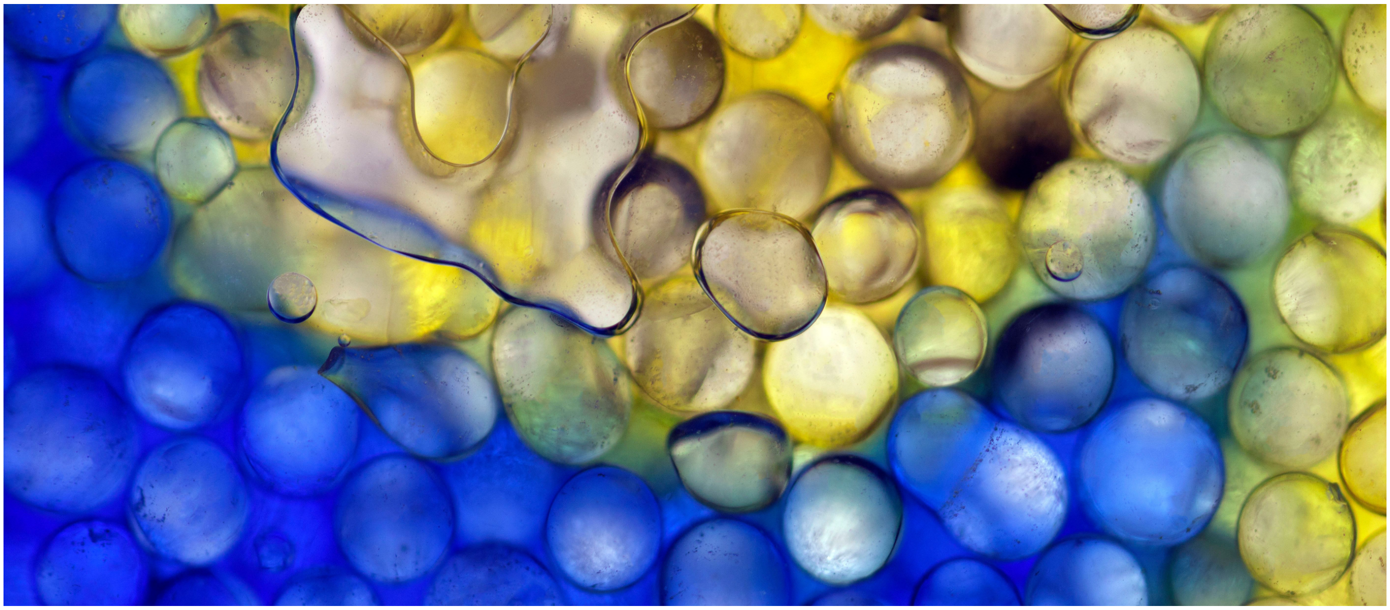

Demonstrating Safe, Globally Distributed Geological CO_2 Storage at Scale

The 6th IPCC climate change assessment report concludes that "the only path out demands intensive, immediate efforts to bring net-carbon emissions to zero, combined with unprecedented efforts to extract carbon from the atmosphere." We and many others believe that CO_2 capture and storage (CCS) will be critical to following this path; however, this will be a key contributor to the climate-change mitigation portfolio only if it is deployed at the gigaton-per-year (Gt/y) scale. Negative emissions technologies (NET) like blue hydrogen, direct air capture (DAC), and bioenergy with CCS (BECCS) all rely on disposing of huge quantities of CO_2 but have important geographic constraints resulting from either feedstock or energy supplies. The white paper by Gallant et al. ("Harnessing CCUS at Scale to prevent Overheating of our Planet") provides an overarching view of CCS, including proposals for significant advances in CO_2 capture.

What to do with the CO_2 once it has been captured is the Grand Challenge that we take on here, arguing that the most promising way to store CO_2 is via geological CO_2 storage (GCS) in the subsurface. GCS has been ongoing for decades, as evidenced for example by the Sleipner project, offshore Norway. Thus, it is tempting to misunderstand it as a proven—as opposed to radical—solution to combat climate change. The reality is very different: scaling up the technology from the megaton-per-year (Mt/y) to the gigaton-per-year (Gt/y) scale is an extraordinary scientific, technological, and regulatory challenge. To give a sense of the magnitude of this challenge, one gigaton of carbon per year is equivalent to about 100 million barrels of compressed CO_2 per day—comparable to the amount of oil that circulates around the globe daily.

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STRATEGY

While much progress has been made over the past two decades in the identification of trapping mechanisms, capacity estimation at the geologic scale, and decades of actual field experience at the Mt/y scale, two issues have emerged as critical to ensure safe and effective geologic CO_2 storage:

1. Risk of induced seismicity
2. Risk of leakage

We address those directly in our white paper and propose novel practical technologies to reduce improve storage security and reduce environmental concerns (Task 1), as well as characterize the geology of prospective storage regions, with a focus on offshore sedimentary basins, to significantly expand the geographic footprint of GCS and increase storage capacity in regions where it is most needed (Task 2).

If successful, our proposed geology-grounded, physics-based, computing-enabled, integrated approach will allow rigorous and quantitative assessment of:

1. the competing objectives of maximizing storage capacity and reducing leakage risk, and
2. the value of information from different monitoring technologies, relative to their deployment complexity and cost.

The outcomes from this project contribute to the future deployment of CCS through tools and analyses that will help streamline the permitting process for new commercial-scale CCS projects, and lead to better science-based policy for post-closure design and transfer of responsibility to the government. Making GCS at scale a reality, however, requires going beyond science and technology and addressing the societal, legal, regulatory, and political aspects. Recognizing this fact, our proposed work focuses on public acceptance, regulatory/permitting, liability, and environmental justice (Task 3).

GCS AS THE SOLUTION

This white paper delineates the key challenges to achieving GCS at scale, and how our work will contribute substantially to overcoming them. The cost of GCS will be reduced by identifying globally distributed sites that allow minimization of transport costs and by the more efficient approaches to monitoring that we develop. Demonstrating management of leakage and induced seismicity based on sound science should help reduce concern about these perceived risks. Identifying offshore reservoirs will also lead to increased public acceptance, avoiding NIMBY arguments. Wider appreciation of the need for carbon removal from the atmosphere will help GCS be seen in a positive light.

We recognize that time is of the essence in solving the climate problem. For that reason, we are now engaged with hydrocarbon companies in researching GCS with the goal of accelerating field testing in the short term. Our hope is that this engagement will be given the opportunity to grow quickly as MIT promotes implementation of our integrated approach to GCS at the scale required to enable NETs and mitigate climate change.

TEAM

This focused but interdisciplinary effort requires an interdisciplinary team. The PIs of the project—**Bradford Hager** (Earth, Atmospheric, and Planetary Sciences), **Howard Herzog** (MIT Energy Initiative) and **Ruben Juanes** (Civil and Environmental Engineering)—are each leading experts on complementary aspects of GCS. The MIT team, which also includes **Michael Fehler** (Earth, Atmospheric, and Planetary Sciences), has been expanded with critical expertise with the addition of **John Shaw** (Harvard; a world's leading expert in computational structural geology) and **David Reiner** (University of Cambridge; a renowned expert in techno-economic modeling and public perception of decarbonization pathways).