Carbon Removal Purchase Application

General Application

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

Company or organization name

Carbo Culture

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

Helsinki, Finland & Woodside, CA

Name of person filling out this application

Henrietta Moon

Email address of person filling out this application

henrietta@carboculture.com

Brief company or organization description

Fossilization of lignocellulosic waste into stable and functional biocarbons.

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.

<1500 words

Carbo Culture is building an industry leading biocarbon production facility in Finland and offering Stripe carbon removal from the plant in 2022/2023. Our exothermic process converts more than half of the original carbon in lignocellulosic waste into an extremely stable biocarbon product akin to a mineral, effectively fossilizing it in a functional form.

Why our process significantly differs from pyrolysis is the high heat and pressure combination that is impossible to achieve in a process that needs excess heat. Our process is exothermic and based on an instant flame front that traverses the material, changing its matter composition.

According to a research paper in Nature Magazine [1], biochar using sustainably sourced biomass has the potential to reduce global net emissions of CO_2, methane and nitrous oxide by **up to 2Gt of CO_2-e per year**.

We are currently operating a TRL6.5 technology demonstration facility in California's Central Valley, California capable of processing up to 500 lbs of waste biomass an hour. The proven process accommodates variable waste biomass feedstocks from agriculture and forestry and is suitable for fossilising biomass into a stable biocarbon storage for more than 1000 years (scientifically proven with O:C < 0.05 and lower [2]).

Our process has unique advantages when compared to other state-of-the-art pyrolysis processes:

- It does not require external heat to function; it's exothermic
- The bio-oil component normally associated with pyrolysis is cracked into additional biocarbon and syngas in-situ, thereby increasing stable carbon yield and useful energy output.
- Our process is therefore **best suited for scaling up from all the current technologies.**

Carbo Culture sequesters 3.2 tonnes of CO_2 per tonne of biocarbon produced, making it one of the most efficient ways to sequester carbon in the world today. These metrics have been independently verified and audited by: Puro.earth & EnergyLink, 2020 [3].

Our planned Phase I interim scale facility in Finland is projected to produce 1500 tonnes of biocarbon and sequester 4800 tonnes of CO_2 annually. We will also produce renewable heat that will be fed into the municipal district heating network and offset a further 1800 tonnes of CO2.

Once proven at the interim scale we will expand the biocarbon production to our fully scaled Phase II facility, which will sequester 12 800 tonnes of CO2 per year. Our aim is to design a replicable biocarbon plant model and scale it to reach 100 million tons of CO2 by 2027.

References

[1] Nature, 2019 https://www.nature.com/articles/s41586-019-1681-6.pdf?origin=ppub
[2] Labs available: https://www.carboculture.com/for-researchers
[3] Verification:
https://puro.earth/services/biochar-carbon-drawdown-in-ca-us-demo-facility-100020

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.)*

Carbo Culture is the builder-owner-operator of the carbon removal facilities, and sells the associated biocarbon.

Key partnerships are a local energy company that utilises our process heat and local providers for sustainably sourced biomass waste.

Our carbon removal is always verified by science-based methodologies, such as Puro.earth.

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

Technology: Scaling the process to a larger size includes risks in operational capacity, technical design and output quality. Processing of new feedstocks also introduces new, but solvable risks. We're working to mitigate this by working with experienced engineers who are bringing in knowledge from hundreds of previous engineering projects in various domains. Finland, where we are building the Phase I plant, has a lot of industrial bioengineering knowhow as over 10% of GDP comes from it!

Market/commercial risks include lack of long-term offtake contracts for output, in turn delaying Phase II implementation and subsequent deployments. We're aiming to become a quality and price leader driving down costs of the end product and increasing adoption rates.

Feedstock sourcing risk could affect the price or availability of feedstock. Our advantage is that we are able to utilize a range of different biomass feedstocks, which gives us both the opportunity to tap into a multitude of agricultural waste feedstocks in various sizes and forms, and into forestry / wood products biomass waste that is too far from bioenergy facilities or other use cases. This flexibility of feedstock also opens up business avenues as some types of biomass waste are actually causing problems and emissions for the companies that generate them (food companies).

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

- Our exclusive patent https://patents.google.com/patent/US8585867B2/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.*	Q3/2021 - Q4/2023
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.*	Q3/2021-Q4/2023
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".*	Carbon removal occurs the moment the decomposable biomass is heated to 750C and effectively fossilized, thereby removing it from the active carbon cycle. Delivery schedule outlined below.
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.*	At least 1,000 years

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

1,000 - 1 million years

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.)*

<200 words

It is not possible to directly measure the durability over this time scale, however the most widely recognized method of assessing the durability of biochar lies in the ratio of Oxygen to Carbon (O:C), [1] which is used by the European Biochar Certification process for measuring durability with values of less than 0.2 representing a half life of at least 1,000 years. Our biocarbons have O:C ratios of less than .05, representing an estimated half life of 10,000 to 1,000,000 years [1].

A second method of determining carbon stability is the Hydrogen to Carbon (H:C) ratio [2]. The H:C ratio provides an indication of the aromaticity of the carbon with lower the H:C ratios representing higher aromaticity and therefore increased resistance to oxidation and stability. Our biocarbons have H:C ratios of less than 0.15, Using the correlations of [2] implies that more than 95% of the carbon will remain after 100 years. Further evidence of the aromaticity of our material can be found in its high inherent electrical conductivity (~1ohm*cm).

The exceptionally low O:C and H:C ratios of our materials have led us to refer to them as biocarbon instead of biochar. Materials with similar attributes include anthracite and graphite.

[1] Reference: https://www.ars.usda.gov/ARSUserFiles/41695/cmt.10.32_spokas.pdf

[2] Reference:
https://www.researchgate.net/publication/298722030_Biochar_Carbon_Stability_Test_Method_An_assessment_of_methods_to_determine_biochar_carbon_stability/download

[3] Lab analysis:
https://carboculture.docsend.com/view/ykfz8knbxnrv6iem/d/a59knqivci88hvje
More lab results available for download carboculture.com/for-researchers

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?

<200 words

The carbon removal process is tried, tested and externally validated and no fundamental technological uncertainties exist.

There is virtually no physical risk of re-emission, leakage or miscalculation of the biochar's sequestration capacity. We've successfully operated our demonstration plant since 2019 without material leakage / damage. The production process is designed to minimise any dust leakages.

The main socioeconomic risk relates to biochar use. If it were used for example in energy generation, the stored carbon would re-enter the carbon cycle. We will address this risk with strict customer selection and legal protection. Furthermore, it is simply economically unviable for an energy company to use biochar as an energy feedstock.

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.)*

<200 words

Both biocarbon production and use are monitored by a third party with a scientific verification methodology (e.g puro.earth) and we will enforce strong legal protection: the customers are contractually required to comply with our regulations and rules, including not selling the material for combustion usage or uses where end - of - life disposal would require combustion.

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	1067.38 tCO_2
If applicable, additional avoided emissions e.g. for carbon mineralization in concrete production, removal	Our process produces high-quality heat and syngas representing roughly half of the original biomass energy as a by-product, further avoiding fossil emissions from other energy sources, eg natural gas - at an estimated rate of 1.2 tCO_2 / ton

would be the CO_2 utilized in concrete production and avoided emissions would be the emissions reductions associated with traditional concrete production	of biochar produced. Biochar applications introduce strong co-benefits, ecosystem services and additional carbon emissions suppression/avoidance potential, which we have excluded from the scope of this proposal.

b. Show your work for 2(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)*

<150 words Each tonne of our biocarbon material sequesters 3.2 tonnes of CO_2, as confirmed by an external LCA calculation. This number is based on the amount of stable carbon in each ton of product and is largely independent of feedstock. This means that at 1500 $t_{Biochar}$, we have an annual sequestration capacity of 4800 tCO_2. However the first year of running may not be at 100% capacity and therefore we're being cautious in the amounts that we guarantee to deliver in the given timeframe. The LCA calculation will be re-calculated for the new plant, but there will be no significant uncertainty/changes to the sequestration rate. References [1] Mulagagl, V., Baah, D.A., Egiebor, N.O., Chen, W-Y (2015) Biochar from Biomass: A strategy for carbon dioxide sequestration, soil amendment, power generation and CO_2 utilisation. Handbook of Climate Change Mitigation and Adaptation. pp.1 – 31.

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).

Current capacity (technology demo TRL6.5): 150 metric tonnes of CO_2/yr Q2/2022: Phase 1: 2400 metric tonnes CO_2/yr (Year 1 assumed at 50% capacity) Q2/2023: Phase 1.5: 4800 metric tonnes CO_2/yr 2024: Phase 2: 12 800 metric tonnes CO_2/yr

stripe

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.)*

<200 words Our model is based on direct measurement and continuous operational monitoring of our TRL 6.5 demo plant, as well as engineering plans for the Phase I plant. Our LCA is calculated in adherence to the Puro.earth methodology [1]. Feasibility study and detailed LCA report of the plant available upon request. The amount of carbon removed is based on the actual amount of stable carbon in our product that has been removed from the active carbon cycle. References [1] https://static.puro.earth/live/uploads/tinymce/Puro_Documents/Puro-Rules-CO2-removal-marketplace_v2.0_final.pdf

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.

- Our Puro.earth project site for verified carbon removal from our technology demonstration site: https://puro.earth/services/biochar-carbon-drawdown-in-ca-us-demo-facility-100020
- Our blog post on carbon removal certification and biochar as a carbon sink https://medium.com/carboculture/carbo-cultures-carbon-removal-is-now-certified-5914a3d4582b?source=collection_home---4------0-----------------------
- Independent Lab analysis verifying biocarbon properties including (O:C) and (H:C) ratios: https://carboculture.docsend.com/view/ykfz8knbxnrv6iem/d/a59knqivci88hvje

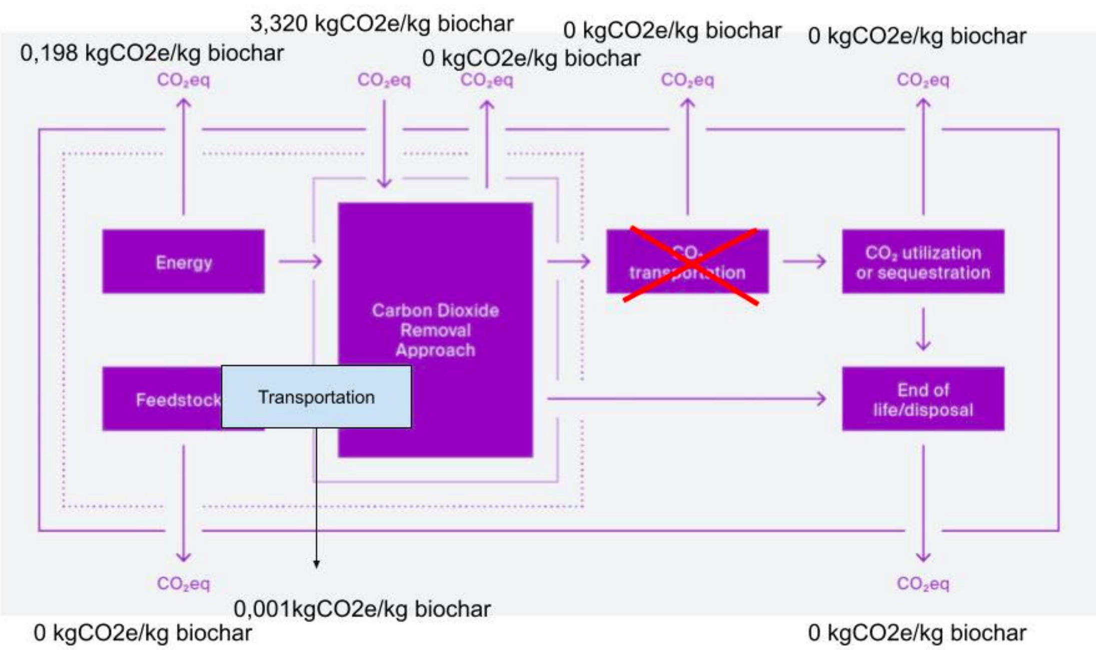
4. Net Capacity / Life Cycle Analysis (Criteria #6 and Criteria #8)

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	**1067.38 tCO_2e**

	$321.5t_{biochar}$ x $3.32tCO_2e/t_{biochar}$ = 1067.38 tCO_2e
Gross project emissions	(indirect emissions from energy production + feedstock transportation) x $t_{biochar}$ (0.198+0.01)$tCO_2e/t_{biochar}$ x 321.5 $t_{biochar}$ = **66.872 tCO_2e**
Emissions / removal ratio	$0.199tCO_2e/t_{biochar}$ / $3.32t_{biochar}$ = **0.063**
Net carbon removal	(3.32t * $321.5t_{biochar}$) - 66.872 tCO_2 = **1000.508 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?

- The calculation includes all major life cycle stages of biochar production and all components of the Carbo Culture production process
- The system boundary of the calculation follows the methodology developed by Puro.earth and follows cradle-to-gate emissions.
- For simplicity, the biogenic carbon sequestration is assumed to happen in the "Carbon Dioxide Removal Approach" boundaries, not when the biomass is still live plants
- Biochar applications not expected to create more emissions
- Based on sensitivity analysis included in the LCA performed by independent expert, production machinery production and package production and transport to site would result in less than 3% increase in the product carbon footprint.

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.

The calculation is done by an independent LCA expert, UseLess.fi and is based on real data from our technology demo. The LCA followed the methodology developed by Puro.earth, the first carbon removal calculation methodology developed specifically for biochar.

The system has been audited by EnergyLink auditing services.

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.)

Verification done by Puro.earth and Energy Link

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)*

<50 words

The unit is a tCO_2 in one plant that is in continuous operation approximately 300-320 days a year (100% deployment)

- Unit #1: The 2019 plant is live today
- Unit #2: The next plant ("Phase I") is expected to go live Q3/2022

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
2024	*2*	$200	*14.000 tCO_2/yr*	Phase 2 modular scale-up of the same facility
2022	*2*	$400	*2400 - 4800 tCO_2/yr*	New plant "Phase I" • Year 1 expected at 50% capacity - interim • 100% capacity from Year 2 onwards
2021	1	$600	150tCO_2/yr	Demo I:Technology demonstration, approximate OPEX costs at 100% deployment
2020	1	$1300	150tCO_2/yr	Demo I: Technology demonstration, approximate OPEX costs at irregular deployment
2019	1	$1300	150tCO_2/yr	Demo I: Technology demonstration, approximate OPEX costs at irregular deployment
...				

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.)*

Our early costs have been high as our technology demo is still in an R&D stage, has not been optimised for continued usage and its deployment rate has not been consistent.

Our operating expenses will go down as we scale production. Our Cost-Efficiency Ratio will decrease dramatically in both Phase 1 and Phase 2, approximately by 50% with every scale-up iteration.

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)
321.5	3.32 tCO_2/unit

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?

$1300 /ton CO_2

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."

>100 words
OPEX costs, incl HR, biomass costs (if any - currently mostly free of charge), energy, feedstock transport, rent/utilities, other misc costs

Excluded: CAPEX costs

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?	Target for achievement (eg Q4 2021)	How could we verify that you've achieved this milestone?

		(200 words)		
1	Financial close, and construction and building start<100 words	All pre-engineering work and partnerships completed and timeline detailed and locked in	Q4/2021	The plant build starts
2	Entry into operation, initial commissioning	The plant enters into operation	Q2/2022	Start producing biochar
3	Delivery of 500 tCO_2 to Stripe	The plant is scaled up to full operational capacity and continuous production at 4800 tCO_2/y	By Q2/2023	Carbon removal delivery, 50% shipment, to Stripe sent

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	150tCO_2 Should match 3(c)	150tCO_2	This is our CA demo plant ongoing carbon removal
2	150 tCO_2	2400 tCO_2	We start biochar production at the plant, thus moving first to a 2400 tCO2/year production schedule (startup period), and later to 4800 tCO2/y
3	2400 tCO_2	4800 tCO2	The plant is operational

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	*Should match 6(a)* $1300/t$CO_2$	$600/t$CO_2$	We expect to intensify the production at our Tech Demo site, as we've improved its capacity
2	$600/t$CO_2$	$400/t$CO_2$	The next plant starts more efficient production of biochar
3	$400/t$CO_2$	$400/t$CO_2$	

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?

<50 words

We would ask President Joe Biden to issue an Executive Order directing the DOE to do an actual side by side comparison of our carbon removal process against others to determine the true thermodynamic/cost effectiveness and time/resources required to reach a meaningful scale.

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

<50 words

Similarly Stripe could facilitate a competition or comparison of the actual monetary and energy costs associated with the various carbon removal technologies in an apples to apples manner to help clarify the most cost effective, durable and rapid solutions taking into account actual energy and material costs.

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?

<100 words Local governance, local community and jobs at the community level

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're addressing public acceptance at both local and national/international level. Local public acceptance at the site will be aided by co-location of the facility with an already operational bioenergy plant in an industrially zoned area. Our planning and environmental assessment will ensure we are fully aware of and can mitigate any environmental threats and manage aspects including noise, odour, traffic and visual issues. We will work with the community to increase understanding and awareness of biochar and at the local level provide educational opportunities (e.g. site visits for local schools, educational materials and internship opportunities) and our green economy employment in a remote/rural region / frontline community. We are committed to raising visibility and reach of biochar. Our focus is on understanding of the technology, the safety and permanent nature of the carbon sequestration offered and co-benefits in terms of functional end use cases, and we regularly engage in public discourse on these topics in both national (Finland) and international level.

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?

Biochar is at an early stage of commercialisation, and the chemical characteristics of the biochar materials that are commercially available differ. There are misconceptions about how to use biochar and how to optimise its performance. We've learned that public and academic sector engagement is important in implementing clear guidelines and quality assurance levels for the biochar market. We've also identified more work needed in education stakeholders of carbon sequestration and permanence, and are e.g working on a seminar series around this for corporate emissions neutralisation customers.

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?

<100 words In biochar material commercialisation, we're working on - Further development of our product branding. - Communications via our website and channels - Press engagement to outline key business milestones and partnerships. - Publication of research results including co-author papers and articles. - Development and dissemination of end use cases. Carbon removal: We are working on a seminar series and whitepaper content in biochar production, sequestration and permanence for customers in the corporate emissions neutralisation sector. We'll engage with academia to further study and share results on durability

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

<100 words Our plants are and will be located in frontline farming communities, close to available feedstock. In contrast to many CAPEX intensive solutions, more than 50% of our projected carbon removal cost is labor (not accounting for waste biomass collection). Deployment at scale will result in creation of thousands of green jobs in areas that will be disproportionately impacted and vulnerable to climate change.

11. Legal and Regulatory Compliance (Criteria #7)

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

We're in active conversation with the municipality governing our prefered site in Finland and the regional authority to understand the permits required to build and operate a biochar plant. We've also seeked a regulatory overview of biochar chemical composition and physical properties that must be in line with materials regulations and performance in order to ensure that they can be used in the EU.

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.

Our Escalon pilot plant is operating under a Research and Development permit issued by the San Joaquin Valley Air District. Our Finnish facility will require air and construction permits that are in process now that a site has been selected. Overall processing time is expected to be < 6 months. We will also seek regulatory compliance and voluntary quality certificates for the output materials, including European Biochar Certificate, EU REACH, CLP, etc. We're in the process of obtaining building permits and on track to obtain them in scheduled time. We are in active discussion with all the relevant stakeholders.

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 know the current Phase I permitting, and clear regulatory guidance exists. When we expand our scope in Phase II (2024), the plant needs to be re-permitted, and if we utilise non-wood biomass, local governance practices vary within the EU.

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)	*Should match the last row in table 4(a), "Net carbon removal"* 1000 tCO_2
Delivery window (at what point should Stripe consider your contract complete?)	*Should match the first row in table 2(a), "Project duration"* Q3/2021-Q4/2023
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.*	*This is the price per ton of your offer to us for the tonnage described above. Please quote us a price and describe any difference between this and the costs described in (6).* Price before Q3/2022: $621/$tCO_2$ Volume offered before Q3/2022: 50 tCO_2 Price Q3/2022 onwards: $550/$tCO_2$ Volume offered Q3/2022 - Q4/2023: 950 tCO_2

Application Supplement: Biomass

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

Feedstock and Physical Footprint (Criteria #1)

1. What type of biomass does your project rely on?

<100 words Our technology can utilize different lignocellulosic biomass, like agricultural residues and forestry waste. The plant can also utilize various particle sizes. Our Finnish facility will use sustainably sourced and PEFC certified forestry waste biomass, including tree trimmings, tree trunks and raking residues. The Escalon demo plant uses walnut shells that would otherwise be spread as alternative road base for dust suppression and rapidly decompose. **As we use waste biomass and side residues, no land-use change happens.** All biochar will be certified by an external verifier (e.g Puro.earth) with strict criteria and rules on feedstock origins, sustainability certifications and avoidance of additionality.

2. Are you growing that biomass yourself, or procuring it, and from whom?

<200 words The demo plant in Escalon, CA is co-located next to a nut processing unit. In the Phase 1 plant, we procure the biomass locally from the region, from an 80 mile radius from the biocarbon plant in a multi-year offtake agreement with a local circular economy service provider.

3. Please fill out the table below regarding your feedstock's physical footprint. If you don't know (e.g. you procure your biomass from a seller who doesn't communicate their land use), indicate that in the table.

	Area of land or sea (km^2) in 2021	**Competing/existing project area use (if applicable)**
Feedstock cultivation	*E.g. 1 km^2 (floating kelp array) OR N/A (procuring waste biomass)* N/A - waste biomass	None - we use waste residues and by-products from forest maintenance

Processing	*E.g. 0.1 km^2 (boat yard, manufacturing facility) OR 0.5 km^2 (manufacturing facility for mobile biochar plants)* 5000 m2 plant footprint (including onsite storage for feedstock and product) ~1 Acre	None at the moment - currently industrially zoned vacant land
Long-term Storage	*E.g. N/A (uncertainty in final state of kelp) OR 2 km^2 (ag fields in which biochar is deployed)* Highly variable depending on the context - if we applied the biochar material (321.5 tonnes, or 1000 tCO2) to soil at a rate of 5 tonnes / hectare, the land area would be 64 hectares (0.64 km2) - exact biochar-to-land application ratio varies based on the soil condition.	N/A - the biochar in the soils is an additional material, not directly replacing or affecting land-use.

4. 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)**
Feedstock cultivation	Our aim is to utilize localised waste biomass streams, without a direct impact on land-use	
Processing	Assuming we do not further scale the production facilities, which is highly likely, and each facility removes ~15Kt/yr, we would need ~6,600 facilities. This represents a total area of 33km2.	Our model is to setup next to a biomass source in a relatively small footprint operation. The competing area use would be other industrial operations. By co-locating next to sites that have features we need e.g in logistics, biomass weights etc, we can share resources and increase efficiency / land area.
Long-term Storage	Applied at 5 tonne/hectare would require 64,000km2 of farmland or degraded soil.	Low / not significant

Permanence, Additionality, Ecosystem Impacts (Criteria #4, #6, and #7)

5. How is your biomass processed to ensure its permanence? What inputs does this process require (e.g. energy, water) and how do you source these inputs? (You should have already included their associated carbon intensities in your LCA in Section 6.)

The biomass is exothermically converted into biocarbon at much higher temperatures than conventional slow or fast pyrolysis resulting in a more stable product than traditional biochar. Our process produces the water required for (quenching) and generates excess energy amounting to roughly half of the energy in the original biomass thus enabling true carbon negative heat or electricity generation.

6. (Criteria 6) If you didn't exist, what's the alternative use(s) of your feedstock? What factors would determine this outcome? *(E.g. Alternative uses for biomass include X & Y. We are currently the only party willing to pay for this biomass resource. It's not clear how X & Y would compete for the biomass resources we use.* OR *Biomass resource would not have been produced but for our project.)*

Alternative use for our feedstock is mainly in bioenergy, and to lesser extent in making particle boards / chipboards. Bioenergy is a debated form of energy generation, and one that the EU might re-classify as a "non-renewable energy", so we don't expect its use to be on the increase anymore. The biomass volumes we need locally are modest compared to small scale bioenergy, that we don't expect there to be a competition. In contrast, our process enables the local energy company to decrease bioenergy use to optimised, high-peak situations and instead utilise our renewable heat for district heating purposes.

7. We recognize that both biomass production and biomass storage can have complex interactions with ecological, social, and economic systems. What are the specific negative impacts (or important unknowns) you have identified, and what are your specific plans for mitigating those impacts (or resolving the unknowns)? *(200 words)*

<200 words Ethical concerns with edible biomass: Is the biomass we use suitable for e.g animal feed or human food use? Our first facility is located in Northern Europe, with strict environmental and circularity regulation and practice. We expect that any biomass that's suitable for food/feed will be unviable as a feedstock for us, simply by being too expensive to source if nothing else. Thus we focus on pure waste biomass with no food value. Increasing use of bioenergy in our location: Currently, Finland has plenty of woody biomass, and even more growing - its annual tree growth is over 20 million cubic meters more than

logging and natural tree decay combined. Maintenance logging and raking alone is close to 90 million cubic meters a year. If more biomass in Finland was directed to bioenergy, we might be competing on the same resources. However, as Finland aims to transition to a net-zero energy system by 2035, we don't see this as a long-term threat.

8. Biomass-based solutions are currently being deployed around the world. Please discuss the merits and advantages of your solution in comparison to other approaches in this space.

<200 words

Our process is a true negative emissions process with the end product being mineral-like biocarbon that is stable for at least a thousand years, while simultaneously releasing half of the embedded biomass energy as a combination of heat and syngas that can be used for a wide range of applications including providing the heat for many of processes being proposed to Stripe in this call, including DAC. We do not require underground storage or energy inputs and the primary cost driver is labor (ie Green Jobs).

Our solution represents a simple, elegant, and effective means of leveraging the natural power of photosynthesis to sequester carbon from the atmosphere. We allow nature to do the energy intensive work of capturing the carbon.