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House of COMMONS

MINUTES OF EVIDENCE

TAKEN BEFORE

SCIENCE AND TECHNOLOGY COMMITTEE

(SCience and TEchnology sub-committee)**THE REGULATION OF GEOENGINEERING****WEDNESDAY 13 January 2010****DR JASON BLACKSTOCK, PROFESSOR DAVID KEITH and JOHN VIRGOE****SIR DAVID KING and DR MAARTEN VAN AALST****JOAN RUDDOCK MP, PROFESSOR DAVID MACKAY and PROFESSOR NICK PIDGEON**

Evidence heard in Public Questions 1 - 73

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Oral Evidence

Taken before the Science and Technology Committee

(Science and Technology Sub-Committee)

on Wednesday 13 January 2010

Members present

Mr Phil Willis, in the Chair

Mr Tim Boswell

Mr Ian Cawsey

Dr Brian Iddon

Graham Stringer

Memoranda submitted by Dr Jason Blackstock and John Virgoe

Examination of Witnesses

Witnesses: **Dr Jason Blackstock**, Fellow at the Centre for International Governance Innovation (CIGI) Canada and research scholar at the International Institute for Applied Systems Analysis (IIASA) Austria, **Professor David Keith**, Director, ISEEE Energy and Environmental Systems Group, University of Calgary, Canada, and **John Virgoe**, an expert in climate change policy, gave evidence via video link.

Chairman: Could I say a very warm welcome to our guests around the world and, indeed, thank you very much indeed for joining us at what must seem an unearthly hour. It is snowing here in London and I am sure you will tell us what it is like around the world. We are very tight to timescale, and I am going to ask each of you to introduce yourselves very, very briefly so that we know that our feed is up and live, but first I am going to introduce our Committee to you. I am Phil Willis, the Chairman of the Science and Technology Committee here in the House of Commons, and on my immediate right is?

Dr Iddon: Dr Brian Iddon, Member of Parliament for Bolton South-East, Labour.

Graham Stringer: Graham Stringer, Member of Parliament for Manchester, Blakely.

Mr Cawsey: Ian Cawsey, Member of Parliament for Brigg and Goole.

Mr Boswell: Tim Boswell, Member of Parliament for Daventry.

Q1 Chairman: And on my immediate left is Glenn McKee, the clerk. That is our panel this morning. I wonder if I could ask John Virgoe if you could identify yourself, please?

John Virgoe: I am John Virgoe. I am on the line here from Canberra, where we have been enjoying 38° today.

Q2 Chairman: Professor Keith?

Professor Keith: David Keith, University of Calgary, where it is around zero.

Q3 Chairman: What time in the morning is it?

Professor Keith: One-thirty. No, it must be two-thirty; sorry.

Q4 Chairman: Thank you very much indeed. Dr Blackstock?

Dr Blackstock: Yes, is the audio working at this point in time?

Q5 Chairman: It certainly is: yes.

Dr Blackstock: Wonderful. I am Jason Blackstock from the International Institute for Applied Systems Analysis and the Centre for International Governance Innovation. I am in Boston right now and it is four-thirty in the morning and about 0° Celsius as well.

Q6 Chairman: John Virgoe, I wonder if I could start with you. It has been suggested that there is a need for geoengineering intervention. First of all, do you think that there is and do you agree that it needs global regulation?

John Virgoe: On the need, I think it would be premature to make that judgment at this point. The state of knowledge about geoengineering, both on the technical side but also on the political, ethical and regulatory sides, is simply not at a point where I think any sensible person would be able to recommend that we should be implementing a geoengineering technique at this point. I think, however, there is increasing reason to think that we may be heading that way in the future. I suppose it depends to some extent on your degree of optimism about whether the world will actually get on top of global warming through the mitigation methods and through international negotiations. If we believe that we may be heading in that direction and that in some years from now (and I would not like to put a figure on it) we may be looking seriously at a geoengineering intervention, I think it does make sense for us to be starting, at this point, not only to research the science and the technology, but also to think through some of these issues around the politics and the regulation so that when we do get to the point, if we get to that that point, where we want to go ahead with these sorts of acts, we have thought about it and we are in a position to take a mature, measured and informed decision.

Q7 Chairman: Dr Blackstock, if we take John Virgoe's position as a sensible starting point, there is a huge number of international conventions with the potential to regulate geoengineering. Is there sufficient out there, or do we need to establish new positions? Dr Blackstock, can you hear me?

Dr Blackstock: Yes, I can.

Q8 Chairman: I was just saying that there is a huge number of international conventions with the potential to regulate geoengineering. Is that so, or do we need new ones?

Dr Blackstock: I think this depends in part on the types of geoengineering that you are talking about. Geoengineering is not a monolithic subject. The differences between carbon dioxide removal and solar radiation management and even, within carbon dioxide removal, the types that are engineered and, therefore, can be done on a global scale versus the ecosystem management, each of them requires different types of regulation, different regulatory structures. I think that for the engineering of carbon dioxide removal we do have methods in place that can fit largely within the local and national regulatory structures, but once you start getting into managing ecosystems or interventions into ecosystems at a larger scale across borders, we start to have more questions. CDR that is ecosystem-based, like ocean fertilisation, has already gone to the Convention on Biological Diversity and the London Convention and we have some regulatory mechanisms there. For solar radiation management I think we really lack the regulatory structure right now, and because solar radiation management - the sort of techniques of stratospheric aerosols, cloud whitening - are the only category of techniques that could be used with a rapid impact on the climate system if we were to intervene, I think that we need to get these regulatory structures in place before large scale field tests are implemented. Because even when you start talking about field testing solar radiation management techniques, you start running into the potential for transboundary impacts, or at least a perception of transboundary impacts, and so international mistrust, international concern of what another country will do with that technology can come up very rapidly.

Q9 Chairman: Are you saying, Dr Blackstock, that the Convention on Biological Diversity would be a good starting point, or are you saying that that is sufficient?

Dr Blackstock: I am saying that for the different techniques we need different systems. There will not be (and I do not think we should think of there being) one framework which is sufficient to regulate geoengineering as a whole. If we differentiate the categories of geoengineering into the two broad categories of carbon dioxide removal and solar radiation management, I think those techniques that aim to remove carbon dioxide from the atmosphere, we largely have the appropriate regulatory mechanisms. There are some changes that could be made, but they largely exist. For solar radiation management, on the other hand, I believe we do not have the appropriate regulatory mechanisms in place, and I do not believe we have even a forum in which that discussion has begun to occur. I think we need more discussion at the international level of what type of regulatory mechanisms are needed, and that discussion should begin soon.

Q10 Chairman: Mr Virgoe, you disagree with that? You feel that we need a single regulatory body. I just wonder if you would let our Committee know how you think that that could work.

John Virgoe: In fact, I do not disagree with that; I agree with almost everything that Dr Blackstock said at that point. I certainly agree that when we are talking about CO₂ removal, the aspiration, at least, must be to make this part of a broader greenhouse gas management regulatory structure; that once we have addressed the issues around

measurability, verification, the efficiency of some of these methods, then, ideally, we will be looking to see these methods implemented as part of a portfolio, if the price makes it sensible to do it that way. So that the countries faced with emissions reduction targets would have the option, and it would be a market-driven process, to what extent they wished to meet those. I agree with him entirely. We do not have the structures in place which would allow us to take the decisions and to regulate that process. The one area that I would differ slightly with him on that is I would certainly agree that we need to start the conversations around these issues as soon as possible, but that does not mean that we should necessarily be jumping straight into an international negotiation. The state of knowledge around these techniques and the possible unintended consequences is such that I just do not think we have enough knowledge to get into that sort of international negotiation and that actually getting into that international negotiation could lead us to some unwanted consequences, but I certainly think that we need to start the discussion and we need to start the discussion, in particular, around how we are going to manage the process of researching these things.

Q11 Chairman: Professor Keith, we have just had a rather disappointing Copenhagen summit with, arguably, science coalescing around a clear understanding that the planet is warming up and that we need to take very, very drastic action. We have still failed to be able to get the sorts of compensation agreements to support countries that require a great deal of support in order to put in carbon mitigation measures. How do you feel? Do you feel that there would need to be significant compensation for geoengineering which might be deployed by one nation but have quite a significant effect on another? Do you think it is possible to work that out?

Professor Keith: I cannot see the video. Can you hear me?

Q12 Chairman: We can hear you, so please carry on. We can see you now as well.

Professor Keith: Again, talking about geoengineering in general is almost meaningless, because there are completely different things in that project. I think the question really refers to solar radiation management, and that is governance is central at the point where we lock it, and the reason is that it is so cheap that the challenge for the international system will be to restrain unilateral action. It is precisely the opposite, or the converse, of the kind of challenge we face to reducing CO₂ emissions, but the challenge is to incentive as a collective act. I think we will need methods to do that and, indeed, those may be some of the most challenging developments, some of the most challenging the international community has ever faced. I do not think it makes sense to begin now to develop the full mechanisms for managing full-scale deployment, because I think we simply do not know enough. I agree with what John Virgoe has said. The crucial thing now is to think about how to start doing this from the bottom up through the management of a research programme in an international and transparent way. From the bottom up does not mean just that the scientists decide - that is certainly not the right answer - but it means, I think, that it would be premature to start a full UN scale EU Court treaty process, because it is simply not clear yet what the capacities are and states, individuals, have not had long enough to consider seriously what the trade-offs are.

Q13 Chairman: Very briefly, before I pass you on to Dr Iddon, it has certainly come to my attention that there is a real worry that the military use of geoengineering might become an attractive proposition for some countries. Is that something that worries you?

Professor Keith: Yes.

John Virgoe: I understand the concern. I am not a lawyer, but my understanding is that such action would actually be prohibited by the 1977 ENMOD Convention, which does outlaw the hostile or military use of environmental modification techniques. That does not mean, however, that the development of these sorts of techniques would not give rise to concerns, and that is certainly the case if militaries or, indeed, powerful governments were seen to be involved in developing some of these techniques. If we decide to move ahead with researching and possibly deploying these sorts of techniques, I think one of the big challenges for the world will be how do you actually deal with those sort of concerns? As I say, I think the legal position is that this would not be allowed under the Convention, but that does not mean there would not be concerns about it.

Q14 Chairman: Professor Keith.

Professor Keith: I would echo Mr Virgoe's comments on this. Let us try getting a scenario on the table. If a very small state, right now, decided to go out and deploy geoengineering with no prior consultation and with no adequate margin to go on, then, whether or not we had some prearranged international regime, it is pretty clear that the great powers would stop that small state. On the other hand, if a large state - and that does not necessarily mean a rich first-world country - began a serious ten-year programme of geoengineering research, subscale testing, and if that programme has international transparency in the form of an advisory committee that had some of the world's best scientists, and then that state moved, after, say, a decade, to say, "We are going to begin slowly and incrementally subscale deployment because we feel it will protect our world's interests", it would be extremely hard to stop. That state would effectively seize the initiative, especially if it was a nuclear power state. The reality here is that there are limits to what we can do in international law because, in the end, this gets to the core national interest. That is not to say we should not try, because, I think, in the end, the stability of the world is going to depend on this over time, but I would use this example to give you a sense of just how valuable it will be. Let us say China decided to do some modification that they think will improve their monsoon but make India's monsoon worse: that will not be directly, as

John says, prohibited by an ENMOD treaty, but there is no question that will have a military response on all sides.

Dr Blackstock: I would build on Professor Keith's statement quickly and say that those two scenarios that he painted are the ends of the spectrum of possibilities, but as geoengineering research is developing, particularly on solar radiation management, somewhere in the middle ground seems more likely at this stage, where powerful nations begin research programmes on geoengineering and other states' perceptions of how transparent that is. For example, the EU, the UK and the US are all having these conversations about geoengineering; developing countries are not yet present. We need to consider the knock-on consequences of that middle ground perception that powerful countries are beginning to develop these technologies and may be pursuing not necessarily militaristic interests, but simply national climatic interests by developing these technologies. For example, on the next attempt at Copenhagen, the next attempt to get mitigation discussions going, there will be these arguments. I would agree with Mr Virgoe, we are not ready for international negotiations, but, I think, particularly by countries that are now starting serious geoengineering research, there needs to be an attempt to engage a broader dialogue with those countries which would otherwise feel marginalised on these subjects.

Q15 Mr Boswell: My specific question was about the regulation of these processes and what might be termed the international validation of them. It would seem to me (and this prompted my asking to intervene) that the UN Charter and the principle of self-defence, at one level, could actually be invoked by a nation state who wanted to do this by saying, "It is essential we do this in order to protect ourselves." Perhaps you would like to comment on that. Secondly, there is some analogy with the development of nuclear programmes, for example, in states which are not at the moment nuclear weapon states. There may be some suggestion that they are able to shelter under civilian regimes in order to develop what are essentially nuclear military programmes. Do you have any comments on those two?

Professor Keith: Let me pick up on the connection of nuclear weapons and point out that we do not just succeed on an international basis by formal treaties. Normal behaviour is very important, even if they are not formally within a treaty. So the norm that said no state should have that first use of nuclear weapons, no first use for them, had a profound role in the Cold War and yet it was not the core of any treaty. I think what we need to develop here are both norms and treaties and we should not look at necessarily getting through a written treaty.

Chairman: I am going to leave that there and bring in Dr Brian Iddon.

Q16 Dr Iddon: Good morning, gentlemen. Are we quite clear about the width of geoengineering? What I mean by that is that weather-changing techniques such as cloud seeding might be considered to be geoengineering. Do you encompass those techniques within your definition? Could we start with John Virgoe perhaps?

John Virgoe: I certainly would not encompass that. One of the criteria for me for geoengineering is that the effect needs to be at a global level, and cloud seeding is a weather modification technique. We should not get hung up, though, on the precise definition of geoengineering for a couple of reasons. One is that the term is a very scary term and I think it does inhibit sensible debate around these techniques. The second is that the term has come to encompass at least two quite different things which are both technically different. I am talking about techniques for solar radiation management on the one hand and for taking CO₂ or other green house gases out of the atmosphere on the other. They are quite different technically but also in terms of their non-technological implications. Certainly I find it more helpful to think in terms of unconventional or complementary techniques and then to look at them one by one. I think the category of geoengineering is possibly starting to no longer be a particularly helpful one.

Q17 Dr Iddon: Professor Keith, do you agree or disagree with John Virgoe?

Professor Keith: I strongly agree. I think all three of us have said that in different ways. Let us try and help this by being specific. If biochar is geoengineering, it certainly does not bring out the kinds of direct international security concerns that are brought out by the capacity to do stratosphere solar radiation management, and the reason is all about leverage and money. The fact is that with the right technology it may be cheap enough, through engineering the stratosphere, that literally individual human beings may have the wealth necessary to introduce an ice age. I say that to be deliberately provocative, but there is evidence that is in fact correct, and that enormous leverage - the concept being so cheap - means that the threat of unilateral action is real and the impacts could be very substantial. There is no comparable issue with, say, biochar, and for that reason the sort of regulation management we need is completely different.

Q18 Dr Iddon: Dr Blackstock, do you have any comment?

Dr Blackstock: I would echo the comments that were just made and build on them, just saying that it is the transboundary impacts, the impacts that go beyond the boundary of one country, that are really going to drive the international regulatory frameworks that we need to develop, and so for a working definition of geoengineering there is obviously the question of intentional intervention requirements. As David Keith just raised, biochar does have the intent of keeping the global atmospheric concentrations of CO₂ down, but the near-term transboundary impacts are minimal. When we think of developing regulatory structures for what we class as geoengineering, our primary concern should be about how large is the transboundary impact and how soon will that transboundary impact

manifest? This is what focuses a lot of the conversation that you heard on solar radiation management, the fact that that can impact the climate system in the near-term, whereas the CDR techniques, the carbon dioxide removal techniques, have a much longer time lag behind them. Just to echo the last question that was asked about nuclear technology and build-up - Professor Keith's point - as David mentioned a couple of times now, solar radiation management technologies appear relatively cheap, which also means relatively technically simplistic. Therefore, the analogy to nuclear technologies becomes much more challenging, because most of the technologies required to actually deploy solar radiation management are things that are available to numerous countries already. These are not technologies that require huge technological progress from where existing technologies are at. The idea that we can potentially regulate and control the technology underlying solar radiation management, like we do, or attempt to do, with nuclear technologies, is not a good analogy for this. The technology is going to proliferate and be accessible to a large number of individuals or countries and, therefore, we have to look at controlling behaviours in this case, not just access to technology.

Q19 Dr Iddon: My second question is about risk. Should we be categorising geoengineering techniques as low risk, medium risk and high risk? If you agree with that, should there be separate regulatory regimes for each risk area? Could I start with Dr Blackstock, please.

Dr Blackstock: Simply having three categories of low, medium and high risk, as all three of us have already echoed, there are slightly different things that you would want to lump into categories, that you would want to define the technologies according to, and I think what you have heard echoed here already is an attempt to classify these things in precisely that way. The high risk technologies in this case that we have been discussing, high risk geoengineering methods, are those of solar radiation management because of the cheap and easy technology for implementation, the near-term impact it can have and, therefore, the potential for unilateral action. That creates a high risk category that does require a different type of regulatory framework than, for example, is necessary for biochar or the other carbon dioxide removal techniques, that is a useful framework of low key and higher risk, but understanding why those classifications of higher risk versus lower risk are made will be a very important part of any regulatory framework. That echoes Mr Virgoe's comment that we need a lot more research to understand the science underlying these techniques before going for full-scale negotiations and real international regulation.

Q20 Dr Iddon: Professor Keith, do you agree?

Professor Keith: Yes, generally I agree with what Dr Blackstock has said. I think that categorising things like the amount of leverage might be more useful than boundaries. There are things like that, low leverage, where it is implausible for a small amount of money or a small stated effective load and may have high or low risk, and those things do not need a kind of international governance that they will eventually need for these high leverage technologies like solar radiation management. I think actually that high, low, medium risk categorisation is not a particularly useful way to think about overall governance. We need to think about the specific, very different timescale and leverage differences.

Q21 Dr Iddon: John Virgoe, finally?

John Virgoe: I would agree with both of those comments and just observe that I think we are talking about a number of different sorts of risk here, and it is going to be important to pick these apart. There are environmental risks, risks of things going wrong or risks of unintended side effects. There are also political risks, and we have touched on some of these already, and I think there are a number of other potential political risks, risks to the international system, to multilateral or bilateral relations. It is something that particularly concerns me. There is clearly a risk that the techniques do not work and there are also risks around things like legal issues and liability. I think there is a whole range of different risks, and we probably need quite a sophisticated framework for assessing those, but ultimately, you are right, we will be in the business of balancing risks and balancing them against the risk of runaway climate change essentially.

Dr Iddon: Thank you, gentlemen.

Q22 Mr Boswell: I will start with Mr Virgoe, if I may. In your paper, which is very helpful, you suggested developing guidelines that would apply to the whole area of research into geoengineering. My first question is: who should be formulating these? Should this be individual governments, international organisations or, possibly, some kind of consortia of academics or NGOs that does it?

John Virgoe: I think that is an extremely interesting question. I do think that the development of, I suppose, what might more appropriately be called norms or principles is the first task and is a particularly urgent task given the urgent need to restrain what we might call irresponsible entrepreneurial activity in this field. We need to develop these norms and we need to socialise them among the community of nations, the community of scientists and other stakeholders. How do we do that? As I suggested earlier, I do not see turning, in the early instance, to the international multilateral process, DECC naming it a treaty, as the right way to go in this. I think the state of international understanding and also the knowledge base is currently so weak that you could get outcomes that would not be the right one. I think it is very possible to imagine, if this is put on the table in some sort of UN forum, you could end up with a decision, basically, to make geoengineering a taboo, to outlaw it, and that would be a mistake, for a couple of reasons. One is that it may be that we actually need to be doing this research and that, some decades down the line, we will be very sorry if we have not started thinking through these techniques. The

second is that I think there are a lot of actors out there, as we have all already said several times, with the capacity to research and implement these techniques. Some of them may not feel bound by that sort of international decision, some of them may not be as responsible, and it would be very unfortunate if what geoengineering research was happening was going on under the radar screen, if you like. What we need is an open process which builds on some of the principles that are already out there around similar issues; for example, principles developed to deal with long-range air pollution where there are modification principles around openness, transparency and research, notifying a neighbouring country or countries which might be affected. We probably develop these through maybe a slightly messier process than an international negotiation. Individual countries will have a role; communities of scientists will certainly have a role. I think if you look at some analogues, for example, around genetic engineering, fusion physics or, indeed, carbon capture and storage, to come a bit closer to home, you can see examples where research norms and principles have been developed almost from the bottom up in that way involving (?) or groups of scientists, other stakeholders and interested countries.

Q23 Mr Boswell: That is very helpful. Would the other two, Professor Keith or Dr Blackstock, like to comment?

Professor Keith: Yes. I think there is a role for bottom-up generation of norms that has to start most of all with just transparency alone. I think there are parts of the international scientific community, such as the national academies and bodies that link the national academies, such as the InterAcademy Council, that can play an important role here. That is not to say that this should just be the domain of scientists, because it should not. It is vital that we find a way to get a larger set of witnesses in here, not have a reality or perception that the scientific community alone are deciding what to do purely based on research. One of the wonderful things about the global scientific community has been its ability to operate internationally and have some level of transparency even in the middle of the Cold War, and I think that building on that is a certain key way to start but it needs to be done in many places, and we need to have different efforts to develop these norms of behaviour going on, whilst I think it would be a mistake to go for a single, unified system too early.

Dr Blackstock: Could I just add one thing on top of what my colleagues have said, which is that when speaking about research on low scales where the research itself has no transboundary impact - for example developing the deployment technologies, laboratory research, computational modelling - for that the framework of developing norms within the scientific community as a bottom-up process, I think, is very political and will work well. I am more sceptical, however, when we start talking about field tests, particularly what Professor Keith has been referring to as high leverage geoengineering technologies, which are specifically the solar radiation management type. When we start talking about field tests, it is a question of ---

Q24 Mr Boswell: I interrupt you. Typically crossing national boundaries at that level. The field test would be typical.

Dr Blackstock: Yes, at some scale you can do what you refer to as subscale field tests, which are tests of such a small scale that they do not have transboundary impact, but defining where that boundary is between subscale and actually having transboundary impact - and this goes a little bit to what Mr Virgoe has just said - there are two types of risk. There is the actual technical risk, the environmental risk, but then there is the political risk in just the perception. One can conduct what is nominally a subscale test, but the political perceptions of your neighbours can be different to that, and so when talking about the types of research that begin to get into actual environmental testing of these technologies, I think we have to be more cautious about what we are seeing, based on norms alone, prior to a political agreement. We saw an example of this in this last year with the ocean fertilisation experiment, the Lohafex example, that was the Indo-German collaboration that ran it, and the political controversy that emerged surrounding that. Nominally that test would have had very subscale impacts in terms of the ecosystems and certainly in terms of transboundary, yet the political controversy agreed because of the perceptions and the fact that the Convention on Biological Diversity and the London Convention had already been discussing these issues. When you start doing field tests, you start raising more political issues. I think the consideration of the norms is partly necessary but not sufficient to address the sort of political issues that will raise.

Q25 Mr Boswell: The second question is really for all of you. By prefacing it, I think I would say that it sounds to me as if the words "norms", "guidelines" and "principles" are pretty well interchangeable, and you might like to comment on that, but a group of leading academics have suggested five key principles - that is the word they use - for guiding research. Broadly, first of all, that geoengineering be regulated as a public good; secondly, the importance of public participation in decision-making; thirdly, disclosure of geoengineering research and open publication of results; fourthly, the independent assessment of impacts; and, fifthly, governance before deployment. I think that last one implies that you start the guidelines and you work on the governance at the stage where you need to perhaps develop specific research projects. They sound pretty good to me at first sight, but are they practicable as a basis for at least starting to consider the acceptability of research? Would Dr Virgoe like to start on that, or whoever?

John Virgoe: I am happy to go first, but I should say I am not a doctor.

Q26 Mr Boswell: I am sorry.

John Virgoe: On the five key principles, I also agree that they sound pretty good at first sight, or at least three of them do. I would absolutely agree with the principle of open publication and disclosure of research. I think this is

absolutely key. The surest way to excite international suspicion about what you are doing is not to be open about it, and that applies whether you are a community scientist or whether you are government, of course. Starting with governance first, independent assessment of impacts sounds like a good idea to me as well. The two that I have some question marks over are the first two, however. Implementation in the public good. Yes, it is motherhood and apple pie, but I think when you delve below that you have to ask: who is the public in this case? The global public. We are talking about interventions which will affect the planet as a whole, and there are number of publics out there. There are some publics out there who are suffering very badly, or will be suffering very badly, from the effects of climate change. There are some populations out there who may have seen some benefit from climate change and, therefore, not be very happy to see climate change being put into reverse gear, if we were ever able to achieve that. The impact of some of these techniques is likely to be heavily differentiated. It is not necessarily the case that we will simply be able to slow climate change or put it into reverse at the same rate across the world. You may find some areas were continuing to warm, other areas cooling faster and, of course, unintentional side effects. I think once you peer below the surface of the public good, it becomes quite hard to define it and you get into some difficult ethical territory. As far as public participation is concerned, again it sounds good, but I find it hard to imagine quite what that means at the global level. How do you actually bring about public participation at the global level and how do you ensure that certain parts of the public, or the public in certain countries, do not have privileged access compared with other countries, publics or other parts of the global public?

Q27 Chairman: Could I ask you to be as brief as you can, because I am desperately trying to get in another set of questions before we run out of our link. Can I ask you to be very brief in your answers, please. Dr Keith?

Professor Keith: I want to return to a previous conversation, because I think it got on to the key point where there is a little disagreement probably between us. Dr Blackstock was suggesting that we need to have political agreement before we do any subscale testing. I would submit that that is problematic. For one thing, the Russians are already doing subscale testing. For another thing, it has recently become clear that, despite all the talk about stratospheric geoengineering, the main method people talk about basically does not work. That is, if you put sulphur in the stratosphere the way we have been assuming, it does not do what we thought. You could do tests on this (?). These would have no detectable climate effect, but they would be subscale tests, and if we want to actually understand whether this technology works or it does not, we need to do those tests relatively soon. If we say we are not going to allow them until we have a political agreement, essentially that gives a veto to any power that does not want to see that. I think we have to really think hard about whether that would be an appropriate strategy or whether the default outcome of that would be that there was no serious progress in our standard of understanding.

Dr Blackstock: I would quickly respond to Professor Keith's point and say I agree with most of what he has just said. The issue that I am trying to raise is the question of how the politics play out. As he pointed out, Russia has begun doing subscale field tests, and they are extremely subscale, at a point where there will clearly be no transboundary impact. While I would agree that we want to progress our science - and we will need to do some of this subscale testing to understand the feasibility of some of these technologies - we want some international mechanism, some mechanism of legitimacy, for defining what subscale actually means to begin with, and then, before we start pushing the boundaries of what questionability of subscale, that is, I believe, where we really need to have, not just scientific, but political agreement. As Professor Keith raised before, the international grouping of national academies could be the right body for being able to make a declared statement of a subscale test being actually subscale, but there will be cases where the politics will overrun that and individual scientists, and particularly nation states supportive of subscale testing, need to be very aware of the political issues it can raise and be proactive. In responding directly to this last question, norms, guidelines and principles are all, I feel, interchangeable words, but what I think needs to be considered are commitments. There are some debaters that have operationalised these principles, but I think that nation states who are now starting to fund research, particularly if it goes to funding subscale experimentation, we need to ask what preventive commitments, what precautionary commitments nation states need to make about the sort of research and transparency that they are going to want to commit to up front in order to avoid exacerbating all the mistrust that already exists within the international climate arena.

Q28 Mr Cawsey: Mr Virgoe, in your written submission to us, you make the point that it would be necessary to be cautious in the way international debate on geoengineering is initiated. Indeed, you went further to say it may well be banned in line with the precautionary principle if we do not. Why do you think this might happen? Should we prevent it and, indeed, can we?

John Virgoe: I think we can try to prevent it by being careful in the way that we raise the issue. To take a very crude example, if you were to take a proposal around geoengineering straight to the floor of the United Nations, in whatever format you liked, you have to think about the politics of how countries would respond to that. At the moment the state of knowledge around geoengineering, the state of understanding, is not great. I think a number of countries will be very alarmed by that proposal. A number of countries might see it as an attempt by the developed nations to escape from having to make cuts in their greenhouse gas emissions; others might be very excited to hear about this potential solution to climate change. I think the consequences of that sort of unprepared debate in that sort of format would be very unpredictable, but you might get a decision of one extreme or the other, either to ban geoengineering or to rush ahead with it when we are really not at the point where we can say that this is at all a sensible road to be going down. That is why I am arguing for a much more cautious and bottom-up approach to putting this on the international agenda.

Q29 Mr Cawsey: The UK's Natural Environment Research Council has launched a public consultation on geoengineering and it has asked for comments on two topics: what are your thoughts on the hopes and concerns

about the potential use of geoengineering technology and what questions people should be asked about the future of geoengineering research? Is that going too far too quickly, or is that sensible? Do you support that consultation and what issues and options should be considered? I will start with Mr Virgoe, but I would be interested in what other witnesses have to say as well.

John Virgoe: I thought that was a very interesting initiative and seems to me to be a sensible way of starting to start debate.

Q30 Mr Cawsey: Professor Keith?

Professor Keith: For other consultations to really work, it requires more than just having an open door for the public to pour comments. I think that is a necessity but it is really not sufficient. Good public consultation requires help to give members of the public the tools to ask scientists what is going on and understanding the technical facts, and it typically is more effective if a small group of representatives of the public get to debate and work issues out for themselves and then report. There are various methods of this kind of symmetrical democracy that can work, and I think that pure kind of classic consultation patterns may not be all that helpful.

Dr Blackstock: I agree. I would echo that statement from Professor Keith that a more active educational role or involvement in education about these ideas is essential. I would just build back up to something that Mr Virgoe raised in his framing of how we could go wrong by rushing forward in the international community. This programme of starting communications within the UK is a good start, but because of the truly international scope of these geoengineering technologies that we are talking about, we have to ask ourselves who are going to be some of the most sensitive communities within the international sphere who we definitely need to take a proactive role engaging in the conversation early. I can think particularly about countries who already have populations marginalised in terms of climate change or are on the edge of suffering from climate change impacts, because those marginalised populations are likely to be the ones most sensitive to geoengineering experiments and a high level of solar radiation management experiments and particularly implementation. There is that risk that without directive public engagement, an attempt to reach out and provide the information proactively and indeed in a conversation, that we end up with them inevitably being surprised later on by rapid climate change impacts for these technologies which can lead to the unilateral and rash actions that we have been trying to steer that by doing informed research and responsible research we can hopefully avoid, but that requires international public consultation, not just domestic.

Q31 Mr Cawsey: I was going to go on about the Engineering and Physical Sciences Research Council undertaking workshops and sandpit events and ask if you thought other countries should do the same or whether it should be internationally focused, but you are clearly saying you think this should be an international endeavour, not just done by individual states?

Dr Blackstock: That would be my opinion on this, yes.

Q32 Mr Cawsey: Mr Virgoe?

John Virgoe: Certainly I agree with all of that. I think you have to look at the physical structures in some of the countries that I think we are referring to and ask yourself whether going straight to public consultation nationally would actually make sense, but the broad principle that we have to avoid anybody, any country, certainly any powerful country, feeling either threatened, or suspicious, or surprised by any action or discussions we may be having in this area: I absolutely agree with that principle.

Q33 Chairman: I will have to call this session to a halt. I am sorry, Dr Keith, not to bring you in there. Could I thank you all very much indeed for joining us on what is the beginning of a journey. It is a piece of work we are doing jointly with the US Congress Science and Technology Committee, but we thank you very much indeed, Dr Blackstock, Professor Keith and John Virgoe, for your help in answering our questions this morning. We wish you either a good night or a good morning. Thank you very much indeed.

John Virgoe: Thank you.

Witnesses: **Sir David King**, Director of the Smith School of Enterprise and the Environment and former Government Chief Scientific Adviser, and **Dr Maarten van Aalst**, Associate Director and Lead Climate Specialist at the Red Cross/Red Crescent Climate Centre, gave evidence.

Chairman: We welcome our second panel this morning, Dr Maarten van Aalst, who has flown in this morning from Holland - and we thank you very much indeed, Maarten, for doing that - and an old friend of the Science and Technology Committee, former Government Chief Scientific Adviser, Dr Sir David King. Sadly, we have lost our third panel member, Dr Kilaparti Ramakrishna, who should have been coming to us from India. Unfortunately, our video link has not worked, which is sad, but it means we have more time for our other two distinguished witnesses this morning. I wonder if I could start with you, Graham Stringer, in this round of questioning.

Q34 Graham Stringer: Should we be putting a lot of investment into geoengineering research at the present time?

Sir David King: Good morning. I am delighted to be here. Could I congratulate you on conducting much of this by video conference, which must have saved a lot of carbon dioxide, and in a sense that reply addresses this question: because, quite clearly, the major effort has to be around defossilising our economies, and the point about defossilising our economies is that it manages a problem which is an anthropogenic problem directly rather than indirectly, which is what we have been discussing this morning. It gets right to the root of the problem. I think that, while there are real concerns about what the impact on economic growth might be, I do not really share those concerns. If we manage the transition over the next 40 years into a defossilised economy, I think we can manage it and, at the same time, even get a boost to growth through the innovation that follows from this necessity to move away from high-carbon technologies. The shorter answer to your question is, however (and it is a very important however), we need to factor in the probability distribution functions that the best science can deliver around what the temperature rise for the planet will be even at a level, let us say, of 450 parts per million of greenhouse gas CO₂ equivalent in the atmosphere. The best that science can tell us at the moment is that the eventual temperature rise is going to lie somewhere between 1° Centigrade and 4° Centigrade with a peak in that probability distribution function above 2° Centigrade, and so we only have a 50 per cent chance of staying below a 2° Centigrade rise. There is still, for example, a 20 per cent chance that the temperature rise will be above 3.5° Centigrade, and I am putting to you the idea that the 450 parts per million figure is what we ought to aim for globally - it is the lowest figure that is manageable - but even there we have to manage risks by keeping in reserve an alternative way forward.

Q35 Graham Stringer: Dr Aalst?

Dr Aalst: First of all, let me say that I am not speaking on behalf of either the British Red Cross or the International Federation of Red Cross/Red Crescent Societies but in a personal expert capacity. I would echo many of these remarks. I think we need to be cautious of investing at too large a scale to even give the impression that this is a suitable alternative in the short-term to mitigation or, I would add, much more extensive capacity building and adaptation, especially among the most vulnerable groups, so I would just add to that. On the side of the risks, I agree that it is something that we might want to have up our sleeves, and we are nowhere near the level of certainty about what these different options are that we could consider these options that we have at this stage, so further research, in that sense, on a small scale to get slightly further in our understanding would be important. To give you my primary perspective on that right away, it is not about what is per square metre, it is about people. I think in looking at those options, those distributional effects (and, in particular, the effects on the groups already most affected by climate change as we see it progressing and the end of the probability distribution, not just in terms of the global temperature rise but also the impacts from there) would be crucial.

Q36 Graham Stringer: Sir David, when you were advising on the preparation for the Climate Change Bill - and one part of good regulation is that you look at different alternatives to the proposals in the Climate Change Bill - did you seriously consider geoengineering and the costs and benefits of geoengineering as against CO₂ reduction?

Sir David King: I think the answer is, yes, seriously consider, but then, following the answer to your previous question, I do not see that what we are now discussing with geoengineering issues should be a high profile way forward. In other words, it is something, to repeat, that should be there, kept in reserve, there should be a significant effort made both into research and into regulation at this stage, but I do not think that the effort should match in any way.

Q37 Graham Stringer: I understand the arguments. I suppose what I am really asking is when you were doing the regulatory impact assessment on the Climate Change Bill did you quantify the costs and benefits of geoengineering against the mitigation of carbon dioxide?

Sir David King: A very simple answer is, no, simply because the cost of carbon dioxide capture from the top end of a coal-fired power station is already rather large and there is a much higher density of carbon dioxide at that point of the atmosphere than in the general atmosphere, where it is only 400 parts per million. The cost at our present estimate is already expensive from the top end of a coal-fired power station and, in my view, is prohibitive. It was not eliminated without examination.

Q38 Graham Stringer: Geoengineering is going up the agenda in a way: more people are talking about it. Where do you think the pressure is coming from for a greater investment in geoengineering? Is it from industry, NGOs, people who are profoundly sceptical about global warming?

Sir David King: I do not think it is any of the above. I think it is more pressure coming from people who (a) are concerned about us not managing the problem by defossilising, but (b) a group of people who do not wish to go down the defossilising route and would like to provide an alternative, and I fear that there may be quite a largish group emerging, particularly in the United States, which come from that particular line.

Dr van Aalst: Yes, that is my impression as well. I think on the scientific side, this debate was probably started by people with a genuine concern, wanting to map out these options for that tail end of distribution. I think we are now in a shift, and with political attention growing, there is also political attention from the other side. I would also be

cautious, including the caution of establishing very large research programmes which might be interpreted as on a similar scale as the investments we are making in mitigation and adaptation.

Q39 Graham Stringer: I was going to say, do you think that the risks are too high to consider geoengineering, but in a sense, you have already answered that question by saying we should have it in reserve. It might be a more pertinent question to ask: what do you think the major risks of geoengineering are?

Sir David King: I think if I can now adopt the same approach as the previous group, we need to separate geoengineering into carbon dioxide capture and solar radiation management. In terms of solar radiation management, my own view is that there should be, if possible, a temporary ban on solar radiation management. I think the unintended consequences of that are extremely difficult to foresee. I am all in favour of research that would examine possible consequences of putting aerosols up in the stratosphere to reflect radiation away. The concerns expressed by the previous group I would match as well, the total cost of managing to put sulphates into the stratosphere is relatively small, and the technology is there, and I do think that this is something that needs to be addressed immediately, but now moving on to carbon dioxide capture, carbon dioxide capture should be dealt with as well in two forms: one is capture from the atmosphere, and one is capture from the oceans. I think as soon as we move into capture from the oceans, then again, we are dealing with an issue of long range pollution and impact problems, so cross-boundary problems. So the simple categorisation of two is not in my view sufficient. Let me just go back and make a comment about solar radiation management. Let us suppose that we could all be persuaded that Crutzen is right, and we can reduce temperatures in this way. We would still not be managing the acidification of the oceans. In other words, carbon dioxide levels going up means that we would get more carbonic acid formed in the oceans, and why is this a problem? The oceans are part of the ecosystem services for humanity. It is the oceans that provide the beginning of the food chain, and if we do not understand what is going to happen to the oceans as they become more acidified, and there are questions about that already being examined by the scientific community, then I would also very concerned about this, even as a potential solution. So I am focusing then on these two methods, carbon dioxide removal from the atmosphere and from the oceans, and I would say we should be investing in research in those areas, and we need prior regulation particularly on ocean removal.

Q40 Dr Iddon: Good morning, gentlemen. Earlier, we were talking about regulating geoengineering, and, of course, it goes from modelling by computer and in the laboratory through to pilot scale, you know, on differing scales in the environment. At what stage do you think the regulation should kick in, assuming that we can get international agreements? Should it apply to the research throughout, or just to quite large scale applications in the environment?

Dr van Aalst: I should say, I am not an expert on research regulation per se, so with that qualifier, my impression is that there is probably some regulation in place for some of the experiments that would be considered. The risks are primarily on the trans-boundary implications, that is where we probably do not have the good structure in place, and we need to look much further; and then there is the moral side of where you invest and how you look at options, and particularly how you include all the distributional effects there, which would probably kick in much earlier. So I think it is clear that we are in that stage, once we are in the stage of testing, once we are testing, and I support the previous views that you want regulation in place before you do large scale testing. For the earlier experiments, in general, I tend to be in favour of fairly free research, so that we can explore these options, and I think we are in too large uncertainty still about many of these options to be able to even design the right regulations.

Sir David King: I certainly believe that early regulation in any issue of this kind is essential. That does not mean that we leap straight into regulation, but examining what is the optimal form of regulation is well worth doing in advance. I think, however, that in terms of solar radiation management, I would move fairly swiftly, as I have suggested, into a temporary ban, and find the feasible way forward for that. I am not happy about smaller experiments being conducted at this stage in time before the unintended consequences have been fully evaluated. We are dealing with an extraordinarily complex issue here, and we all know scientifically that complex phenomena, as complexity increases, we get emergent properties that are not always easy to predict. So I do think we need to watch the stratosphere very carefully, but at the same time, in terms of regulation of the others, get ahead of the game, precisely because firstly, you want to keep the public on side, if we lose the public, then we lose the game; and secondly, we want to see that the regulation encourages the right behaviour. Car exhaust regulation has always been progressive, saying this is the way -- the new cars have to meet that standard in three years' time, and it has produced the investment in the right direction. So if the regulatory system is set out there, everyone knows what the playing field looks like.

Dr van Aalst: May I just add a comment, just to clarify? On regulation, I think we definitely need that sort of regulation once we go towards testing, and I would agree with the suggestion to have a ban, even on relatively small scale testing of solar radiation management. I do not think we can go quickly towards regulation of, say, model experiments of stratospheric aerosol injection, that would not even be feasible. I would think that as an alternative, or as a complement to eventual development of regulations for deployment, the sort of consultations that were discussed in the end of the previous panel would be crucial, and those should be international consultations, it should be very pro-active and engaging the public, because I think that will be a crucial factor to understand the feasibility, the acceptability of these options. That discussion needs to take place much before political decisions about eventual deployment, and I think also much ahead of actual regulation, except for a regulation to say let us try and stop it for now. I also think that we need to be realistic here; there is probably a difference between the sort of debate now taking place here in the UK and the debate around the globe, including in several different states which may already be at the stage of small scale testing of some of these options. So I think the UK is in a way also operating as an international arena, and in a way setting moral standards and setting an example for how globally we should be

approaching this, which is a very important side effect for your own considerations, I think, at this stage.

Sir David King: Can I come back very briefly, because I think there is an important scenario or set of scenarios that we do need to examine here. If we roll forward in time, and we reach the point where the worst impacts are happening, temperature rises are quite excessive, and we take on the notion that came up in the previous discussion about one country protecting its monsoon, and another country finding it is not acceptable, this discussion is critically important to have now, well ahead of time, for two reasons. One, because we want to avoid that being done; but the second reason is knowing the nature of the possible challenges in the future is a very sobering way of managing the business of defossilising. We need to really know what the potential disastrous eventualities will be, if nations start having to take matters into their own hands, and away from the international procedures.

Q41 Dr Iddon: Earlier, Tim Boswell read out five principles that have been laid down by the geoengineering community to guide their research. I will not read them out again, I will just read one: "Geoengineering is to be regulated as a public good." Do you think everybody understands what public good is, and who should define it? Who should decide what is in the interests of the general public?

Sir David King: I feel like saying pass.

Q42 Dr Iddon: You leave that to us, do you not?

Sir David King: It is obviously a very important issue, and within this, I presume, comes the issue of intellectual property rights as well, so I think it is a critically important issue to understand what we mean by the phrase "public good". If we are saying that there should be no intellectual property rights capable of being awarded in this area, I think I would be a bit hesitant to back it.

Q43 Dr Iddon: What is your view on IPR?

Sir David King: I think it is a very complex issue, because if we are going to go down the route of carbon dioxide capture from oceans or atmosphere, and this is going to be a good thing, we also need to know, where is the investment going to come from, to take the research into demonstration phase and into the marketplace, and there will be a marketplace with a price of carbon dioxide. That is going to be the private sector companies. If we do not allow protection of IPR, are we going to actually inhibit that process of investment? So I think I am a little hesitant to simply back the pure public good argument without IPR protection.

Dr van Aalst: Yes, I would support that. If these are good options, then we want the private sector to play a role in rolling them out, and then we might be excluding -- but again, I think for many of these questions, we are so far from large scale deployment that it is difficult to even imagine what we need, but I would say that in principle, good regulation of the deployment, not regulation of the early stage of research, but regulation of the deployment, but having the private sector play a role, might be more effective, if we all agree that there are options in that whole range of potential techniques that we do want to use.

Q44 Dr Iddon: I just want to finish by looking at the developing countries, obviously some of the developing countries are already badly affected by climate change, more so than some of the developed countries. How do you think the international community should involve the developing countries in the geoengineering debate?

Sir David King: Brian has the difficult questions today! I think it is very clear that one of the positive things to come out of Copenhagen, and the transformation of the global community between Kyoto and Copenhagen, is the much fuller engagement of the emerging powers and of the poorer countries, and the recognition that we now have at least three categories of countries: the developed nations, the emerging powers and the poorer countries. If we talk about the emerging powers in your question, I would engage them as closely as the developed world, as part of the world that can afford the investment that we are now talking about into geoengineering research as a possible way forward. The poorer countries of the world, I do not believe that this is the issue that they will be raising, and I am advising several governments in this category. I think the focus there has to be on adaptation and low carbon economic growth. I do not think this is an issue that comes to them.

Dr van Aalst: I would slightly disagree here. Your first point about the emerging powers is clearly right, they need to be involved, and I think if you want a good international regulatory framework, they are going to be crucial. I think they are going to be the ones very cautious once this is brought to the UN, because they want to keep all their options open. So it is also a strategic consideration, if you do want to move towards some sort of international mechanism. The more vulnerable ones, I think, are the more difficult ones, I think they will feel threatened by the possibility that the winners will protect their wins, and the losers, which clearly are mostly them, will not get anything. So politically, they are already very worried. I think there is a second dimension to it, which is the distributional effects within countries, and we have seen that in adaptation, which is, of course, much more local than some of the large scale solutions that we are talking about here, but these large scale solutions, let us not kid ourselves, we are talking globally average watts per square metre, but these options, particularly on the solar radiation management side, will have specific local impacts as well, and similarly to adaptation, we will need to manage those as well. On the adaptation side, we have seen so many examples, I just heard one last week of a little

village in Senegal which was facing increasing flooding, so you think, go and do something about it; well the city further downstream was also facing increased flooding, so they made a little canal to spill some of that floodwater towards the Atlantic, and the little village got hurt. This is the sort of adaptation intervention, of which we know so many have side effects, particularly on the most vulnerable populations, which are not paying for the solutions so they do not get to have a say. I am really afraid we will get similar parallels on the geoengineering side, and I would really like the international debate that will be fostered, and that we had a little discussion about at the end of the last panel as well, to really include attention for that human dimension, and to try and involve that side of the debate early on. They do not come to the table naturally, and certainly not based on a call for comments by the Research Council in the UK or anywhere else in the developed world.

Q45 Dr Iddon: With respect to the international discussion, where should that be carried on? Should it be in the United Nations, and if so, is it being carried on there, to your knowledge, or should it be going on in the scientific/engineering communities, or both?

Sir David King: I would have said, in terms of the scientific community, the intergovernmental panel on climate change ought to be addressing this issue. It is obviously something that has to become part of their four yearly report in my view, and that would be the proper focus for the international scientific community. In terms of the international community, again I would turn to the United Nations bodies, UNEP, it is a pity we have not got the UNEP person here, is an obvious body, but I think this is an issue that, in terms of regulation, would need to be addressed at a G20 heads of states meeting to have a real impact. I do think in terms of the solar radiation management, it is of sufficient importance that it ought to be raised at that level.

Q46 Dr Iddon: Dr van Aalst, do you have a view on this?

Dr van Aalst: Let me just be frank, and say that I hesitate, in the sense that I worry that if we elevate it to too high a political level too early, we may be sending the wrong signals, so that would be my concern, putting it that high on the agenda right away. I do think that there are more technically oriented United Nations bodies that would be more appropriate, certainly the IPCC, and I would hope that along with possibly some conscious efforts at consultation, which should primarily be looking at risks, and at whether this is an appropriate thing, and might actually be then guiding us towards more investments on the mitigation and adaptation sides. I would hope that those discussions in those UN bodies would then trigger a much wider debate, involving a larger range of stakeholders, and a more diverse set of stakeholders than have been taking part in this discussion so far.

Q47 Mr Boswell: It is coming across to me, gentlemen, that it seems that witnesses are looking at this as being a contingency if defossilisation does not do the job, and I suppose it is the nature of a contingency that it needs to be ready to go fairly quickly if that situation arises, although we are not committing ourselves to that yet. I am really asking a little bit more, if I may, about research into the impacts, and the importance of doing that now, and also, and this has been touched on in evidence, in particular research into the differential impacts, either by nation states, and that may be a contingent matter, or regionally, or within quite small areas or different categories of people. I can think of hill farming, for example, if one was looking at that. I just wonder if Sir David and Dr van Aalst could say something about the importance of that research, as it were, digging down into this, in terms of physical impacts, also possibly economic impacts, which I suspect spills back into public acceptability, and the final point would be, to bring all this together, what about having some prior understanding about whether or not there needed to be some compensation mechanism, so that if we did have to use these weapons at short notice, if I may call them that, would we have got the machinery in place, and we would not be bogged down in yet another round of international argument about who should compensate who, or what could be done to mitigate it in individual cases. Is that clear? So with the backdrop of possible need to deploy at short notice, and a need to keep the political debate going, it is really looking at what research do we need to do, and in particular, how do we need to handle the findings of that research in relation to smaller impacts on individual groups?

Dr van Aalst: I think these are the critical questions, and also the questions where we have to be quite honest, particularly for the solar radiation management techniques, we are now in a stage of such high uncertainty that we are not really yet doing risk management, it is dealing with vast uncertainties.

Q48 Mr Boswell: So we need to get on with that in some sense.

Dr van Aalst: Yes, getting on with that in some sense to get a slightly clearer picture on what we are actually looking at is important, so I also think we are not yet at a stage where we can do proper economic impact assessments, I think the uncertainties are probably too large for most of these techniques, although you can do some back of the envelope calculations possibly. I would caution against purely economic impact assessments, in the sense that they tend to lose out on the perspective of the most vulnerable groups, which do not count much on the economic analysis side sometimes, so that is something to consider. On the compensation side, again, my previous comment hints at the fact that I think we are very early in the game to be talking about that even, but if we were, the attribution question is going to be as difficult or probably more difficult as it is for mitigation, or for carbon dioxide emissions. So I think that is a critical one, that we need to consider in how we treat this as a risk management option in the end. If we would ever deploy these options, we would be throwing it out on the world, and the attribution would make it difficult for anyone actually to take the blame, so there will be losers, but the losers will not be able to defend themselves in court possibly, to some extent, unless we go towards precautionary principles and so forth, but then from my perspective, at this stage in the game, we should be keeping them off the table

mostly.

Sir David King: I think the issue in terms of the research into impacts, both in terms of the physical and economic impacts, would need to take into account the impacts from rising temperature. In other words, we are talking about an issue that would come into play if we are in that piece of the distribution curve that we are hoping we are not going to move into. So this is going to be playing off a temperature rise of, let us say, 3.5 degrees centigrade against the impacts of whatever might happen if we, for example, put up sulphates into the stratosphere.

Q49 Mr Boswell: There are always choices, are there not, between two difficult scenarios?

Sir David King: Right. I think this is an enormously complicated series of questions. If we look at the impacts from temperature rise, whether it is purely temperature rise, whether it is the changes in weather patterns, rainfall patterns, and therefore food productivity, sea level rises, if you look at all those impacts against the possible impacts of an intervention of the kind we are now discussing, I think that this is an issue that we cannot really tackle in advance. We are now talking 40 years in advance of the situation arising. But we just need to remember that it is going to be a balance of impacts.

Q50 Mr Boswell: I am going to ask you a contingency question prompted by that, which is if we were into that position, or thinking ahead at least, to look at the scenario, what kind of mechanism would be the best one for looking at this? Because clearly, there are political feedback loops and inputs as well, and people will be trying to avoid a situation where they or their country or their region may lose out. I mean, how on earth do we keep the integrity of this process if we need it, and the management of it, because of its scale?

Sir David King: We are already seeing, Mr Boswell, the problems of trying to achieve equity in negotiations around dealing with CO2 emissions, and the equity issues that would arise around what we are now discussing would be much more severe. That is why I think that the most important thing is to recognise the problems associated with going down this route, so that we amplify the need to go down the route of defossilising our economy.

Chairman: On that note, we will bring this session to an end. Could I thank you very much indeed, Dr van Aalst, for coming and joining us this morning; and thank you, Professor Sir David King, for joining us too.

Witnesses: **Joan Ruddock MP**, Minister of State, Department of Energy and Climate Change, **Professor David MacKay**, Chief Scientific Adviser to the Department of Energy and Climate Change, and professor of natural philosophy in the department of Physics at the University of Cambridge, and **Professor Nick Pidgeon**, on behalf of RCUK, gave evidence.

Chairman: We welcome our third panel in what has been a pretty hectic morning, looking at geoengineering and the regulation of. We warmly welcome Joan Ruddock MP, the Minister of State for the Department of Energy and Climate Change. We seem to be seeing a lot of each other at the moment, Joan, we are both working on the Energy Bill. A warm welcome to Professor David MacKay, the Chief Scientific Adviser at the Department for Energy and Climate Change, we have not met you formally before, but you are very welcome to our Committee, Professor MacKay. And last but by no means least, representing RCUK, Research Councils UK, Professor Nick Pidgeon. Welcome to you all. We are very tight for time, we are finishing at 11.25, so if we could keep our answers really quite tight, we would be very grateful.

Q51 Graham Stringer: What sort of urgency does the Government give to research into geoengineering? I suppose, so that we are all talking about the same thing, it might be useful to have the Government's definition of what they understand to be geoengineering.

Joan Ruddock: Thank you for the question. Can I first of all apologise to the Committee for the fact that I understand for some completely unknown reason, you failed to receive, and it is undoubtedly our fault, we did not succeed in delivering to you our written evidence. I understand you now have it, but obviously you would have appreciated it much sooner, and I apologise for that. I will answer your question on urgency, and then I will ask David if he would like to define the geoengineering which he knows that we understand, just in case I fail to be precise in the technical terms. Is there an urgency in this matter? Our view is there is not. We do not think that at the moment, it is a priority for Government. The techniques that are involved are ones which are far from being developed to the point of viability at the moment. That is quite different from saying one should not keep a watching brief, but we do not think there is an urgency in terms of this particular dimension to addressing climate change. What we do believe is utterly urgent is to continue on the route which this Government has followed so keenly of reducing greenhouse gas emissions in this country, of legislating to that effect, and of participating in the international discussions about trying to arrive at a global deal, which goes beyond the Copenhagen accord that we have just struck, so that we can ensure that the world effort is designed to keep us within no more than a two degree Celsius temperature rise. That is the priority of these times, and that is where the Government is on that matter.

Q52 Chairman: That is clear. Definition?

Professor MacKay: I think in DECC, we recognise the same categories that the Royal Society use in their report, we recognise the important distinction between carbon dioxide removal and solar radiation management. I think we would include in geoengineering some forms of activity that I think would be viewed as innocuous and legal, such as someone growing trees and putting them into a disused coalmine, that activity would be essentially the reverse of our current coalmining activity, and I think we would include that as an example of small scale geoengineering activity. We would also include, I think, the growing of biomass for co-firing in a power station that has carbon capture in storage, we would include that as another example of a geoengineering option that again I think would not be viewed as politically unacceptable.

Q53 Graham Stringer: Let me be clear, so that I understand you are both saying the same thing, I understand what Joan is saying, that you want to concentrate on reducing carbon dioxide, but does not the Government's energy policy and the security of supply depend on developing carbon capture technology, as Ed Miliband said? If I understand what you are saying, Professor MacKay, carbon capture is understood to be geoengineering but it is not getting urgent treatment?

Professor MacKay: Yes, I am sorry to have --

Q54 Graham Stringer: That is what I really want to understand.

Professor MacKay: I am sorry to have complicated things. Clearly we do have a policy of developing coal power stations with carbon capture and storage. If those power stations were used to co-fire biomass, then that would cause carbon dioxide reduction, so I was just wanting to give a complete answer. There are some forms of geoengineering that clearly are possible and also are perhaps not controversial --

Q55 Graham Stringer: So what you are really talking about that you are not putting research into is solar radiation management; is that too simplistic an understanding?

Professor MacKay: I think the Minister's answer was yes, the more controversial forms of geoengineering, especially the forms of geoengineering that would have cross-boundary impacts, are not a research priority. We do think they are important concepts that we would like to understand better, and we are happy to see the EPSRC, for example, investing in research into these options, but it is not an urgent priority to have research into these boundary crossing methods, which would include solar radiation management, and also some other forms of geoengineering that do carbon dioxide removal, for example, using the oceans; again, those would have cross-boundary impacts. We view these, as Professor King said earlier, as interesting options to keep on the table, but they are very much options of last resort, and they are not an urgent research priority right now.

Joan Ruddock: Can I just for the record, Mr Willis, make it very, very clear that whereas, and perhaps I was foolish to ask our Chief Scientific Adviser to give the definition, because in its broadest sense, it does include things that are already part of the Government programme. So in its broadest sense, yes, carbon capture and storage, where it is considered to be geoengineering, is part of the programme, and is a matter of considerable urgency, and we are applying ourselves to that, not least in the Energy Bill, which is currently going through Parliament. So there is a distinction which I think we need to be very clear about. The areas that we are not pursuing except in a small way, which I am happy to explain to you if you want that detail, are those of carbon dioxide removal of the kind that is --

Q56 Graham Stringer: I just wanted to be clear we were talking about the same things really. Just going back to your original answer, Joan, which I understand, are you not open to the charge of being complacent? Copenhagen, to put it mildly, was not a success, there is no guarantee that the international community will reduce the amount of carbon dioxide in the atmosphere. Do you not think we should be doing research for a Plan B, if the international community fails, as it patently did in Copenhagen?

Joan Ruddock: First of all, I do not agree the international community failed in Copenhagen. We did not succeed in getting certain things, we did not get as great reductions as we sought to get, and we did not get a timetable to move towards a legally binding treaty. But we have got, for the first time ever, agreement between developed and developing countries that they will make changes in their emission reductions; those are to be codified, they are going to be delivered by the end of this month, and we have got the agreement that we need the world community to stay within the two degree centigrade rise that all our activities in reduction should be aimed to keep us within that framework, and to avoid dangerous climate change. So I do not agree it was a failure, it is a good start, in my view, and it has got to be built upon, and I think the danger of adopting a Plan B, if that were even feasible, which I would question, but the danger in adopting a Plan B is that you do not apply yourself to Plan A, and the point of Plan A is it is all entirely do-able. We know how to do these things. Every country in the world knows how to reduce greenhouse gas emissions. With a financing mechanism, it is possible to help the developing countries that cannot otherwise afford it. If the argument is that we failed to make an international agreement of the best substance on this occasion, then how much more difficult might it be to create a regulatory framework for geoengineering which has greater implications for the whole world, in terms of possible risks and environmental damage and concern? So if one is difficult, then I would suggest the other might be more difficult, and that is why the priority must be to enhance and move further beyond what we have with the Copenhagen accord.

Q57 Graham Stringer: I understand the priority, and I understand the arguments. I do not agree with you about Copenhagen, I think it was a fiasco and a failure, but we can disagree about that. Is not the danger with the policy that it is all the Government's eggs or all our eggs in one basket, and if that does fail, then there is not a Plan B? Should not the Government be at least considering in a theoretical sense what choices it would make within the sort of range of geoengineering possibilities, that if things go wrong, and there has to be a different approach, should not the Government be considering that?

Joan Ruddock: Well, it is not to say that the Government should not consider, it is a question of urgency, which is the question I was asked.

Q58 Graham Stringer: Well, if it has considered, has it made a choice then?

Joan Ruddock: I said it is clearly not in our view a matter of urgency, it is clear that we have other and much greater priorities which we need to apply ourselves to very vigorously, and we will. So what I am suggesting is that we look to more of a watching brief, and that we do things at a de minimis level. I think that very much accords, as I understand it, with what the Royal Society is suggesting, and I think they are a very good barometer in these matters. So, for example, we do have some small expenditure on modelling techniques, for example, and if the Committee has time, Mr Willis, I can just say what research is being undertaken with Government money.

Q59 Chairman: I think that is in your note to us, is it not?

Joan Ruddock: It is.

Chairman: No, we will leave that on the record.

Q60 Graham Stringer: Just within that spectrum, have the Government made any choices? Does it have any priorities of which way it would want to go if Plan B was necessary?

Joan Ruddock: I think it would be entirely premature, because we are dealing with techniques here which are not proven techniques, which have great risks, which do not have a regulatory framework, and frankly, at the moment, it would be, I think, quite ridiculous for Government to be making any choices. But in terms of the major areas where there is interest, injecting sulphate aerosols into the stratosphere, for example, there is some current work which has Government funding; there has been work on low level cloud development, which again has some Government funding; and there has been another study on the impact of oceanic iron fertilisation on cloud formation. So on some of these areas, which are the ones that are particularly being put forward by those who advocate these kind of solutions as a Plan B, there is what I would call a watching brief taking place, and some small amount of Government funding, and as you continue to question, I can indicate further what the Government is interested in doing.

Q61 Chairman: I think just before we leave this particular angle, you have made it clear that you do not want to spend a great deal of money in terms of putting money into research.

Joan Ruddock: Correct.

Chairman: We will come on to RCUK in a second to look at some of the work that is going on there, but surely, Minister, you have an interest in supporting international regulation, because if somebody in the United States or China or Indonesia actually goes heavily into geoengineering in terms of large scale experiments, that may well affect not only neighbouring countries but, of course, work in the oceans, for instance, could significantly impact ultimately on our ecosystem as well. So what are we doing in terms of that global regulation?

Q62 Dr Iddon: Could I just add a rider to that, Chairman? Sir David King in the previous panel actually suggested that we ban temporarily solar radiation management techniques, because once you put trillions of mirrors in the sky, for example, they are irretrievable. Do you have an opinion on that as well, Joan?

Joan Ruddock: I do indeed. I mean, I think first of all we need to look at what might be being done within any particular research group, and the extent to which we seek to put any legal constraints on that. When it is a case of theoretical work, when it is modelling work, obviously Government does not seek to put any restraint on that. I think the Royal Society has suggested there should be a code of conduct; for research at a certain level, a code of conduct is probably entirely appropriate, and we would very much support that. But as you have just indicated, Mr Willis, and I did not hear Sir David King, but I can imagine why he would have said what he said, there are very, very clear implications for every country in the world, if any individual country were to start on a course of interfering with our atmosphere to that sort of degree. So it is absolutely the case that we need to develop an international regulation that comes before any deployment. Now there is an in between stage, which would be infield experimentation, and we may need to be thinking about that, and what implications that might have --

Q63 Chairman: I think my question is: have you done anything in terms of discussions with international partners about the possible regulation of geoengineering? I am not talking about domestic geoengineering, which from this

Committee's point of view would not be regarded as geoengineering, but have you had any discussions, I mean, yes or no?

Joan Ruddock: There are continuing discussions obviously between people in the department and people who are engaged in this work. What we have been considering is setting up within the department a working group that would actually study this issue. Now we are considering that positively, but we are also very aware of the position of the Royal Society, and we will, I think, need to work closely with them, because they are also setting up a series of working groups, and so (a) we do not want to duplicate, (b) there is undoubtedly more expertise, not to embarrass our Chief Scientific Adviser, but more expertise in the whole of the Royal Society than we could possibly have within DECC itself. So we are considering this matter, we are aware that this is work that needs to be done, but we want to proceed in the most useful way, and that is why we are continuing to have discussions with the Royal Society. I do not know if David might want to add something to that?

Chairman: Can I just bring in Tim Boswell?

Q64 Mr Boswell: I am grateful, Minister, not least because I fear I have to go in a moment, but may I just pick you up on what you have said? I understand why in a sense you are devolving the scientific burden to the Royal Society, but in terms of, as it were, the ministerial clout, you need to be introducing some of your counterpart ministers, either in the EU or climate change fora or whatever, to the importance of this. Is this something that you are doing as a department as well as, as it were, the professional scientific network?

Joan Ruddock: I personally cannot recall any ministerial involvement in discussions, and I do not believe our Secretary of State either has been holding such discussions. So I think at this stage, it is unlikely that we have had any ministerial discussions on regulation, but we are aware, our officials are alive to the issue, and it is something that we know needs to be done. Of course, the IPCC is going to be reporting itself, and we have taken a lot of our leads from reports from the IPCC. It is clear that if there is to be regulation, it is going to have to be in some international body, whether a scientific body, or whether the UN itself, but clearly, this is something that will have to be developed over time.

Chairman: You have made that clear. You have mentioned the Royal Society, and I know Ian Cawsey wishes to pick that up.

Q65 Mr Cawsey: It is quite interesting that an awful lot of what has been said so far is about the Government almost holding a watching brief on this, and waiting to see what the developments are. I just wonder to what extent that is enough, certainly in terms of public opinion, because it strikes me that if you look at quite recent things, GM crops being one, even climate change really, there is quite a significant dislocation between where public opinion is and where scientific opinion is. I can see geoengineering ever so easily fitting into that category yet again. The Royal Society did say in their recent report on it that the acceptability of geoengineering will be determined as much by social, legal and political issues as by scientific and technical factors. Do you agree with that assessment, and if you do, what will the Government do to encourage debate on the social acceptability of geoengineering?

Joan Ruddock: Well, I do not think it is for the Government to encourage a debate on the social acceptability of geoengineering, because that presumes that the Government has taken a view that geoengineering is a good thing, and that we should actually deploy. We have not taken that view. I think that it is important to involve the public in discussions as these things develop. It is important not to allow the public to get into a position where the public has been alarmed or is ignorant, so it is very important that the dialogue includes public communication. It is one of the considerations that we make about setting up a working group; should we do so, then indeed we would want to see that it contained a wide spectrum of people, including social scientists, ethicists, as well as scientists and administrators. So we are alive to the fact that there would need to be public engagement, and we know that NERC have a public dialogue programme that they are about to launch. So it is important to talk with the public and to avoid ignorance and prejudice, but at the same time, it is not for the Government to persuade the public of the need for this.

Professor Pidgeon: From the RCUK perspective, I will just make one comment about research: obviously, as you know, a small amount of money following the Royal Society report will be going into fundamental research on top of the research that is currently being done, and also the public dialogue has been initiated. That will be a first, really, across the world. The points earlier there, for the UK to do that, that is fine, but we might want to think more widely, because this is an international question, so the poor and people in other countries will have an interest in the outcome of geoengineering research. But the point about research I would like to make is that although it is not urgent, the science and the social and ethical research should come together at an early stage. Very often, those of us who study public acceptance of technology, nuclear power is a good example of this, social scientists were only asked 20 years after nuclear had become extremely unpopular to actually look at why this might have occurred. I think we have learnt that lesson, so RCUK and ESRC in particular are very keen that as research progresses on the science, research on the ethical, legal, economic and public acceptability issues also takes place as well.

Q66 Mr Cawsey: In the first session we had this morning, where we had people from different countries via videolink participating, I think they all came to the conclusion that whilst the NERC was going off and doing this consultation here, it was actually much more important that there were international talks going on and protocols and things being established there, so what is the Government doing to try and encourage that to happen? If we do

continue with this public consultation through the NERC, how can we diminish criticism that actually, this is what we always do, we always consult the public, and then actually it has no effect on the policies at the end of the day anyway?

Joan Ruddock: I think if I may say so, Mr Cawsey, your questioning is still in my view premature, we are not at that point. The Committee clearly may like to comment on this, but our first decision is as to whether we set up a separate working group within Government to look at all of these issues, or whether we work with the Royal Society to look at all of these issues. We are going to do something, it is not that we are doing nothing, we just want to see the lie of the land, and make our decisions as to how we progress, but whatever progression is undertaken, as Professor Pidgeon has said, it will quite rightly engage social scientists and others alongside scientists.

Q67 Mr Cawsey: I can understand why the Government would take that view, and I do not necessarily disagree with it, for what it is worth, but it is not necessarily premature to take a decision that this would be better dealt with internationally rather than nationally, is it?

Joan Ruddock: I think it is going to be for the working group to -- whether with us or jointly, or however it is done, we need a basis on which people have the opportunity to do some work, to do some thinking, and to come up with some proposals, because it is not possible for a government to just leap into an international negotiation. We have to develop our own thinking, we have to decide what it is we think is appropriate to put forward in an international forum, and we have to decide which international forum it would be appropriate to attempt to engage with. So at the moment, none of these things have been worked through, and that is why I cannot say to you, we are just going to rush off to the UN or wherever and say, let us all start this debate. Clearly, the initiative might come from others, but we have to get our own framework sorted out as to what we think is appropriate, and that is work that has not yet been done.

Q68 Chairman: Can I bring in Professor Pidgeon here? I am really quite confused about RCUK's position, and certainly the evidence that you have given us. There is an international convention on biological diversity, which deals with issues surrounding the oceans, and yet in your evidence to us, you are suggesting that any sort of regulatory framework is premature, and yet there is a regulatory framework in existence, which presumably the UK participates in developing.

Professor Pidgeon: I should add, I am not a lawyer myself, so I cannot comment in detail on the law.

Q69 Chairman: I am not either, so we are on common ground.

Professor Pidgeon: My reading of the evidence, which I had some input to, but obviously not all of it, is that RCUK are saying, as many have said today, that we have a heterogeneous field here that we call geoengineering, so many, many techniques, and it is likely that some techniques and deployments, if they were to come about, will fall under existing regulation, and others will fall between aspects of regulation. For others, there may be nothing at all. Again, that is why we need the analytic work now, to look at what regulation applies. To take another example, with nanotechnology five years ago, we were in a very similar situation, and DEFRA sponsored a gaps analysis to look at what areas of regulation would apply to certain nanomaterials, and that has been very valuable for them, to look at where the gaps are, so I think that is --

Q70 Chairman: Sorry, is RCUK doing that?

Professor Pidgeon: Not at this point in time.

Q71 Chairman: Because the Government is not doing it, the Minister has just said the Government is not, and you are not as the Chief Scientist.

Professor Pidgeon: But we are at what could be said an upstream moment, that is the way it is described, in emergence of a technology.

Q72 Chairman: What does an upstream moment mean?

Professor Pidgeon: So early that the uncertainties are wide. Compare it to nuclear energy, which is a mature technology, we know what it is, people have views on it. In the upstream moment, we do not even know how it will develop, and what responses there will be. There is very low public knowledge, which is a big challenge for public engagement, and great uncertainties. So we are in a phase which is very murky and difficult to give definitive answers, it is not that people are not trying to give answers, it is just very, very early.

Q73 Chairman: I will leave the last word with you, Minister, because we are about to close: I think what we are trying to get is that the UK is arguably, well, I would say definitely the world's second scientific nation, second to the United States. We have a position of real leadership in here. We are a nation surrounded by oceans, and we have given, I think with respect to our Government, a real lead in terms of climate science, and yet here is an area where

clearly it is a long way off, we are not even prepared to seriously lead the debate in terms of a regulatory framework. Do you not find that disappointing?

Joan Ruddock: No, because as I have indicated at the outset of this evidence session, we have real priorities which we are working on. We have within every part of Government people all of whom are engaged in moving us to a low carbon economy, and making the emissions cuts that we have committed to in law. Now that is a way forward to deal with climate change. It is a proven way forward, and we need to do as much of that as we can, and we need to work as intensively as we can in the international community to ensure that as much of that as possible happens. So there is no question about the leadership continuing in this Government and in this country, and you are absolutely right about the climate science. But what I have made clear is not that we are unaware, and totally neglectful of this area of endeavour, it is that we have not prioritised it, and it is that we are on the point of making some decisions about how we as a government should move forward. So we are aware of what is required, it will be undoubtedly some international regulation, that we need to have that in place before there is any question of deployment, but we think deployment is rather a long way off, and therefore, we do have time, and we should not be panicked into this, we know what we are doing, we understand the issues, we will look to international regulation in due course, we will play our part in that, and as I indicated to this Committee, and the Committee may like to comment on it, we either set up a working group within Government, or we work with those who have clearly led this field to date, and that is the Royal Society. That is the point at which we are at, and we will be active.

Chairman: Minister, thank you very, very much indeed for your presence this morning. Thank you, Professor David MacKay and Professor Nick Pidgeon.

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