Microsoft

Microsoft Carbon Removal

Observations from our third year

June 2023

"Reforestation in the style of Picasso," created with DALL-E

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Foreword

We are very pleased to present this update to the lessons observed and learned through Microsoft's efforts (alongside other companies) to establish a robust, worldwide carbon removal market. We continue to be transparent with the public at large and the carbon removal community on the challenges and opportunities in the market. Healthy dialogue will enable us all to quickly scale the carbon removal capacity that—following deep and rapid decarbonization—will be crucial to addressing hard-to-abate sectors in the middle of this century.

When we started this third whitepaper in Microsoft's series, two things became clear. First, there is a large amount of market activity and energy to design and deploy many megatonnes of carbon dioxide removal (CDR) this decade—expectations are high and a community is coming together to meet them. Second, given the pace of developments and our own scope of sourcing, we need to increase the cadence of our communications to reduce the latency of our observations and maximize iterative learning within the CDR field. For these reasons, we will move hereafter from producing annual updates to more frequent snapshots.

While 2030 may seem far off, project development timelines mean that the groundwork for end of decade capacity must be laid now.

Program Observations

Time is non-renewable and the next several years are crucial for global carbon removal capacity. We are approaching a crunch-moment between bottom-up projections built on actual deployment rates and top-down models solving for carbon removal 2050 climate scenarios, where actual deployments planned this decade are not on track to meet estimated global needs this century. Moreover, we assess that most global CDR capacity available in 2030 will have been designed by the end of 2025, and all by the end of 2027. Please read this paper with that backdrop in mind.

The good news is that proposals for new supply are increasingly mature, buyers are more numerous and more sophisticated, and market infrastructure now includes several ratings agencies which can drive quality. Before we dive into those segments, here are some broad observations and outlooks:

Portfolio: Microsoft continues to plan for a portfolio of greater than 5 million metric tonnes of carbon removal per year in 2030. We're committed to a portfolio that balances relatively proven low-durability, nature-based solutions with medium- and high-durability solutions, where low-durability options face perhaps the greatest qualitative challenges and the high-durability opportunities need the greatest scaling. Limiting warming this century to anything close to 2ºC will likely require scaling CDR to not less than 6 billion metric tonnes per year by 2050. Carbon removal will not reach the magnitude needed at mid-century without an all-of-the-above approach.

To execute on our plan, we are increasingly focused on long-term offtake agreements such as our recently announced deal with Ørsted[1] that both help to secure long-term supply and drive new capacity development. We believe such offtakes are the fundamental demand-side lever to alleviate the shortage of highly durable, affordable solutions that we highlighted in past lessons learned reports. Structures which give sellers confidence in revenue while providing buyers with firm supply are crucial to rapid and mature scaling. We see power purchase agreement (PPA)-style offtakes from the renewable energy industry as the key starting model for carbon removal

[1] For more on the deals since our last whitepaper, please see New additions to our carbon removal portfolio.

The name of the game? Long-term offtakes.

CDR is self-evidently not one single industry; instead it is distributed across multiple distinct sectors which each have their own market, financing, and forecasting dynamics. We're ready to adapt deal structures to build pragmatic, risk-balanced arrangements. At this moment, nature-based solutions appear farthest from the mature PPA model because they more consistently need concessionary, upfront finance, and we are still searching for repeatable deal models that can take these nature-based solutions to scale.

Environmental Justice and the Pace + Scale of Deployment: Perhaps the most important *tension* we face in developing CDR capacity from scratch is that, on the one hand, the IPCC-endorsed science suggests we must very rapidly ramp up removal capacity. On the other hand, the world knows, from hard experience, that insufficient attention to local effects and to community and justice concerns will slow projects, harm communities, or both—and such attention takes time. This is particularly salient in CDR given the number of novel solutions with limited data on efficacy in all environments. We are staying informed on the latest thinking on this tension,[2] speaking with experts, and are seeking development models that incorporate reparative, procedural, and distributive justice throughout project lifetimes. We are keen to find project developers intent on similar approaches.

Emerging Themes: Within the total set of carbon removal, which is growing rapidly through innovation and scale, two trends stand out:

- First, while techniques like Direct Air Capture (DAC) may dominate headlines, there is an expanding list of carbon removal techniques which fit within *smaller-scale circular economy principles*. Chief among these might be agroforestry, which delivers both increased carbon sequestration and, in many contexts, enhanced agricultural output. In an adjacent area, biochar valorizes biomass waste, preserves carbon, and can enhance crop yields. Alongside these, industrial ecology firms like O.C.O. and Neustark combine CO2 and waste materials to create, respectively, manufactured aggregate and new concrete. Where we see such solutions that can remove CO2 as well as reduce waste and/or substitute for emissions-intense products, we see systems that are primed to accelerate with multiple tailwinds.
- Second, we believe carbon removal will accrue to places that signal they're ready to deploy the future. For example, Climate Robotics' work in Texas, Arkansas, and elsewhere; to valorize crop waste for farmers; Carbon Capture Inc's ambitions for DAC in Wyoming; and Land O' Lakes' work with farmers

[2] In particular, Carbon 180's Removing Forward and From the Ground Up, by XPrize and Carbon180 together.

to incentivize restorative practice change up and down the Great Plains. The work of mining the sky will flourish where people are ready to build.

Supply-Side Learnings

Our deals this year highlighted a number of new and renewed lessons from which the market may benefit.

Cross-Cutting Issues

Additionality

The risk of non-additionality is an important and nuanced principle of carbon markets. Existing and new incentive programs worldwide need to be accounted for when considering project-level additionality. This year we saw more than a couple of projects which appeared to be *entirely* funded by existing government policies, which we could not consider additional.

At the same time, we also saw a bevy of proposals with many revenue streams (especially in Biomass + Carbon Removal and Storage (BiCRS) and Bio-energy with Carbon Capture and Storage (BECCS)). In some cases, such as our deal with Ørsted , we determined the deal was clearly additional given that both public subsidies and a corporate offtake were required to cover the costs of the project.

Recognizing that there are cases where additionality is not as straightforward, we believe that the field overall would benefit from new tools to consistently evaluate the additionality of such projects. At this time we are focused on how carbon revenues impact bottom line internal rates of return (IRRs) on different projects as a proxy for the risk of non-additionality. This may immediately beg the question of how much the market can rely upon self-reported and forecasted revenue projections. We are examining options for structuring such forecasts into procurement contracts.

In addition to analyzing the additionality of a project given prevailing policies, it is important that new policy supports include robust additionality tests. Indeed, our comments on the EU Carbon Removal Certification Framework (CRCF) proposal underlined the importance of watertight additionality tests to address any concerns about rewarding non-additional efforts.

Model Reliance

A range of CDR techniques, including soil sequestration, enhanced rock weathering (ERW), and ocean alkalinity enhancement (OAE) rely heavily on modeling carbon outcomes given the large expense or impossibility of direct measurements. We see rapid advances in modeling and MRV science as essential to being able to rely upon such systems at scale. We are encouraged by the work of ERW developers like Undo and Lithos Carbon, which are refining our understanding of key uncertainties by targeting a broad range of proxy weathering parameters. We appreciate the observation from our colleagues at CarbonPlan and Frontier that there may need to be an uncertainty buffer in some cases. In a good illustration of parallel innovation, we already incorporate accounting uncertainty into our contracting and claims process. For example, O.C.O Technology showed pragmatic, long-term thinking by holding back some tonnes in escrow for our deal pending the finalization of the carbon accounting findings for its innovative mineralized aggregate. Other projects are utilizing internal buffer pools for similar ends.

Environmental Justice

Agroforestry is a particularly promising area for extensive carbon and environmental justice benefits. As one example, our supplier Rabobank's Acorn program promotes a wide variety of agroforestry designs in multiple developing countries, which broadly increases crop resiliency and yields. Moreover, the program pays 80% of carbon revenues back to local stakeholders. By its nature, agroforestry often means engaging deeply with local communities and we look forward to more projects in this space. As our comments on the EU CRCF proposal indicated, policy can play a role in advancing environmental justice and pursuing co-benefits by adding them as additional objectives under certification schemes.

Low Durability Carbon Removal

Monocultures

We saw an increased number of proposals this year that involved monoculture plantation forestry. Introducing a single-crop varietal diminishes biodiversity and sustainable land use and moreover begs questions about additionality and about over-optimizing for carbon. To consider such projects, we want to see both robust certification safeguards and a clear story about how these projects can help serve co-beneficial purposes like natural regeneration and equity. Despite the pressure to scale rapidly, the carbon removal industry *must* design projects that incorporate other benefits such as biodiversity and equity, alongside driving towards carbon outcomes. Failing to do so risks fundamentally undermining climate goals.

Afforestation and Reforestation

Looking ahead for afforestation and reforestation projects, we increasingly observe two challenges that project developers and policymakers should bear in mind.

- First is the need to thoughtfully select land for reforestation based on its biophysical potential, alternative uses (e.g. food production), clear legal title, and market availability. While we don't think that Microsoft's scale of demand will exhaust the supply of prime afforestation land, that constraint may be felt sooner than expected due to overall growing market demand. Wherever possible, project siting should enhance landscape-level connectivity of biodiversity corridors.
- Second, we are concerned that current worldwide nursery capacity will be insufficient to meet demand for mass re/afforestation at scale. We especially hear about shortfalls in regionally-acclimatized, tropical seedstock for species outside the usual high-yield timber set used by commercial forestry. Mass afforestation efforts on the scale of commercial forestry necessitate commercial nursery operations to avoid equity issues for access to native seed stock. Multi-year offtakes with local nurseries and seed collectors can be employed to signal future market needs and ensure equitable access to native seedstock throughout the duration of a project.[3]

Medium Durability Carbon Removal

Biochar

Biochar is currently the mainstay of our medium-durability portfolio and plans. We find it to be a good option that bridges the durability and cost gap between pathways like afforestation and DAC, yet it presents its own challenges. Principally, we sense genuine uncertainty about the depth and extent of the market for physical biochar, including significant assumptions around adoption rates in the agricultural sector—i.e. how fast land owners and managers will integrate biochar as a crop additive and substitute for other inputs. Illuminating this market with empirical results will be crucial to derisking biochar business plans.

In addition, given that most biochar projects offer some combination of energy, physical charcoal, and negative emissions, it is important for us to see a clear story about the additionality of removals payments. Increasingly, we are considering what difference removals payments make in the internal rate of return for a given project and how such a model might be built into diligence and contract structures. Finally, with a patchwork of frameworks defining biomass sustainability, it is important to make sure feedstocks truly are waste or sustainable, and to make sure they will be available for the practical life of the project.

[3] For more on this and related topics, please see 10 golden rules for restoring forests | Kew

Open-Ocean MRV

The rapid emergence of open-ocean CDR underlines the need for certifications in this area as well as strong measurement, reporting and verification (MRV) science. For example, considering prevailing uncertainty, Microsoft utilized innovative contracting structures to require the development of direct observational MRV as part of our procurement from Running Tide. As the market continues to evolve in this area, Microsoft encourages project developers to partner with academic and governmental agencies. Such partnerships are needed to develop new mechanisms for observation and measurement of carbon outcomes as well as research towards ensuring safety for the vital ocean ecosystem.

High Durability Carbon Removal

Enhanced Rock Weathering (ERW)

Our experience with ERW suggests that underlying carbon sequestration models need calibration and validation to estimate carbon removal in specific operational conditions. Moreover, we observe that persistent monitoring networks would be enormously useful and could pair with the soil organic carbon observatories that have been suggested by, among others, C180.

Biomass Principles

As we evaluate potential BiCRS/BECCS projects with hundreds of kilotonnes of annual CDR capacity, it is apparent that existing biomass sourcing guidelines are both a useful start and do not wholly resolve major questions about deploying BiCRS at megaton+ scale. We know there are limits to the amount of sustainable biomass, whether used for heat and power, carbon removal, bioproducts, sustainable aviation fuel or other deep decarbonization goals. We believe that current biomass usage for carbon removal is far below the actual limits of sustainability. However, inconsistent principles, operational opacity, and variable public expectations could land early projects in trouble with communities and carbon accounting if they are not careful. Moreover, absent a clear, widely understood narrative of biomass use, deployment of new projects will be restricted. With all these points in mind, as projects scale they should embrace conservative biomass sourcing principles. If applied consistently, we think these should help avoid harms to communities and ecosystems, underpin accurate carbon accounting, and support broad social acceptance. We see the following key principles as a starting point and have already begun applying them in our deals:

1. Avoiding harvest from protected areas and from areas without strong implementation of existing rules.
2. Avoiding the utilization of biomass with a higher-value use, e.g. in long-lived wood products.

3. In the case of forest biomass, sourcing only from sustainable harvest of areas with stable or increasing forest carbon stocks.

Since we need to establish these strong guidelines in advance of a wave of project development, these principles will be a key area of focus for us and our collaborators in the coming six months. Moreover, in addition to implementing the principles above, we see a need for widely-used, transparent systems that track load-by-load biomass sourcing.

Demand Side Commentary

Robert Hoglund called market dynamics 'upside down,' with way more marketplaces than buyers or sellers. We agree: bringing more buyers into the market and more projects to fruition are at the heart of this challenge. The surge[4] in announced deals in May was a necessary boost to the market and we look forward to many more such announcements. Demand signals *now* will drive the majority of capacity deployment by 2030. As our fellow buyers have repeatedly signaled, if you are planning to have removals in your portfolio in 2030, you need to be planning, sourcing projects, and signing purchase agreements now. We, and others in the industry, are ready to help and to coordinate offtakes to make sure projects get built.

Buyers relying on carbon removal for 2030 plans need to mobilize *now*.

Good projects need to be matched with a critical mass of demand, especially the many CDR approaches which need major upfront CAPEX investments. Understanding that different buyers have their own timelines and processes—and that converging on 'market standard' terms in CDR may require a more developed market—we think in terms of general demand coordination. Our objective is to make sure that other corporate buyers are actively engaged in growing market supply by focusing on promising opportunities. If possible, we look forward to collaborating with other buyers on diligence expectations for given technical approaches and (with appropriate permissions) technical analysis of major projects to speed execution.

Buyers and independent experts will need to define a whole gamut of common standards and terms for carbon removal deals. This process is already underway. We have already heard from project developers seeking to design to the Criteria for High Quality Carbon Removal that Microsoft and Carbon Direct publish, which is hugely encouraging. To the extent that the market can rapidly coalesce around any set of quality requirements, capacity development will be accelerated and transaction costs will fall. The challenge lies in agreeing on common expectations and requirements. We look forward to feedback on our own Criteria for High

[4] See: Corporate heavyweights unveil major carbon removal deal (axios.com), plus JPMorgan Chase seeks to scale investment in emerging carbon removal technologies, announces agreements intended to durably remove and store 800,000 tons of carbon, and Boeing signs alternative fuel deal with Los Angeles startup to cut carbon footprint | AP News

Quality Carbon Removal and on this whitepaper to advance the dialogue towards such common agreement.

Market Infrastructure Observations

Core utilities that we might expect in a mature market—like performance data, financing, and liability structuring—remain inchoate, frustrating capacity development. We expect clarity and new tools to emerge in the following areas that will better allocate risk and accelerate deployment.

Insurance & Finance for Nature Based Solutions

Despite many deployments over many years, we have yet to see mature financing or insurance options for nature-based solutions, each of which could significantly align buyers and sellers by providing comfort through distributed risk. We frequently see offerings, pitched as innovative, where buyers pay 100% upfront and then collect a stream of carbon credits over 20 years. Given that separation of financial interest from operational control, these structures are not attractive on their own merits (though we are open to specific arguments for a given project about why the buyer in particular needs to bear this risk). Conversely, we would prefer a 100% pay-as-you-go arrangement, which keeps capital raising responsibilities on sellers. In other contexts, developers have solved this sort of problem through project finance and/or insurance. Moreover, global banks have significant environmental and net zero financing goals, while presumably seeking large scale capital deployment opportunities. We wonder if there may be a major opportunity for an organization that can collect and analyze the performance of nature-based projects over the last 30 years and combine that with forward-looking climate modelling. This could make output more predictable, approach something like a performance guarantee, and—in conjunction with offtakers with strong credit ratings—bridge this market gap.

CO2 Storage Projects

We are highly encouraged to see momentum build around North Sea carbon storage projects and DAC hubs in the United States, as well as by the recent announcement of Heirloom and CarbonCure's CO2 storage collaboration. These are

important first steps in the nascent industry and show key pathways to permanent sequestration. At the same time, while we believe that storage will not be a long-term bottleneck, we are concerned that early risk structuring between storage providers and CO2 suppliers will unnecessarily drive-up costs. Better risk balancing will depend on:

a) an appreciation by storage providers of the core value of CO2 removed from atmosphere and the importance of reversal scenarios to buyers of voluntary carbon credits,

b) widely accepted and updated standards for quantifying the risk of reversals from geologic storage and any mechanical or operational failure risk during CO2 transport, and

c) (potentially) government policy-prescribed definitions of the appropriate liability carried by the storage provider where national governments are backing the initial deployments of these carbon transport and storage projects.

We see the nascent EU CRCF as potentially a helpful route to more robust standards for strengthening and clarifying liability mechanisms for long-term storage.[5]

[5] Microsoft encouraged the EU Commission and the UNFCCC through its recent submissions to include similar clear delineation and definitions for avoidance and removal credits. Please see The EU Carbon Removal Certification Framework: a key building block in the race to net zero - EU Policy Blog (microsoft.com)

Policy & Standards

Any discussion of the carbon removal market necessarily makes major assumptions about the voluntary standards and policy structures underlying the market. On this front, there have been several positive developments since our last paper, in particular:

- The revision of the US 45Q tax credit in the Inflation Reduction Act is a major tailwind for the industry in the United States. The differentiation of DAC as a highly novel technique with greater support is sensible; we hope that in future there may be such an enhanced tax credit on a technology-neutral, outcome-focused basis.
- With the CRCF, the EU has begun the process of defining carbon removals as a specific carbon solution and delineating what will count. This is a major development and—although much work remains to be done to refine specifics—it presents a significant opportunity to create forward-thinking, crisp, and high standards for removals.
- Among the voluntary standards, it was particularly positive to see the American Carbon Registry start to mark removals separately from emission reductions. Paired with improvements in standards (e.g. the prospect of dynamic baselines for forestry projects) and the emergence of a cadre of credit ratings firms, this is a signpost pointing towards a world with a closer alignment between certification and quality, and therefore a more reasonable diligence burden on buyers.

Areas for Focus

We see important room for innovation and improvement in the policy environment and in voluntary certifications. For starters, we have not yet seen all major policy proposals and voluntary certifications peel apart removals and avoidance/reduction activities.[6] We believe this distinction is critical in voluntary markets and policy paradigms, given the core arithmetic difference, that removals are best placed to address historical or 'legacy' emissions and the need to mark out the increased work that removals entail. We are not alone in this view: last year, 75% of respondents to the Voluntary Carbon Markets Initiative's (VCMI) provisional Claims Code of Practice indicated a need for differentiation based on credit types (reductions vs. removals). We are also strong believers in strict claims of the durability of carbon storage and more specific reversal risk calculations. Clearly marking and defining this difference within compliance and voluntary markets is needed to effectively operationalize the Paris Agreement's Article 6.4 mechanism and corresponding adjustments for

[6] Please see Microsoft-comments-on-the-EU-Carbon-Removals-Certification-Framework-March-2023.pdf and Methodologies_requirements_input_Microsoft.pdf (unfccc.int)

Internationally Transferable Mitigation Outcomes (ITMO) under Article 6.2 and to bring cogency to global carbon markets. If the market fails to distinguish removal from avoidance and thus negates the ability of ambitious actors to address their historical emissions, it would represent a significant missed opportunity globally.

A few further specific observations on the existing certification structures:

- We often reject projects on the basis of poor additionality arguments; this issue deserves persistent scrutiny by certifications.
- We observe a particular gap in how prevailing certification systems evaluate and ensure environmental justice benefits. For example, confirming that procedural justice principles are in place and stakeholder engagement is both meaningful and well-planned throughout the duration of a project. This is a frontier for carbon removals overall and we are on the lookout for certification schemes that do this work particularly well.
- When we think about the certification of high durability CDR techniques, where there is less accumulated learning and standard setting, we believe a financially disinterested voluntary standard will serve best in the long term.

Opportunities for Harmonization

As we examine the overall outlook, we see much of the government and voluntary policy outlook as uncertain and tangled, which leads us to recommend rapid harmonization and clarification amidst substantial industry growth. Absent such rationalization, fragmented markets will persist and capacity will be built-to-spec for the buyers with the largest orders. Definitions, registries, and MRV guidance—as a few examples—should be made more uniform among the various governmental, inter-governmental organizations and non-governmental leaders in this space.[7] Make no mistake: the impetus towards evolution and reform in this market is

[7] As a sample of the private, national, and international efforts trying to reform, evolve, and clarify the voluntary and compulsory carbon markets, consider the following:

- Definitions from the Greenhouse Gas Protocol, Science Based Targets Initiative (SBTI) and Voluntary Carbon Markets Integrity Initiative (VCMI) are widely utilized by companies for GHG reporting. The VCMI is working on a Claims Code of Practice to guide credible voluntary use of carbon credits and associated claims. Likewise, the more supply side focused Integrity Council for the Voluntary Carbon Market (IC-VCM), is currently developing their Core Carbon Principles (CCPs) and Assessment Framework (AF).
- At a national level, the World Bank is tracking 70 carbon pricing initiatives covering 47 national and 37 sub-national jurisdictions.
- At an international level, there are multitudinous negotiations around the various portions of Article 6, progress on definitional and methodologies for greenhouse gas accounting frameworks, and of course the ongoing CRCF deliberations in the EU.

overwhelmingly positive; it would simply benefit from simplification and unification. Aligning definitions among Article 6 of the Paris Agreement, the emerging EU CRCF, the Voluntary Carbon Market Initiative (VCMI), the Integrity Council of the Voluntary Carbon Market (IC-VCM), and the Greenhouse Gas Protocol (GHGP) could facilitate a greater influx of private capital for funding mitigation measures (both avoidance and removal) from both corporate and private entities.

Corporate and National Accountings

As the global community seeks to mitigate the worst effects of climate change, including by fulfilling the goals of the Paris Agreement, one constraint is that existing guidelines do not clarify how private sector contributions should be accounted for in relation to national contributions. We see many situations where both public and private funds are necessary to make new projects economically viable; were it not for *both* public subsidies *and* corporate offtake agreements, many projects expected to generate high-quality carbon removal would not get built. While the atmospheric concentrations of greenhouse gases—which are the ultimate indicator of progress—do not care who pays to get projects built or takes credit for them, carbon accounting systems do. However, the world's extant carbon accounting systems are not set up to effectively account for removals created through blended finance from public and private funds. There are currently two separate accounting systems (corporate and national) which operate in parallel. The national accounting system, tied together by the Paris Agreement, is the definitive mechanism to track global progress. The corporate system is an important mechanism to track companies' progress.

Considering these constraints, we will pursue opportunities to leverage government incentives that enable the purchase of high-quality carbon removal, while working to make corporate and national accounting systems more interoperable. This approach will enable faster development of carbon removal capacity and establish crediting for national, corporate, and joint efforts without double counting outcomes from an atmospheric perspective.[8]

In thinking about the two separate carbon accounting systems, we found it helpful to consider business accounting. In the economic sphere, national gross domestic product and corporate earnings reports routinely and by design describe the same economic activities. Moreover, when a corporation emits a greenhouse gas, in

[8] For more on gaps in global greenhouse gas accounting, we recommend: Make greenhouse-gas accounting reliable — build interoperable systems (nature.com)

theory, that emission is reported on both corporate and national ledgers. Therefore, where corporate procurement of carbon removals is additional,[9] we believe that parallel (e.g., national and corporate), non-conflicting claims to the carbon outcome are wholly appropriate, in line with the goals of the Paris Agreement, and are an important component of rapidly scaling the carbon removal industry.

Given that this point and other important questions remain under discussion, we look forward to collaborating on pragmatic, systemic solutions that accelerate climate action with appropriate urgency.

[9] That is, that the project producing the removals goes beyond baselines, common practice, and legal requirements, and that it required carbon finance (e.g., through the voluntary carbon market) in order to be implemented. Additionality is always important and is a particularly crucial test in this context; non-additional parallel claims by corporates and countries risk reducing global ambition in emissions reductions and removals. Our latest guidance on additionality can be found in our Criteria for high-quality carbon removal (microsoft.com)

New additions to our carbon removal portfolio

- **Low-durability solutions:** five forestry projects (>1.8 million $mtCO_2$), one soil carbon project (200,000 $mtCO_2$) and a mangrove blue carbon project (100,000 $mtCO_2$)
- **Medium-durability solutions:** three biochar projects (>81,000 $mtCO_2$) and one kelp-sinking project (12,000 $mtCO_2$)
- **High-durability solutions:** one BECCS project (>2.67 million $mtCO_2$), one CO_2 mineralization project (25,000 $mtCO_2$), three DAC projects (~12,000 $mtCO_2$), and two ERW projects (>5,000 $mtCO_2$).

Durability definitions and examples

- **Low**—In general, these are solutions that sequester carbon for less than 100 years. Forestry and soil approaches are the main examples. While some forestry projects in our portfolio have a contracted durability of 100 years or more, we categorize them as low durability because of inherent reversal risks.
- **Medium**—In general, these are solutions that sequester carbon for hundreds of years to 1,000 years. Biochar is the main, incumbent medium-durability approach.
- **High**—In general, these are solutions that sequester carbon for thousands of years. Biomass approaches with geologic storage, direct air capture, and mineralization are the best-known approaches in this category.

Supplier	Project(s)	Location	Type	Description	Newly contracted volume ($mtCO_2$)	Certification	Contracted durability (years)
Climate Impact Partners	Communitree	Nicaragua	Afforestation/ Reforestation	Reforestation of underused farmland that was historically deforested	646,111	Plan Vivo	50
Coöperatieve Rabobank U.A	Acorn	Colombia, Cote d'Ivoire, Nicaragua, Uganda, Peru, Tanzania	Agro-forestry	Agroforestry with smallholder farmers in multiple developing countries	147,601	Plan Vivo	20
Grassroots Carbon	Grassroots Carbon Microsoft Project	United States	Soil Carbon	Sequestering soil carbon through rotational grazing	200,000	VCS	30
Green Diamond Resource Company	Klamath West IFM FY23	United States of America	IFM	Improving forest management on 185,000 acres	830,000	CARB, ACR	100
Indus Delta Capital Limited	Delta Blue Carbon	Pakistan	Coastal Blue Carbon/ Mangroves	Mangrove project on 350,000 hectares in Sindh Province, Pakistan	100,000	VCS	60
The Nature Conservancy Cumberland	TNC Cumberland	United States	IFM	Improving forest management on 108,182 acres	194,676	CARB, CAR, ACR	100
The Nature Conservancy	Washington Rainforest	United States	IFM	Improving forest management in Washington on nearly 22,855 acres	40,000	ACR	40

Supplier	Project(s)	Location	Type	Description	Newly contracted volume ($mtCO_2$)	Certification	Contracted durability (years)
CarbonFuture GmbH	Pacific Biochar	United States of America	Biochar	Biochar produced from feedstock to directly lower water consumption of drought-stricken agricultural areas or as soil enrichment with compost additives	1,500	EBC	>100
Climate Robotics	In-field Biochar Production from Crop Waste	United States of America	Biochar	In-field waste collection, biochar production, and biochar disposition system	77,526	None (to certify in future)	200
MASH Makes	MASH Makes	India	Biochar	Modular pyrolysis of nut residues for soil amendments.	2,000	EBC	800
Running Tide	Carbon Sinking - Tranche 1	Iceland	BiCRS: Ocean Biomass Sinking	Carbon removal through biomass sinking and ocean alkalinity enhancement	12,000	None	800
Carbon Capture	Bison - Carbon Capture FY23	United States of America	DAC	Direct Air Capture project to be built in Wyoming.	1,740	None	10,000
Climeworks AG	Climeworks Direct Air Capture	Iceland	DAC	Direct Air Capture project in Iceland	10,000	None, verified by DNV-GL.	10,000
Heirloom	Heirloom DAC facility	United States of America	DAC	Direct Air Capture project in United States of America	200	None	10,000
Lithos	Enhanced Basalt Weathering	United States of America	ERW	Spreading upcycled basalt fines on US cropland farms while advancing measurement and verification to scale this pathway	500	None	10,000

Supplier	Project(s)	Location	Type	Description	Newly contracted volume ($mtCO_2$)	Certification	Contracted durability (years)
O.C.O Technologies	O.C.O Carbon Negative Manufactured Aggregate	United Kingdom	CO_2 Mineralization	Mineralization of synthetic aggregate in the UK	25,000	Puro.Earth	10,000
Ørsted	Ørsted Kalundborg Hub	Denmark	BECCS	Capture of biogenic CO_2 from combined heat and power plant	2,671,500	None (to certify in future)	10,000
UNDO	Barley	UK	ERW	ERW project in the UK which advances measurement + verification and scale for this pathway.	4,698	Puro.Earth	10,000

ACR = American Carbon Registry; **BECCS**: bio-energy with carbon capture and storage; **CARB** = California Air Resources Board; **CAR** = Climate Action Reserve; **CO_2** = carbon dioxide; **DAC**= direct air capture; **ERW**= enhanced rock weathering; **$mtCO_2$** = metric tons of carbon dioxide; **N/A** = not applicable; **VCS** = Verified Carbon Standard