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2050 Today

June 14 – 15, 2018

Carbon dioxide removal: carbon sinks and sustainability

Pre-read packet

Background

We have made terrific progress deploying wind and solar technologies. But to stay well below Paris commitments, we have to peak and dramatically mitigate emissions, and we have to remove gigatonnes of carbon dioxide. Removal is not geoengineering, and it is not just bioenergy with carbon capture—a modeling artifact. In order to achieve gigatonne-scale removal by mid-century, we need support today in the development of a vast array of removal approaches, ranging from restorative agriculture to direct air capture. During this interactive session, participants will discuss the state of natural and technological removal approaches, how advocacy and policy levers can accelerate the deployment, and what cutting-edge companies are doing to store carbon in a way that reduces fertilizer and water use while sustainably growing grains.

Session objectives

1. Provide background and general level setting
2. Define the most urgent problems for advancing carbon removal solutions
3. Propose concrete actions that foundations can take to address these challenges

Literature Review of Mercator Institute Negative Emissions Technologies Studies

1. Negative emissions—Part 1: Research landscape and synthesis. Jan C Minx et al 2018 Environ. Res. Lett. 13 063001. Link to PDF.
2. Negative emissions—Part 2: Costs, potentials and side effects. Sabine Fuss et al 2018 Environ. Res. Lett. 13 063002. Link to PDF.
3. Negative emissions—Part 3: Innovation and upscaling. Gregory F Nemet et al 2018 Environ. Res. Lett. 13 063003. Link to PDF.

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These three studies represent the largest and most comprehensive synthesis of the current state of knowledge around negative emissions technologies (NETs) and the need for carbon dioxide removal (CDR). Drawing on a corpus of 2093 documents, the authors assess the research landscape, the current state of the scenario literature, costs, potentials and side effects of NETs, and the need for innovation and upscaling. Key themes that run through the series include the necessity of CDR for meeting the Paris long term temperature goal under most (but not all) scenarios; the desirability of a portfolio of NET options over relying on one approach; and the immediate importance of accelerating innovation and upscaling today in order to deploy NETs before mid-century at the levels necessary in most recent 1.5°C/2°C scenarios.

What are negative emissions technologies (NETs), and why focus on carbon dioxide removal (CDR)?

- NETs are defined as "intentional human efforts to remove CO_2 emissions from the atmosphere"

- NETs use photosynthesis (afforestation/reforestation, bioenergy with CCS, ocean fertilization, soil carbon sequestration, biochar) or other chemical processes (direct air capture, enhanced weathering) to reduce atmospheric CO_2 concentrations

- The authors argue that CDR is a mitigation strategy as it addresses the root cause of climate change (atmospheric CO_2 concentrations), as opposed to geoengineering techniques such as solar radiation management which they classify as adaptation measures because they are attempts to ameliorate the negative consequences of climate change; see their Fig. 1 below:

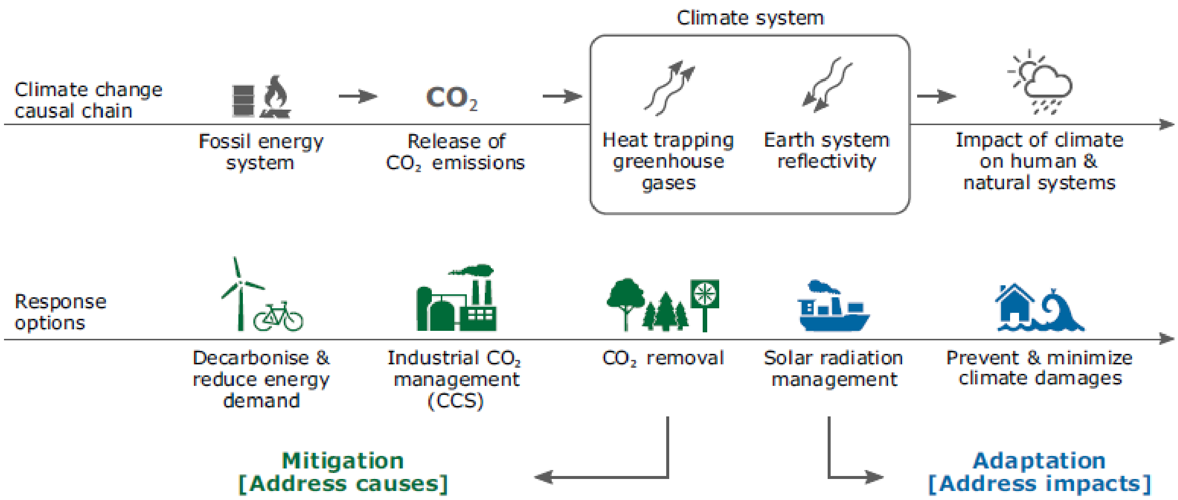

Figure 1. Human response options to the climate problem. Horizontal arrows in the top row show the causal chain of the climate change problem. Vertical arrows and bottom row define locus and modes of intervention for climate policy. Graph further developed from Keith (2000).

Do 1.5°C and 2°C compatible scenarios have different dependencies on NETs and CDR?

- For 2°C, there are options to reduce dependency on NETs (at least for now), but for 1.5°C, there is no way around large-scale deployment of NETs (although this doesn't have to entail BECCS)

- The window of opportunity for limiting CDR while still meeting Paris' long-term temperature goal is closing; if the current NDCs are met but not exceeded in 2030, 1.5°C would be out of reach. Salvaging the 2°C target would then require reliance on CDR at levels similar to those 1.5°C scenarios that feature rapid decarbonization progress starting by 2020

How much CDR may be necessary, and what do pathways for 1.5°C look like?

- In recent 1.5°C scenarios, a median of 15 Gt CO_2 per year is removed by 2100 (range: 3-31 Gt); CDR begins well before mid-century, with cumulative removal ranging from 150-1180 Gt

- For 2°C, the higher carbon budget expands the policy option space; one can limit the need for CDR, although most scenarios include NETs as part of a cost-optimal mitigation portfolio

- CDR can provide intertemporal and intersectoral compensation – decarbonization alone is no longer enough to avoid overshooting the 1.5°C carbon budget, and some sectors would be very difficult to decarbonize completely, such as aviation, industry, and agriculture

- The ability to shift the emissions reduction burden across sectors and over time could engender moral hazard, but the lack of decarbonization progress over the last few decades has rendered negative emissions non-negotiable for 1.5°C and pivotal, though not required, for 2°C scenarios

- Socioeconomic pathways with low energy demand, sustainable consumption patterns, low population growth, and high crop yield gains can limit the need for CDR

- The transition pathways for 1.5°C scenarios are divided into 2 periods:

    - ~2030-2050: Sharp, immediate reductions in net CO_2 emissions (about 3%-7% reduction per year relative to 2030); the timing for non-CO_2 emission declines is less constrained

        - Net-zero global emissions are thus achieved between ~2046 and 2056

    - ~2050-2100: Sustained period of net negative emissions, ranging from 1.3-29 Gt CO_2/yr depending on cumulative emissions before hitting net-zero, and residual emissions after

What are the NET options, and what are their costs, potentials, and side effects?

- This review investigates seven NETs, and finds that all (except for ocean fertilization) have sustainable medium-scale potential

- None of the NETs are sufficient in and of themselves to reach the levels of negative emissions in most scenarios, but a portfolio of several of them could have a substantial impact on global average temperatures while respecting biological limits and minimizing negative side effects

- The authors assess potentials (Gt CO_2/yr) and costs ($/t$CO_2$) in the year 2050 for six NETs:
    1. Afforestation/Reforestation (AR): 0.5-3.6 Gt, $5-50. Competition for land; limited to the tropics
    2. Biochar (BC): 0.3-2 Gt, $90-120. Soil quality co-benefits; requires residual biomass, also more study
    3. Bioenergy w/ CCS (BECCS): 0.5-5 Gt, $100-200. Competition for land, water, and nutrients
    4. Direct air capture (DAC): 0.5-5 Gt, $100-300. Competition for energy; cost is the major barrier
    5. Enhanced weathering (EW): 2-4 Gt, $50-200. Competition for energy; soil quality co-benefits
    6. Soil carbon sequestration (SCS): 2-5 Gt, $n/a. Soil quality co-benefits, but sink potential saturates

What are the current priorities for NETs, and what needs are there for innovation and upscaling?

- The broader innovation literature finds long time lags for scale-up and adoption of novel technologies; progress is urgent as models deploy NETs aggressively well before 2050
- This leaves precious little time for novel NETs to evolve into commercially viable and scalable options, although some NETs (such as afforestation/reforestation) could be deployed today
- Innovation includes both the supply-side (such as scientific research) and demand-side (public acceptance and market or regulatory incentives, such as a price on carbon)
- Ex ante, it is unclear which NETs will be successful, which argues in favor of a portfolio approach
- Several NETs are emerging out of R&D and into the demonstration phase; many ideas stumble at this pivotal stage and will require patient capital and policy support to emerge into commercially viable NETs; we need to focus not on CO_2 removed, but on knowledge gained

- Scale-up is next; one potential model is 'iterative upscaling' with successive designs at larger and larger scales, with each incorporating knowledge from the previous demonstrations

Further Reading

- 2050 Priorities for Climate Action: Carbon Dioxide Removal is a Necessary Complement to Deep Decarbonization, by Jan Mazurek and Surabi Menon, ClimateWorks Foundation (2018). Link.

- Grantmaking Strategy to Advance Carbon Removal Solutions prepared for ClimateWorks Foundation, by Noah Deich and Giana Amador, Center for Carbon Removal (2018). Link.