[Sustaera] Carbon Removal Purchase Application

General Application

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

Company or organization name

Sustaera

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

Cary, North Carolina

Name of person filling out this application

Sudarshan Gupta

Email address of person filling out this application

x

Brief company or organization description

Developing systems for direct air capture and storage of CO_2

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.

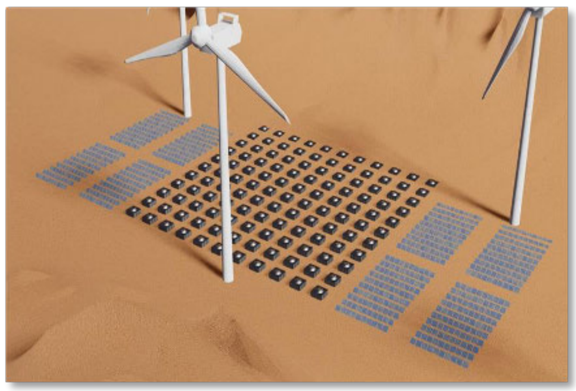
The Sustaera team has developed a Direct Air Capture (DAC) of CO_2 technology solution powered entirely by carbon-free electricity using an abundantly available, low-cost capture agent (alkali metal based) in a modular design that can work in any geographic location in a wide range of ambient temperatures and humidities. Our engineered solution for DAC consumes <100 acres of land per million tons/year of CO_2 sequestered, significantly lower than land-based or natural CO_2 capture methods, to provide a platform technology for gigatons of CO_2 removal and permanent storage.

This technology emanates from a number of breakthroughs and innovations in material science, process design, and modular manufacturing. These breakthroughs include: low cost alkali-based sorbents (compared to amines); high adsorption/desorption rates and capture capacity of sorbent with high durability; and fast desorption using targeted electrical heating. Additionally, we are able to leverage existing raw materials and manufacturing supply chains to allow for a rapid scale-up to gigaton scale. Our current estimates provide for a cost projection of <$100/ton at 1 million ton per year scale forecasted for deployment by sometime in 2030.

The fundamental material science has been in development for over a decade, with the most recent work being done with a university partner for the last 7 years. The DAC sorbent development and system design and testing has been supported through multiple Department of Energy (DOE) projects over the last three (3) years through competitive grant proposals.

For a very low pressure drop, we are using structured materials such as ceramic monoliths which are extensively used in catalytic converters in automobiles (allowing us to build from existing automotive manufacturing infrastructure). In a potential commercial embodiment, an active CO_2 capture agent (e.g., alkali carbonate) is coated on a monolith surface and several coated monoliths are assembled to operate in parallel and placed in a mechanical air contactor, creating a module. Depending upon the desired CO_2 capture rate, many modules are arranged with fans to pull or push air through monolith channels. Leveraging the fast adsorption and desorption rates as demonstrated by our experimental results, the total process cycle for this potential commercial embodiment would be very short, manifesting into high overall adsorbent productivity and low capital cost.

We have completed extensive material testing to identify optimum sorbent composition and synthesis methods. We have also conducted laboratory testing of the system to demonstrate the technology viability under different conditions. Currently we are on track to demonstrate this technology at bench-scale prototype at 1-2 kg of CO_2/day in our lab facility in Cary, North Carolina. Through Series A funding, we are engineering to build a 1 ton/day pilot unit by early 2023 to demonstrate integrated operation of the adsorbent, process, and control systems to produce a sequestration quality CO_2 stream. In parallel, we have identified a CO_2 sequestration site and are in discussions with the site owner in Florida to start injecting CO_2 in late 2023 for up to 10 ton/day (TPD) or 3,000 ton/year in an existing CO_2 well. We intend to deploy our first commercial unit capable of capturing and sequestering 10 TPD in a Class VI well at this facility in Q4 2023. Additionally, the site has ample renewable energy (600 MW Solar PV) available for direct integration with our technology to provide a high carbon removal efficiency. Following this phase, we will then expand the footprint of the project at this sequestration site in Florida to an eventual build out of 100 TPD by 2025.



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.)*

Sustaera is the technology owner focused on designing, building, and deploying the DAC technology. Sustaera will partner with an EPC vendor, CO_2 storage site, and measurement, monitoring and verification (MMV) company. Our business will be supported by selling carbon credits that include capture and storage and eventually utilization.

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

Technology Risks:

Our technology is based on over 10 years of extensive R&D by our team members and partners. Our current technology team has significant experience in scaling up CO_2 capture technologies from lab-scale to 1,000 to 3,000 ton/day from point sources. Nevertheless, there are inherent risks in scaling any new technology from lab to pilot to commercial scale. (1.) For our technology, these risks include reaching the commercial targets for sorbent productivity, overall energy use for desorption and pressure drop, and scalability. We do not need any new manufacturing or engineering infrastructure for scale-up to million ton/year quantities.

Market Risks:

(2.) Currently there is no price for CO_2 and the only market is the sale of voluntary credits; therefore, it is difficult to build a business which requires significant capex. However, with incentives like Federal 45Q and LCSF in California, and further tax credits and incentives in the pending Bipartisan Infrastructure bill on CO_2 from DAC, a robust market is emerging to enable the development and deployment of innovative DAC technologies. Customers like Stripe, Shopify, Microsoft, etc. who are willing to pay a premium for DAC CO_2 to encourage development of capture technologies will play a huge role in establishing a CO_2 marketplace. Based on our current cost model, we have a clear roadmap to reach <$100/ton at million ton/yr scale, provided we meet the technical targets of productivity, energy use and scalability. This includes availability of 24/7 carbon-free power at 3 cents/kWh. (3.) Higher cost of electricity will increase the cost of CO_2 capture.

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

We have filed two provisional patents in the US Patent and Trademark Office associated with our parent company Susteon.

- Patent Application No. 63/158,807: "DIRECT AIR CAPTURE CO2 REMOVAL SYSTEM AND PROCESS"
- Patent Application No. 63/183,751: "SYSTEMS AND PROCESSES FOR REMOVAL OF CARBON DIOXIDE (CO2) FROM CO2-CONTAINING GASES USING ALKALI METAL ABSORBENTS"

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*	Our first unit is estimated to go live Dec. 2023 with a design capacity of 10 tpd. This facility will be

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.	operational for 20+ years (~350 days/year). **Offer to Stripe:** December 2023 to December 2024
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 carbon removal occur?* *E.g. Jun 2021 - Jun 2022 OR 500 years.*	Carbon removal will occur in tandem with the launch of our first unit scheduled for Dec. 2023 and last at least 1000 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".*	At design capacity of 10 tpd, carbon removal will be evenly distributed for the entire duration of the project
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.*	CO_2 will mineralize in the well and will be stored for >1000 years.

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

Lifetime once sequestered (>1000 years lower bound, upper bound is unknown/not proven)

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.)*

Yes, we have measured this durability directly by characterizing the caprock from various depths of the CO_2 injection well. We have performed extensive modeling and experimental work on CO_2 permeation in these rock samples.

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?

A detailed risk assessment has been performed on some of the key uncertainties associated with this injection. Some of these risks include: the creation of sink holes, the acidic nature of CO_2 plume and its impact on nearby water resources. Since this well is located in a rural, unincorporated area, it will have negligible impact on local socioeconomic resources such as population, housing, schools, and police and fire protection.

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.)*

Injection of CO_2 in the sub-surface aquifers has been practiced in the oil and gas industry for multiple decades. The pressure inside the aquifer will be monitored continuously from the adjacent monitoring well while CO_2 is being injected through the injection well. We will have an extensive MMV plan to validate and verify the permanence of CO_2 storage.

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	3,500 tons per year for 20 years

embodied/lifecycle emissions or permanence, we will ask you to subtract this later	**Offer to Stripe:** Dec. 2023-Dec. 2024 = 3,500 tons
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	N/A

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)*

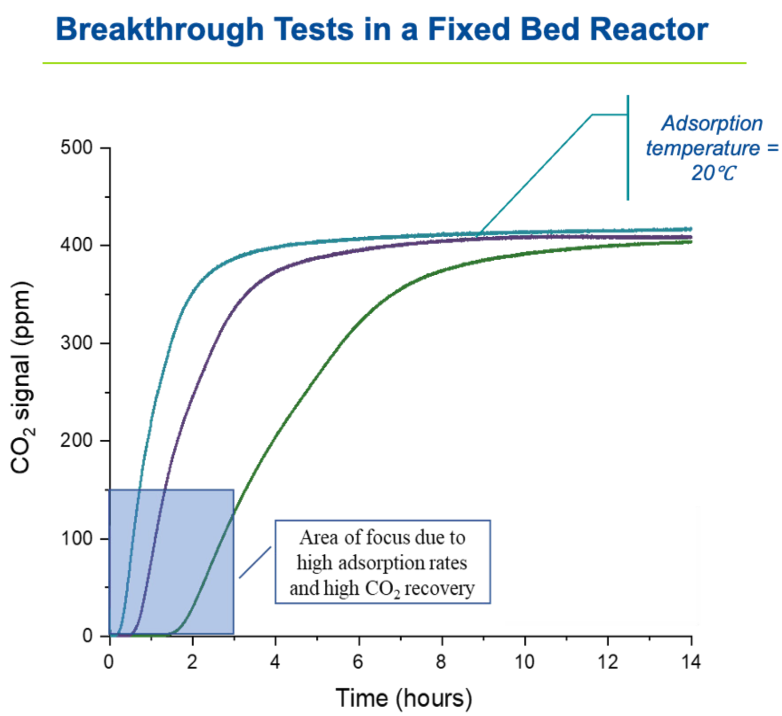
10 tons/day * 350 days/year = 3,500 tons/year gross removal

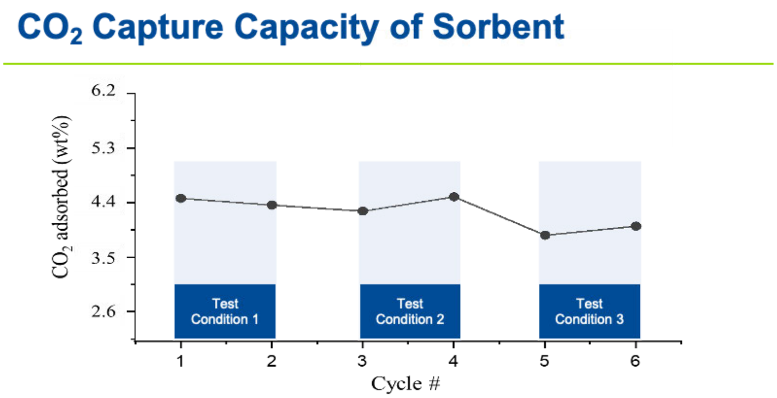
c. What is your total overall capacity to sequester carbon at this time, e.g. gross tonnes / year / (deployment / plant / acre / etc.)? Here we are talking about your project / technology as a whole, so this number may be larger than the specific capacity offered to Stripe and described above in 3(b).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

Although the current capacity for CO_2 storage at the proposed sequestration site is about 8 million tons/yr, we only plan to use this well for storing 1 million tons/yr. The site has an area of 4,000 acres so there is plenty of land available for installing DAC units as well as access to solar energy for the DAC unit. The approximate footprint of the 10 tpd DAC unit will be 1.2 acres.

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.)*

Based on extensive laboratory testing of the sorbents, we measured the adsorption and desorption rates of CO_2 under realistic operating conditions. We also demonstrated coating of the active sorbent compositions on commercial monolith structures and validated CO_2 capture performance. From our prior scale-up experience of first-of-a-kind novel CO_2 capture processes, we developed a high-fidelity process and cost model to develop realistic performance targets on sorbent productivity, overall energy use and sorbent lifetime, along with a preliminary design of a process cycle which a module would undergo by integrating adsorption (CO_2 removal from air), desorption (efficient removal of CO_2 from the sorbent), CO_2 purity, and purges in-between adsorption/desorption steps. Some of these results have been disclosed in two patent applications referenced above. Key results on CO_2 removal using our sorbents and cyclic performance under various space velocities are shown in the figures below.





Based on our extensive experience with scaleup of the chemisorption processes operating in a temperature swing mode, we used the laboratory results to develop a process design for a 1 tpd pilot plant as well as 100 tpd demonstration unit. The key data used were adsorption and desorption rates, working sorbent capacity for CO_2 capture and cycle time. The key design parameter was sorbent productivity defined as CO_2 captured in ton/day per m^3 of the sorbent. This parameter will be validated in our 1-2 kg/day bench unit.

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.

- www.sustaera.com
- https://susteon.com/dac-dfm-sbir-phase-ii/
- https://susteon.com/doe-award-dac/
- https://susteon.com/project/direct-air-capture-high-capacity-sorbents/
- https://dailyenergyinsider.com/featured/30749-doe-awards-12m-for-six-direct-air-capture-co2-removal-technology-efforts/

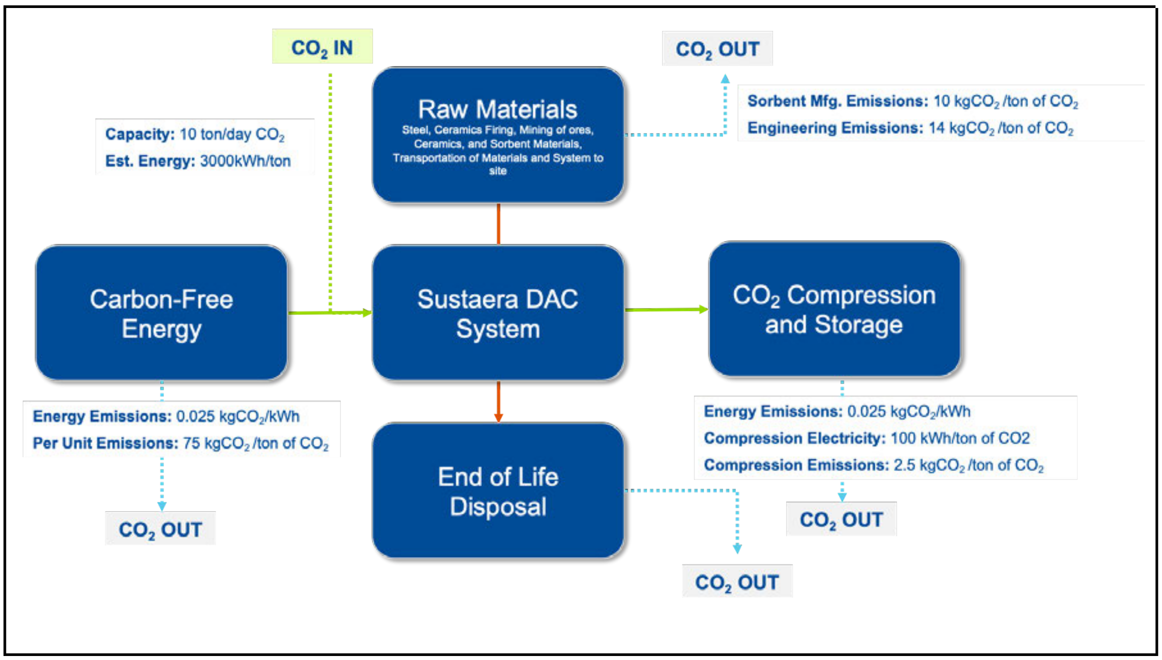
4. Net Capacity / Life Cycle Analysis (Criteria #6 and Criteria #8)

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	3,500 tCO_2
Gross project emissions	350 tCO_2
Emissions / removal ratio	0.1
Net carbon removal	3,150 tCO_2

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.



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?

We have included all the components necessary to create the hardware to both capture, compress, and provide electricity from raw materials, produce energy needed for capturing and sequestering as well as the end of life disposal.

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.

We have modeled the emissions into and out of the system based on literature values such as those available in Climeworks LCA paper. We match or exceed Climeworks benchmark for negative emissions.

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.)

N/A

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)*

The 10 tpd DAC unit that we plan to deploy contains a single large fan with 24 modules in an air contactor structure. These units can then be numbered up to meet any CO_2 capture capacity which is set by: (1) land space, (2) availability of carbon-free electricity, or (3) access to a CO_2 storage site.

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.

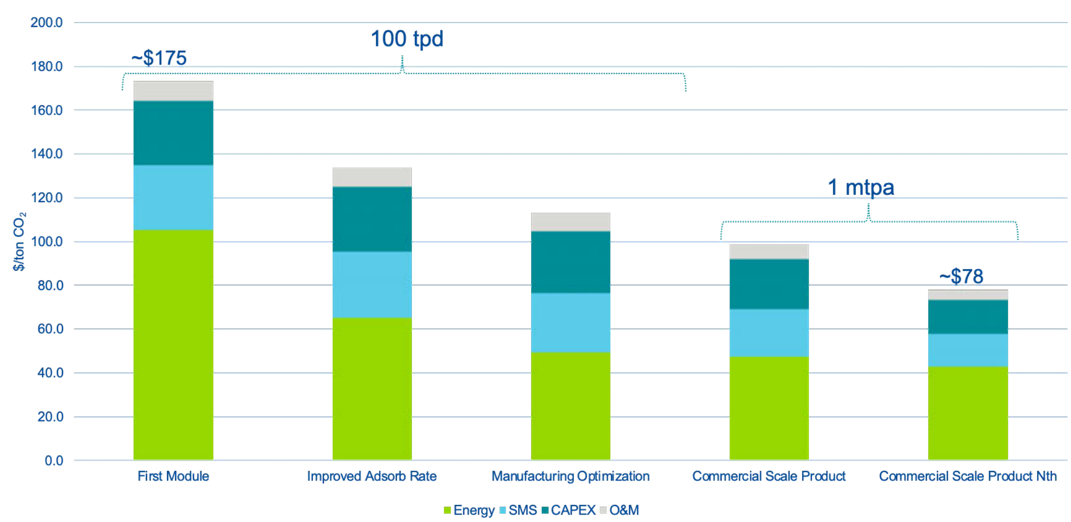
Year	Units deployed (#)	Unit cost ($/unit)	Unit gross capacity (tCO_2/unit)	Notes
2021	1	N/A	1.5 kg/day	Bench-scale system

2020	1	N/A	0.5 kg/day	Lab-scale system
2019	0			
…				

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.)*

We have built a detailed TEA model forecasting costs at various capacities that have been shared and reviewed with our investors. Please see below a forecast of our costs as we scale.

We have conducted a detailed engineering and scale-up analysis to forecast our long-term capture cost for CO_2. Once this technology becomes commercial with successful demonstration of our first 100 TPD unit, the cost of capture is expected to reduce from $175/ton to <$120/ton with manufacturing and sorbent optimizations. As we scale to 1 million ton/yr and build larger commercial units, we project our costs at scale to be ~<$80/ton.



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)
1	70,000 tons over 20 years (3,500 ton/year)

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?

$1,500/ton CO_2 based on the lab-scale test results.

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.

The $1,500/ton number includes both the CAPEX and OPEX burden including the full return on investment for capital costs over the initial operating period of 20 years. CAPEX represents ~70% and OPEX is ~30% of the total cost. Our model assumes the cost of electricity at $0.07/kWh. However, we believe that long term renewable electricity prices have the potential to be lower in the future (e.g., Texas has ~$0.03/kWh renewable electricity today in some locations, albeit intermittently).

Furthermore, this cost includes some risk premium for a first-of-a-kind scale up unit, in the form of contingencies and unexpected project cost overrun.

These estimations are based on the sorbent productivity data obtained in the lab under unoptimized conditions. The overall energy input is assumed at a higher value than the target for a commercial unit to accommodate for heat losses and unoptimized air flow design (leading to higher pressure drops) in the proposed 10 tpd unit. No cost reduction has been accounted for large scale manufacturing of the system components.

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	Demonstration at 1-2 kg/day	Demonstration of integrated testing of the sorbent coated	Q4 2021	We can provide a written report showing the test

	bench-scale	on structural support for CO_2 capture from ambient air, desorption with electricity and determination of CO_2 purity during regeneration to validate process design and TEA assumptions		data and analysis.
2	Design, build and operate the 1 tpd pilot plant	Integrate sorbent modules, energy input, process cycle, and CO_2 recovery at 1 tpd scale to demonstrate that system components work as designed. Obtain process performance results to design and build a 10 tpd proposed system.	Q4 2022	We can provide a written report showing the system design and performance results.
3	Set up partnerships with an engineering company and the host-site with CO_2 storage and initiate building of the 10 tpd system	We will enter into binding partnerships with an engineering company, who will design and build our 10 tpd pilot plant. We will also sign an agreement with the host site for operating the unit as well as accessing the CO_2 storage well. Completion of this milestone will allow Sustaera to sell CO_2 commercially and will prove scalability.	Q1 2023	We can provide operational reports, commitment letters from the engineering company and the host site. We can also organize a site visit to our operating unit.

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	N/A	~1-2 kg CO_2/day	N/A
2	~1-2 kg CO_2/day	~1 ton CO_2/day	
3	~1 ton CO_2/day	~10 ton CO_2/day	

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	N/A	N/A	
2	N/A	~$1,000/ton-$2,000/ton	Our 1 TPD unit will initially operate as a capture unit only and will not be sequestering CO_2. The cost estimate range assumes a sequestration well is available nearby for the captured CO_2
3	~$1,000/ton-$2,000/ton	~$500/ton-$1,500/ton	Once the 10 TPD unit is operational, several risk factors would have been resolved. The costs at 10 TPD scale can be as low as $500/ton in the most aggressive estimation. However, a range of $500/ton to $1,500/ton is provided to be more realistic.

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?

We would ask Senator Joe Manchin to support federal policy centered around CO_2 stored from DAC. This would enable deployment of capital for building DAC plants (1 million ton/yr or larger) based on our technology.

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

Stripe could lead the way by initiating a public private partnership between the government and corporations to coordinate market mechanisms enabling more customers for carbon credits. This would significantly improve the cost curve, specifically if the government could take the lead in facilitating large pre-purchase agreements based on shared learnings from Stripe's early CO_2 procurement, coupled with smaller purchase agreements from corporations.

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?

Our external stakeholders include Climate Tech investors (who are funding Series A), EPC companies, utility companies, energy companies, companies supplying raw materials and structured support materials for manufacturing of the adsorbent modules, philanthropic organizations, and the Department of Energy.

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

We have formed partnerships with all the above stakeholders. The nature of the partnerships are different with different stakeholders and could include funding support, design support, material procurement, and cost benchmarking insights.

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?

> Yes. Our technology and commercialization roadmaps have been significantly improved with interactions with these stakeholders.

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?

> Yes. A lot of changes will depend on the results of testing in out 1-2 kg/day bench unit

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

> We are extremely cognizant of the overwhelming impact climate will have on developing / third world countries. We have made a conscious effort to build a modular system, on existing supply chains and utilize carbon-free energy. This will allow us to deploy our units wherever we can have access to wind / solar / etc. Our main concern is the land required at scale, and we want to ensure our units do not impede on existing communities, but instead improve the livelihoods of any neighboring communities, including creation of good paying jobs in green energy and climate change.

11. Legal and Regulatory Compliance (Criteria #7)

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

> Based on our extensive experience with previous deployment of similar technologies in CO_2 capture space, we are well aware of permitting and other regulatory issues, which we plan to address early-on during engineering and pilot-scale demonstration.

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.

> We have all the permits and approvals in place for the bench-unit test unit. For 1 tpd pilot plant, planning for permitting is ongoing. For the proposed 10 tpd plant, we will seek the permits based on site requirements. The CO_2 injection well will undergo a permit update in 2022.

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.

The regulations for Class VI CO_2 injection well are now quite clear as there are five years of 1 million ton/yr CO_2 injection experience by ADM. Obviously, local, state and federal permits must be all synchronized to meet the project goals. This issue will be addressed early on.

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)

Currently we do not receive any credits from government compliance programs.

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)	3,500 tCO_2
Delivery window (at what point should Stripe consider your contract complete?)	December 2023 – December 2024
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.*	$700/$tCO_2$

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	N/A
2022	0.004 km^2 (1 acre)
2023	0.005 km^2 (1.25 acres)

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	N/A
2022	150 m^3/ton
2023	100 m^3/ton

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

1. What sorbent or solvent are you using?

Alkali-based solid sorbent

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

3 wt% (g of CO_2 per 100 g of sorbent) - working capacity. Equilibrium adsorption capacity is >9 wt%.

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

3 wt% (g of CO_2 per 100 g of sorbent) - working capacity.

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)

Our active capture component of our sorbent is an alkali carbonate which can be sourced from natural sources (mineral deposits, e.g., mines in Colorado and Wyoming), other components are produced by chemical processes in large quantities. Monolith structures are produced in large quantities for catalytic converters for automobiles.

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

The sorbent is cycled in a temperature swing process where adsorption occurs at ambient conditions, and regeneration occurs at 80-120°C. Our estimate for total energy consumption for 1 tpd pilot plant is about 3,000 kWh/ton of CO_2. Our technology roadmap for a fully scaled-up system has total energy consumption of <2,000 kWh/ton of CO_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)

Carbon-free electricity (solar PV, wind, hydro, nuclear, or a combination thereof). Assumed carbon intensity is 0.025 kg CO_2 per kWh. Our project location has over 600 MW of solar capacity and our project needs <1.5 MW. Assumed cost is $0.07/kWh.

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)*

No other resources for cycling. Our system does not use steam.

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

N/A

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

Every 30 to 45 minutes

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

Yes, the sorbent will degrade very slowly over several years due to thermal and chemical cycling. We do not have any significant impact from environmental conditions. (Sorbent is inert to O_2).

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

We have conservatively planned on a replacement cycle of 3 years for the sorbent. However, we believe that the actual life can extend much beyond 3 years. This will be verified during operations.

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.

Our sorbent is on a support which can be reused when the sorbent is washed off and requires no special 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.

Please see the attached table below for comparison on key metrics across the leading DAC technologies based on publicly available data.

Company	Material	Working Capacity		Regeneration Conditions		ΔH (kJ/mol)	Challenges	Cost
		mol/kg	Wt%	bara	°C			
Global Thermostat	▪ PEI ▪ Monoliths	▪ 0.3-0.6	▪ 1.32- 2.64	▪ 0.15	▪ 100 (Steam from Natural Gas)	▪ ~80-90 (ads)	▪ Desorption steam condenses, stripping amine ▪ Amine reacts with O_2 in air	▪ N/A
climeworks	▪ Amine ▪ Amine+ MOFs ▪ Laminate Filters	▪ 0.4-0.5	▪ 1.76-2.2	▪ 0.5	▪ 90-120 (Relies on low grade heat source)	▪ ~85-95 (ads)	▪ Amine reacts with O_2 in air ▪ Higher pressure drop	▪ ~300 to 600 \$/t-CO_2
Carbon Engineering	▪ K_2CO_3 – $CaCO_3$ loop ▪ Liquid Solution	▪ N/A	▪ N/A	▪ 1.01	▪ 900 (Natural Gas heat)	▪ -95.8 (contactor) ▪ +178.3 (calciner)	▪ Equipment count and cost ▪ Oxygen impurity in CO_2	▪ ~94 to 232 \$/t-CO_2 (?)
Sustæra	▪ Alkali carbonate ▪ Monoliths	▪ 0.8-1.0	▪ 3.5-4.4	▪ ~0.9	▪ 80-100 (Renewable electricity)	▪ ~65-75 (ads)	▪ Electricity for regeneration	▪ Commercial projection <\$100/t-CO_2

Application Supplement: Geologic Injection

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

Feedstock and Use Case (Criteria #6 and 8)

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

We are injecting supercritical CO_2. This CO_2 meets the sequestration specifications (<100 ppm of nitrogen and <15 ppm of H_2O).

2. Do you facilitate enhanced oil recovery (EOR), either in this deployment or elsewhere in your operations? If so, please briefly describe. Answering Yes will not disqualify you.

No. It is purely for long-term storage of CO_2.

Throughput and Monitoring (Criteria #2, #4 and #5)

3. 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 permanence matches what you described in Section 2 of the General Application?

> The storage site has been well characterized by 3D seismic and rock samples. The target injection zone is a deep saline carbonate (dolomite/limestone) reservoir extending between 4,200 and 8,000 ft below the land surface. This geology has shown the potential to mineralize CO_2 during storage. In addition to an injection well, there is a monitoring well to do measurement, monitoring and verification of CO_2 storage.

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

> Class VI

5. At what rate will you be injecting your feedstock?

> The well is designed to inject 1 million/ton CO_2 per year.

Environmental Hazards (Criteria #7)

6. What are the primary environmental threats associated with this injection project, what specific actions or innovations will you implement to mitigate those threats, and how will they be monitored moving forward?

> We have worked with the federal, state, and local authorities to do a detailed risk assessment for this injection. We will be happy to share the detailed report. This well was constructed in 2012 and we plan to get a recertification in 2022 with updated plans for injection, measurement, monitoring and verification.The hydrodynamic and geochemical properties are favorable for long-term CO_2 storage.

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

> A risk assessment has been performed on some of the key uncertainties associated with this injection, including creation of sink holes, acidic nature of CO_2 plume and its impact on nearby water resources. Since this well is located in a rural, unincorporated area county, it will have negligible impact on local socioeconomic resources such as population, housing, schools, and police and fire protection.