Postscript

The Review on the Economics of Climate Change, published on 30th October, has generated substantial interest and debate. We have now had the opportunity to present the Review to a wide range of audiences, including economists, scientists, business leaders and the international community, including the participants in the Nairobi Conference of the Parties to the UNFCCC, and to policy-makers at the European Commission and the African Union.

In this postscript, we offer some reflections in the light of the reactions and comments we have received in the first weeks since publication. In the main text, we have also taken the opportunity to correct any typographical errors found or which have been drawn to our attention. For example, revising the magnitude of hurricane losses in table 5.2. The discussion here follows the structure of the Review. The first issues concern the strength of the evidence base underpinning the recommendation of the Review that all countries should take urgent action to stabilise the concentration of greenhouse gases in the atmosphere at between 450-550ppm CO_2e. The second set of issues concern the policy mechanisms that will support an effective, efficient and equitable approach to this action, and the importance of international co-operation to support adaptation to the adverse impacts of climate change.

The case for urgent action

Two key conclusions from our analyses of the science and economics of climate change provide important underpinning for the case for urgent action.

First, under a business-as-usual scenario, the stock of greenhouse gases could be more than treble pre-industrial (greater than 850ppm CO_2e) by the end of the century. This may be a conservative estimate, for example, some IPCC scenarios suggest that the stock could be more than four times pre-industrial by 2100. Current scientific understanding suggests that a trebling of the stock would give at least a 50% risk of temperatures exceeding 5°C above pre-industrial levels during the following decades (Chapter 1).

In Part II of the report we brought together what can be said about impacts at high temperatures, based on the current state of the underlying science. This analysis has brought us to our second broad conclusion that the impacts of climate change across multiple dimensions are likely to be highly convex, with marginal damages that increase strongly as temperatures rise. Most impacts analyses focus on levels of warming of around 2 – 3°C above pre-industrial. Little is known about how the environment and human society will respond to larger increases in temperature. A warming of 5°C on a global scale would be well outside the experience of human civilisation, and would transform where we live and how we live our lives.

The analyses presented in Chapters 3 - 5 of the report demonstrate the great dangers of allowing temperatures to continue to rise, in terms of the environment, human health, and economic growth and development. Chapter 3 demonstrates that many of the impacts of climate change increase strongly in severity as temperatures rise. For example, the damage caused by hurricanes; the frequency of extreme events; and above a threshold, effects on agricultural production and heat-related mortality. Further, impacts can interact, bringing about rapid increases in damages at high temperatures: rising levels of pests in some areas may aggravate declines in agricultural production caused by heat or changes in water availability. In addition, current understanding suggests that at high levels of warming, the risks of major, irreversible changes to the climate, ecosystems and society are very real indeed. These include physical changes, such as a collapse of ocean currents, and also the risk of major societal changes, such as mass migrations and political instability. Putting all these impacts together builds a strong picture of impacts rapidly rising with temperatures, with increasing damages for each marginal increase in temperature. High temperatures are likely to generate a hostile and extreme environment for human activity in many parts of the world.

It is the scale of these risks and an appreciation of the types and severity of damages involved that provide the *main case* for urgent and strong action to stabilize emissions below 550 ppm CO_2e, when one considers that the risks can be very substantially reduced by an expenditure of around 1% of GDP per year. Further, the costs of action to stabilize at any given level would rise rapidly if action were delayed.

In Chapter 6, as a complement to the disaggregated analysis, we investigated the role of formal economic modelling in providing an aggregate monetary estimate of the damages of climate change. We were explicit and clear about the severe limitations of such modelling, but we saw it as a perspective, which could provide some support, by adding structure, to an analysis of the case for action based on the disaggregated impacts.

As we made clear, the role of integrated assessment models is to give an illustration of the potential effects of climate change. Modelling of the economic impacts of climate change over very long time horizons cannot give precise results. The value of the approach is that it allows the investigation of the role of different specifications of model structure and ethical assumptions. The ethical judgements that have to be examined include those concerning how society should weight impacts on different generations. The impacts have been expressed in this Review using a technique that allows averaging over time, over risk and over country in a way that permits direct comparison with the costs of mitigation.

Two main modelling issues have been raised with us in discussions since the Review was published: first, concerns that the model we used may under-estimate the level of damages likely to be caused at different temperatures, particularly high temperatures, and second, concerns about the assumptions used in valuing or discounting the damages. The former is captured in the parameters of the function relating damages to temperature and the latter in the shape of the relationship of social utility to consumption and the pure time discount rate (see Chapter 2, its appendix and Chapter 6).

We have subsequently carried out sensitivity analysis on these issues, presented in a technical annex to this postscript. The sensitivity analysis allows us to explore the effect of different assumptions, but it does not change our overall conclusion, that climate change is likely to cause damages which are very severe and of much greater consequence than the costs of greatly reducing risks by strong reduction in emissions. In the report we calculated damages from business-as-usual which were equivalent to at least a 5% loss in consumption, based on a narrow definition of risks and impacts, and up to 20% if a broader range of risks and impacts are considered. The sensitivity analysis marginally reduces the lower end and increases the upper end. The only exception is where we use high pure time discounting rates, which are in our view implausible relative to most positions on ethical values and take a very narrow view of impacts (i.e. excluding environment and health). In other words, unless the interests of future generations are heavily disregarded there is a very powerful case for strong mitigation.

Our estimates of damage from business-as-usual are higher than some previously published for the following sound reasons:

- We treat aversion to risk explicitly – this issue is all about risk and we invoke the economics of risk directly.

- We use the more recent literature, from the science, on the probabilities. This points to significant risks of temperature increases above 5°C under business-for-usual by the early part of the next century. Previous studies have focused on temperature increases of 2 or 3°C. The damages from 5°C would be very much higher – damages rise much faster than temperature.

- We adopt lower pure time discount rates than some earlier literature and thus, it was argued in Chapter 2 and its Appendix, the analysis gives future generations appropriate ethical weight. The effects of changing this assumption were set out clearly in Chapter 2 and its appendix, Chapter 6 and are explored in more detail in the Technical Annex to this postscript.

- We take account of the disproportionate impacts on poor regions, reflecting the fact that those in poverty will feel losses in consumption more keenly.

Few existing studies include all these factors, and as a result their estimates of the damages tend to be lower. One can compare these losses with the size of the losses from a recession, but climate impacts are actually more like an adverse supply-side shock than a large contraction in demand. And they are much more difficult to reverse. Our estimate in terms of per annum consumption losses (averaged over time, possible outcomes and across countries) of the costs of climate change can be interpreted as like a tax being levied each year, with the proceeds of the tax simply being poured down the drain. You could also think of it like an insurance premium – society would be willing to pay up to this amount to avoid the risks of climate change – in fact the actual cost of action to avoid climate change is much less, as Chapters 9 and 10 of the Review show, and as we will discuss again briefly below.

Our analysis leads us to the conclusion that the risks can be substantially reduced, but by no means eliminated, if concentrations of greenhouse gas emissions can be stabilised at 550ppm CO_2e or below. The upper limit, 550ppm CO_2e, is still a risky place to be. The analysis presented in the Review, based on an average of several models, suggests a 50:50 chance of a temperature increase above or below 3°C, and the Hadley Centre model predicts a 10% chance of exceeding 5°C even at this level (Chapter 8). Whilst the modelling of chapter 6 and part II of the Review in general, brought together in Chapter 13, suggests that the damage from a 550ppm CO_2e stabilisation level is far smaller than business as usual, many people have suggested that this limit is too high. There is a strong case to examine whether it is possible to reduce these risks still further by reaching lower levels of stabilisation, and to keep this continually under review as policy-makers gain experience in managing the transition to a low-carbon economy.

The Review finds that the costs of bringing down the risks by stabilising at 500-550ppm CO_2e are equivalent to around 1% of GDP by the middle of the century, with a range of +/-3%. This range assumes that sensible policies are put in place and deliver the induced technological progress required. Some people have questioned whether the central estimate of 1% is too low, and others have suggested that while the overall level may be acceptable, the distribution of the costs may give rise to an unacceptable burden on some countries or sectors.

In response to the suggestion that the estimate of 1% is too low, it is worth noting a number of points. The figure of 1% is a central estimate within a range that is consistent with the literature, and that is therefore likely to be consistent with the review of the same literature currently being finalised by the Intergovernmental Panel on Climate Change for its Fourth Assessment Report. Achieving stabilisation at the lower end of the range of costs depends upon good policy frameworks, to bring forward appropriate low-carbon technologies and to provide flexibility in when, where and how emissions are reduced. The cost of 1% of GDP each year is certainly not trivial – in 2050 it would be equivalent to a cost of $1 trillion at market exchange rates (GDP in 2050 is expected to be $100 trillion). But this is manageable without slower growth. An overall cost of around 1% of GDP to achieve stabilisation below 550 ppm CO_2e, as suggested here, would have an impact similar to a one-off 1% rise in price or cost indices. However, if investments in the next two or three decades were made in high-carbon infrastructure, it could cost far more than 1% subsequently to reduce the resulting emissions to levels consistent with stabilisation below 550ppm CO_2e.

As we made clear in Chapters 11 and 12, the costs of mitigation will not be evenly distributed across industry sectors. Carbon-intensive sectors will face higher costs, and it is right to consider

the impacts of these costs on their competitiveness. Similarly, the costs of unabated climate change will fall more heavily on sectors that depend upon environmental resources, such as agriculture and tourism.

If all countries act in a broadly similar way, the impacts on competitiveness from action to mitigate climate change will be small for all of them. Where different policies are in place in different countries for mitigation, it is important to assess the increased carbon costs in the context of overall conditions for doing business in a particular country or region. For many industries, the impact of any higher energy costs associated with mitigation is very small in relation to the cost differentials of different wage rates between rich and poor countries or to transport costs over long distances. For a small number of internationally traded, carbon-intensive sectors, including aluminium and cement, it may make sense to develop specific sectoral arrangements that provide an international framework to support the efforts of those industries to upgrade their equipment and processes and reduce or offset their emissions. And it is important to recognise that the new technologies and investments will open up new economic opportunities.

While action is delayed, greenhouse gases in the atmosphere continue to accumulate, committing the world to greater impacts in the future or to the higher costs of bringing down flows of emissions more sharply to attain any stabilisation level. This cost of delay is a key element in the argument for urgent action.

Overall, we have heard three main arguments from those who do not support the conclusion that urgent action to reduce the risks of climate change, economically speaking, is a good deal. We suggest that all three are misplaced.

1) Some still deny the science of climate change.

There are legitimate debates over many particular details of the climate system, but it is no longer credible to doubt the underlying physical mechanisms associated with increases in greenhouse gases in the atmosphere, nor to doubt the importance of the natural carbon cycle and the potential for amplifying feedbacks that would be outside our control.

2) Some people accept the basic science, but still believe it is preferable to wait and see before taking significant action on mitigation. Some suggest a new technology will come along that will greatly reduce the costs of action, or that the changes will be such that future generations, with a higher capital stock available to them, will be able to adapt.

It is certainly true that for most countries, major transformational damages affecting the whole economy are not likely to be seen for several decades, or even a century or more - but if we wait until they appear and they are as difficult as we have reason to expect then we cannot go into reverse. Stocks of greenhouse gases are extremely difficult to reduce.

The range of human activity that gives rise to emissions is so broad, that there will be no single technology breakthrough that will bring about stabilisation. Further, technology development is not independent of the policy framework that is in place. The range of technologies required can only be brought forward by an appropriate policy framework.

Adaptation is necessary, but it is not the whole answer. The longer stocks of greenhouse gases are allowed to accumulate in the atmosphere, the greater the impacts to which we are committing the world. There are limits to adaptation at higher temperatures. Many of the effects could involve major dislocation, to whole nations and regions, with consequences that would be felt around the world. The only way to prevent very high future damages is to reduce greenhouse gas emissions today.

We should recognise the balance of risks. If the science is wrong and we invest 1% of GDP in reducing emissions for a few decades, then the main outcome is that we will have more

technologies with real value for energy security, other types of risk and other types of pollution. However, if we do not invest the 1% and the science is right, then it is likely to be impossible to undo the severe damages that will follow. The argument that we should focus investment on other things, such as human capital, to increase growth and make the world more resilient to climate change is not convincing because of these irreversibilities and the scale and nature of the impacts. Similarly if we wait and see for 30 or 40 years then we are likely to go past the 550ppm (CO_2e) that we argued would be a plausible upper limit. We might try to move rapidly from there but one cannot stop emissions in their tracks without great cost and disruption, if indeed it is feasible.

> 3) Some people prefer to place very low value on the future, or to put it another way, to place a very high value on near-term opportunities for consumption. It is a key feature of the challenge of climate change that we must think long-term to understand the issues and to respond to them. It will always be possible to choose a pure time discount rate that makes the benefit of reducing future damages appear trivial.

In the Review, we do discount future damages for the likelihood that future generations will be richer than we are. But we apply only a low discounting to the future simply because it is the future (we account for the possibility of extinction). Choosing a high rate of pure time preference to analyse a long-term issue that affects the global environment is to make a profound ethical choice with, in this case, irreversible effects on future generations. It is as though a grandparent is saying to their grandchild, because you will live your life 50 years after mine, I place far less value on your well-being than I do on myself and my current neighbours, and therefore I am ready to take decisions with severe and irreversible implications for you. Nevertheless ethical choices appear different to different people and that is why in the technical appendix to this postscript we investigate different possible ethical positions concerning inequality and pure time discounting. The conclusion that strong mitigation is warranted is robust except where high pure time discounting is embraced.

An alternative view, associated with Bjorn Lomborg, that it is agreed, places dealing with climate change low on the agenda, arises from comparing it with “other ways” of spending public money and suggests that they have higher social rates of return. There are important deficiencies in this approach. First, correcting an externality is a different policy question from spending public money. Second, the argument as conveniently put takes little account of the severe risks of very high temperature increases from climate change which we now know are possible, or indeed likely, under business as usual, and which cannot be reversed if they start to appear. Third, the costs of action for any given stabilisation level rise rapidly if action is delayed. Thus, this type of argument for low priority or for delay is completely unconvincing.

Responding to the challenge

We have also received comments and reactions to the policy issues discussed in the second half of the Review – the policy instruments to promote mitigation, approaches to adaptation, and the international framework.

Many people have welcomed the breadth of discussion on policy instruments, including the emphasis on the importance of all three strands of policy intervention - correcting the market failure on greenhouse gases, technology policy, and complementary measures to remove other barriers and to change perspectives on responsible behaviour. There has also been strong interest in the potential of each of tax, trading and regulation to play a role in the creation of a carbon price. We have been asked several times about the relative importance of each of these three approaches.

The answer to these questions must be guided by the principles of effectiveness (in terms of delivering greenhouse gas emission reductions), efficiency and equity. For different countries

and different sectors, different approaches are likely to prove appropriate and effective. Many European countries have high fuel taxes, whereas in the USA regulation of vehicle efficiency standards has historically been more important. In the EU, emissions trading has from the outset taken the form of a mandatory cap and trade scheme, while in Japan and for some businesses in the USA, voluntary approaches are proving helpful in building up experience of using this instrument. For some areas, for example household appliances, labelling and standards are likely to bring about the fastest changes. Efficiency does not require that all these approaches be merged into one single scheme, but it does require that across countries and policies, a broadly similar price of carbon emerges. Otherwise, some sectors will be carrying a greater burden of emissions reductions when there are more cost-effective opportunities elsewhere. Equity does not mean that poorer countries should take no action to reflect the price of carbon in their own economies – otherwise producers and consumers in those countries will not see the signals that are required to support a transition to a low-carbon economy – but it does mean that these countries should be supported by rich countries in the process of managing the adjustments.

Emissions trading is particularly well suited to addressing both efficiency and equity across borders. If the rich countries set ambitious targets, consistent with the overall objective of achieving stabilisation between 450-550ppm CO_2e, emissions trading will allow the private sector in those countries to seek out the most cost-effective opportunities to reduce emissions. Some of these opportunities will be at home – provided the signal is strong, credible and long-term, the carbon price will discourage further investment in high-carbon capital stock in rich countries. But many of the opportunities in the short term will be in developing countries, and trading can create substantial flows of carbon finance that will allow developing countries to avoid locking in new high-carbon infrastructure during the next few years, when substantial growth and investment is likely to take place. These flows must be supported by effective mechanisms, linked to national or sectoral policies and programmes to move away from carbon-intensive investment strategies. Such large-scale flows from the rich countries combined with strategic national or sectoral approaches in developing countries have the potential to transform the carbon intensity of the global economy, without capping national aspirations for growth and development in poor and rich countries. A project-by-project approach to such flows is very unlikely to be able to deliver the results required, either in terms of the effectiveness of emissions reductions or the potential scale of flows from rich to poor countries. Programme or policy-orientated schemes will be necessary to manage flows on a much larger scale.

Large-scale international flows of carbon finance will go a long way to addressing the issues of equity. However, the least developed countries have the fewest opportunities to benefit from private sector investment in emissions reductions. For some people, this suggests that a more equitable international framework would be based on equal per capita rights to emit. This view has some attractions but there are some practical and conceptual problems, which were discussed in Chapter 22. An alternative approach is to consider the challenges for the poorest countries directly. International co-operation can support access to clean, low-carbon energy for poor people, as demonstrated by the initiative of the World Bank and others in creating Clean Energy Investment Frameworks with a specific focus on energy access. The initiative on removing barriers to the use of the CDM in developing countries, launched at the Nairobi Conference of the Parties to the UNFCCC, also has the potential to increase the use of carbon finance in poorer countries. The underlying investment conditions for foreign and domestic private capital are fundamental to the success of such initiatives.

It is of great importance to move quickly on those actions and policies that can be rapidly agreed and implemented and to build the knowledge and trust that could arise from the experience. Fundamental to all of effectiveness, efficiency and equity and particularly to equity is strong ambition from the rich countries in terms of caps implemented and thus level of carbon price and potential financing flows to developing countries. From all three perspectives, implementing caps embodying ambitious reductions should be of high priority in rich countries. And it is crucial that trading schemes such as the EU ETS be long-term, to provide effective private sector signals,

and open, so that as many countries as possible can be included, both from the perspective of efficiency and the building of international collaboration.

Equity also clearly points to support for adaptation to the adverse impacts of climate change. It remains very clear that adaptation to climate change is now both inevitable and very important. For developing countries, good adaptation and good development policy are very strongly intertwined, and it is right that climate change should now become central to national planning processes and to development assistance. International support for adaptation will come in large part through the delivery of the commitments made by rich countries to double aid by 2010 and the commitments made by many countries to meet the target of 0.7% of GNI by 2015. This will deliver an increase of hundreds of billions of dollars.

But there are limits to adaptation. Small island developing states threatened by sea level rise have fewer options to adapt. Sea defences are particularly costly for low-lying islands, and may do little to protect the tourism and fisheries that sustain the local economy. Development and diversification are still important strategies wherever possible, but ultimately the international community will have to find ways to support alternative responses, including the managed resettlement of some people in these states. This will bring many challenges, particularly for those people that must move. There will be much greater pressures if unabated climate change leads to sea level rise that threatens much larger populations in low-lying coastal areas.

Finally, some people have asked if it is really possible to create structures that will sustain co-operation and overcome the incentives for free-riding. Here, it is important to understand that public pressure for an effective response is growing in many countries, as people begin to realise the scale of the risks they and their successors face if no action is taken and as they see the wide range of initiatives by local governments, businesses and community groups that demonstrate that it is possible to do something about the problem. It is now more important than ever to build trust, through transparency and mutual understanding about the actions that different countries are taking, and to look for international mechanisms that build on and support national objectives, including by reducing costs and increasing the prospects for success.

Conclusions

Climate change presents a very serious challenge. The most severe damage will be felt in the future, often the far future, but decisions that we take now could lock in those damages.

The broad conclusion of our analysis is that urgent action should be taken to reduce the risk of committing the world to the real possibility of very high temperature increases. The next few years will be critical. Action is required now, if we are to stabilise somewhere in the range from 450-550ppm CO_2e. Success will depend on continuity in the process of building carbon markets, and imagination and ambition in scaling up co-operation in areas such as technology and reducing deforestation.

The Review is intended as a contribution to the discussion. We welcome the debate that has been stimulated, and hope that further work will take place on all the issues raised by the Review, including those explored further in this postscript and its technical appendix on aggregate modelling.