stripe

General Application

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

Company or organization name

Carbofex Oy

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

Tampere, Finland

Name of person filling out this application

Sampo Tukiainen

Email address of person filling out this application

sampo@carbofex.fi

Brief company or organization description

Biochar technology and CO2 removal company

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.

Carbofex will double its CO2 removal capacity during 2021 by removing bottlenecks from production and doubling is biochar production. So far the limiting factor at our current plant has been drying capacity, and we have tried technical approaches to address that. Now our plan is to buy up enough spruce thinnings (small diameter roundwood from 1st thinning of replanted forests)) to guarantee availability of pre-dried wood. The biochar will be used to make structural growing media, and placed under the streets of Stockholm and other major

Swedish cities. Our biochar has the steepest O/C ratio of any biochar in the market, with 98% carbon content (ash free basis). According to an equation used by Carbon plan and other prominent organisations, the permanence of our biocar is 90% after 1500 years in temperate region topsoils.

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.)*

We will produce the biochar at our plant in Tampere and have established a methodology with puro.earth to determine and quantify the CO2-drawdown value of biochar

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

If we are not able to procure the wood early in the season, our wood will not have time to dry enough, and our capacity will be proportionally reduced. Extremely wet weather could also hinder the harvesting and transportation of wood, and reduce the amount of water evaporated during storage. Carbofex plant and the stockpile could also burn due to various risks, vandalism, technical failure, operator failure etc.

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

PCT/FI2020/050226

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

a. Please fill out the table below.

	Timeline for Offer to Stripe
Project duration *Jul21-April22*	*<10 words*

When does carbon removal occur? *Jul21-April22* **The physical removal occurs by the photosynthetic organisms (trees), but we fix the carbon into a mineral form and make sure the carbon ends up in geological formations (topsoils and aquatic bottom sediments)**	*<10 words*
Distribution of that carbon removal over time *Constant between Jun21-April22*	*<50 words*
Durability *90% after 1500 years*	*<10 words*

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

Min 90% after 1500 years, probably much better and longer (based on archeological evidence)

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.)*

This is a science based estimate based on an equation used by Carbon plan, universities etc.

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?

Very few risks of re-entering the atmosphere. The biochar is mixed in topsoils and urban soils, and can not burn, decompose be ingested by organisms

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.)*

Decay is estimated by a formula / equation established by prof Johannes Lehman, and is broadly applied in the realm of universities, carbon consultants etc.

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 1151 t	*1000*
If applicable, additional avoided emissions 500 t avoided in Tampere district heating	*E.g. XXX tCO_2*

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)*

Our biochar has been thoroughly analysed under the EBC certification system, O/C, H/C C-fix are analysed periodically. Biochar LCA has been conducted by an independent evaluator, and our operations are audited annually by DNV. They give us the net sequestration "co-efficient". Additional avoided emissions: We measure how many MWh we pump into the grid, and the utility has established a mean CO2-footprint for the heat in the network: formula is delivered MWh x avoided emissions / MWh .

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).

3000 t + bio oil (800 t) for our current plant, highly dependent on the availability of pre-dried biomass. More oil could be recovered but we use it to produce district heat for the city of Tampere

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 know the carbon content of our biochar, and the life cycle emissions from production (raw material, production, transportation). We have used outside evaluators to verify the claims, and everything is based on science, verification and transparency. Please see the puro.earth website link provided here:

https://puro.earth/services/biochar-finland-100008

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.

- *Everything can be found here https://puro.earth/services/biochar-finland-100008*

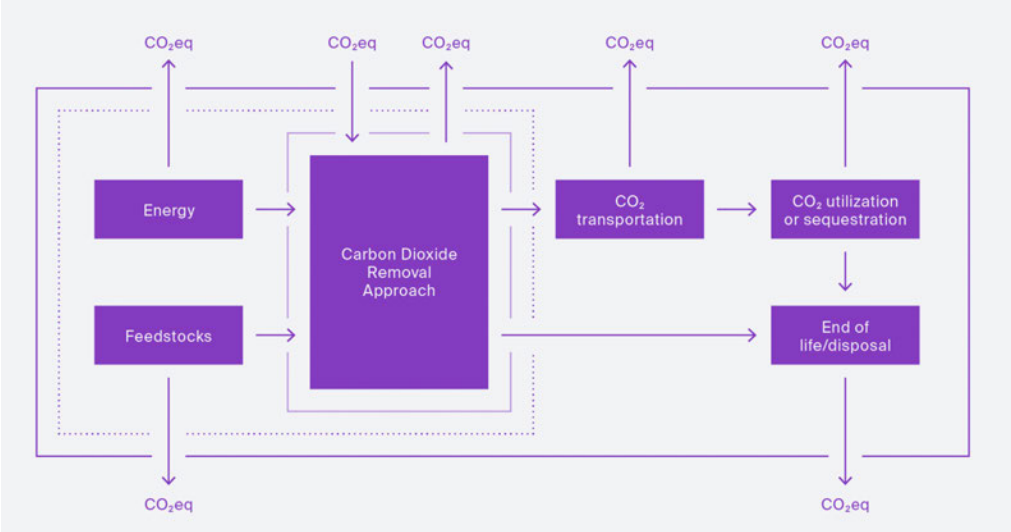
4. Net Capacity / Life Cycle Analysis (Criteria #6 and Criteria #8)

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	*1151 t*

Gross project emissions	*51 t*
Emissions / removal ratio	*0.157 / 3.43*
Net carbon removal	*1100 t*

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?

I am having trouble linking the LCA tonight. I will send in via email, or share a link in our drive where you can access it. <We have only included the net removals based on biochar. The oil, or additional avoided emissions are not included

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.

Thorough 3rd party LCA and operations audits,

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.)

Please see the DNV audit report on puro.earth. LCA will follow

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

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	180-250	3800	*<50 words*
2020	1	200-300	3000	*<50 words*
2019	1	300	2000	*<50 words*
...				

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 costs are coming down as we are learning our technology, it's limitations and strengts. We have gone into 24/7 operations, and operate nights and weekends unmanned with somebody on standby. Our drying situation is improving, and if we can increase the utilisation rate substantially, all costs come down proportionally (except raw material)

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	*4500*

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?

We could survive with income from CO2 removals alone at a price level of 180 euros / t CO2. If we can earn extra revenues from biochar, energy or gate fees, the costs can easily be brought down to 100 eur / t

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."

Raw material, Labor, CAPEX, consumables, utilities, the whole lot

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	*Delivery of first plant to a customer*	*We will be more ready to produce the units in volume.*	Q2 2021-Q12022	*Contract with the client, delivery and commissioning of the plant*
2	*Delivery of a larger plant to Tampere power company*	*We will have scaled our unit size to enable a substantial scale up project volumes*	Q32021-Q42022	*Contract with the client, delivery and commissioning of the plant*
3	*We will have injected the first 1000 t CO2 worth of bio-oil in geological formations*	*Recovering and injecting the oil component will boost the carbon removal efficiency of our process by 50%*	Q12022-Q22023	*Measured, verified, done with*

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	*3000 (+800)*	*3000 + 3000 + (800)*	*We will recover all of the bio oil*
2	*6.800*	*36800*	*5 x larger unit*
3	*36800*	*55200*	*<100 words*

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	*180-250 eur/t*	*180*	*2nd generation plant comes on-line. Fully automated feedstock handling will reduce labor costs by 50%*
2	*180*	*160*	*10 x scale will further reduce labor cost and bring economics of scale*
3	*160*	*100-150*	*Bio oil injection will increase feedstock efficiency and carbon recovery by 50%. The cost range exists due to feedstock cost.*

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?

I would ask President Biden to put a price on CO2 emissions and its equivalents such as N2O and CH4

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

You are already helping by doing what you are doing. It is highly appreciated.

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?

Cities, companies, farmers, co-ops

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

I think we are all in this together. We have come out with new business models such as carbon co-ops and enabling technology such as phosphorus removal based on biochar. We have also provided a uniform homogenous biochar product to many researchers and developers. We hope to enable others and provide sustainable business opportunities

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?

We have received tons of information, analyses etc. and learned that our biochar is very effective in filtering out various substances, just like activated carbon. We have also learned about its effects on farmland, productivity, drought tolerance etc..

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?

We need to scale and get the oil separation technology commercialised.

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

No one will be hurt or loose anything because of our activities.

11. Legal and Regulatory Compliance (Criteria #7)

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

We are fully compliant with all regulatory norms, air quality, safety etc..

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.

<possibly an environmental permit, depending on country, feedstock and scale

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.

Feeling pretty good in that regard. CE and UL in the works

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)	*1000*
Delivery window (at what point should Stripe consider your contract complete?)	*July 2021-April 2022"*
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.*	*180*

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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?

We use 1st thinnings from commercial managed forests. It is small diameter wood and often is left into the forest as it is not economical to harvest. Thinnings are trees that are removed to allow more room for stronger trees to grow bigger.

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

We buy it from sustainably managed certified forest owners in Finland

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	*We harvest from 100 ha / year, but require no new land*	*No competing use*
Processing	*Our production plant uses 500 m2 for the building and 10.000 m2 for outdoor storage*	*We use existing builidings and infrasturcture of a shut down pulp mill*
Long-term Storage	*Agricultural fields, 100 ha*	*No competing 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	*We are going to harvest residues from agriculture and forestry, no new land is required for our operatios. We will simply increase the utilisation rate of streams that would normally go to waste.*	
Processing	500 m2 / 4500 t / a	
Long-term Storage		

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.)

<Our biochar has the highest carbon content and O/C ratio of any biochar, due to oxygen free processing, and high final temperature. We use less than 3% of the heating value of the produced biochar, in wind power to run our plant. We use a tiny amount of fuel oil to start the plant every couple of weeks.

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.)*

First thinning is not profitable for the forest owners, and to minimise the cost, the felled wood is often not recovered. Often the thinnings are postponed due to costs and the productivity is reduced. If the wood is recovered, it is used for energy or pulp (seldom from first thinnings), in both cases the carbon returns to the atmosphere rapidly.

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)*

We only buy wood from winter loggings, when the ground is frozen and covered by snow. The birds are not nesting in the winter, and the spring and summer can be utilised for natural drying of the feedstock. We also only buy from certified forest, and no wood from clear cuts. In the

summertime we buy wood that was logged by pulp and paper companies, but "did not make it to the train on time". If the wood has any insect damage or bluing marks, it will not qualify for pulp or lumber, and will end up burnt.

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.

We convert biomass into a stable form of carbon with a novel production process that will not leak methane and hydrocabons into the atmosphere. The carbon produced by our process is exeptionally stable due to the very steep O/C ratio. The low oxygen in the carbon is due to the high final processing temperature and completely oxygen free processing environment, effectively preventing the oxidation of the produced carbon.