Climate Science and Engineering
at Intellectual Ventures™

Intellectual Ventures™ is an invention company. We identify hard problems of great importance to society and come up with ideas for new technologies that address those problems. Because major shifts in the global climate would pose a challenge like no other that humanity has faced, we at I.V. have devoted a substantial amount of effort and investment to develop ways to avoid the emissions that cause climate change. We have also begun inventing practical ways to reverse some of the possible effects of climate change if, despite humanity's best efforts, they become intolerable. Such tools should be seen as a last resort. But they might be needed to buy time for the nations of the world to complete the transition to cleaner energy systems, because a technological shift of such magnitude and speed is unprecedented in human history.

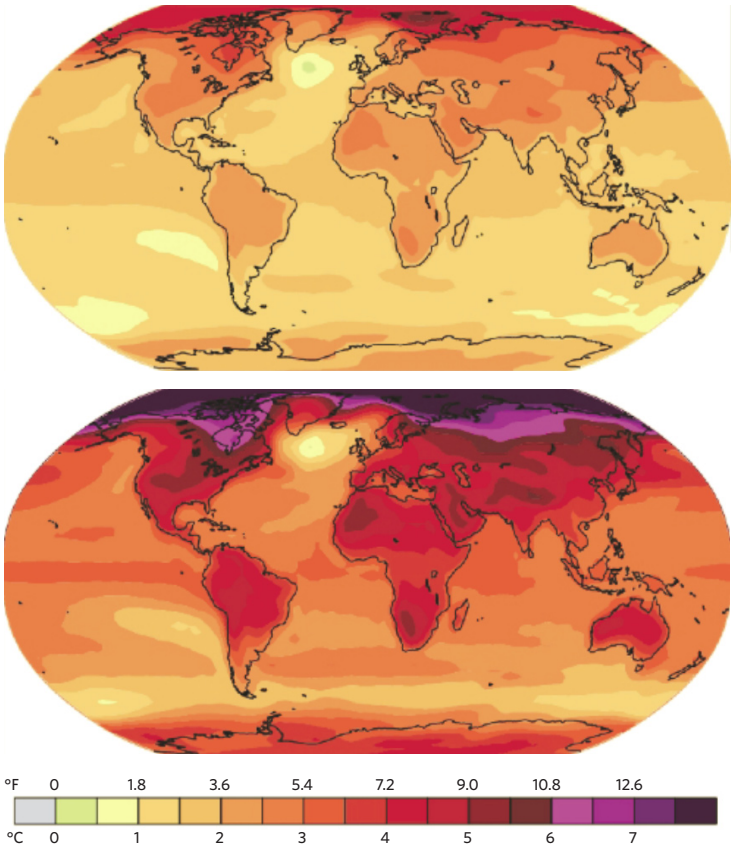
Our work has already generated new ideas—and numerous patent applications—for a number of promising technologies:

- better batteries that could allow electric vehicles to be refueled more quickly and easily;
- ways to improve the engine efficiency of hybrid vehicles;
- fuel-saving technologies for airplanes;
- improved systems for transmitting the electricity generated by renewable sources, such as wind farms and solar arrays.

Intellectual Ventures is also designing a new class of advanced nuclear reactors, called traveling-wave reactors, that can generate affordable, carbon-free electricity. Traveling-wave reactors offer the promise of a power source that has an inexhaustible fuel supply, that is much more reliable than other sustainable energy sources, and that produces far less waste per kilowatt than conventional nuclear reactors do. In 2006, I.V. launched TerraPower LLC, a subsidiary whose world-class team of nuclear scientists and engineers is designing traveling-wave reactors in a range of sizes. With the help of established partners in the nuclear industry, TerraPower aims to bring this technology to market by the early 2020s.

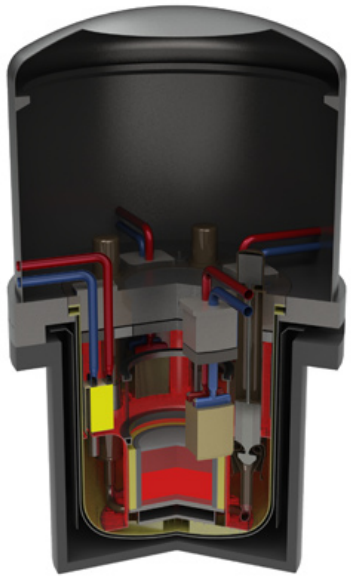
Technologies for Climate Emergencies

Policy makers, business leaders, and entrepreneurs around the world have been working hard for many years to improve energy efficiency and to reduce the emissions released by the ever-growing global economy. These efforts are accelerating. Yet



TWO POSSIBLE FUTURES projected by the U.N.'s International Panel on Climate Change project a warmer Earth, particularly in northern latitudes. The maps plot temperature increases from the average in the period 1980-1999 to the average in 2090-2099, under two plausible scenarios of social and economic growth.

CREDIT: Climate Change 2007: The Physical Science Basis. Working Group I Contribution to the Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Figure SPM.6. © 2007 Cambridge University Press. Used with permission.



TRAVELING-WAVE REACTOR being designed by TerraPower LLC offers a new way to produce affordable electricity with no greenhouse emissions, less waste than current reactors, little or no need for fuel enrichment or reprocessing, and fuel resources that will last for millennia.

CREDIT: Wayt Gibbs and Ash Odedra, Intellectual Ventures

emissions of greenhouse gases continue to rise, and it remains unclear when they will crest and begin to decline.

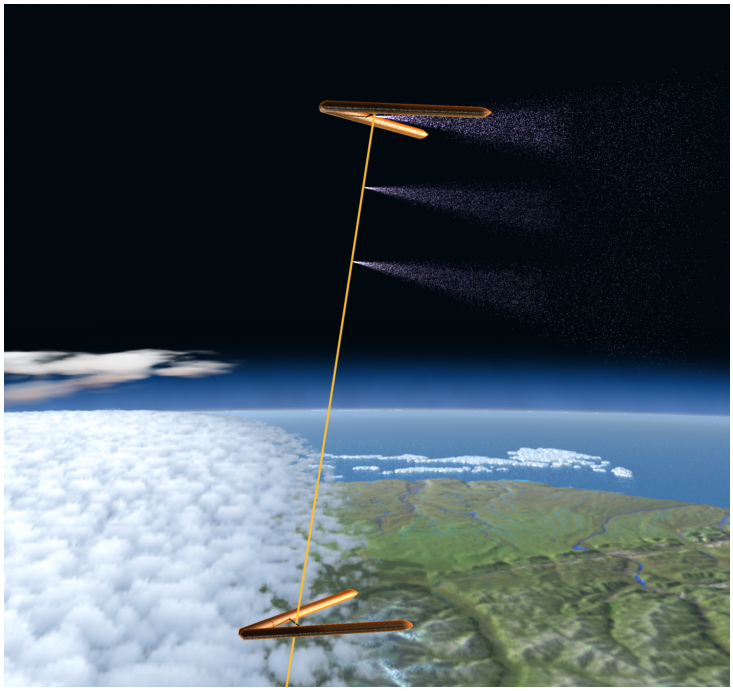
Climate science, despite tremendous progress in recent years, is also still uncertain in many ways about the timing and severity of changes on the horizon. Greenhouse warming is real and measurable. But the interaction of sun, clouds, sea, ice, land, and the biosphere is mind-bendingly complex, and computer models can still capture only a fraction of this complexity.

Many glaciers and ice caps are shrinking faster than was projected. Paleoclimate data suggest that abrupt periods of warming can occur, perhaps as a result of positive feedback loops: for example, melting ice can expose open ocean, which absorbs more sunlight, which then warms more quickly, melts more ice, and so on. Conversely, some global climate models suggest that changes in the century ahead will be moderate and manageable.

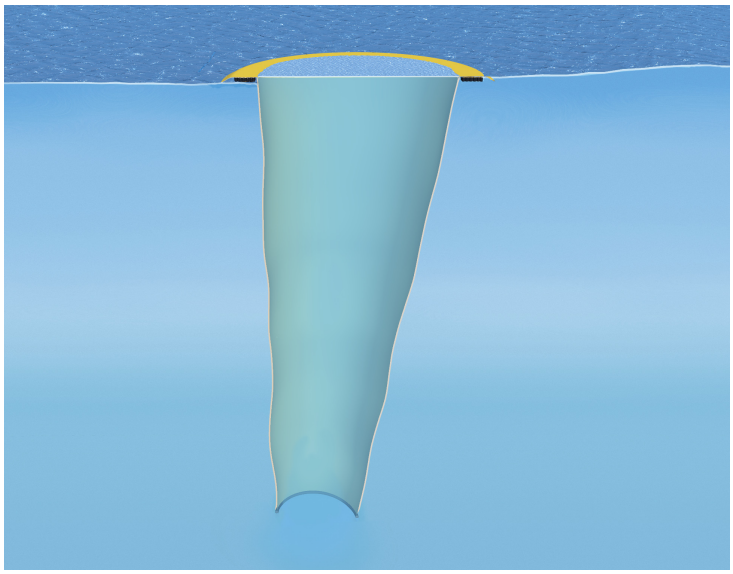
In the face of such uncertainty about the rapidity and magnitude of both climate change and the social and economic responses to it, the technical community has a responsibility to explore backup strategies for dealing with an unexpected climate emergency. Developing, studying, and testing climate engineering solutions will take years. If the climate begins shifting abruptly before that work has started, humanity may not have enough time to deploy the technology responsibly. Many in the scientific community thus now agree that exploratory studies on geoengineering systems should begin immediately. (For examples of some of the scientific discussion of this question, see Further Reading below.)

Intellectual Ventures is in a good position to contribute ideas to this process. IV's unique business model creates an environment in which scientists, engineers, and inventors can combine their talents to create radically new ideas for solving difficult problems. Already IV's work in this area has generated two promising sets of inventions: one for a relatively inexpensive and practical way to offset warming in the Arctic or other parts of the planet, and another for reducing the ferocity of hurricanes before they blow over major cities.

Intellectual Ventures does not advocate moving straight ahead to construction and deployment of systems such as these. We see geoengineering not as a permanent fix for an intolerable climate, but merely as a temporary (and hopefully unnecessary) bridge to a cleaner global energy system. A great deal of scientific and engineering work must be done to understand how such systems could work and what unintended consequences they might have if used. Indeed, the clearer a picture we have of possible side effects, the more likely we will be able to invent solutions to those as well. But because the research and design efforts will take many years to complete, it would be irresponsible to put them off further.



A STRATOSPHERIC SHIELD to reverse severe warming and rescue the Arctic ice cap might be possible with current technology and at relatively low cost, using Intellectual Ventures inventions.



OCEAN COOLING SYSTEM proposed by I.V. and Prof. Stephen Salter may offer one way to reduce the strength of hurricanes before they make landfall.

CREDIT: David Fierstein

Further Reading

J. J. Blackstock, D. S. Battisti, K. Caldeira, D. M. Eardley, J. I. Katz, D. W. Keith, A. A. N. Patrinos, D. P. Schrag, R. H. Socolow and S. E. Koonin, *Climate Engineering Responses to Climate Emergencies*, Novim, 2009.

P. J. Crutzen. Albedo enhancement by stratospheric sulfur injections: a contribution to resolve a policy dilemma? *Climatic Change* **77**, pp. 211-220, 2006.

R. Michal and E. M. Blake. John Gilleland: On the traveling-wave reactor. *Nuclear News*, September 2009, pp. 30–32.

The Royal Society of London. Special issue on geoengineering. *Philosophical Transactions of the Royal Society A* **366**, September 2008.