

Opening remarks: Plan B – Engineering a cooler Earth  
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Dec. 9, 2017

I'd like to welcome you to Caltech. My name is Paul Wennberg and I direct The Linde Center for Global Environmental Science. Today's symposium is a joint project of the Linde Center, the Keck Institute for Space Studies – which hosted a workshop on geoengineering in 2011 – and the Resnick Sustainability Institute. The excellent logistical support for our program is wholly due to the staff of the Keck Institute – Michele Judd, Iryna Chatila, Janet Said, and Amy Leong.

Our symposium today was made possible by a generous grant from Charles Munger who joins us in this conversation – thank you very much Charlie.

The welcome to today's symposium was supposed to have been delivered in person by Caltech's president Tom Rosenbaum, but fortunately, he had a not-to-be missed date with the Royal family of Sweden. Thru the magic of technology, however, he has just sent us a video message:

<play message from Tom Rosenbaum>

Caltech has a storied history of research in Environmental Science and Engineering. Our faculty and alumni have made major contributions toward engineering a better world thru their efforts to diagnose and design mitigation strategies for air and water pollution. The route from lead added to gasoline to blood poisoning was identified at Caltech and this evidence played a major role in its phase out in 1990 via an amendment to the Clear Air Act.

In response to climate change, Caltech again has taken a leading role. Thru the generous donation of Stuart and Lynda Resnick, we have created a center devoted to engineering solutions for low environmental impact energy sources and sustainable development. Thru the generous donation of Ronald and Maxine Linde, we have created a research center devoted to improving our understanding of climate science.

It is clear that we face peril on our current path. In response to the increase in greenhouse gases, surface temperatures are increasing rapidly. While a path to decarbonization of our energy supply is becoming more obvious, it is not at all clear that our efforts or policy response will be sufficient. Indeed, it seems more likely that by themselves they will not.

This brings us to our topic today: Can we engineer a cooler earth? What solutions exist that are technically feasible? What would they cost?

To the first question, How can we cool the earth, we need to start with a basic understanding of what sets Earth's climate.

- Slides illustrating basic thermodynamics of Earth's climate.

So, to cool the Earth, there are really only two knobs to turn: We can increase the reflectivity of the earth or reduce the strength of the greenhouse. We have structured our discussion today around these two, quite disparate, topics.

We begin our symposium with a brief presentation by Caltech's Simona Bordoni on the trajectory of the greenhouse and the response of the climate system over the past 150 years. Next, Tapio Schneider, with input from our colleague Andrew Stuart (who unfortunately cannot be with us today) will describe where we are headed – as well as the uncertainty in that trajectory.

After our coffee break, we address how CO<sub>2</sub> can be removed from the air and 'disposed' of. The issues here are technical and economic – and, of course, the economics depend critically on the global policy response to climate change.

After lunch, we will discuss how we might turn the other knob – altering the reflectivity of Earth. We break this discussion into two parts. The first is organized around how this might be done, what the uncertainties are, and what potential technical risks exist. In the second part, we will hear about the ethical, economic, and governance challenges that would certainly accompany this approach.

I hope you all find these conversations thought provoking and come away from the symposium with a deeper appreciation for both why we need to research these Plan B(s) as well as understanding the major policy, ethical, environmental, and governance concerns that surround these technological solutions.

With that, I would invite Caltech's Simona Bordoni to tell us about Earth's climate of the recent past. As with all speakers, Simona's bio can be found on the sheet that accompanied today's agenda.