Frontier

Applicant Instructions: Prepurchase Track

Thank you so much for your work on carbon dioxide removal (CDR), and thank you in advance for taking the time to apply for Frontier's prepurchase track. Please read the following information carefully and in full before beginning your appklication, as well as take a look at Frontier's 2024 Request for Proposals which includes information on this year's specific areas of focus, target purchase criteria, and how we review applications. For your reference, all previously submitted applications are available here.

For application guidance, please join us for application coaching sessions. The first will be at 9 am PDT on June 11 focused on general application tips, and the second at 9 am PDT June 18 for open Q&A. If you have any further questions as you work through, please email us at prepurchase@frontierclimate.com.

Timeline

	Step	Approx. date
1	This application is due. You are welcome to submit early.	June 25, 2024 9:00 pm PDT
2	Frontier reviews your application for completeness and basic scientific validity with respect to our criteria. Qualified applications are sent to external experts for scientific, commercial, and governance review.	Late June
3	Frontier will share anonymized expert review comments with you, and give you two days to submit a short response to these comments, if you choose to.	Mid-to-late July
4	Frontier will invite a subset of applicants to advance to a video interview to discuss your application.	Late July
5	Frontier notifies all applicants of prepurchase decisions.	Mid August
6	Frontier and teams jointly build application-specific contract terms such as milestones and tonnage within Frontier's standard purchase template.	Mid-to-late August
7	Frontier announces prepurchases and uploads the public portion of the applications to Frontier's GitHub.	Mid-September

How to apply

Step 1: Determine which category supplements apply to your project

- This document includes the General Application as well as all approach-specific supplements. All applicants should fill out the General Application, along with whichever (typically 1 - 2) supplements apply to your approach.
- Using examples from Frontier's existing portfolio:
    - RepAir would fill out the DAC supplement AND the Geologic Injection supplement.
    - Lithos Carbon would fill out the Alkaline Feedstock supplement.
    - CarbonRun would fill out the Ocean/Inland Water supplement AND the Alkaline Feedstock supplement.
    - Vaulted Deep would fill out the Biomass supplement AND the Geologic Injection supplement.
    - Carbon to Stone would fill out the DAC supplement AND CO_2 Utilization supplement.
- If it's not clear which supplements apply to your project, please ask at prepurchase@frontierclimate.com.

Step 2: Delete the supplements that don't apply to you

- This results in a document with the General Application and your applicable supplements only. Please delete these first four pages of instructions too!

Step 3: Fill out the application in this document

- When you see "tons" throughout this application, please respond in metric tons.
- We invite you to attend one of two application coaching sessions we will be hosting at 9 am PDT on June 11 and June 18 for general application guidance or email us at prepurchase@frontierclimate.com. Please reach out with questions as early in the application process as possible.
- We remain committed to transparency in our purchasing process and to helping advance knowledge-sharing across the ecosystem as commercial-scale CDR develops, while also protecting company IP. Like last year, we will only publish a subset of application details from this year's cycle on our GitHub repository. The sections that will be public are clearly marked within the application materials below.
- Frontier's expert reviewers have non-disclosure agreements (NDAs) in place with Frontier. If you have any concerns around confidentiality, please contact our team to discuss.

Step 4: Complete the techno-economic analysis (TEA) spreadsheet

- Your application invitation email includes a TEA spreadsheet which allows our review team to standardize our assessment of project costs. Instructions on how to complete the spreadsheet are detailed in the TEA spreadsheet's START HERE tab.

- When submitting your application, please indicate whether you give Frontier permission to share a fully anonymized copy of your TEA with select academic researchers. This information will be used to shape research on current and projected costs across CDR pathways and varying TRLs. This is completely optional, and the TEA will not be published on our GitHub repository under any circumstance.

Step 5: Submit your application here by June 25, 2024 9:00 pm PDT

- Please submit this application as a Microsoft Word document, and the TEA spreadsheet as an Excel sheet. Please submit your files using the following filename formats:
    - [COMPANY] Prepurchase Application 2024
    - [COMPANY] TEA 2024
- This year, you can choose to submit a pitch deck of no more than 10 slides that helps our review team build a quick understanding of your company, experience and overall approach. You can also share additional materials such as data, schematics, or other supplements. This is optional, and there is no expectation to provide materials beyond the application form and TEA. Neither the pitch deck nor supplemental materials will be shared publicly.
- **Your submission constitutes your consent for Frontier to make the content of the public sections of your application (first section marked "public" which includes the approach summary, project description and offer to Frontier) available publicly under a CC-0 "Public Domain" License, regardless of whether or not Frontier selects you for purchase.** For more details, see *Why we make some sections of each application public* below.

What we're looking for

Please refer to Frontier's 2024 Request for Proposals for a characterization of projects Frontier is excited to support and details on our selection process. There, we discuss the three lenses we use when making purchase decisions: approach, execution, and portfolio. Our approach criteria are:

Criteria	Description
Durability	Stores carbon permanently (>1,000 years)
Physical footprint	Takes advantage of carbon sinks and sources less constrained by arable land
Cost	Has a path to being affordable at scale (<$100 per ton)
Capacity	Has a path to being a meaningful part of the carbon removal solution portfolio (>0.5 gigatons per year)
Net negativity	Maximizes net removal of atmospheric carbon dioxide
Additionality	Results in net new carbon removed, rather than taking credit for removal that was already going to occur
Verifiability	Has a path to using scientifically rigorous and transparent methods for monitoring and verification
Safety and legality	Is working towards the highest standards of safety, compliance, and local environmental outcomes; actively mitigates risks and negative environmental and other externalities on an ongoing basis

Why we make some sections of each application public

Making applications public allows potential collaborators and investors to connect with promising projects. It also enables subsequent academic works and independent analysis from nonprofits like CarbonPlan (examples here and here), and we've heard from a wide range of investors, engineers, and scientists that the shared applications are a valuable source of data on the current state of the field and opportunities for advancement.

In Frontier's first two purchase cycles, we published the complete applications from each applicant here. **This year, as in 2023, we will only publish a subset of application details (approach summary, project description and offer to Frontier), rather than the full application.** We are continuing that practice so as to not put supplier IP at risk, particularly as our application form has expanded and competition in the field grows (a good thing!).

We're grateful to all our applicants for providing this level of transparency; hopefully this will enable impact beyond the dollar amount of any particular purchase we may make.

Fine print

We intend to make the selection process as informal as possible. However, we do expect that (a) the content of your application is, to the best of your knowledge, complete and correct; (b) you do not include any content in your application that breaches any third party's rights, or discloses any third party's confidential information; (c) you understand that we will publicly publish the 'Public Section' of your application at the conclusion of the selection process. You also understand that Frontier is not obliged to explain why or how it decided to facilitate the CDR purchase that it did, and that Frontier buyers may decide to not purchase CDR from your application or make an offer to purchase less than what you proposed. Finally, if you are selected as a recipient for funding, Frontier buyers will not be under any obligation to provide you with funding until such time as you and Frontier buyers sign a formal written agreement containing the funding commitment.

Frontier

[Company Name]

Carbon dioxide removal prepurchase application

Summer 2024

General Application

(The General Application applies to everyone; all applicants should complete this)

Public section

The content in this section (answers to questions 1(a) - (d)) will be made public on the Frontier GitHub repository after the conclusion of the 2024 summer purchase cycle. Include as much detail as possible but omit sensitive and proprietary information.

Company or organization name

Company or organization location (we welcome applicants from anywhere in the world)

Name(s) of primary point(s) of contact for this application

Brief company or organization description <20 words

1. Public summary of proposed project[1] to Frontier

a. **Description of the CDR approach:** Describe how the proposed technology removes CO_2 from the atmosphere, including how the carbon is stored for > 1,000 years. Tell us why your system is

[1] We use "project" throughout this template, but the term is not intended to denote a single facility. The "project" being proposed to Frontier could include multiple facilities/locations or potentially all the CDR activities of your company.

best-in-class, and how you're differentiated from any other organization working on a similar approach. If your project addresses any of the priority innovation areas identified in the RFP, tell us how. Please include figures and system schematics and be specific, but concise. 1000-1500 words

[public answer]

b. **Project objectives:** What are you trying to build? Discuss location(s) and scale. What is the current cost breakdown, and what needs to happen for your CDR solution to approach Frontier's cost and scale criteria?[2] What is your approach to quantifying the carbon removed? Please include figures and system schematics and be specific, but concise. 1000-1500 words

[public answer]

c. **Risks:** What are the biggest risks and how will you mitigate those? Include technical, project execution, measurement, reporting and verification (MRV), ecosystem, financial, and any other risks. 500-1000 words

[public answer]

d. **Proposed offer to Frontier:** Please list proposed CDR volume, delivery timeline and price below. If you are selected for a Frontier prepurchase, this table will form the basis of contract discussions.

Proposed CDR over the project lifetime (tons) *(should be net volume after taking into account the uncertainty discount proposed in 5c)*	[public answer]
Delivery window *(at what point should Frontier consider your contract complete? Should match 2f)*	[public answer]
Levelized cost ($/ton CO_2) *(This is the cost per ton for the project tonnage described above, and should match 6d)*	[public answer]

[2] We're looking for approaches that can reach climate-relevant scale (about 0.5 Gt CDR/year at $100/ton). We will consider approaches that don't quite meet this bar if they perform well against our other criteria, can enable the removal of hundreds of millions of tons, are otherwise compelling enough to be part of the global portfolio of climate solutions.

Levelized price ($/ton CO_2)[3] *(This is the price per ton of your offer to us for the tonnage described above)*	[public answer]

Non-public sections

The content in all following sections, including application supplements and the techno-economic analysis spreadsheet, will NOT be made public and will be shared only with the Frontier expert reviewers assigned to your application who have non-disclosure agreements in place with Frontier. Please include as much detail as possible.

2. Project details

a. What is the current technology readiness level (TRL)? Please include performance and stability data that you've already generated (including at what scale) to substantiate the status of your tech. <500 words

b. What are the key performance parameters that differentiate your technology (e.g. energy intensity, reaction kinetics, cycle time, volume per X, quality of Y output) from others in the same CDR pathway? What is your current measured value and what value are you assuming in your nth-of-a-kind (NOAK) TEA?

Key performance parameter	Current observed value (units)	Value assumed in NOAK TEA (units)	Why is it feasible to reach the NOAK value?
[add rows as needed]			

c. Who are the key people at your company who will be working on this? What experience do they have relevant to the technology and project development? If your team is part of a larger organization, how does this project align with your organization's existing operations, experience, and priorities? If applicable, what skills do you not yet have on the team that you are most urgently looking to recruit? <300 words

[3] This does not need to exactly match the cost calculated for "This Project" in the TEA spreadsheet (e.g., it's expected to include a margin and reflect reductions from co-product revenue if applicable).

d. Are there other organizations you're partnering with on this project (or need to partner with in order to be successful)? If so, list who they are, what their role in the project is, and their level of commitment (e.g., confirmed project partner, discussing potential collaboration, yet to be approached, etc.).

Partner	Role in the Project	Level of Commitment
[add rows as needed]		

e. What is the total timeline of your proposal from start of development to end of CDR delivery? If you're building a facility that will be decommissioned, when will that happen? <100 words

f. When will CDR occur (start and end dates)? If CDR does not occur uniformly over that time period, describe the distribution of CDR over time. Please include the academic publications, field trial data, or other materials you use to substantiate this distribution. <300 words

g. Please estimate your gross CDR capacity over the coming years (your total capacity, not just for this proposal).

Year	Estimated gross CDR capacity (tons)
2024	
2025	
2026	
2027	
2028	
2029	

2030	

h. List and describe at least three critical milestones for this project (including prior to when CDR starts), that are needed to achieve the amount of CDR over the proposed timeline.

	Milestone description	**Target completion date** (e.g. Q4 2025)
1		
2		
3		
4		
5		
6		

i. What, if any, large shifts in technology design or project strategy have you made since getting started? What is your strategy to enable rapid future iteration? We recognize the difficulty of new technology development and deployment and are looking specifically to understand your past and expected learning rate. <200 words

j. What is your IP strategy? Please link to relevant patents, pending or granted, that are available publicly (if applicable). <200 words

k. How are you going to finance this project? <300 words

l. Do you have other CDR buyers for this project? If so, please describe the anticipated purchase volume and level of commitment (e.g., contract signed, in discussions, to be approached, etc.). <200 words

m. What other revenue streams are you expecting from this project (if applicable)? Include the source of revenue and anticipated amount. What are your ideas for generating revenue for your project beyond voluntary market credit purchases? Examples could include tax credits and co-products. <200 words

3. Durability

a. Describe how your approach results in permanent CDR (> 1,000 years). Include citations to scientific/technical literature supporting your argument. What are the upper and lower bounds on your durability estimate? < 300 words

b. What durability risks does your project face? Are there physical risks (e.g. leakage, decomposition and decay, damage, reversal etc.)? Are there socioeconomic risks (e.g. mismanagement of storage, decision to consume or combust derived products, etc.)? What fundamental uncertainties exist about the underlying technological, geochemical or biological process? <200 words

4. Gross removal & life cycle analysis (LCA)

a. How much **gross CDR** will occur over this project's timeline? All tonnage should be described in **metric tons** of CO_2 here and throughout the application. Tell us how you calculated this value (i.e., show your work). If you have uncertainties in the amount of gross CDR, tell us where they come from.

Gross tons of CDR over project lifetime	
Describe how you calculated that value	

b. How many tons of CO_2 have you captured and stored to date? If relevant to your technology (e.g., DAC), please list captured and stored tons separately.

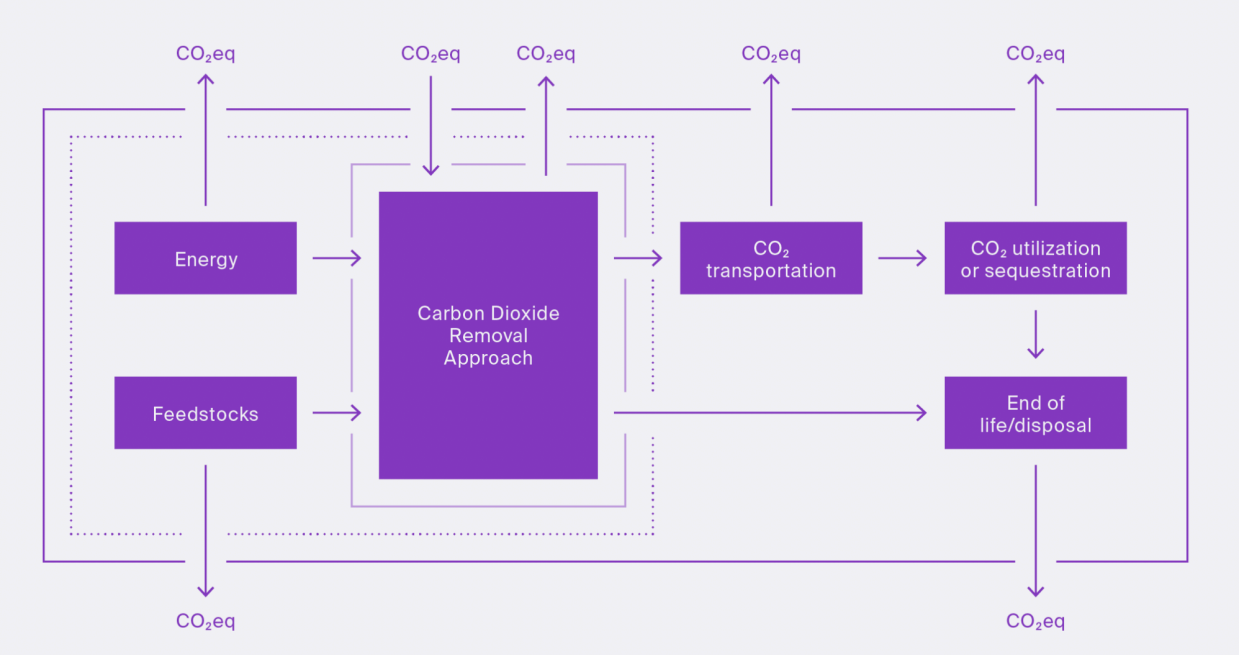
c. If applicable, list any avoided emissions that result from your project. For carbon mineralization in concrete production, for example, removal would be the CO_2 utilized in concrete production and avoided emissions would be the emissions reductions associated with traditional concrete production. Do not include this number in your gross or net CDR calculations; it's just to help us understand potential co-benefits of your approach.

d. How many **gross emissions** will occur over the project lifetime? Divide that value by the gross CDR to get the emissions / removal ratio. Subtract it from the gross CDR to get the net CDR for this project.

Gross project emissions over the project timeline *(should correspond to the boundary conditions described below this table)*	
Emissions / removal ratio *(gross project emissions / gross CDR – must be less than one for net-negative CDR systems)*	
Net CDR over the project timeline *(gross CDR - gross project emissions)*	

e. Provide a process flow diagram (PFD) for your CDR solution that provides the basis for your life cycle analysis (LCA) and helps visualize the project emissions numbers above. Some notes:

- The LCA scope should be cradle-to-grave
- For each step in the PFD, include all Scope 1-3 greenhouse gas emissions on a CO_2 equivalent basis
- Do not include CDR claimed by another entity (no double counting)
- For assistance, please:
    - Review the diagram below from the CDR Primer, Charm's application from 2020 for a simple example, or CarbonCure's for a more complex example
    - See University of Michigan's Global CO_2 Initiative resource guide
- If you've had a third-party LCA performed, please link to it.



f. Please articulate and justify the boundary conditions you assumed above: why do your calculations and diagram include or exclude different components of your system? <100 words

g. Please justify all numbers used to assign emissions to each process step depicted in your diagram above. Are they solely modeled or have you measured them directly? Have they been independently measured? Your answers can include references to peer-reviewed publications, e.g. Climeworks' LCA paper.

Process Step	**CO_2(eq) emissions over the project lifetime (tons)**	**Describe how you calculated that number. Include references where appropriate.**
[add rows as needed]		

5. Measurement, reporting, and verification (MRV)

Section 4 above captures a project's lifecycle emissions, which is one of a number of MRV considerations. In this section, we are looking for additional details on your MRV approach, with a particular focus on your quantification of carbon removal outcomes and associated uncertainties.

a. Describe your ongoing approach to quantifying the CDR of your project, including methodology, what data is measured vs modeled, monitoring frequency, and key assumptions. If you plan to use an existing protocol, please link to it. Please see Climeworks' DAC protocol or Isometric's bio-oil sequestration protocol for reference, though note we do not expect proposals to have a protocol at this depth at the prepurchase stage. <300 words

b. How will you quantify the durability of the carbon sequestered by your project discussed in 3(b)? If direct measurement is difficult or impossible, how will you rely on models or assumptions, and how will you validate those assumptions? *(E.g. monitoring of injection sites, tracking biomass state and location, estimating decay rates, etc.)* <200 words

c. This Quantification Tool maps components that we anticipate should be measured or modeled to quantify CDR and durability outcomes, along with high-level characterizations of the uncertainty type and magnitude for each element. We are asking the net CDR volume to be discounted in order to account for uncertainty and reflect the actual net CDR as accurately as possible. Please complete the table below. Some notes:

- In the first column, list the quantification components from the Quantification Tool relevant to your project (e.g., risk of secondary mineral formation for enhanced weathering, variability in air-sea gas exchange efficiency for ocean alkalinity enhancement, etc.).
- In the second column, please discuss the magnitude of this uncertainty related to your project and what percentage of the net CDR should be discounted to appropriately reflect these uncertainties. Your estimates should be based on field measurements, modeling, or scientific literature. The magnitude for some of these factors relies on your operational choices (i.e., methodology, deployment site), while others stem from broader field questions, and in some cases, may not be well constrained. We are not looking for precise figures at this stage, but rather to understand how your project is thinking about these questions.
- See this post for details on Frontier's MRV approach and a sample uncertainty discount calculation and this Supplier Measurement & Verification Q&A document for additional guidance. Please see CREW's application for an example of a detailed response to this section.

Quantification component Include each component from the Quantification Tool relevant to your project	**Discuss the uncertainty impact related to your project** Estimate the impact of this component as a percentage of net CDR. Include assumptions and scientific references if possible.
Ex: storage leakage	*Ex: Based on historical monitoring data from well operator*
[add rows as needed]	

d. Based on your responses to 5(c), what percentage of the net CDR do you think should be discounted for each of these factors above and in aggregate to appropriately reflect these uncertainties? <50 words

e. Will this project help advance quantification approaches or reduce uncertainty for this CDR pathway? If yes, describe what new tools, models or approaches you are developing, what new data will be generated, etc.? <200 words

f. Describe your intended plan and partners for verifying delivery and issuing and listing credits in the long run, if known. If a protocol doesn't yet exist for your technology, who will develop it? Note: For prepurchase deliveries, we do not expect that companies work with third party verifiers or credit issuers. <200 words

6. Cost

We are open to purchasing CDR at a price >$100/ton today with the expectation that the price per ton will rapidly decline over time. The questions below are meant to capture some of the key numbers and assumptions that you are entering into the separate TEA spreadsheet (see step 4 in Applicant Instructions). There are no right or wrong answers, but we are looking for realistic projections vs optimistic. If we select you for purchase, we'll work with you to understand your milestones and their verification in more depth.

a. Broadly, what would need to be true for your approach to achieve a cost of $100/ton? Describe the parameters that have the greatest sensitivity to cost (e.g., manufacturing efficiencies, material cost, material lifetime, etc.). For each parameter you identify, tell us what the current value is, and what value you are assuming for your NOAK commercial-scale TEA. If this includes parameters you already identified in 2(b), please repeat them here (if applicable).

Parameter with high impact on cost	**Current value (units)**	**Value assumed in NOAK TEA (units)**	**Why is it feasible to reach the NOAK value?**
[add rows as needed]			

b. What aspects of your cost analysis are you least confident in? <100 words

c. How do the CDR costs calculated in the TEA spreadsheet compare with your own models? If there are large differences, please describe why that might be (e.g., you're assuming different learning rates, different multipliers to get from Bare Erected Cost to Total Overnight Cost, favorable contract terms, etc.). <200 words

d. Please break out the components of the underlying levelized **cost** per ton for this project.

Component	**Levelized cost of net CDR for this project ($/ton)**
Capex	
Opex (excluding measurement)	
Quantification of net removal (field measurements, modeling, etc.)	
Total	

e. What is the estimated revenue from co-product sales per ton of carbon removed (if applicable)?

$/ton CO_2

7. Public engagement[4]

In alignment with Frontier's Safety & Legality criteria, we are looking to understand your approach to responsible CDR project development. Frontier requires projects to consider and address potential social, political, and ecosystem risks associated with their deployments. We recognize that this work may be quite nascent for early projects, but it is worth considering now since strong community engagement can accelerate deployment, build positive press, and generate demand. Projects with effective public engagement tend to:

- Take time to understand the social, economic, and environmental context in which they're deploying
- Identify key stakeholders (e.g., labor unions, workforce development boards, frontline communities, Tribes), including potential sources of support and conflict
- Have mechanisms in place to engage and gather opinions from those stakeholders early in the development of the project, and *integrate* that input into revised project plans over time

a. Who have you identified as relevant external stakeholders, where are they located, when in the development of your project did you engage them, and what process did you use to identify them? Please include discussion of the communities potentially engaging in or impacted by your project's deployment. <300 words

b. If applicable, how have you engaged with these stakeholders and communities? Has this work been performed in-house, with external consultants, or with independent advisors? If you do have any reports on public engagement that your team has prepared, please provide. *See Project Vesta's community engagement and governance approach as an example and Arnestein's Ladder of Citizen Participation for a framework on community input.* <300 words

c. If applicable, what have you learned from these engagements? What modifications have you already made to your project based on this feedback, if any? If you have yet to meaningfully engage, what potential concerns or barriers do you expect to face from the community? <100 words

[4] For additional resources on community engagement and CDR, please see these resources: U.S. Department of Energy's Community Benefits Plan Guidance and Section 7 of the ICVCM's Assessment Framework

d. Going forward, do you have changes to your processes for (a) and (b) planned that you have not yet implemented? How do you envision your public engagement strategy at the megaton or gigaton scale? <100 words

8. Environmental justice[5]

As a part of Frontier's Safety & Legality criteria, Frontier seeks projects that proactively integrate environmental and social justice considerations into their deployment strategy and decision-making on an ongoing basis. We are particularly interested in projects that address procedural justice (fair decision making processes, which we expect is covered in Section 7; distributional justice (maximizing the fair distribution of benefits and minimizing negative impacts to disadvantaged communities); and reparative justice (redressing past harms).

a. What potential project benefits, risks, and impacts have you identified associated with this project? What steps have you taken to avoid / minimize harms or negative impacts to disadvantaged communities? What steps have you taken to maximize the fair distribution of benefits? Consider the supply chain impacts, expansion of infrastructure, land use concerns, and workforce development, for example. <300 words

b. Does your project have implications for communities currently reliant on the fossil fuel industry or already harmed by industrial pollution or fossil fuel infrastructure? If so, does your project provide benefits to those communities (e.g., retraining fossil fuel workers, cleaning up legacy pollution, repurposing legacy infrastructure)? <300 words

9. Legal and regulatory compliance

a. What legal opinions, if any, have you received regarding deployment of your solution? <100 words

[5] For helpful content regarding environmental justice and CDR, please see these resources: C180 and XPRIZE's Environmental Justice Reading Materials, AirMiners' Environmental and Social Justice Resource Repository, and the Foundation for Climate Restoration's Resource Database

b. What permits or other forms of formal permission do you require, if any, to engage in the research or deployment of your project? What else might be required in the future as you scale? Please clearly differentiate between what you have already obtained, what you are currently in the process of obtaining, and what you know you'll need to obtain in the future but have not yet begun the process to do so. <100 words

c. Is your solution potentially subject to regulation under any international legal regimes? If yes, please specify. Have you engaged with these regimes to date? <100 words

d. In what areas are you uncertain about the legal or regulatory frameworks you'll need to comply with? This could include anything from local governance to international treaties. For some types of projects, we recognize that clear regulatory guidance may not yet exist. <100 words

Application Supplement: DAC

(Only fill out this supplement if it applies to you)

Note: these questions are with regards only to air capture: e.g. your air contactors, sorbents or solvents, etc. Separately, there exist Geologic Injection and CO_2 Utilization supplements. We anticipate that most companies filling out this DAC supplement should ALSO fill out one of those supplements to describe their use of the CO_2 stream that's an output of the capture system detailed here.

Physical footprint

1. What is the physical land footprint of this project, and how do you anticipate this will change over the next few years? This should include your entire physical footprint, i.e., how much land is not available for other use because your project exists (include land for supporting energy infrastructure). Also, what is the estimated footprint if this approach was removing 100 million tons of CO_2 per year?

Land footprint of this project (km^2)	
Land footprint of this tech if scaled to 100 million tons of CO_2 removed per year (km^2)	

Capture materials and processes

2. What material(s) are you using to remove CO_2? How much of this capture medium do you estimate to use per ton of CO_2 (now and at scale)? What happens to your capture medium at end-of-life? Please note if it is hazardous or requires some special disposal, and how you ensure end-of-life safety. <150 words

3. How do you source your material(s)? Discuss how this sourcing strategy might change as your solution scales. Note any externalities associated with the sourcing or manufacture of it (e.g., hazardous wastes, mining, etc.). You should have already included the associated carbon intensities in your LCA in Section 4. <300 words

4. How much energy is required for your process to remove 1 net ton of CO_2 right now (in GJ/ton)? Break that down into thermal and electrical energy, if applicable. What energy intensity are you assuming for your NOAK TEA? <100 words

5. What is your proposed source of energy for this project? What is its assumed carbon intensity? Will this change over the duration of your project? Does your approach include innovations that allow it to use or procure low-carbon energy efficiently? (You should have already included the associated carbon intensities in your LCA in Section 4). <100 words

6. Besides energy, what other resources do you require (if any, such as water)? Where and how are you sourcing these resources, and what happens to them after they pass through your system? (You should have already included the associated carbon intensities in your LCA in Section 4). <100 words

7. Several direct air technologies are currently being deployed around the world. Why does your DAC technology have a better chance to scale and reach low cost than the state of the art? <200 words

Application Supplement: Biomass

(Only fill out this supplement if it applies to you)

Feedstock

To ensure the responsible scaling of biomass-based CDR approaches, Frontier has developed sourcing principles, which we encourage you to read prior to completing this section.

1. What type(s) of biomass does your project rely on? What is the current fate of this biomass and what are alternative potential future use cases or counterfactuals? <150 words

2. How much CDR is feasible globally per year using the biomass you identified in question 1 above? Please include a reference to support this potential capacity. <100 words

3. How is the biomass sourced (e.g., waste corn stover)? Do you have supply agreements established? <200 words

4. Describe the logistics of collecting your biomass, including transport. How much carbon emissions are associated with these logistics, and how much does it cost? How do you envision this to evolve with scale? <200 words

5. There are many potential uses for waste biomass, including avoiding emissions and various other approaches to CDR. What are the merits and advantages of your proposed approach in comparison to the alternatives? <200 words

Ecosystem impacts

6. We recognize that both biomass production (e.g. residues from forest or agriculture,) and biomass storage (e.g., subsurface bio-oil injection) can have complex interactions with ecological, social, and economic systems. What are potential negative impacts (or important unknowns) you have identified, and what are your specific plans for mitigating those impacts (or resolving the unknowns)? <300 words

Application Supplement: Alkaline Feedstock

(Only fill out this supplement if it applies to you)

Source material and physical footprint

1. What source material are you using, and how do you procure it? <100 words

2. Describe the ecological impacts of obtaining your source material. What's the alternative use(s) of this material? Is there an existing industry that co-produces the minerals required? <150 words

3. How much CDR is feasible globally per year using this approach? Please include a reference to support this potential capacity. <100 words

4. Do you process that source mineral in any way (e.g., grinding to increase surface area, applying an accelerant, treatment to remove impurities)? What inputs does this processing require (e.g. water, energy, chemicals)? You should have already included their associated carbon intensities in your LCA in Section 4. <200 words

5. Please fill out the table below regarding your project's physical footprint. If you don't know (e.g. you procure your source material from a mining company who doesn't communicate their physical footprint), indicate that in the table below.

	Land area (km^2) for this project	Competing/existing project area use (if applicable)

Source material mining		
Source material processing		
Deployment		

Human and ecosystem risks

6. What potential ecosystem risks have you identified (e.g. release of heavy metals, dust aerosol hazards, P loading to groundwater etc)? Give estimated release rates if possible and indicate how this will be monitored? <150 words

7. If minerals are deployed on croplands, what are the estimated effects on crop yields? Include citations to support this claim. How will actual effects be monitored? <100 words

8. How will you monitor potential impacts on organisms in your deployment environment? (e.g. health of humans working in agricultural contexts, health of intertidal species, etc.) <100 words

Application Supplement: Ocean and Inland Water

(Only fill out this supplement if it applies to you)

Physical footprint and scaling

1. Describe the geography of your deployment, its relationship to inland water bodies, riverine systems, coastlines, shipping channels, other human or animal activity, etc. <200 words

2. Please describe your physical footprint in detail for both (1) your proposed project and for a deployment at 100Mt scale. Consider surface area, depth, expected interaction with inland water systems, ocean currents and upwelling/downwelling processes, etc. <200 words

   If you've also filled out another supplement and fully articulated these details there, simply write N/A.

3. Building large systems on or in the water is hard. What are your core engineering challenges and constraints (not covered already within 1(c)? Is there any historical precedent for the work you propose? <200 words

Ecosystem impacts

4. What are potential negative impacts of your approach on aquatic and/or ocean ecosystems (riverine, coastal, surface, benthic etc.)? <200 words

5. How will you mitigate the potential for negative ecosystem impacts (e.g., eutrophication and alkalinity/pH)? How will you quantify and monitor the impact of your solution on aquatic ecosystems and organisms? <200 words

Application Supplement: Geologic Injection

(Only fill out this supplement if it applies to you)

Feedstock and monitoring

1. What are you injecting? Gas? Supercritical gas? An aqueous solution? Biosolids? What compounds other than C exist in your injected material? <50 words

2. Describe the geologic setting to be used for your project. What is the trapping mechanism, and what infrastructure is required to facilitate carbon storage? How will you monitor that your durability matches what you described in Section 3 of the General Application? <300 words

3. For projects in the United States, for which UIC well class is a permit being sought (e.g. Class II, Class VI, etc.)? <10 words

4. At what rate will you be injecting your feedstock? <10 words

5. Do you facilitate enhanced oil recovery (EOR), either in this project or elsewhere in your operations? If so, please briefly describe. <50 words

Environmental hazards

6. What are the potential environmental impacts associated with this injection project, and what specific actions or innovations will you implement to mitigate those impacts? How will they be monitored moving forward? <200 words

7. What are the key uncertainties to using and scaling this injection method? <200 words

Application Supplement: CO_2 Utilization

(Only fill out this supplement if it applies to you)

CO_2 Feedstock

1. How do you source your CO_2, and from whom? If your approach includes CO_2 capture and is described above (e.g., general application and one of the supplements), simply respond N/A here. <200 words

2. What are alternate uses for this CO_2 stream (now and potentially in the future)? <100 words

Utilization methods

3. How does your solution use and permanently store CO_2? What is the gross CO_2 utilization rate? (E.g. CO_2 is mineralized in Material at a rate of X tCO_2 (gross) / t storage material). <100 words

4. What happens to the storage material (e.g. concrete) at the end of its service life, and how does that impact its embodied carbon storage over time? How do you know? <100 words

5. How do you ensure that the carbon benefits you are claiming through a CO_2 utilization process are not double counted? (E.g. If sourcing CO_2 from a DAC system, or selling your product to a user interested in reducing their carbon footprint, who claims the CDR benefits and how could an independent auditor validate no double counting?) <200 words