

Climate Grand Challenges: A Call to the MIT Community

Richard Lester
Associate Provost

Maria Zuber
Vice President for Research

July 23, 2020

Today the world lacks the solutions that will be needed to achieve global net-zero carbon emissions at reasonable economic and social cost later this century. Nor are the solutions in hand to adapt equitably and efficiently to the climate-related risks that will occur even if that mitigation goal is met. These problems are among the most urgent facing humankind. Much can and must be achieved with existing technologies and policy approaches, but without game-changing advances in multiple fields of science, technology, and policy the world's efforts to address the climate challenge will not succeed. Before the pandemic, there was no greater priority for the MIT community than to work towards this goal. Obviously, we must continue to muster our energies to respond to the pandemic. Yet, just as obviously, the climate challenge still looms. We cannot afford to put our efforts to address it on hold.

In response, MIT is launching a new research effort – *Climate Grand Challenges* – to focus the best efforts of our diverse and multi-disciplinary community and our partners on developing and implementing high-impact, science-based mitigation and adaptation solutions on an accelerated basis. **This is an invitation to all MIT PIs to participate in the development of this initiative.**

Climate Grand Challenges is designed to complement and enhance the work of existing MIT units which are pursuing climate science and solutions as a core part of their missions, including the MIT Energy Initiative, the MIT Environmental Solutions Initiative, the Departments of Earth and Planetary Sciences and Civil and Environmental Engineering, and many others.

Climate Grand Challenges

The world's climate challenge has many aspects. The most important driver of climate change is the atmospheric buildup of carbon dioxide released by fossil fuel combustion, as well as methane released from the production, distribution and use of natural gas and by agricultural activities. The social and economic damage that will be caused by climate change are byproducts of the buildup of carbon dioxide, methane, and other greenhouse gases, including rising sea levels that threaten coastal and low-lying regions, increased incidence of certain weather hazards, and declining crop yields due to changes in growing seasons, diminished water supplies, and proliferation of insect pests. Still other effects include climate-induced human migrations, the accelerated spread of infectious diseases, and hardship resulting from both the direct effects of climate change and the economic and political disruptions that will follow.

***Climate Grand Challenges* will address some of the most difficult and highest-impact research problems related to climate change. These include: (1) problems whose solutions would make possible major advances globally in mitigation or adaptation, or in both simultaneously, within a few decades; and (2) strategically important scientific problems whose solutions would enable quantification of climate risks and improve our ability to weigh these risks against the costs of mitigation and adaptation. *Climate Grand Challenges* will focus specifically on those problems where progress depends on the advancement and application of frontier knowledge in the physical, life, and social sciences and/or the advancement and application of cutting-edge technologies.**

Examples of **important scientific problems** that urgently need to be addressed include the stability of continental ice sheets, the role of the deep ocean in climate change, and the specific risks to coastal regions and to agriculture from a variety of physical, chemical, and biological hazards. Only by better understanding these phenomena will it be possible to identify and quantify the 'tail risks' associated with extreme outcomes, which in turn is essential to estimating the true social cost of climate change. The scientific foundations and implications of climate change remediation via solar radiation management ('geoengineering') also need further development.

Examples of **unmet mitigation needs** and related unsolved problems include cost-competitive long-term energy storage systems (advanced batteries, fuel cells, thermal storage, and clean hydrogen systems); scalable low-carbon firm electricity generating technologies (e.g., advanced nuclear); low-carbon manufacturing processes for cement and steel; viable alternatives to these materials; long-distance low-carbon transportation by land and sea; low-carbon aviation; and carbon capture, storage, and utilization.

Examples of **unmet needs in the adaptation domain** include the development of scientific models with sufficient spatial and temporal resolution for reliable quantitative prediction of future climate risks at local scale (e.g., heat waves, cyclones, floods, hailstorms, droughts), enabling pro-active adaptation measures, effective emergency planning, and sound insurance risk assessments. Countering the human health impacts of climate change and environmental degradation, especially regarding infectious diseases, will also be essential. New concepts for climate-friendly cities may provide combined opportunities for successful mitigation and adaptation. New, high-value applications for hydrocarbons that are not associated with greenhouse gas emissions would offer economic hope for fossil fuel companies and the communities that depend on them.

Even with such scientific and technological advances, behavior and habits will also need to change. Both technology adoption and behavioral change on a large scale are possible, if we understand their economic, political, psychological, and social drivers, and if governments and firms adopt and implement effective policies. Research leading to significant advances in both scientific and humanistic understanding of these phenomena, coupled to practical demonstrations and implementations based on these insights, would be among the highest-impact research-based contributions to climate mitigation and adaptation.

Faculty Review Committee

A **faculty committee** has been charged with organizing and overseeing the process leading to the selection of a group of grand challenge research projects. The committee consists of research leaders from all five of MIT's Schools and the Schwarzman College of Computing as well as participating Institute-wide units, and is co-chaired by the Associate Provost for International Activities and the Vice President for Research.

The Grand Challenge Process

The identification of grand challenge research projects will proceed in two phases:

Phase I -- submission, refinement, and evaluation of **Letters of Interest**;

Phase II -- invited submission of full **White Papers**, each articulating a grand challenge research problem and a plan for solving it.

The principal purpose of Phase I is to stimulate ideas for potentially transformative projects -- projects that are broad in scope and large in ambition and that have the potential to make major advances in solving the big problems which currently stand in the way of an effective global climate response.

Single-authored and multi-authored Letters will both be welcome. Since solving the most challenging and consequential research problems will likely require combining knowledge and techniques from multiple disciplines, we expect the problem scope identified in these Letters to substantially exceed the disciplinary reach of the authors. As the process continues and these projects become better defined, individual authors will be encouraged to build connections with colleagues in complementary fields, including from other universities. Accordingly, we expect that the White Papers in Phase II will be developed not by individual authors but by project teams.

The overall goal of these two phases of the Grand Challenge process is to draw on the creativity and commitment of the MIT community to identify game-changing solutions to hard climate-related problems *and* to make progress towards assembling the integrated, focused teams -- eventually including partners from industry, finance, non-profits, and other sectors of society -- needed to develop and implement these solutions rapidly.

Phase I

All MIT PIs are invited to submit a Letter of Interest briefly describing a high-impact climate-related research problem, explaining its significance for mitigation, adaptation, risk assessment, or other objective, and outlining a solution approach. Letters should be no more than two pages in length and should briefly describe:

- the characteristics of the research problem that will be addressed;
- how the potential impact of solving the problem should be measured (for example, in terms of greenhouse gas emissions or atmospheric concentrations; human well-being and welfare, including economic impact; or the enhanced capacity to determine science-based priorities for climate action at national, regional or global scale);
- the timeframe over which this impact could be achieved;
- the principal disciplines and fields of knowledge that will be necessary to accomplish the task (unnecessary to identify individuals at this stage);
- the principal obstacles – scientific, technological, economic, societal -- that will need to be overcome to accomplish the task and implement the solution at scale.

The Letters of Interest will be reviewed and collated by the Faculty Review Committee. The authors will be invited to participate in a series of discussions and exchanges with authors of related submissions as well as the broader MIT research community. Depending on the level of interest, several webinars will be organized by broad theme. These webinars will provide the authors with opportunities to learn more about the climate-related research landscape at MIT and to connect with other PIs. The Committee anticipates that the webinars, and subsequent discussions with Committee members and others, will result in some refining and combining of the project ideas described in the initial submissions, as well as gap identification. Revised Letters of Interest will then be submitted for further review. Authors may participate in more than one Letter of Interest.

Phase II

The Committee will invite a subset of Phase I authors to develop comprehensive White Papers that will describe in detail the problem area, its significance, and a plan for achieving a solution. As appropriate, these papers will also describe plans for accelerated innovation and/or broad societal uptake. The White Paper leads will be encouraged to continue building the teams needed to define and execute on

these plans. There will likely be important roles here for experts in public policy and in business models suitable for rapid scale-up of new products, services, and systems. For applied research that is focused on developing particular products or services, a plausible pathway to commercial viability will be an important element, with due consideration of cost effectiveness relative to alternatives.

Each invited team will receive funding (approximately \$100K) for development of the White Paper.

A review committee comprised of internal and external experts will review and rank the submitted White Papers using uniform evaluation criteria. An important focus of this review will be the larger significance of the problem that is being solved in terms of the potential for impact on climate-related risk. Each of the leading White Paper submissions will also undergo external review by panels of prominent international experts in the relevant technical domains and in processes and policies for innovation and societal take-up. Reviewers will include research leaders in the natural, physical, social, and management sciences, the humanities, and engineering, as well as leaders in the public policy domain and practitioners with successful track records in commercializing environmental and energy technologies and/or in mobilizing stakeholder groups around social goods and goals.

More details on the White Paper guidelines and the evaluation process will be released when the White Paper invitations are issued at the beginning of Phase II.

Schedule

The timeline for this process is as follows:

Milestone	Date Due
Phase I:	
First deadline for submission of Letters of Interest	September 21
Webinar(s) for discussion of Letter topics	Weeks of Oct. 19 & 26
Submission of revised Letters of Interest (optional)	November 30
Phase II:	
Invitations to submit White Papers issued	December 18
Submission deadline for White Papers	May 1, 2021
White Paper Reviews	May/June 2021
Selection of Grand Challenge Research Projects	July 2021

Long-Term Goal

The ultimate goal of *Climate Grand Challenges* is to launch up to five large-scale, multi-year grand challenge projects. ¹ MIT is committed to helping raise the funds for these projects. Plans are being developed to connect the White Paper teams with interested organizations and individuals, including philanthropic and industrial interests. An important objective is to build new relationships with companies from a wide range of industries around the climate research agenda.

Submission

PIs may submit Letters of Interest on [MIT's Internal Funding Opportunities InfoReady](#) site.

A Note on Project Teams: Cross-disciplinary collaboration will be strongly encouraged, and while this call is directed to MIT researchers, Letter authors and White Paper team leaders are free to include researchers from other institutions as part of their project teams. However, collaboration is not an end in itself; Grand Challenge White Papers will be judged on the significance of the problem, the likelihood of the project making a major advance in solving it, and the quality of the attention given to accelerated implementation and take-up at scale.

For further information, please contact us at climategc@mit.edu.

¹ For calibration purposes we estimate that each Grand Challenge project might require support of up to \$5-10M/year for about five years.



Massachusetts Institute of Technology
Cambridge MA 02139-4307
