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GreenSand

APPLICATION FOR STRIPE 2020 NEGATIVE EMISSIONS PURCHASE

Section 1: Project Info and Core Approach

1. Project name

greenSand

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

CO2 removal with Olivine

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)*

Olivine sequesters CO2 by a gradual weathering process that permanently removes CO2 from the atmosphere..
In a chemical form: $Mg_2SiO_4 + 2\ H_2O + 4\ \mathbf{CO_2} \Rightarrow 2\ Mg^{2+} + SiO_2 + 4\ HCO_3^-$

There are scientific studies that show the carbon removal rates.
See for instance for land applications:
https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0042098
And for marine applications:
https://pubs.acs.org/doi/abs/10.1021/acs.est.6b05942
(both open access).

Finer grades of olivine will typically show a higher rate of CO2 sequestration, due to the greater surface.
Locations with lower pH and/or higher levels of CO2 will also show a higher rate of sequestration.

Olivine (and Serpentine) are common minerals. So the olivine rock, gravel or sand could be applied in any geographical area. Sites with the highest CO2 removal or larger scale can be selected.

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So far greenSand has only applied Olivine in the Netherlands with the applications:
Infrastructure:

- applying olivine as road- or railside gravel or sand
- Parkings
- Gravel roads

Consumer:

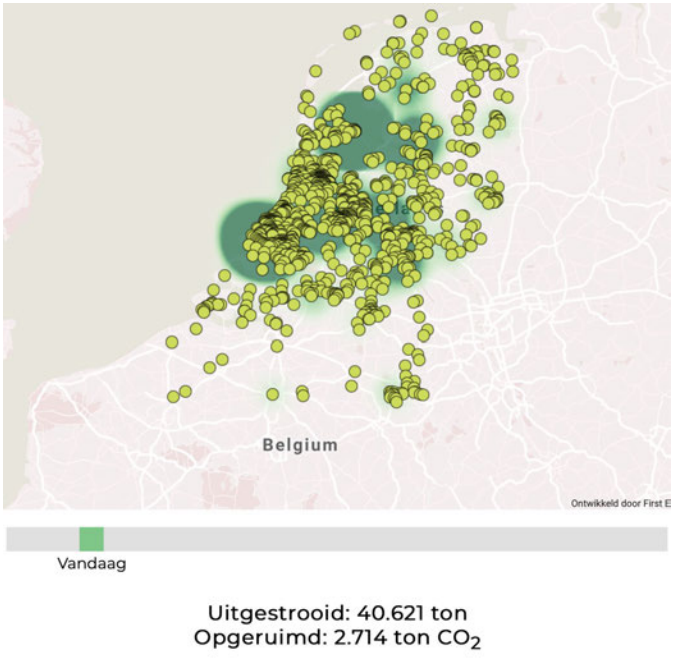
- Applying olivine as gravel/sand for paths, gardens
- Purchase of "Cleanup certificates" where olivine sand is sown in designated locations for CO2 sequestration (no specific economic use)

The solution is not patentable . It requires is:

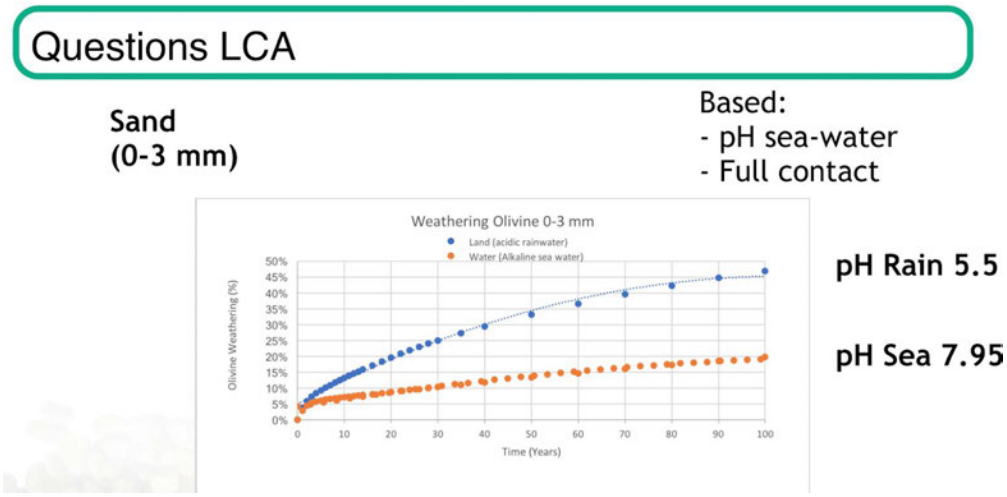
- Purchase of material from a local mine or logistic suited location
- Grind the material to required grades
- Ship to locations where it will be applied
- Sell in bulk to infrastructure/construction contractors
- Sell as certificates or in bags consumer home/garden retail

People (and companies) can buy either separate olivine or CO2 credits (Cleanup certificates) or combined. Most buy both the physical olivine and the associated CO2 credits.
But for people that do not have the option to spread and use the olivine, they can buy just the Cleanup Certificates. The olivine can then be used for certain projects or applications..
See example of University of Twente.
https://www.utwente.nl/en/eemcs/bios/news/2019/4/195755/olivine-compensation-for-co2-footprint
This offsets the flights of the department of prof. Albert van de Berg.
These CO2 credits are used at a parking place in another part of the country.
https://www.zuidhollandslandschap.nl/nieuws/nieuwe-entree-staelduinse-bos

All of the olivine sold is tracked on the website. And for each and every order or project, the start date (when the olivine is spread out), the duration and particle size are known. This is then used to calculate the CO2 sequestration over time. The amount of sequestered CO2 is shown in a heatmap:
At this heat map it shows both the location and the CO2 sequestration over time. The latter can be shown by sliding the ruler at the bottom.
https://www.greensand.nl/nieuws/greensand-op-de-kaart



Please note the CO2 sequestration is by nature a geological process, which keeps continuing after the material is applied.
So after applying the olivine the reaction will continue for a long time, with a slowly decaying rate. The exact rate depends in particle size, temperature and some minor items. An example is shown below:



The current (upto today) of sequestered CO2 (with the sales upto today) is 639 ton CO2 per annum (and will continue with a slowly decaying rate over the time).
We expect to sell more olivine in 2020. Most of the CO2 sequestration is allocated for the project owner. Some owners want to buy CO2 credits. For these clients Greensand finds other (more social) projects where the olivine is applied.

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).

1.000 ton CO2

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.

200 ton CO2

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

The olivine applied in 2020 will sequester a limited amount of CO2 in 2020.
But the material applied in 2020 will start removing CO2. And will be doing this for a long time.

The CO2 credits of the current sales of olivine are already allocated.
People can also buy CO2 credits (in which case GreenSand will apply the olivine). For this year 200 ton CO2 credits will be available. The buyers of these CO2 credits will receive a certificate number. WIth this number can the project in which the olivine is applied be found.

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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)*

We need to perform a LCA. For bigger projects we are performing a detailed CO2 balance, which is explained below.
The CO2 balance is slightly dependent on the location, logistics. For the Netherlands we need to import this material from either Spain or Norway (with different qualities and shipping distances)

For the project Hoekse Lijn the CO2 impact calculated.

This project is a railway service path for a novel railway track between Rotterdam and Hoek van Holland.

The applied material is from Spain (Pasek, serpentinized olivine, with a lower CO2 uptake as purer olivine).
The CO2 uptake is calculated for a life-time of 100 years.
Due to the size of the project this was directly shipped to a harbour very close to the railway and trucked for the last part. This CO2 impact is calculated.

If Olivine wouldn't' be used for this project, Granite from Belgium (Quenast) would have been used (the reference).
The CO2 emissions of the reference is subtracted from the CO2 emissions of the olivine.
And this is compared with the CO2 sequestration.

Olivine/Serpentine Sequestration									
Amount	16.000	ton	Olivine from Spain						
	24%	Weathered (over 100 years)							
	0,75	kg CO2/kg material (Spanish material)						**-2.880**	ton CO2 sequestered
CO2 emissions Olivine									
CO2 mining	1,79-3,9	kg CO2/ton			2,8	kg CO2/ton	44,8	ton CO2	
CO2 milling (	0,46-1,02	kg CO2/ton			0,7	kg CO2/ton	11,2	ton CO2	
CO2 ship	30	gr CO2/ton km	1400	km	42	kg CO2/ton	672,0	ton CO2	
CO2 truck	138	gr CO2/ton km	10	km	1,38	kg CO2/ton	22,1	ton CO2	
Total CO2 emissions								**750**	ton CO2 emitted
Reference		Granite from Quenast (Belgium) to Hoek van Holland							
CO2 emissions									
CO2 mining	1,79-3,9	kg CO2/ton			2,8	kg CO2/ton	44,8	ton CO2	
CO2 milling (	0,46-1,02	kg CO2/ton			0,7	kg CO2/ton	11,2	ton CO2	
CO2 truck	138	gr CO2/ton km	205		28,29	kg CO2/ton	452,6	ton CO2	
Total CO2 emissions reference								**-509**	ton CO2 emitted (ref)
						Difference Olivine - Reference		241	ton CO2 emitted
						Nett sequestration		-2.639	ton CO2
						Efficiency		**92%**	

So the CO2 uptake depends on the Magnesium content, particle size, life time of the project.
The CO2 emissions of the project are mainly dependent on the logistics.
And as Olivine is used to replace another material, the CO2 emissions of the reference material is also calculated.
This in total results in an efficiency calculation.
Based on other assumptions, olivine sourcing this can change a bit.

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.

For the Project Hoekse Lijn 92%.
For other projects between 80%-95%

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:

Permanent, geological storage

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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 permanency of the storage is undisputed. As this is thermodynamically favoured.

As this is nature's way of storing CO2
What will cause differences in actual CO2 sequestration from case to case::

- The origin and quality of the olivine (the higher the amount of Magnesium, the higher the CO2 uptake), Olivine always contains Iron, Nickel and Chromium).
- The particle size of the used material
- The life-time of the project
- The reference material (What other material would have been otherwise used to in this project?)

For bigger projects these things are documented and reported for the project owner. For smaller projects this is usually not performed.

The usual reaction formula is $Mg_2SiO_4 + 2\ H_2O + 4\ CO_2 \Rightarrow 2\ Mg^{2+} + SiO_2 + 4\ HCO_3^-$

If the produced ionic end-products would be dried, half of the sequestered CO2 would be released as
$2\ Mg^{2+} + SiO_2 + 4\ HCO_3^- \Rightarrow 2\ MgCO_3 + SiO_2 + 2\ H_2O + 2\ CO_2$
So the CO2 sequestration is less. For the applications as made by GreenSand, this is always with sufficient rainwater. So the end-products will be ionic.

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 are dividing the projects in bigger projects and smaller.
For bigger projects typically a comprehensive LCA./CO2 report and calculation is made.
This takes into account the location, reference material, particle size, application.
So the CO2 impact is calculated. And if required a CO2 certificate is issued..

For smaller projects this is too cumbersome. And a slightly different approach is used.
All of the sales are recorded. Of these sales the date, amount and particle size are recorded.
We established a model (based on particle size) to calculate the CO2 uptake over time. This is implemented in our database and uploaded to our heatmap on the greenSand website. It visualizes for each project the CO2 sequestration over time..

See i.e. the example of Hoekse Lijn. for three time frames

In 2018 62 ton will be sequestered by this project.
2045 282 ton CO2
2099 507 ton CO2
This shows the CO2 sequestration over time.

We are participating in the Dutch Greendeal National CO2 market. To have a better external validation of the sequestered CO2. For the forthcoming years the certification will require more attention.
So we are in a better position to quantify and explain the CO2 uptake.

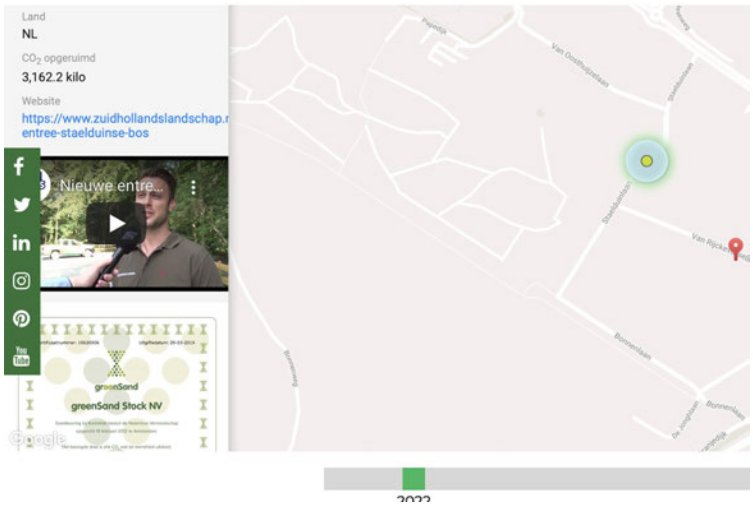
In the future we are considering performing A LCA. But for the Dutch requirements a CO2 balance is sufficient.

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

The customers which are buying olivine become owners of the CO2 credits. This is mentioned on the greenSand website (if the customer agrees to/wants this). More photo's and video's will be added in due course.

There are also people and organizations which are buying CO2 credits, without the physical olivine. This money is used to realise more social projects. The buyer of the CO2 credits receives a certificate number. This number can be used to track the realized project. And quite often with pictures and more information.



Most customers want to buy the olivine (instead of granite) for the CO2 sequestration capabilities and are prepared to pay a premium for this compared to conventional civil products.

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

It is known that Olivine can contain asbestos. So by the selection of the mine this needs to be taken into consideration. Pol Knops is involved in another project (www asbeter nl) to destroy asbestos, so he is very good aware of the risk of this hazardous material.

Another point is that Olivine contains smaller amounts of Nickel and Chromium. The fate of these elements needs to be monitored. The partner Deltares (and especially Jos Vink) is very well known for his expertise in this field.
https://www.deltares.nl/nl/experts/jos-vink/

For most applications is the chemical reaction towards ionic Magnesium and bi-carbonate ions. This implies that about 1 kg CO2 is sequestered per kg olivine.
When these ionic liquids are dried, solid Magnesium-Carbonate is formed. And half the CO2 will be released again. Given the fact all applications are in the open atmosphere, there is sufficient rain water for the dissolvement of the olivine.

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 $)	35	20	10
Est. Net-negative volume (in tons of CO2)	1000	500000	10000000

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

The most significant driver of cost is the mining activity and the logistics cost of bringing olivine to the location where it is applied. As this market develops we will become better at:

- Mining efficiently in the right locations for large volume.
- Choosing mining locations that are closest to the locations where olivine will be applied
- Olivine will likely be applied in large port, coastal protection projects (sand suppletion) where large volumes can be applied at once at the highest possible sequestration rates.

These developments will bring down per tonne cost significantly.

Another way to scale is to investigate more market opportunities. Currently are most of the applications in the replacement of conventional civil products. Other applications are in soil improvement, lime replacement.

In order to expand we are looking into setting up local franchisers, with local mines abroad. So these franchisers can start their business with the experience gained by GreenSand. A truly global brand, marketing, awareness, research can be performed. While (due to the local mines) transportation costs (and CO2 impacts) can be minimised.
This would facilitate the scaling up. The first preliminary talks are with Belgium, UK, Switzerland and the United States. Of course this will be performed with local mines.

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

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

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

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

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

1. *Guaranteed annual demand would supercharge our project as it would allow us to scale and reduce cost and (already limited) CO2 footprint of the operation moren quickly.*
2. *Awareness. Mineralisation is not very known as compared to other CO2 removal techniques.*
3. *Facilitate research. Compared to other options is mineralisation less researched.. This is quite remarkable given the amount of (geological) sequestered CO2 and the permanency of this storage.*

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

Max 500 words

The Netherlands is becoming the hot spot for Olivine research.
The universities of Wageningen, Utrecht and the knowledge institutions of Deltares, NIOZ are all involved in this kind of research. Usually with material supplied by GreenSand and in most of these projects is GreenSand involved. Both to increase the awareness and to learn more about the CO2 uptake, by-effects. etc.

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

stripe

[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.