The Path Forward

OLIVER MORTON: Hello everyone, and welcome to The Path Forward panel. I'm not going to introduce the panel because I think, A, its name introduces itself. And B, I think we're going to define what this panel is about in the doing of it rather than in prospect.

I'm Oliver Morton, I'm down on your programs as an editor of *The Economist*, which is indeed something that I am, but I'm here more in the context of being someone who's written about this subject and still has a select interest in it through a program. We have an excellent panel here. We're going to divide it into two parts. We're going to have three presentations, first which will have slides for your visual delectation, and then we're going to have a go around at talking about those things that we've heard. Then we're going to pull it back in with some unslided but nevertheless utterly fascinating remarks from Andrew and Jane, and then we're going to go all big and inclusive and talking about it all with you and the roving mics.

So on that note, our first speaker is my friend Kelly Wanser. I say that, in fact, they're all my friends. So that all makes it all sounds too chummy and very incestuous. But anyway, there we go. Kelly is an entreprenuer in the Bay Area. She's been personally involved in trying to put forward the marine cloud brightening idea for at least eight years, and possibly longer. And she's going to have a little bit about her view of paths forward through technology and innovation.

KELLY WANSER: I am Kelly Wanser. I hail from the technology industry for about 20 years. And so I'm going to bring a little bit different perspective in thinking about geoengineering on the climate system, and looking at it as we might look at the whole system's problem in some big areas of science. This trails a lot of the work that Jane Long does, and I was hoping to talk after her or before her about mission-driven science. And how you might think about what those research programs look like, and what the umbrella rubric is that they operate in.

So, the climate system is one of the more complex systems that you can face, and one of the challenges we've trying to solve is that we have anthropogenic stressors that are changing the system, potentially in irreversible ways. And so from one perspective, we're here talking about whether we can we relieve one major stressor, which is heat. And I work with Sarah Cooley from Ocean Conservancy on a project. An emerging project to look at ocean systems and accelerate the understanding from system science perspective. And heat is one of the major stressors on the ocean and ocean ecosystem. And so, if you look at something like solar climate engineering and [INAUDIBLE] in that context, you have ecosystems like coral reefs where localized geoengineering might make a difference in terms of heat stress on those coral reefs. As one way to look at this sort of system effects.

So when we think about the whole system's approach in mission-driven science, I use these slides as an example framework for how we might think about things. So, if one of our missions is we have the time bound problem on the system, we don't know what that time bounding is, but there might be something that we want to achieve in terms of information and readiness in a certain period of time. That could be 50 years, that could be 20 years, that could be 10 years.

And so, how do we define, in this category, in our portfolio of ways to adjust the system, what is the information, and what are the readiness options that we might like to have available? And then in that context, if we said to ourselves that within 20 years we would like to have process level information

about these alternatives in terms of feasibility, inputs the climate models, and some form of readiness around some of the technical tools we might need as an example. And then, along with that, we would say, what is the end user vision of a system that we would want? And this isn't specific to any particular technique. In fact, it could be a portfolio of techniques that could solar climate engineering and other things. But, what we're talking about is some context for managed deduction of solar radiated forcing.

I use the term managed very specifically, because that implies some system structures around it. And so, an example for some requirements of a system like this. And again, we can talk about what these requirements are, by thinking about what some of them might look like. One is, we want to optimize the types of particles that we're using, and in particular we'd like them to be benign with respect to atmospheric chemistry. I'll talk a little about that later. We need scalable operation of different systems, and I'm calling real time state information. But we need aggregated process information about what's actually happening to the climate system ideally.

And then I'm calling this the coupled human system. So that's the technical side of the system when we have the coupled human system, and there's an array of requirements we might think about here. But just in terms of a couple of the high level things we might like to have, is a policy and legal framework that are pragmatic for the knowledge and that state of readiness that we're trying to achieve. And public and stakeholders support, so that we're not moving forward without it, just as examples of things you might want for the human system. And you can tell what generation I am because [INAUDIBLE].

So, a system like this. This actually has some [INAUDIBLE] But, one of the things in a mission-driven research program is, we have an array of what you're seeing here is kind of my conceptual scale from a tiny particle of research all the way to global impact, and all the way up to human systems. And the array of interdisciplinary research efforts where we're dealing with many novel questions in the cycles of research. And we're trying to do that in a coordinated way, to hit whatever that target is, that 20 year tenure or 50 year target, to move these things along and it gets to that question of whether you're going parallel or serial.

So if I wait until I have a screen system for five or 10 years, and I wait until I have that governance model for another 10 years, then I have this array of things going on which I'm happy to talk people through later. But that's a sort of picture of the kinds of silos of research we'd actually like to pick up in parallel, because in most of those tracks there are showstoppers, I would argue. And I would rather carry those on and figure out if those showstoppers are there, are we going to need alternatives as we go in parallel.

So I want to talk about two examples of requirements of a system like this [INAUDIBLE] The first is about our state of readiness against this notional timeline that we set up. So one is benign materials for [INAUDIBLE] the atmosphere. It's state of the art today in sulfates. And that's true in the troposphere and that's true of the stratosphere. And having worked with a team in Marine Cloud Brightening engineering the type of aerosols that you want with the properties you want to do the things you want to do is a hard problem at this scale. And David's super smart so he might solve it faster than most humans alive. But it's a hard problem, and we don't have that today.

The real time system state problem you heard me refer to you before about observational platforms and models. We have silos of data produced in bifurcated ways, and in layers. [INAUDIBLE] This is an example of the work that, if Amanda is here, the National Academy of Science is doing on sustained ocean observations. They're running a workshop program on ideally what layers of information would we like to have to observe the ocean state continuously. This is a big set of information, most of which

we don't have today. Once I have the collection of that data, how am I my processing and modeling that data? And so what we're talking about is a pretty big scale of data gathering, data operation, in order to achieve the kinds of feedback information that we would really want to have if we were having this system of perturbing the atmospheric intention.

Now the beauty of this is this is fine-grained information on climate, analyzing what is happening. The beauty of this is that the kind of system—we've been doing whole systems thinking about the kind of information that we want to have—is not too precisely the information we'd want to have about managing the inadvertent climate impacts that we're making. And so, I'm encouraging this whole system thinking [INAUDIBLE] disciplines we have for adapting in parallel as long as it's safe, so that we can coalesce that information and think really hard about the timelines that we want to reach.

OLIVER MORTON: Thank you very much. Next I'm going to turn to Peter Kareiva. He's the director of the Institute of the Environment and Sustainability at UCLA, and he used to be at the Native Conservancy. He thinks a lot about how climate and other environmental issues fit into broader social and public imagining of things. So, Peter.

PETER KAREIVA: Thank you. I'm going to take a little bit of an orthogonal approach. I'm going to draw on some personal experience that you might remember—the very first field release of GMOs that was in 1987 in northern California. And I did a risk assessment of that. 30 years later, I was on the National Academy committee to sort of summarize everything we learned, and project forward to the future prospects for GMOs. And there's a lot you can learn from that history of involvement for the topic before us today, geoengineering.

So we talked about some of the lessons. First off, before that first field trial 12 years before, in 1975, there was a conference at a [INAUDIBLE] by a molecular biologist. Without any government, the scientists set up guidelines for how to do the experiments and the field experiments. And those guidelines still guide us very much today. Some of the other lessons are that it's different than the geoengineering because there was corporations and private gain to be made. But some of the mistakes that were made speak to mistakes that we have to avert with geoengineering. One was there was a reluctance to deal with basic ethical questions. They just wanted to deal with the scientific issues. Many meetings like this avoided the ethics. The other one was the arrogance of the scientists, especially in engaging the public. The arrogance would be either impatience with explaining it, with the assumption that public couldn't possibly understand, or proposing grandiose things like the GMO crops were going to solve world hunger. A third thing that was really obvious early on was a failure to deal with who loses. What happens in developing nations, what happens to the small farmers?

So while the GMO biotechnology had the grand picture of world food production, it didn't pay enough attention to the disadvantage and who loses. And certainly it had issues of secrecy, in this case, because of patents. One of the things they did right is it did have publicly funded risk assessment, and that scientists doing the risk assessment did not have an interest in promoting the field trials. So I was one of those scientists doing a risk assessment.

Another thing they got right, there was an earlier discussion today this morning about, once you commit to a field trial, does that mean you're committing to implementation? A good example is from biotechnology, where it wasn't. A good example of that is to get a permit for the field trial, you had to basically predict the outcome of a field trial. [INAUDIBLE] for farmer crops putting drugs into things like corn, and they predicting it could be contained. They did field trials with corn and farmer crops. It could

not be contained. That whole pathway for commercial development was shut down. So the field trial, and the results of the field trial, actually shut down major commercial enterprise.

But the biggest failure of biotech and its risk assessment and their whole scenario and the legacy that lives with us today, and I really saw that with the National Academy report we did last year, is it didn't frame the problem correctly the way society wanted it framed. In other words, it was just about wheels, and maybe profitability to farmers, when actually what society wanted reframed was obvious, and the questions we were asked we were doing the committee reports was, what's the trajectory of the world's food production systems with GM crops compared to the trajectory of the world's production systems without GM crops? That was the question people wanted to have answered. And all that investment had not addressed that question. What's the trajectory of the world's climate futures with and without? And I think that's a fundamental question. If you don't start answering it right away, it's a big mistake.

And the last thing I want to end on is another lesson I learned from that, which I think pertains especially in the climate arena. We talk about the climate arena. We use things like uncertainty analysis. We do economics and cost benefit analysis, economic costs. They did all of that with biotech.

Again, it didn't speak to public concerns. Instead what is needed what I call advanced counting. So by advanced counting, what I mean is what you really want to know, is for something like extreme events. The floods we just had in Los Angeles. That was a 100 year flood. Well, given recent trends in climate trends, it's now a 1 in every 20 year flood. That's advanced counting. You want to do uncertainty? It's between a one and every five year, and a one in every 30 year flood. And if we can take our climate—and I teach environmental science to undergraduates, and I struggle with the scientific literature. I'm technical enough. I'm trained as an applied mathematician. Our failure to represent the climate scenarios in something as simple as once every 10 years, once every 20 years, once every 100 years for very particular events that matter to people. And that's the framing for all sort of climate futures that I think we should be striving for.

OLIVER MORTON: Thank you very much indeed, Peter. And the third of our first round of speakers is Anna-Maria, who is an associate professor in law in University of Calgary and also has a position at the University of Oxford and was previously at the IAS in Potsdam, and has been thinking a lot about the way that geoengineering of various forms fits in to current and future legal framework. Anna-Maria.

ANNA-MARIA HUBERT: I'm going to start with this map of the world, and I'll start with a strawman, really. So we've heard a lot of the perspective of climate modelers in particular who see the world and relevant boundaries in terms of grid boxes. And international legal scholars are concerned with political boundaries. So on borders between sovereign states. And so to bring you in that dark place of the mind of a lawyer, I'm going to take you through some of the basic principles of the international legal system and the challenges that geoengineering poses, both on the long term, but also in the short term to international law. And then I'll end with some ideas about how the law needs to be changed or governance needs to be created to address some of these concerns.

So in terms of structural principles and fundamental tenets of the international legal system, the international system was founded on the need to guide a peaceful coexistence of a few subjects of international law based on the sovereign equality of states. So I thought this quote was apt. The system is ideally to keep its subjects peacefully apart, that is to say, in a state of negative peace or the absence of war. It suffices to impose on them the obligation of respecting each other's sovereignty, not to encroach on other spheres of confidence, so that the conditions of equilibrium might be satisfied, or at

least not in danger. And it's important to point out that international law has developed from this fundamental premise to being more communitarian in nature.

Nonetheless, the idea of geoengineering appears antithetical to this idea of peaceful coexistence, not interfering in other people's states. So this idea of planetary scale interventions in the environment of other states is a contrast. When we think about geoengineering, it's useful research, even small scale research. It's useful to think about the end aim, in particular, given that although we can learn things about the environments, the sort of fundamental things about the climate system, we're mostly talking about solar engineering in the context of mission- driven research.

And if we were to assume that a deployment could be carried out in a way that's consistent with fundamental tenets of the international system, this would include respect for the sovereign equality of states, which implies a need to consent through, for example, a universal agreement or treaty, widespread cooperation and coordination likely through international institutions over decades. So implying it's [INAUDIBLE] and geopolitical. Stability within the international legal system. And so scientists here have pressed the case. Some scientists about the urgency of starting outdoor research given the climate risks that we're facing.

I think the same case can be made from the governance side, namely that we're far from implementing this level of stable and sophisticated global governance, and to quote Professor Barrett who is in the audience, "Governance is perhaps the greatest challenge when we talk about solar engineering." And so what are some of these challenges? This is a picture and you can't really see it, but it's just to demonstrate. I drew this for a colleague of mine when I was working in Germany. He was a human geographer, and he's interested in concepts of space in international law. And what we see here is that within the context of international law we have a number of different treaty regimes that govern different aims and pools and different subject matter. And also, what's important is to consider where the activity is taking place.

So we're concerned about jurisdiction when we apply the rules. And I think a number of jurisdictional issues arise even with respect to smaller scale research, and we've seen this already in the case of ocean fertilization. So one idea is the protection of the global comments.

So, on research activities that for example take place beyond 200 nautical miles on the high seas where there are relatively few protections. Also the issue of foreign shopping. So looking for jurisdictions where the rules are lower, or less strict. And that's also born out already in the case of ocean fertilization where [INAUDIBLE] first tried to conduct his ocean fertilization activities in the Galapagos and moved to the Canaries, and finally carried out his research off the Canadian coast where I'm from. So I think that we should assume that we'll have the activities taking place. So this is a forum about US solar energy geoengineering research.

We can assume that activities may occur in other states as well, and would the US be interested in what's going on in some of those other countries? You also have this problem of long term regime interactions. So in international law, we call that regime fragmentation. And so one of the concerns which may arise is that you'll have different sets of rules and international treaties for geoengineering that potentially conflicts. So we've already seen action by the connection on biological diversity in this area, albeit non-binding guidance, and also [INAUDIBLE] connection and protocol which unregulates GMO engineering, or will if the amendment should come into force.

I think the other and the bigger risk really is that geoengineering will develop apart or separate from a wide body of international rules that govern the protection of the marine environment, sustainable development, and human rights, and that geoengineering as a concept could undermine this fragile but important system of international rules and cooperation that we have. And so I think there is a need to consider how geoengineering governance fits within this existing regulatory context.

Finally, justice and equity. I think the equity issue is on the long term when we think about the termination effect, we can think about inter-generational equity. But I think intergenerational equity issues are most pressing now, when we think of small scale research. And that includes a role for not only developed states, which clearly have a foothold in this area now, but developing states in defining research questions and whether they matter as well as civil society.

And I think that's and another international interest that has manifested in the near term. And finally, to build on Janos's comments, I think there is really a lack of governance capacity in terms of knowledge of these issues within at all levels. So international, national levels and within civil society. And though I think the need for educating states, government actors as well as civil society on these on geoengineering concerns is really quite important. And it's going to take significant time to build that capacity. Also the scientific cooperation across borders is a major issue. And I think one of the issues is that there's really a lack of demand from policymakers at all levels in addressing these issues.

I'd just like to highlight some ideas about what early measures we can take to address this issue. So a colleague and I, when we were in Germany wrote a 96 page paper, so I apologize for the length. It was an exploration of how international law could be developed to address some of these issues as I framed them today. The bulk of the legal scholarship that existed before this repeated this refrain that there is no international law that directly applies. But I think the point here is that there's a lot that we can draw from in terms of experience in other areas of the law, and procedural mechanisms that could be adjusted and combined to address some of these issues.

So the paper explores generally applicable general principles that are consistent with international law, including the Paris Agreement, and I think that's important. The relationship between litigation and geoengineering. Best practices on for outdoor research. There are examples of instruments that do that, mainly in the marine context. And also issues of legal form. So the need for an adaptable and flexible instrument, and also guidance that's not within the traditional domain of state actors, but also on non-state actors, such as businesses, scientific institutions and scientists.

OLIVER MORTON: Thank you very much. I wanted to start off the discussion by thinking back to some of the things that Rose said in the first session this morning about a space for critical reflection, and from this select three different viewpoints that you took. How would you imagine research leading to the abandoning of this idea?

KELLY WANSER: Well, we actually talk about that in the marine cloud brightening research effort, because we had two and maybe three of the principals who originally joined the effort to disprove that. So I think that when actually thinking about the research silos, there are actual real technical feasibility questions that are different across the techniques. But we could actually run into some issues where it's actually not that feasible to produce the kind of forcing that we want to do in a predictable way. And we look at it and we say, we don't know yet if it's feasible. We certainly don't know if it's feasible to deal with benign materials in a predictable way. And so I think just from a practical perspective that's certainly true. I think there are other things on the research path if you looked at marine cloud

brightening to say, well, do we know enough about whether we could get susceptible to clouds in particular areas, for example, and we study it and we find, actually, no you can't. So there are certainly scientific questions that could come into play.

We may learn more about what would happen to precipitation. And there would be scenarios that we say, no these are unacceptable, or they're only acceptable under certain other extreme scenarios that we look at. So I think that if we define find the mission driven research objective as a set of questions we want to answer in a certain period of time, that's a framework where the wrong answers to those questions don't proceed. And I think there are similar social science questions. Anna's point about whether this really does threaten the framework for mitigation in national policy even at the research level, that's a really interesting question. We should look into that right away.

ANNA-MARIA HUBERT: I'm going to challenge this idea of the rational decision maker, especially given that we're in DC.

OLIVER MORTON: I didn't impute any rational decisions.

ANNA-MARIA HUBERT: I know. In contrast to the previous statement, I think we presume that if the science shows that this is a bad idea, that we'll axe that from the list of possible future activities that we can undertake and move on to more promising science. But I think that may or may not be the case. This isn't my area of expertise. But I think the idea that policy makers make their decisions based on science and an evidence-based way is a bit tenuous. And also I think within the context of geoengineering we've already seen, like ocean fertilization, has not gone away even though the majority of scientific opinion is that it's not a good idea. A couple of weeks ago, a new company cropped up in Vancouver. Kind of a new iteration of a scientific board and scientific principles and so forth which they'll cover in their activities. So I think the idea that it's not a viable option scientifically doesn't necessarily match up with whether it will be [INAUDIBLE].

PETER KAREIVA: I think that the three stages by which it could go away are first sort of an advanced public comment area by which the public could weigh in and say these are things we worry about. And that typically the response would be we don't worry about them. And in fact, we'll show you that. And it's clear to me that field trials could show that statement, that we do not need to worry about them, is patently wrong. And it's the explicitness that helps on that, as opposed to being vague about it. And to preempt the public comment.

The third way is, there is often the claims of this is going to help people or nations or something that are most at risk to the climate impacts. That's one of the arguments for geoengineering. That's something you could look at more carefully than just letting it be a glib statement. That was often the glib statement for the biotechnology—this is going to feed Africa. But it was never really seriously investigated. You could seriously think about that as you're developing. So I think those two questions, is it really going to help those who are most at risk, and then show me that we don't want to have to worry about it, give you intervention points to turn it back.

OLIVER MORTON: Any questions on this discussion so far? And particularly on that idea, I'm intrigued by this idea of, obviously people do not think that deployment is a certainty. Do people think that there is a chance of research on this subject just stopping? Is there anyone who thinks that? Or any other

thoughts on these issues in this or legal systems and public perception framework that we've just be looking at?

AUDIENCE: Thanks. Holly Buck. I was wondering this. After hearing two papers, one was at AGU, which looked at how species could adapt after a termination shock, and another was a recent paper that I don't think has been published yet but has been presented about insulation impacts on major crop production, showing that solar geoengineering might be negative for world food production. And both of those made me think, oh, I didn't realize that there was a scientific uncertainty about that, number one, and number two, how many more repeatable studies would we need on these types of things before we collectively decided not to research? And so my question is, should there be a systematic look at what would be the conditions to falsify geoengineering as an idea. And in the absence of a court [INAUDIBLE] government research program, you might design it that way, could scientists self-organize to do something like that?

OLIVER MORTON: Sylvia please, and then Mike, and then David.

AUDIENCE: I'm Sylvia Ribeiro from the ETC Group. I think this is not only about this panel, but I think that there are many things that have not been taken up here. And one of them is that this is kind of a small group of friends that have been working with each other for some time, and if we are going to have a debate on geoengineering, this is not the right forum. We need a much wider forum. That is one thing. But the other thing also that I am very concerned that, for instance, here it has been mentioned that some outdoor experiments are being planned, particularly David Keith, but also the cloud brightening experiments. All those experiments as far as I can see will be in violation of the Convention on Biological Diversity. The US is not a signatory of that, but even those will be not taken into account.

The fact of a moratorium [INAUDIBLE] changing and that the CBD has established. So for instance, I think that is a point. The third and last point is that I think that it wont be helpful with the technology that can be so powerful like geoengineering. To have these kind of voluntary, friendly kind of things would really need real governance. And real governance is independent, is extended to the people that are working on it. Either it is research or much more deployment that we are not even speaking about. And because some of them fundamental questions, for instance is, do we really want to go this path, is not being taken here. Because we are just assuming that we have to compare these with climate change. But there are a lot of other alternatives. It's not only about geoengineering. And there are a lot of other things that are being left out. So those were my questions.

OLIVER MORTON: Thank you.

MIKE: The whole idea of experiments is that they won't be large enough to really do anything beneficial. They will almost always raise questions about something. And so it's a little bit hard to see how sometimes how you go ahead, in doing something that might have very large net benefits later, if it were done at scale. So I guess I'm curious how you would even sometimes conduct experiments if people are going to always find problems with them, which they will, when there is really no prospect of benefits at the experimental stage.

DAVID KEITH: I'm trying to understand Anna-Maria's opening statement. I think that Anna-Maria said that this is in some fundamental way incompatible with the core principles of international law, because it represents some action that affects other states. So I have several questions. I suppose that would

also make any burning of fossil fuels or other things that affect other states illegal under an international law. And you have a directionality question. So if one state puts you [INAUDIBLE] an atmosphere which alters the radiative forcing another state, and then does solar energy sharing which imperfectly and partially reduces that radiative forcing. Does the direction matter, or is anything you do incompatible with international law?

OLIVER MORTON: I'll take that one first, since it was nice and direct and at someone in particular.

ANNA-MARIA HUBERT: Actually, that's not what I am asserting. I guess my argument is if we wanted to be consistent with the fundamental tenets of international law, we would want an agreement. We would want a sense in some Institutional cooperation and so forth. Some colleagues and I in Germany published a paper that examined whether on a unilateral intervention by a state would contravene customary international law. And I think the jury's out on that. Probably not. So whether there would be enforcement at the international level by a unilateral action by state, I think probably not. So I think my argument is not that. That somehow it is incompatible international law. I think my argument is if you wanted to make it compatible with our core ideas of how the international system operates, you'd want fundamental mechanisms in place.

OLIVER MORTON: I ask you to address the CBD point as well.

ANNA-MARIA HUBERT: I think it's not true to say that there is a moratorium at the international level under the CBD. I have that decision in front of me. I think the main point is that it's a legally non-binding decision, and also there is an exception for small scale research. So for example this SCoPEx experiment. All scale provided that it meets some of the other criteria in that decision, but it's not legally binding. So it's really not a moratorium.

ANDREW LIGHT: I don't think we should spend too much more time on this, but I'd actually put it stronger than Anna-Maria does. Look very closely at the three operative decisions by the CBD on this. This is in no way a moratorium, it's not a de facto moratorium. It's a call for transparency for countries to report what they're doing, which they have not complied with since the decision was made. Let's be very clear, with no penalty. We're not even complying with recording on any research that they were doing. And secondly that if this is done then there's a whole laundry list of precautionary advisory things that you should take into account if you're thinking of doing this. That's what it is. I'm happy to go through very carefully those three decisions with anyone who'd like to with me.

OLIVER MORTON: I just want to come back quickly on Holly and Mike's points. It's an interesting way of shaping a geoengineering research project looking for a falsification process. Looking for reasons, saying OK, let's not do that. Is that a useful way of going forward? A path forward? Jane says yes.

JANE LONG: It has to be part of it. I think that I was going to talk about it, I'll say it now instead. Part of the issue is how do you charter an institution to do this research? What do you tell them you want them to do? And one of the things you really want these institutions to do is be able to tell you it's a bad idea. You don't want them to be so vested in the success of the idea that it gets into the slippery slope of technical lock-in. So what has to happen is the charter has to include assessment and reward for saying this is crap and you shouldn't do it. And that's hard to do, and that's the challenge.

OLIVER MORTON: Can anyone on the panel offer examples of where that's been well done? Where people are being rewarded for getting rid of crappy ideas?

KELLY WANSER: Not necessarily a crappy idea. I mean SPICE didn't go ahead for various reasons.

JANE LONG: You gave an example.

PETER KAREIVA: Well, right. I mean the farmer crops. Originally it was activists against it, but eventually, the field trial was done. The claim was made we could contain them. And the data were so unambiguous you cannot contain the gene. And so it changed the whole regulatory framework.

ANNA-MARIA HUBERT: That's also something you might want to consider in a governance framework, because the requirements for these negative results in terms of transparency. I think that's super important.

OLIVER MORTON: I'm now going to bring us back in a little bit more with the last two panelists, the first one of which is Andrew Light. I'll probably get the last word. But Andrew is very distinguished in many ways, some of them are the World Resources Institute. He's also a professor at George Mason University, and has a distinguished career in the State Department, negotiating deals about just this sort of thing. So, Andrew.

ANDREW LIGHT: Thank you. I want to say just a couple of things at the top about the current state of play that weren't mentioned in the last session. So two things I think are relevant to our discussion. Number one, if I were to bet today on what the Trump administration is going to do on the Paris Climate Agreement. They will decide to stay in the agreement and then change the US nationally determined contribution, US pledge, in 2025. That's where I would put money down today. We can talk more about why I think that's the case. I would think it's an exaggeration of some of the media reports on this and somewhat exaggerated to sort of an Ivanka Trump versus Steve Bannon kind of thing. I don't think that's really happening. But I do think that there is a that there is an emerging view that that's probably what they're going to do.

At the same time, we know with the release of the budget blueprint the week before last, and from what we expect to be an executive order that probably will end on Tuesday on the Clean Power Plan, and rescinding other Obama era executive orders on resilience and other things, that they will effectively pull out of Paris even though they might actually legally stay in. And so I think it creates a very interesting set of issues that will have to work out.

The other thing is that there is a lot of what I would call innovation noids, not innovative noise but innovation noids, that is accompanying this emerging decision around the Paris agreement, which could, if it doesn't impact what the Trump administration does with this with respect to solar or geoengineering. You could anything or anything else that's being talked about. I think there is going to emerge some kind of cover under the guise of some kind of fossil fuel technology strategy that will be rolled out as what their contribution is going to be. There was a letter yesterday that was released by Kevin Cramer, the Republican representative from North Dakota, who has actually been an adviser to the Trump team in the White House and in the campaign, which gives an indication of that. There's some good stories about that today we can talk about.

Now I think that sets up the following scenarios, in terms of what's going to happen. And then what I would argue would be firstly with the scenario in terms of what I think will immediately happen with respect to this administration and the possibility of moving forward with respect to coordinated international action. And then I would actually advocate that those of us who would like to see our research agenda on [INAUDIBLE] move forward and more importantly, I think the governance discussion, a robust governance discussion, move forward. That doesn't interfere with innovation but in fact, I think, in a way we've learned from the examples that Peter gave, they actually make some kind of research more plausible and possible.

So everyone who said today that they think that Trump will not do anything on this, no one in the US federal government will do something on it I, think that's right. There is, however, this interesting phenomenon, which is quite different from the Obama years. The beginning of the Obama administration, all eyes expected that Obama would do something on climate change, which he did. And at the very beginning, many of you were involved in some of these discussions, John Holdren tried to organize some discussions on climate engineering that frankly got shut down from the environmental left. I think there's actually room at this point, that there might be a very quiet discussion not involving principles, not involving members of the cabinet. That there might be room for discussion of actually talking seriously about governance which we were never able to.

Governance issues on geoengineering which we were never able to do in the State Department when I was in office, because frankly we were just too busy trying to get the Paris climate deal done. We had no capacity to work on this, but there are a lot of people who are still around who are going to have their budgets mightily slashed, and they're still going to need something to do. And this is a time where they could potentially gin up a very quiet debate, and I think it might actually advance things. Once we get back to that administration, we could get serious about this problem again. And then we would actually have something teed up to move forward to, and there are some ways we can do that. I think there was a signal of that, potentially unintentionally, in the mid-term report that was released by the US GCRP, where you get the sort of the shout out for thinking about that and I think we can imagine that happening even in the context of the National Climate Assessment.

I think that in terms of what I would like, what I would want to see happen internationally with or without the US, is it's absolutely critical, as mentioned the last panel, that we get to transparency. The CBD decision could cause countries to actually dig down and be public about what they are spending now on this with vague numbers, we can go through the public databases, we can go on to get a sense of what's going on here in Germany, the EU, a couple of other countries, China, India now looks like it's going to fund its first project. So if that process had actually resulted in public reporting, that would've been great. And we need to encourage that. And part of the reason I think it needs to be encouraged is because it is critically important to me that climate engineering not be this discussion that happened separate of all other discussions of mitigation scenarios. I think it has to be integrated in order for us to ever have a rational conversation about whether we want to do it and under what circumstances.

So to that degree, I would I would advocate for two things. Inside the Framework Convention, those who know the Paris Agreement, one of the things that we did was not only set up a continual process for people putting up pledges, so by 2025 we will get into these annual five year cycles of countries going forward, putting forward new pledges, we hope, with more ambition. And part of that was also creating something called the global stocktake. So just a couple of years before those commitment periods you do a big report on the world of hazard and opportunity. Where are we in terms of

temperature? Where are we in terms of mitigation scenarios? Where are we in terms of hazards? And importantly, those of us who created it wanted to create it not just as a stick but also a carrot.

Ideally, the global stocktake when it happens will also describe what is the remaining low hanging fruit up there. What are the technology opportunities that people don't understand that could cause them to choose to increase their ambition in the future because they do not realize that it could actually be cheaper than they imagine. Now I think optimally the global stocktake needs to look at everything. All technology options, including solar engineering. This would also be an opportunity to get more transparency from parties on what they're actually funding, either under the official title of solar geoengineering or something else, and the best way of doing that is there will be a trial run of the global stock take in 2018, which goes by the ungainly title the 2018 facilitative dialogue. And if we can get this technology and an assessment of this technology included in the 2018 [INAUDIBLE] dialogue, it then will become part of the global stock take. We don't hit that marker, I think we can still do it, but will take some effort. It will take the effort of parties coming aboard.

The second way that I would suggest doing this is outside the Framework Convention. And again, looking at it as a technology option. There are two prime candidates for this—the clean energy ministerial, which was created as an offshoot of the major economies forum, which was originally a Bush era process which collects together the 20 top emitters in the world. It mirrors the G20. And out of that, in the first Obama term, we spun out a companion set of meetings with the energy minister so they would have some stake in global climate policy. Very successful in terms of a process, doesn't include anything on these technologies, certainly could be included and I think you've got a smaller number of parties, so it's less unwieldy than the Framework Convention in terms of getting to move from talk shop to actually doing something that's more coordinated, especially on the governance side. The other opportunity is something called mission innovation, which was also launched just before we started the formal negotiations around Paris. And this is around 20 countries who are pledged to double their non-fossil energy budget by 2020. Oddly enough, I think we're probably going to formally stay in that even though we will not hit the target given what it looks like the Trump administration would like to do to the DOE budget.

The last thing I want to say is, there is a scenario, and this is the speculative part of what I'm going to say, more speculative than the others. There is a scenario where I actually do think there's a possibility that this administration does move forward and that it creates something that will necessitate an international response. And that is if we get a second Trump term. If we get a second Trump term, and it's got to be considered, folks. You've got to be thinking about what are the possibilities here if you're interested in the marathon which is global policy on climate change. If there is a second Trump term, one way or the other, then you've got a White House which is no longer thinking about reelection immediately. Number one.

Number two, the White House with no heir apparent at all. I think Trump, unless he succeeds in recreating the Republican Party as purely a Populist Party, there is no one he's passing the baton to. In that—now you know I will not get any sleep tonight—under those conditions, I think we could see something that happens like we saw in the second term of the Bush administration. In the second term of the Bush administration, we saw after relentless calls on the Bush administration to reengage on climate policy, they finally decided to do it because it was causing them too much collateral damage in terms of everything else that they wanted to do. So they finally did. It was orchestrated mostly by Tony Blair to push the Gleneagles G20. And after that, you've got the Bush administration creating the Major Economies Forum, getting behind the creation of the climate investment fund and the World Bank,

which was the first big international climate finance fund, and a number of other things—the first time they finally declared that climate change was real, and many other things that happened.

There will be pressure, mostly from the G20 parties, for Trump to eventually rejoin the committee on this. In that term, you could imagine that this is one of the things they decide to do. They decide to basically create a small coalition of countries who want to do that. I think that at this point, if I were to predict if that happens, no matter what they do, I think it involves most likely Russia and the Saudis. We will see at the G20 this July whether you get an emergence of a Russia- US- Saudi Arabia axis on global climate policy. Saying no we've seen an indication of this at the G20 finance ministers meeting a couple of weeks ago, when they took fulfilling the finance goals in the {INAUDIBLE] all out of the communique coming out of that. And if that happens, then I think that this becomes, in a weird way, their signal of innovation. And then we're really back in the scenario where we think about who takes money, who doesn't, to what degree are we pushing back or we're actually trying to put this into a bigger context.

OLIVER MORTON: Thank you Andrew. Jane.

JANE LONG: I never contemplated eight years. I don't want to contemplate eight years. But I do think that one of the ideas I do want to play off on is this idea that you have this hiatus rationality. And that it is an opportunity to really think carefully about how we would go forward. And so I feel like it's really important to stick to our guns about what we've been thinking is important, and to do right. I don't believe in a kind of relativism. I actually don't think that if Trump comes up with money for geoengineering research that we should automatically reject it because it's Trump. I think that if it's the right thing to do, we should take the money. If it's asking us to do things we don't think are right, then we shouldn't do it. And I think that's the way we ought to think about it.

So with that in mind, I'd like to talk a little bit about what I think whoever is going to start research, and serious research, not just sort of one off stuff, and not just modeling but actually getting out in the field what. What you need to think about, what are some of the things that you should be putting into your design of this research program programmatically. And the first thing I want to dwell on is that we know that geoengineering is fundamentally strategic. It fundamentally requires, at least at the global level, and I agree with Scott this morning when he talked about the fact that geoengineering is liable to emerge as a lot of regional actions that grow larger and larger.

So everything I'm saying, every argument I'm making right now, has a kind of counterpoint in that scenario which is in reality more likely and has to be thought through. But back to this idea of global geoengineering which may grow towards that regional concept. It is fundamentally strategic. You have a goal that you want to achieve. You decide on actions. You take the actions. You have some procedure for saying how you're going to say whether it's going in the right direction or not, what you want to stop and keep going. And the attribute of that is that we have been unable on a global level, or in pretty much any level, to be strategic about climate. And so I think that this understanding of geoengineering as a strategic action means that we should do everything we can to keep the research on geoengineering in the context of all the tools that we have at hand. Or that we wish we had at hand.

And so, I am very much against what Janie Wise said about separating this out. I am very much against separating the governance of these two things. I believe that we can best keep this technology in the right context of how it should be used by including as much as we possibly can in that governance regime. And it may be different. But I think once you have it under the umbrella, you can say this is low risk and we'll move out under the low risk scenario whatever is low risk, and this is high risk whatever is

high risk. And don't forget that many of the CDR technologies are going to require putting that carbon dioxide someplace. And that aspect of it is not going to be necessarily lower. So I think that we should keep that strategic context in mind.

Secondly, I think that it's incredibly important that we start to learn about governance at the same time we're starting to learn about geoengineering, and that we do it while the risks are low. So if we have experiments like we heard about this morning from Tom and David where these are very low physical risk experiments, this is the time to start putting certain attributes of governance in place, because you can imagine if you finally do get to the place in research where there is some risk, if you haven't put some of the basic elements together and exercised them and gotten those muscles toned up, how you would call really address some aspect that had real risk in it. So one of the first things I think you can do to address that issues is to have an independent advisory board. And that independent advisory board can help to put a lot of things in place, to start to learn about the things that we need. For example, how are you going to be transparent? It is not necessarily an obvious question. How are you going to have deliberation between you and society? How are you going to assess the research? How are you going to know that it's reliable?

So let's talk about some of those things. Let's talk about reliable research. So we think we need to have institutions set up that are going to produce research in a way that we find reliable. We talk about just a couple of those. One of the most important points to me is transparency. What is transparency? It is not releasing your data, not telling everybody you're doing an experiment. It is having information available in a way that will facilitate understanding and dialogue, and I like to call it meaningful transparency. So it is designed to get to develop trust in the research.

So you need to talk about what you need to be clear about what the intent of the research is, why you're doing it the way you're doing it, what the quality of your information is, what you hope to learn, what are the research questions you're trying to answer? And those questions for example become a really wonderful fulcrum for discussion with the public. It is that place where the public can engage. If you just say I'm putting sulfur in the atmosphere so I can understand particle size and do some of the things that Joyce was talking about, the public will probably come back and say, but I want to know if I'm going to have to breathe it. Can you answer that question? And sometimes, they will also question your methods. And that dialogue about what your method is, why you're doing it, why you understand what you do, is very important.

Secondly, and I think this is a discipline that we absolutely have to have in this field, is that we have to predict the results of every experiment a priori and compare the results to what we predicted. This is the reason. We are never going to know everything about this. We are never going to know how to do this perfectly. The best we can hope for is that we have some kind of accuracy in our understanding of what direction it's going to go, and some confidence that we understand accurately. So as we move through, experiment by experiment, and we predict the results and we compare. If we get better and better at predicting these experiments, we're going to have a sense that we kind of know what direction things are going to go. If we don't, if the corn gets out, we know that it's bad. And so this discipline of formally saying, here's the experiment I'm doing and here's the result I expect, and then formally showing how that—

I'm going to say one more thing about this. So the peer review process needs to be amped. I won't talk about that. I just want to talk about one other thing that I think is critical. And Kelly did such a good job I'm not going to have to say much. The mission driven research has to be reinvented. This has to be

mission driven research that is based on systems analysis, as Kelly did a beautiful job explaining what that is this morning, but we haven't been doing that very well in this country. At least here. I don't know about other countries. We've lost that. We did it in the Cold War and we made a mess. There were recently examples from NSF. I don't know if anybody followed the neon program, the National Ecological Observation Network. It was funded as a mission- driven research project. It became aggrandizement of the company that was formed to do it. There was no communication between bottom and top.

We need to have something that has a systems approach, that defines the system, defines the components that have to be researched just like Kelly did, and is allowed to also bring forward the ideas from the bottom to the top of the organization and good communication. The attributes of this need to be studied. We need to look back at things that were good and bad and redesign it.

OLIVER MORTON: Thank you very much, Jane. I want to go directly with a question on that. What examples do we have of mission driven research done in a non-governmental context? And given there's been a lot of discussion about A, the unlikelihood that there will be a large government program. B, the difficulty about a large government program or any government program at a time when the same government is costing other parts of the climate research agenda. Can you point to anything that suggests this mission-driven approach having a public non private sector success?

JANIE LONG: That's a really good question. I guess I would start to look at some of the big corporations and companies that had big mission-driven research.

KELLY WANSER: I would argue driverless cars. I mean, if we're looking at something that has a lot of science, a big systems approach, is being done in the private sector, is mission driven, is risky, it's being done at scale where it is being proposed at scale and it's almost entirely private sector.

OLIVER MORTON: I'm going to take questions now.

ROGER COOK: Thank you. Roger Cook, Resources for the Future. I'd just like us to remember Star Wars. I think you were referring to this. This was Reagan's initiative with death stars and ray guns and weaponized satellites. All of the scientists at the beginning said, this is a bad idea, it won't work. And then he put out a lot of money. Then suddenly people started saying well, OK, maybe we can do something. I'm just putting that out there.

AUDIENCE: Thank you. I want to pick up on the last two panelists. So I won't come in on Andrew's two terms that frighten everybody. But I will say this. I believe that there is a non-trivial case that this White House comes around on climate change much sooner, meaning in the first term. And the case is the following. It is that A, the business community in America wants action on climate change very clearly. Most of the large companies are international. They have customers. They want that.

Number two, if there's anything to be learned from today's debacle in the health care debate, it's the Republicans will learn they cannot repeal a major program area without replacing it with something better. There is no issue in America today where there is a broader gap between the Republican base and the Republican leadership than climate change. And what they are doing right now is such an overreach its Pruitt bull in the china shop in the EPA. It will cause a backlash. And when that backlash

comes, the question will be what is the Republican replacement program for what they have now, which is a repeal only strategy.

And there are only two things they can do. They're not going to go back to the Obama style regulations. They're either going to go with a market based climate policy, or they're going to go with some interest in geoengineering, or both. So I think that there is a near-term case. And finally, I want to mention just on Jane's comment of the advisory board. Having listened to everything today, if there is one thing that I think this whole community could do to validate the field, it would be to go with that idea of an advisory board but in a specific way. Bring together elder statesmen, former heads of state who have ultimate credibility, who have time on their hands, and who could, just by convening around this, bless the idea as a serious topic. Help you develop the government structures. That would be a very concrete umbrella to move this forward.

AUDIENCE: Thank you. So I'd like to highlight something that has been said repeatedly over the course of the day that. I have the impression that at a level of a superficial slogan everybody agrees very forcefully on, but I want to press to more specificity and suggest some disagreement than [INAUDIBLE] otherwise [INAUDIBLE] more specificity. The statement is, Jane said it nicely, it's imperative that we do everything possible to keep all research on geoengineering in the context of a complete climate response. So yes. I think everybody said. But consider the range of implied consequences that we've heard over the course of the day. We've heard at least two or three people, including Rose on the panel, Sylvia and I think a couple of others, suggest that there's an intrinsic structural inability to do that as long as you're talking about geoengineering, and so to talk about geoengineering is basically improper.

At the other extreme it seems to me there might be something like a reflexive formal recognition. It's like once you've genuflected in the direction of the importance of mitigation, you can sort of concentrate on what you're doing to try to contribute to solve the problem. I just want to point out, there's a huge range of contradiction among those interpretations of almost the same statement. And the only way I can think of to resolve and reconcile them is to move to the level of specifics. And so my question to the panel is, I bet you all agree with that. If you wanted to take that really seriously and take it on board, what concrete, specific things should some identifiable person or actor, maybe somebody in this room, do now, to do it more effectively than we're already doing it? Because everybody is certainly paying—not just lip service—sincere, intense homage to this before they start talking about geoengineering.

THOMAS ACKERMAN: A quick response to the comment earlier about scientists and pots of money. It wasn't the scientists that responded to the pots of money. It was industry, particularly the defense industries. Scientists mostly still swore off. The question that I have, and it's something that really concerns me, is if we start down this path, how do we maintain some separation from that pot of money in the industrial complex? I don't know the answer to that, but it worries me a lot.

AUDIENCE: Paul Bledsoe. I just wanted to make a quick comment, which is that I don't believe the American public thinks climate change is a very serious problem right now. And I think that that's our biggest problem. Despite the fact that Louisiana floods are made twice as likely because of climate change and costs the taxpayer $12 billion, people don't know that. And so, I think the biggest hurdle is to show the true costs of climate change. 2/3 of the Forest Service budget goes to fighting fires. All these very practical things that are happening. And until we educate the public and governors, civil society, about the true nature of the problem, I just think that you're never going to gain public consent.

AUDIENCE: Jane Flegal, UC Berkeley. I was really interested in Peter's discussion about the potential parallels with biotechnology. And I think you talked a bit about the unwillingness of the community advocating for GM at that time to open the conversation up to broader ethical, political and social concerns. But it strikes me that there is another risk which is what folks like Dan Goldstein have called the scientization of politics. And David actually hinted at this earlier. And so I'm wondering if as an example, if I might ask you in the biotech case, if you think that if highly rigorous scientific studies of the ability of biotechnology to feed Africa had been conducted, to what extent do you think that would have addressed broader social and political concerns or quelled broader political debate? And what might we take from your answer to that question about geoengineering?

OLIVER MORTON: Peter, you take that one first.

PETER KAREIVA: At the Academy where we discuss that report we just came out with, it was clear that the ethical debate—and much of the debate was about values, so science had nothing to do with that—but you had to allow that conversation to happen. But to speak to your Africa issue, I think if there had been sort of serious data collected and research done to say what happens to small farm holders, and what happens to that community, to even consider that in advance, to consider that scenario to say not what happens to a company's profits but what happens to the small holder's ability to use this technology. If that had been asked from the beginning, it would have changed some of the scenarios, and it certainly would have changed the information we have available now, which is pretty skimpy, to even address those questions which still lurk.

OLIVER MORTON: And did you want to come back on that, or did you want to come back? Ted one then first, and I'm going to come back to everyone on Ted two.

AUDIENCE: So for Ted one. It's a compliment.

ANDREW LIGHT: Of course I hope you're right. I applaud the work that you guys have done on this. It's extraordinary. Three problems. Three big hurdles. Number one, I agree there's a business community out there voice on this. I agree that they have an active audience in the White House, mostly run the national economic [INAUDIBLE], but you've got to worry about the US Chamber of Commerce. One of your biggest hurdles there. We just released a report that compliance with the Paris Agreement would cost the United States $10 trillion. Right? $10 trillion. Now, this is a little evil genius on my shoulder. I started doing back of the envelope calculations. What kind of policy could I design of any sort that would cost $10 trillion? That's actually an interesting talent.

So that's a big hurdle, is that there's a lot of noise out there in terms about the messenger. Secondly, Steve Bannon and the Breitbart people have got to be completely sidelined because Trump's popularity ratings just plummet, or decide for some reason not to get involved in this debate. And third, I think the problem is getting Congress. Whether or not this administration to be willing to go to war with Congress to try to force the coalition between Republicans and Democrats do something like the proposal you guys put forward. So that's all I'll say on that. I totally agree with you. There's some room for something out there, and we're going to be very careful about how we sort of what we're applauding and what we're not.

OLIVER MORTON: Gentlemen, I want to come in on the idea of elder statesmen. Or the rather despairing [INAUDIBLE] that people still don't know. Before we go to Ted's question.

JANE LONG: I want to do both at the same time. So I think that one of the really important things about geoengineering is that it is a fulcrum around which you can engage that conversation. That once you bring up the idea that we might have to do this, I think I wrote a paper on this called Frankenstein's Academy. I mean, it basically gets people's attention that things are bad. And so we have to use it that way. Which is another reason why we need to keep this context broad and not divided up into academic reductionist research projects. To Ted's point then. For example, I think this is hard. And I think that I'm really impressed.

I mean, there are examples. Like, I think the stuff that Doug MacMartin and Kate Ricke are doing for example, where they're looking at how the knobs of geoengineering turn effectively, given different scenarios on mitigation and adaptation. How do you—they're actually couching or understanding. And I think Kate showed you some similar things with all those little graphs. It gets complicated. It gets hard. But we need to think about this all the time. If you're a program manager, how would you define the mission of the program, and how would you ensure that the context is kept broad? I don't think that's just something you can answer glibly right now. I think it is area of focus. How do you do that? Because it's important to do it. Andrew when answering comes on 10 second Western you know we're on the take cycle the dogs are at our heels

ANDREW LIGHT: If I understand the question correctly, it was very specific recommendations on how to advance the [INAUDIBLE] I think that I did that in my comments. I think that I did that. And I think that I sort of said, look inside the framework convention. We need to get geoengineering considered among the suite of indicators that are going to be looked at for the global stock-take. And I think that the first pass at that is a 2018 facilitative dialogue. This is one of the recommendations that I believe that those of us who are working on the American university Forum for Climate Engineering Assessment Report on Governance, it's one of the things that we are coalescing on making that recommendation. We'll see whether it survives at the end of the day, but I think it will.

And then also using these other clubs of countries that have already been established, that were part of how we got Paris across the finish line, which is where you can actually, I think, insert this and kind of mainstream it. And I think it has to be. It's not going be the only time. Look, in those conversations we get discussions of things that people don't like that there is not unanimity on. Nuclear power and carbon markets. A lot of people don't like carbon markets, folks, I mean for the reasons that were mentioned on the previous panel. When the clean development mechanism was first articulated, it was thought to be this big cop out by developed countries to get away from their obligations. That's still out there. But you don't need agreement on the technology pathway or the policy instrument in order to want to mainstream it within the broad discussion on that. And I think those are the [INAUDIBLE].

OLIVER MORTON: Peter, I want to come to you again. Ted's specific point about specific things people can do to situate geoengineering within a complete climate response.

PETER KAREIVA: Well, it hasn't really been addressed in the IPCC reports. So you can put it in two ways. You could put it in the scenarios. But you could also put it in the impacts. So you can have geoengineering as an impact of climate change, in terms of a response. And both of those ways of putting it in were I think situated.

KELLY WANSER: There is a working group emerging for the next IPCC report with geoengineering as a cross-cutting topic. So I think it will start to emerge there. So from my point of view, I guess I'm really heartened to hear about the stocktaking report, because I've been putting things in the context of

relative risk. Geoengineering is a component of a portfolio of relative risk. And if you take something like sea level rise and talking to the general public and policy makers and our choices are managed retreat. They are highly engineered attempts to thwart sea level rise, or they're geoengineering. And if there are other options, obviously whatever mitigation trajectory we're on. But these are relative [INAUDIBLE] in this context. The more work we can do there that keeps geoengineering as part of a portfolio. It's other parts of the portfolio that are relative risk, and then by God, we should do them. We just need to understand the risks of this one.

ANNA-MARIA HUBERT: I agree that there is an institutional context to this. But I think also we can think about rules and principles of international law, and how they can be reinterpreted and applied in a particular context. So when we think about, for example, article 4.1 of the Paris Agreement, that states are supposed to reach a global peaking of greenhouse gas emissions, we can think about how that objective is a bit [INAUDIBLE].

How that goal maps onto geoengineering and could be interpreted in that context. I'll give an example. When we talk about a emissions, that's defined as a release of gases. And I was involved in London protocol negotiations leading to the [INAUDIBLE] geoengineering. And So though this isn't quite the language that I suggested, there's an idea inserted in the preamble that says that emphasizing that ocean fertilization and other types of marine geoengineering should not be considered as a substitute for mitigation measures to reduce carbon dioxide emissions. And in the meeting subsequent to that, in fact, the Saudis were there arguing that they have a right to develop, and their economy is based on oil, and therefore they should be allowed to use geoengineering as an option to maintain business as usual. So I think these kinds of principles would be really helpful. And so defining general abstract principles in relation to international environments will always be really important.

OLIVER MORTON: Thank you all very much. I'm actually going to abuse my chair position to give my answer to Ted's point, which is when prominent people in the environmental movement see people make claims about the impossibility or otherwise of the two degree and 1.5 degree [INAUDIBLE] that with no mention of geoengineering whatsoever, they should say something, rather than just letting it slide. So I'm going to end on that one. That was blatant editorializing. [INAUDIBLE]. Thank you all very much indeed.

GERNOT WAGNER: Thank you everyone. Especially on this even for DC unusually crazy day. It's amazing to have so many of you here. I hope you all consider this sort of a retreat from serious debate outside.

I won't attempt to summarize so much substantive content—maybe just two very quick points. Context matters. We've heard about this over and over again. Versions of context. Without it solar energy engineering. You can describe it in various terms. Some profound. Some profane. Context matters. Second bit. Steve Hamburg sitting right here and I guess I'm not revealing that I did spend eight years out of the past ten at EDF myself, most recently as the lead economist. The EDF statement, ignorance is our enemy. Yes. Research matters, which is exactly why we are here. And frankly, what's interesting to see is the ecosystem developing. Ecosystem of researchers, institutions, Janos Pasztor's C2G2 initiative. UCLA School of Law. Ted Parson's initiative. Lots of open questions.

Frankly, this is probably the best time to introduce very quickly, very briefly, Harvard's Solar Geoengineering Research Program. Lots of open questions. Lots of reasons for debate. Inclusiveness, transparency. Though one where we have put our stake in the ground is with the name. There was

albedo modification, climate engineering, and lots of other names. We did in fact admittedly consult some of you. We decided to name it the solar engineering research program.

Two great bits we heard. Quite a bit today about David Keith's proposed small scale flight experiments. Just to try to put that in a bit of context. Yes, it is an important element. It's the sexiest sounding proposed research in fact happening. It is one of many proposed research projects, research ideas like that. Only one of many. There are several. About a dozen Harvard faculty involved. Students, postdocs from all across the university. Increasingly, of course, we are trying to get many, many others involved.

Just one quick example, one very concrete thing that we are about to roll out is a residency program within our research program inviting postdocs, junior senior faculty researchers from all sorts of institutions to come work with us. This doesn't mean you have to agree with us. Quite frankly, it is very, very healthy to have folks come in who strongly disagree with certain things we are doing. In fact, that's the point of having a residency program like this. Which is my last point now. I'd like to point you to our website where both these proceedings are live-streamed today. We'll have an archive after today up there, and very soon this report as well, which is still only available to participants. There are no secrets in there, just some copy-editing errors essentially. We will have an edited version of this very soon on a website. Geoengineering.environment.harvard.edu. Thank you very much.