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Carbofex (via Puro.earth)

APPLICATION FOR STRIPE 2020 NEGATIVE EMISSIONS PURCHASE

Section 1: Project Info and Core Approach

1. Project name

Carbofex Hiedanranta 1

2. Project description. ***Max 10 words***

Biochar and carbon negative energy

3. Please describe your negative emissions solution in detail, making sure to cover the following points:
   a) Provide a technical explanation of the project, including demonstrations of success so far (preferably including data), and future development plans. Try to be as specific as possible: all relevant site locations (e.g. geographic regions), scale, timeline, etc. Feel free to include figures/diagrams if helpful. Be sure to discuss your key assumptions and constraints.
   b) If your primary role is to enable other underlying project(s) (e.g. you are a project coordinator or monitoring service), describe both the core underlying technology/approach with project-specific details (site locations, scale, timeline, etc.), and describe the function provided by your company/organization with respect to the underlying technology/approach.
   c) Please include or link to supplemental data and relevant references.

Max 1,500 words *(feel free to include figures)*

We operate a commercial biochar / CO2-removal plant in the circular economy district of Hiedanranta, Tampere, Finland.

We are the largest certified producer of biochar in Europe. Last year we sequestered 973 tons of CO2 and this year we are shooting for 2500 tons of CO2 (see figures attached).

We use residual wood (thinnings) from PEFC-certified, sustainably managed forestry operations. Normally these are either not recovered, or are used for energy. Our region has 80% forest coverage (managed spruce monoculture). Globally, agricultural residues will be the most significant feedstocks in most cases.

The main idea in hacking the short carbon cycle is that biomass that otherwise would be burned or left to rot, is converted into biochar. More than 50% of the carbon in the biomass is locked down into biochar, and substantial amounts of energy can be harvested in the process.

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In the next three years, our plan is to build 2-3 more plants for our own use, and sell a similar number to other operators. We are also in the process of scaling our unit size to 5 x to enable much larger plants. The theoretical scale of carbon capture with this method is 10-20 gigatons of CO2 / a.

As the first biochar company, we have established a system for trading the CO2 removals together with Puro, a Finnish CO2-removal trading platform, and have sold CORCs to financial institutions like Swiss Re and South Pole.

Carbofex CO2 capture: Sequestered Carbon By Carbofex 2019-2022

We are proud of our technology and products and we are happy to provide all laboratory results and analyses regarding our production to anyone interested. We actually publish all of our significant lab reports for all to see. Unlike anyone else in the industry.

Our carbon cycle in a figure: Carbon Cycle

In optimal condition, the biochar is used in water treatment, eg. to reduce eutrophication by removing phosphorus and nitrogen from various agricultural and industrial effluents. By decreasing the eutrophication and growth of the cyanobacteria, further and significant CO2 mitigation is performed. After being loaded with nutrients, it is recycled into agriculture to improve food and water security.
Eutrophication is a global challenge affecting both food and water security.

1 kg of phosphorus in lake will grow 1 ton of algae, and 1 ton of algae can emit 0.25 t of CH4.

0,25 t of CH4 equals 21.5 t of CO2. Thus 1 kg of phosphorus in the lake is capable to emit 21.5 t of CO2e/a.

If the current global trend of eutrophication is not reversed, by 2050 lakes will emit more CH4 than all wetlands combined.
Carbofex biochar is used to recover phosphates from the waters and recycle them back to the soil to act as a fertilizer. 1 m3 of biochar can hold as much as 5-10 kg of phosphorus.
After being loaded with nutrients, it is recycled into agriculture to improve food and water security.

In addition to biochar, many other revenue streams are generated. In short, the following products can be obtained, their ratios depend on what is emphasized.

Carbofex Hiedanranta 1 in numbers:

Biochar 1000 t
Pyrolysis oil 300-600 t (depending on heat production)
District heat 2000-5000 MWh / a
CORCs 2500 t CO2 / a

We have obtained the following certificates and approvals:

EU organic approved, EBC-premium certified, raw material supplier PEFC-certified

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Section 2: 2020 Net-Negative Sequestration Volume

See Stripe Purchase Criteria 1: The project has volume available for purchase in 2020.

4. Based on the above, please estimate the **total net-negative sequestration volume** of your project (and/or the underlying technology) in 2020, in tons of CO2. (Note: We're looking for the net negative amount sequestered here, net lifecycle emissions. In Section 3; you'll discuss your lifecycle and why this number is what it is).

2500 tons

5. Please estimate how many of those tons are still available for purchase in 2020 (i.e. how many tons not yet committed). This may or may not be the same as the number above.

2000 tons from this years lot is still for sale.

6. (Optional) Provide any other detail or explanation on the above numbers if it'd be helpful. ***Max 100 words.***

We also have 585 tons of CORCs in our inventory, ready to be sold.

Section 3: Life Cycle Analysis

See Stripe Purchase Criteria 2: The project has a carbon negative complete lifecycle (including energy use, etc).

7. Provide a life cycle analysis of your negative emissions solution demonstrating its carbon negativity, as complete as possible given limited space, and making sure to cover the following points:

a) Include a flow sheet diagram of direct ingoing and outgoing flows (GHG, energy, materials, etc) that bear on the LCA.
b) Please be explicit about the boundary conditions of your LCA, and implications of those boundaries on your life cycle. Let us know why the conditions you've set are appropriate to analyze your project.
c) Make sure to identify assumptions, limitations, constraints, or factors that relate to ingoing and outgoing flows, citing values and sources (for example: land and resource scarcity, limitations on a required chemical, energy requirements). Also identify key sources of uncertainty in determining these values.
d) If your solution results in non-CO2 GHG emissions, please be sure to separately specify that (e.g. in units of GWP 20 or 100 years, ideally both).
e) For solutions that rely on modular components (for example: incoming energy flows or outgoing CO2 streams), feel free to cite values associated with those interfaces instead of fully explaining those components. For these values, please identify the upstream and downstream life cycle emissions of the component.
f) Explain how you would approach a more comprehensive LCA by citing references and underlying data needed for the analysis.

Max 1,000 words *(feel free to include figures or link to an external PDF)*

Before we started trading CO2 removals with Puro, we had an LCA done by Ecobio Oy, a professional LCA consultant. Please find a the link to the LCA attached. It considers the CO2-balance of our biochar production.
Figures from our mass-energy-cycle: Mass_energy_Carbofex

Our LCA pdf by Ecobio Ltd : LCA Carbofex

Quote from the LCA: " 1 kg of biochar contains approximately 0,92 kg carbon which is equivalent to 3,4 kg CO2.
The majority of the global warming potential impacts of biochar are caused by the air emissions from pyrolysis process and the raw material supply, including the wood biomass and its transport. The production of 1 kg of biochar causes approximately 1,86 kg CO2e emissions, of which 1,69 kg CO2e is biogenic and 0,17 kg CO2e from fossil sources."

The biogenic CO2-component would be released regardless of pyrolysis, thus here we focus on the part that is "saved" in biochar.

The ratio of fossil CO2 emissions from the production chain (0,17 kg CO2 / kg C), divided by CO2 bound in biochar (3,4 kg CO2 / kg C) = 0,05. This is a very good number, and one must remember that as a bonus, a lot of high quality energy is generated in the production process, further reducing emissions from heating systems and industrial processes.

Different sources of CO2 emissions from the production chain are presented in the table:
:Carbofex_LCA_Table

b) The system boundary is as required by Puro.earth Cradle-to-gate i.e. from sourcing the feedstock to putting the product in our warehouse. Boundary conditions: we do not include the transportation from our production site to the customer, as those emissions are covered by the carbon accounting of the customer.

Here our carbon sequestering methodologies as presented publicly on the Puro website:

https://static puro earth/live/uploads/tinymce/Puro_Documents/Carbofex_Puro_Supplier_Factsheet_2020 pdf

c) Allocation of CO2 emissions to various output products from the same production line is based on the energy content (in MJ). This is in line with the ISO 14044 recommendation that the inputs and outputs of the system shall be allocated between the different products by reflecting the underlying physical relationships between the products

In addition of sequestering 937 tons of CO2 in 2019, we have since November 2018 generated a total of 1026 MWh of carbon negative district heat.

Hiedanranta 1 cumulative district heat production: Carbofex_District_Heating_distribution_03/2020

Carbofex is certified according to EBC (European Biochar Certificate) to be of "Premium grade" biochar. (EBC_Laboratory_Analysis_Carbofex).

Current EBC certificate: EBC certificate Carbofex

According to EBC Premium quality standards, the biochar production process must consume less than 3% in fossil energy of the total biochar energy content

EBC quidelines: European Biochar Certificate Guidelines

8. Based on the above, for your project, what is the ratio of emissions produced as any part of your project life cycle to CO2 removal from the atmosphere? For true negative emissions solutions, we'd expect this ratio to be less than 1.

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~0,05

Section 4: Permanence and Durability

See Stripe Purchase Criteria 3: The project provides durable, long-term storage of carbon.

9. Provide an upper and lower bound on the likely durability / permanence of sequestered carbon provided by your project, in years:

100-5000 years

10. Please provide a justification for your estimates, and describe sources of uncertainty related to: the form of storage, effects of environmental or climatic variability, difficulty in monitoring or quantification, etc. Specifically, discuss the risks to permanence for your project, the estimated severity/frequency of those risks (e.g. 10% of the acres of forest in this forest type are burned by fire over a 100 year period), and the time-horizon of permanence given those risks.

Max 500 words

The durability and recalcitrance of biochars is greatly affected by the pyrolysis process, as well as post-production oxidation. Most pyrolysis processes produce “oxidated chars”, which means that the carbon has taken a lot of oxygen onto it’s surface. This happens either due to oxygenating pyrolysis conditions or through exposure of hot char to air and water.

Carbon-oxygen bonds are most easily attacked by fungi and bacteria. Carbon-Carbon bonds and especially C=C (aromatic) are the most durable. Saturated carbon hydrogen bonds are also quite recalcitrant, but oxygenated carbonylic (C=O) and especially carboxylic (COOH) are very easily attacked by decomposer organism.

Our biochar is not oxidised during or after production and is highly aromatic (pure carbon). This means it is very durable once buried in the soil. We do not sell biochar to applications where it might get burned in the end of the cycle, but only to applications where it ultimately ends up in topsoils.

References on verification:
Research: Carbon longevity in biochar

Section 5: Verification and Accounting

See Stripe Purchase Criteria 4: The project uses scientifically rigorous and transparent methods to verify that they’re storing the carbon that they claim, over the period of time they claim to.

11. Provide detailed plans for how you will measure, report, and verify the negative emissions you are offering. Describe key sources of uncertainty associated with your monitoring, and how you plan to overcome them.

Max 500 words

We periodically analyse our biochar. Of special importance are the carbon content, carbon-hydrogen ratio and carbon-oxygen ratio.
Latest laboratory resulst of our biochar: EBC_Laboratory_Analysis_Carbofex

Detailed production records are maintained to be able to track both raw material consumption, other inputs and biochar output. Also detailed records of shipments and end users are maintained, so that the entire process can be audited at any time. The amount of carbon bound into the biochar can easily be calculated, also emissions arising from production are easy to quantify.

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12. Explain your precise claim to ownership of the negative emissions that you are offering. In particular, explain your ownership claim: 1) in cases in which your solution indirectly enables the direct negative emissions technology and 2) when, based on the LCA above, your solution relies on an additional upstream or downstream activity before resulting in negative emissions. Please address the notion of "double counting" if applicable to your project, and how you'll prevent it.

Max 200 words

At the moment we are only offering CO2 removals generated from our own operations. According to general principles of carbon removal, the rights to the issued CORCs belong the one who generates them.

Section 6: Potential Risks

This section aims to capture Stripe Purchase Criteria 5: The project is globally responsible, considering possible risks and negative externalities.

13. Describe any risks or externalities, any uncertainties associated with them, and how you plan to mitigate them. Consider economic externalities, regulatory constraints, environmental risk, social and political risk. For example: does your project rely on a banned or regulated chemical/process/product? What's the social attitude towards your project in the region(s) it's deployed, and what's the risk of negative public opinion or regulatory reaction?

Max 300 words

There is some uncertainty regarding the durability of various chars is soils, but the principles laid out above apply and are generally accepted.

We are safe to assume that the biochar from our process is among the most persistent of all the chars. This can be determined from the extremely low O/C and H/C ratios., and overall very high fixed carbon content with minimum volatile fraction.

Great care must be taken throughout the cascade of applications, to ensure that the biochar is not incinerated at any point, especially at end of cycle. Since it is never a waste product, someone will always pay to get it in their fields. So in the end our biochar is recycled in an appropriate manner, as soil amendment, landscaping substrate etc..to topsoils where it can not burn, or be collected for energy use.

Section 7: Potential to Scale

This section aims to capture Stripe Purchase Criteria 6: The project has the potential to scale to high net-negative volume and low cost (subject to the other criteria).

14. Help us understand how the cost and net-negative volume of your solution will change over time. Note that we aren't looking for perfect estimates. Instead, we're trying to understand what the long-term potential is and what the general cost curve to get there looks like. (Note: by "cost" here we mean the amount Stripe or any other customer would pay for your solution):

	Today	In ~5 years	In ~20 years
Est. Cost per net-negative ton (in $)	100	80	50
Est. Net-negative volume (in tons of CO2)	2500	15000	1000.000.000

15. What are the drivers of cost? Which aspects of your costs could come down over the next 5 years, and by how much? Do you think your eventual scale potential is limited by cost or by volume? Why? Refer to any relevant constraints from question #7, like land or materials scarcity, and specify the boundary conditions for which you consider those constraints.

Max 300 words

Our projects currently generate CO2-removals as a "by-product" - meaning most revenue will come from other sources like biochar, bio-oil or heat. This will enable relatively cost effective removal of CO2.

In the future, as we enter the mass production of our systems, we anticipate the CAPEX to come down by as much as 50%, further lowering the cost of CO2-removal.

However, if the sequestration price is sufficiently high, a lot of projects would be made viable based on CO2-recovery alone. This is especially true for developing countries, from where it is difficult to access markets. A higher price would lead to gigaton scale production and a global mass movement.

Ideally, the biochars would be used to first to remove nutrients from water systems, or as bedding for animals, and then blended into agricultural soils, improving the resilience (water and nutrient retention, + healthy soil biology) of croplands.

Section 8: Only for projects with significant land usage

See Stripe's Purchase Criteria 2: The project has a net cooling effect on the climate (e.g. carbon negative complete life cycle, albedo impact, etc.) ***This section is only for projects with significant land usage requirements: Forest, Soil, and BECCS/Biochar/Biomass sequestration projects.***

16. Location: Please provide baseline information about the geographic location(s) of your project; and link shapefile(s) of project area(s).

Max 100 words

Our idea is not to dedicate land for the production of biomass, but to use the existing resources from current land use, mostly urban residues, agricultural residues and forestry residues. No additional land is required to execute this scheme.

17. Land ownership: Please describe the current (and historical as relevant) land ownership and management for the area(s) provided in (16). If your project is not the landowner, describe your relationship to the landowner.

Max 150 words

Land ownership is not a relevant consideration here as no land is required.

18. Land use: For forest projects, please provide details on forest composition as well as forest age and basal crop area/density. For soil projects, please provide details on land use and crop type (if agricultural), soil organic carbon baselines, and regenerative methodology. For BECCS, biochar, or wooden building materials projects, please provide details on biomass crop type and methodology as applicable.

Max 500 words

Any crop residue or forest residue can be used, also urban residues such as waste wood, demolition wood, green waste, biowaste, biosolids etc.. The idea is to utilise materials from existing operations, that normally would get burned or left to rot (releasing all of their carbon back into the atmosphere).

19. Net effect on climate: Please discuss the non-CO2 impacts of your project that may not be covered in your LCA, such as your impact on albedo.

Max 150 words

LCA system boundary as required by Puro.earth covers cradle-to-gate GHG impact. In addition to the removed and stored CO2, our production has the following climate impacts:

1) Our system produces negative district heat into municipal heating system.

2) Replacement of materials and their emissions: Use of our product can displace use of other materials that cause emissions, such as zeolite, rockwool, perlite, peat.

3) Together the Puro.earth ecosystem companies create jobs in the new carbon net-negative economy and enable various circular economy schemes..

4) Avoid decomposing un-utilised feedstock biomass to GHG: The biomass we use would otherwise decompose naturally or be used for energy. Those emissions are avoided by stabilizing the GHG into our product.

5) Harvesting and managing forests sustainably decreases risk of forest fires, insects and diseases.

6) For biochar: Short-lived impact on albedo: Biochar when applied to farmlands needs to be ploughed down into the soil. This is typically done when normal tillage is carried out and the land is already “black”. It can decrease the albedo effect (reflectivity) slightly. However, this is typically a short period (day of spreading).

7) For biochar: Yield increase impacts: 10% yield increases reported with biochar. Crop productivity impacts carbon sequestered in crop biomass as well as reduction in land-use requirements for food production.

8) Our operation will not have a significant effect on albedo, as the biochar is tilled into the topsoil layer, down to depths of 50 cm. Most of this land is covered by vegetation, which will block solar energy before it reaches the ground. Biochar will also greatly enhance the water retention ability of topsoils. 100 m3 of our biochar (10-20 t) in the field will retain 90.000 liters of water. This means that there will be much more water available and evaporative cooling will be considerable, possibly reducing surface temperatures.

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Section 9: Other

20. What one thing would allow you to supercharge your project's progress? This could be anything (offtakes/guaranteed annual demand, policy, press, etc.).

Max 100 words

If someone came and bought up all of our capacity at a price reflecting the difficulty of the task. This would make us the first serious CO2-removal company, and would give a lot of credibility to our claims. Ideally, it would enable us to access sufficient funding to launch this into the gigaton scale.

21. (Optional) Is there anything else we should know about your project?

Max 500 words

We are the first biochar company in the world to publicly trade CO2 removal certificates in industrial volumes. We are extremely delighted to see that others are finally taking the challenge seriously, and understand the difficulty of the task.

Section 10: Submission details

*This section **will not** be made public.*

22. Please insert below the name and title of the person submitting this application on behalf of your company (or, if you are submitting this application on your own behalf, your own details). By submitting this application, you confirm that you have read and accept the Project Overview (available HERE), as well as the further conditions set out below. As a reminder, all submitted applications will be made public upon Stripe's announcement. *Once you've read and completed this section, submit your application by March 20th by clicking the blue "Share" button in the upper right, and share the document with **nets-review-2020@stripe.com**.*

Name of company or person submitting this application

[redacted]

Name and title of person submitting this application (may be same as above)

[redacted]

Date on which application is submitted

[redacted]

We intend to make the selection process as informal as possible. However, we do expect that (a) the content of your application is, to the best of your knowledge, complete and correct; (b) you do not include any content in your application that breaches any third party's rights, or discloses any third party's confidential information; (c) you understand that we will publicly publish your application, in full, at the conclusion of the selection process. You also understand that Stripe is not obliged to explain how it decided to fund the projects that are ultimately

funded, and - although extremely unlikely - it is possible that Stripe may decide to not proceed, or only partially proceed, with the negative emissions purchase project. Finally, if you are selected as a recipient for funding, Stripe will not be under any obligation to provide you with funding until such time as you and Stripe sign a formal written agreement containing the funding commitment.