stripe

Charm Industrial

APPLICATION FOR STRIPE 2020 NEGATIVE EMISSIONS PURCHASE

Section 1: Project Info and Core Approach

1. Project name

Charm Industrial Bio oil Sequestration

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

Geological sequestration of bio-oil

Pl d rib your n g tiv mi ion olution in d t il m king ur to ov r th following point

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. B ur to di u your k y umption nd on tr int

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 omp ny/org niz tion with r p t to th und rlying t hnology/ ppro h

c) Please include or link to supplemental data and relevant references.

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

Biom i w ll known our of tmo ph ri rbon Typi l biom rbon qu tr tion proj t convert biomass to a sequesterable solid (e.g. biochar on fields) or a sequesterable gas (CO_2 in underground g ologi l form tion) Th p rm n n of bio h r i hotly d b t d nd CO_2 g ologi l tor g i g n r lly used controversially for enhanced oil recovery and is expensive due to high energy associated with gas p r tion ompr ion nd tr n port tion In t d w pl n to onv rt biom to liquid (bio oil) vi well-known process called fast pyrolysis, which is generally self-heated. Bio-oil is similar to crude oil removed from g ologi l form tion ft r m ny million of y r but bio oil i h vily oxyg n t d (m king it l valuable as a fuel/chemical, but just as carbon-rich for sequestration). We plan to pump the bio-oil into an EPA Und rground Inj tion Cl l Indu tri l nd Muni ip l W t Di po l W ll for xtr m ly long t rm geological storage. We will effectively be refilling deep underground porous rock formations with a partially oxyg n t d rud oil look lik xtr t d from th tmo ph r

Both k y t hnologi f t pyroly i to bio oil & und rground w t inj tion r w ll r r h d nd even commercially available. See 20+ years of fast pyrolysis and bio-oil research documented by [IEA Task For 4] nd th [EPA' Cl l W ll w b it] (v n [h wh y i ommonly inj t d down th w ll]) However, to our knowledge, the two technologies have only been conceptually connected as a potential carbon sequestration pathway twice before (Schmidt 2018 and Werner 2018). We do not believe an actual inj tion of bio oil h v r b n tt mpt d

Thi proj t k to (1) d mon tr t g ologi l qu tr tion of bio oil for th fir t tim nd t bli h baseline cost, (2) allay key practical risks in geological sequestration of bio-oil with our patent pending m thodology (whi h ov r mong oth r thing pro for pr v nting blo k g du to bio oil particulate & corrosivity, safety with respect to bio-oil vapor flash point, storage duration and polymerization imp t on bio oil vi o ity t for diff r nt d p inj tion w ll typ)

For thi proj t w h v rr ng d bio oil upply in luding tr n port from xi ting omm r i l bio oil producers, and underground injection well capacity from existing injection wells, both in North America and in Europ W xp t to b bl to b gin qu tr tion tiviti within f w month

Section 2: 2020 Net-Negative Sequestration Volume

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

4 B d on th bov pl tim t th **total net negative sequestration volume** of your proj t (nd/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).

10 000

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.

10,000

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

W r urr ntly limit d by bio oil produ tion p ity

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 ompl t po ibl giv n limit d p nd m king ur to ov r th following point
   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 lif y l L t u know why th ondition you'v t r ppropri t to n lyz your proj t
   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 v lu
   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).

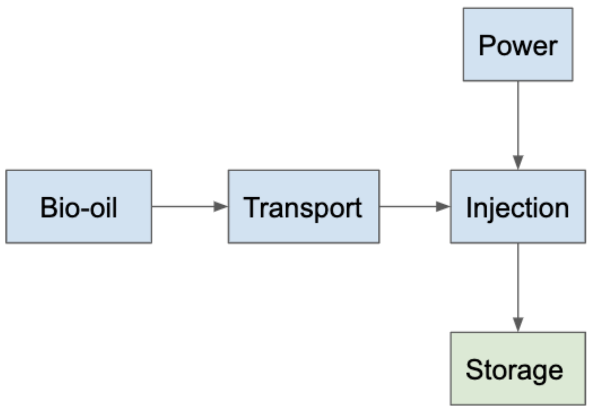
e) For solutions that rely on modular components (for example: incoming energy flows or outgoing CO2 streams), feel free to cite values associated with those interfaces instead of fully explaining those ompon nt For th v lu pl id ntify th up tr m nd down tr m lif y l mi ion of the component.

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 in lude figures or link to an external PDF)*

Every 1 tonne of bio-oil we procure contains 1.55 tonnes of CO e. In the process we emit 0.36 tonnes of CO e from transport and power usage, for a net sequestration of 1.19 tonnes CO_2e per ton of bio-oil.

This diagram shows the overall process, beginni g with bio-oil and ending with geological storage:



We plan to complete a comprehensive LCA as soon as possible with an outside consultant, but this LCA is our best estimate and model as of today:

Carbon Intensity Calculations					
			GREET		
Production Step	**Use Rate**	**Unit**	**LCI Data**	**Unit**	**Emissions (t CO2e/t bio-oil)**
Bio-oil					
Bio-oil Production	1.00	tonne bio-oil/tonne bio-oil	0.296	tonne CO2e/tonne	0.296
Transport to Well					
Fuel Efficiency	436	tonne-miles/gal			
Transport Distance	2000	miles			
Fuel Consumption	4.6	gal/tonne	10.16	kg CO2e/gal	0.047
Injection					
Electric Power	35	MJ/tonne bio-oil	102.5	g CO2e/MJ	0.004
Storage					
Bio-oil Water Content	24%	tonne water/tonne bio-oil			
Bio-oil Carbon Content	55%	tonne C/tonne bio-oil dry			
Bio-oil Carbon Content	42%	tonne C/tonne bio-oil			
Molar Mass CO2	44.12	g/mol			
Molar Mass Carbon	12.01	g/mol			
Stored CO2e		tonne CO2e/tonne bio-oil			-1.53
Total					
Net CO2e Emissions					-1.19

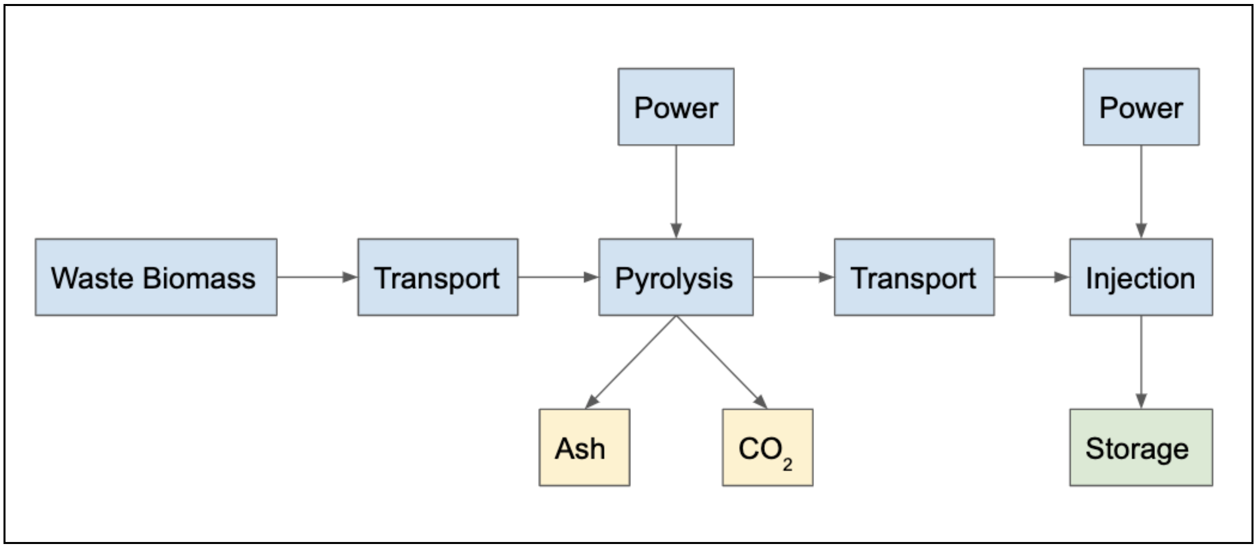
For this project’s LCA, a few notes:

1 “Bio oil Produ tion” rbon int n ity i b d on v r g of publi inform tion bout our bio oil suppliers, including GREET LCA analyses approved by CARB.
“Tr n port to W ll” rbon int n ity i b d on v r g r l fu l ffi i n y nd th r l tr n port distance from one of our bio-oil suppliers to one of our injection wells.
“Inj tion” rbon int n ity i b d on m ximum tim t of inj tion pumping pow r om wells are gravity-fed and require no power.

4 “ tor g ” rbon ont nt i b d on v r g of publi inform tion bout th typi l bio oil w t r and carbon content from our suppliers.

5 W ’v v lid t d th t ( ) th bio oil pro ur d for thi proj t i x p ity o w r not g tting bio-oil that would have otherwise replaced fossil fuel burning, (b) the bio-oil procured for this project i produ d from biom th t would oth rwi h v rott d o w r not g tting bio oil produ d from biomass that would have otherwise replaced fossil fuel burning.

For future scaleup we anticipate localizing the bio-oil supply chain, leading to a different life cycle analysis bound ry th t would b gin with th w t biom Addition lly futur proj t will v lid t th t th w t biomass entering the process does not have a legitimate alternative use that would displace fossil fuel burning



B d on th bov for your proj t wh t i th r tio of mi ion produ d ny p rt of your proj t lif cycle to CO2 removal from the atmosphere? For true negative emissions solutions, we'd expect this ratio to be less than 1.

0.28

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 proj t in y r

300,000,000

10 Pl provid ju tifi tion for your tim t nd d rib our of un rt inty r l t d to th 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 tim horizon of p rm n n giv n tho ri k

Max 500 words

We are injecting an oxygenated crude-oil lookalike into a geological formation whose existing crude oil has b n tr pp d th r for 00 000 000 y r https://en wikipedia org/wiki/Permian Basin (North America)#Depositional history

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 can provide: 1. Carbon intensity/lifecycle analysis from our bio-oil suppliers and injection partners. 2. Verification of receipt/transport of the bio-oil to our injection site from our bio-oil suppliers. 3. Verification of injection from our injection partners. 4. Lot-sampled bio-oil composition analysis to confirm carbon content.

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 down tr m tivity b for r ulting in n g tiv mi ion Pl ddr th notion of “doubl ounting” if applicable to your project, and how you'll prevent it.
Max 200 words

Bio-oil suppliers sell their product assuming that it will be burned, re-emitting CO_2 previously removed from the atmosphere. As the consumer of the bio-oil, it's entirely under our control what we do with the bio-oil and the negative emissions credit lies clearly with us, not with any other party.

Section 6: Potential Risks

This se tion aims to apture Stripe Pur hase Criteria 5 The proje t is globally responsible, onsidering possible risks and negative externalities.

13. Describe any risks or externalities, any uncertainties associated with them, and how you plan to mitigate th m Con id r onomi xt rn liti r gul tory on tr int nvironm nt l ri k o i l nd politi l ri k 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 face risks associated with injecting bio-oil into an injection well for the first time. Specifically, particulate content, acidity, polymerization and vapor flash point are examples of potential risks that we intend to mitigate through the course of the project. COVID-19 represents a challenge to our supply chain's ability to operate in a timely manner. One bio-oil supplier continues to operate, while another bio-oil supplier has had to pause operations until a partial re-opening allows them to fully staff their production facility. Note that the amount of bio-oil required for this project is less than two days of production capacity, so we feel the likelihood of COVID-19 preventing execution of the project is unlikely over the remainder of 2020.

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):

	Tod y	In 5 y r	In 0 y r
Est. Cost per net-negative ton (in $)	$600	$175	$55
E t N t n g tiv volum (in tons of CO2)	10 000/y r	1 Mt/y r	7 Gt/y r

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 r l v nt on tr int from qu tion #7 lik l nd or m t ri l r ity nd p ify th bound ry ondition for which you consider those constraints.

Max 300 words

Cost
Today: approximately 55% of our costs are bio-oil, 37% transport, and 8% injection. This is an extremely inefficient configuration. The bio-oil is produced "over quality" for our purpose and must currently be transported nearly 3,000 km to the injection site.

In ~5 years: bringing bio-oil production near the site of injection, achieving some economies of scale on the fast pyrolysis equipment, and negotiating bulk rates on injection slashes the cost dramatically.

In ~20 years: achieving meaningful-but-standard economies of scale (30% unit cost savings for first three 10x in capacity built) for fast pyrolysis plants, commissioning our own injection wells, reducing electricity costs from $0.12 to $0.08/kWh and eliminating 90% of electricity consumption by using internal char for combustion (also improves carbon balance), reducing *waste* biomass costs from $30/ton to $20/ton, reducing transport costs through co-location with injection well, and lowering the cost of capital to 15% 5-year IRR due to widespread existing proof points.

Scale
Biomass availability is a potential constraint on scale. We can estimate lower and upper bounds on the biomass constraints:

- *Lower bound*: rice straw, sugar cane bagasse and corn stover are examples of large-scale agricultural waste products that have little value in replacing fossil fuels. They are commonly burned in the field or allowed to rot. For example, 3-5% of rice straw is estimated to be collected and used none of it for fossil fuel replacement use cases. These three crops alone yield 1.7 Gt/year of waste biomass:
    - Rice straw: 3.7 tons/ha over 158 million ha = 580 Mt/yr
    - Bagasse: 300 Mt/yr
    - Corn stover: 43 billion bushels at 2 tons recoverable / 100 bushels = 860 Mt/yr
- *Upper bound*: globally we generate roughly 140 Gt/year of waste biomass, or roughly 35 Gt/year on a dry basis. Of this, only a portion is available, accessible and usable for bio-oil production… let's say an upper bound of 20% or 7 Gt/year. Bio-oil conversion is 70% efficient and bio-oil:CO e sequestered is 1:1.3 ratio, so that suggests very approximately an upper bound of 7 Gt CO_2e/year of potential from bio-oil sequestration.

Geological sequestration capacity is another potential constraint on scale. The EPA estimates a theoretical global capacity for CO_2 storage (which is far less dense than bio-oil per ton of carbon) at 13,000 Gt. This would be at least 1,800 years at 7 Gt/year (not accounting for the massively better carbon density of bio-oil than CO_2). Additionally, we've extracted at least 150 Gt of crude oil, implying we could refill 150 Gt of bio-oil. Geological sequestration capacity is unlikely to be limiting.

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Section 8: Only for projects with significant land usage

See Stripe s Pur hase Criteria 2 The proje t has a net ooling effe t on the limate (e g arbon negative omplete 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 Lo tion Pl provid b lin inform tion bout th g ogr phi lo tion( ) of your proj t nd link shapefile(s) of project area(s).

Max 100 words

> The current project does not have substantial land use associated with it.

17. Land ownership: Please describe the current (and historical as relevant) land ownership and management for th r ( ) provid d in (16) If your proj t i not th l ndown r d rib your r l tion hip to th landowner.

Max 150 words

> In the long-term we plan to enter offtake agreements for waste agricultural residues, with growers (eg. corn farmers) or processors (eg. nut processors, sugar mills). We will not own or operate the land directly. It could eventually become interesting to look at purpose-grown, high-yield biomass crops, but that has significant land use change impacts that would need to be more deeply understood and considered.

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, pl provid d t il on biom rop typ nd m thodology ppli bl

Max 500 words

> In the long-term we expect to primarily depend on waste agricultural residues like nut shells, corn stover, b g ri tr w Th t rg t r idu r p ifi lly ho n b u th y r g n r lly not u d fossil fuel replacements. This ensures that the sequestration of the downstream bio-oil has a carbon impact r l tiv to rotting/burning oppo d to fo il fu l void n
>
> E h of th rop h diff r nt nu n to n ur th t th r idu u g do not r t ddition l unexpected emissions. For example, corn stover represents 860 Mt/yr of potential residues. However, either ground ov r rop or m ll portion of th tov r hould b l ft on th fi ld to prot t th ground from direct rainfall (which can decrease soil porosity and cause soil-based CO_2 emissions). While not applicable for our urr nt proj t futur proj t will n d to d ign nd ount for th nu n on residue-by-residue basis.

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

> M ny nvironm nt l r vi w in pl lik C liforni fo u on nvironm nt l imp t pot nti l lik mi ion of particulate and NOx, or increased road traffic.
>
> For some crops, like nut shells, which are already processed at central facilities, we expect to decrease p rti ul t NOX nd ro d tr ffi by ond n ing (nd po ibly inj ting) bio oil imm di t ly on it r th r than grinding up the shells and applying them across broad areas.

For oth r rop lik orn tov r whi h r g n r lly not pro d ntr lly w will lightly in r particulate, NOx, and road traffic by offtaking this biomass from the fields to bring it to a local bio-oil onv r ion nd inj tion it Thi will n d to b on id r d p rt of ny nvironm nt l r vi w prior to building a permanent conversion and injection plant.

Injection wells are believed to cause increased seismic activity by lubricating interfaces between rock layers. Thi i n r for on rn th t n d furth r r r h How v r rough ord r of m gnitud approximately 3-10 Gt/year of brine and other waste material is already injected into wells in the US today.

Section 9: Other

20. What one thing would allow you to supercharge your project's progress? This could be anything (offt k /gu r nt d nnu l d m nd poli y pr t)

Max 100 words

We have more capacity than Stripe can buy at present, we welcome introductions to additional purchasers.

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

Max 500 words

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 r ubmitting thi ppli tion on your own b h lf your own d t il) By ubmitting thi ppli tion 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 do ument with **nets review 2020@stripe com***

Name of company or person submitting this application

Charm Industrial, Inc.

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

Kelly Hering, Co-founder; Shaun Meehan, Co-founder; Peter Reinhardt, Co-founder

Date on which application is submitted

4/28/2020

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 ppli tion th t br h ny third p rty' right or di lo ny third p rty' onfid nti l inform tion ( )

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 fund d nd lthough xtr m ly unlik ly it i po ibl th t trip m y d id to not pro d or only p rti lly 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.