stripe

Carbo Culture

APPLICATION FOR STRIPE 2020 NEGATIVE EMISSIONS PURCHASE

Section 1: Project Info and Core Approach

1. Project name

Carbo Culture

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

Turning woody biomass waste into stable, high-purity biochar

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)*

Carbo Culture converts biomass waste into high quality biocarbons. If left unattended, waste biomass will decompose into methane (CH_4) and carbon dioxide (CO_2), leaving only a tiny fraction of carbon into soil. If the biomass is burned in open air, the emissions are released immediately.

Leveraging a decade of research, we have further developed a novel technology to effectively convert agricultural biomass waste into stable biocarbon, sequestering the CO_2 into a stable form.

Our process reduces CO_2 -emissions by 50% compared to decomposing biomass and increases the carbon stored by 50x. Each ton of biochar produced sequesters 3 tons of CO_2 in a stable form. This biocarbon is made by using a safe, affordable and real-world

TRL 7 demonstrated technology that converts the waste into toxin-free, high fixed carbon containing biochar.

We're leveraging nature's natural carbon cycle and the annual megascale drawdown in capturing the carbon into the biomass, from what we then convert it into a stable form.

We envision an entire new carbon negative industry that converts biomass waste into biochar. The biocarbons will be used for a wide range of soil, material, and environmental remediation purposes.

The biocarbon enhances natural processes. When integrated into organic processes like composting and anaerobic digestion, they not only reduce the GhG release from the microbial process, but also enhance the quality of the resulting compost, and coat the biochar with the good microbes prior to adding to soil.

Our technology is based on over a decade of scientific research focused on finding the most efficient way of converting unstable organic carbon (necromass) into nearly pure and inert biocarbon that can be stable for hundreds to thousands of years.   We have demonstrated near theoretical yields of fixed carbon. The biomass is transformed into near elemental carbon in seconds, preserving the 3D structure down to the micron scale, and the resulting products are graphitic and show remarkable electrical conductivity.

Advantages of our technology include higher carbon yields, scalability, and an ability to use a wide range of upcycled feedstocks. Perhaps most critically, our unique process can deliver biocarbons with characteristics that are not achievable in standard pyrolysis systems.

Milestones

Q2/2018: Completed the first proof-of-concept Flash Carbonization reactor in Central Valley, California that uses walnut shell waste. This was a leap in technology readiness level, as the Flash Carbonization system was operated in a real-world setting outside of a lab and succeeded in showing that the technology works consistently on a larger scale.

2019: Successfully scaled up the demo reactor 8x in volume, and produced roughly 10 tonnes of biochar. Test and pilot customers in organic fertilisers, farming, and carbon negative materials in the US, Finland and Germany.

Q1/2020: 1M€ in LOIs for the coming years.
Research projects planned for 2020 include: electrical conductivity in water treatment at Stanford (US), lab studies to reduce nitrogen runoff and ammonia volatilization in the Netherlands and biochar mixed in animal feed with Swedish partners, and electrical conductivity in the Uni. of Alcala (Spain).

Next steps

stripe

O2-Q3/2020: Design, planning, permitting of a new production facility. Growing production capacity and working with clients.

Lab studies, preparations for scaled, multi-site research projects.
Hiring, team, engaging with multidisciplinary researchers, and partnership network building

References

The technological and economic prospects for CO2 utilization and removal (Nature, 2019) https://doi.org/10.1038/s41586-019-1681-6

Biocarbon production from Hungarian sunflower shells (Journal of Analytical and Applied Pyrolysis, 2006)

stripe

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).

62t

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.

42t

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

Every tonne of biochar we produce sequesters 3.12 tonnes of Co2 or more. We're looking to enlist some of our offsets to a carbon offset trading mechanism (such as Puro.earth), and we still have about 60% of the total production volume available for purchase.

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.

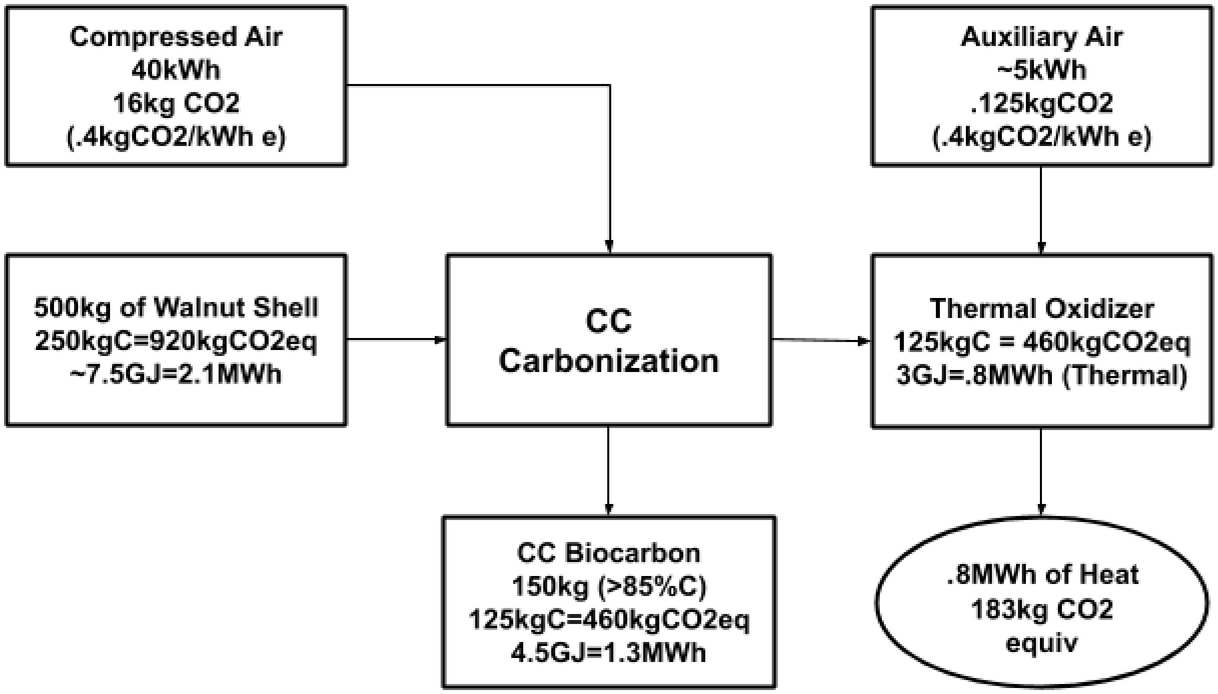
c) Make sure to identify assumptions, limitations, constraints, or factors that relate to ingoing and outgoing flows, citing values and sources (for example: land and resource scarcity, limitations on a required chemical, energy requirements). Also identify key sources of uncertainty in determining these 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)*



b) LCA Boundaries

- Locally produced agricultural residue used as feedstock. Our pilot plant uses walnut shells produced by the landowner where we operate. These walnut shells would be dumped on the ground and used as dust suppression or sent to a biomass power plant. CC Biocarbon product is >85% fixed carbon with very low oxygen and hydrogen levels (O:C and H:C ratios). The material is extremely stable relative to traditional biochars. It is assumed that >90% of the carbon in the product is stable for more than 100 years.
- The CC Process is net exothermic and does not require input energy other than compressed air. It is a net generator of heat, with approximately 40% of input energy being released as combustible gases and 60% of the feedstock energy being retained in the product.

c) LCA Assumptions

- It is assumed that at least 95% of the carbon in the feedstock is destined for the atmosphere in less than 5 years. LCA of growing the walnuts is not included. CO2 emissions from the feedstock are not included because they are from a renewable source. Feedstock is available on site and thus emissions associated with feedstock transport are not included.
- The afterburner is assumed to completely oxidize all of the non-biocarbon emissions from the process to yield heat, CO2 and steam.
- In future scaleup ~20% of electrical energy can be used to provide air compression
- LCA does not include the GHG benefits associated with its end use (reducing compost emissions for example)

d) Other GHG Emissions

- The CC process does not emit GHG other than CO2. It should be noted that the application of the material to composting and the soil can deliver significant CH4, NH3,N2O and VOC emissions that can exceed the carbon sequestered in the material itself. It is these multiplier effects that can play out over decades that may be the most impactful aspect of CC process.

e) Modular components

- The current LCA is modeled without heat recovery. Using the heat produced instead of natural gas for process heat has the potential to offset ~180kg of CO2. This would increase

f) A more comprehensive LCA analysis would include:

- A more accurate accounting of the footprint associated with walnut production as well as a comparison to business as usual approaches such as land spreading and co-firing in biomass power plants.
- A comparative analysis of downstream biocarbon application

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.

.035

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 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

Recent research has brought the permanence question of biochar into focus. The overriding factor is the O:C ratio of the biochar. More on the subject can be found here: https://www.ars.usda.gov/ARSUserFiles/41695/cmt.10.32_spokas.pdf. In summary:

> "From evaluating the current biochar and black carbon degradation studies, there is the suggestion of an overall relationship in biochar stability as a function of the molar ratio of oxygen to carbon (O:C) in the resulting black carbon. In general, a molar ratio of O:C lower than 0.2 appears to provide, at minimum, a 1000-year biochar half-life" -Kurt Spokas, Carbon Management (2010) 1(2), 289–303

The unique conditions of CC process yield a biocarbon product with extremely low O:C values (<.08). This remarkably low oxygen content not only implies longevity in the soil, but also imparts other beneficial characteristics that have been shown to reduce CH4 and N2O emissions from composted and natural soil respiration.

Charcoal was amongst the first thing humans ever manufactured, and along with the control of fire, charcoal production predates homo sapiens by more than 500,000 years. Our most educated estimate as to the stability of biochar comes from the manmade Terra Preta soils in the Amazon Basin created by farming communities in 450 BCE to 950 CE. The charcoal has remained stable and remains in the soil for thousands of years, continuing to bind nutrients and minerals in the soil.

stripe

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

The following reports will be shared with Stripe

- Production logs (weight, volume, run data)
- Third party audits and certifications (OMRI, IBI, EBC)
- Third party LCA calculations (currently being done by Ecobio.fi who have experience in biochar operations), and corresponding audits

Key source of uncertainty: The varying added benefits (on top of the actual carbon locked as biochar). For example,how much methane can the carbon further hold down when it is mixed with compost? Which times of mixing the carbon into bacterial processes yield the highest benefits?

These are some of the questions that we have partnered up with Wageningen University in the Netherlands to test. They have a ready lab setup, and the testing is supposed to start in Q2 and finish in Q3 2020.

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

Our ownership limits to and we can only offer quantifiable negative emissions / offsets for our direct and proprietary biochar production and not for other positive downstream externalities (soil Ghg reductions, water control or others which are dependent on the material's usage and context).

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

We expect social and political risks to be low. In contrast, for example the EU's Green Deal and many Californian policies call for enhanced circular economy and climate mitigation technology to enter markets.

In our facility design, we envision small, modular plants that can be quickly deployed on-site and operated within a closed loop community: This way biomass waste gets processed near the source of origin, and provides some local production jobs.

Economic and production risks: Availability of suitable feedstock biomass waste needs to be mapped out and secured before we can lock-in a new facility construction site. The feedstock should ideally be high density and low moisture, and the use cases for the biochar might have more requirements (if the facility's intended customers are animal feed manufacturers for example).

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 $)	1000	125	50
Est. Net-negative volume (in tons of CO_2)	65t	1 000 000	1 Gt +

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

At scale of large volumes production, labour is by far the largest cost. We're looking into automating some of the mechanics of the feedstock handling and other parts of the process to further streamline it.

For the facility investment, the design, construction and hardware still cost multiple years revenues. These will come down significantly as we learn at each new facility, and productize our model.

Our eventual scale potential is not limited by volume: there's an estimated billion tons of biomass readily available to use annually, plus much more in less convenient ways, and we only need three tons per ton of biochar. In Central Valley alone, there's enough biomass for our five-year target.

The production method and technology is proven to work, has a high technological readiness level and is ready to be scaled today. At present, lack of funding and small market is the main blocker to scale.

The global biochar market is forecasted to grow at 14.5% CAGR to €3.0 bn by 2024. Premium biochar is currently being sold for > 1000 USD/t, and we're on a path to produce biochar at a considerably lower cost and dependable cost margins.

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

1) Proof of concept demonstration: Currently based in Central Valley, California on a nut processing facility and using locally available agricultural residue
2) The second demonstration facility site is planned to be located in Northern Netherlands, possibly in connection with a green chemicals and bioprocessing innovation park

We're able to process a multitude of waste feedstocks and hence we're not reliant on energy wood or new planted forest, dramatically reducing the needed land for growing feedstock.

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

1) We rent the location of our test reactor from the nut processing site
2) We would rent the site, likely in an industrial bioinnovation park where we might be able to find suitable feedstocks and a market for our excess by-products.

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

In our demonstration facility, we use walnut shells. We get them from the nut hullers, who would otherwise spread them on roadsides to get rid of them.

Our production technology can use different types of feedstock, depending on what is locally available. We don't use virgin biomass and the feedstock should be proven waste material.

So far, we've done runs with nut shells, fruit pits and woody waste in our production process. Ideally, we'll use high density biomass with up to 30% moisture content.

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

Depending on its use cases, biochar has many beneficial properties.

When used in urban built environments, biochar can regulate water in soils, preventing flooding and non-plant available water. Its nutrient and water holding capacity promote plant and crop growth and longevity, which in an urban context helps provide shading in urban heat islands. In agricultural use, biochar can make soil and added nutrients more plant available, reduce nutrient and water runoff and increase yield, all while reducing agrochemical fertilizer usage.

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

Annual guarantee and long-term customers are what funders, vc's, and loan backers need to see. Without the proof of demand, biochar can't make it out of the early stages! We're working on this issue on two fronts: one is working with universities to show in rapid testing the actual benefits (xx % less runoff.. Xx % less lost as greenhouse gases.. Xx % heavy metals absorbed, etc) and the other part is to work with customers and build trust and pilot projects with them.

21. (Optional) Is there anything else we should know about your project?
Max 500 words

Biochar is a systemic, biomimicry project. It's not something totally new to nature: Over thousands of years, nature has been making Pyrogenic Carbon PyC on it's own, and depositing it in the soils to make the soils more fertile. This has a snowballing positive effect chain: The carbon can help the microbiome with new surface area, hold on to nutrients, drain the soil better with better structure, and hold on to water when it otherwise runs through. The carbon can help the soil become all in all healthier, and increase the soil microbiome renewal. Healthy soils will sequester more carbon in the short-term stored carbon as well. Carbon is such a useful, abundant element in the universe, that it's a wonder we haven't thought of using it as a tool instead of thinking of it as a nuisance. Biochar is a way to sequester carbon safely and in a stable form for hundreds to thousands of years, and Nature wrote in a paper by Hepburn et al. (below) that biochar has a 2Gt annual removal potential, in a profitable way. The science has been proven for our manufacturing technology and now it's a question of skilled engineering. We're operating a demo facility today - and we're gearing up to scale from TRL 7 -> 9 in 2020. This rfp will help us get there! (https://www.nature.com/articles/s41586-019-1681-6?fbclid=IwAR2_ZQ5_V4yR-qiX8OKQYbocwncCudzzxQwlFXWlEukzEPv19Xw2XvUrHWI)

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.