The atmosphere is being held hostage in exchange for our submission to an impossible future: one saved by geoengineering. To some, geoengineering—deliberate large-scale interventions in Earth's natural systems to counteract climate change—seems more urgently needed and rational with each passing day. But while technology-focused solutions like geoengineering often "seem to have magical advantages in terms of affordability, efficiency, and scalability,"[1] there are no magic solutions to real-world problems. These interventions have been thrust upon us by proponents of the same energy-intensive industries responsible for the climate crisis in the first place. Their legacy is that of a costly distraction. Reckoning with their political roots should lead us to conclude that geoengineering will not save us, and that it is much more important to curb energy demand at the societal level than often acknowledged. Doing so will require colossal near-term investments, scaling down energy-intensive segments of the economy that cater to the global elite, and undoing wealth disparities between the Global North and the Global South. Achieving these aims will be deeply political, more so than technological. They demand our unity in support of an internationalist, anti-imperialist, and explicitly pro-worker agenda.

Geoengineering is a catch-all term that includes solar radiation management (SRM) and CO_2 removal (CDR) from the atmosphere. These interventions work in fundamentally different ways. SRM aims to reflect incoming sunlight back into space before it can heat the atmosphere, while CDR aims to slow or reverse global heating by reducing the atmospheric concentration of CO_2. While SRM would indeed be likely to reduce average global temperature, it could also modify regional weather patterns.[2] If SRM were started and then abandoned, global temperatures could also spike back to previous levels.[3] For these and other reasons, energy researcher Simon Pirani writes that SRM is often viewed as "the last word in technofixes that is broadly reviled."[4]

There is more widespread support for CDR, especially at the intergovernmental level. CDR is a two-step process that aims to (1) use biological and chemical processes to draw CO_2 down from the atmosphere, and (2) durably store it in biomass (e.g., forest cover), commercial materials (e.g., concrete), or as waste in disposal sites. Voluntary commitments under the Rio Conventions and other pledges aim to restore around a billion hectares of land in the next decade—an area about the size of China.[5] The

International Energy Agency (IEA) has called for annual investment in CO_2 capture, disposal, and reuse infrastructure to increase about fifty-fold by 2030.[6] Many observers view CDR as a climate solution that is both novel and promising, but the history of CDR research, rhetoric, and governance tells a different story.

Decades of Deceit

In 1993, the year Bill Clinton assumed US presidency, corporations were well-aware of how their businesses were contributing to climate change. Some US corporations had known for more than twenty years,[7] but against the backdrop of conservative politics at home and energy market deregulation abroad, they had little incentive to deviate from business as usual. These corporations were a crucial instrument of fossil capitalism, the economic model whereby fossil fuels and industrial production serve the logic of capital by offering labor control and seemingly endless growth.[8]

Governments, too, were deeply dependent on fossil capitalism, which had facilitated the economic and imperialist expansion of Western powers from the Industrial Revolution onward. Growing political attention to climate change in the late 1980s and early 1990s yielded few, if any, tangible measures to reduce fossil fuel production or use. In 1992, all five US Democratic Presidential candidates supported capping CO_2 emissions,[9] but neither party seems to have questioned the basic premise of fossil capitalism. Nevertheless, by the start of Clinton's presidency, several industries including oil and gas, electric utilities, and transportation were turning to more aggressive tactics to evade prospective regulatory risk. With only mixed support from the new administration compared to the full backing of the Bush and Reagan administrations, the corporate community viewed continued deregulation and research privatization as key. Their tactics included climate change denial, conservative activism, and industry posturing.

While insidious corporate associations like the Global Climate Coalition and the Information Council on the Environment sowed doubt on the science of climate change,[10] lobbying groups embraced conservative activism to shift the political window of discourse further rightward. One of those groups, the Heritage Foundation, went so far as publishing a plan to shut down the Department of Energy.[11] In parallel, industry postured itself as the key to unlocking global climate solutions by forming relationships with universities and touting voluntary corporate sustainability efforts. Under competing pressures and unprepared to stake out a progressive platform, the Clinton Administration vowed to work in collaboration with industry.[13]

Meanwhile there was an explosion of research on CO_2 disposal. Universities, research agencies, and corporations hailing from the US, Japan, and several European countries worked in close collaboration, gathering for at least four major conferences between 1992 and 1998.[14] The CO_2 disposal methods they proposed were expensive, environmentally questionable, and out-of-step with the concerns of activists. However, the charade was a triple win for industry, enhancing the appearance of industry-driven environmental innovation, positioning climate change mitigation as a technology-dependent issue, and reinforcing corporate access to research funding and universities.

The Perfect Fix?

Geologic and direct-ocean CO_2 disposal surfaced as prominent options to mitigate emissions.[15] Both share the same logic: CO_2 emissions from fossil fuel combustion can be captured at the smokestack and disposed of away from the atmosphere like waste. Abandoned oil wells and saline aquifers, which occur under land and sub-seabed in the ocean, were viewed as prime geologic storage sites. CO_2 could also be disposed of directly into the ocean, either by pipeline in dense localized pools or by nozzle to mix and dissolve. Regardless of how the CO_2 would be stored, the value of CO_2 disposal was almost entirely the promise of mitigating emissions without eliminating fossil fuels.

There were major barriers to implementing CO_2 disposal. Cost estimates typically ranged from about $30–180 USD per ton of CO_2 avoided, whereas the energy tax proposed by the Clinton Administration in 1993 was less than $5 per ton of CO_2 for most forms of stationary combustion.[16] Both sub-seabed geologic and direct-ocean CO_2 disposal also seem to have been prohibited by the 1996 Protocol to the London Convention, an international treaty. The London Convention was established in 1972 as a framework to prevent pollution from ocean dumping and strengthened in 1996 with the addition of the Protocol, which explicitly prohibited at-sea disposal of most kinds of industrial waste. According to the scientific advisory body to the United Nations, CO_2 was included by the Protocol's definition of prohibited industrial waste.[17] There were also persistent concerns about the marine ecosystem impacts of direct-ocean CO_2 disposal due to acidification.[18] Collectively, these barriers should have been enough to reinforce the urgency of more immediate action to reduce emissions, but instead they served as fodder for new studies.

Until 1997, most planned and completed studies of direct-ocean CO_2 disposal were purely hypothetical; but in January that year, MIT's Howard Herzog penned a report for the US Office of Fossil Energy, advocating for further research. According to the report, the limited pool of existing research made it "difficult to fairly assess the potential of these technologies compared to other longer-term CO_2 mitigation options … (e.g., switching to nuclear or renewable energy sources)." The report estimated CO_2 capture, reuse, and disposal costs that were on the lower end of those reported in the literature.[19] By December, Herzog was among the recipients of $4 million of funding to conduct direct-ocean CO_2 disposal field experiments in Kona, Hawaii. Years later, Herzog's academic advisee Mark Anthony de Figueiredo documented the project in a fascinating master's thesis.

Initially, the project agreement was celebrated as a landmark achievement, signed at the annual United Nations Climate Change Conference. With several phases planned, the project would have culminated in a two-week-long CO_2 dump into the ocean in 2000, if not for opposition mounted by local organizers. Under the leadership of Kona resident Isaac Harp, the "Coalition Against CO_2 Dumping" was formed. Its members opposed the field experiment for several reasons. Some members were distrustful of the funders and research team—the same distrust shared by Hawaiian sovereignty and Indigenous rights groups. Some were opposed to direct-ocean CO_2 disposal for religious or environmental reasons. Lastly, some felt that CO_2 disposal was a distraction from the need to phase out fossil fuels.[20] The activist campaign went on for years. As a result, the experiment faced several permitting delays and was covered by more than fifty local news articles.[21] In a last-ditch effort, Herzog's team pulled out of Hawaii in 2002 and attempted to relocate the project to Norway. Herzog's team succeeded in obtaining a permit from the Norwegian government, but the project was ultimately vetoed by Norway's environmental minister, seemingly due to pressure from Greenpeace and the World Wildlife Fund.

Researchers like Herzog seem to have been allured, at least in part, by corporate sponsorship and professional fame. Despite the spectacular failure of the Hawaii experiment, Herzog accrued sustained support from Chevron, ExxonMobil, Shell, Saudi Aramco, Peabody Energy, Ford, General Motors, and other corporations in the following years. As members of Herzog's Carbon Sequestration Initiative, whose objectives included "[linking] industry to expanding government activities on these topics,"[22] these corporations have incontrovertibly influenced academic climate mitigation research and policy recommendations. As of 2022, Herzog occupies a senior research position at MIT's Energy Initiative.

Concerns over geoengineering, which includes CDR, are as relevant today as they were twenty years ago. First, critics are still distrustful of the researchers, corporations, and politicians who support geoengineering due to their fossil fuel industry ties. Second, CO_2 disposal necessitates an expansion of pipeline networks and geologic injection sites, which are opposed by some frontline communities. Third, betting on geoengineering can be used to justify weaker near-term action.[23] For these reasons, it's crucial for geoengineering to be deprioritized in our immediate efforts to resolve the climate crisis.

A Brief Survey of Alternatives

With less reliance on geoengineering, energy-related emissions need to be cut more aggressively to stop climate change from worsening. There are three main ways for this to happen: improving energy efficiency, substituting renewable energy for fossil fuels, and reducing demand for energy services. Whereas energy efficiency is used to minimize the amount of energy lost as waste in factories, buildings, and vehicles (e.g., better car mileage), a different set of social and infrastructural interventions are needed to reduce demand for energy services (e.g., eliminating the need for car ownership).

Policies to improve energy efficiency and expand renewable energy enjoy widespread popularity but are not universally supported. Efficiency standards, touted as a way to reduce utility bills for households and businesses, can also result in higher upfront costs. Similarly, renewable energy can confer long-term economic and public health benefits, but a shift would require high social spending and strong regulatory support. Despite these near-term challenges, energy efficiency and renewable energy are low-hanging fruit. They do not necessarily challenge consumption habits or social inequality across race, gender, and class. There are also limits to energy efficiency improvements and renewable energy growth—especially when aiming to minimize harm from mineral supply chains. For these reasons, reduced demand for energy services from countries in the Global North is also crucial.

Calling to reduce demand for energy services like personal transportation, air travel, material consumption, and even building heating/cooling can seem like a political lightning rod, but strongly principled policies could facilitate such changes while delivering a higher quality of life to most people. Unfortunately, such policies have not yet been widely implemented. On the contrary, some recent policy attempts—like consumer-facing fuel taxes—have been criticized for disadvantaging the poor. Better policies to reduce demand for energy services must challenge the root causes of high energy demand and global energy access disparities: fossil capitalism and its legacy.

Demand for energy services is intrinsically linked to built and unbuilt infrastructure, cultural norms, and economic pressures. In the United States, high rates of personal vehicle use due to "automotive city" design and commuter culture are a clear example of this relationship. Similarly, high rates of air travel correspond to poor rail infrastructure, lack of accessible recreation near population hubs, and business obligations.[24] Around the world, economic pressures seem to prevent families and communities from practicing more sustainable lifestyles. These pressures are often framed as naturally occurring, but they are actually a function of unequal capital accumulation.

Consequently, it is essential to undo not only energy-access disparities but also wealth disparities between the Global North and Global South. Social researcher Max Ajl proposes that centering North-South climate debt payments, anti-imperialism, and degrowth could achieve these aims as part of a transformative and necessary climate agenda.[25] At the domestic level, complementary policies should also limit the accumulation of wealth, challenge the *de facto* arrangement whereby one's personal wealth determines how much they can pollute, and deploy government spending to achieve social and infrastructural goals. Some Green New Deal proponents emphasize the need to increase government spending on work programs, universal healthcare, physical infrastructure, and sustainable leisure, while redirecting government spending from policing and militarization toward community-run services.[26] These internationalist and domestic policy platforms recognize the importance of wealth redistribution and reparative justice for meeting climate and societal goals, in part by removing the drivers of high energy service demand in the Global North.

These aims are inherently political and pro-worker, as they entail a transfer of wealth and power. Such framings for the climate crisis might be perceived as radical but they are not especially new. Climate debt payments, the return of Indigenous lands to Indigenous peoples, and mass democracy are central facets of the Cochabamba People's Agreement adopted in 2010. The Cochabamba summit convened more than 30,000 people from over one hundred countries, and its People's Agreement has remained a cornerstone of some resistance movements. Its demands are echoed and expanded upon by the Red Nation in their 2021 book, *The Red Deal*. It reminds us that "we must build the world we seek through building power. We build power by building movements, and we build movements through coming together with other working-class people."[27]

Politics of the (Im)possible

Supporters of geoengineering often emphasize the importance of listening to science. Indeed, there is much for us to learn from science in climate mitigation. As we look toward the future, science makes the stakes of the climate crisis clearer and provides us with an incomplete, yet insightful, collection of climate mitigation scenarios entailing different risk tolerances and technology options. As we look to the past, history shows that the practice of science is deeply political, having been leveraged as a tool of climate delay at the bidding of governments and corporations indebted to fossil capitalism. Thus, it is no surprise that geoengineering is prominent in "realistic" mitigation scenarios, which are often produced by institutions in the Global North and grounded in the continuation of historical economic trends. Fossil capitalism is at the root of these trends, as much as it is at the root of geoengineering.

Under alternative economic models, there are powerful steps that can be taken to halt the climate crisis from worsening and mitigate the need for geoengineering. These steps entail undoing energy and wealth disparities between the Global North and the Global South, in addition to coordinated mobilization to phase out fossil fuels, expand clean energy, build infrastructure, and transform the global supply chain. Inevitably, mass mobilization and political-economic transformation are needed. Some will claim that these steps are unrealistic or impossible, but the same should be said of halting the climate crisis from worsening under fossil capitalism.