, instances, efforts to improve efficiency can be justified for reasons other than decarbonisation. Moreover, modernising and improving the efficiency of energy systems creates the conditions for their diversification and decarbonisation. In this way, efficiency policies can prepare the way for other decarbonisation policies.

1) The political prerequisite of energy efficiency strategies

While the acceleration of decarbonisation of energy supply is the only long-term approach that can deliver a radical acceleration of decarbonisation of economic activity, it will not be quickly or easily deployed and the primary RDD&D will have to be funded from the public purse. That means that tax-payers must be persuaded that it is in their interests for this to happen. The political goal therefore has a technological edge. The goal must be to make clean energy cheaper at point of use to the consumer than dirty energy and – a vital point – the price differential must be capable of being maintained without permanent subsidies.

At a time when public opinion polls show that the resumption of economic growth and the creation of jobs rank far higher than action on human-induced climate change for most voters in OECD countries, it makes eminent sense to promote policies which can to some degree engage both. The fact that energy efficiency saves money, makes industry more productive and attains other worthwhile objectives, and is therefore a much more immediately attractive prospect politically, makes it worth doing irrespective of the benefits to carbon policy. That means recognising the importance of reducing energy intensity which in turn is most elegantly achieved by the systematic application of a sectoral approach that concentrates efforts on the most energy intensive sectors first, pre-eminently power production, aluminium, cement and steel production. These are also sectors that are prime movers in modern economies.

The case study documents one of the world's most indispensible and energy intensive industries. The global steel industry illustrates the potential for and limits to emissions reductions achieved by disseminating best technological practices across an industry sector. An effective international sectoral regime can help control substitution of production by lower standard producers (as the case study documents in the Asia Pacific Partnership [APP] context). Such improvements are worth doing for a host of economic reasons. However, as the case shows, they cannot alter the long-term need for the decarbonisation of global energy supply if targets for CO_2 emissions reductions are ultimately to be met.

The Potential for and Limits to a Sectoral Approach Focused on Efficiency: A Case Study of the Steel Industry's Global Sectoral Approach

Global steel demand has been rapidly growing. In the past ten years, strong economic growth in developing countries, particularly in the BRIC (Brazil, Russia, India, China) countries, pushed up steel demand by 60%. Considering the fact that the *per capita* steel consumption in China and India, compared with developed countries, is still one third and one tenth, respectively, this demand growth will continue for coming decades[59]. Meeting this growing steel demand with minimum CO_2 emissions is an important issue for the steel industry. But CO_2 emission is unavoidable in crude steel production, which uses carbon (coke) as a reducing agent to make iron ore into pig iron. However, crude steel production is also a heavily energy intensive process. Therefore, efficiency improvements, including energy recovery and re-cycled use in the process, not only save energy consumption but also reduce CO_2 emissions per ton of steel produced. Energy savings and CO_2 savings are almost synonymous for steel. The Japanese steel industry experience may be unusual in the way in which it has increased production and reduced energy and emissions; but it can serve as an example of what can be achieved in practice and it has helped inform a global approach across the steel sector.

Since the oil price shocks in the 1970s, various energy saving technologies have been developed and invested in by the Japanese steel industry. In consequence, about 30% energy efficiency improvement has been achieved in the past 30 years .[60] As a result, the Japanese steel industry is equipped almost 100% with currently available major energy saving technologies. The APP[61] Steel Task Force has listed such energy saving technologies and surveyed the diffusion ratio of those technologies to member countries. The conclusion was that if those existing energy saving technologies were to penetrate 100% into the steel industries within the original six member countries of APP (Australia, China, India, Japan, Korea, and the United States), as much as 127 million ton-CO_2 could be saved every year[62]. The APP Steel Task Force has listed such technologies and published them as the SOACT Handbook, which is publicly accessible on the APP website.[63]

Similar CO_2 saving potential was estimated by the IEA, and 340 million ton-CO_2 per year can be saved in the steel industry by the global base diffusion of currently available energy saving technologies.[64] The amount is almost 25% of the entire Japanese CO_2 emissions in 2008.

The mission for the steel industry is to meet the global demand growth with minimum energy consumption (= minimum CO_2 emission). This can only be achieved by penetration of the current best available energy saving technologies.

Since most of the energy saving technologies are 'negative cost' processes, if not very profitable, their diffusion in the steel industries not only saves CO_2 emissions but also brings some economic benefit to steel industries in recipient countries. However, the technologies described above are not necessarily widely spread in the industry. The APP Steel Task Force has analysed and identified diffusion barriers. Among them are longer investment recovery periods and the lack of engineering capabilities in steel industries in developing nations. One important factor is that the Internal Ratio of Return (IRR) for production expansion tends to be much larger than that for energy saving investments in most of the fast growing developing countries. Therefore, scarce resources such as capital and engineering capacity are not necessarily allocated to energy saving investments.

Since most of the energy saving technologies in the steel industry have been commercialised and made widely available in the global engineering market, technology accessibility is not a barrier and some kind of public incentive mechanism, which places priority on energy saving investment, is necessary and could be expected to reduce the investment barrier.

Since steel is so CO_2 intensive, the CO_2 emission per value added in steel is far larger than other industries or economic activities. Therefore, CO_2 reductions achieved by energy saving investments in the steel process should be much larger than the additional CO_2 emissions resulting from extra profits generated by energy savings.

In conclusion, it should be borne in mind that the global base diffusion of best available energy saving technologies in steel is an effective measure only in the short and mid-term (10-20 years). Once 100% penetration ratio has been achieved, there will be no more opportunity for energy savings/CO_2 emission savings from those existing technologies. So, the energy efficiency route is a pathway to and complementary to more fundamental decarbonisation.

2) The primacy of accelerated decarbonisation of energy supply

There have been nearly twenty years of efforts to influence emissions *directly* by – paradoxically – *indirect* methods. Principally, these methods are 'top down' regulation of the end uses of energy. They have been highly ambitious, including the attempted and flawed manufacture of a market for carbon; but they have failed to reduce emissions or, more importantly, accelerate the rate of decarbonisation of economies. In their Byzantine complexity, they have also just crashed politically at Copenhagen. Nevertheless, they have huge bureaucratic momentum because of vast sunk political capital, notably in Europe. So, as they roll on, they are also irritating more increasingly sceptical citizens in democracies, as the costs to families and to individuals from this "Kyoto" type of strategy are gradually but inevitably revealed. We have yet to see how electorates react to large and rising increases in electricity bills when the public understand that they are discretionary, for so-called 'green' reasons, and not because of market conditions.

Aware of this, we therefore propose as an act of policy to accelerate a well understood and successful trend aiming to achieve real reductions in emissions *indirectly* by – not so paradoxically – *direct* methods. This strategy is aimed with intensity and focus on the supply side at the primary production of energy. We are optimistic about its technical promise. We are also much more confident about its political realism. Unlike the previous "Kyoto" strategy, this one goes 'with the grain' of the three overarching goals that we set earlier. The other leading benefits that will arise are all eagerly sought and are widely endorsed. This strategy is also harmonious with economic growth, which is a prerequisite for any sort of political traction in major economies. The trajectory of the Obama administration's attempts to engage the climate issue is an illustration of this basic truth.

In 'How to get climate policy back on course', where it was explained thus, this strategy was called the "Kaya Direct" approach in recognition of the insight of Professor Yoichi Kaya:

> The Kaya Identity shows that there are four – and four only – macro-scale policy levers in pursuit of emissions reductions. These are, respectively, **population, wealth, energy intensity** (meaning units of energy per unit of GDP) and **carbon intensity** (meaning the amount of carbon produced per unit of energy). Each of these factors is amenable to the action of a particular lever and each lever prescribes a particular approach to policy.
>
> In the case of population, the lever is population management. In the case of wealth, the lever is to reduce the size of the economy. In the case of energy intensity, the lever is to increase energy efficiency.

And for carbon intensity, a switch to energy sources that generate fewer emissions is the primary lever.

The relationship between the four factors in the Kaya Identity can be expressed mathematically as follows:

$$\text{carbon emissions} = C = P \times \frac{GDP}{P} \times \frac{TE}{GDP} \times \frac{C}{TE}$$

(where TE is total energy)

Our strategy is to find ways to pull the levers of energy and carbon intensity.

Even without the goal of expanding access to energy to all people, the IEA projects that global energy use will roughly triple between today and 2050. (It is useful to recollect by way of comparison that energy use increased sixteenfold during the twentieth century.) Under such conditions, achieving the large emissions reductions suggested in climate policy discussions can realistically only be achieved through radical improvements in the cost and performance of zero or very low carbon energy supply. Reducing global carbon emissions associated with energy use by 50% from current levels, while tripling energy consumption, entails an 87% reduction in the carbon intensity of the global energy supply. As we shall see, that is an endeavour which, for all practical purposes, requires the same breakthroughs in the cost and performance of zero carbon energy technology as the complete decarbonisation of the global energy supply.

Were global energy use to grow more slowly, the percentage of global energy supply that would need to be decarbonised would be marginally less. But this would not alter the fundamental nature of the challenge of decarbonisation. For instance, in the unlikely event that global energy demand only grew by a factor of two and not three, implying a significant gain in efficiency, global energy supply would need to decarbonise by 75% rather than 87%. So, as in the higher energy demand scenario, such a decline in the carbon intensity of energy requires practically the same energy technology revolution as complete decarbonisation.

But limiting the growth of global energy demand to a factor of two rather than three appears highly unlikely, particularly given that the IEA baseline estimates for global energy demand growth already make very robust, indeed unprecedented, decarbonisation assumptions, largely driven by very high assumed annual rates of global energy intensity decline. In any case, if concentrations of carbon dioxide in the atmosphere are to be stabilised at a low level, then a near complete decarbonisation of energy supply will be needed, and this conclusion is not particularly sensitive to individual assumptions in energy scenarios.

Thus, long-term public policy effort to reduce global carbon emissions must focus inevitably on decarbonising the global energy supply.[65] The principal obstacle to doing this is the high cost of low or non-carbon sources of energy. Fossil fuels are still abundant and have many desirable characteristics. They are energy-dense, transportable, widely available, easy to access, and contain their own storage mechanism. Low-carbon alternatives are almost universally more expensive than fossil fuels. When in competition with other sources (i.e. except in very remote or very poor settings) renewables (wind, solar thermal, solar PV, geothermal, wave, etc.) are more expensive except under the best of circumstances, i.e. when located at optimal sites; close to existing transmission lines; displacing peak generation rather than base load, and serving a constituency willing to pay higher prices.

In several OECD countries, renewables are growing quickly from a low base thanks to generous government subsidies. But these subsidies will become increasingly difficult to maintain politically as renewables increase their market share. For example, if electricity from wind in the USA, which is currently at 2 percent, reached 20 percent, the US subsidy would rise to $20 billion annually (discounting the significant technical challenges that would accompany such an increase of scale).[66] Already we have seen some backlash to subsidies for solar photovoltaics (PVs) in California and Germany. In Britain, a leading deep green environmental activist is currently leading a newspaper campaign against the very generous PV 'feed-in' tariff that has just been introduced, on the grounds that it takes money via increased electricity bills from poor people without large south-facing roofs and deep pockets and gives it to those who have both.[67] The chilling history of European and particularly British wind-power, recently, is a salutary warning of what can happen if politicians and issue advocates ignore the realities of energy economics by using their control of public money to make large structural subsidies and of legal and political processes to grant exceptional zoning permissions. It has led to poorly-chosen wind facilities that have performed much less well than promised, with serious financial and social consequences because they also distort overall portfolio investment decisions in significant ways.[68]

A current obstacle to the expansion of renewables is the difficulty in establishing transmission lines from windy and sunny places to cities and industrial centres, where the power is needed. Perhaps an even greater obstacle is the development of utility-scale storage for intermittent renewable energies such as wind and solar, a development that waits major technological breakthroughs. President Obama's stimulus plan contained only modest investments in new transmission, leading some experts to wonder whether renewables can be brought to scale.[69] The final total budget for new lines is thus a fraction of the President's original goal.

The politics of this failure stand in stark contrast to the politics that were in play when the interstate highways were built in the US in the 1950s. There was widespread local support for them, since local communities wanted the development benefits associated with a major interstate passing by. There is no such local economic benefit to transmission lines: the power generated benefits the producers and their distant consumers, not the consumers or local governments underneath the transmission lines. Similar stories of local community hostility apply to government-driven attempts in Britain to expand on-shore wind farms. People just would not put up with it for aesthetic reasons, or noise pollution reasons and are decreasingly persuaded that their sacrifice of landscape or of silence would be for any useful purpose, given the evidence of an inherently low ratio of actual availability to installed capacity of wind-power, which is only rentable under regimes either of permanently very much higher energy costs or of permanent taxpayers' subsidy, as earlier mentioned.

Nuclear power may be experiencing a revival. In the US, President Obama announced new loans for the industry, and nuclear is viewed as a key low-carbon power source in Britain, Japan and China. However, new plants continue to be far more expensive to build than coal and other fossil fuel plants, due to the safety, waste, and proliferation concerns, both real and imagined. [70]

So things are tough for the low carbon primary energy technologies already in view.

Hence, we assume that for as long as the technology and price gap between fossil fuels and low-carbon energy remains so wide, those parts of the world experiencing rapid economic growth will deepen their reliance on fossil fuels. China is currently increasing its deployment of renewables and nuclear plants, but it is understandably doing so for more than CO_2 abatement reasons, including increasing its energy security, reducing its air pollution, and expanding its market leader status. But China is not deploying renewables at a rate fast enough to slow substantially its expansion of coal power generation, much less to replace coal generation. Like India, China has made it perfectly clear that it will accept no externally imposed constraints on its rate of economic growth, and most of this growth continues to be driven by expansion of use of fossil fuels. The situation is the same in much of the developing world.

Therefore, the bottom line is that there will be little progress in accelerating the decarbonisation of the global economy until low carbon energy supply becomes reliably cheaper and provides reliability of supply. This will require significant, step-change improvement to currently available low carbon technologies. In short, we need to ignite effort to achieve an energy technology revolution[71] in all the currently active areas: for solar panels to convert sunlight into electricity much more efficiently; for biofuels to be grown cheaply without intensive fossil fuel inputs and without an opportunity/cost for food production, and for batteries to be less energy intensive to manufacture and to store much more energy in smaller amounts of space. Given the low energy density of any individual wind turbine, which is just a fact of physics, there is little to be done there except to compensate by deploying great numbers in empty or wild places where the wind blows in the right speed ranges, constantly (in Mongolia or the Sierra Nevada, for example) and where the transmission problem mentioned above is not present. Such places are not that common. For nuclear plants to become much cheaper they will probably need to be smaller, mass manufactured, proliferation-proof and need to store, recycle or otherwise find a satisfactory solution to their own waste.

Thus, improving the efficiency of solar panels, improving the energy density of electric batteries and fuel cells, development of Third Generation (cellulosic) bio-fuels, and solving the design and materials challenges associated with mass manufacture of small, self contained nuclear plants are clear technical challenges upon which clean energy research, development, and deployment efforts must focus. These improvements must achieve cost and performance improvements that will not come about in the absence of determined participation of governments.

Such efforts must be led by the public sector for several reasons. First, private funding of R&D is unusually low in the energy sector, worldwide, because there are few incentives to innovate. In the US, pharmaceutical firms invest 20 percent, information technology 15 percent, and semiconductors 16 percent, whereas energy firms invest 0.23%.[72] The reasons for the low investment in energy are obvious: energy is cheap, and an electron or (British Thermal Unit) BTU obtained from one source is as good as one obtained from another. In contrast, US public sector health R&D investment is today at $30 billion per year, and private sector investment is at nearly twice that level, because an aging population demands new treatments for many incurable, acute and chronic conditions.[73]

Secondly, the high capital costs associated with energy technologies – as compared to say, software development – create enormous obstacles to private sector investment in new, costly, and unproven energy technologies.

Barriers to private sector development of new energy technologies – high capital costs, low end-use product differentiation, limited first mover advantage, low cost of existing energy sources, widely deployed and optimised incumbent technologies – are likely too high to be overcome. Indeed, virtually every existing low carbon technology was developed by the public sector, not the private sector. [74]

France and Sweden have decarbonised more than any other nation through public deployment of nuclear power and hydro, respectively. By contrast, Europe's Emissions Trading Scheme (ETS) and other price and market based policies have failed to drive substantial development or deployment of clean energy technologies, despite creating a much-touted but very volatile 'price on carbon'. (It has crashed already three times in the short history of the ETS.)[75]

The cases of France and Sweden teach two other important lessons. The general lesson is that governments must not only *push* innovation through R&D, standards setting or demonstration; they must also *pull* new energy technologies into the market through their role as large, early-adopting purchasing customers. Indeed, the role of government as a customer for emerging technologies has been a key catalyst – arguably *the* key catalyst – for technological innovation across most of the important areas of new technology since World War II, from aircraft and jet engines to telecommunication systems and information technologies.[76] This argument applies even more so to energy technologies, for the reasons we have enumerated. The particular lesson is classic "Capability" Brown. In each case, there was another strong motivation to act from which the power programme flowed as a contingent benefit. In the French case, famously, the prime mover was a Gaullist feeling after the Suez debacle of 1956 that never again should France's security of energy supply be allowed to be hostage to the English-speaking powers.

There are almost certainly hard political and economic constraints on the expansion of heavily subsidised low emission technologies to any scale that will have any significant impact upon the trajectory of global carbon emissions, particularly in the developing world, where the bulk of those emissions will originate. Driving cost reductions must be the explicit purpose and primary design of deployment policies. Achieving consistent reductions in the *unsubsidised* cost of clean energy technologies must be the measure that determines which technologies will fly and which will stall in the long term.

C: How to pay for it: the case for a low hypothecated (dedicated) carbon tax

Recent accumulating experience suggests that whereas it might seem straightforward to use taxation to modify consumer behaviour by settling a carbon price, energy demand is pretty inelastic and it has not proved possible to create carbon tax regimes that are simultaneously efficient in reducing demand or in stimulating innovation and that are accepted or even well tolerated by democratic electorates.

The direct approach to establishing such a price is flawed for four reasons.

First, economic theory would suggest that an efficient solution requires that the marginal cost of emissions be equal to the marginal damages these would produce. The estimates of appropriate climate damage functions are extremely difficult and controversial and vary from 15$/ton C to 300$/ton C. Valuing the extent and timing of the damages resulting from current emissions involve not only climate model uncertainty, but also subjective pricing of public goods (landscapes, biodiversity etc.). Even assuming that it is possible to agree to an 'efficient' carbon price, say around 40$/ton C, the next obstacles become immediately apparent.[77]

Secondly, the inability to achieve a global, political consensus for operating a carbon market means, as the European experience shows, that there will be significant incentive to leakage from carbon-restricted economies to non-restricted ones; and there will be incentive within the carbon-restricted area to evade or to minimize the regulations.[78]

Thirdly, in the most elaborate experiment of this sort to date, the case of the EU ETS, there has also been the problem that the desire of governments to claim that they are taking decarbonisation seriously is in flat conflict with a stronger desire not to antagonise voters. This has made the offset games played via the Clean Development Mechanism both useful and attractive, politically.[79]

Fourthly, and perhaps most important substantively, is the lack of 'clean' technological alternatives that has just been discussed in the previous section. It is wrong to assume that a price on carbon can induce the generality of firms to undertake the requisite R&D.[80] This is for a simple and powerful reason. Generally, basic research, development and demonstration cannot be easily patented. So the market has no incentive to fund it. The endless business battles in the pharmaceutical industry tend to revolve around the control and release of intellectual property and illustrate this point. As explained above, since much of the energy technology revolution will require just such basic RDD&D investment, public funding on a long-term basis is essential; and that is why an hypothecated tax is so important.

The Japanese steel industry described in the case study is a best practice exception, not the rule by any means. The sectoral approach to provide a level playing field is equally best practice and is not yet a norm. Most firms are simply unlikely to undertake research on the scale needed even if faced with a high carbon price. They would rather translocate to lower labour cost and less regulated places or play the emissions-permit shell game. So, this means that any restrictively high price or 'cap' on emissions would require a slowing of economic growth, or alternatively, the outsourcing of all 'dirty' industries, often referred to as carbon leakage. And both these, especially the latter, have been confirmed in practice.

So, if the innovation activities will of necessity be sponsored initially by the public sector (even if significantly performed by private sector firms under government contract), let us now consider as a means to fund it an 'inefficient' (in strictly theoretical terms) tax: that is to say one that is not equated to the marginal damages of emissions, nor aspires to be so. Here, we propose a low hypothecated carbon tax that is not justified on the basis of trying to alter short-term consumption behaviour as the once popular "Cap & Trade" approach hoped to do.[81] Equally, we would emphasise that the form and purpose of the tax proposed here is quite different from that which the French government proposed in September 2009, that was halted by the Constitutional Court in January 2010 and which President Sarkozy dropped on 23rd March 2010.[82] The French recognised correctly that pan-European taxation was not likely to be adopted easily or soon and that national action was required. But the announced goal was to change behaviour significantly and to use the fact of French executive power to install a tax that could leverage the rest of the EU. The tax would thus become a precedent for EU tax harmonisation also. So, it carried multiple framings and it was strongly polarising: vehemently supported and vehemently opposed by different constituencies.

In contrast, our strategy is more modest and specific. Under it, the political priority of governments would switch from the preoccupation with emissions targets under the previous "Kyoto" regime to credible long-term global commitments and methods to invest in energy innovation.[83] A slowly rising but initially low carbon tax has the advantages of avoiding negative growth effects. We are aware that as a general rule politicians in general and Ministries of Finance in particular hate the principle of hypothecation, because it ties their hands. We see that fact as one of the virtues of hypothecation, because it removes the issue from the political arena in just that way, and by doing so, may help to restore public trust at a time when the stock of politicians is not high in many of the democracies. None of this is hypothetical. In the February 2010 Union Budget, the Indian Minister of Finance, Pranab Mukherjee, established a National Clean Energy Fund to support RD&D and to be funded by a tax of Rs.50/ton on both domestic and imported coal.[84]

Of course, we are also aware that suitable arrangements will then need to be set up to manage the revenue from an hypothecated carbon tax and to direct investment. There are innovative models to be studied. We do not offer the examples as a complete blue-print. For example, we believe that experience shows that national rather than global agents are more likely to be effective in this field. China, India and the USA in particular are cool about multilateral enterprises. That said, the approach of the Global Fund to Fight AIDS, Malaria and TB is particularly relevant because it too was faced with a need to promote "blue skies" research efficiently. The way that it avoided the dilemma of 'winners' was by explicitly refusing to specify preferred research models. Instead it invited applications from people with medical models for new drugs, for new ideas in treatment regimes etc. The Fund spent time and money on high-grade and intensive review processes through its Technical Review Panels, worked with applicants and then invested in the successful projects with successive grants, thereby funding success and discontinuing failure.[85] Other examples are the Global Alliance for Vaccines and Immunization (GAVI), which recently announced the establishment of advanced market commitments to incentivise the pharmaceutical industry to develop vaccines for poor countries, and the Consultative Group on International Agricultural Research (CGIAR), the set of then-innovative regional research centres that provided the scientific and technological foundations of the Green Revolution. The way that the Government of India chooses to manage the product of its new hypothecated coal tax will be of the greatest interest.

The conceptual model of the Global Fund is innovative and we think that it has much to recommend it. So we give the example to illustrate the sort of innovative institutional responses to new challenge that can be found and must be developed. The three examples given show that such challenges can be met.

The proposed hypothecated tax would be used to conceive, develop and demonstrate low-carbon or carbon-free technologies. It would provide a dependable and secure means of financing R&D essential to decarbonisation. The slowly increasing nature of the tax provides a forward price signal that incites firms to take up the lower-carbon technologies and in turn to develop any particular firm-specific adjustments.[86] These two characteristics of the slowly rising hypothecated tax allow for the most rapid path to a low-carbon economy.

The success of an hypothecated tax will depend largely on the ability of policy-makers to recognise past mistakes, adopt a low tax that voters can accept, convincingly hypothecate the tax revenues and equally convincingly support and permit innovative institutions to manage that investment effectively. As already noted above, historical precedent suggests that governments will also have important 'pull through' roles as lead customers – not to be confused with 'picking winners' among technologies beforehand, and distorting markets with subsidies, which has generally not been a success.

Underlying all is the degree to which the "Kaya Direct" model can help restore public trust. The restoration of public trust, as we observed at the beginning of this paper, is the indispensible prerequisite for any productive action at all on the vital, complex and hitherto badly misunderstood and mismanaged subject of climate policy.

Conclusion

The aim of this paper has been to reframe the climate issue around matters of human dignity. Not just because that is noble or nice or necessary – although all of those reasons – but because it is likely to be more effective than the approach of framing around human sinfulness—which has just failed. Securing access to low-cost energy for all, including the very poor, is truly and literally liberating. Building resilience to surprise and to extremes of weather is a practical expression of true global solidarity. Improving the quality of the air that people breathe is an undeniable public good. Such a reorientation requires a radical rethinking and then a reordering of the climate policy agenda. In "Capability Brown" fashion, we have argued that the best ways to make practical and not merely rhetorical progress on decarbonisation of the global economy are by an indirect approach. To attain this goal we recommend an innovation-focused strategy funded by an hypothecated carbon tax, priced as high as is politically acceptable, which will certainly be rather low (bearing in mind most recently the lessons of the March 2010 jettisoning of its proposed carbon tax by the French government). We believe that such a framing offers the greatest potential for securing sustainable and effective action on any – and hence on all – these issues. Detailed description of policy responses to our three overarching objectives goes well beyond what we have discussed, or indeed, what can be discussed in a single paper. Nor was that its intention. We write this paper as a first, not as a last word on the radical reframing that we advocate.

Reframing the climate issue in this manner also means giving up the idea that all manner of other policy goals can be attained by grinding them onto a sparkling, myriad-faceted gem of global carbon policy which then dazzles so mesmerically that it carries all before it. It does not and it did not. Instead, the all-inclusive "Kyoto" type of climate policy as it had become by late 2009, needs to be broken up into separate issues again, each addressed on its merits and each in its own ways. Adaptation, forests, biodiversity, air quality, equity and the many other disparate agendas that have been attached to the climate issue must again stand on their own. We believe that this will, in many cases, make the possibility of political action more likely than has been the circumstance in recent years when carbon policy was asked to pull the whole load of our aspirations for a better future. Of equal importance, it means that progress cannot be held hostage to a single policy framing. If the politics of improving air quality proves intractable for a time, or in a place, then perhaps the politics of adapting to climate impacts will have resonance.

Policies about managing human influences on climate also need to be disentangled, with a recollected awareness of and response to their sheer diversity. A range of policies and methods to execute them will be needed. Some exist today and can be exploited for this purpose; others are still to be developed.

Climate change presents a challenge that will never be 'solved' – but, as we observed throughout, we can do better or worse in our managing of it. We aspire to do better. Therefore, this paper is offered as a guide to how we believe that humanity might more effectively achieve this important work.

[1] D. Victor, 'Global Warming Policy After Copenhagen', *Willard W. Cochrane Lecture in Public Policy,* University of Minnesota, 21 January 2010, mss.

[2] See details of public opinion reaction in fns 33 & 39 below.

[3] The principal e-mails of concern are reproduced and discussed in A.W. Montford, *The Hockey Stick Illusion,* London: Stacey International, 2010, pp. 402–49. This work conveniently relates the topics back to a detailed narrative of the major disputes in climate science, and specifically paleoclimate studies, with which much of the Climatic Research Unit archive is concerned. Hitherto, none of the specific critiques of this work by those auditing it have been adjudicated by reviews of the matter, and indeed were explicitly not investigated by the Oxburgh review (para. 9) http://www.uea.ac.uk/mac/comm/media/press/CRUstatements/Report+of+the+Science+Assessment+Panel.
Allegations concerning handling of FoI requests, subversion of peer-review processes, and general chaotic management of climate data continue to be under investigation by the Muir-Russell Inquiry established by the University and due to report in the spring of 2010. Context and ToR are given in M. Kinver, 'Climategate e-mails inquiry under way', *BBC News*, 11 February 2010, http://news.bbc.co.uk/1/hi/8510498.stm.

[4] The point was explained at length (and thereafter ignored in political practice) in T. O'Riordan *et al.* 'Institutional frameworks for political action', in (eds) S. Rayner & E.L. Malone, *Human Choice and Climate Change,* Vol. 1, Columbus: Battelle Press, 1998, pp. 345–439.

[5] ***Professor Gwyn Prins,*** Mackinder Programme for the Study of Long Wave Events, London School of Economics; ***Dr Malcolm Cook*** Program Director (East Asia), Lowy Institute for International Policy, Sydney; ***Professor Christopher Green,*** Department of Economics, McGill University; ***Professor Mike Hulme,*** School of Environmental Sciences, University of East Anglia; ***Professor Atte Korhola,*** Department of Biological and Environmental Sciences, University of Helsinki; ***Eija-Riitta Korhola,*** Department of Philosophy, University of Helsinki; ***Professor Roger Pielke Jnr,*** Center for Science and Technology Policy Research, University of Colorado; ***Professor Steve Rayner,*** Institute for Science, Technology and Society, University of Oxford; ***Professor (Emeritus) Akihiro Sawa,*** Research Center for Advanced Science and Technology, University of Tokyo, and Senior Executive Fellow at the 21st Century Public Policy Institute; ***Professor Daniel Sarewitz,*** Consortium for Science, Policy and Outcomes, Arizona State University; ***Professor Nico Stehr,*** Karl Mannheim Chair for Cultural Studies, Zeppelin University, ***Professor Hans von Storch,*** Institute of Coastal Research, GKSS Research Centre & Meteorological Institute, University of Hamburg, 'How to get climate policy back on course', LSE Mackinder Programme/Oxford University Institute for Science, Innovation & Society, 6 July 2009.

[6] 'How to get climate policy ...' pp. 5–6, and fn 3 citing J.C. Scott, *Seeing Like a State: How Certain Schemes to Improve the Human Condition Have Failed,* New Haven: Yale University Press, 1998. For a long time this point has been authoritatively argued from different philosophical standpoints and, as resolutely, it has been ignored by makers of policy, *cf* F.A. Hayek, *The Constitution of Liberty,* London: Routledge, 1960, p. 27; I. Berlin, 'The decline of utopian ideals in the West', (1978), *The Crooked Timber of Humanity: Chapters in the History of Ideas,* (ed.) H. Hardy, London: Pimlico, 1990, pp. 46–8.

[7] Hartwell House had a special resonance for our work, for it was not the first time that climate matters had been discussed there in a fundamental way. On 3 April 1850 Mr Lee, the owner, convened a meeting of ten gentlemen in the Library, including the future inaugurating President, Samuel Whitbread, which resolved to found a society that became the British (later Royal) Meteorological Society.

[8] J.E. Hansen, D. Johnson, A. Lacis, S. Lebedeff, P. Lee *et al.*, 'Climate impact of increasing atmospheric carbon dioxide', *Science*, 213 (4511) 1981, pp. 957–66; M. Hulme, *Why we Disagree about Climate Change,* Cambridge: CUP, 2009, passim.

[9] R. Pielke Jr, *The Climate Fix: What Scientists and Politicians Won't Tell You About Global Warming,* New York: Basic Books, forthcoming September 2010.

[10] (eds) M. Verweij & M. Thompson, *Clumsy solutions for a complex world: governance, politics and plural perceptions*, Basingstoke: Palgrave Macmillan, 2006.

[11] *Cf* D. Helm, 'Climate change policy: why has so little been achieved?' and especially his lacerating dissection of the EU ETS, 'EU climate-change policy – a critique' in (eds) D. Helm & C. Hepburn, *The Economics & Politics of Climate Change*, Oxford: OUP, 2009.

[12] "Capability" Brown (1716–83) left no treatises: only landscapes. But the spirit of the dictum was in common currency in writing on landscape and good taste. In *Epistle IV to the Earl of Burlington* (December 1731), Alexander Pope, wrote: "Let not each beauty ev'rywhere be spied/When half the skill is decently to hide./He gains all points, who pleasingly confounds,/ Surprises, varies, and conceals the bounds." But the clearest statement of the rationale that Brown translated into his designs comes from Shenstone: "When a building or other object has been once viewed from its proper point, the foot should never travel to it by the same path, which the eye has travelled over before. Lose the object, and draw nigh, obliquely", W. Shenstone, *Unconnected Thoughts on Gardening*, 1764.

[13] G. Prins & S. Rayner, *The Wrong Trousers*. *Radically rethinking climate policy*, LSE/Oxford, 2007, p. 38.

[14] 'How to get climate policy …', Fig. 1 p. 5.

[15] M. Thompson & S. Rayner 'Cultural discourses', in: S. Rayner & E.L. Malone (eds), *Human Choice and Climate Change: An International Assessment, Vol.. 1*, Battelle, 1998; M. Hulme, *Why we Disagree about Climate Change,* CUP, 2009.

[16] R. Pielke Jr, *The Climate Fix*. It will be evident, therefore, that we feel that the debates about 'peak' oil/gas/other source are not an efficient framing and we do not use them. They are frequently breathless and catastrophising in tone and indebted to the "Limits to Growth" framing from the early 1970s, which encountered problems of credibility when the predicted deadlines for different predicted 'peaks' did not materialise because of human ingenuity and/or unforeseen changes of circumstance. *Cf* J. Eastin, R. Grundmann & A. Prakash, 'The Two Limits Debates: "Limits to Growth" and Climate Change', *Futures* (2010) in press , doi: 10.1016/j.futures.2010.03.001.

[17] http://www.google.org/rec.html;
http://www.cnn.com/2010/TECH/02/12/bill.gates.clean.energy/index.html

[18] *E.g.* A. Agarwal & S. Narain, *Global Warming in an Unequal World*: *A case of environmental colonialism*, Centre for Science and Environment, New Delhi, 1991; L. Rajamani, 'India's Negotiating Position on Climate Change: Legitimate but not Sagacious', Centre for Policy Research, New Delhi, 2007, http://www.cprindia.org/morepolicy.php?s=18.

[19] Compare, http://www.cgdev.org/content/publications/detail/1423191.

[20] For discussions of why and how this can be achieved see: A.P. Grieshop, C.C.O. Reynolds, M. Kandlikar and H. Dowlatabadi, 'A black-carbon mitigation wedge', *Nature Geosciences* 2, 2010, pp. 533–534.

[21] T.C. Bond & H.L. Sun, 'Can Reducing Black Carbon Emissions Counteract Global Warming?', *Environ. Sci. Technol.*, 39, pp. 5921–5926 (2005); C. Reynolds & M. Kandlikar, 'Climate Impacts of Air Quality Policy: Switching to a Natural Gas-Fueled Public Transportation System in New Delhi', *Environ. Sci. Technol.* 42, 2008, pp. 5860–5865.

[22] IPCC, AR4 WGI report, 2007, p. 206 (Fig. 2.22).

[23] See papers by O. Venter, W.F Laurance, T .Iawamura, K.A. Wilson, R.A. Fuller, and H.P. Possingham, 'Harnessing carbon payments to protect biodiversity', *Science* 326, 2009, p. 1368; and U.M. Persson, and C. Azar, 'Preserving the world's tropical forests – a price on carbon may not do', *Environ. Sci. Technol.* 44, 2010, pp. 210–215, for discussion of moving beyond the REDD mechanism.

[24] *E.g.* by Al Gore in *Time* Magazine: 'We have to be careful not to siphon off political will from job one, prevention, and dissipate it with adaptation.' http://205.188.238.109/time/specials/2007/personoftheyear/article/0,28804,1690753_1695417_1695747,00.html, *cf* H. von Storch, 'On adaptation – a secondary concern?', *The European Physical Journal Special Topics*, *176*(1), 2009, pp. 13-20. doi: 10.1140/epjst/e2009-01145-0.

[25] N. Luhmann, *Risk*. *A Sociological Theory*. With A New Introduction by Nico Stehr and Gotthard Bechmann. New Brunswick, New Jersey: Aldine Transaction [1993] 2005.

[26] S. Rayner and E. Malone, 'Ten suggestions for policymakers', Ch. 4 in (eds) S. Rayner & E. Malone, *Human Choice & Climate Change*, Vol. IV, Battelle, 1998, pp. 109–38; M.L. Parry, N. Arnell, M. Hulme, R.J. Nicholls, and M. Livermore, 'Adapting to the inevitable', *Nature* 395, 1998, p. 741; D. Sarewitz and R Pielke Jr, 'Breaking the Global-Warming Gridlock', *The Atlantic Monthly*, 286(1), 2000, pp. 55–64.; R. Pielke Jr, G. Prins, S .Rayner, D. Sarewitz, 'Lifting the taboo on adaptation', *Nature* 445, 2007, pp. 557–8.

[27] Prins & Rayner, *The Wrong Trousers*, pp. 13–21; T. Nordhaus & M. Shellenberger, *Breakthrough: From the death of environmentalism to the politics of possibility*, Orlando: Houghton Mifflin, 2007, Ch. 5, pp. 105–29.

[28] H. Rittel & M. Webber, 'Dilemmas in the General Theory of Planning', *Policy Sciences*, 4, 1973, pp. 154–59, applied to this issue in S. Rayner, 'Wicked Problems: Clumsy Solutions – diagnoses and prescriptions for environmental ills', Jack Beale Memorial Lecture, UNSW 2006, http://www.sbs.ox.ac.uk/centres/insis/Documents/jackbealelecture.pdf.

[29] L.P. Gerlach & S. Rayner, 'Culture and the Common Management of Global Risks', *Practicing Anthropology,* 10/3, 1988, pp. 15–18.

[30] P.M. Haas, 'Introduction: Epistemic Communities and International Policy Coordination', *International Organisation*, 46:1, Winter 1992.

[31] E. Malone & S. Rayner, *Human Choice & Climate Change*, Vol. IV, 'What have we learned?', Battelle, 1998; M. Hulme, *Why we Disagree about Climate Change,* CUP, 2009, pp. 359-364.

[32] Prins & Rayner, *The Wrong Trousers*, pp. 13-14.

[33] P. Kellner, 'Climate change a low priority for most Britains (sic)', 6 Jan. 2010, *YouGov, Founder's Blog,* http://shakespeare.yougov.com/2010/01/06/peter-kellner-climate-change-a-low-priority-for-most-britains/; *Ipsos Mori* poll 'Climate change omnibus, 2010' ,24 February 2010, http://www.ipsos-mori.com/Assets/Docs/Polls/poll-climate-change-omnibus-results-january-2010.pdf; F. Newport, "Americans' Global Warming Concerns Continue to Drop: Multiple indicators show less concern, more feelings that global warming is exaggerated, " *Gallup Annual Update*, 11 March 2010, http://www.gallup.com/poll/126560/Americans-Global-Warming-Concerns-Continue-Drop.aspx

[34] Hulme, *Why we Disagree about Climate Change*, deficit model at pp. 217–19*;* pp. 202–6 and Fig. 6.3 (Frequency of UK broadsheet newspaper articles 1996-2007 citing 'climate change' and 'terrorism' within the same sentence).

[35] R. Pielke Jr, *The Honest Broker: Making sense of science in policy & politics,* Cambridge: CUP, 2007, pp. 40–2.

[36] D. Sarewitz, 'Curing climate backlash', *Nature,* 3 March, 2010.

[37] B. Girod, A. Wiek, H. Mieg & M. Hulme, 'The evolution of the IPCC's emissions scenarios', *Environ. Sci. Policy 12*(2), 2009, pp. 103–118, Elsevier Ltd. doi: 10.1016/j.envsci.2008.12.006.

[38] Contrast two sources. On the one hand, the visually imposing folder 'Science: driving our response to climate change; announcing that it is "... providing a clear and impartial response to those who cling to doubts ..."' (the 'deficit model' choice of language is of interest too), published in late 2009 by the Met Office's Hadley Centre with the imprimatur of three departments of state of HM Government, the seal of State and the logos of many academic institutions. On the other hand, the evident awareness of doubt and puzzlement

about matters that the brochure presents confidently, that can be read in the private exchanges between climate scientists in the CRU e-mail archive that was posted at around the same time.

[39] According to the annual Gallup Social Series Environment poll, conducted March 4-7 2010, the American public has over the last two years become less worried about the threat of global warming, less convinced that its effects are already happening, and more likely to believe that scientists themselves are uncertain about its occurrence. The poll said that 48% of Americans now believe that the seriousness of global warming is generally exaggerated, up from 41% in 2009 and 31% in 1997, when Gallup first asked the question. The survey, based on interviews with 1,014 adults in the United States, also showed that a majority of Americans still agree that global warming is real – although the percentage is dwindling. Thirty-five percent said that the effects of global warming either will never happen (19%) or will not happen in their lifetimes (16%). Meanwhile, 36% of Americans said they believe that scientists are unsure about global warming while 10% said most scientists believe global warming is not occurring. http://www.gallup.com/poll/126560/Americans-Global-Warming-Concerns-Continue-Drop.aspx.

[40] Most famously explained as 'paradigm switching' in T. Kuhn, *The Structure of Scientific Revolutions,* University of Chicago Press, 1968.

[41] The finest exposition of this power is written by J. Vansina, 'The power of systematic doubt in historical enquiry', *History in Africa*, 1, 1974, pp. 139–52; Jocelyn Bell Burnell can be seen explaining the power of systematic doubt in her discovery of pulsars at, http://www.bbc.co.uk/programmes/p0077gdm; J.E Lovelock FRS, *Gaia: A New Look at Life on Earth,* Oxford: OUP, 1979, Ch. 3, 'The recognition of Gaia', Table 2 (Atmospheric composition of Venus, Mar and Earth), p. 39.

[42] 'Spin, science and climate change', p. 13 and 'The clouds of unknowing', pp. 81–84, *The Economist*, 20 March 2010.

[43] Trends in atmospheric CO_2, "Recent Mauna Loa CO_2", NOAA, http://www.esrl.noaa.gov/gmd/ccgg/trends/.

[44] '... according to "business as usual" scenarios, [CO_2] will reach twice the pre-industrial level by 2050 and three times that level later in the century. This much is entirely uncontroversial ... The most recent IPCC studies still quote wide uncertainly in just how sensitive the temperature is to CO_2 level ...', Lord Rees, PRS, 'The Challenge of science', *The Athenaeum Lecture*, September 2008.

[45] 'Has global warming increased the toll of disasters?', The Royal Institution of Great Britain. 5 February 2010, http://www.rigb.org/contentControl?action=displayEvent&id=1000; Pielke, *The Climate Fix, passim.*

[46] Command economies have without exception been vastly less innovative and more energy intensive. The USSR and its satellites and Mao's China were the best documented cases of this.

[47] P. Brimblecombe, 'Fifty years on from the Clean Air Act', School of Environmental Sciences, UEA, 2002, http://www.iapsc.org.uk/presentations/1206_P_Brimblecombe.pdf. Such legislation is often initially socially controversial, as witness the riots which punctuated the judicially-driven introduction of CNG for public service vehicles in New Delhi since 1998, which now has one of the world's largest fleets of CNG buses and tricycle rickshaws, and has seen significant improvement in air quality as a result. *Cf* Reynolds & Kandlikar, 'Climate Impacts of Air Quality Policy: Switching to a Natural Gas-Fueled Public Transportation System in New Delhi', *cit supra.*

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[57] IPCC AR4, 2007.

[58] B. Stone Jr, 'Land use as climate change mitigation', *Environ. Sci. Technol*. 43 (24), 2009, pp. 9052–9056.

[59] World Steel in Figure, 2009, World Steel Association, see worldsteel website: http://www.worldsteel.org/?action=publicationdetail&id=90

[60] Source: 'Measures for Post Kyoto' (Japanese), Japan Iron and Steel Federation, November 2009 , see JISF website: http://www.jisf.or.jp/business/ondanka/kouken/post-kyoto/index.html.

[61] Asia Pacific Partnership for Clean Energy and Environment.

[62] "APP Steel Task Force, Flagship Projects", presentation by Joji Tateishi, 15 Oct., 2007, 2nd Ministerial Meeting (New Delhi) see APP website: http://www.asiapacificpartnership.org/english/second_ministerial_meetpresent.aspx.

[63] APP website: http://www.asiapacificpartnership.org/english/steel_tf_docs.aspx.

[64] 'Energy Technology in 2008', IEA.

[65] The case first made authoritatively in M.I. Hoffert, K. Caldeira, *et al*., 'Energy Implications of Future Stabilization of Atmospheric CO_2 Content', *Nature* 395, 1998, 6705, pp. 881–884; M.I. Hoffert, K. Caldeira, *et al*., 'Advanced Technology Paths to Global Climate Stability: Energy for a Greenhouse Planet', *Science*, 298, 5595, 2002, pp. 981–987.

[66] This is a production subsidy of 2.1 cents per kilowatt hour for 790 billion kwh of wind, which is 20% of 2009 total electricity generation, with the subsidy rising to $20 billion as total generation increases. US Department of Energy, Energy Information Administration, Electric Power Monthly, March 15, 2010, Table 1.1, http://www.eia.doe.gov/cneaf/electricity/epm/table1_1.html .

[67] http://www.guardian.co.uk/environment/cif-green/2010/mar/09/george-monbiot-bet-solar-pv.

[68] These two factors are now generally understood to have been significant in allowing wind turbines to be installed in sites with poor potential. Performance figures show overall poor availability – well below government assumptions. But in exceptional times, the problem can become radically worse. On 4 January 2010, for only the second time, the National Grid issued a Gas Balancing Alert in Britain, to constrain large users and divert gas to power generation. At the coldest point in the coldest winter for 30 years, there was immense demand. But because very cold weather is usually associated with high pressure, the wind does not blow. Between 4–7 January, wind contributed 0.6% to the Grid. Coal was ramped up to 43%. Gas carried most of the demand, with nuclear providing the third segment. www.bmreports.com/bsp/bsp_home.htm. But the current nuclear fleet is retiring soon, with no replacement succession in place and many of these base load coal (and oil) plants are supposed to be phased out by 2015 under the EU climate policy's Large Combustion Plant Directive.

There are no credible plans to substitute their output, either. Reliance on gas will soar. Old and inefficient coal and heavy oil plants will simply have to be kept in commission to help keep the lights on. T. Lodge, *Step off the gas: why overdependence on gas is bad for the UK*, CPS, 2009, Appendix 2 'Planned power station closures by 2015', p. 31 (19.2GW of installed 77GW total national capacity).

[69] Cf M. Wald, 'Hurdles (Not Financial Ones) Await Electric Grid Update', *New York Times,* 6 February, 2009, http://www.nytimes.com/2009/02/07/science/earth/07grid.html.

[70] John M. Deutch *et al*., 'Update of the MIT 2003 Future of Nuclear Power', 2009, http://web.mit.edu/nuclearpower/pdf/nuclearpower-update2009.pdf.

[71] In the felicitous phrase from the title of Charles Weiss and William Bonvillian's book *Structuring an Energy Technology Revolution,* Cambridge, Mass: MIT Press, 2009.

[72] National Science Board. *Science and Engineering Indicators 2010*, Arlington, VA: National Science Foundation (NSB 10-01), Appendix Table 4-14.

[73] *Ibid*, Appendix Table 14-17; see also G.F. Nemet and D.M. Kammen, 'U.S. Energy Research and Development: Declining Investment, Increasing Need, and the Feasibility of Expansion', *Energy Policy* 35: 2007, pp. 746–755.

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[75] 'The European Union Emission Trading Scheme: a status report', Mitsubishi Research Institute, Tokyo, April 2010 and D. Helm (*cit supra* fn 11).

[76] *Cf* V.W. Ruttan*, Is War necessary for Economic Growth?*, OUP, 2006; J. Naughton, *A Brief History of the Future: the Origins of the Internet,* London: Weidenfeld & Nicholson, 2000.

[77] Richard Tol, 'The Economic Effects of Climate Change', *Journal of Economic Perspectives,* Vol. **23** Number 2, 2009, pp. 29–51.

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