



Energy and Climate Change

Oral evidence: [IPCC 5th Assessment Review](#), HC 907 Tuesday 11 February 2014

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Written evidence from witnesses:

- [Royal Society](#)
- [Royal Meteorological Society](#)
- [James Painter](#)

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Members present: Mr Tim Yeo (Chair); Dan Byles; Ian Lavery; Mr Peter Lilley; Albert Owen; Christopher Pincher; Sir Robert Smith; Graham Stringer

Questions 113 - 193

Witnesses: **Sir Peter Williams**, Royal Society, and **Dr Emily Shuckburgh**, Royal Meteorological Society, **James Painter**, Reuters Institute, Oxford University, **Guy Newey**, Policy Exchange, and **Jonathan Grant**, PricewaterhouseCoopers, gave evidence.

Examination of Witnesses

Witnesses: **Sir Peter Williams**, Royal Society, and **Dr Emily Shuckburgh**, Royal Meteorological Society, gave evidence.

Q113 Chair: Good morning and welcome. Thank you very much for coming in. You are probably aware that there is quite a lot of interest in this particular inquiry that we are engaged in. Indeed, since we last met on this subject, Working Group 1 has released the full 50,000 reviewer comments for the Fifth Assessment Report. Would you like to say whether you think these documents demonstrate that the reviewers' comments were indeed adequately addressed by the authors of the report?

Dr Shuckburgh: Perhaps I should explain who I am representing. I am here on behalf of the Royal Meteorological Society. We are the professional and learned society for weather

and climate and we serve not just the interests of academia but also professional meteorologists, and indeed anybody who has a general interest in the weather.

Chair: Quite an interesting subject right now, I guess.

Dr Shuckburgh: A particularly interesting subject right now for very large numbers of the general public. We have about 3,000 members. I am one of the members of the governing council of the society and it is in that capacity that I am speaking. The first thing to say is that the IPCC as a whole is a monumental effort and gathers together the voluntary efforts of many scientists worldwide and, as a society, we commend the efforts of all those volunteers. You asked specifically about the reviewers' comments that have now been released and there are three things that are important to say about that.

The first is that it is to be commended that this process has become very transparent now that all these comments have been published. The second thing is to note that it is a very open process. Anybody was able to submit reviews to that process and the way that has now been documented, as was demonstrated in the released documents, is that every single one of those reviewer comments has been looked at, taken account of and then a review editor has come in and overseen that each one of those different comments has been addressed. In that sense, it is a very thorough review process. The third point to make is that, of course, the IPCC Working Group 1 primarily draws on the published literature that itself has been peer-reviewed, so what we are talking about is a peer review of a peer review. As a society, we feel that that is a very robust mechanism.

Q114 Chair: Where comments are rejected, should there be an explanation of why they have been rejected?

Dr Shuckburgh: I had a scan through the comments the other day. I certainly did not read through every single one of the 50,000, but every single one has been acknowledged and responded to. The ones that I read seemed to be perfectly acceptable in terms of the explanations given.

Sir Peter Williams: Chairman, I had a glance as well. I am labelled in your programme as the Royal Society and I was indeed the treasurer of the Royal Society until December of the year before last. However, I am not a climate scientist and you are probably wondering, therefore, what I am doing here. When the IAC were invited by the UN and the IPCC to review the IPCC in 2010, I was nominated by the Royal Society to join the IAC team precisely because I was not a climate scientist. My background is primarily in the world of business and industry. As issues regarding the processes and procedures under which the IPCC operates were to be reviewed, not the fundamental science, it was felt that it might be useful to the committee to have a breadth of experience and background. That is why I was there. I am one of the dozen people you can blame or compliment for the IAC report.

What you picked up on is one of the most important issues that we identified, which was in the light of the famous AR4 error on the Himalayan glaciers that we analysed in depth in the report—I don't know if you have had a chance to read it—how that could be avoided in the future. We made a variety of recommendations on treatments of uncertainty, likelihood, probabilities and so forth in here, but we also requested greater

transparency and greater power for the review editors in the face of the understandable and inevitable political pressures that the IPCC operates under.

By the way, just as an aside, I experienced that first hand. I was one of the quartet who presented this to the UN and I was the sole member of the group that went and presented it to the IPCC plenary in Busan in October 2010. I have seen 194 government delegations in operation, so political pressures are undeniably there. Therefore, it is transparency and empowering review editors and encouraging them to use that power. We were looking for evidence in AR5 that those recommendations had been adhered to not just in letter but in spirit as well.

Like Emily, I flicked through. I would not purport to say to you that I have read all 50,000 or however many review editor comments there were. Some of them, which I just cherry-picked at random, indicated that what we wished to happen was indeed happening, that review editors were doing their job and, moreover, the evidence in AR5 is that they are doing a transparent job.

Q115 Chair: Were there any important recommendations from the IAC that the IPCC did not implement?

Sir Peter Williams: Yes. You might imagine that, with my background, I was both fascinated by and in some respects concerned by the governance and management issues. I endorse everything Emily said at the outset. The IPCC has done a wonderful job for humanity in bringing the science to governments and the population the world over. However, the way it is operated, as a bottom-up operation with an overlay at the end of the process of this famous IPCC panel plenary, means that the piece in the middle of the jigsaw puzzle, the management that brings it all together and enables the Working Group 1 report, for example, to be published, is very thin on the ground in governance and management terms. We made a number of recommendations about tenure of the chairman, about the secretariat in Geneva, which I personally visited with another colleague, and so forth.

The one recommendation that has been implemented is the way in which the 194 governments operate through the bureau of 30-odd strong, which meets very infrequently. It was crying out for some form of sub-committee in a PLC sense to look after the shop between meetings. The so-called e-team, the executive team, that had been tried previously and did not meet and was not effective, has given way to a properly-appointed executive team that does meet. However, that is only part of the governance and management recommendations that have been made. I would personally like to have adherence to the letter of what is recommended here for the sake of the IPCC and everybody else.

Q116 Chair: Are there any other improvements the IPCC should make to try to deflect the criticisms that have been occasionally levelled at it?

Sir Peter Williams: There will always be criticisms. This is a subject with great implications for humanity. Inevitably there will be a spectrum of views. I think in adhering to greater transparency and openness and having a more secure governance and

management structure, for example, in the executive committee, the one element that has not been brought about is the appointment of three independent non-climate scientists to sit alongside the IPCC professionals. That, in a typical PLC-type context, would also improve transparency, openness and good governance.

Q117 Chair: The whole process is, necessarily, quite slow. Is there a danger that conclusions might be out of date by the time they are published?

Dr Shuckburgh: Here I speak in a personal capacity rather than on behalf of the Royal Meteorological Society, because no doubt there is a spectrum of views within the society. From a personal perspective, I think it is the case that IPCC reports have become very onerous. They have become very large in their extent and, as you say, there is a gap between each report. The amount of effort that it requires from the scientific community to put together those reports each time is very significant, and that poses a challenge. I imagine it is also a challenge, from the perspective of anybody interested in the conclusions of the reports, to wade through these enormous reports.

Purely from a personal perspective, but I suspect it is the viewpoint shared by a number of other scientists, I think it may be the case that modifications to the process would create an improvement. In particular, I think there may be an opportunity to put more emphasis on the scoping stage. These documents are supposed to be a policy-relevant assessment of the state of the science rather than being a literature review, which could cover all sorts of other topics. If there was a more careful and narrow scope to the report and more effort was put in—in terms of having a strong dialogue at the outset between those people from a policy side who are interested in the outcomes of the results and the scientists—to work together to identify where there is both a strong interest and a science base that can be brought to bear on that strong interest, then I think we might be able to have more focused reports. These would be less challenging for the science community to provide input to and less challenging than having to wade through however many thousands of pages were you to read the full report.

Sir Peter Williams: I think this is an appropriate moment to make this comment given the possibility of an AR6, for example. It is for you and your fellow member Governments, at this early stage in any potential AR6 process, to ask those questions and to seek to go down the pathway that Emily has just advocated.

Chair: All right. Interesting.

Q118 Mr Lilley: Since 1997, one-third of all the carbon dioxide emitted by mankind has been emitted and during that period there has been no statistically significant rise in the surface temperature of the earth. Does that increase, decrease or leave unchanged your confidence that the scale of warming will be as high as previously thought?

Dr Shuckburgh: The first thing that is important to note is there is a strong—

Mr Lilley: First of all answer the question: increase, decrease or unchanged?

Dr Shuckburgh: Mr Lilley, I am going to answer your question. Do not worry.

Mr Lilley: It is quite unusual for people to answer questions. They normally go into a great dialogue.

Dr Shuckburgh: Do not worry, I will answer it. The first thing that is important to recognise is that surface temperature is but one measure of the increase in heat in the entire climate system and it is not a perfect measure. For example, you could increase the temperature of the earth and not change the temperature elsewhere or you could increase the temperature elsewhere and not increase the temperature of the surface of the earth. What has happened over the most recent time period is that, as you say, over the last 15 or so years there has not been a very significant increase in temperature.

Mr Lilley: No significant increase.

Dr Shuckburgh: However, we are in the warmest decade over the temperature record. In fact, the last three decades have been successively warmer than each other. This is crucially important for understanding the context of your question. We have also seen very dramatic changes elsewhere in the climate system. We have seen strong decreases in Arctic sea ice, an increase in sea level, increasing heat content of the ocean, and decreasing snow cover in the northern hemisphere. Other parts of the system have clearly demonstrated change in temperature.

Our understanding of the physics of the system is that changes over short time periods of 15 years cannot be used from the temperature record to look at the long-term temperature increase that one would expect from climate change. To answer your question of whether or not the recent temperature period has had any impact on our understanding of the implications of increasing carbon dioxide in the atmosphere, I would say that it is of interest. It is of significant scientific current research to investigate it, but I do not believe that strong conclusions can be drawn. That is reflected in the statements of the IPCC report, which did go to significant effort to investigate those last 15 years based on the current scientific literature to the cut-off date on which the report was written.

Q119 Mr Lilley: You promised to answer my question. Did it increase, decrease or leave unchanged your confidence that warming will be as rapid as previously thought?

Dr Shuckburgh: I tried to explain that the context of your question was important.

Mr Lilley: You did not answer my question.

Chair: Give her an opportunity.

Dr Shuckburgh: Your question in itself is not well formed because you are—I am sorry, but—

Mr Lilley: I decide on the questions.

Dr Shuckburgh: You can decide on the questions, absolutely, but the critical point is that you asked whether it leaves unchanged future projections of temperature change and—

Mr Lilley: Your confidence.

Dr Shuckburgh: —confidence in future projections of temperature change, but in order for your question to be well defined you need to articulate over what time period. If we are talking about the next decade or so, then what has happened over the last few years undoubtedly changes our projections for temperature over the next few decades. It is clearly relevant, just as if we were looking at the weather for tomorrow, today's weather would be relevant for what weather we are likely to anticipate tomorrow. If we are looking at temperature changes at the end of this century, it is less relevant.

Mr Lilley: Right, witness refuses to answer question.

Dr Shuckburgh: No, come on. You are playing politics.

Chair: It was rather a comprehensive answer.

Q120 Mr Lilley: The body of the excellent report—and the body is excellent—does reduce estimates over the next 20 years of warming, but this is not highlighted at all in the summary for policymakers. Perhaps I could ask Peter Williams whether he thinks that is a good approach to reporting information to the policymakers.

Sir Peter Williams: It is an approach with something of a deficit in it. I agree with the comment. My answer to your earlier questions is “unchanged”, by the way, but I will not re-explore that. I think Emily gave a very full answer.

One of the problems that the IPCC or any such organisation has in reporting to policymakers is the extent of detail and the sheer scale of what they can invite policymakers to study. I am quite sure you have read the summary for policymakers very carefully a number of times. Have you had a chance to look through the technical summary report of Working Group 1, which is, I am afraid, 84 pages long?

Mr Lilley: Not completely, but I have perused it.

Sir Peter Williams: Yes. You have probably noticed that, whereas there is a paragraph on the subject of hiatus in the summary for policymakers in the comment, in the technical summary there are three pages dealing with the hiatus and the points that Emily has made. By pure coincidence, yesterday's *Times* reported the paper in the *Nature Climate Change* that was published recently by the University of New South Wales, who in the context of the Pacific, in a regional context, have addressed the question of what has happened in the last 15 years.

As Emily pointed out earlier, the challenge of looking at a single parameter, which is global average surface temperature, as opposed to where the heat that has undoubtedly come into the planet in those 15 years has gone to, is a complex one. They have articulated a mechanism involving more prevalent than usual trade winds, which is an endemic feature of the Pacific at the moment, and exchange of heat between warm surface oceans and subsurface. This is an area where the IPCC itself, in AR5, has acknowledged a relative weakness, and I speak in the presence of someone who is an ocean scientist, in knowledge going back over significant periods of time on deep sea temperatures and temperature variations.

However, the hiatus is not a new phenomenon. I think you are probably aware of that. A Royal Society Green Paper we put out in 2010 pointed out that in the last 150 years there have been two major periods: 1945 to 1970 was something of a hiatus, then an acceleration between 1970 and the late 1990s and then the current hiatus. These are not new phenomena and they are consistent with the overall warming of the planet.

Dr Shuckburgh: Can I also respond to that question? You were referring in particular to the temperature forecasts over the next decade or so and your assertion was that the way in which those projections were put together was not mentioned in the summary for policymakers. I don't know if you have the summary for policymakers there, but if you go to page 18 and section E1 on the Atmosphere: Temperature, then the first bullet point refers exactly to these forecasts, and I will read it for you. It says, "The global mean surface temperature change for the period 2016–2035 relative to 1986–2005"—so these future projections in the near term that you are referring to—"will likely be in the range of 0.3°C to 0.7°C (medium confidence)." Then the crucial statement that you are referring to is the next one, "This assessment is based on multiple lines of evidence and assumes there will be no major volcanic eruptions or secular changes in total solar irradiance".

The critical point is that there are multiple lines of evidence. As I was explaining, there is a difference between predicting the weather for tomorrow, which I am sure rather a lot of people around the country are interested in just at the moment, predicting the temperature over the next decade and predicting the temperature at the end of the century. In particular, if you are interested in the temperature over the next decade then what the temperature is now is highly relevant. The climate models that have been used, what are called the CMIP5 climate models, are designed to project the temperature at the end of the century. If you are interested in understanding the temperatures over the next decade, you need to draw in other lines of evidence, and that is exactly what was done in the report. As is then further described, it refers to section 11.3 on that point.

Q121 Mr Lilley: But it did not point out the bit that you mentioned there in the main technical study. The models forecast an increase, being 0.48° and 1.15°, whereas the expert judgment has been—

Dr Shuckburgh: No, you are mischaracterising things.

Mr Lilley: Can I finish my point? The expert judgment has been reduced by 40% to 0.3° to 0.7°.

Dr Shuckburgh: I understand what you are saying, and it is what you said at the last hearing of this Committee as well, but you misunderstand the point that I tried to explain. These models are formulated to project temperature in the long term. If you are interested in the short term, you need to bring in other lines of evidence as well in order to pull together a robust projection over that shorter time period. It is not a question of an expert judgment. It is a question of producing a projection.

Mr Lilley: It is odd that we were not told that you do not believe the—

Dr Shuckburgh: But I would argue that you were told, Mr Lilley.

Mr Lilley: We were not told in the summary for policymakers.

Dr Shuckburgh: You can argue whatever you like, but the fact of the matter is it says here, “This assessment is based on multiple lines of evidence”. That is what it says in black and white. I am reading it. It then refers to section 11.3, where more details of those multiple lines of evidence are given. I do not know how much clearer one would want to be other than that. I have tried to explain the details as well.

Q122 Mr Lilley: Can I just respond to your point? I am a humble policymaker. We expect the summary for policymakers to give us something to go on. It talks merrily about models. It then gives us some figures that are not those forecast by models but, as you say, multiple lines of evidence, that is that they do not believe the models give a full account. They take some other unspecified factors into account, known as fudge factors in my trade, and produce a lower figure. They have to because the models have been consistently running too hot, do they not?

Dr Shuckburgh: I can only explain again what I feel I have explained already. The models are of projections of the long term. They explicitly do not attempt to predict short-term natural fluctuations in the climate system. They cannot in the way they are currently formulated and consequently—

Q123 Mr Lilley: I have the point. What are these other lines of evidence that you use that do predict the short-term fluctuations that allow you to override the model forecasts over the next 20 years?

Dr Shuckburgh: The critical thing is to look at the current state of the climate system. That is absolutely relevant to projecting the next few decades. As you move to the end of this century, the current state of the climate system today is not so relevant, and I draw the analogy again with weather forecasts. You could use one of the climate models to try to predict tomorrow’s weather, but it would not do a good job if you did not know what the current weather today was because, over that short term, what in mathematical terminology is known as the initial conditions are critically important. That is because of something that you may have heard about, which is the butterfly effect, the effect of chaos. These initial conditions are critically important to understanding tomorrow’s weather. They are also relevant to understanding the next decade.

In statistical terms, if you look at the long-term, end-of-century time scale, if you average over a long enough period of time, those natural fluctuations that occur do not have such significance over that longer time period. That is exactly why it is also relevant to look back at the last 15 years in the context of longer-term temperature change, because the simple physics of the weather and climate system are such that you cannot take short time periods without taking into account the natural fluctuations that occur over those short time periods. El Niño is a particularly well-known example of how those sort of short-term fluctuations are important.

Q124 Mr Lilley: Are you saying, therefore, that the experts taking into account multiple lines of evidence start from here, but the models do not get initialised at the present point? Is that what you are saying?

Sir Peter Williams: It is critical, the initialisation at that point.

Mr Lilley: It is indeed. That is why I am asking the question.

Sir Peter Williams: Chairman, Mr Lilley raises a very important issue of a procedural nature as to the extent to which it is even possible to digest issues of this scientific complexity into the level of summary for policymakers that you currently have before you. I keep referring back to the technical summary where the issues that you are raising are very fully addressed.

Q125 Mr Lilley: I am sorry, I asked a very specific question. Please don't go off at a tangent. You are saying the reason why experts differ is that they take into account the current situation of the climate, but the models surely should start from the current situation of the climate. Do they not do so? If they do so, why would they get it wrong?

Dr Shuckburgh: Let me explain again. There are three different things that we are talking about here: weather forecasts start from the current state of the weather; forecasts over the next decade, and there are a number of different ways of producing those forecasts; and forecasts for the end of the century. If we are talking about forecasts for the next decade, which is what you are interested in, Mr Lilley, there is a significant amount of research going into producing those forecasts. It is very challenging.

It is not an easy thing to do and there are a number of different models that are used around the world to produce those decadal forecasts. Those decadal forecasts are initialised not just with the state of the atmosphere but, crucially because it is important over that longer time period, also with the state of the oceans, and there are a number of different techniques for doing that. That constitutes decadal forecasts.

In addition, you can, as another line of evidence, take the climate models that are used for the end-of-century projections and incorporate other information into those projections to produce a forecast that is relevant for the next decade. In that case, it is critically important to take account of the fact that you are looking at temperature change with respect to a particular time period. The time periods you choose from makes a critical difference to the results that you get. All of that is carefully explained, as Peter says, in the technical summary.

Mr Lilley: I am hoping you will carefully explain it now, Dr Shuckburgh. If I can cut short a very long and irrelevant answer, I asked a very specific question.

Dr Shuckburgh: You did and I tried to give a very specific answer, Mr Lilley.

Q126 Mr Lilley: I am sorry, you did not. The specific question I asked, first of all, was why the experts' judgment differed from the models. You said it was because the experts start from the present climate, implying that the models did not. I then said, "Am I correct in—"

Chair: We are satisfied with the answers we have had, which have gone into great detail and been repeated at least three times.

Mr Lilley: That is disgraceful, Chair.

Chair: That is your opinion.

Mr Lilley: Absolutely disgraceful.

Chair: We have a considerable agenda we want to cover this morning. We have given you the chance to ask the same question several times. We have had a very thorough answer from both our witnesses.

Mr Lilley: You have protected a witness who cannot answer a question.

Chair: Are the Committee happy to move on to the next question? Thank you.

Q127 Graham Stringer: A previous director of the British Antarctic Survey suggested that we should not be looking at climate disruption or surface temperature, we should be looking at the climate's energy balance and that is a better measure of what is going on. Can we do that? Can we measure the planet's energy balance?

Dr Shuckburgh: Do you want me to kick off with it then?

Sir Peter Williams: You are the climate expert. I will assay an addition to what Emily says, drawing your attention to the report itself.

Dr Shuckburgh: This alludes to what I was trying to articulate, perhaps poorly, in response to one of the previous questions. It is the energy balance of the system that we are looking at. It is an imbalance as a result of, we believe, increasing greenhouse gases in the atmosphere that is changing that balance of input and output energy into the system. Looking at the global average surface temperature is a poor proxy for what we really want to do, which is looking at the total energy balance. Can we do that from observations? There are satellite observations that we can draw on to try to estimate that. Also, what is being done increasingly and was mentioned in the report is that there are now new measurements of the deeper ocean. Were one to properly try to calculate the entire heat budget of the climate system, you need those ocean measurements as well.

Unfortunately, we do not have a long time history of those measurements and, again going back to one of the questions Mr Lilley asked me, one of the reasons why the strength of our scientific statements is able to increase year by year is that we have, year by year, a longer, more comprehensive temperature record coming from the atmosphere, satellite data and now, increasingly, measurements of the deep ocean. That means that we are able to better constrain and characterise that total heat budget.

Sir Peter Williams: I would add that the question you have asked is addressed, to some extent, in AR5 in the technical summary. Quite clearly, temperature is one of the most important parameters we would all like to learn about with a greater degree of precision and certainly in forecasting the future, but sea level rise—which, by the way, as Emily did point out, has continued during this hiatus period—is indicative of the fact that the heat balance of the planet, which was a massive thermodynamic calculation if you think about it, is the parameter we want to get traction on. We are equally concerned, particularly in low-lying countries, about the possibility of inundation and sea level rise in the distant

future, as we are about temperature rise in sub-Saharan Africa and crop failures and so forth.

Your question is well taken. Again, if we go back to the point I made earlier about the scoping exercise for any future assessments, I think that is a valid input question at the scoping stage.

Q128 Graham Stringer: You have said it is something we should be measuring. Can we measure it?

Sir Peter Williams: We will be measuring more data from deep oceans. We will be continuing to measure increasingly from satellites. We will be measuring any of the parameters that you could possibly conceive of, but we do not have the length of data available to us and yet we are trying to make predictions into the decadal future.

Q129 Graham Stringer: Let me ask you another question. Can we distinguish between natural variation in the temperature or the energy balance, what would have happened anyway without the extra carbon dioxide in the atmosphere, and what is caused by the increased carbon dioxide? In another Committee, we have had several submissions saying that there is not a scientist on the planet who knows where that balance is. Do you agree with that?

Dr Shuckburgh: I can explain to you the procedure that is undertaken by climate scientists to try to distinguish between those two different factors. The state-of-the-art approach is one that I think was mentioned in the previous hearing, an approach called fingerprinting that is rather analogous to what you might imagine fingerprinting is. There are particular patterns that one anticipates, being the pattern of change that you would expect from increasing greenhouse gases. That is a pattern of the change over time and the change in space. The change in space is both the geographical pattern of the change and the change with altitude as you go up through the atmosphere.

There are particular patterns that one can identify that would be characteristic of the changes to the climate system you would anticipate from increasing greenhouse gases and that you would anticipate from natural fluctuations. For example, the most well-known natural fluctuation, the El Niño phenomenon, is associated with particular temperature changes, particularly in the Pacific Ocean. There is a particular pattern that one identifies with the El Niño phenomenon. If you look to the pattern of temperature change geographically, which one would anticipate from increasing greenhouse gases, it is different.

You identify those patterns—those are the fingerprints—and then you can look to the observations of what has occurred over the recent time history and disentangle how much of a contribution has come from one pattern and how much of a contribution has come from another pattern. That is the scientific basis for formulating those statements.

Q130 Graham Stringer: I understand there is a process or a method for getting there. Perhaps a better question would be to ask: when you go through that process, what estimate of the error do you give in that calculation?

Dr Shuckburgh: Yes. I am sorry to say that does mean you have to refer to the famous technical summary where exactly that calculation has been done very carefully and the error bars are clearly shown on that. If you are lucky I might even be able to find the relevant figure for you to look at, but it is on the basis of that calculation, along with the error bars associated with it, that then the statement was made back in the summary for policymakers about the—here we go. It is on page 66 for those of you who feel like reading through the technical summary. It is figure TS10 and then it refers to the main text figure, 10.5. It is on the basis of the results of that figure, together with other lines of evidence, that then the statement was made in the summary for policymakers about most of the observed warming, which somebody will be able to find somewhere. That is the basis of the statement and the reason it says “most” is that that is taking account of the error bars in that figure.

Graham Stringer: It is quite a large error bar. The error is quite large, is it?

Dr Shuckburgh: You can look at the figure yourself. One of the key things from that figure, if you look, is that it shows the observed temperature change with the error bars on the observations, because of course there are errors on that as well. Then it shows the total anthropogenic contribution estimated with the error bars and the two are remarkably similar. There are also estimates for the contribution from internal variability—they are the sort of changes we have been talking about from El Niño and other natural oscillations in the system—and that is very much smaller. I would say that the error bars are not huge.

Graham Stringer: They are what they are.

Sir Peter Williams: I think one has to compliment IPCC on the fact that their treatment of error and uncertainty in AR5 is ahead of its level in AR4. They have definitely improved.

Q131 Chair: Just while we are looking at that charge, I have mine in colour. I do not know if it is the same colour as yours.

Sir Peter Williams: Yes.

Dr Shuckburgh: It is, yes.

Chair: Greenhouse gas is in green, the second one down. The error bar goes quite widely up and down. Combined manmade, which is the next one down, is presumably the average of the green one and the other manmade one below. Am I interpreting that correctly?

Dr Shuckburgh: The green one is greenhouse gases. The yellow one is aerosols. I think OA stands for other anthropogenic something or other. The orange one is the anthropogenic total, but these are calculated separately. There is a more robust signal that one can calculate, if we do not try to separate out the greenhouse gases and aerosols, which is the reason why there are larger error bars on the greenhouse gases and on the aerosols than there are if you consider the total, but they are calculated separately.

Sir Peter Williams: If you look at the figure on TS6 on page 54 of the technical summary, you will see the aerosol versus greenhouse gas balance in a little bit more detail than it is in that later figure.

Q132 Graham Stringer: How do you explain the increase in the Antarctic ice that was not predicted, I understand, by the models? Just on that, we have seen a decrease in ice in the Arctic. What percentage loss of ice or increase in ice on the planet has there been when you add it all up?

Sir Peter Williams: You talk and I will find the figure.

Dr Shuckburgh: The first important thing is to recognise the difference between different types of ice. I think you are particularly talking about sea ice. In the Arctic, we have seen a very significant decrease in sea ice over recent years. We have had very good measurements from the satellite record over the last 30 years. If we look at that, if we look at September, which is the minimum extent of sea ice in the Arctic, then the lowest year in that temperature record was 2012 where the amount of sea ice was about 50% reduced compared to the long-term average. If you want to visualise that, because I think not everyone is familiar with the geography of the Arctic, that decrease amounts to the equivalent of about three-quarters of the size of Europe. It is a very significant area.

You then asked about the Antarctic and what is happening in the Antarctic. Again, I will focus on sea ice because I think that is what you are referring to. There is a critical difference between the Arctic and the Antarctic and that is that the Arctic is essentially an ocean surrounded by land and the Antarctic is an icy continent surrounded by an ocean and so the constraints on the sea ice at the two poles are very different. In the Antarctic the sea ice is, we believe, predominantly controlled by the winds and in the Antarctic there is essentially very little sea ice left at the end of the melt season, unlike in the Arctic at the moment. That is because you have the continent sitting where the pole is unlike in the Arctic.

Another critical component of the Antarctic system, which is related to the fact that you have a continent surrounded by oceans, is that you have very strong winds that circulate over the ocean around Antarctica. That essentially isolates Antarctica from the rest of the system and consequently the physics of Antarctica are different. As you described, we have not seen significant changes of any great note in the sea ice in Antarctica; perhaps a slight increase, although the observations have uncertainties associated with them. That overall picture, however, for the Antarctic hides very considerable regional differences. There has been a decrease in sea ice along the Antarctic Peninsula, which is the part of Antarctica that sticks up towards South America, whereas there have been increases in other parts.

As I described, the current understanding is that that pattern of change is predominantly related to the wind changes. Over the longer term, the influence of the ocean and the temperature of the ocean is important. In particular, it relates back to the winds because, as the winds blow strongly around the Southern Ocean, they drive the circulation of the ocean and bring water of a different temperature up underneath both the sea ice and then the ice sheets, so changing the winds over the Southern Ocean is critically important.

What I am trying to describe is that you have a rather complicated climate system where you have many different aspects interacting that you need to take account of. It is not simply the case that all we are considering is an increase in temperature. There are knock-on effects where the temperature change can influence wind patterns, the wind patterns affect ocean circulation and the ocean circulation affects the sea ice. You need to take all these things into account in order to properly characterise and then project future climate change. Sea ice is a particularly challenging parameter to be able to project because it depends sensitively on key aspects. Therefore, it is the case that at the moment we do not have strong confidence in our climate model projections of Antarctic sea ice.

Sir Peter Williams: I think the question involved not just sea ice but glacial ice mass and ice sheets on land. Was that the case, Mr Stringer?

Graham Stringer: I just want to know, of all the ice on the planet, how much less or more was—

Sir Peter Williams: The total cryosphere.

Graham Stringer: The total. What have we lost on the—

Sir Peter Williams: Again, one of the unfortunate things in condensing the summary for policymakers, is that there is an excellent section on both sea ice and glacial and on-land ice sheets in the technical report, which has a beautiful map—and one picture is worth a thousand words—of the Greenland ice sheet and Antarctic ice sheets that can express far more clearly than I could these differences that Emily has been trying to explain.

The ice loss—and this is the core of your question—that is quoted with confidence of “very likely” is 226 gigatonnes per year in the period 1971 to 2009. I think one of the things that climate scientists the world over are united on is the manifest obviousness of the glacial ice loss on the planet wherever you look. I myself was down in the Antarctic Peninsula flying over some of the ice shelves that are collapsing there. I trekked, for a bit of light recreation on the way back, in the Southern Andes and the Torres del Paine. I trekked up the Grey Glacier, which has moved 2.2 kilometres back up the valley in the last 20 years. These glacial ice loss figures that the IPCC are quoting with high levels of confidence are at the core of the answer to your question.

Dr Shuckburgh: These are new results that have been relatively recently published on the basis of a comprehensive assessment of the observational record, and we believe the contributions from that glacial ice and ice loss from the ice sheets has contributed about 20% to sea level rise to date.

Q133 Graham Stringer: Aerosols and other positive and negative feedback mechanisms within the atmosphere, as I understand it, are not very well understood and give rise to a level of uncertainty. How close are you to accurately assessing those positive and negative feedbacks?

Dr Shuckburgh: Just for clarification, because I think there might have been some confusion last time round, when we talk about aerosols we are not talking about hairspray. We are talking about small soot particles in the atmosphere and other similar particulates in the atmosphere that can, as you indicate, have either a positive or a negative climate

impact. It is certainly the case that it is an active area of scientific research. It is fair to say that some aspects of the cloud processes that are related to this in particular have seen significant improvement from the AR4 to the AR5 reports. Scientific progress is occurring at the moment and that is on the basis of observational campaigns to try to better understand the impact as well as improvements in the theoretical understanding, all of which lead through into improvements in the modelling. So it is a combined effort on all three fronts to better constrain those scientific uncertainties.

Q134 Sir Robert Smith: I remind the Committee of my interest in the Register of Members' Interests, in particular to do with the oil and gas industry and a shareholding in Shell. Sir Peter, the Royal Society has a long history of observing and commenting on science as it has evolved over the centuries. Has there been any other area of science outside of climate science that has undergone such a frequent and exhaustive public assessment procedure?

Sir Peter Williams: In recent times issues such as GM crops hit the headlines and the slightly more epidemiological matters of foot and mouth and so forth, of course. If you go back into the less recent past, shall we say, but within my lifetime, probably not. I would say that GM crops and now climate change are two issues that have gripped the public's imagination and created interest for a diversity of reasons.

Q135 Sir Robert Smith: Climate change is the only one that has undergone this formal IPCC-style process.

Sir Peter Williams: Yes, it is. In that sense, the IPCC as a process is a very eliminative one. It truly is a bottom-up synthesis of the knowledge that is available to humanity, interpreted not just for policymakers but the general public as a whole. Due to the implications of the findings of the various assessments, it has attracted not just the attention of people such as yourselves but that of the lay scientific community in climate change terms. It is just so important to all of us in that sense and it is quite natural that it has figured quite high on the radar screen of the Royal Society.

Q136 Sir Robert Smith: Back in 1955, former president Lord Adrian said, "It is neither necessary or desirable for the Society to give an official ruling on scientific issues". There are some dots then, but it goes on to say, "It is an established rule of the Society, to which they will always adhere, never to give their opinion as a body upon any subject either nature or art that comes before them," yet the Royal Society has expressed an opinion on climate change. Is there a conflict there between that—

Sir Peter Williams: There is a potential conflict there. It is obviously an interesting situation to find oneself in as a senior member, as I was, of the Royal Society that, for very understandable reasons, Governments and policymakers in general wish to consult their own national science base in order to get an interpretation of complex facts such as are presented to you in AR5. In that sense, I think it behoves an organisation such as the Royal Society to try to act as an interlocutor in that great public debate. That we occasionally fail to get things 100% correct is indeed both a feature of humanity and inevitable.

In the case of climate change, I think you are probably referring to the GWPF report. Indeed, you quote Lord Adrian's words from that. We have been criticised for some of the public stances we have taken. In recognising that criticism, I think you have probably seen the small booklet we put out in 2010 for general consumption, not just by policymakers but by the public and other scientists, as a method of bringing together the whole science community, including those who perhaps disagree with the conclusions of the IPCC as well as more mainstream scientists who have contributed to IPCC assessments and produced the statement. I have re-read it, as you might imagine, over the weekend and find it is still a very good guide to this rather complex topic.

I would put it to you that were we, the Royal Society, not to attempt such a document who will? How can you place trust and faith in such an attempt to act as an interlocutor other than by asking a national academy of science to do that?

Q137 Sir Robert Smith: Both of your organisations have individuals who take a different view from the conclusions of the organisation.

Sir Peter Williams: It was ever thus and therein lies the richness of science. It is built on dissent, constructive contention and vigorous debate. In this august establishment here and across the street you do not thrive on bland consensus; you thrive on vigour, disagreement and teasing out the fundamental truths. So it is with all science. Go and look at Charles Babbage's letters—the invention, of course, of the digital computer in the 1800s—and you will see dissent. Look at the correspondence between Hook and Newton. You will see voices not in unison as a feature of the three and a half centuries that we have existed. It is very healthy and long may it continue.

Dr Shuckburgh: Just to involve the Royal Meteorological Society, it is important to stress, first of all, that we are very open to a broad spectrum of opinions. In fact, we held a meeting to discuss the IPCC report and its results just last week. That was open to any member of the public to register and come along and air their views and thoughts. Nevertheless, it is the case that, as a society, we strongly support the conclusions of the IPCC reports.

Perhaps I should emphasise that we have a governing council, as I described, and when we were putting together written evidence for submission to this inquiry, responding to the questions that you had posed, we thought it was appropriate to ask that governing council to vote on and approve that submission so that you had a feeling for how comprehensive our support of those statements was. That was unanimously approved by the governing council, and I can tell you that the governing council contains seven scientists, eight practising meteorologists and four people from an amateur or business background. There is a broad spectrum of representatives on that governing council. That gives you a sense of where the society is coming from. We are both encompassing all viewpoints, but also strongly supportive of the conclusions of the IPCC.

Q138 Sir Robert Smith: But the Royal Society has a range of science disciplines. I suppose quite a few of them can look at the scientific process of climate science, but they would not necessarily have a fundamental understanding of the subject area.

Sir Peter Williams: Scientifically, I would disagree with the assertion in that you have had before you one or two members of the society already giving evidence—I think in January. You would find other members of the society with different perspectives and backgrounds within what you might call climate science. It is probably a fair assertion that when you consider, as I am sure you will later this year, Working Groups 2 and 3 of the IPCC AR5, which involve economics and other aspects and implications of adaptation, mitigation and so forth, the classic core strengths of the Royal Society are not necessarily reflected in all those disciplines. We cover the natural sciences in the round. We cover in depth. We have some of the world’s most eminent climate scientists among that number, but we do not cover the entirety of the waterfront when it comes to the complexity of all the issues, economically in particular, that the IPCC covers.

Q139 Dan Byles: I would like to talk about the implications of the IPCC conclusions for us as policymakers. Professor Sir Brian Hoskins from the Grantham Institute has stated that there is not a huge change in the conclusion of the AR5 report and the science compared with previous reports. Do you agree with that and, if so, is the conclusion that there is no real need for a policy change in the UK based on AR5?

Sir Peter Williams: Yes is the short answer to your question, bearing in mind Mr Lilley’s exhortation to witnesses to be brief. It should reassure you, in a phenomenon as long-lived as global warming undoubtedly is, that spot measurements—they are not, of course; they are a synthesis of data that has been accumulated on an hourly or daily basis throughout—are separated only by seven years. Were they to have differed fundamentally in their conclusions and direction of travel, I would put it to you as policymakers that you should be somewhat worried. So you should derive a degree of reassurance.

The scientific world, of course, has to address issues that Mr Lilley has put to us about the hiatus and about previous hiatuses that have occurred. There are uncertainties. This is a bubble in all the branches of sciences that I have ever been involved with. The uncertainties in this particular area do matter to policymakers because, ultimately, you are going to be in the game of risk evaluation. That is a parameter that we have not discussed, which will undoubtedly guide your policies as Governments here in the United Kingdom and elsewhere, and this is possibly the biggest global risk assessment exercise humanity has ever undertaken.

Q140 Dan Byles: Do you agree, Dr Shuckburgh?

Dr Shuckburgh: I broadly agree with that statement. I think it is the case that between AR4 and AR5 some of the evidence base has strengthened. You have seen that reflected in the strengthened statements about the human contribution to climate change. It is also the case that some new advances in the science have been made that are particularly pertinent, and I point in particular to sea level rise. In AR4 we were not able to assess the contribution from ice sheets, and an estimate has now been made, so there have been scientific advances over that period.

Particularly relevant to policymakers also is the fact that quite prominent mention is given, including in the summary for policymakers, to what has been termed in IPCC-speak as the carbon budget, so the total amount of carbon that we can put into the atmosphere while

likely not raising temperatures by more than 2°C. I suggest that all those things are very relevant to policymakers, but it is certainly not for the science to do anything other than put those forward to policymakers to decide how they want to act upon them.

Sir Peter Williams: Chairman, Robert Smith has reminded me that I should declare at the outset an interest in the sense that, as Chairman of the National Physical Laboratory, our Centre for Carbon Metrology seeks to attempt precisely what it says on the tin, to measure carbon budgets and carbon outputs. I just put that on the record.

Dan Byles: I visited the National Physical Laboratory yesterday morning.

Sir Peter Williams: You did?

Dan Byles: It was absolutely fascinating.

Sir Peter Williams: Good. You spoke to Jane Burston and she will give me the full background.

Q141 Dan Byles: Absolutely. However, is there a danger—again quoting Professor Sir Brian Hoskins—that the IPCC is too conservative on some climate issues? He stated that the consensus nature of IPCC means that the report tends to be conservative, for example on issues such as sea level rise, the release of methane from permafrost and these sorts of issues.

Dr Shuckburgh: I think I would politely disagree that it is conservative. I think that the report has tried very carefully to assess levels of confidence and where there are aspects of the science where we have less confidence then it has clearly articulated those. All the aspects that you have just mentioned in terms of sea level rise and Arctic methane release are mentioned in the report and mentioned in the context of the confidence we have of that science. I think you could probably argue that less attention is given to some areas of the evidence base that would be of significant policy interest.

I imagine, but you are the people to tell me, that low-probability, high-impact events are of considerable policy interest, and that is where you bring in the potential for rapid or abrupt changes in the climate system. That is an area of challenging science and there is less in the literature for the IPCC to be able to draw upon, which is why it has been of low confidence. You might argue that more effort and more emphasis should go into those areas in the future and I refer back to my earlier suggestion that a narrowing and clearer focus of the scoping of the IPCC report could potentially be very helpful, not least to then drive research in areas of significant policy interest.

Q142 Dan Byles: You anticipated my next question brilliantly, which was precisely on the uncertainty around issues such as abrupt climate change. Do you think that, both nationally and internationally, the potential risk associated with abrupt climate changes have not been explored sufficiently?

Dr Shuckburgh: As I described, this is a challenging area of science. It is challenging because you are talking about low-probability events that, by their nature, have not occurred in the past or, if they have occurred in the past, it was in the distant past. It is

challenging to obtain the relevant observations. It requires significant advancements in theoretical understanding. If you want to characterise the risk, then there are two aspects that you want to understand. One is the likelihood of such an event occurring and the other is the impact that it would have should it occur. From a scientific perspective, I suspect that it is more likely that we will make advances in terms of understanding the impact. The probability is fundamentally challenging, but from a policymaker's perspective it is probably the impact that I imagine is most useful for you. Were we to be able to make more progress in that area, I think that would be very beneficial. It is an area that is taken very seriously by the scientific community.

One of the big topics associated with that is understanding what might happen to the West Antarctic ice sheet and a very significant research project is being undertaken at the moment, funded by the Natural Environment Research Council, called iSTAR. Many of my colleagues from the British Antarctic Survey have been involved in that project and are down in Antarctica at the moment studying and taking observations from the ice sheets in Antarctica. In particular Pine Island Glacier is a location where we have seen a significant amount of loss of ice into the sea and what we are trying to understand, as I described to Mr Stringer earlier, is the influence of the ocean on the ice sheets because, as the warm ocean comes underneath the ice sheets, much of West Antarctica is below sea level and sloping downwards. There is the concern that, with the warmer ocean temperatures, the water could encroach underneath that ice and destabilise it, and that is what we want to understand. Significant research effort at the moment is focused on looking at some of these key questions.

Sir Peter Williams: If I may add a gloss on it, I think your questions were posed in the context of policymakers. The one risk that remains, which the IPCC is very resilient against, is that the immensely complex science is ultimately digested by the plenary, which is the government delegations from around the planet. I think it does remarkably well not to be conservatised as a result of that process and nor, from my experience of having attended the plenary, does the message acquire a degree of interpretation or, as you might term it, a spin. From what I can see, the IPCC has done a very good job of resisting those tendencies, but I think UK policymakers need to take extremely seriously your responsibility with your fellow Government delegations for ensuring that the robust truth of what the science is telling us comes through and shines without gloss or over-interpretation, and that risk remains.

Q143 Dan Byles: The other side of the coin from abrupt events is subtle changes such as air quality and ocean acidification, and sometimes it seems that headline issues of sea level rise and so on are the ones that can dominate discourse. Do you think perhaps we should have a wider discussion of some of the more subtle issues such as ocean acidification and the potential impacts?

Dr Shuckburgh: I would point to the fact that there is a very significant UK research programme looking at ocean acidification, and you are absolutely right to point it out as being a significant concern. Colleagues of mine from the British Antarctic Survey last year published a paper that showed the first signs of damage to marine organisms in the Southern Ocean as a result of ocean acidification. While it is not my area of expertise at all, I understand that our beautiful coast contains one of the world's greatest cold-water

coral reefs, which is potentially significantly at risk from ocean acidification. I absolutely agree that it is a key topic that often does not receive as much attention as perhaps it should. I do not think that is the case from the scientific perspective—there is a significant research effort—but I do think it is the case from the public discourse perspective.

Sir Peter Williams: I would draw your attention to a report, which again the Royal Society published almost 10 years ago now, on ocean acidification as a compilation of the issues to draw the attention of yourselves—the policymakers—to what remains a very important issue.

Q144 Dan Byles: Finally, a question specifically to Dr Shuckburgh. The Royal Meteorological Society quoted IPCC in your written evidence to us, stating that, “Most aspects of climate change will persist for many centuries even if emissions of CO₂ are stopped”. That begs the question, to what extent will minimising our CO₂ emissions nationally and internationally have an effect on our climate?

Dr Shuckburgh: You have to understand the context of that statement. It is the case that enhanced temperature levels would increase for many centuries, but the critical component is of course that it would increase very dramatically more if you kept increasing greenhouse gases.

Dan Byles: I just wanted to clarify that point. Thank you.

Q145 Sir Robert Smith: Is there a linking up of the learned societies in the relevant disciplines across the world on this issue of climate change?

Sir Peter Williams: Yes and no. You are possibly aware—I think it was in the Royal Society’s submission—that the US National Academy of Sciences is about to publish its response to AR5 Working Group 1. Although I am now retired and out of circulation, I think it is coming out later this month or possibly early March. The academies around the world talk together. I tend to visit South East Asia and I talk to colleagues in Malaysia, Singapore, Japan and China quite regularly, who of course were members of the IAC review. I would say it is an informal network, just ensuring that there is good communication.

Q146 Sir Robert Smith: Is it the same for the Royal Meteorological Society?

Dr Shuckburgh: It is. We certainly have good relations with other meteorological societies. There is the European Meteorological Society and an American Meteorological Society. We have good relations and organise a number of initiatives in collaboration with those organisations. It is also the case that within the UK we have initiatives with other learned societies, and I point in particular to the Royal Geographical Society. For example, we have a number of joint journals that we organise with the Royal Geographical Society. We have also engaged in a number of activities with the Royal Statistical Society. I would say that, as with science in general, we are very joined up both within the UK and internationally.

Q147 Chair: We have touched on some of the controversies that have arisen from previous IPCC work and conclusions. Do you think that the media focus on some of those controversies has detracted attention from the main conclusions of the IPCC?

Sir Peter Williams: It is certainly a risk. Doubtless in your next session you will touch on such topics. I can just say from personal experience that when we released the IAC review I was interviewed real time by BBC News from their studio at the United Nations, and the interviewer wanted only to talk about the Himalayan glaciers, to which my response was that there were 4,000 other pages of text that perhaps they should be paying a degree more attention to. It is an unfortunate fact that the highlights such as the Netherlands being flooded and the Himalayan glaciers disappearing are the sorts of one-liners that the media will willingly grab and publicise. They detract from the import of the body of evidence that one is trying to communicate.

However, if you look at the media in the round, forgiving these one or two understandable excesses of highlighting, there is a balance of reporting that does not give me as a scientist a great deal of trouble. I think the way in which Working Group 1 has been received has been somewhat more sober and more thoughtful than perhaps how AR4 was received. It is just a feature of life as a scientist and it does not matter whether you are talking about GM crops or climate change or whatever the next controversy of import to humanity is, it will ever be thus.

Q148 Chair: Are you also relaxed about the sort of balance of coverage in the media?

Dr Shuckburgh: What is absolutely important for the public and for decision-makers is to consider the evidence base. Science is about reproducible results and that is at the absolute heart of it. It is critically important, on a matter that clearly has such societal implications, that that evidence base is clearly articulated and communicated to all those interested parties, whether they be a single member of the general public or MPs like yourselves. I think that there is an onus on all of us to ensure that that is the case. That is at the heart of good democracy in order to make sensible decisions on matters of importance.

It concerns me at times that some, and only some, of the media organisations in the United Kingdom perhaps one could even go as far to say let the public down in that regard, because there are examples—as may be alluded to in the coming discussion with the next panel members—where the science has perhaps not been as clearly articulated as possible. I think that that has at times led to a failing of the communications process that has potentially let down the public. The onus is on all of us to try to improve that, and I—again speaking in a personal capacity—have put a lot of emphasis over the last few years on trying to understand public opinion and how to communicate those messages more effectively. The Royal Meteorological Society also takes this issue of communication very seriously and in the last couple of years we have set up a climate science communications group, of which I am chair, specifically to address this issue of trying to communicate dispassionately the results of the climate science to the general public. It is critically important.

Q149 Chair: We have seen in some other areas the difficulty of communicating probabilities and the balance of risk. The MMR controversy is an example. Some people

made decisions that were based on a misunderstanding of what the probability of balance of risk was. It seems to me there is a danger of that here. Obviously, a lot of very important long-term decisions are being made in the light of the scientific conclusions. Do you think people have been misled at all by some of the coverage, thinking of both the policymakers and the public? Is there a danger that decisions will be made on the basis of information that is not interpreted correctly?

Sir Peter Williams: That is a big question. It is a deeply philosophical one. I am sure that that danger exists, and each and every one of us in this room could cite a specific example of it. I go back to my earlier comment that in the round in this current exercise of AR5 the response has been more thoughtful, has highlighted uncertainties where they exist and has been less spectacular. I think in great measure that is because the IPCC sought to eliminate the unfortunate errors that were undoubtedly made in AR4 that resulted in the spectacular headlines that could have superficially misled. I hope it did not mislead policymakers such as yourselves, but it could be said to have misled the general public.

But your more general point is well taken, which is that unfortunately our citizens at large are not terribly good at assessing risk in any aspects of their lives, whether it is MMR, financial services, travel and so forth. We are just not very good at assessing in a cold, rational, analytical way the risks that we face, but that is why your role as policymakers is so important.

Dr Shuckburgh: In our written evidence, we responded to your questions about communication, risk and uncertainty, and perhaps I will just read what we wrote because I think it is absolutely true. “In general it is challenging to communicate the scientific meaning of the words “uncertainty” and “risk” because they differ in subtle ways from the common usages of those words, and indeed are used in slightly different ways in other fields such as economics.” Part of the challenge is exactly what you alluded to and Peter has elaborated on—the general challenge of communicating scientific uncertainty and what we mean by that.

Q150 Sir Robert Smith: One of the concerns put by those that are worried about the conclusions on climate change is that the scientific herd community follows the resources that are there for research projects and it becomes a self-fulfilling prophecy that scientists will tailor their research projects to what the funding comes to and the funding will then reinforce it. On behalf of your members, do you have a view on that?

Sir Peter Williams: I have a clear view personally, which is at the micro level the individual scientist, and this is a global comment not just within the context of the United Kingdom. Bearing in mind the number of scientists involved in something like the Working Group 1 report you are considering today, it is simply impossible for some sort of herd instinct group-think with funding bias to take root in that diverse spectrum of people.

All scientists are different. It is a general term that conjures up images of white coats and stereotypical conformity. The truth could not be further from that. The very idea that some form of funding bias, because of the popularity of the topic, could itself skew the observations of what are natural phenomena, which in turn could somehow skew the interpretations that are apt to mislead policymakers, does not bear examination.

Dr Shuckburgh: Also I go back to the point that science is about reproducible results and it is the evidence base that speaks for itself.

Chair: I am going to pass to Peter to ask his question. In the event that the answer is not completely satisfactory, we will produce a written question as well afterwards.

Q151 Mr Lilley: I am grateful, Chairman, for letting me come back. I originally just wanted to raise the fact there was a difference between the model predictions and the overall assessment that had not been highlighted. But then I followed a line of questioning that I had not planned at all to establish why it was. You said it was due to other factors being taken into account. The only other factor you enumerated was that the expert assessment starts from the world as it is, implying to me—perhaps wrongly—that the models did not start from the world as it is. Could we just clarify that simple point? Do they both start from the same point or do they start from different points?

Dr Shuckburgh: I think the easiest would be if you and I sat down and we carefully went through this. This is all described in clear detail in the report itself and maybe I can sit down with you and explain it to you because we are clearly not going to get a shared understanding.

Q152 Mr Lilley: I am very grateful for that offer, but I do not see why a simple question cannot be answered.

Dr Shuckburgh: I will articulate the answer that I already gave. There is a difference between projecting temperature to the end of the century, projecting temperature over a decade and projecting temperature for tomorrow. There is a difference.

Q153 Mr Lilley: We are trying to establish what that difference is, but clearly we are not going to now. I will happily meet. We will record the conversation and I can play it back to my colleagues.

Dr Shuckburgh: We can meet after this session today if you really want to.

Mr Lilley: Sadly not

Chair: We will be fascinated to see a summary of this dialogue. Thank you both very much for coming in. It has been very interesting for us.

Examination of Witnesses

Witnesses: **James Painter**, Reuters Institute, Oxford University, **Guy Newey**, Policy Exchange, and **Jonathan Grant**, PricewaterhouseCoopers, gave evidence.

Q154 Chair: Good morning. Thank you very much for coming in. We are approaching this subject from a slightly different standpoint. We do not expect you all to answer all the questions. We may direct some of them more particularly to one of you, but do not feel inhibited about commenting on anything as the discussion proceeds. Could I start with you,

Mr Grant, please? What would you say is the reaction of business to the increased confidence, one could say, that human behaviour is having an influence on the climate?

Jonathan Grant: In general, companies are less likely to question the climate science than they have been in the past. In general, companies accept the science on the big questions of: is the climate changing, is it caused by higher emissions and is it likely to have far-reaching implications? I can give you an example of a response from a big six power company to a question on climate change in 2003. The power company said, “The question implies that climate change is mainly caused by human activities. We hold the opinion that this has not yet been proven and that a significant part of the scientific community is sceptical about this interpretation for present climate data.” That same power company in 2013 said that, “Climate change has significantly affected our long-term strategy because our power stations are operated for several decades. Our mid-term strategy is aimed to reduce our normalised emissions by about 20% by 2020.” I think that business views have evolved over time with the science, as the science has become increasingly clear.

Q155 Chair: Would you say that there are any sectors of business that do not now accept the scientific consensus?

Jonathan Grant: During the 1990s, when there was more uncertainty about the science, many fossil fuel companies were actively engaged in focusing on that scientific uncertainty. More recently, as the science has become more certain, businesses are less inclined to argue the science and they get more actively engaged in the debate about the policy response. I think they think that is more productive.

Q156 Chair: Mr Newey, do you think there has been a similar process—change perhaps—in the view of policymakers, either nationally and perhaps internationally? What Mr Grant said exactly parallels my own experience of quite a considerable shift of opinion over the last 20 years in the attitude of business, but has there been a similar process with policymakers?

Guy Newey: If you look at the evidence of what new policy is being added, certainly in the UK context, then obviously policymakers are taking the issue more seriously than they were before. On the question of whether the latest IPCC report changes the position for policymakers, I do not think it does in any particular way. There are lots of arguments, and you have heard them rehearsed earlier today and at previous sessions, about the detail of the science, but the broad thrust is roughly the same. The question is what do you do in the face of uncertainty about future events, and that is a very difficult political and economic question to get to. But, yes, there has been an increase. You can see that increasing policy action. There is still a lot of debate about what we should do about it though.

Q157 Chair: Is there a divergence between the debate here in the UK, and perhaps in Europe, and the debate, for example, in North America?

Guy Newey: I am not sure how well qualified I am to answer that question. My sense is that there remains—if you look at opinion polls in America, as you do in the UK—a generally pretty good consensus for action on climate change. The debate is about the pace

of decarbonisation we should be pursuing. That debate is raging in America, as it is here and as it will continue to do, I would imagine, for a long time.

Q158 Chair: Mr Painter, what about the public perception? Is that also changing in the same way that business attitudes have changed?

James Painter: It depends on what period you look at, but if you go back to 2007 when AR4 was released, most of the opinion polls would suggest that the British people are marginally less concerned than they were. There is a small increase in those who doubt some of the science and that is, to a certain extent, paralleled in the US as well. In other words, the science is going one way and, to a certain extent, public opinion is going another way. I am not a public opinion expert, but you do have to be very careful about what you are measuring. Are you measuring levels of concern, levels of belief, the public's willingness to make changes in their personal behaviour? There are different drivers of those attitudes. Most opinion polls show that there is probably a small decline in the level of concern, but there might be all sorts of reason for that.

Q159 Chair: Do you think the reasons might be some of the controversies, Climategate or some of the controversies surrounding AR4? Would that have contributed to this?

James Painter: There are some pollsters who think that there was a temporary increase in the amount of trust that the general public had in climate scientists at the time of Climategate, although that has largely rebounded. There are also pollsters who think that the controversy over Climategate and the controversy over Himalayagate did lead to some public drop in belief in climate change, not necessarily levels of concern. But it is a very complicated mapping and I would not want to make too bold claims for it.

Q160 Chair: It does not sound as though the actual decisions or actions that people are making, whether it is in business or Governments, or indeed the public and what they decide to do about these challenges, have been materially affected by these controversies.

James Painter: I would not think so, no. There is a lot of scholarship on this about what drives people's willingness to change their behaviour and there are all sorts of factors that do that. Belief or a knowledge of the science is not necessarily one of the biggest drivers of what might make people want to change their behaviour.

Q161 Sir Robert Smith: How well do you think the messages of the IPCC are communicated to business policymakers and the public?

Jonathan Grant: The IPCC has done a much better job with the AR5 than in the past. Certainly the summary for policymakers is much more readable this time round than it has been in the past. I do not want to give you the impression that the business community as a whole is reading the assessment reports. There are some businesses that are particularly interested in the science of climate change. That might be energy companies or mining companies that have very long life infrastructure projects. Insurers are obviously interested in the climate science and retailers are also interested in the impacts of climate change on

their supply chains. I think they will look to the assessment reports for a summary of the knowledge of science, but where there is a particular question on a particular region or a particular type of impact, they will refer directly to the latest science rather than the assessment reports.

James Painter: Do you want to talk about the media, and how effective they have been? I suppose point No.1 is that the public get most of their information about the science in the UK from mainstream media, so you do have to assess and make some sort of judgment on how effectively the IPCC communicated AR5 to the media. I would agree with Jonathan that they did a much better job than in 2007. I think there is a structural problem, in that probably the most important scientific body in the world has only two communication or media people working for it, which is probably not enough in an environment of 24/7 news and constant demand on their ability to talk wisely about the science.

Having said that, I thought they did a pretty good job on the actual day of the release, and we have been doing some sort of content analysis of how newspapers in the UK and television around the world reported it. I would say that the key messages that the IPCC perhaps wanted to get out, or at least in the media who are driven by novelty, are three key messages at least measured by headlines, which were the movement from very likely to extremely likely, the rise in sea level rises and the carbon budget. That got quite a lot of mainstream straight up and down coverage, so you could argue they did a pretty good job on that.

Q162 Sir Robert Smith: I suppose it depends on how climate-critical the business is. Do quite a lot of businesses that are tangentially affected rely on the media or do they go to their own independent sources?

Jonathan Grant: We know that insurance companies have teams of climatologists looking at catastrophe risk. They are at one end of the spectrum. There are different degrees of engagement on the science depending on the type and size of the company. We have looked at the FTSE 350 companies and the FTSE 100 tend to be more engaged in looking at risks in the longer term than the smaller companies in the FTSE 250. Of course, in general those companies are concerned about growth and costs and their reputation rather than the science itself. They will look at how weather extremes can affect their businesses and not necessarily refer to the IPCC assessment reports when they come out.

Q163 Sir Robert Smith: In business quite a lot of it is a secondary effect. It is all very well their taking an interest in the science and the climate, but presumably what affects them is the intermediary of the policymakers because it is the impact on policy that will affect many of the businesses' bottom line in the short term.

Jonathan Grant: I think that is right. Most businesses in the FTSE 350 refer to physical risks, but many more refer to the policy risks of climate change, and that is where they can be most immediately affected in the short term. Clearly extreme weather events can have a direct impact as well, and many companies prepare for that. But I think that the reason why some in the business community are interested in the assessment reports is that they can influence policy. They catalyse policy change. We have seen that with previous assessment reports being published a year or two in advance of major shifts in policy. That is something that business is clearly engaged on.

Q164 Sir Robert Smith: Mr Painter, is there any way we can solve the problem of how to represent uncertainty?

James Painter: There is no easy way. It is a difficult problem, and if I were to make a criticism of the IPCC communication and climate scientists, it is that I do not think there is enough explanation of what they mean and how they measure uncertainty. There is quite a lot of evidence, particularly for the general public; they want scientists and expect scientists to know things. The way some people categorise the distinction is between school science and research science. Most people's perception of science is school science; that is a sort of body of knowledge. They see Professor Brian Cox on the television telling them about planets or whatever and these are facts. Many people do not realise that a huge body of research science is about uncertainty, and this is where climate science fits in.

There is an enormous amount of public education that needs to be done about what scientific uncertainty means. Let me give you just one brief example. If you remember, when AR4 came out they said that it was very likely, 90% certain, that most of the warming is caused by humans. A number of academics in the United States did a study with focus groups and the general public about what their understanding of "very likely" was and it was much less than the 90% that the IPCC meant. A real public education drive is needed to explain what 95% certainty or "extremely likely" mean, because I do not think people know that.

It is interesting if you talk to some of the scientists who were interviewed by the media that some of them were asked, "If it is 95% certain, what do the other 5% of scientists think?" That is not what 95% certainty means. It means that all the authors of AR5 together were 95% certain that this was going to happen. What would be helpful—and there was some media coverage along these lines—is an explanation of what 95% certain means, and some of the scientists came out saying that was the equivalent of certainty that smoking causes lung cancer. I think it is those metaphors to explain what these degrees of certainty mean that can help in the wider public education aspect. I suppose my big point was that it was necessary to come out of your ghettos where you all understand what these uncertainty levels mean and explain it and find interesting ways to explain it to a wider audience.

Q165 Mr Lilley: The two things that struck me about the latest reports were, first, that the forecasts presented for the next 20 years were 40% below those generated by models and, secondly, that the measurement of aerosols had been changed, which has grave implications for future forecasting. Mr Grant, you are an accountant, I believe, maybe a scientist as well.

Jonathan Grant: I am not an accountant. I work for PwC as a consultant.

Mr Lilley: So you know a bit about accounts. If a company were to reduce its forecast to 40% below the guidance previously given and not draw that to the attention of the market, would that not be a serious offence?

Jonathan Grant: I do not want to be drawn into a discussion about the science with you.

Q166 Mr Lilley: I am not talking about the science; I am talking about the reporting of the science. No one is disputing the science. It was in the body; it was not at all obliquely mentioned in the summary for policymakers. I am saying, shouldn't it have been? We are talking about presentation. Shouldn't it have been brought to the attention? A 40% reduction is quite significant, isn't it?

Jonathan Grant: I think the way the science was summarised was pretty clear in that for the business community, or in general, the big questions have been settled. There is always uncertainty.

Q167 Mr Lilley: Were you aware, for example, that the forecast now is 40% below what the models predict for the next 20 years?

Jonathan Grant: No, I did not read the summary for policymakers or the technical summary—

Mr Lilley: You did not read it, and you have come to give evidence.

Jonathan Grant: No, I have read the summary for policymakers, but I do not think I have read it as many times as you have and I have not read the technical summary. The way the business community thinks about the science is that in general the big questions have been answered by the scientists. They accept that the climate is changing, it is caused by our emissions, and that it is likely to have far-reaching implications. The question now is about what the appropriate policy response should be, and that is where business typically engages.

Q168 Mr Lilley: So you do not think they are interested in the size of the effect at all?

Jonathan Grant: Some companies will be, and they are challenged to translate those climate uncertainties into business decisions. There is a risk that they over-engineer or under-engineer the response. But those companies—they might be energy and utilities companies, retailers, insurers—tend to focus on the later science rather than relying on the assessment reports. As I have said with my example from the insurance company, they often have teams of their own scientists to support them in making those decisions about how to engineer an oil rig in the Gulf of Mexico, for example.

Q169 Mr Lilley: Do you think they will be surprised to learn of this very significant change in the assessment of the impact of aerosols? Previously it had been thought that the sensitivity of the climate to carbon dioxide and other greenhouse gases was high, but the reason why we have not seen great heating up to now is that that had been masked to a substantial effect by aerosols. Now they have concluded that the aerosol effect is much less, but they have not rerun the models with the reduced effect. Do you think business would be interested to know that?

Jonathan Grant: I think businesses that take an interest in the science are interested in those details but—

Q170 Mr Lilley: The detail is pretty substantial. How fast the heating is going to be is the core of the issue.

Jonathan Grant: In general the business community engages more on the policy than the science and on a day-to-day basis those specifics about the science are not things that the business community would engage with.

Q171 Mr Lilley: To Mr Painter in particular, but anyone is free to reply, have you any comments on the BBC's policy for handling global warming issues where they have a specific policy of not giving airspace to those they deem to be doubters of the science? I have never met anyone who doubts the underlying science of global warming, but it means in practice that those who, like me, are lukewarmists tend to be excluded or ridiculed, while those who disagree with the IPCC from an alarmist perspective get airspace. Do you think that is good for public understanding?

James Painter: I am not sure it is my understanding, and do correct me if I am wrong, that the BBC is following a policy of not giving airspace to lukewarmists. I gave evidence to the Science and Technology Committee, and I think David Jordan did that as well as editorial policy. Indeed, he was criticised later by some sectors for saying that we do give airtime and we do not have a ban. My understanding of it—again, do correct me—is that in the coverage of the AR5 there was a considerable amount of criticism that the *World at One*, on the day that the AR5 WG1 was released, gave an enormous amount of coverage to Bob Carter, who is a well-known sceptic. I think this idea that the BBC does not give airspace to lukewarmists, as you call yourself, is not correct empirically.

Q172 Mr Lilley: But it was news that they gave airspace to one. You can remember the occasion. I can remember hundreds of the other points of view being put.

James Painter: I am an ex-BBC person and I do not want to jump too much to their defence, but when I was there the whole drive of editorial policy was to consider due impartiality. You went and understood where the mainstream consensus was on the science and you tried to reflect that as far as possible. My understanding of mainstream science is that, yes, climate change is happening, yes, humans are causing most of it, yes, we do not know what the ranges are, you are absolutely right, and what confidence levels, so it would be entirely appropriate to reflect certain types of sceptics. My impression is—I have not done the contents analysis—that sceptics get quite a lot of airing. I believe that Professor Jones' report came to the same conclusions as well. I am not sure I buy your argument that the BBC is not giving enough airtime to sceptics.

Mr Lilley: Let us leave it at that.

Q173 Graham Stringer: What are the major economic arguments for and against the mitigation of climate change?

Jonathan Grant: Are you talking about at a macro level or a micro level?

Graham Stringer: Both.

Jonathan Grant: I think that most CEOs would worry about growth and costs and reputation, so many would be taking action to reduce their emissions in order to reduce costs. The driver would be to save energy and reduce their bills. Similarly, infrastructure developers would be looking to build projects that are resilient to extreme weather and they will make a calculation as to the degree of engineering that is required for that project to withstand extreme weather events, for example. We have a host of examples of installing low-carbon technology within PwC's buildings that have paid back over a period of seven years or so and have saved us several hundred thousand pounds in our energy costs. So I think that at the micro level there is a good case for mitigation.

At the macro level, there is a debate about whether taking action now is justified versus the cost of responding to the potential impacts of climate change in future, and I think that is an ongoing debate. But many say that the justification for taking action now is clear because it is like taking out an insurance policy. It is worth investing in those low-cost opportunities to reduce emissions now in order to mitigate those emissions.

Guy Newey: Can I come in on that, Mr Stringer? First of all, there is huge uncertainty. There will be some positive economic benefits from a warming climate, probably in the short term. This is what the economic models say. But then as we go on there is increased likelihood of more extreme weather events with damaging impacts. There still remains a huge amount of uncertainty, if we are talking about a 50 or 100-year time scale, about what the impact might be. They look as if they potentially could be very severe in a warming world.

I guess the question for policymakers is what you do in the face of that uncertainty going forward, which is more straightforward? On one side of it you could have people of future generations being much richer than we are, so we should not do anything about it. On the other end of the scale we should reduce all risk immediately and stop permitting carbon in any human processes we can. I tend to think the debate is somewhere in the middle, but that should be where the debate is. The difficulty is—and I understand this is a huge difficulty for policymakers—in the face of uncertainty about what the economic impacts are going to be for sure, what policy measures that should lead to.

Q174 Graham Stringer: I understand the case with regard to climate change for having greater energy efficiencies. It is sensible to insulate and have more efficient ways of heating and lighting buildings. What surprises me is that from the commercial sector there has not been more direct criticism of the Government's policies. While they have concentrated on emissions, the carbon footprints of the United Kingdom and Europe have increased. There are extra costs on industry, either taxation or direct costs, and yet our carbon footprint is going up, so we are responsible for more carbon dioxide going into the atmosphere than if we had done nothing. Why is there not serious criticism from the commercial sector about that?

Jonathan Grant: I think that you are referring to the indirect emissions as a result of imported goods.

Graham Stringer: Yes. We are importing goods that are often produced less efficiently and then there are the carbon emissions when they are transported here. Dieter Helm has

produced figures that show that both Europe's and this country's contribution to carbon dioxide in the atmosphere is increasing not decreasing, although our emissions have come down, yet businesses are saying they are happy with the extra costs of emissions reduction. I do not understand it. Can you explain it to me?

Jonathan Grant: I think that the concerns the business community has about competitiveness feed through. The competitiveness impacts of climate policies on business is something that the business community will raise and they will highlight the risk of carbon leakage and the risk that climate policies may drive investment abroad. I think that policymakers respond to that and policymakers are also concerned about the effect of carbon policy on competitiveness.

We have looked at that issue for developing countries in Asia, for example, who are also looking at implementing a carbon policy. As more and more countries start to implement those carbon policies, there is less risk about competitiveness impacts. Korea, China and states in the US are implementing carbon prices, and that will reduce the competitiveness threat. It also means that if more of the emissions are covered by carbon policy there will be more drivers elsewhere to reduce those emissions. I think the effect of that is that, while businesses raise the issue about competitiveness, the competitiveness effect of the carbon policy is unlikely to be as significant as, say, the impact of energy costs, the difference between energy costs in the US and Europe, for example, or the difference between labour costs in Europe and Asia. Those are likely to have more powerful effects on investment decisions than the business community make than a carbon policy.

Q175 Graham Stringer: But it is still not helping, is it, if you have a counter-productive policy and an increase in energy charges and an increase in taxation? I am really mystified. I accept what you say—that the lower cost of energy in the United States is likely to be a bigger competitive factor than the issues I am talking about—but they are not helping, and I do not hear the commercial sector complaining about it very much.

Jonathan Grant: Right now carbon prices are so low that I do not think they are driving investment decisions.

Guy Newey: Mr Stringer, I disagree. I think businesses are moaning about the costs of these policies all the time.

Graham Stringer: Businesses often do moan and I am surprised—

Guy Newey: I am constantly lobbied about the carbon floor price or ETS reform or their carbon reduction commitment or other things. If you are a business that is benefiting from a particular subsidy then you are probably in favour of that subsidy. But I would say there is lots of criticism going on with policy and then there is a balance between environmental risk versus the economic risk to individual businesses.

Q176 Graham Stringer: Given that the increased contribution from this country to carbon dioxide in the atmosphere is still less than 2%, why should we do anything? Why should we not wait until there is an international agreement that is legally binding on everybody? Whether it is the biggest factor in competitiveness, we are making ourselves less competitive

now and there is not an international agreement on the price of carbon or on mitigation effects at all. Why should we do anything?

Jonathan Grant: Any country apart from China and the US can make the same argument that their emissions are small relative to total anthropogenic emissions. I agree with you that having a global deal will be critical to addressing the problem, otherwise you are likely to just shift emissions around the world. In terms of taking action in the UK first, I think it is important for developing countries that developed countries show leadership in moving down the low carbon transition, and that unless the developed countries can start to show they are taking action on climate change it is going to be hard to persuade developing countries to follow suit.

Q177 Graham Stringer: That is what John Gummer says—that we should show leadership. I am never convinced that China is very interested in what we are doing with our policies. But do you think it is possible to cut our impacts with greenhouse gases without causing economic pain?

Guy Newey: At present, if you are talking about decarbonising electricity, those technologies are more expensive than coal, which is pretty cheap right now. The question for policymakers is, how do you balance the costs you are putting on this generation with the potential benefits that you may see later?

Q178 Graham Stringer: That was not quite the question I was asking about. That relies on discount rates and all sorts. I was asking whether we could decarbonise without economic pain.

Guy Newey: Only if we discovered a low-carbon or zero-carbon technology or set of technologies that were at the same cost or cheaper than current fossil fuel technologies.

Q179 Chair: Is it directly relevant to this subject that the time frame needs to be specified? We had some interesting discussion with the previous panel about whether you are trying to forecast the weather tomorrow, for 10 years or the end of the century. A lot of investment decisions are made in the light of not just what costs are today but what costs may be in 15 or 20 years time, particularly in the energy sector where very long-term decisions are made. Do you think it is conceivable that perhaps in the mid-2020s or by 2030 there might be a carbon price, whether in the form of carbon taxes or driven by emissions trading, that became a significant element in the cost structure of various businesses and that it would be wise to at least think about that today, even though it may not be in effect for another 10 years or so?

Jonathan Grant: Businesses in the past have already made investment decisions that incorporate the cost of carbon. Carbon was above €20 a tonne several years ago, and that did have an influence on investment decisions and, of course, on operational decisions. Do you burn coal or gas to generate electricity? While it is at €6 it sends a much weaker signal. But those policy signals will influence investment decisions and that is why you probably hear from the business community regularly that they seek clear long-term signals. It is a mantra that many in business will repeat.

Q180 Sir Robert Smith: Don't you think the experience of having planned for €20 and found it at €6 will have made them wary?

Jonathan Grant: I think that it has. There was a lot of investment in CDM projects in developing countries by businesses and the price of the carbon credits generated by those projects has fallen even more dramatically and is less than €1 now. Investment in those projects has fallen dramatically over the last couple of years as demand for those credits has dropped to very little. The efforts now are to reform the ETS in such a way that you have a clearer and longer signal in the market—an emissions cap out to 2030 and mechanisms of intervening in the market to avoid those significant price fluctuations that have resulted from the economic downturn across Europe.

Guy Newey: I think most businesses are factoring a carbon price of whatever level going forward to 2030, 2040, especially in the energy sector. They would be insane not to, I would have thought, in the current direction of travel of climate policy. Whether the policy and the changes to the ETS or the carbon price are able to match those shadow carbon prices that businesses impose is another question, but they are certainly factoring decisions now.

Jonathan Grant: While a central case might be today's price, they will do sensitivity analysis around that to look at the economics of the investment at a much higher price.

Q181 Dan Byles: On that specific point, is there not a real issue right now with the carbon floor price in the fact that it is not hedgeable? It is not predictable, it is an arbitrary political number and we do not know what it will be in 2020 or 2025 or 2030. I have had it put to me by companies who say it is a real impediment to some investments because they simply cannot hedge against that cost.

Guy Newey: To a certain extent, that is true and if you were designing a carbon tax with guarantee with a contract for difference based on it that would be an ideal policy instrument from a certainty point of view. That said, I am always slightly cautious of the kind of business certainty case because there are lots of other difficult, moveable, volatile factors going into investment decisions, such as oil prices, gas prices and so on. The question for policymakers is, how do you best design policy that gives you a general sense of direction but allows as much of the risk as possible to sit with people making investment decisions rather than consumers at home.

Q182 Dan Byles: But it is the case that for every one of those examples you mentioned, you can hedge against them for all markets, but there is no way of doing that with an arbitrary political cost. It is different.

Guy Newey: I am not an expert on carbon trading, but there are probably some products around carbon trading

Q183 Dan Byles: It has been put to me that it is a very real impediment to the economics of building new gas-fired power stations, for example. Above a certain level it becomes uneconomic and because it is an arbitrary political risk, people just cannot take the risk and

there is no way of hedging even against the cost. But we do not necessarily have to go down that route.

Jonathan Grant: But it is clear to business that it is rising to £30 by 2020, and that is a fairly clear signal. The level of support is uncertain because it depends on what the current EU allowance price is.

Q184 Dan Byles: I want to talk about climate change policy in the international context. Graham has touched on quite a few of these issues, but I want to explore them a little bit more. Guy, in the first instance, we have already talked a little bit about us being a small country. With large countries dropping out of the Kyoto process and with China not obliged to reduce greenhouse emissions under the Kyoto treaty, why should the UK continue with our tough carbon-cutting agenda in the face of mainstream global rivals who apparently are not?

Guy Newey: To go back to the point Mr Stringer was making, this is a collective action problem. Somebody has to move first and—

Dan Byles: It is like game theory almost.

Guy Newey: Exactly. In trying to think of a collective action problem of this level of difficulty, you are probably talking about the Cold War in terms of how you get people to act. First of all, it is really difficult and the question is, “Do you do nothing and wait for everyone or do you move forward?” But the most important thing the UK can do in climate policy is give an example to the rest of the world that decarbonisation does not have to be ruinous to your economy, that you can decarbonise in the most cost-effective way possible, that you take no-regrets measures that have non-climate benefits anyway. I would probably say that lots of our policy choices over the last 10 years have not helped make that case and that is the challenge going forward: can you convince people that decarbonisation can happen as cost-effectively as possible?

Q185 Dan Byles: This is probably a question for Mr Grant. Is there any evidence that the UK has become a less attractive place for companies to come to, based on our climate policies?

Jonathan Grant: I have not seen evidence about the competitiveness impacts of the UK’s climate change policies on investment or on business decisions. I think that is affected by all sorts of other factors: energy costs, ease of doing business, labour, the labour market. Those factors are probably more important than the carbon price.

Q186 Dan Byles: I know you have talked a bit already about, as you call it, the indirect carbon cost from imports. Do you not think there is a real danger that we could end up saddling higher costs on our domestic economy in the interests of reducing carbon emissions, but by focusing on geographical carbon emission measurements rather than consumption carbon measurements we are fooling ourselves into thinking we have done it? We could shut down our entire steel and aluminium industries and import steel and aluminium from China and our carbon emissions will have reduced, when our carbon consumption will have gone up because of the steel and aluminium we are still consuming. We are just importing it from

somewhere else. It is probably being produced less efficiently in terms of emissions and then it is being shipped halfway across the world. Do you not think that the way we currently measure things does not adequately capture that dynamic impact?

Jonathan Grant: Businesses primarily focus on their direct emissions from their operations rather than their indirect emissions, and that is particularly the case as you get to smaller companies. Of course, UK businesses are very international and have a very international footprint, so the implications of climate policy they are interested in are on the international scale. Some of the analysis we have done for DEFRA in the past year has shown that the impacts of climate change abroad could be much more significant than the direct impacts of climate change in the UK.

Q187 Dan Byles: Switching it round now, rather than looking at the concerns to the UK economy, to this whole issue of the potential impact on the developing economies, you have already suggested that if everybody is moving forward together it does not necessarily disadvantage certain economies. But developing economies are playing catch-up with developed economies. There has been some work done, particularly by the Tyndall Centre, who have suggested that if you are going to give developing economies the breathing space in carbon terms in order to develop their economies and come forward, that is going to significantly restrict, even more than we already are, the amount of carbon the developed economies can allow themselves to burn in the decades going forwards, if you see what I mean. Do you think we are adequately taking that sort of calculation into account? Are we giving developing economies room to breathe in carbon terms?

Jonathan Grant: One of the significant findings or points that the Fifth Assessment Report makes is about the carbon budget and the total amount of emissions that we can emit in order to stay within certain representative concentration pathways. I think that if you take that to its logical conclusion, instead of having the debate at the international level about X% reductions on 1990 levels or Y% reductions on 2005 levels, we have a mix of reduction targets, a mix of baselines, you should be looking at how much of that carbon budget is available and how that should be shared between developed and developing countries.

Q188 Dan Byles: That is very much the thrust of the Tyndall Centre's work, but they then calculated that there was virtually none left for us if we were going to genuinely—

Guy Newey: It depends on how you are going to divide it up. How you divide it up is a very difficult political problem, attempts at theories, common but differentiated responsibilities, how that fits in. It is extraordinarily difficult, but it is a political decision. There is no right answer you can come to, saying that the UK's proportion is X versus China's.

Q189 Dan Byles: But do you see any evidence that there is any real thinking going on among policymakers on that kind of question?

Guy Newey: There is a lot debate about it. I am sceptical about our ability to get a perfect international deal that will ever come forward. It seems to me it is going to come from the

bottom up of policy efforts at various different points and from technology development, so that we can produce energy or manufacture where there is low carbon at a reasonable cost. That is your best hope, I would have thought.

Jonathan Grant: In the international negotiations there is a lot of talk about limiting warming to 2°, but the reality of the targets that are suggested fall far short of that. We found that when we look at the emissions per unit of GDP across the G20 economies since the turn of the century, emissions per unit of GDP have fallen by about 0.7% per year. To get on to the 2° pathway, emissions per unit of GDP would need to fall 6% per year. To put that in perspective, when the UK dashed for gas in the 1990s it achieved 3% reductions per unit of GDP each year of that decade. When the French switched to nuclear in the 1980s they achieved 4%. What we are talking about is significant changes.

Dan Byles: Nobody has done it without a conscious effort previously. Nobody has done it, do you mean, through—

Jonathan Grant: Yes. Most of the reductions that we have seen since the turn of the century are the result of efficiency improvements rather than major shifts away from higher carbon—

Q190 Dan Byles: Out of interest, do you have the figures for the percentage reduction per GDP figure of the recent move by the US from coal to gas?

Jonathan Grant: Yes. In our low-carbon economy index the US were at the top. They achieved reductions in their carbon intensity of 5.9% in 2012. That was primarily the result of their switch from coal to shale gas for power generation. What has happened—and it highlights the importance of having a global deal—is that the price of coal was depressed and coal has been imported to Europe and we are now burning more of it in Europe.

Q191 Dan Byles: I see. Before I finish, Mr Painter, how challenging is this whole discussion about how large the UK contribution is internationally in, for want of a better word, public relations terms? It seems it is a very easy cry for people who are concerned about this to say China is building a new coal-fired power station every week. They increase their emissions by the whole of the UK's every X months or years. How difficult is that as a public perception challenge?

James Painter: I think it is very difficult. I must stress that my area is the media rather than public opinion polls, but it is one of the factors that when you measure people's willingness to take action at a personal level or believe that Governments should, one of the arguments that is often cited is why should we do it when other countries are not? It is an important obstacle to get over, but I would not have said that is the biggest driver of opposition to taking action.

Guy Newey: If you were going to design a problem for people not to care about it would be climate change. The effects are uncertain, they happen to people in other countries in future generations. There is plenty of evidence that there are some increased problems

with weather now, but there is future uncertainty. It is extraordinary that we get any policy action at all on this issue.

Dan Byles: That is a sort of positive note.

Q192 Chair: Returning to the point in the IPCC report about the total available consumption of carbon in the future, it seems to me a very helpful part of the report in that it focuses the debate in a different way. You have also very tellingly drawn attention to the enormous acceleration in decarbonisation per unit of GDP that is needed to get anywhere near where it is thought we need to be. There is a market solution available, at least in theory, is there not? If we were to have a global cap and trade system that capped what the IPCC conclusions show need to be the cap and simply auctioned those emissions to the highest bidder, we would have a global market-driven solution that would then allow businesses to make rational decisions about where they wanted to save carbon and whether one should invest in low-carbon technology. That is possible in theory at least, is it not?

Jonathan Grant: I think that when the Kyoto Protocol was being drafted the anticipation at that time was that more countries would sign up in subsequent years and that it allowed for that approach of setting an overall cap on emissions and allowing countries to trade between them. What has happened subsequently, as you know of course, is that a few countries have dropped out of it and there is still something of a divide between developed and developing countries within the negotiations about who should take action and who should not. What organisations like the International Emissions Trading Association are doing is working at a more bottom-up level to try to introduce those market-based approaches to tackling climate change. They are working with different national Governments to support the implementation of those cap and trade schemes and they are doing that in developing countries such as China, Chile, Korea and elsewhere.

Guy Newey: Theoretically it is possible that we will get a global deal and have a nice cap and trade system. But I think the more likely scenario is that we get a series of emissions trading schemes working individually, first of all, and then we go through the process of joining them up. It is still extraordinarily difficult, but I think it is a better chance than an international deal.

Q193 Chair: Yes. I did not expect to have a global top-down system achieved. But if you think about what is happening now, the EU, although only about 7% of the world's population, is still a quarter of the world's GDP. China has quite seriously piloted schemes in this area. It is 20% of the population and may not quite be there in GDP yet. In the US the biggest state, California, often regarded as the most advanced, has already started emissions trading. The bottom-up process could cover quite a big chunk of the world's GDP relatively soon.

Jonathan Grant: I think that is right and I do not think that will be sufficient because the challenge of staying within that carbon budget will have pretty significant implications for the way we do business.

Chair: Is there anything else any of you want to say that we have failed to ask? That is a disappointment. Thank you very much for coming in. We have had a very useful morning.

