[Cquestr8] Carbon Removal Purchase Application

General Application

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

Company or organization name

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

Cquestr8 Ltd

Name of person filling out this application

Steve Willis

Email address of person filling out this application

[redacted]

Brief company or organization description

<10 words

Ocean DIC addition: Safe, Scalable, Affordable & Permanent Carbon Sequestration

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.

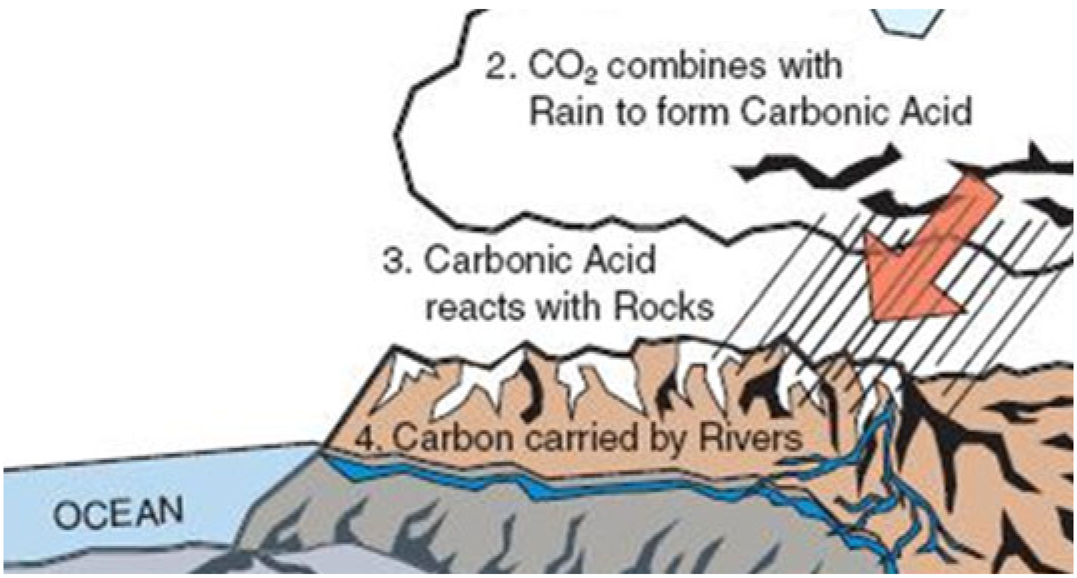
<1500 words

The Cquesrt8 process is a large-scale, low-cost sequestration system based on the accelerated weathering of limestone. Water, CO2, and limestone are combined to form a calcium bicarbonate solution in a large flow of water that is added to the oceans to both sequester the CO2, and strengthen the natural pH buffer of the ocean to resist ocean acidification.

BACKGROUND

Nature maintains the historic equilibrium level of CO2 in the atmosphere using the slow carbon cycle. Rain falls through the atmosphere, absorbing CO2. This forms a weak carbonic acid that reacts with limestone and other rocks. Soluble calcium bicarbonate formed in the reaction with limestone enters rivers and is transported to the oceans. The oceans contain a massive stock of carbon as dissolved inorganic carbon (DIC), around 90% of which is in the form of calcium bicarbonate. This slow carbon cycle moves hundreds of millions of tonnes of CO2 each year out of the atmosphere and into the ocean as stable calcium bicarbonate, which also buffers the ocean at around pH 8.1.

The calcium bicarbonate laden water is also known as 'hard water'. This is common in nature, and many rivers pass through limestone areas. The Yangtze River, for instance, has a pH of around 8. Alkaline rivers often have more biodiversity than acidic rivers.



It has been said 'When you deal with natural systems, you should look for the simplest explanation, always'. Building on this thought, a man-made method is needed to emulate the slow carbon cycle, and to do this at a large scale, at as many locations and as efficiently as possible.

As noted above, the ocean carbon sink is the largest stock of mobile carbon on the planet, at around 40,000 Gt contained as DIC – most of which is calcium bicarbonate. If we were to add another 100 Mt/y of carbon as calcium bicarbonate for 100 years, the ocean DIC (Dissolved Organic Carbon) would increase by a mere 0.025% compared to the existing global variation in DIC concentration of +/-10%. It is essential that a means is found to transfer CO_2 from the atmosphere, and convert it into a beneficial pH buffering form, to add to this sink (in addition to all and every other option that can be developed, nature based or otherwise – the excess CO_2 problem is far too large to be solved by any one method alone.)

We applied the simple question ‘if the problem had to be solved using this approach, if there was no other option, how would it be done?’ This is a good sharpening tool.

CAN IT PHYSICALLY BE DONE?

We have worked on some of the largest industrial sites and processes around the world. These processes undoubtedly contributed to the CO_2 problem. The solutions to the problem will need to be built on the same scale and operated in similar ways. The CDR industry will eventually be very large indeed.

AWL, accelerated weathering of limestone, is a low energy process, reacting CO_2 and limestone together in water. We have established that a suitable process can be built and that existing industries are already handling water, CO_2 and limestone at the required scale. This means that existing equipment suppliers could provide much of what is needed to build large scale plants quickly – no radically new technology needs to be developed or scaled, a crucial shortcut to rapid deployment.

This large-scale equipment could be used to build million tonne per year scale units next to large, hard to abate industries, giving them a safe, low cost, secure CO_2 disposal route which at the same time benefits the ocean.

THE CQUESTR8 PROCESS

The Cquestr8 process can take CO_2 from a variety of sources, including eventually DAC and bioenergy. providing a sequestration pathway for CO_2 that is already being extracted from existing processes.

A Cquestr8 unit will be built on industrial sites adjacent to CO_2 sources at coastal locations. The reaction system produces calcium bicarbonate solution which is stabilised and monitored prior to being returned to the ocean.

We plan to build a 1000 TPY demonstration unit in 2022.

stripe

Carbon Removal Target Criteria (for your reference)

Cquestr8

Carbon Removal Target Criteria	Cquestr8
1. **Physical footprint**: Takes advantage of carbon sinks less constrained by arable land	1. Uses the ocean
2. **Capacity**: Has a path to being a meaningful part of the carbon removal solution portfolio (>0.5Gt CO_2/yr by 2040)	2. Yes, ample limestone and water available
3. **Cost**: Has a path to being affordable at scale (<$100/ton by 2040)	3. ~$25/tonne to sequester. Capture processes exist:
4. **Durability**: Stores carbon permanently (>1,000 years)	4. 200,000 years
5. **Verifiability**: Uses scientifically rigorous and transparent methods for monitoring and verification	5. Metered capture
6. **Additionality**: Results in net new carbon being removed rather than taking credit for removal that would have occurred regardless	6. See Oxford Principles
7. **Safety and compliance**: Legally compliant, responsibly and actively engaging with the public to determine and mitigate possible risks and negative externalities	7. Ongoing studies on positive marine impacts. Discharge subject to issue of permit.
8. **Net-negative lifecycle**: Results in a net reduction in atmospheric CO_2	8. Yes

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.)*

<50 words

Cquestr8 Ltd is a company providing a large scale sequestration process. We expect to take CO2 that has been gathered by others, from point sources, and eventually from DAC processes.

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

<300 words

1. Carbon Pricing: This solution is based on the expectation that the cost of emitting CO2 will exceed the cost of sequestering it.

2. Financial: Ensuring access to funding to allow scale up to reach commercial scale.

3. Societal Acceptance: It is clear that natural processes cannot, alone, restabilize the atmosphere and climate fast enough to avoid catastrophe - although clearly, they must be deployed to the maximum possible extent. Industrial-scale, man made assistance is also urgently required. Unfortunately, despite this inconvenient truth, there is a societal preference for nature-based solutions and resistance to large-scale human intervention, despite the

uncomfortable reality that human activities have geo-engineered the planet for centuries. Negative views of engineering are understandable because very often industries have used the ocean to dump their waste for profit. Our goal is to use industrial scale methods to sequester CO2 to expressly improve the ocean. Public support by STRIPE and others is important in gaining societal acceptance of managed clean up processes, in the same way that we already deal with sewage through industrial plants, and not relying on nature.

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

• *List of links* Patent work is ongoing.

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

a. Please fill out the table below.

	Timeline for Offer to Stripe
Project duration *Over what duration will you be actively running your DAC plant, spreading olivine, growing and sinking kelp, etc. to deliver on your offer to Stripe? E.g. Jun 2021 - Jun 2022. The end of this duration determines when Stripe will consider renewing our contract with you based on performance.*	*<10 words* September 2022 to September 2023
When does carbon removal occur? *We recognize that some solutions deliver carbon removal during the project duration (e.g. DAC + injection), while others deliver carbon removal gradually after the project duration (e.g. spreading olivine for long-term mineralization). Over what timeframe will carbon removal occur?*	*<10 words* During plant operation. The discharge contains sequestered CO2.

E.g. Jun 2021 - Jun 2022 OR 500 years.	
Distribution of that carbon removal over time *For the time frame described above, please detail how you anticipate your carbon removal capacity will be distributed. E.g. "50% in year one, 25% each year thereafter" or "Evenly distributed over the whole time frame". We're asking here specifically about the physical carbon removal process here, NOT the "Project duration". Indicate any uncertainties, eg "We anticipate a steady decline in annualized carbon removal from year one into the out-years, but this depends on unknowns re our mineralization kinetics".*	*<50 words* The CO2 removal rate is around 3 t/d (= 1,000 TPY) whilst the plant is online. The unit will also be used for further testing, so the removal rate will be varied up and down over the period of operation to collect optimisation data.
Durability *Over what duration you can assure durable carbon storage for this offer (e.g, these rocks, this kelp, this injection site)? E.g. 1000 years.*	*<10 words* Ocean stability of calcium bicarbonate is at around 20,000 years

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

Number/range

An additional 100 Mt/y of DIC in the world's oceans would have a residence time of around 20,000 years plus or minus a few thousand years, depending on the rate of addition compared to the decades long rates of mixing and transportation in the oceans.

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.)*

<200 words

Bicarbonate dissolved in the ocean is the largest sink of mobile carbon on the planet. The ocean carries a stable inventory of around 40,000 GT of dissolved inorganic carbon (DIC) which has remained around this level for millennia. The DIC concentration varies by around

+/-10% across the globe (the Atlantic Ocean is high compared to the Pacific Ocean which is at the lower end of the range).

Nature adds around 1 to 2 Gt/y of carbon. 2 Gt/y of carbon addition equals a residence time of ~20,000 years.

An additional 100 Mt/y of industrially formed DIC would reduce the average residence time from ~20,000 to ~19,000 years.

https://www.fs.usda.gov/ccrc/topics/global-carbon

https://www.globalcarbonproject.org/

Rattan Lal - Managing Soils and Ecosystems for Mitigating Anthropogenic Carbon Emissions and Advancing Global Food Security, BioScience, October 2010 / Vol. 60 No. 9, (2010) 708–721. ISSN 0006-3568, electronic ISSN 1525-3244
https://watermark.silverchair.com/60-9-708.pdf

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?

<200 words

Durability risks are low as the bicarbonate added to the sea will be widely dispersed and indistinguishable from the existing DIC. The ongoing ocean risk is for acidification to continue causing pH to fall. Adding calcium bicarbonate resists this acidification but can't stop it, however falling pH ensures increased stability of added calcium bicarbonate – precipitation would only occur if the pH rose significantly, yet expectations are for pH to fall throughout the remainder of this century.

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.)*

<200 words

The amount of bicarbonate produced by the process will be carefully monitored – the CO2, limestone and water will be measured and metered.

The composition of the water leaving the unit will be continuously monitored to ensure a complete mass balance. The ocean surrounding the discharge will also be monitored for signs of positive effects as well as any small negative impacts – tests indicate that some commercial seaweeds respond positively to elevated bicarbonate levels in water, and calcifying organisms respond positively as the calcite saturation is returned to the natural background level.

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 Do not subtract for embodied/lifecycle emissions or permanence, we will ask you to subtract this later	*E.g. XXX tCO_2* 1,000 tCO2
If applicable, additional avoided emissions e.g. for carbon mineralization in concrete production, removal would be the CO_2 utilized in concrete production and avoided emissions would be the emissions reductions associated with traditional concrete production	*E.g. XXX tCO_2* NA

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)*

<150 words

1000 tCO2 reacts with 2273 t limestone to form calcium bicarbonate solution.

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).

metric tonnes CO_2/yr

50 tonnes/year

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.)*

<200 words

Calcium bicarbonate is a soluble salt found in the ocean at a concentration of 2 mmol/litre.

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.

- *Up to 5 links*

Links

https://hcs1000.org/hcs-whitepapers/where-is-all-the-carbon-on-earth/

https://hcs1000.org/hcs-whitepapers/ocean-bicarbonates-to-store-carbon-at-global-scale/

https://www.researchgate.net/publication/353600696_A_Negative_Emissions_Paper_from_Herculean_Climate_Solutions_Anthropogenic_Discharges_to_the_Coastal_Environment_A_Revie

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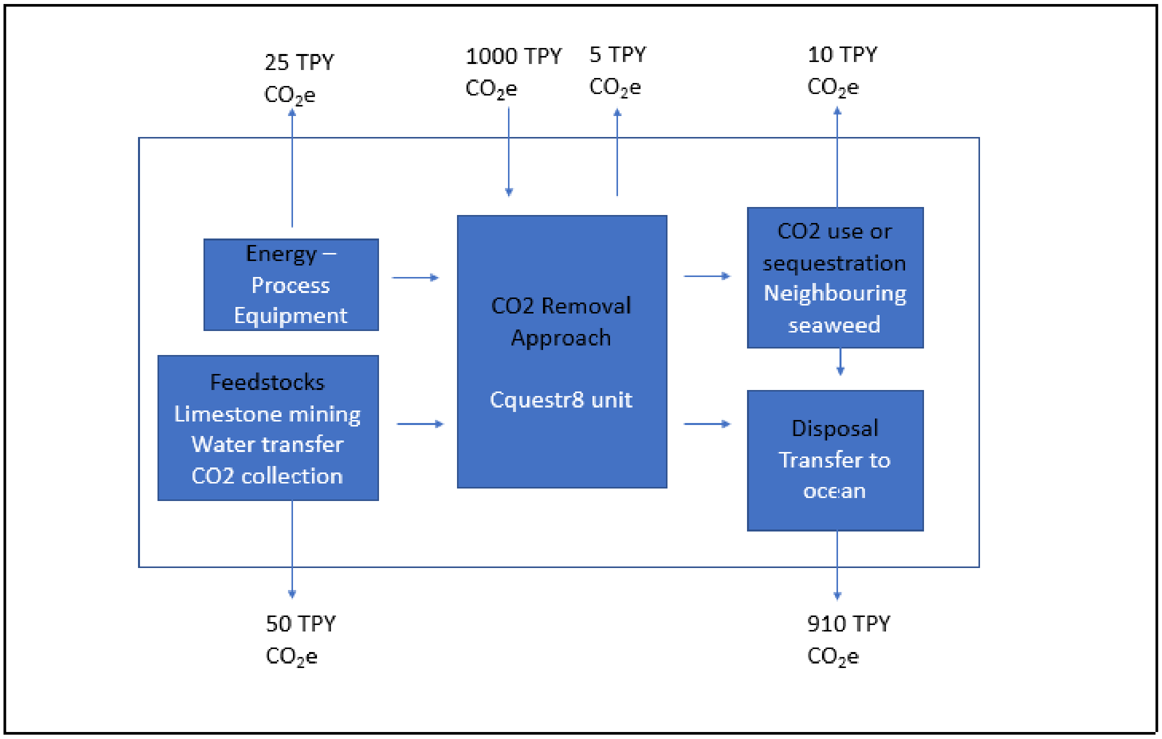
4. Net Capacity / Life Cycle Analysis (Criteria #6 and Criteria #8)

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	*Should equal the first row in table 3(a)* 1,000 TPY
Gross project emissions	*Should correspond to the boundary conditions described below this table in 4(b) and 4(c)* 90 TPY for power and other raw materials
Emissions / removal ratio	*Gross project emissions / gross carbon removal: should be less than one for net-negative carbon removal systems, e.g. the amount emitted is less than the amount removed* 0.09
Net carbon removal	*Gross carbon removal - Gross project emissions* 910 TPY

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 last year 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?

<100 words

Water is widely moved at large volumes and low cost

Limestone is one of the most common mined minerals and can be produced at low cost and low impact – furthermore, cement works will be big users of the Cquestr8 process and can use limestone from their own quarries, reducing costs

CO2 is already available at reasonably high concentration, 10-100% in many locations, and considerable efforts are going into the development of processes such as DAC that aim to produce CO2 for CCS type systems. Some of this CO2 can go to Cquestr8 ocean storage.

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](#).

<200 words

Standard calculations can be used to size equipment to provide the necessary processing conditions that allow the conversion to take place. Although the equipment is large, it is commercially available and even the biggest items could be ordered tomorrow and installed and running within 18 months.

The CO_2 to bicarbonate energy conversion is very small – the chemical reaction is very slightly exothermic although any temperature changes would probably be undetectable. The main energy input will be as electrical power consumption on the processing equipment. Calculations indicate that this will be a small percentage of the total energy load, depending on the particular requirements of the host site.

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. (We may request such an audit be performed.)

<100 words

When the plant has been built we will review the actual power consumption vs predictions and explore further ways to reduce the loads. Further integration opportunities have been identified and will be explored

The use of existing process components will reduce cost and complexity, speed up delivery and provide a ready pool of existing suppliers which will be happy to provide equipment for this new and growing market.

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 your progress.)

a. Please define and explain your unit of deployment. (*E.g.* # of plants, # of modules) *(50 words)*

<50 words

The demonstration unit will be 1,000 TPY, but a full-size unit for a cement works or similar is expected to be 1,000,000 TPY. There will be many thousands of units of several different sizes to dispose of CO_2 near the source

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 if necessary.

Year	Units deployed (#)	Unit cost ($/unit)	Unit gross capacity (tCO_2/unit)	Notes
2021	Two	$50,000	50 TPY	*<50 words* Closed and open loop units to establish process operating conditions.
2020	One		grammes	*<50 words*
2019	zero			*<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.)*

<50 words Test units have been built at minimal cost from off the shelf process equipment. As size increases, processing cost per tonne drops At full scale, 50kT and above, significant savings will be possible

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)
Number One	*# tCO_2/unit* 1,000

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

We ask these questions to get a better understanding of your growth trajectory and inflection points, there are no right or wrong answers. If we select you for purchase, we'll expect to work with you to understand your milestones and their verification in more depth.

a. What is your cost per ton CO_2 today?

\$/ton CO_2

The 50 tpy unit is so small that the costs are not relevant to the costs of a production scale plant. We estimate the 1,000 tpy plant will capture cost at around \$1,000 taking into account the expected short plant lifetime - it will be shut down once the next generation 50,000 tpy plant is built

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, assumptions around energy costs, etc.

>100 words

The 1,000 tpy facility will include energy purchased from the electrical grid at around \$0.10 / kWh - Future units would likely have dedicated energy supply contracts at a substantially lower price.

These costs include the plant CAPEX, cost of limestone, water and electricity, and site personnel. It does not cover the cost of CO2 supply

c. 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	*<100 words* Extended run of 50 TPY open loop rig on host site.	*<200 words* To establish operating conditions and collect data for detailed design of 1,000 TPY and	Q2 2023	*<100 words* We will prepare a report capturing the operating conditions and the design

		50,000 TPY units		criteria
2	*<100 words* Preparation of FEED (front end engineering design) for 1,000 TPY unit, along with a detailed study of the expected size and cost of a 50kT an 1MT unit	*<200 words* The FEED will allow us to get a detailed handle on the likely CAPEX costs, along with the footprint and the likely structural requirements. We have an estimate in work and have already discussed the requirements with the experienced contractor The FEED will also provide a detailed set of drawings and images of the various units so that customers and investors can see what they will be buying The study of the larger sized units will provide details on the likely long-term cost of full scale operation and indicate where savings can be made	Q2 2023	*<100 words* Stripe will be presented with evidence of the FEED study
3	*<100 words* Construction of a	*<200 words* This rig will allow	Q3 2023	*<100 words* We will invite

	1,000 TPY demonstration unit that will comply with XPRIZE requirements	optimisation of processing conditions over an extended operation and provide more design information for the larger plants It will allow real customers and funders to walk around a real plant and see it at work It will be our entry to the XPRIZE The building of a rig will also address the challenge of where they might be built and which companies might host/own/build and operate them, and clarify how at least one of the business model options might work		Stripe, funders and future customers to visit the site

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	*Should match 3(c)* 50 TPY	50 TPY	*<100 words* While trials of the open loop rig will be to confirm operating conditions, opportunities to extend the operating window will be

			investigated
2	50 TPY	50 TPY	*<100 words* The FEED exercise may identify further opportunities for improvement and optimisation of the design – reducing costs, footprint, complexity and potentially increasing capacity and flexibility
3	50 TPY	1000 TPY	*<100 words* The 1000 TPY unit will be run for an extended period on the host site, taking every opportunity to improve performance and explore ways of effectively integrating the unit into the operations of the host site

d. 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	*Should match 6(a)* $5,000	$5,000	*<100 words*
2	$5,000	$5,000	*<100 words*
3	$5,000	$2,000 CAPEX $360 OPEX	*<100 words* The 1000 TPY unit will be 1000 times smaller than the intended full-size plant, so both CAPEX and OPEX are

			high for a demonstration site However, the OPEX is the main concern, and even at this small scale, the disposal cost has dropped substantially. Prices are higher than they would be at full scale because of the higher price of small batches of limestone, transportation costs and the likelihood that CO2 will have to be purchased for at least some of the work.

e. 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?

<50 words

The shining example of a person who has achieved seemingly impossible goals in very short timeframes is Elon Musk. We would invite him to join the board and ask him to both provide the necessary early funding AND lend his immense scientific-technical intellect to guiding us on how to go much, much faster – for example, perhaps by finding a way to factory assemble our process plants and automate that process to drive down costs

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

<50 words

It is essential that routes to large scale CO2 disposal sinks are identified and deployed as quickly as possible, following the principle of

- Will it work?

- Can it do a million tonnes?

- Is it a genuine negative emission?

All and every idea that fulfills these criteria should be enthusiastically supported and trumpeted as good examples of what needs to be done – efficiency improvements, offsets and targets cannot deliver net zero. Real, physical negative emissions are urgently required.

Owen Hewlett, chief technology officer of Gold Standard "You can't offset your way to net zero."

7. Public Engagement and Environmental Justice (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 some mechanism 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. There are no right or wrong answers, and we recognize that, for early projects, this work may not yet exist or may be quite nascent.

a. Who are your external stakeholders, where are they, and how did you identify them?

<100 words

The Cquestr8 process was designed for hard to abate industries that will struggle to hit zero emissions – including cement, lime (CaO), steel, chemicals, bioenergy and other heavy industries.

When it becomes established, the DAC industry will need a low-cost destination for all the CO2 that it collects. The Cquestr8 process will supply an economic option to many of these operators

Operational units will be built on or next to these large industrial sites, will have a low height and noise profile compared to the main site and will not have a major impact on neighbours

The water returned to the sea from the process will have a mostly positive effect, improving water quality and encouraging seaweed, fish and shellfish.

Other primary stakeholders are the purchasers of carbon credits. Many of the credits produced will be used by the companies operating the sites

b. If applicable, how have you engaged with these stakeholders? Has this work been performed in-house, with external consultants, or with independent advisors?

<100 words

We have spoken directly with stakeholders in the Lime and Cement industries, and they recognise that the rising price in EU emissions permits, the growing number of carbon taxes and other international restrictions pose an existential threat to their industries.

If they are to keep operating, they need to find GT scale carbon sinks – and for most of these industries, there are no realistic alternatives at a relevant scale

A leading international lime producing company is hosting our open loop trial on their production site in Malaysia and have been fully supportive our work.

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?

<100 words

We have learned that the large emitting industries are very keen to see practical solutions that are compatible with their current operations and can which be rapidly deployed

The discussions have encouraged us to widen our discussions and we have spoken to a large Water Authority. They are also very interested in this approach, as they already handle and discharge large volumes of water which are big enough to host large scale trials in the coming months and years.

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?

<100 words

Our plans have been adjusted as the project has developed. There are several possible pathways ahead, mostly focusing on where the 1,000 TPY rig might be built, as this changes which other feedstocks need to be sourced and which are readily available.
We fully expect the plan to adjust further as we involve more people and choose particular development paths.

e. What environmental justice concerns apply to your project, if any? How do you intend to consider or address them?

<100 words

This is an industrial scale process that will be installed for the most part on industrial sites. There are few directly affected indigenous or neighbourhood groups

Discussions with a producer of seaweed indicate that they would favour processes of this type as calcium bicarbonate encourages the growth of seaweeds and shellfish.

Cquestr8 processes will be deployed to respect and improve the local marine environment and the associated coastal communities.

Unfortunately, there is little indigenous knowledge of how to reverse ocean acidification and reduce CO2 levels in the atmosphere. A sustained industrial effort caused the problem, and a sustained industrial scale effort will be needed to reverse it.
The relevant traditional knowledge in this case is chemical engineering and the application of industrial techniques that can stabilise the ocean and the atmosphere. This is what we intend to do with the Cquestr8 process

11. Legal and Regulatory Compliance (Criteria #7)

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

<100 words

For all the initial Cquestr8 projects, national regulations will govern the operations. Detailed EIAs (environmental impact assessments) will be conducted to ensure that the best possible outcome is achieved, improving the quality of coastal waters.

The London Protocol is often raised in the context of Ocean Alkalinity enhancement, Ocean Nutrification and other unfortunately-named geoengineering solutions.

The London Protocol has a long and complex history, and recent discussions suggest that this is acknowledged and that there may be some revision.
However, the protocol is only ratified by 5 countries and is understood to only apply to international waters, and does not apply in coastal waters, so will not affect Cquestr8 projects.

b. What permits or other forms of formal permission do you require, if any? 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.

<100 words

As this is a large industrial process, EIAs will, of course, be required. Demonstration projects will take place on sites that already have a discharge permit, and water will be controlled to ensure that water remains within the existing discharge range

c. 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.

<100 words As the projects will be wholly within coastal waters it appears that the London protocol will not be a legal impediment (although it will remain a psychological one for many)

d. Does the project from which you are offering carbon removal receive credits from any government compliance programs? If so, which one(s)? (50 words)

<50 words The hard to abate industries such as cement and lime are already or soon will be subject to the ETS and other international schemes. In the EU charges have already reached 60 Euros. The stakeholders have told us that they are looking for disposal routes for CO2 that are less than $100 which will not swing ever upwards with the market price.

12. 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 (metric tonnes CO_2)	*Should match the last row in table 4(a), "Net carbon removal"* 910 TPY

Delivery window (at what point should Stripe consider your contract complete?)	*Should match the first row in table 2(a), "Project duration"* 12 months
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.*	*This is the price per ton of your offer to us for the tonnage described above. Please quote us a price and describe any difference between this and the costs described in (6).* $420 = 360 opex + 60 to reflect capex Total $382,200

Application Supplement: Surface Mineralization

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

Source Material and Physical Footprint (Criteria #1 and #8)

1. What source material are you using, and how do you procure it?

<100 words There are three raw materials, CO2, water and limestone. CO2 will be provided by businesses emitting CO2, including bioenergy, biogas, cement, steel (not coal/nat.gas power because they can be abated with RE) There are numerous commercially available processes to capture CO2. Limestone is widely available at low cost around the world. We plan to initially source from existing mines. Water is by far the largest ingredient. Sites will be located where water can be accessed at low cost. Ideally, piggybacking on an existing water handling facility. There are a great many sites with substantial water flows that can be considered.

2. Describe the ecological impacts of obtaining your source material. Is there an existing industry that co-produces the minerals required?

<100 words

Around 10 Gt of limestone is mined for cement, lime and construction, which is covered by existing EIAs. The environmental considerations are well understood and accepted. Sequestering 100 Mt/y CO_2 adds only about 1% more mining.

Vast amounts of water are already processed. We will use many of the existing streams, and operate within existing discharge permits. When ocean water is lifted for the process, it will be returned to the oceans at a better quality – a focus on undoing existing harms, and 'being the best that it can be' for the oceans and atmosphere.

CO_2 from the source will be prevented from reaching the atmosphere – an inherently more efficient proposition than collecting it from the atmosphere once it has been released.

3. Do you process that source mineral in any way (e.g grinding to increase surface area)? What inputs does this processing require (e.g. water, energy)? You should have already included their associated carbon intensities in your LCA in Section 6.)

<200 words

The input limestone can be accepted as small gravel, and being a much softer rock than silicates the crushing energy is moderate. The electrical input for crushing is estimated around 4 to 5 kWh/tonne limestone, or 11.4 kWh/t CO_2 captured. Ideally this should use renewable power.

However, if the electricity comes from a 55% efficiency CCGT burning natural gas (45 MJ/t) this will create 2,500 kWh/t CO_2 released.

The net benefit of the crushing is 220 t CO_2 sequestered per tonne CO_2 produced by the power plant.

4. Please fill out the table below regarding your project's physical footprint. If you don't know (e.g. you procure your source material from a mining company who doesn't communicate their physical footprint), indicate that in the square.

	Land area (km^2) in 2021	**Competing/existing project area use (if applicable)**
Source material mining	*E.g. X km^2 (dedicated basalt mining facility) OR N/A (material is waste product from X km^2 mine)*	*E.g. Existing mine for basalt*

	By way of example a small lime production facility in Malaysia already extracts 500,000 t/y of limestone. Any single limestone mine providing an additional 1000 t/y of extraction would not be noticeable. We do not expect any increase in the land area already allocated for limestone mining.	Limestone is one of the most widespread and commonly mined minerals, which is one reason why it is an attractive option as a feedstock.
Source material processing	*E.g. 2 km^2 (manufacturing facility or mine)* The limestone can be used in its rough gravel form, the same size as is used to feed a cement works.	*E.g. Gravel production facility* The limestone produced will be a supplement to existing production. Some additional equipment and labour may be required
Deployment	*E.g. 20 km^2 (transportation hub + beach area)* For the demonstration unit the footprint will be around 10m x 50m For a full sized plant of a million tonnes per year, a footprint of less than 0.5km2 is expected	*E.g. Agricultural land + beach* The operating unit will, in many cases, be on the same site as industrial facility either producing the CO2 or processing the water – there is usually sufficient space on existing industrial sites to be able to install a utility process like this.

1. 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)**
Source material mining	The process will be operating on hundreds of mostly coastal sites and will be supplied by nearby existing limestone quarries.	Some storage area will be required, perhaps using old coal marshalling yards.

	Limestone will be taken from existing quarries and will marginally increase the extraction from these mines – a 1% increase in extraction would capture 100 Mt/year CO_2 We do not expect any significant increase in the land area already allocated for limestone mining.	Bulk material will be shipped by rail or sea from the quarries to the processing plants
Source material processing	The limestone will be processed in the same manner as the existing product from the quarry. Some existing capacity will be needed, but even at 100MT/yr rate, the limestone usage for Cquestr8 is small compared to cement and other uses	The limestone will be delivered to sites by train or ship, and there will be moderate sized stock piles which are maintained by regular deliveries.
Deployment	There will be several hundreds of Cquestr8 plants installed at CO_2 sources and water handling plants around the world. These plants will be part of the industrial operation, either on the same site or over the fence. The units will be small compared to the main factory and will be operated as a simple utility, much less complex than the main plant.	Industrial sites are usually fairly 'brownfield' sites – old, sometimes contaminated, undesirable land that can't be used for much else. Cquestr8 sequestration units could be built on such sites and make beneficial use of land that is of little use for anything else.

5. If you weren't proceeding with this project, what's the alternative use(s) of your source material? What factors would determine this outcome? *(E.g. Alternative uses for olivine include X & Y. It's not clear how X & Y would compete for the olivine we use. OR Olivine would not have been mined but for our project.)*

<50 words The limestone quarries would still exist and be producing material for cement, lime, and building materials.

Measurement and Verification (Criteria #4 and #5)

6. We are aware that the current state of the field may include unknowns about the kinetics of your material. Describe how these unknowns create uncertainties regarding your carbon removal and material, and what you wish you knew.

<200 words Cquestr8 offers an aqueous based mineralisation reaction which takes place under controlled conditions within the facility and to a measurable end point. The discharge stream contains the already sequestered CO2 converted to calcium bicarbonate. There are practical limits to the maximum concentrations that can be achieved which is demonstrated in our test rigs. The results are supported by literature and open surce computer modelling tools. The monitoring and verification uses standard industrial flow meters, pH sensor and other widely available, reliable equipment. CO2 sequestered into this route will be accurately measured and will be easy to verify.

7. If your materials are deployed extensively, what measurement approaches will be used to monitor weathering rates across different environments? What modelling approaches will be used, and what data do these models require?

<100 words The 'weathering' of limestone in the Cquestr8 process takes place within the reactor. There is no reaction taking place in the environment.

Human and Ecosystem Impacts, Toxicity Risk (Criteria #7)

8. What are the estimated environmental release rates of heavy metals (e.g. Cr, Ni, Pb, Hg)? Dust aerosol hazards? P loading to streams? How will this be monitored?

<100 words

There are numerous rivers around the world, such as the Yangtze, that do run through natural limestone areas and have a pH of 8 or above. These rivers pick up soluble calcium bicarbonate and whatever other minerals or elements that may be mobile from the limestone.

The same applies for the Cquestr8 process. Any small proportion of other soluble elements will leave with the water and the calcium bicarbonate. Cquestr8 will avoid using limestone deposits containing any other soluble or reactive minerals that would be undesirable to release to the oceans.

Non-soluble minerals remaining after reaction will be filtered out before discharge.

The Cquestr8 outlet will be the equivalent of a manmade river from a limestone or chalk area, with high DIC, high alkalinity and a relatively high pH. Alkaline rivers such as these are recognised as more healthy rivers and support a wider biodiversity than more acidic rivers.

9. If minerals are deployed in farmland, what are the estimated effects on crop yields, what's this estimation based on, and how will actual effects be monitored?

<100 words

Outlet water from the Cquestr8 process will not be discharged onto farmland.

Calcium bicarbonate directly benefits some seaweeds, including commercially farmed varieties, many of which also absorb carbon from the water as bicarbonate. Similarly, shellfish struggling in areas with depressed calcite saturation benefit from the higher alkalinity occurring from adding calcium bicarbonate.

Note that it is NOT intended that any more than a tiny fraction of the sequestered carbon should be taken up by seaweed, this is a useful co-benefit which will encourage wide deployment of the Cquestr8 system, as aqua-culturalists will welcome having a unit near their farms.

10. How will you monitor potential impacts on organisms in your deployment environment? (E.g. Health of humans working in agricultural contexts, health of intertidal species, etc. depending on the context of deployment)

<100 words

The water entering and leaving the process will be closely monitored, as will the wider discharge area with regular sampling and fixed instruments.

The materials used are naturally abundant, non-toxic and will be managed within strict parameters.

11. If you detect negative impacts, at what point would you choose to abort the project and how?

<100 words

The Cquestr8 system mimics the reaction that occurs as rainwater flows through limestone areas and then into rivers, the impact of which is already known.

If there are effects, both positive and negative, these will be studied so that the cause can be properly understood. Being a reactor-based process, we will be able to adjust the operation to ensure positive outcomes, and we can of course instantly stop the flow if there are as yet unexplainable impacts.

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.

<200 words

The amount of land required is small and the Cquestr8 units will be installed on or alongside industrial sites such as cement works or WWTP that are producing large amounts of CO2 and/or water. Many will be on existing coastal industrial sites (brownfield sites) which are often poorly suited to redevelopment.

The water from the process will, in many cases, be released through existing discharge systems and as part of existing discharge permits – effluents are often on the acidic side, so increased alkalinity and raised pH will be beneficial.

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.

<200 words

The land-based footprint is covered in the previous sections.

We know from studying both natural subsea vents and industrial water discharges (e.g. RO plants, power plant cooling, etc.) that dispersion and dilution occurs within a few hundreds of meters of the discharge point. The Cquestr8 discharge will not change water temperature, overall salinity or density and so will mix well with the ocean. The added DIC will be indistinguishable from what is already present in the ocean, and the DIC concentration increase unmeasurable after 200m or so. The net improvements to water quality will be very small and steady.

We have the opportunity to further condition the discharge if it would benefit the local coastal waters. For example we could reaerate if the water source is low in oxygen, helping to reverse any eutrophication effects that area common in coastal waters.

It is intended that the released water should be beneficial to the sea in as many ways as possible, balanced pH, higher alkalinity, higher DIC, aerated and closely monitored.

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.

<200 words

There will be many hundreds of Cquestr8 plants installed at CO2 sources and water handling plants around the world.

These plants will be part of the industrial operation, either on the same site or over the fence. The units will be small compared to the main factory and will be operated as a small, simple utility, much less complex than the main plant.

The water flows on some sites will be very large and likely to create stable local conditions of high alkalinity, aeration and some up welling. These conditions will be monitored and managed to ensure as many beneficial outcomes as possible, encouraging fish populations and abundant ocean life in the area. Such areas would be combined with other ocean improvement strategies and improved fishing practices to create a stable ongoing, high yield area which would take pressure off areas which have been over fished and give them chance to return to normal.

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?

<200 words

In our previous careers we have worked offshore and been involved in large scale installations and operations. Working offshore can be difficult, expensive, unpredictable, and hazardous.

The Cquestr8 processing units will be built onshore and the discharge pipes will be run out along the seabed to suitable release points. There are a great many pipes of this type in operation already, and some of these pipes can be used for the Cquestr8 duty – for example, either piggybacking on an existing WWTP, or reusing an old power plant cooling water outfall.

The discharge points on the seabed will be designed to ensure that there is good uplift and mixing. Installations of this type are simple, durable and can be installed at low cost.

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?

<200 words

The Cquestr8 process will improve the quality of water returning to the ocean, helping to rebalance the ocean in several different ways: adjusting the pH to bring the local coastal waters back to the required values (if needed), increased DIC and total alkalinity to further resist acidification, and where there is existing eutrophication we could add aeration and modify the outlets to encourage mixing.

The water chemistry and quality will be monitored by sensors that are available (this is a rapidly evolving field) to test ocean waters, including fixed buoys, on-pipe sensors, sail drones and other systems as they become available.

Detailed monitoring, including automatic data transfer to a global central collection facility, will confirm the beneficial effects. This will also allow any additional 'blue carbon' benefits to be assessed and eventually for the associated carbon credits to be claimed.