8 Rivers Carbon Removal Purchase Application

General Application

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

Company or organization name

8 Rivers Capital, LLC

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

Durham, North Carolina

Name of person filling out this application

Adam Goff

Email address of person filling out this application

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Brief company or organization description

8 Rivers invents and commercializes net zero solutions

1. Overall CDR solution (All criteria)

a. Provide a technical explanation of the proposed project, including as much specificity regarding location(s), scale, timeline, and participants as possible. Feel free to include figures.

The proposed project would build a Direct Air Capture facility in Peach Springs Arizona that will capture up to 10,000 tonnes per year of CO_2 from the air and lock it permanently into stone as calcium carbonate ($CaCO_3$). The project will be the first commercial deployment of the Calcite Carbon Removal process invented by 8 Rivers which uses calcium hydroxide to pull carbon directly from the air, in this case starting with the calcium within lime kiln dust (LKD). 8 Rivers is the developer of the project and will be working with Lhoist North America to deploy the project on its existing lime facility in Peach Springs. Lhoist North America is the North American subsidiary of the Lhoist Group, a world leading producer of lime, dolomitic lime, and minerals.

The project will capture carbon through calcium hydroxide made from Lhoist's lime kiln dust, a waste product which is currently being landfilled. Fans will pull air into a warehouse air contactor multiple stories tall, where the Calcite Carbon Removal process will utilize the lime kiln dust in order to pull CO_2 from the air, delivering carbon dioxide removal and locking carbon into stone as calcium carbonate, which can then be disposed of. The carbon will be locked into permanent storage for millennia. The LKD would be trucked approximately 5 miles from the kiln to the identified 1 acre site for Calcite, with land use minimized by using vertical space in the warehouse air contactor. Generated calcium carbonate would be trucked 5 miles from the project site to the disposal site.

The key next steps for the project are to secure carbon removal offtakes, close development capital, and then start Front End Engineering and Design (FEED). This would allow the project to raise sufficient construction equity, with this Calcite project slated to come online as early as 2024. It would kickstart the Calcite technology, allowing for large-scale deployments of projects to be fed by limestone instead of Lime Kiln Dust. With fresh limestone input, Calcite has the potential to deliver gigaton-scale carbon removal at <$100 per tonne of net carbon removal.

8 Rivers invented the Calcite technology in H2 2019, and in H2 2020 8 Rivers in partnership with Massachusetts Institute of Technology was awarded an $810,000 ARPA-E grant that involves advancing the costing and design of the Calcite process. In 2021, 8 Rivers began seeking a site with a Lime Kiln Dust supply that would allow for a small-scale carbon negative first deployment of Calcite without the need to build a calciner with carbon capture and storage, and in Q3 of 2021 finalized Lhoist's Nelson plant in Peach Springs Arizona as the host site. In Q4 of 2021 8 Rivers and a prominent National Laboratory began collaborating to provide scientific validation of the Calcite process with a 6 month validation program, where Lab scientists will soon begin conducting testing in their lab facilities.

As host site Lhoist will provide the land lease, the supply of the Lime Kiln Dust, and the disposal of the generated calcium carbonate. The project would source its small power demand via the Mohave Electric transmission line that borders the plant site, would drill an on-site water well for water supply, and does not need a natural gas supply or a CO_2 pipeline.

8 Rivers invented and tested Calcite in H2 2019, with continued testing and advancement ongoing, with demonstrated carbonation on both industrial calcium hydroxide and lime kiln dust. The technology uses a thin calcium hydroxide paste to remove CO_2 from the air at low cost with low technology risk, maximizing vertical space to reduce land area. 8 Rivers has experimentally demonstrated this system, showcasing that with minimal optimization carbonation is complete in <100 hours. Calcite is designed around this slower rate of carbon capture, compared to faster capture in competing technologies which use amines or sodium hydroxide or potassium hydroxide to speed up air capture. This allows Calcite to run on the

calcium cycle eliminating complexity and relying on proven components. The main components of this system are affordable and technologically available: a lime kiln with associated carbon capture infrastructure, a slaker, a warehouse, a lime dipping and material removal system, and a material conveyance system.

8 Rivers is also working to develop the second Calcite Carbon Removal facility at a different location, which would include the lime kiln with carbon capture and associated CO_2 injection. A high-potential site has been identified with suitable energy inputs and available CO_2 offtake, suitable to support >100,000 MT of carbon removal. The project will continue to be advanced and the success of the first Calcite project in Arizona will enable it to hit Final Investment Decision and start construction.

b. What is your role in this project, and who are the other actors that make this a full carbon removal solution? *(E.g. I am a broker. I sell carbon removal that is generated from a partnership between DAC Company and Injection Company. DAC Company owns the plant and produces compressed CO_2. DAC Company pays Injection Company for storage and long-term monitoring.)*

8 Rivers is the project developer as well as the technology developer and licensor. The project must raise sufficient funds for development and construction. It would then pay for inputs and operations, and would receive revenue for carbon removal. The project would need to receive a Calcite license from 8 Rivers.

c. What are the three most important risks your project faces?

Risk 1: Low Relative Humidity and Low Temperature Conditions in Peach Springs.

Risk mitigation: Humidification system will boost the humidity of the plant air. Plant economic model takes into account lower capacity factors from decreased output due to cold weather conditions.

Risk 2: LKD Quality and Consistency of Supply

If the lime kiln dust quality were to change, the resulting carbon removal could increase or decrease. As LKD is a waste product, the quality of the LKD does vary. Additionally, if Lhoist were to run their kiln less often, the supply of Lime Kiln Dust would proportionally decrease.

Risk mitigation: Historical data on lime kiln dust calcium content and supply provides bounded estimates for lime kiln dust quality and quantity. Key project contracts will include provisions that appropriately account for changes to the Lime Kiln Dust supply. The nature of supply contracts from Lhoist may decrease the proportion of debt possible in project financing. Thus construction could primarily be equity financed, with investors who can take the LKD risk.

Risk 3: First of a Kind deployment

This will be a scale up from the previous testing and pilot scale Calcite units. which as with any first of a kind project entails risks of unexpected challenges or costs. These could be related to the material handling of the caustic material and the impact on the plant equipment, substrate management, air flow within the facility, removal of the generated calcium carbonate, baghouse operation to mitigate dust production, or some as-yet-unforeseen issue. This scale up risk will be made manageable by the testing that has been done and is being done by 8 Rivers and by a National Lab, and by the Front End Engineering Design process, which will confine the capital and operating cost estimates sufficient for project financing.

d. If any, please link to your patents, pending or granted, that are available publicly.

- https://patents.google.com/patent/WO2021111366A1/en

2. Timeline and Durability (Criteria #4 and Criteria #5)

a. Please fill out the table below.

	Timeline for Offer to Stripe
Project duration *Over what duration will you be actively running your DAC plant, spreading olivine, growing and sinking kelp, etc. to deliver on your offer to Stripe? E.g. Jun 2021 - Jun 2022. The end of this duration determines when Stripe will consider renewing our contract with you based on performance.*	2024-2025
When does carbon removal occur? *We recognize that some solutions deliver carbon removal during the project duration (e.g. DAC + injection), while others deliver carbon removal gradually after the project duration (e.g. spreading olivine for long-term mineralization). Over what timeframe will*	2024 – 2025

carbon removal occur? *E.g. Jun 2021 - Jun 2022 OR 500 years.*	
Distribution of that carbon removal over time *For the time frame described above, please detail how you anticipate your carbon removal capacity will be distributed. E.g. "50% in year one, 25% each year thereafter" or "Evenly distributed over the whole time frame". We're asking here specifically about the physical carbon removal process here, NOT the "Project duration". Indicate any uncertainties, eg "We anticipate a steady decline in annualized carbon removal from year one into the out-years, but this depends on unknowns re our mineralization kinetics".*	100% in the first 12 months of operations. Approximately evenly distributed. Exact distribution month by month will vary up and down with LKD composition provided and weather, but average carbon removal year by year is expected to be roughly constant. Slower rates of carbonation in cold temperatures will lead to lower carbon removal in winter months.
Durability *Over what duration you can assure durable carbon storage for this offer (e.g, these rocks, this kelp, this injection site)? E.g. 1000 years.*	>1,000 years

b. What are the upper and lower bounds on your durability claimed above in table 2(a)?

The durability guarantee can be as long as is practical from a contracting and financeability point of view. Upper bound durability >10 million years. 100% of the carbon removal from this project is captured and stored in rock as calcium carbonate. Calcium carbonate is stable and cannot leak or escape, as a stored gas might. Limestone is made of calcium carbonate and is often tens of millions to hundreds of millions of years old.

c. Have you measured this durability directly, if so, how? Otherwise, if you're relying on the literature, please cite data that justifies your claim. *(E.g. We rely on findings from Paper_1 and Paper_2 to estimate permanence of mineralization, and here are the reasons why these findings apply to our system. OR We have evidence from this pilot project we ran that biomass sinks to D ocean depth. If biomass reaches these depths, here's what we assume happens based on Paper_1 and Paper_2.)*

It has not been measured directly, however the stability of calcium carbonate is well understood. In the earth's calcium cycle, there are two principal mechanisms whereas the calcium carbonate could be transformed, as described in the next section. Also see:

https://earthobservatory.nasa.gov/features/CarbonCycle/page2.php

https://www.nature.com/articles/s41467-021-24750-0

d. What durability risks does your project face? Are there physical risks (e.g. leakage, decomposition and decay, damage, 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 or biological process?

We are aware of three durability risks:

The first is subduction of the material into the earth's crust where it eventually feeds a volcano. Such a process would take millions of years.

Secondly, rainfall or extreme wind washes away the calcium carbonate from its current disposal site. This is unlikely: Peach Springs gets 11 inches of rain a year, and has disposed of kiln dust for decades, with wetting to ensure no dust can be blown away. Even if it occurred, it would not lead to physical reversal. Either the $CaCO_3$ would simply be moved and deposited elsewhere, or the calcium ion could be dissolved in the ocean to form calcium bicarbonate, increasing the carbon removal, as two CO2 molecules would be bound up and ocean acidity would actually be reduced.

The most plausible risk of reversal would be if the generated CaCO3 was intentionally removed from the disposal pit and placed into a kiln to release the captured CO2. This would need to be an intentional act. Doing this would not be economic, as the landfilled CaCO3 is low quality and mixed with grit, and is adjacent to high quality in situ limestone.

e. How will you quantify the actual permanence/durability of the carbon sequestered by your project? 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.)*

The project will work with Lhoist to dispose of the calcium carbonate. Lhoist already monitors the disposal pile, as is part of their current business practice. Regular pictures can be taken of the disposal pile to track the pile over time and to ensure material is not intentionally removed.

This could likely also be tracked by satellite imagery if desired by the client. Should disposed of calcium carbonate be washed away or somehow removed, the project would directly alert the buyer, though this still would not constitute a reversal. During air contactor operation, CO_2 monitoring at the inlet and outlet of the warehouse air contactor will provide real time measurement of carbon removal, and compositional analysis of the LKD before and after carbonation could provide further validation of carbon removal.

3. Gross Capacity (Criteria #2)

a. Please fill out the table below. **All tonnage should be described in metric tonnes here and throughout the application.**

	Offer to Stripe (metric tonnes CO_2) over the timeline detailed in the table in 2(a)
Gross carbon removal Do not subtract for embodied/lifecycle emissions or permanence, we will ask you to subtract this later	2,446 MT CO2
If applicable, additional avoided emissions e.g. for carbon mineralization in concrete production, removal would be the CO_2 utilized in concrete production and avoided emissions would be the emissions reductions associated with traditional concrete production	0

b. Show your work for 3(a). How did you calculate these numbers? If you have significant uncertainties in your capacity, what drives those? *(E.g. This specific species sequesters X tCO_2/t biomass. Each deployment of our solution grows on average Y t biomass. We assume Z% of the biomass is sequestered permanently. We are offering two deployments to Stripe. X*Y*Z*2 = 350 tCO_2 = Gross removal. OR Each tower of our mineralization reactor captures between X and Y tons CO_2/yr, all of which we have the capacity to inject. However, the range between X and Y is large, because we have significant uncertainty in how our reactors will perform under various environmental conditions)*

Lime kiln dust is expected to contain .3 to.5 tonnes of calcium oxide (CaO) per tonne of LKD, with .38 ton CaO per ton of LKD used herein. 90% carbonation of this calcium oxide in the Calcite system is projected. The total project is expected to utilize 37,500 MT of lime kiln dust per year for 10,064 MT of gross carbon removal. We have allocated Stripe 24% of this carbon removal from the first 12 months of operations, for 9,115 MT of LKD input. 8,333 MT * .38 MT CaO / MT * 90% carbonation * 44 MT CO2 / 56 MT CaO = 2,446

c. What is your total overall capacity to sequester carbon at this time, e.g. gross tonnes / year / (deployment / plant / acre / etc.)? Here we are talking about your project / technology as a whole, so this number may be larger than the specific capacity offered to Stripe and described above in 3(b). We ask this to understand where your technology currently stands, and to give context for the values you provided in 3(b).

Calcite has no existing plants, so has no capacity for carbon removal at this time. The full Arizona project will be the first plant, and is intended to have capacity for 10,000 MT of gross carbon removal which is over 8,000 MT net carbon removal, across an approximately 1 acre site.

d. We are curious about the foundational assumptions or models you use to make projections about your solution's capacity. Please explain how you make these estimates, and whether you have ground-truthed your methods with direct measurement of a real system (e.g. a proof of concept experiment, pilot project, prior deployment, etc.). We welcome citations, numbers, and links to real data! *(E.g. We assume our sorbent has X absorption rate and Y desorption rate. This aligns with [Sorbent_Paper_Citation]. Our pilot plant performance over [Time_Range] confirmed this assumption achieving Z tCO_2 capture with T tons of sorbent.)*

We assume the calcium hydroxide in the air contact reaches 90% of its maximum carbonation capacity in less than a week. Our lab testing on both lime kiln dust pure calcium hydroxide reached this speed for >75% carbonation in ambient air.

Our experiment program in the second half of 2019 was weight based, with carbonation in ambient air, measurement of ensuing weight gain, with heating of the generated calcium carbonate to remove water at the end of the experiment. Our experimental program in the second half of 2021 utilizes measurements from tests in a fixed CO_2 environment, where carbonation could be tracked hourly by the flow of CO_2 into the experiment. The scale of these experiments was such that multiple grams of CO_2 could be absorbed in each test. Follow-on experiments in Q4 of 2021 Durham are ongoing to generate further data. A prominent US National Lab will then do larger scale demonstration tests on both pure calcium hydroxide and lime kiln dust over the next 6 months.

e. Documentation: If you have them, please provide links to any other information that may help us understand your project in detail. This could include a project website, third-party documentation, project specific research, data sets, etc.

• N/A

4. Net Capacity / Life Cycle Analysis (Criteria #6 and Criteria #8)

a. Please fill out the table below to help us understand your system's efficiency, and how much your lifecycle deducts from your gross carbon removal capacity.

	Offer to Stripe (metric tonnes CO_2)
Gross carbon removal	2,446 MT CO2
Gross project emissions	446 MT CO2
Emissions / removal ratio	18.2%
Net carbon removal	2,000 MT CO2

b. Provide a carbon balance or "process flow" diagram for your carbon removal solution, visualizing the numbers above in table 4(a). Please include all carbon flows and sources of energy, feedstocks, and emissions, with numbers wherever possible *(E.g. see the generic diagram below from the CDR Primer, Charm's application from last year for a simple example, or CarbonCure's for a more complex example).* If you've had a third-party LCA performed, please link to it.

Indicative Carbon Flow Diagram

Input	Volume	CO_2
Lime Kiln Dust	37,500 MT/yr	+1,420 MT CO_2 Background Carbonation Annual
Air, 410 PPM	1.5 M CFM	-13,400 MT CO_2 Annual
Water	160 GPM	None (power demand below)
Power	.5 MW	+130 MT CO_2: Annual
Steel	117 MT	+212 MT CO_2: 21 MT CO2/yr over 10 years
Plastic	929 MT	+1,700 MT CO_2: 170 MT CO2/yr over 10 years
Trucking		+99 MT CO_2: Annual

→ **Calcite Carbon Removal Facility** →

Output	Volume	CO_2
Lime Kiln Dust, CO_2 absorbed as $CaCO_3$	47,600 MT/yr	-10k MT CO_2 in $CaCO_3$ Annual
Air, 400 PPM	1.5 M CFM	+3,350 MT CO_2 Annual
Evaporated Water	160 GPM	None

Net Carbon Removal: 8,200 MT CO2 per year

13,400 MT – 3,350 MT – 1,420 MT – 130 MT – 21 MT – 170 MT – 99 MT= 8,200 MT CO_2 Removal
Stripe would be receiving a 24% allocation of this carbon removal for the first year of operations.

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

The boundaries of this analysis are the Scope 1, 2, and 3 emissions of the Calcite facility, from embodied emissions in raw materials, to power use, to trucking miles during operations. All major components are included to our knowledge. Some amount of raw materials in the balance of plant have not been included, as we have not yet completed FEED and so do not know their quantities, but the CO2 impact is expected to be minor.

The significant related emissions not included are the annual CO_2 emissions from calcination at the neighboring kiln operations for the production of saleable lime products. Lime kiln dust is not a saleable product, it is a waste byproduct of producing lime that is currently disposed of. The CO_2 from the kiln and this lime kiln dust will both be produced whether or not this project exists. The CO_2 emissions from lime production are not caused by the production of lime kiln dust, and we assume they are attributed and allocated to the lime product. This project will divert that waste product from the landfill and utilize it for carbon removal. To ensure the carbon removal is additional, potential partial carbonation of the lime kiln dust when landfilled is also included in the boundary.

The negative emissions potential of direct air capture / enhanced weathering from industrial waste products including but not limited to kiln dust is well documented in the literature, utilizing a similar lifecycle boundary approach as described above. For example: https://www.nature.com/articles/s41467-019-09475-5

d. Please justify all numbers used 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.

All of the numbers in the above diagram are based on the project's models and assumed CO_2 intensities for inputs, using 8 Rivers experimental data and vendor data where possible. They will continue to be refined during detailed engineering and further testing. Only the carbonation of calcium hydroxide has been measured directly, in a lab setting, and further such experiments are ongoing. The numbers utilized have not been independently measured. Where possible, industry standard life cycle analyses have been utilized, such as: 1.5 kg CO2e per kg of plastic, 1.8 kg CO2 per kg of steel, 161.8 grams CO2 per ton-mile of trucking, and .4 MT CO2 per MWH power (the average carbon intensity for the US gas power plant fleet, the assumed marginal generator)

e. If you can't provide sufficient detail above in 4(d), please point us to a third-party independent verification, or tell us what an independent verifier would measure about your process to validate the numbers you've provided. (We may request such an audit be performed.)

An independent verifier could review all of the raw materials inputs from the FEED study, as well as the operations plan and generated test data of carbonation, to validate the numbers provided ahead of construction. During plant operation, CO_2 monitoring at the inlet and outlet of the warehouse air contactor will provide real time measurement of carbon removal, and compositional analysis of the LKD before and after carbonation could provide further validation of carbon removal.

5. Learning Curve and Costs (Backward-looking) (Criteria #2 and #3)

We are interested in understanding the learning curve of different carbon removal technologies (i.e. the relationship between accumulated experience producing or deploying a technology, and technology costs). To this end, we are curious to know how much additional deployment Stripe's procurement of your solution would result in. (There are no right or wrong answers here. If your project is selected we may ask for more information related to this topic so we can better evaluate your progress.)

a. Please define and explain your unit of deployment. *(E.g. # of plants, # of modules) (50 words)*

Our unit of deployment is each Calcite facility, engineered, financed, and constructed as a unit, consisting of an air contactor and (in future deployments) a calcination system. The carbon removal capacity of each facility will vary and is expected to increase with the number of deployments. Though Stripe is only purchasing 2,000 MT of net removal, it's purchase could be used as development funding to accelerate the entire Arizona facility, which will have a capacity for 8,200 MT CO2 per year for >10 years.

b. How many units have you deployed from the origin of your project up until today? Please fill out the table below, adding rows as needed. Ranges are acceptable if necessary.

Year	Units deployed (#)	Unit cost ($/unit)	Unit gross capacity (tCO_2/unit)	Notes
2021	0	N/A	N/A	*Testing and modeling.*
2020	0	N/A	N/A	*Grant funding received. Modeling.*
2019	0	N/A	N/A	*Invention and testing*
...				

c. Qualitatively, how and why have your deployment costs changed thus far? *(E.g. Our costs have been stable because we're still in the first cycle of deployment, our costs have increased due to an unexpected engineering challenge, our costs are falling because we're innovating next stage designs, or our costs are falling because with larger scale deployment the procurement cost of third party equipment is declining.)*

Through experimental testing and process optimization and cost modeling, our projected costs have declined moderately while also improving in their fidelity, as we receive vendor quotes for key pieces of equipment, find ways to increase the carbonation rate, and reduce material inputs and capital costs. Continued engineering and testing during FEED will continue this process. Our internal cost modeling projects that a next-of-a-kind Calcite facility would

capture carbon for below $100 / MT net CO2 removal

d. How many additional units would be deployed if Stripe bought your offer? The two numbers below should multiply to equal the first row in table 3(a).

# of units	Unit gross capacity (tCO_2/unit)
.24	*10,000*

6. Cost and Milestones (Forward-looking) (Criteria #2 and #3)

We ask these questions to get a better understanding of your growth trajectory and inflection points, there are no right or wrong answers. If we select you for purchase, we'll expect to work with you to understand your milestones and their verification in more depth.

a. What is your cost per ton CO_2 today?

<$500 / ton CO2. This modeled cost is specific to a first of a kind lime kiln dust deployment in Arizona.

b. Help us understand, in broad strokes, what's included vs excluded in the cost in 6(a) above. We don't need a breakdown of each, but rather an understanding of what's "in" versus "out." Consider describing your CAPEX/OPEX blend, assumptions around energy costs, etc.

Levelized cost is 60% from CAPEX, with vendor quotes received on most major pieces of equipment, and standard factors applied to calculate "Total As Spent Cost" from "Total Equipment Cost" Levelized cost is 40% from OPEX, including power, water, material inputs, O&M, and labor costs. The only energy input is electricity, which is assumed to cost $90 / MWH using Mohave's public rates: https://www.mohaveelectric.com/member-services/rates/. The project will explore approaches to lower the cost and CO_2 intensity of purchased electricity.

c. List and describe **up to three** key upcoming milestones, with the latest no further than Q2 2023, that you'll need to achieve in order to scale up the capacity of your approach.

Milestone #	Milestone description	Why is this milestone important to your ability to scale? (200 words)	Target for achievement (eg Q4 2021)	How could we verify that you've achieved this milestone?
1	Carbon removal offtakes secured	To build the first Calcite plant, carbon removal offtakes must be secured to fund development, construction, and ongoing operations of the facility. Securing offtakes by the end of 2021 will keep the project on track for carbon removal in 2024. Success of the first plant will allow for rapid scale-up in larger Calcite plants integrated with a calciner with carbon capture, each with capacity for hundreds of thousands of tonnes of carbon removal each year.	Q4 2021	Verify the receipt of sufficient term sheets / contracts from counterparties for carbon removal from the project.
2	FEED and permitting started and then completed	Front End Engineering and Design will significantly advance the engineering and cost estimation of this Calcite project, and learnings will also be applicable to	H1 2022 start. Q4 2022 finish.	Verify that signed contracts have been obtained from an appropriate FEED vendor and permitting vendor and receive

		future Calcite projects. It will generate a cost estimate with sufficient accuracy and detail for a financeable EPC contract. Advancing through air and water permitting in Arizona will enable the project to hit Final Investment Decision, while also creating a template for permitting future Calcite projects.		confirmation that work has begun. Verify the completion of FEED and the receipt of permits.
3	Start of construction	The start of construction signifies	H1 2023 start. 2024 finish.	Verify construction financing has been obtained. Verify EPC contract is in place. Attend the groundbreaking ceremony. Monitor the progress of construction.

i. How do these milestones impact the total gross capacity of your system, if at all?

Milestone #	Anticipated total gross capacity prior to achieving milestone (ranges are acceptable)	Anticipated total gross capacity after achieving milestone (ranges are acceptable)	If those numbers are different, why? (100 words)

1	0 MT CO2	0	N/A
2	0 MT CO2	0	N/A
3	0 MT CO2	10,000 MTPA gross CO2 removal.	Completion of construction will start the commissioning of the first Calcite plant, which has 10,000 MT gross carbon removal capacity as previously described.

d. How do these milestones impact your costs, if at all?

Milestone #	Anticipated cost/ton prior to achieving milestone (ranges are acceptable)	Anticipated cost/ton after achieving milestone (ranges are acceptable)	If those numbers are different, why? (100 words)
1	<$500 / ton	<$500 / ton	N/A
2	<$500/ton	$300 - $600 / ton (Calcite on LKD)	During FEED, costing accuracy will be improved with AACE Class II/III budgetary estimate. This will lead to a new cost estimate that could be lower or higher than the current Class V estimate, hence the range given.
3	<$500/ton	$300 - $600 / ton (Calcite on LKD) Improvements of Calcite	At the start of construction, financing costs and EPC costs will be finalized, further refining the actual levelized cost estimate for the first

		cost on limestone and in higher humidity environments are also expected.	unit. At the end of construction, the further refinement of cost estimating from the learnings will be applied to future plants. Learnings from the first plant are expected to decrease the levelized cost of future Calcite plants, which will run on limestone instead of LKD. Calcite will have lower costs when running on calcined limestone, due to the higher purity of calcium hydroxide in the feed, and positive scaling effects of operating at >10x scale.

e. If you could ask one person in the world to do one thing to most enable your project to achieve its ultimate potential, who would you ask and what would you ask them to do?

Ask United CEO Scott Kirby (or equivalent carbon removal market leader) to agree to purchase terms for the first 10 million ton of carbon removal from Calcite projects, enabling rapid acceleration of the project development cycle to build large scale carbon removal plants.

f. Other than purchasing, what could Stripe do to help your project?

-Help introduce us to other potential carbon removal offtakers

-Help to identify potential carbon removal project equity investors interested in funding development and our construction of multiple Calcite facilities

-Continue to lead and grow the carbon removal ecosystem

-Support federal policy improvements that support carbon removal, such as 45Q enhancement and threshold removal.

7. Public Engagement and Environmental Justice (Criteria #7)

In alignment with Criteria 7, Stripe requires projects to consider and address potential social, political, and ecosystem risks associated with their deployments. Projects with effective public engagement tend to do the following:

- Identify key stakeholders in the area they'll be deploying
- Have some mechanism to engage and gather opinions from those stakeholders and take those opinions seriously, iterating the project as necessary.

The following questions are for us to help us gain an understanding of your public engagement strategy. There are no right or wrong answers, and we recognize that, for early projects, this work may not yet exist or may be quite nascent.

a. Who are your external stakeholders, where are they, and how did you identify them?

> Key external stakeholders would include Lhoist as the site host, the local community and nearby residents, the Hualapai Tribe, nearby businesses, local and state officials, federal policymakers considering carbon removal policies and funding, national laboratories and other carbon removal researchers, investors, employees, as well as the wider industry that's focused on engaging with and purchasing carbon removal. These stakeholders were identified in a high-level review of potentially interested parties. A formal stakeholder identification process would be conducted at the formal start of the project.

b. If applicable, how have you engaged with these stakeholders? Has this work been performed in-house, with external consultants, or with independent advisors?

> Engagement has not yet started. Engagement with key stakeholders would begin after development funding was received and the project was publicly launched.

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?

> *N/A*

d. Going forward, do you have changes planned that you have not yet implemented? How do you anticipate that your processes for (a) and (b) will change as you execute on the work described in this application?

> *N/A*

e. What environmental justice concerns apply to your project, if any? How do you intend to consider or address them?

This specific project is not expected to produce any air pollution, water pollution, or other negative externalities for the surrounding community, and thus is not intending to create any environmental justice concerns. While any DAC project at large scale is land intensive, this project only utilizes approximately 1 acre, and so this is not expected to be a significant concern. During development the project would work to further analyze and validate these environmental impacts, as well understand and boost the economic benefit from this project, such as jobs and tax revenue, to the neighboring communities, to provide positive value.

11. Legal and Regulatory Compliance (Criteria #7)

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

None

b. What permits or other forms of formal permission do you require, if any? 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.

The project has not yet obtained any permits. It will hire an external permitting firm to handle permitting in Arizona, to receive an air permit, a water permit, and other standard project approvals. This process has not yet started. Since the limestone mine and kiln is pre-existing, the project is not expected to contribute any significant air pollutants, and there is no need for CO2 injection; these permits are not expected to require a long timeline.

c. 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.

We are uncertain about the legal and regulatory framework (if any) for air permitting of direct air capture plants, at a local, state, and federal level.

d. Does the project from which you are offering carbon removal receive credits from any government compliance programs? If so, which one(s)? (50 words)

The project cannot yet claim 45Q, but could potentially receive 45Q credits if minimum qualifying thresholds are removed or lowered in upcoming congressional legislation. We are

not aware of any other credits from government programs that we would qualify for at this time.

12. Offer to Stripe

This table constitutes your offer to Stripe, and will form the basis of our expectations for contract discussions if you are selected for purchase.

	Offer to Stripe
Net carbon removal (metric tonnes CO_2)	2,000 metric tonnes of CO2
Delivery window (at what point should Stripe consider your contract complete?)	2024-2025, within the first 12 months of plant operation
Price (\$/metric tonne CO_2) ***Note on currencies:*** *while we welcome applicants from anywhere in the world, our purchases will be executed exclusively in USD (\$). If your prices are typically denominated in another currency, please convert that to USD and let us know here.*	\$460 / metric tonne net CO_2 removal

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 (Criteria #1 and #2)

1. What is the physical land footprint of your 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.

Year	Land Footprint (km^2)

2021	0
2022	0
2023	≈.004

2. What is the volumetric footprint of your contactor? (How big is your physical machine compared to how much you're capturing?) and how do you anticipate this will change over the next few years? These numbers should be smaller than (1) above.

Year	Contactor Footprint (m^3)
2021	0
2022	0
2023	≈44,500 m^3

2. Capture Materials and Processes (Criteria #5, #7, and #8)

1. What sorbent or solvent are you using?

Calcite can utilize calcium hydroxide and magnesium hydroxide. In this project, calcium hydroxide is formed from lime kiln dust containing calcium oxide.

2. What is its absorption capacity? *(grams CO_2 per grams material/cycle)*

1 gram of calcium hydroxide ($Ca(OH)_2$) can absorb up to a maximum of .78 grams of CO_2. At 90% carbonation, .70 grams of CO_2 per 1 gram of $Ca(OH)_2$ would be absorbed.

3. What is its desorption capacity? *(grams CO_2 per grams material/cycle)*

This Arizona project has no desorption. Future Calcite deployments with a calciner. At 90% calcination efficiencies, .4 grams of CO2 per gram of $Ca(OH)_2$ would be expected

4. How do you source your sorbent or solvent? Discuss how this sourcing strategy might change as your solutions scales. Note any externalities associated with the sourcing or manufacture of it (hazardous wastes, mining, etc. You should have already included the associated carbon intensities in your LCA in Section 6)

In this project, calcium is sourced from a lime kiln dust waste product produced by Lhoist. In future projects, limestone would be mined for the sorbent feedstock, with Calcite facilities located in close vicinity to or at the mine mouth of limestone mines to minimize sorbent transport costs. Limestone is globally abundant and could support gigatons of annual carbon removal indefinitely. The negative externality from this sourcing would be land disturbance from new limestone mining, and potential dust production from these mines. Limestone mining and its impacts are well understood, as the industry operates at massive scale globally to supply cement and construction industries.

5. How do you cycle your sorbent/solvent? How much energy is required?

Carbonation of calcium hydroxide produces calcium carbonate. For cycling, this calcium carbonate would be collected and removed from the Calcite air contactor, and inputted into a calciner with carbon capture, which heats the material to ~900°C, generating calcium oxide which then goes through a slaker to produce calcium hydroxide. Heat requirements would vary by the calcining process, which as an example could require 4.9 gigajoules per ton of CaO, equivalent to 3.7 gigajoules per ton of $Ca(OH)_2$

6. What is your proposed source of energy? What is its assumed carbon intensity? What is its assumed cost? How will this change over the duration of your project? (You should have already included the associated carbon intensities in your LCA in Section 6)

In this Arizona project, the only source of energy is electricity, which is assumed to have an emissions intensity of .4 MT CO_2 / MWH and a cost of $90 per MWH. Throughout development and operations the project will look to both lower the cost of purchased electricity and the emissions intensity, including through solar power, either purchased or potentially deployed behind the meter on site, with the goal of reaching zero CO_2 emissions per MWH of power used.

7. Besides energy, what other resources do you require in cycling (if any), e.g water, and what do they cost? 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 6) *(100 words)*

Water is the other key resource, which is utilized both to mix with calcium oxide, and to boost humidity within the air contactor. Water costs vary by location. In this project, a water well will be drilled on site for the water supply, incurring both initial capital costs and then operating costs expected to be $2-4 / thousand gallons. Water that passes through Calcite is evaporated into the air and output in the exhaust fans with the CO_2-lean air.

8. Per (7), how much of these resources do you need per cycle?

In this project, up to 3,344 gallons of water are expected to be required per metric ton input of lime kiln dust, and 6,312 gallons of water per gross tonne of carbon removal, primarily for boosting humidity in arid Arizona. Larger scale projects in areas with higher baseline relative humidity would require significantly less water input.

9. How often do you cycle your sorbent/solvent?

2-3 cycles per week. Note that in this project, a cycle involves passing the lime kiln dust through the Calcite process and then disposing it, and no sorbent is regenerated. Cycle timing is expected to be similar on deployments with dedicated calcination producing pure calcium hydroxide.

10. Does your sorbent or solvent degrade over time? Is degradation driven primarily by cycling, environmental conditions, or both?

Cycling would decrease the reactivity of the calcium sorbent, due to calcination.

11. In practical operation, how often do you need to replace your sorbent or solvent material, if at all?

In this project, the sorbent is used once and then disposed of and replaced with fresh lime kiln dust. Future projects with dedicated calcination are expected to have anywhere from 0-10 cycles of sorbent before it is replaced by fresh limestone input. This will be dictated by balancing the cost of fresh limestone versus the costs and decreased reactivity from each cycle of sorbent.

12. Per (11), what happens to your sorbent/solvent at end-of-life? Please note if it is hazardous or requires some special disposal, and how you ensure end-of-life safety.

At the end of life, the sorbent is in the form of calcium carbonate, which will be disposed of in a standard mining disposal process, as is currently used for cement kiln dust, lime kiln dust, fines, and other similar mining wastes. Calcium carbonate is not hazardous and has a centuries-long history of being disposed of safely, but disposal needs to be managed with wetting and other means to reduce any dust production. Projects would contract with an experienced firm for the disposal.

13. Several direct air technologies are currently being deployed around the world (e.g. Climeworks, which Stripe purchased from in 2020). Please discuss the merits and advantages of your system in comparison to existing systems.

Calcite has multiple advantages over competing technologies. It utilizes only limestone as a key input, a low cost and abundant feedstock. By relying solely on the calcium cycle, it reduces cost and complexity associated with sodium hydroxide and potassium hydroxide. Because calcium carbonate is abundant, cycling degradation can be easily remedied by fresh input of calcium carbonate when required. No new complicated components or proprietary catalysts are required by the Calcite process, as it relies on readily available equipment widely used in existing industries such as cement, lime, limestone, and materials handling, enabling a much faster scale-up and progression to next-of-a-kind costs.

The Calcite process specifically accelerates the rate of carbonation of calcium hydroxide so carbonation is complete in a matter of days, which is key to reducing costs of material handling and reducing land use. The energy use of Calcite is similar to that of competing technologies, as this is driven by the energy for calcination and carbon capture. However due to its simpler low cost design, Calcite has lower capital costs and lower technical risks for large scale deployments, giving it the potential to scale quickly with financeable projects, and to achieve next-of-a-kind costs well below $100 per ton of net carbon removal.

Application Supplement: Surface Mineralization

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

Source Material and Physical Footprint (Criteria #1 and #8)

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

Lime kiln dust, picked up by truck from the existing kiln operations in Peach Springs, Arizona

2. Describe the ecological impacts of obtaining your source material. Is there an existing industry that co-produces the minerals required?

The LKD is diverted from a landfill, so there are no additional impacts from obtaining the material, which is a byproduct of the lime industry.

3. Do you process that source mineral in any way (e.g grinding to increase surface area)? What inputs does this processing require (e.g. water, energy)? You should have already included their associated carbon intensities in your LCA in Section 6.)

The LKD is already very fine. It is mixed with water in the Calcite facility, slaking the calcium oxide in the LKD into calcium hydroxide.

4. 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 square.

	Land area (km^2) in 2021	Competing/existing project area use (if applicable)
Source material mining	≈3 km^2	Existing limestone mine
Source material processing	Included in the area above in the	Existing lime plant

Deployment	.004 km^2	Vacant land alongside road

1. Imagine, hypothetically, that you've scaled up and are sequestering 100Mt of CO_2/yr. Please project your footprint at that scale (we recognize this has significant uncertainty, feel free to provide ranges and a brief description).

	Projected # of km^2 enabling 100Mt/yr	**Projected competing project area use (if applicable)**
Source material mining	N/A, full scale deployments will use limestone not LKD. Limestone mining is not yet evaluated.	Limestone mining to supply cement, construction, and other industries. Agricultural land. Vacant land.
Source material processing	N/A, full scale deployments will use limestone not LKD. Limestone mining is not yet evaluated.	N/A
Deployment	For 100 million tonnes of CO2 / yr, Calcite would run on limestone not LKD. Land use analysis is not yet complete at that large scale.	Agricultural land. Mining operations. Wind farms. Vacant land.

5. If you weren't proceeding with this project, what's the alternative use(s) of your source material? What factors would determine this outcome? *(E.g. Alternative uses for olivine include X & Y. It's not clear how X & Y would compete for the olivine we use. OR Olivine would not have been mined but for our project.)*

LKD would otherwise be disposed of in an existing disposal pile, as is done currently.

Measurement and Verification (Criteria #4 and #5)

6. We are aware that the current state of the field may include unknowns about the kinetics of your material. Describe how these unknowns create uncertainties regarding your carbon removal and material, and what you wish you knew.

There are uncertainties on the kinetics of carbon absorption in ambient conditions across a wide variety of weather conditions and climates and seasons, as well as on different limestone sources, uncertainties which we wish we had better data on to evaluate for the Calcite system.

We also wish we had better data on the decreased reactivity from cycling calcium through multiple calcinations which was relevant to the Calcite process.

7. If your materials are deployed extensively, what measurement approaches will be used to monitor weathering rates across different environments? What modelling approaches will be used, and what data do these models require?

During plant operation, CO_2 monitoring at the inlet and outlet of the warehouse air contactor will provide real time measurement of carbon removal, and compositional analysis of the source material before and after carbonation could provide further validation of carbon removal. Conducting these analyses across different sites with different climates and different limestones would provide key input data to model Calcite performance optimization.

Human and Ecosystem Impacts, Toxicity Risk (Criteria #7)

8. What are the estimated environmental release rates of heavy metals (e.g. Cr, Ni, Pb, Hg)? Dust aerosol hazards? P loading to streams? How will this be monitored?

No heavy metals expected. Dust aerosols are possible, and will be removed by a dedicated baghouse dust removal system. The plant will have particulate matter monitors to ensure minimal dust emissions.

9. If minerals are deployed in farmland, what are the estimated effects on crop yields, what's this estimation based on, and how will actual effects be monitored?

N/A

10. 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. depending on the context of deployment)

There are no projected impacts, as LKD is diverted from a landfill and processed inside of a warehouse.

11. If you detect negative impacts, at what point would you choose to abort the project and how?

The project is not yet at the stage to have this decision matrix in place, however during development we will actively monitor for potential adverse impacts, proactively seeking solutions to issues before they become large problems. If a large negative impact was detected that wasn't able to be suitably addressed and was serious enough to justify cancelling the project, the project would choose to be paused, cancelled, or modified to mitigate that negative impact.