Carbon Solutions Living Lab

Carbon Removal Strategy for Harvard University

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What Exactly Is Carbon Dioxide Removal (CDR)?

Greenhouse Gases Mitigation

- Is the GHGs already in the atmosphere?
  - Yes
  - No

Carbon Removal

Emission Reduction

How is the carbon stored?

**Short-lived Storage**
- Afforestation & Reforestation
- Soil Carbon
- Ecosystem restoration

**Long-lived Storage**
- Direct Air CCS*
- Bioenergy with CCS
- Mineralization
- Enhanced Weathering

**CCS on industrial facilities**
- CCS on fossil-fuel power plant
- Avoided damage to ecosystems

*CCS: Carbon capture and storage

Source: Adapted from The Oxford Principles for Net Zero Aligned Carbon Offsetting, September 2020
Nature-based vs. engineered

Nature-Based
- Afforestation & Reforestation
- Improved Forest Management
- Soil Carbon
- Blue Carbon

Engineered
- Ocean Alkalinity Enhancement
- Biomass Storage
- Direct Air Capture (DAC) with Storage
- Carbon Mineralization
- Biomass Energy with Carbon Capture and Storage (BECCS)

Source: CDR Primer
Nature-based vs. engineered

**Short-lived Storage**
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Vastly different potentials to scale

IPCC WG3 report predicts that the deployment of CDR will reach **5.8 GtCO2/yr** in 2050:

- **2.75 GtCO2/yr** of BECCS
- **2.98 GtCO2/yr** of land-based carbon removal (e.g. soil carbon)
- **0.02 GtCO2/yr** of DAC

Removal in the context of Harvard’s Fossil Fuel-Neutral Goals: Counterbalancing unavoidable emissions

Guidance according to Science Based Targets initiative (SBTi)

Implications to Harvard

1. Near-term targets

Source: Science-based Targets Initiative (SBTi)
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1. Near-term targets
2. Long-term targets

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3. Beyond value chain mitigation

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Guidance according to Science Based Targets initiative (SBTi)

1. Near-term targets
2. Long-term targets
3. Beyond value chain mitigation
4. Neutralization of residual emissions

Source: Science-based Targets Initiative (SBTi)
Engaging in CDR beyond offsets

Reduce footprint
- Decarbonize buildings
- Purchase Renewable energy certificates
- etc.

Engage in Carbon Removal
- Harvard as a buyer of offsets
  - Removal offsets
  - Emissions reduction offsets
- Harvard as a leading educational and research institution
  - Scientific R&D
  - Advocacy
  - Credibility
Both Capture AND Storage are necessary for complete carbon removal

Simultaneous Solutions

- Improved Forest Management
- Blue Carbon
- Ocean Alkalinity

Sequential Solutions

1. DAC (Climeworks) +
2. Mineralization (Carbfix)

Source: ClimeWorks, Running Tide
## Carbon removal market is nascent

<table>
<thead>
<tr>
<th>Supply side</th>
<th>Demand side</th>
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<tbody>
<tr>
<td>● &lt;100 startups backed by venture capital</td>
<td>● ~30 known buyers$^1$</td>
</tr>
<tr>
<td>● Variable in scientific rigor</td>
<td>● First movers accrue reputational gains as thought leaders</td>
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<td>● Lack of supply will constrain the market in the future</td>
<td>● Cannot rely on widely known standards; conduct due diligence in house or through 3rd parties</td>
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<tr>
<td>● Seek long-term offtake &amp; early buyers</td>
<td>● Frontier: $925 Mil commitment</td>
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$^1$https://docs.google.com/spreadsheets/d/1BH_B_Df_7e2l6AH8_Ba0aK70niAJXJTwfyCgxkL5C8/edit#gid=0
Scope of our project: Key questions

1. What proportion of offset credits purchases be removal credits? What else can Harvard do to scale carbon removal beyond buying offsets?

2. Which categories of carbon removal technology are most attractive to include in Harvard’s offset portfolio?

3. How should Harvard operationalize its removal offset strategy? Specifically, how can Harvard ensure validity of the offset credits it purchases and reduce transaction risks through contracting?
Recommendations for Harvard

Become an early and thoughtful buyer of removal offsets by joining Frontier consortium

Foster scientific research to unblock technical constraints in removal technologies and assess risks

Advocate for adoption of removal standards in policy
Criteria led to three purchasing principles

Criteria
- Cost attractiveness - current cost and future potential
- Quality - permanence, additionality
- Ability to scale - technical maturity, regulatory support
- Co-benefits - employment, innovation spillover
- Potential for negative impacts

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**Purchasing principles**

1. **Purchase thoughtfully** rather than focus on total money spent or % of offset portfolio
2. **Balance the portfolio** too early to bet on one technology or company
3. **Build the market** long term offtake, join other credible buyers (i.e. Frontier)
Recommendations based on criteria

**Short-lived Storage**
- Afforestation & Reforestation
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**Nature-Based**

**Long-lived Storage**
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# Four key technologies recommended

<table>
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<th>Technology</th>
<th>Benefits</th>
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<td><strong>Afforestation &amp; Reforestation</strong></td>
<td>● Ranks high on <strong>cost attractiveness</strong> and <strong>market maturity</strong></td>
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<tr>
<td></td>
<td>● Should <strong>emphasize co-benefits</strong> (community, health)</td>
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<td><strong>Tech-enabled forest management</strong></td>
<td>● New tech for better <strong>monitoring, reporting &amp; verification (MRV)</strong></td>
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<td>● Support <strong>“additionality”</strong> claims of nature-based offsets</td>
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<td><strong>Carbon mineralization</strong></td>
<td>● Catalyze <strong>“high quality” nascent technology</strong></td>
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<td>● Potential <strong>lower energy usage</strong> compared to DAC</td>
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<tr>
<td><strong>Biomass (“Storage” and “Energy + CCS”)</strong></td>
<td>● <strong>Highest removal potential</strong>, comparable to DAC (0.2 GtCO$_2$ per year with US biomass alone)</td>
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<td>● Ability to leverage H$_2$ production to low <strong>&lt;$50/tCO_2 cost</strong>**</td>
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CASE STUDY: How to Purchase Removal Credits from Heirloom (Mineralization DAC)
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A. Budget → Determines Bargaining Position

B. Technical Diligence to Identify Risks

C. Contracting to Allocate Risks
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   - 3P e.g. CarbonPlan

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   - Duration
   - Audits
   - Co-benefits
   - Walk-away or Renegotiation Provisions
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per ton of carbon removed. By December 31, 2022, Company will allow Stripe to visit Company’s plant to view the plant’s operations.

As part of the completion of the Carbon Removal Purchase, Company will furnish a written report to Stripe outlining: (i) how funds were used to remove carbon; (ii) how many tons of carbon were removed and at what cost; (iii) proof of tons removed; and (iv) a narrative description of Company’s progress and challenges to completing the Project. Company shall provide Stripe with copies of any research or publications that it produces in connection with the Carbon Removal Purchase and Project.

- Duration
- Audits
- Co-benefits
- Walk-away or Renegotiation Provisions
Overview of Tools

- Factsheet on carbon removal
- Infographics comparing and ranking different CDR technologies

- Sample contract language
- Hypothetical contract for a carbon removal offset deal with Heirloom

- Resource hub on removal offsets
- Public website containing all established standards for removals
Thank you

Experts interviewed
1. Katie Holligan (Charm Industrial)
2. Max Scholten (Heirloom)
3. Bradley Rochin (Running Tide)
4. Karan Khimji (44.01)
5. Celia Francis (Terraformation)
6. Henry Lee (Harvard Kennedy School)
7. Jop Wettering (McKinsey)
8. Ariel Hayward (Patch)

CSLL teaching team
Aladdine Joroff, Debra Stump, Jacqueline Calahong, Henry Tepper

Guest speakers
Stacy Kauk (Shopify), James Stock (Harvard), Marcus Extavour (XPrize Foundation),
Elizabeth Willmott (Microsoft)