General Application

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

Company or organization name

Carboniferous Inc.

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

Oakland, CA

Name of person filling out this application

Drew Felker

Email address of person filling out this application

[redacted]

Brief company or organization description

Stopping biomass decomposition by placement into deep ocean anoxic zones

1. Overall CDR solution (All criteria)

a. Provide a technical explanation of the proposed project, including as much specificity regarding location(s), scale, timeline, and participants as possible. Feel free to include figures and system schematics.

In this project we propose an anoxic biomass carbon sequestration (ABC'S) experiment. Building from in progress small scale experiments and academic research we expect to sequester net 522 tonnes of CO_2 equivalent by placing 800 bales of rice straw within the 2400M deep Anoxic Orca Basin in the Gulf of Mexico in December 2023. The deep hypersaline anoxic basin has been separated from the general ocean for 50,000 years via density gradients, causing a lack of oxygen and inhospitality to multicellular organisms. These conditions, coupled with physical boundaries on the bales, nearly eliminate digestion of biomass into CO_2. One example of this type of preservation is the black sea shipwrecks that are still preserved after 2000 years in the anoxic zone of the black sea.

The experiment will use the carbon stored in rice straw as a sequestration medium. Like most terrestrial biomass, rice straw is ~40% carbon by dry weight. Rice straw is a low cost and negative value biomass stream that is typically burned in the field after the rice grain is harvested. The straw will be purchased from farmers in Crowley, La in baled form, wrapped in a standard plastic covering. It will then be shipped to our staging facility in New Orleans. At the staging facility a ballast will be added, the bales loaded on a rented AHTS vessel, moved above the anoxic basin, and sunk. The sinking characteristics including final resting location of the bales will be tracked.

In addition to the bales, multiple benthic landers will be deployed into the basin. The benthic landers will have a suite of experiments and monitoring equipment designed by our scientific advisor Organic Geochemist Dr. Morgan Raven of UCSB. The goal is to understand the process parameters that create the strongest resistance to digestion, and the hydrodynamic conditions within and between the general ocean and the hypersaline basin.

One benefit to the ABC'S process is the scale and maturity of the existing supply chain. We have been able to secure Letters of Intent and quotes for up to 1M tons of biomass a year for most of the supply chain, and are working on the rest (see below).

b. What is your role in this project, and who are the other actors that make this a full carbon removal solution? *(E.g. I am a broker. I sell carbon removal that is generated from a partnership between DAC Company and Injection Company. DAC Company owns the plant and produces compressed CO_2. DAC Company pays Injection Company for storage and long-term monitoring.)*

Our role is the responsible party, ballaster, and carbon sequestration monitor. We purchase the biomass from farmers, hire a transport company to move the biomass to the Louisiana Merchant Terminal where we compress the biomass and add ballast. We then hire a shipping company to move the ballasted biomass and sink it in the correct location, and we monitor the biomass to make sure the carbon stays sequestered.

The supply chain we are building is composed of parts of existing supply chains and portions we will perform in house. We either have or are in the process of getting letters of intent from each piece of the supply chain as noted below:

(LOIs for participation available under NDA)

- **Merchant Company** - coordinates the agricultural part of the supply chain including its emissions data, namely the Soil Laboratory, the Farmers, Inland Transportation, and the Fertility and Agronomy provider. (LOI In progress)
    - **Soil Laboratory** - The soil laboratory will sample the soil before and after material removal to show that soil carbon and fertility has been maintained in the soil after the byproduct removal. (LOI received)
    - **Farmers** - Farmers will grow a crop as normal, then contract for an extra equipment pass to rake and bale excess straw ((i.e. not the grain/ edible portion, only the leftover byproduct of the economic crop) in an appropriate amount for their cropping system. (LOI received)

- ○ **Inland Transportation** - (Many transportation companies are set-up to move biomass, LOI not needed, quotes available)
- ○ **Fertility and Agronomy** - Any of the national or large regional ag retailers are set-up to replace nutrients removed and know the supply chain emissions for the nutrient replacements (each farmer has an agronomist they consult with)

- **Material Handling, Measurement, and Loading** - this company will provide the handling process which will measure the contents of the bales portside and load onto the ship (LOI Received)
- **Maritime Transportation** - Will transport the bales, already ballasted, from the terminal and will place them in the deep hypersaline anoxic basin (LOI Received)
- **Ocean and Sub-Ocean Monitoring** - (We will perform in house)
- **3rd Party Verifier** - Look at supply chain and ocean/sub-ocean monitoring data, perform independent audit, and opine about efficiency of sequestration relative to credit standards; organize MVS protocol creators (LOI in progress)
- **Regulatory Attorneys** - Obtain demonstration permits from EPA and Dept. of Interior (On retainer)

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

The three most important risks in order are getting the research permit (Regulatory), the carbon sequestration market being large enough (Market) and in situ testing of our process (Scientific).

The regulatory environment for placing items in the ocean is very complex and doesn't have a clear carbon sequestration pathway. We have hired law firms in New Orleans and Washington DC, in addition to a consultant who previously was the chief counsel, committee on Natural Resources at the U.S. House of Representatives, to help find regulatory pathways to allow a demonstration permit. We are fortunate that NOAA, the EPA, BOEM, the DOE and USDA are all promoting carbon sequestration, and we will need to create a regulatory pathway for our company (and the others that will do ocean carbon sequestration) to permit projects similar to ours. We understand this is a large risk, and one of the main goals of our proposal to stripe is to get enough data to receive a full scale permit.

The market risk we face is that there isn't enough demand for high quality carbon sequestration. Our process is simple and can scale rapidly (there is no infrastructure that needs to be built and the entire supply chain is mature and has service providers for every piece), and we need to find more customers who would be willing to purchase 1M tons of high quality CO_2 sequestration at less than $100/tonne .

We view scientific risk as the lowest risk of the three, as there is a large body of evidence that anoxic events throughout prehistory lowered CO_2 within the atmosphere drastically (1) , and there is evidence of biomass sequestration within anoxic zones (shipwrecks) being stable for millennia. There is still risk though that the sequestration will not be as effective as we predict which is why we need tests in the actual environment.

(1) (Schlanger, S. O., et al. "The Cenomanian-Turonian oceanic anoxic event, 1, Stratigraphy and distribution of organic carbon-rich beds and the marine C excursion." Marine Petroleum Source Rocks (1986): 371-399.)

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

We have a provisional patent on the process of using biomass in an anoxic basin for carbon sequestration that we expected to be granted. Our IP counsel, Dunlap Bennett and Ludwig have advised us not to publish the patent in the interim.

e. Who's the team working on this? What's your team's unfair advantage in building this solution? What skills do you not yet have on the team today that you are most urgently looking to recruit?

The team working on this is Robert Morris, Dr. Morgan Raven, Dave Jackson and Drew Felker. Robert Morris is well connected within the agricultural supply chain because of his work as CEO of Teravion and has experience with soil carbon monitoring. Dr. Morgan Raven wrote one of the first papers on sulfidic ocean carbon sequestration processes and has the knowledge and skill to safely deploy and test sequestration stability. Dave Jackson is an experienced entrepreneur and has raised significant amounts of capital. Drew Felker (author) is managing regulatory and academic outreach and engagement.

Our unfair advantage is the simplicity of the sequestration process. All of the services needed to safely deploy 100M tons of CO_2 sequestration annually can be purchased (biomass and benthic landers) or rented (transportation). The supply chain already exists and we only need approval to test and verify the idea. Additionally, soil health sustainment would have been a risk but the study of cellulosic ethanol biomass sources has shown the farming community how to maintain soil health with biomass takeoff.

Our largest skill need is someone with ocean regulatory experience. We're currently talking to a consultant with this skill set and will hopefully have her as part of our team shortly.

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

a. Please fill out the table below.

	Timeline for Offer to Stripe
Project duration	February-December 2023
When does carbon removal occur?	February to Sept 2023
Distribution of that carbon removal over time	The plants will grow in 2023, and therefore 100% of the sequestration will happen in 2023.

Durability	1000 years to 100s of Millions of years

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

The lower bound (1000 years) is the worst case scenario and millions of years is if the biomass sequesters into a geologic formation.

c. Have you measured this durability directly, if so, how? Otherwise, if you're relying on the literature, please cite data that justifies your claim. *(E.g. We rely on findings from Paper_1 and Paper_2 to estimate permanence of mineralization, and here are the reasons why these findings apply to our system. OR We have evidence from this pilot project we ran that biomass sinks to D ocean depth. If biomass reaches these depths, here's what we assume happens based on Paper_1 and Paper_2.)*

The natural process of sequestering carbon within anoxic zones has multiple layers of durability that compound on each other and have been studied independently.

Most importantly, there are ancient preserved sargassum fronds in the sediments under the anoxic basin. This is a physical representation of how stable the basin is for storing carbon. (1). This is because Biomass metabolizes very slowly in anoxic environments. Metabolic rates are orders of magnitude lower within ocean anoxic environments compared with oxygen containing environments (2). A study of oxygen minimum zones even without the density gradient from hypersalinity shows increased biomass accumulation (3). Additionally, there is nonmixing of the water between the basin and the general ocean which causes any digested biomass to stay within the basin (1) and at the depth, pressures and temperatures found in the Orca Basin methane clathrates will form when methanogenesis occurs (4). Finally, water in the Gulf of Mexico takes 250 years to circulate (5).

Our project is similar to carbons sequestration strategies like Running Tide is deploying, with extra layers of durability caused by the complete lack of oxygen and non mixing of the hypersaline basin with the general ocean. Our assumptions are that because of the very low metabolic rates, the very low transmission of material between the anoxic zone and the general ocean, the high observed carbon content of the sediment underneath the basin, and the rate of circulation of the Gulf of Mexico, that all sequestered CO2 will stay within the ocean for over 1000 years.

(1) Denis A Wiesenburg, James M Brooks, Bernie B Bernard, Biogenic hydrocarbon gases and sulfate reduction in the Orca Basin brine, Geochimica et Cosmochimica Acta, Volume 49, Issue 10, 1985, Pages 2069-2080,ISSN 0016-7037, https://doi.org/10.1016/0016-7037(85)90064-X.

(2) D'Hondt, S., S. Rutherford, and A. J. Spivak.2002. Metabolic activity of subsurface life in deep-sea sediments. Science295:2067-2070. DOI 10.1126/science.1064878

(3) Ruvalcaba Baroni Itzel, Palastanga Virginia, Slomp Caroline P.(2020)Enhanced Organic

Carbon Burial in Sediments of Oxygen Minimum Zones Upon Ocean Deoxygenation

(4) Peter G. Brewer, Franklin M. Orr, Gernot Friederich, Keith A. Kvenvolden, Daniel L. Orange, James McFarlane, William Kirkwood; Deep-ocean field test of methane hydrate formation from a remotely operated vehicle. Geology 1997;; 25 (5): 407–410. doi: https://doi.org/10.1130/0091-7613(1997)025<0407:DOFTOM>2.3.CO;2

(5) Chapman, Piers & Dimarco, Steven & Key, Robert & Previti, Connie & Yvon-Lewis, Shari. (2017). Age Constraints on Gulf of Mexico Deep Water Ventilation as Determined by 14C Measurements. Radiocarbon. 60. 1-16. 10.1017/RDC.2017.80.

d. What durability risks does your project face? Are there physical risks (e.g. leakage, decomposition and decay, damage, etc.)? Are there socioeconomic risks (e.g. mismanagement of storage, decision to consume or combust derived products, etc.)? What fundamental uncertainties exist about the underlying technological or biological process?

The potential durability risk is leakage which is low for many reasons. First, the bales of biomass are physically separated from the microbes of the DHAB by plastic, reducing the rate of decomposition. The rate of anoxic biomass decomposition is very low, on the order of 0.08 mm/year which would result in 75% of the biomass remaining after 1000 years if the bales had no protective layer,(1) and decomposition that happens in the deep hypersaline anoxic basin stays within the stratified layers (2). Additionally any methane that is produced will form methane clathrate because of the depth, pressure and temperature (3).

There are no socioeconomic risks because it's difficult to get to the bottom of the ocean and no one will go there to dig up biomass. The fundamental uncertainties that remain are the biological processes. We have evidence of minimal biological risk, but we need to test under various process parameters.

Our fundamental uncertainty that exists is we don't know what we don't know, and though we predict 1000 year sequestration, it needs to be tested and verified..

(1) Pedersen, Nanna Bjerregaard, Łucejko, Jeannette Jacqueline, Modugno, Francesca and Björdal, Charlotte. "Correlation between bacterial decay and chemical changes in waterlogged archaeological wood analysed by light microscopy and Py-GC/MS" Holzforschung, vol. 75, no. 7, 2021, pp. 635-645. https://doi.org/10.1515/hf-2020-0153
(2) Giuseppe Merlino, Alan Barozzi, Grégoire Michoud, David Kamanda Ngugi, Daniele Daffonchio, Microbial ecology of deep-sea hypersaline anoxic basins, FEMS Microbiology Ecology, Volume 94, Issue 7, July 2018, fiy085, https://doi.org/10.1093/femsec/fiy085
(3) Peter G. Brewer, Franklin M. Orr, Gernot Friederich, Keith A. Kvenvolden, Daniel L. Orange, James McFarlane, William Kirkwood; Deep-ocean field test of methane hydrate formation from a remotely operated vehicle. Geology 1997;; 25 (5): 407–410. doi: https://doi.org/10.1130/0091-7613(1997)025<0407:DOFTOM>2.3.CO;2

e. How will you quantify the actual permanence/durability of the carbon sequestered by your project? If direct measurement is difficult or impossible, how will you rely on models or assumptions, and how will you validate those assumptions? *(E.g. monitoring of injection sites, tracking biomass state and location, estimating decay rates, etc.)*

We will use benthic landers to bring back up samples quarterly to test that the biomass is undigested and stable and will be tracking the decomposition rates of biomass within the basin, and water chemistry within the basin and within the bales. Specifically we will be monitoring for dissolved sulfide, ammonium, nitrate, nitrite, Fe(II) concentrations, pH, and methane production.

3. Gross Capacity (Criteria #2)

a. Please fill out the table below. **All tonnage should be described in metric tonnes here and throughout the application.**

	Offer to Stripe (metric tonnes CO_2) over the timeline detailed in the table in 2(a)
Gross carbon removal	556 Tons of CO2 equivalent
If applicable, additional avoided emissions	N/A

b. Show your work for 3(a). How did you calculate these numbers? If you have significant uncertainties in your capacity, what drives those? *(E.g. This specific species sequesters X tCO_2/t biomass. Each deployment of our solution grows on average Y t biomass. We assume Z% of the biomass is sequestered permanently. We are offering two deployments to Stripe. X*Y*Z*2 = 350 tCO_2 = Gross removal. OR Each tower of our mineralization reactor captures between X and Y tons CO_2/yr, all of which we have the capacity to inject. However, the range between X and Y is large, because we have significant uncertainty in how our reactors will perform under various environmental conditions)*

Dry rice straw is 40.9% carbon by weight,(1) and rice straw from around the world has on average 6-7% moisture content (2). For each ton of rice straw there is ~70Kg of water, and 380Kg of carbon. Carbon is 27.29% of the weight of CO2, and therefore each Ton of rice straw contains ~380Kg of carbon/27.29%Carbon/CO2 molecule resulting in 1393 Kg of CO2 equivalent per ton of rice straw. We assume all 1393 tons of the CO2 is sequestered permanently. (1) Tomoaki Minowa, Toshiaki Hanaoka, Shin-ya Yokoyama,Process Evaluation of Biomass to Liquid Fuel Production System with Gasification and Liquid Fuel Synthesis, Studies in Surface Science and Catalysis, Elsevier,Volume 153,2004,Pages

79-84, ISSN 0167-2991,ISBN 9780444516008, https://doi.org/10.1016/S0167-2991(04)80223-4.

(2) Ghaly, A. E., Li, B. & Zhang, Y. (2012). Physical Properties of Rice Residues as Affected by Variety and Climatic and Cultivation Onditions in Three Continents. American Journal of Applied Sciences, 9(11), 1757-1768. https://doi.org/10.3844/ajassp.2012.1757.1768

c. What is your total overall capacity to sequester carbon at this time, e.g. gross tonnes / year / (deployment / plant / acre / etc.)? Here we are talking about your project / technology as a whole, so this number may be larger than the specific capacity offered to Stripe and described above in 3(b). We ask this to understand where your technology currently stands, and to give context for the values you provided in 3(b).

Our method has fundamental physical capacity for more than 2,000 gigatonnes. We have begun the permitting process to access the 3 Gt capacity in US waters. Our existing low scale supply chain can execute 2M tonnes per year (we have an LOI for use of a ship full time when demand is high enough) and once we have a permit and demand we can scale to 100M tonnes/year renting existing infrastructure (limiting factor above 100M tonnes/year is available ship capacity). This would be 50 ships moving full time, and using additional sources of waste biomass like corn stover or primary mill residues within the US. There is ~1Gt of excess biomass produced in the US annually (1), and there are >10Gt of agricultural byproducts produced globally each year we could use as a source of sequesterable waste biomass carbon. At the current time, because we don't have a permit, we are not allowed to sequester any carbon in the Orca Basin and our capacity is essentially 0 tons.

(1) Perlack, Robert & Wright, Lynn & Turhollow, Anthony & Graham, R. & Stokes, Bryce & Erbach, Donald. (2005). Biomass as Feedstock for A Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply. Biomass as Feedstocks for a Bioenergy and Bioproducts Industry: the Technical Feasibility of a Billion-ton Annual Supply. 72. 10.2172/885984.

d. We are curious about the foundational assumptions or models you use to make projections about your solution's capacity. Please explain how you make these estimates, and whether you have ground-truthed your methods with direct measurement of a real system (e.g. a proof of concept experiment, pilot project, prior deployment, etc.). We welcome citations, numbers, and links to real data! *(E.g. We assume our sorbent has X absorption rate and Y desorption rate. This aligns with [Sorbent_Paper_Citation]. Our pilot plant performance over [Time_Range] confirmed this assumption achieving Z tCO_2 capture with T tons of sorbent.)*

The models we used to estimate our solutions capacity are based on known available biomass supply, research that has been done into biomass takeoff for cellulosic ethanol production and animal feed research, discussions with farmers, and quotes and letters of intent from shipping companies. The supply chain is very easy to validate (trucks, trains, barges and ships all exist and have known pricing and capacity), and the volume of the Orca

Basin is known.

For nutrient replenishment needed for biomass takeoff we use the following data (1), but the reality is each farm is different. From talking to farmers, fertilizer companies, and researchers who work everyday in the field, we have learned that there are large ranges of bioproductivity and ability to safely take off biomass (Example, farmers in Illinois recommended we talk to their agronomist to get the data for nutrient replenishment needed safe biomass takeoff on their specific fields).

For USA biomass availability we used the NREL Biofuels Atlas, and additional bio energy reports (2).

(1) Dobermann, A. ; Fairhurst, T., Rice: nutrient disorders & nutrient management. Book : Rice: nutrient disorders & nutrient management 2000 pp.199 pp.

(2) "Biomass as Feedstock for Bioenergy and Bioproducts Industry: The Technical Feasibility of a Billion-Ton Annual Supply. U.S. Department of Energy and Department of Agriculture, 2005." . For trucking transportation we used data from "Estimating the CO2 intensity of intermodal freight transportation) dx.doi.org/10.1016/j.trd.2013.02.016". For

e. Documentation: If you have them, please provide links to any other information that may help us understand your project in detail. This could include a project website, third-party documentation, project specific research, data sets, etc.

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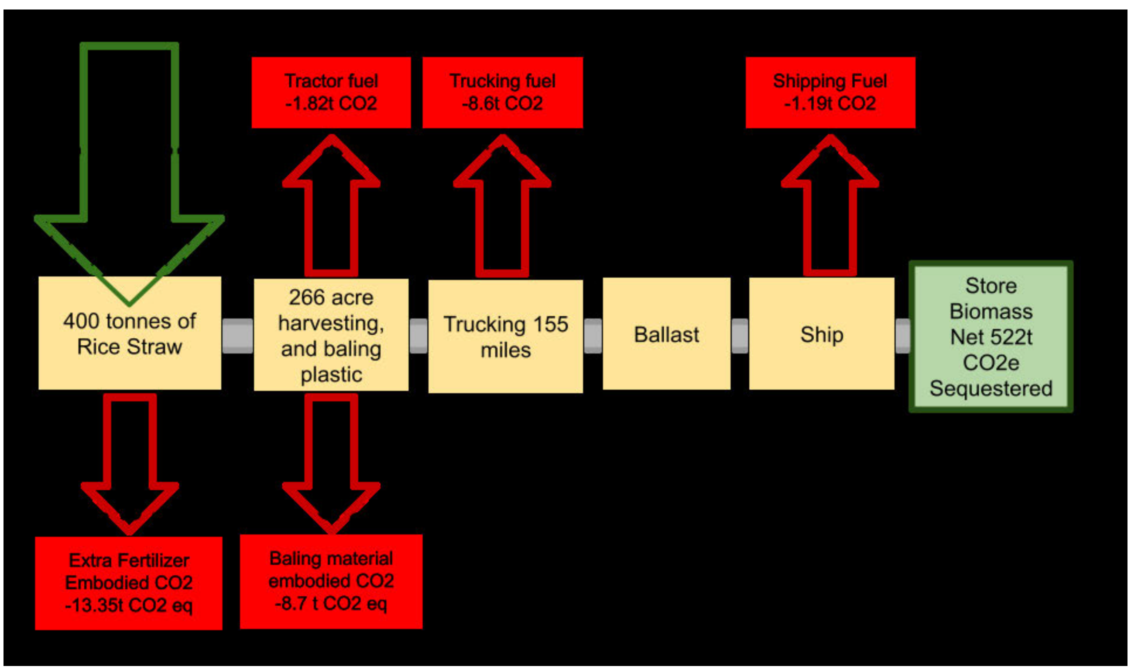
4. Net Capacity / Life Cycle Analysis (Criteria #6 and Criteria #8)

a. Please fill out the table below to help us understand your system's efficiency, and how much your lifecycle deducts from your gross carbon removal capacity.

	Offer to Stripe (metric tonnes CO_2)
Gross carbon removal	556 tonnes of CO_2 equivalent
Gross project emissions	Fertilizer: 13.35tonnes of CO_2 equivalent Baling material: 8.7tonnes of CO_2 equivalent Tractor for harvesting fuel:1.82 tons of CO_2 (266 acres at 0.7 gallons per acre) Trucking Fuel: 8.62 tonnes of CO_2. (20 full 20 tonne flatbed truck loads traveling 155 miles)

	Ship Fuel: 1.19 tonnes of CO2 (5g/Tonne mile, 592 miles round trip) Total: 33.67 tonnes of CO2 emitted
Emissions / removal ratio	0.061
Net carbon removal	522.33 tonnes of CO2

b. Provide a carbon balance or "process flow" diagram for your carbon removal solution, visualizing the numbers above in table 4(a). Please include all carbon flows and sources of energy, feedstocks, and emissions, with numbers wherever possible *(E.g. see the generic diagram below from the CDR Primer, Charm's application from 2020 for a simple example, or CarbonCure's for a more complex example).* If you've had a third-party LCA performed, please link to it.



c. Please articulate and justify the boundary conditions you assumed above: why do your calculations and diagram include or exclude different components of your system?

We excluded the embodied CO_2 of the fertilizer used to grow the rice, because the rice would be grown anyway with or without the biomass being sequestered. We included the embodied CO_2 of the extra fertilizer needed to replenish the fertility of the soil caused by biomass removal. We excluded the embodied CO_2 within the body of the tractors, trucks, and ships we will be purchasing capacity on the machinery and these are already in service. We excluded the embodied carbon of the ballast because we will be using repurposed material that would have gone into a landfill.

d. Please justify all numbers used in your diagram above. Are they solely modeled or have you measured them directly? Have they been independently measured? Your answers can include references to peer-reviewed publications, e.g. Climeworks LCA paper.

Project Variable	Data	Unit
Total Biomass	400	Tonnes
Area of Rice	266	Acres
Trucking Distance	155	Miles
Shipping Distance	593	Miles

Production Step	Use Rate	Unit	LCE	Unit
Biomass Growth	400	Tonne Biomass	-1.39	Tonne CO2e/Tonne Biomass
Total			-556	Tonnes CO2e sequestered
Soil Replenishment				
Nitrogen Fertilizer	6.9	kg/tonne	3.00	kg CO2e/kg
DAP Fertilizer	5.9	kg/tonne	2.00	kg CO2e/kg
Potasium Fertilizer	3.5	kg/tonne	0.25	kg CO2e/kg
Per Tonne			33.38	kg CO2e/Tonne
Total			13.35	Tonne CO2e
Harvest				
Windrow	0.32	Diesel Gal/Acre	10.19	kg CO2/Gal
Baling	0.35	Diesel Gal/Acre	10.19	kg CO2/Gal
Per Tonne			4.54	kg CO2/Tonne
Total			1.82	Tonne CO2
Wrap				
Bale wrap	13.6	Kg plastic/tonne	1.60	kg CO2e/kg PPE
Total			8.70	Tonne CO2e
Transport				
Trucking	62000	tonne miles	0.14	kg CO2/Tonne mile
Total			8.62	Tonne CO2
Shipping	237200	tonne miles	0.005	kg CO2/Tonne mile
Total			1.19	Tonne CO2
Total Emissions			33.67	Tonne CO2e emitted
Net			**-522.33**	**Tonnes CO2e sequestered**

Rice nutrients needed sourced from
Dobermann, A. and T.H. Fairhurst. 2000. Rice: Nutrient Disorders and Management. International Rice Research Institute

Harvest fuel use
https://www.canr.msu.edu/field_crops/uploads/files/MSUCustomWorkRatesJune2019.pdf

Bale Wrap 1-
www.centerracoop.com/wp-content/uploads/2016/12/Bale-Wrap-QAv3-2016-web.pdf
Bale Wrap 2- Amzan Alsabri, Sami G. Al-Ghamdi, Carbon footprint and embodied energy of

PVC, PE, and PP piping: Perspective on environmental performance, Energy Reports, Volume 6, Supplement 8, 2020, Pages 364-370, ISSN 2352-4847, https://doi.org/10.1016/j.egyr.2020.11.173.

Trucking Transportation numbers
Craig, Anthony & Blanco, Edgar & Sheffi, Yossi. (2013). Estimating the CO2 intensity of intermodal freight transportation. Transportation Research Part D: Transport and Environment. 22. 49–53. 10.1016/j.trd.2013.02.016.

Shipping Transportation numbers
Fenhann, J. V. (2017). CO2 Emissions from International Shipping. UNEP DTU Partnership Working Paper Series 2017 Vol. 4

Fertilizer CO2 equivalence
Carbon footprint reference values, Energy efficiency and greenhouse gas emissions in European mineral fertilizer production and use Fertilizers Europe

e. If you can't provide sufficient detail above in 4(d), please point us to a third-party independent verification, or tell us what an independent verifier would measure about your process to validate the numbers you've provided.

<100 words

5. Learning Curve and Costs (Backward-looking) (Criteria #2 and #3)

We are interested in understanding the learning curve of different carbon removal technologies (i.e. the relationship between accumulated experience producing or deploying a technology, and technology costs). To this end, we are curious to know how much additional deployment Stripe's procurement of your solution would result in. (There are no right or wrong answers here. If your project is selected we may ask for more information related to this topic so we can better evaluate progress.)

a. Please define and explain your unit of deployment. *(E.g. # of plants, # of modules)*

Our unit of deployment is a ballasted 500kg round bale of rice straw.

b. How many units have you deployed from the origin of your project up until today? Please fill out the table below, adding rows as needed. Ranges are acceptable.

Year	Units deployed (#)	Unit cost ($/unit)	Unit gross capacity (tCO_2/unit)	Notes

2022	0	0	0	We won't put anything in the basin without a permit. We're within federal waters and want to get permitting and adoption of ocean biomass sequestration of all types.
2021	N/A	N/A	N/A	*<50 words*
2020	N/A	N/A	N/A	*<50 words*
...				

c. Qualitatively, how and why have your deployment costs changed thus far? *(E.g. Our costs have been stable because we're still in the first cycle of deployment, our costs have increased due to an unexpected engineering challenge, our costs are falling because we're innovating next stage designs, or our costs are falling because with larger scale deployment the procurement cost of third party equipment is declining.)*

We're starting durability tests in Q3 of 2022 to observe how standard bales behave and maintain their physical properties when they reach depths of >1000M. The first set of bales sequestered in the basin will cost ~10x more than the second set. This is because fully loaded larger ships are drastically less expensive per ton than smaller ships, and we will have less monitoring on the second set.

d. How many additional units would be deployed if Stripe bought your offer? The two numbers below should multiply to equal the first row in table 3(a).

# of units	Unit gross capacity (tCO_2/unit)
800 bales	0.696 tCO_2e/bale

6. Cost and Milestones (Forward-looking) (Criteria #2 and #3)

We are open to purchasing high cost carbon removal today with the expectation the cost per ton will rapidly decline over time. We ask these questions to get a better understanding of your potential growth and the inflection points that shape your cost trajectory. There are no right or wrong answers, but we would prefer high and conservative estimates to low and optimistic. If we select you for purchase, we'll expect to work with you to understand your milestones and their verification in more depth. If you have any reservations sharing the information below in the public application format, please contact the Stripe team.

a. What is your cost per ton of CO_2 today?

Our first 8 bale test project will cost ~$7K/ton of CO_2 equivalent.

b. Help us understand, in broad strokes, what's included vs excluded in the cost in 6(a) above. We don't need a breakdown of each, but rather an understanding of what's "in" versus "out." Consider describing your CAPEX/OPEX blend, non-levelized CAPEX costs, assumptions around energy costs, etc.

Included in the above is the cost to purchase the bales, ballast the bales, ship the bales by truck, rent the ship, and the price of the monitoring devices (benthic landers) and to have the results of the monitoring experiments.

The main non direct non included cost we will have is permitting. We did not include management personnel, legal advice, or any other non directly sequestration related costs included in the price.

c. How do you expect your costs to decline over time? Specifically, what do you estimate your cost range will be as you reach megaton and then gigaton scale? We recognize that at this point, these are speculative and directional estimates, but we would like to understand the shape of your costs over time.

Our costs will decline as we get larger orders. This is because we will be able to negotiate lower prices with transport companies (larger volumes at predictable intervals cost less than smaller transient loads). The costs are stable once full shiploads are being used (10kton level). Using the ship we have an LOI for the price per ton will be ~$55/Ton of CO_2 equivalent. From 1 million tons to 10 million tons local negative or near negative value biomass in the form of rice straw, sugarcane bagasse and primary mill residues are available. For 10 million tons to 300 million tons biomass needs to be sourced from further up the Mississippi which increases transport costs and the biomass has higher nutrient replenishment needs resulting in ~$70/ton of CO_2 equivalent. For 300 million tons to multiple gigatons per year we will need to also use other basins around the world which will lower the cost again to ~$60/ton of CO_2 equivalent.

d. Where are the primary areas you expect to be able to achieve cost declines? E.g., what are the primary assumptions and sensitivities driving your cost projection? What would need to be true for a long-term cost of <$100/ton to be achievable with your technology? (i.e., you are able to negotiate an x% reduction in CAPEX at scale and purchase renewable electricity at $y/kWh)

The primary sensitivities driving our costs in the near term are ship utilization and monitoring. Once we have a permit and an entity to purchase >10K tons of CO_2 sequestration, the ship will be fully utilized on each load. As we gain more knowledge and data on the sequestration, we will be able to monitor less per ton reducing costs. The supply chain is mature and we have quoted prices, so we are confident we can sequester CO_2 at below $100/ton in the near term.

e. In a worst case scenario, what would your range of cost per ton be? We've been doing a lot of purchasing over the past few years and have started to see a few pieces that have tripped people up in achieving their projected cost reductions: owned vs leased land, renewable electricity cost, higher vendor equipment costs, deployment site adjustments, technical performance optimization, supporting plant infrastructure, construction overruns, etc. As a result, we'll likely push on the achievability of the cost declines you've identified to understand your assumptions and how you've considered ancillary costs. We would love to see your team kick the tires here, too.

There are a couple ways our costs could drastically increase. If there is a hurricane that destroys most of the vessels in the Gulf of Mexico, the price to rent a ship will increase drastically (we would be competing with oil facilities and it would be difficult to compete). If the price of fuel doubles our cost per ton will rise 20%. If the carbon sequestration is less than 100% efficient once the bales reach the basin, our price would increase in proportion to the sequestration efficiency. If there is a bad rice harvest and we have to purchase straw from 5x further away, our price per ton sequestered would increase by 10% (until we got to a large enough scale to hire barges). If all of these things went wrong together in the same year, our prices would be ~$250/tonne CO_2 equivalent.

f. List and describe **up to three** key upcoming milestones, with the latest no further than Q2 2023, that you'll need to achieve in order to scale up the capacity of your approach.

Milestone #	Milestone description	Why is this milestone important to your ability to scale? (200 words)	Target for achievement (eg Q4 2021)	How could we verify that you've achieved this milestone?
1	Bale robustness testing	It will give us some of the data necessary to apply for a research permit in the Orca Basin and information on how bales sink and where they sink.	Q3 2022	We could send you pictures and the report on the process parameters that increase bale durability
2	Purchase agreements for	This is what will make the project	Q1 2023	We can send you the documents

	execution of the entire supply chain	actually happen.		or have you on calls with our suppliers
3	Obtain a research permit for in situ testing of our carbon sequestration strategy	The research permit is the first gating factor in getting a legal pathway to do biomass sequestration within US Federal waters.	Q2 2023	We can send you the permit and champagne so we can all celebrate it together.

i. How do these milestones impact the total gross capacity of your system, if at all?

Milestone #	Anticipated total gross capacity prior to achieving milestone (ranges are acceptable)	Anticipated total gross capacity after achieving milestone (ranges are acceptable)	If those numbers are different, why? (100 words)
1	0 tonnes CO_2e/year	1 tonne CO_2e/year	We will have our first test unit deployed under a small scale research permit in the Santa Barbara basin.
2	1 tonne CO_2e/year	1 tonne CO_2e/year	
3	1 tonnes CO_2e/year	520 tonnes CO_2e/year	This is the small single test run, and its operation is gated by having a permit in place to sequester biomass within Federal waters. If we can use this test experiment to receive a full permit, this immediately goes to 2M tonnes CO_2e/year

g. How do these milestones impact your costs, if at all?

Milestone #	Anticipated cost/ton prior to achieving milestone (ranges are acceptable)	Anticipated cost/ton after achieving milestone (ranges are acceptable)	If those numbers are different, why? (100 words)
1	\$7K/tonne CO_2e	\$7K/tonnes CO_2e	
2	\$7K/tonnes CO_2e	\$750/tonnes CO_2e	We will be purchasing biomass at a larger scale, and the cost of using a larger ship makes the price drastically cheaper per tonne.
3	\$750/tonnes CO_2e	\$750/tonnes CO_2e	The price stays the same because the purchase agreements above dictate the price of the sequestration.

h. If you could ask one person in the world to do one thing to most enable your project to achieve its ultimate potential, who would you ask and what would you ask them to do?

Our gating factor is the permit, which is complex and has no clear pathway. To fix this, I'd ask my acquaintance Teresa to quit her job and come work with us full time as she's executed similar projects with the government agencies we need to work with.

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

We could use a research vessel for two weeks. Do you happen to be able to introduce us to James Cameron or Richard Branson?

7. Public Engagement (Criteria #7)

In alignment with Criteria 7, Stripe requires projects to consider and address potential social, political, and ecosystem risks associated with their deployments. Projects with effective public engagement tend to do the following:

- Identify key stakeholders in the area they'll be deploying
- Have mechanisms to engage and gather opinions from those stakeholders and take those opinions seriously, iterating the project as necessary.

The following questions are for us to help us gain an understanding of your public engagement strategy and how your project is working to follow the White House Council on Environmental Quality's draft guidance on responsible CCU/S development. We recognize that, for early projects, this work may be quite nascent, but we are looking to understand your early approach.

a. Who have you identified as your external stakeholders, where are they located, and what process did you use to identify them? Please include discussion of the communities potentially engaging in or impacted by your project's deployment.

> We have identified stakeholders throughout our supply chain. This goes from farmers, to transportation operators, to maritime shipping companies, to fisheries and shrimpers. Additionally there are governmental stakeholders including the USDA, EPA, NOAA, BOEM, DOI, and the US Fish and Wildlife Service. We identified these stakeholders through conversations with organizers in those communities. For example, we are working with a farming group in St. Louis to understand the needs of farmers and how a project like this would impact farmers and farming communities. For the EPA, NOAA, Department of Fish and Wildlife, we have hired a Law firm in Louisiana to help us understand how to work in conjunction with each. To understand federal stakeholders we have hired a consultant who previously was the Chief Counsel on the Committee of Natural Resources at the US House of Representatives.

b. If applicable, how have you engaged with these stakeholders and communities? Has this work been performed in-house, with external consultants, or with independent advisors? If you do have any reports on public engagement that your team has prepared, please provide. *See Project Vesta's community engagement and governance approach as an example.*

> We have engaged many of these stakeholders by calling them on the phone and asking what they think about our project, and how it would impact their communities. The rest of the stakeholders that are harder to get in contact with (mostly the government agencies) we had consultants tak to them. We do not have formalized results on our public engagement.

c. If applicable, what have you learned from these engagements? What modifications have you already made to your project based on this feedback, if any?

> Some examples of what we have learned are farmers are open to the idea of biomass removal as long as there is evidence of sustainable land practices for biomass removal from reputable sources (I.E. University of Illinois, University of Nebraska), shrimpers and fishers are ok with our project as long as it doesn't interrupt their fishing routes or productivity, and that there are many interested and interconnected parties for deployment of any activity in the ocean who want to see more data. Based on these engagements we've increased the detail in which we are testing our scientific hypothesis.

d. Going forward, do you have changes planned that you have not yet implemented? How do you anticipate that your processes for (a) and (b) will change as you execute on the work described in this application?

We are planning on increasing our public outreach to various trade groups to get their opinion and input and also to start creating formalized documents that make public our interactions with stakeholders. As we execute this project it's expected there will be a greater influx of interested parties and we will need to systematically reach out on a regular basis to see how each group is feeling about our project and what is working or not working for each.

8. Environmental Justice (Criteria #7)

a. What are the potential environmental justice considerations, if any, that you have identified associated with your project? Who are the key stakeholders?

The primary environmental justice considerations we see are for communities that are hurt by climate change, communities whose income streams will be eliminated by climate positive legislation, and communities with historically higher levels of poverty. The key stakeholders we can support in at risk climate communities are small scale farmers (we have ties to the corn growers associations so we're starting with engagement there) and people living within the paths of hurricanes along the gulf. Coal transportation workers and oil workers will lose their jobs as fossil fuels are phased out, but both are very important to making our system run and we will focus on having our supply chains in these areas. There are many areas with historically higher levels of poverty along the Mississippi and we are working to find cities that would like to have biomass staging areas as job centers.

b. How do you intend to address any identified environmental justice concerns?

We plan on trying to do the right thing by making sure there are quality high paying jobs in the communities that are hurt by climate change and climate change legislation. We are fortunate that our supply chain and process lends itself to this easily.

9. Legal and Regulatory Compliance (Criteria #7)

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

Our law firm in New Orleans has provided us with a regulatory pathway memo and the various Federal and State agencies that have jurisdiction over our proposed project. There is not a clear permitting process for Ocean Based Biomass Carbon Sequestration as no project like this has been done before in Federal waters, but our lawyers have shown us interest in Ocean Carbon Sequestration at the Federal level within NOAA, BOEM and EPA which should help create a pathway for sequestration.

b. What domestic permits or other forms of formal permission do you require, if any, to engage in the research or deployment of your project? Please clearly differentiate between what you have already obtained, what you are currently in the process of obtaining, and what you know you'll need to obtain in the future but have not yet begun the process to do so.

We will need to obtain a permit to sequester terrestrial biomass on the seafloor. We will either try to obtain a modified EPA dumping permit or a structural permit from BOEM. We have not begun the formal process as we are waiting to finish our next experiment which will give us drift and robustness data on our bales.

c. Is your solution potentially subject to regulation under any international legal regimes? If yes, please specify. Have you engaged with these regimes to date?

Our solution falls within Federal waters and may fall under the London Convention and Protocol (the London Protoc only covers dumping waste material, while biomass as a carbon storage device may or may not fall under waste). Have not spoken to the London Protocol about our project.

d. In what areas are you uncertain about the legal or regulatory frameworks you'll need to comply with? This could include anything from local governance to international treaties. For some types of projects, we recognize that clear regulatory guidance may not yet exist.

We are uncertain which Federal Agency will take lead on Anoxic Biomass Carbon Sequestration, and which agencies have authority to permit or stop the project. We have hired consultants and lawyers familiar with existing permitting to help us navigate the regulatory environment.

e. Has your CDR project received tax credits from any government compliance programs to-date? Do you intend to receive any tax credits during the proposed delivery window for Stripe's purchase? If so, which one(s)? (50 words)

No.

10. Offer to Stripe

This table constitutes your offer to Stripe, and will form the basis of our expectations for contract discussions if you are selected for purchase.

	Offer to Stripe
Net carbon removal	522.33 tonnes of CO_2 equivalent

Delivery window *at what point should Stripe consider your contract complete?*	December 2023
Price (\$/metric tonne CO_2) ***Note on currencies:*** *while we welcome applicants from anywhere in the world, our purchases will be executed exclusively in USD (\$). If your prices are typically denominated in another currency, please convert that to USD and let us know here.*	\$750/tonnes CO_2e We would use the same price we suggested above as it is our estimate for what the sequestration portion of the project will cost.

Application Supplement: Biomass

(Only fill out this supplement if it applies to you)

Feedstock and Physical Footprint (Criteria #1)

1. What type of biomass does your project rely on?

Rice Straw.

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

We are procuring it from farmers in Crowley, Louisiana.

3. Please fill out the table below regarding your feedstock's physical footprint. If you don't know (e.g. you procure your biomass from a seller who doesn't communicate their land use), indicate that in the table.

	Area of land or sea (km^2) in 2021	Competing/existing project area use (if applicable)
Feedstock cultivation	NA Procuring waste biomass	Rice cultivation is complimentary
Processing	0.01 km square ballasting and boat loading facility	Oil and gas servicing
Long-term Storage	900 square meters within the anoxic basin	None

4. Imagine, hypothetically, that you've scaled up and are sequestering 100Mt of CO_2/yr. Please project your footprint at that scale (we recognize this has significant uncertainty, feel free to provide ranges and a brief description).

	Projected # of km^2 enabling 100Mt/yr	Projected competing project area use (if applicable)

Feedstock cultivation	Still none, 100M tons of CO2 equivalent can come from the byproducts of 101K km^2 (25M acres) of corn	None, using agricultural byproducts reduces the cost of food
Processing	5 x .1 km^2 ballasting and boat loading facilities	Oil and gas staging areas
Long-term Storage	5 square km within basin stacked 100m tall	None

Permanence, Additionality, Ecosystem Impacts (Criteria #4, #6, and #7)

5. How is your biomass processed to ensure its permanence? What inputs does this process require (e.g. energy, water) and how do you source these inputs? (You should have already included their associated carbon intensities in your LCA in Section 6.)

Our biomass is wrapped in plastic and sunk into a basin to ensure its permanence. The baling material (plastic) is included in the LCA, and the ballast material will be waste concrete from construction sourced from New Orleans.

6. (Criteria 6) If you didn't exist, what's the alternative use(s) of your feedstock? What factors would determine this outcome? *(E.g. Alternative uses for biomass include X & Y. We are currently the only party willing to pay for this biomass resource. It's not clear how X & Y would compete for the biomass resources we use. OR Biomass resource would not have been produced but for our project.)*

Our feedstock is currently burned in the field. In the event that cellulosic ethanol becomes economically viable (unlikely given the 20 years researchers have spent trying to develop it), we would compete with ethanol producers for this biomass. Rice straw has been produced for 1000s of years. If there was value to the straw, people wouldn't burn it.

7. We recognize that both biomass production and biomass storage can have complex interactions with ecological, social, and economic systems. What are the specific negative impacts (or important unknowns) you have identified, and what are your specific plans for mitigating those impacts (or resolving the unknowns)? *(200 words)*

Some of the potential negative impacts of biomass takeoff include ground fertility reduction,increased fertilizer use, increased land use, and competition for food production. Ground fertility reduction and increased fertilizer use go hand in hand. To keep existing croplands fertile we do have to increase fertilizer use (this is a mass transport issue because

potassium and phosphorus are always removed when removing biomass). To mitigate the negative impacts we will be tracking our farmers soil health while we track the carbon in their soils. To mitigate increasing croplands, we only use biomass that is a byproduct from existing use and not plants solely grown for biomass. We mitigate competition for food production by being complimentary with food production. By purchasing crop byproducts from food crops, we decrease the price of food by increasing the total profitability per acre.

8. Biomass-based solutions are currently being deployed around the world. Please discuss the merits and advantages of your solution in comparison to other approaches in this space.

There are pros and cons to most biomass based solutions. We happen to think our solution fits in a sweet spot that can have an impact relevant to the scale of need (the need being to quickly, permanently, and at a reasonable cost take 700Gt of CO_2 out of the air)

The main biomass solutions are aforestation/reforestation, soil management, biochar, bio-oil pushed back into the earth, kelp sinking, and BECCS. Forest and soil carbon based solutions (and any solution that stores carbon in living materials) doesn't have permanence with a changing climate. Our solution is permanent. Biochar has soil utility, but puts carbon back into the air during pyrolysis and only sequesters 1/10th of the carbon stored in the biomass (1) while our solution stores all the carbon. Bio-oil will take more time to deploy at scale than our solution (though we do think it's a really cool idea). Kelp sinking is also a good idea, but takes time to scale and has unknown consequences on the ocean nutrient removal at a large scale.

Our solution is permanent, unlike deforestation and soil carbon practices, it doesn't need much time to scale because the industrial equipment exists to reach 100Mt/year already, and it's low cost (~$60/tonne of CO_2 equivalent).

Note: We value all of these sequestration strategies as valid parts of the solution to lowering the level of CO_2 in the atmosphere, and we know all of these strategies will have an easier time with permitting than our solution.

(1) Lefebvre, D., Williams, A., Meersmans, J. et al. Modelling the potential for soil carbon sequestration using biochar from sugarcane residues in Brazil. Sci Rep 10, 19479 (2020). https://doi.org/10.1038/s41598-020-76470-y

Application Supplement: Ocean

(Only fill out this supplement if it applies to you)

Physical Footprint (Criteria #1)

1. Describe the geography of your deployment, its relationship to coastlines, shipping channels, other human or animal activity, etc.

> Our deployment will be from the Port of New Orleans to the Orca Basin (south west of New Orleans 349km). It is within the Gulfmex No. 2 Lightering area, outside of shipping channels, not in a protected marine environment, and >10 miles from the nearest oil platform.

2. Please describe your physical footprint in detail. Consider surface area, depth, expected interaction with ocean currents and upwelling/downwelling processes, etc.
    a. If you've also filled out the Biomass supplement and fully articulated these details there, simply write N/A.

> N/A, see above

3. Imagine, hypothetically, that you've scaled up and are sequestering 100Mt of CO_2/yr. Please project your footprint at that scale, considering the same attributes you did above (we recognize this has significant uncertainty, feel free to provide ranges and a brief description).
    a. If you've also filled out the Biomass supplement and fully articulated these details there, simply write N/A.

> N/A, see above

Potential to Scale (Criteria #2 and #3)

4. Building large systems on or in the ocean is hard. What are your core engineering challenges and constraints? Is there any historical precedent for the work you propose?

We avoid building any systems in the ocean by using existing supply chains and vessels. Our core engineering challenges in the short term will be to make sure the bales are structurally sound when they reach 2000m deep, and to deploy benthic landers for testing. The bale durability research will be very Edisonian in nature (rope+bale+winch), and for the benthic lander we will use off the shelf systems that are currently used for research.

Externalities and Ecosystem Impacts (Criteria #7)

5. How will you quantify and monitor the impact of your solution on ocean ecosystems, specifically with respect to eutrophication and alkalinity/pH, and, if applicable, ocean turbidity?

We will monitor the impact of our solution by first testing the area we will be deploying our solution to observe a baseline, then over time using battery powered sample testers attached to our benthic landers (example deepwaterbuoyancy.com/product/benthic-lander/), along with sample gathering systems that we can signal to release on a quarterly basis.