# RepAir
## Carbon Removal Purchase Application

## Applicant Instructions

**Please read the following information carefully and in full before beginning your application. If you have any questions as you work through, please book time with the Stripe team here and provide context on your questions in the booking request.**

Hi there,

Thank you so much for your work on carbon removal, and thank you in advance for taking the time to apply for Stripe's purchase. This document serves as your application for Stripe's Spring 2022 Carbon Removal Purchase cycle. For your reference, all previously submitted applications are available here.

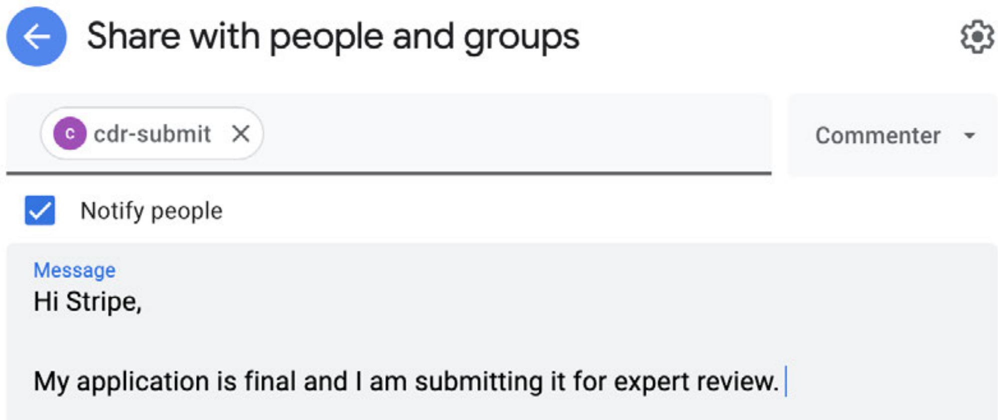
### Timeline

- **Friday, April 1st, 5pm PT:** This application is due. You are welcome and encouraged to submit early.
- **Mid April:** Stripe and Stripe's scientific expert reviewers will assess your application against our target criteria and hold a project interview with each team. We may also contact you during this period with clarifying questions or requests from our expert reviewers for more information regarding your application. Please respond promptly to these requests if you receive them to help enable a swift and fair review process.
- **Mid May:** Stripe notifies selected projects and jointly builds formal purchase contracts.
- **May/June:** Purchases announced, full content of all project applications made public.

### How to apply

- **Step 1: Determine which category supplements apply to your project**
    - This document includes the General Application as well as all category supplements. All applicants should fill out the General Application, as well as whichever (typically 1 - 2) supplements that apply to their approach.

  - You should fill out applicable supplements IN ADDITION to the General Application.
  - Using examples from Stripe's existing portfolio:
    - Sustaera would fill out the DAC supplement AND the Geologic Injection supplement.
    - Eion Carbon would fill out the Surface Mineralization supplement
    - Running Tide would fill out the Biomass supplement AND the Ocean supplement.
    - CarbonBuilt would fill out the $CO_2$ Utilization supplement.
  - It should be clear which supplements apply to your project, but if not, tag us in a comment or email cdr-apply@stripe.com and we can help clarify.
- **Step 2: Delete the supplements that don't apply to you.**
  - Resulting in a document with the General Application and your applicable supplements only.
- **Step 3: Fill out the application in the document itself!**
  - If you have any questions, or are confused by a question, tag cdr-apply@stripe.com inline and we'll do our best to assist. Please tag us as early in the application process as possible.
- **Step 5: TO SUBMIT YOUR APPLICATION, "Share" it in Google Docs with cdr-submit@stripe.com.**
  - Please delete this "Project Instructions" section prior to submitting.
  - Please give us "Commenter" permissions.
  - Please check the "Notify people" box.
  - Please enter a message making clear that your application is complete.




- **Your submission constitutes your consent for Stripe to make your full application and all of its content available publicly under a CC-0 “Public Domain” License, regardless of whether or not Stripe selects you for purchase.** For more details, see “Why we make applications public”.

## What we’re looking for

Please refer to Stripe’s carbon removal target criteria for a characterization of projects Stripe is excited to support. For clarity, we’ve slightly modified these criteria since our purchasing start in 2020, but their spirit remains the same. Our 2022 criteria are:

1. **Physical footprint**: Takes advantage of carbon sinks less constrained by arable land
2. **Capacity**: Has a path to being a meaningful part of the carbon removal solution portfolio (>0.5Gt $CO_2$/yr by 2040)
3. **Cost**: Has a path to being affordable at scale (<$100/ton by 2040)
4. **Durability**: Stores carbon permanently (>1,000 years)
5. **Verifiability**: Uses scientifically rigorous and transparent methods for monitoring and verification
6. **Additionality**: Results in net new carbon being removed rather than taking credit for removal that would have occurred regardless
7. **Public engagement and legal compliance**: Legally compliant, responsibly and actively engaging with the public to determine and mitigate possible risks and negative externalities
8. **Net-negative lifecycle**: Results in a net reduction in atmospheric $CO_2$

This application is meant to solicit high quality information such that we can evaluate you against the above criteria. There's no rubric that will give you points for specific answers. Instead, we are seeking to build a comprehensive understanding of your carbon removal solution. We value clear and accurate information over romanticization, and welcome citations and links to real data where appropriate.

Please be aware that your application and all content you provide here will be made public at the conclusion of Stripe's purchase cycle, to support transparency and knowledge-sharing in the field.

## Why we make all applications public

Commercial-scale permanent carbon removal is a nascent field. We've developed this application and our overall purchase philosophy with the goal of advancing transparency and knowledge-sharing across the field, hopefully enabling impact beyond the dollar amount of any particular purchase we may make.

All applications to our earlier purchase cycles were made public, and can be accessed here. We're grateful to all our projects for providing this level of transparency. Making applications public enables derivative academic works and independent analysis from nonprofits like CarbonPlan (example here, here), and we've heard from a wide range of investors, engineers, and scientists that the corpus of applications is a valuable source of data on the current state of the field and opportunities for advancement.

For these reasons, we're again making applications from this purchase cycle public.

**SPRING 2022 UPDATE:** That said, we've heard feedback over the past year from the founder community that this level of transparency is tough, particularly for companies in stealth or in the process of patent filing. **We hear you and are making an adjustment this cycle.** The application should still serve as a comprehensive, standalone representation of the merits of what you're building, but we will allow for selective sharing of sensitive data directly with our expert review team through email exchange or the team interview outside of the public application. Please email the Stripe team at cdr-apply@stripe.com to identify and discuss any proposed public omissions.

We thank you not only for applying to our purchase, but for providing this valuable contribution to the field's collective knowledge via your public application.

## Fine print

We intend to make the selection process as informal as possible. However, we do expect that (a) the content of your application is, to the best of your knowledge, complete and correct; (b) you do not include any content in your application that breaches any third party's rights, or discloses any third party's confidential information; (c) you understand that we will publicly publish your application, in full, at the conclusion of the selection process. You also understand that Stripe is not obliged to explain how it decided to fund the projects that are ultimately funded, and - although extremely unlikely - it is possible that Stripe may decide to not proceed, or only partially proceed, with the carbon removal purchase project. Finally, if you are selected as a recipient for funding, Stripe will not be under any obligation to provide you with funding until such time as you and Stripe sign a formal written agreement containing the funding commitment.

stripe

# General Application

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

Company or organization name

RepAir DAC Ltd.

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

Israel

Name of person filling out this application

Ben Achrai

Email address of person filling out this application

[redacted]

Brief company or organization description

RepAir develops and commercializes highly efficient and scalable DAC technology

## 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.

RepAir offers a highly efficient and modular solution that utilizes its novel Electrochemically Driven $CO_2$ Separation (EDCS) technology - an electrochemical cell-based technology to separate $CO_2$ molecules from the air by applying electrical current. The RepAir system comprises modules of stacked cells and fans that mobilize atmospheric air through the EDCS modules. RepAir EDCS advantages include:
(1) Very-low overall cost of 50-75 $/t at the Mt/y scale.
(2) Ultra low energy consumption.
(3) Operation at ambient conditions.
(4) Powered solely by electricity from renewable sources.
(5) No dependence on liquids or consumables.
(6) Minor physical footprint.
(7) Minor carbon production footprint.

(8) High modularity and scalability.
(9) Use of only abundant materials.

RepAir proposes a 200 t/y CDR project by collaborating with Carbfix – an Iceland-based company that is operating a proprietary mineralization-based $CO_2$ sequestration technology. Carbfix approach is proven and has been extensively demonstrated in recent years. The joint project approach is to demonstrate $CO_2$ separation by RepAir's novel EDCS-based DAC technology. The captured $CO_2$ will be further streamed, dissolved in water, and injected underground into a nearby well, where $CO_2$ is turned into a stable mineral embedded in the underground rock formations in less than two years. The Carbfix technology accelerates the natural carbon cycle known to regulate the long-term $CO_2$ concentrations in the atmosphere. The carbon mineralization occurs when $CO_2$ dissolved in water reacts with suitable rock formations (mafic or ultramafic rocks), containing high divalent cation concentrations. The acidic carbonated water causes dissolution of the host rock reservoir, causing it to release cations into the fluid, which react with the dissolved $CO_2$ to form stable carbonate minerals in the pore spaces and fractures of the host rock. Carbfix's approach is the safest and fastest carbon storage method demonstrated to date.

The project location is at an already developed site in Iceland, made up of fresh volcanic basalts, which have been confirmed to rapidly mineralize $CO_2$ underground. A Carbfix co-located geothermal plant provides renewable baseload electricity and water. Construction permits and land space for the DACS system have already been secured and an environmental impact assessment for future large-scale injection of $CO_2$ is underway.

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.)*

RepAir brings an innovative EDCS-based DAC solution that can be deployed for any type of permanent $CO_2$ storage. The suggested CDR project will demonstrate RepAir's DAC technology integrated with Carbfix's innovative and already proven permanent mineralization-based sequestration. ON Power is a sister company of Carbfix, which owns and operates the geothermal power plant providing the renewable electricity as well as the land-space for the DAC plant. Both Carbfix and ON Power are subsidiaries of Reykjavik Energy.

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

The three most important risks the project faces:

1. Market risk – although CCUS is not a new concept, DAC has started to gain recognition as a viable mitigation approach to climate change only in recent years. There is an open debate among experts, on whether carbon sequestration or carbon utilization should be the ultimate long-term solution. Meanwhile, carbon price trend is not clear, incentives and tax schemes are not fully developed yet. This makes the voluntary carbon credit market the lowest hanging fruit until the global regulated

market fully matures.

2. First of a Kind technological project – RepAir is developing an innovative technology for a new application. Although the electrochemical cell design is inspired by fuel cells and batteries, this new application requires a thorough understanding and vast experience in electrochemical systems R&D, engineering, and production. The RepAir core team comprises world class scientists and engineers with expertise in electrochemistry, and we intend to collaborate with global manufacturers and integrators to mitigate those risks.
3. Capital needs – like any DAC project, the RepAir project is capital intensive. Cost is mainly attributed to designing and building the hardware in very small quantities. Some of the capital to support the project may come from venture capital funds, however, most of the project financing should come from governments, NGO, competition etc. The inherent uncertainty of the project financing presents a risk. RepAir intends to mitigate this risk by working on multiple financing options for the project.

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

- https://patents.google.com/patent/US10811711B2/en
- https://uspto.report/patent/app/20210036350
- https://patentscope.wipo.int/search/en/detail.jsf?docId=WO2021236979&_cid=P12-L10EOI-51459-2
- https://patents.google.com/patent/WO2020234464A1/en?oq=PCT%2fEP2020%2f064306
- https://patents.google.com/patent/WO2021053084A1/en?oq=PCT%2fEP2020%2f076005

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 diverse and multidisciplinary team working on the project includes managers, scientists, engineers, and technicians with RepAir and Carbfix.

RepAir team brings decades of accumulative experience in developing and deploying electrochemical systems. It excels in design and engineering of the EDCS core technology and its integration to the injection device. The team has the support of a research group at the University of Delaware in the USA, led by Prof. Yushan Yan, one of RepAir co-founder and a world-renowned electrochemistry expert.

Carbfix team has extensive experience in the geophysical and scientific aspects of the injecting system as well as the infrastructure-related and geological knowhow of injecting a mixture of $CO_2$ and water underground at specific locations for mineralization. Carbfix currently operates injection systems in three different sites and has all the in-house expertise required to permit, implement and commission such systems in Iceland.

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

a. Please fill out the table below.

| | **Timeline for Offer to Stripe** |
|---|---|
| Project duration<br><br>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 2022 - Jun 2023. The end of this duration determines when Stripe will consider renewing our contract with you based on performance. | Q4/2024 – Q4/2025 |
| When does carbon removal occur?<br><br>*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?*<br><br>*E.g. Jun 2022 - Jun 2023 OR 100 years.* | Q4/2024 – Q4/2025 |
| Distribution of that carbon removal over time<br><br>*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".* | Evenly distributed |
| Durability<br><br>*Over what duration you can assure durable* | >1000 years |

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| *carbon storage for this offer (e.g, these rocks, this kelp, this injection site)? E.g. 1000 years.* | |

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

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| The durability of solid carbonate minerals, once precipitated, exceeds 1,000 years with no definitive upper limit (Snjæbjornsdottir et al. 2020). |

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.)*

Carbfix injection achieves instant solubility trapping, the second most durable form of geological carbon storage. This has been confirmed by downhole camera imaging (no bubbles were observed) and flux measurements at well-head (Benson et al. 2005 (Cambridge) Sigfusson et al. 2015).

Innovative approaches have also been developed to monitor the fate of the injected gas mixture confirming the rapid mineralization process (Matter et al. 2016, Pogge Von Strandmann et al. 2019). This involves regular sampling and tracer tests using adjacent monitoring wells, a combination of chemical and tracer analyses, geochemical calculations, isotope analyses and physical evidence, showing that the injected $CO_2$ are fixed as predominantly calcite minerals within a few months to two years from injection, depending on the temperature of the storage formation.

The durability of the solid carbonates is generally understood to exceed 1000 years. Carbfix is effectively removing $CO_2$ from the short carbon cycle and placing it in the long carbon-cycle. The vast majority of all carbon on Earth is fixed in rocks with an average residence time of thousands to millions of years (Snæbjornsdottir et al. 2020).

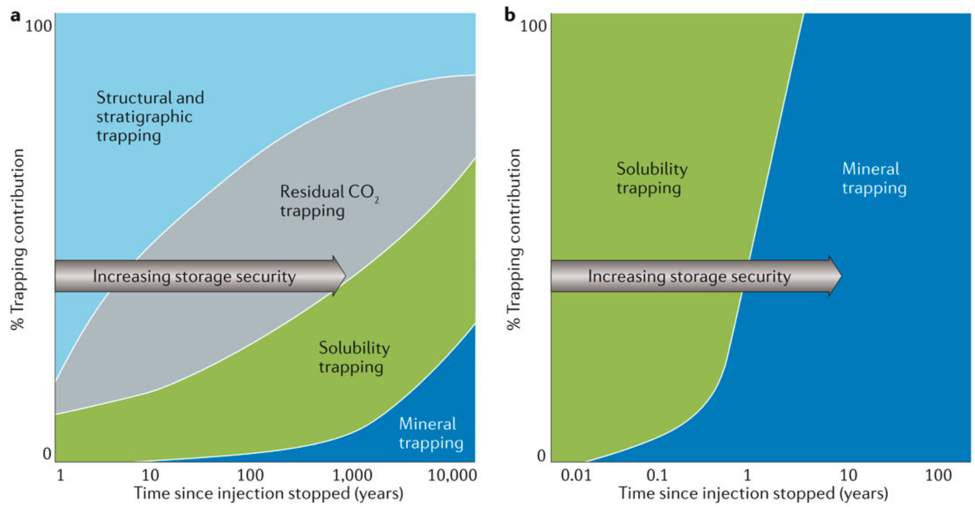


*Figure 1: Comparison of $CO_2$-trapping mechanisms and storage security for supercriticaland dissolved $CO_2$ injections (adopted from Snæbjornsdottir et al. 2020 and references therein).*

References:

Patent: https://patentscope.wipo.int/search/en/detail.jsf?docId=WO2020234464

Literature: http://www.carbfix.com/scientific-papers

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?

Once the subsurface mineralization has been verified (predominantly using tracers) there no need for long term monitoring.

The low-pressure mineralization process occurs through a period of 2 years. During that time, all the $CO_2$ is trapped within the aqueous solution (i.e., dissolved in water) by the time it is injected into the subsurface reservoir. This eliminates the necessity of an impermeable cap-rock trapping the $CO_2$ below it (such as in other sequestration approaches), as the $CO_2$-charged water is denser than surrounding fluids in the reservoir. Therefore, it has no tendency to rise back to the Earth's surface, presenting a negligible risk of re-emission of the sequestered $CO_2$.

Carbfix's innovative approach is well established, commercialized and supported by numerous scientific papers and patents. The company has encountered and overcome socioeconomic barriers for deployment at this site. One such risk is induced seismicity which has been well managed since start of injections (Hjorleifsdottir et al. 2021). No seismicity has been traced to the injection of $CO_2$. In fact, Carbfix has managed to solve the health hazard posed by

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| excessive hydrogen sulfide emissions from the power plant by co-capturing H2S with $CO_2$ and inject it where it rapidly forms iron sulfides (Aradottir et al. 2015). This has earned Carbfix high local public acceptance (Aradottir & Hjalmarsson 2018). |

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.)*

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| The primary method of verification and quantification will be in the form of tracer tests, in which non-reactive, and sometimes reactive, chemical tracers are co-injected with the $CO_2$ and nearby monitoring wells regularly sampled. Coupled with mass-balance calculations based on a transport model, the mineralization, and rates, can be quantified (Matter et al. 2014, Matter et al. 2016, Snæbjornsdottir et al. 2017, Clark et al. 2020). |

## 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<br><br>Do not subtract for embodied/lifecycle emissions or permanence, we will ask you to subtract this later | 200 |
| If applicable, additional avoided emissions<br><br>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 | - |

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)*

RepAir's DAC scaleup plan from the lab prototype to the 200 t/y project includes the following steps:

1. Increasing cell area to an optimized size.

2. Stacking an optimized number of cells to a single stack.

3. Integrating a few stacks to form the basic building block module having a capacity of 50-100 t/y. Each module will include a designated air contractor for streaming air into the EDCS unit.

4. Constructing the needed number of modules to obtain the project capacity.

All modules' $CO_2$ outlet streams will be connected to the inlet of Carbfix's pipeline that will pull and compress the separated $CO_2$ stream for further mineralization in a single designated adjacent well.

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).

*DAC: < 1 t/y*

*Sequestration: 18,000 t/y*

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.)*

Please see RepAir's technological details in the link.

Carbfix has three active injection wells in operation at the site. They are currently injecting around 18,000 t/y but each well has a capacity of around 70,000 t/yr based on average injectivity of 60 L/s assuming a 25:1 ratio of water-to-$CO_2$ at a well-head pressure of 10 bar. All these parameters have been extensively measured and documented during the 15-year lifetime of the nearby geothermal power plant.

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.

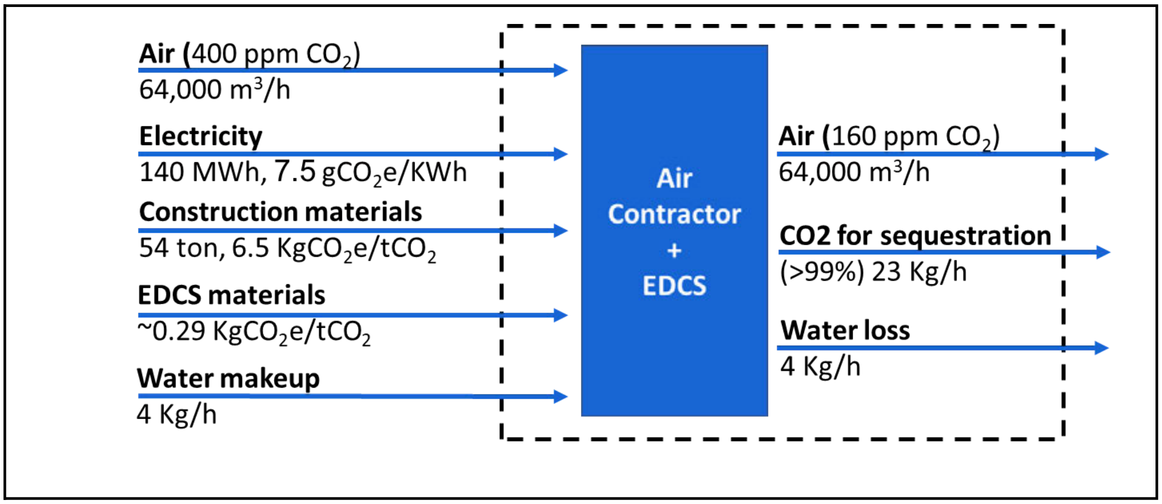
www.carbfix.com/scientific-papers

## 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 | 200 |
| Gross project emissions | *Should correspond to the boundary conditions described below this table in 4(b) and 4(c)*<br><br>*1.41* |
| 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*<br><br>*1.41* / 200 = 0.00705 |
| Net carbon removal | *Gross carbon removal - Gross project emissions*<br><br>200 – 1.41 = 198.59 |

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?

Since Carbfix's emissions due to energy consumption and production of raw materials are negligible (see Deutz & Bardow (2021) LCA paper, which is based on the same injection site), we focus here solely on our innovative EDCS-based DAC technology, including: air stream, water intake and emissions due to electricity and materials fabrication.

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.

The streams and materials values are constructed according to our internal comprehensive cost analysis for a 100 t/y DAC unit (including PFD, mass&energy balance, stream table, quotes, etc.).

The emissions' values are constructed according to our TEA and LCA. The latter is on-going and undergoes refinements as we go - it is focused at this stage on carbon emissions and takes into account values reported in peer reviewed papers and in public literature:

Construction materials - Paper 1, Link 1

EDCS materials - Paper 2, Link 1, Link 2

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.

## 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 basic module will capture ~100 t/y. A 10,000 t/y CDR site may include 100 EDCS modules, aligned in two perpendicular rows such that each row will include two levels. All modules will be connected to a pipeline collecting the separated $CO_2$ for further mineralization stage in a nearby well.

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 | 1 | ~25000 | ~Kg/y | Lab prototype demonstrating proof of concept performance metrics. The prototype includes electrical load, $CO_2$ analyzer, MFCs, humidity and temperature controllers, automated operation. |
| 2021 | 1 | - | ~Kg/y | POC prototype |

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.)*

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| Our costs have been constant since we are still in the first cycle of deployment. Costs will fall with larger scale deployment (materials production, sites construction) and optimizations of EDCS process, reducing CAPEX. |

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) |
|---|---|
| 2 | 100 t/y |

## 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?

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| RepAir's EDCS: > 1000 $/t<br><br>Carbfix: 10-25 $/t |

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.

The cost above is comprehensive and includes CAPEX and OPEX:

**CAPEX**:

- EPC (based on cost analysis for a 100 t/y module, including quotes).
- EDCS core unit (based on cost analysis of DOE reports for small-scale as well as

mass production of automotive fuel cell systems. Cost breakdown was normalized by cell active area (m2) and adjusted to relevant individual elements (e.g., electrode composition, stack hardware etc.). The EDCS core unit is the major contributor to the total costs.
- Carbfix does not envision drilling a dedicated injection well for this project but rather rely on existing wells.

**OPEX**:

- Land, labor, energy (geothermal produced electricity, 0.042 $/KWh).

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.

Based on the above, we expect costs to dramatically decline with increasing number of DAC modules and projects through economies of scale (mass production) and learning curves for projects' EPC.

We target a cost range of 50-75 $/t at the Mt/y scale.

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)

Cost decline will be achieved through the following key areas:

EDCS units: progressing from small-scale to mass production is expected to significantly reduce cost per unit.

Number pf projects: EPC costs are expected to significantly drop through mass production of construction materials, as well as learning curve of project design etc. (e.g., at 1 Mt/y: 100 sites, each site with capture capacity of 10,000 t/y)

Optimized performance: improved capture rate which will result in less EDCS material - the major CAPEX driver.

Optimized streaming mechanism: improved structure will result in improved capture rate which will further decrease CAPEX, but also OPEX since optimized streaming mechanism will

| |
|---|
| demand lower energy consumption.<br><br>Renewable electricity: prices are expected to drop down to 0.02-0.03 $/KWh throughout the present decade. |

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.

| |
|---|
| 150-200 $/t<br><br>The EDCS core unit is the major cost driver. To significantly reduce its cost, we aim to further improve our performance metrics. In a worst-case scenario of that plan, we project the cost stated above. |

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 | MVP demonstration | The MVP is the major stepping-stone towards the 200 t/y project | Q2/23 | MVP V&V documentation |

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 | Anticipated total gross capacity after achieving milestone (ranges are | If those numbers are different, why? (100 words) |
|---|---|---|---|

| | | | |
|---|---|---|---|
| | **are acceptable)** | **acceptable)** | |
| **1** | < 1 t/y | 1-5 t/y | MVP includes scaling up from lab-scale to EDCS stacks |

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** | **$1200-$1800** | **$1200-$1800** | |

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?

| |
|---|
| We would ask Elon Mask to explicitly declare that our RepAir's solution is the technology of choice for DAC and that our project presents the ultimate solution to DAC among all competitors in our space. |

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

| |
|---|
| • Position RepAir as a leading DAC technology in the eyes of other carbon purchasers.<br>• Increase the visibility of RepAir to potential investors.<br>• Endorse RepAir to allow for additional carbon purchase contracts in the near future. |

## 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.

The project will be deployed in Hellisheidi, South-West Iceland. This is the most developed geological mineralization site in the world and host of the world's first commercial-scale full-chain DACCS system (Orca).

Iceland has a total population of 369 000, mostly in the capital area, located 20 km from Hellisheidi. The population has been increasing in the recent years at increasing rates, reaching > 2% from 2017 on along with the share of foreign citizens. In 2021, foreign citizens made up 15,5% of the total population out of which 36% are from Poland. The at risk-of-poverty rate was 10.7% in 2019.

The team has identified the external stakeholders that include:

- Authorities
- Industry and technology providers
- Government agencies
- Nature conservation associations
- Societies

It is crucial to continue the dialogues with stakeholders that Carbfix has been involved in since the beginning of its activity in 2006. Securing a social license to operate via this dialogue is a key for the continued success and scale-up of this process. This includes the continued dissemination of all results to highlight the safety of the RepAir DAC and the Carbfix $CO_2$ mineralization processes. The scale-up of this method at the Mt/y scale will create high-quality local job opportunities, addressing the needs of local and regional communities.

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.*

The project team is strongly committed to maximizing the dissemination to the relevant local stakeholders. This includes information on websites, in local media and news, as well as town hall meetings. There, the local public can learn about the planned project and have the chance to ask any questions regarding the project's activities, securing a social license to operate via interactive dialogue and continuous transparent communication. Carbfix has significant experience with these activities since the initial phases of the project in 2006.

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?

*N.A*

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?

Base interaction with stakeholders on relevant social media, learn as we go.
Work with local media consultant on creating and cultivating the relationships with all stakeholders.

## 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 following main environmental justice considerations:

- Land area required for the deployment of the facility
- Pipelines deployed on the ground that might interfere with natural ecosystems
- The effect of the project on the availability and quality of drinking water

The stakeholders are:

- Local and regional communities and authorities
- Societies
- Nature conservationists

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

The local environmental impacts are limited, as the surface area occupied by the injection and monitoring wellheads and control buildings is minimal (ca. 0.1 ha). Most of this surface is changed from lava fields to gravel well pads without significant environmental impacts. Pipelines will be underground, minimizing their impact in the sparsely vegetated region.

The groundwater needed for the sequestration is available in large quantities. The $CO_2$-charged water injection takes place at several hundreds of meters depth, separated from the regional drinking water reservoirs and aquifers, there is no effect on drinking water resources. For a megaton and gigaton scale deployment water will be re-circulated in the reservoir, by sourcing it from wells drilled out of the mineralization zone where the $CO_2$ has been incorporated into minerals.

## 9. Legal and Regulatory Compliance (Criteria #7)

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

| |
|---|
| *N.A* |

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.

| |
|---|
| Construction permit from the site municipality.<br>Injection permit subject to Environmental Impact Assessment if injection exceeds 100,000 $tCO_2$. An EIA for large-scale injection in this site is currently underway with Icelandic authorities. |

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?

| |
|---|
| $CO_2$ storage is subject to the EIA under Act no. 7/1998. Projects related to $CO_2$ storage with total intended storage below 100 kt/y are exempt from this, provided they are undertaken for research, development, or testing of new products and processes, which are evaluated in the screening process. Should the project lead to scale-up on-site, the EIA will be already in place as it is currently being prepared for the wider Hellisheidi site. |

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.

| |
|---|
| Legal/regulatory hurdles have been overcome by Carbfix on previous commercial DACS system deployment in Iceland. |

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)

| |
|---|
| All R&D demonstrations by local companies (or local subsidiaries of international companies) are eligible for up to 35% tax credit rebate for costs incurred (https://www.rannis.is/sjodir/atvinnulif/skattfradrattur/). |

## 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**<br>*metric tonnes $CO_2$* | *Should match the last row in table 4(a), "Net carbon removal"*<br><br>198.59 |
| **Delivery window**<br>*at what point should Stripe consider your contract complete?* | Q4/2024 – Q4/2025 |
| **Price** (\$/metric tonne $CO_2$)<br>***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).*<br><br>1600 |

# Application Supplement: DAC

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

*Note: these questions are with regards only to air capture: e.g. your air contactors, sorbents or solvents, etc. Separately, there exist Geologic Injection and $CO_2$ Utilization supplements. We anticipate that most companies filling out this DAC supplement should ALSO fill out one of those supplements to describe their use of the $CO_2$ stream that's an output of the capture system detailed here.*

## Physical Footprint (Criteria #1 and #2)

1. What is the physical land footprint of your project, and how do you anticipate this will change over the next few years? This should include your entire physical footprint, i.e., how much land is not available for other use because your project exists.

| Year | Land Footprint ($km^2$) |
|---|---|
| 2021 | Lab prototype: ~0.3 m3 |
| 2022 | MVP (~1-5 t/y): ~1 m3 |
| 2023 | 100 t/y module: ~8 m3 |

2. What is the volumetric footprint of your contactor? (How big is your physical machine compared to how much you're capturing?) and how do you anticipate this will change over the next few years? These numbers should be smaller than (1) above.

| Year | Contactor Footprint ($m^3$) |
|---|---|
| 2021 | ~0.1 m3 |
| 2022 | ~0.3 m3 |
| 2023 | ~1 m3 |

## 2. Capture Materials and Processes (Criteria #5, #7, and #8)

1. What sorbent or solvent are you using?

| |
|---|
| N.A |

2. What is its absorption capacity? *(grams $CO_2$ per grams material/cycle)*

| |
|---|
| N.A - we have a continuous electrochemically-based separation process |

3. What is its desorption capacity? *(grams $CO_2$ per grams material/cycle)*

| | |
|---|---|
| N.A - we have a continuous electrochemically-based separation process | *Grams $CO_2$ per* |

4. How do you source your sorbent or solvent? Discuss how this sourcing strategy might change as your solutions scales. Note any externalities associated with the sourcing or manufacture of it (hazardous wastes, mining, etc. You should have already included the associated carbon intensities in your LCA in Section 6)

| |
|---|
| N.A |

5. How do you cycle your sorbent/solvent? How much energy is required?

| |
|---|
| N.A - we have a continuous electrochemically-based separation process |

6. What is your proposed source of energy? What is its assumed carbon intensity? What is its assumed cost? How will this change over the duration of your project? (You should have already included the associated carbon intensities in your LCA in Section 6)

| |
|---|
| Our proposed source of energy is electric produced by a geothermal power plant on-site. Iceland produces around 20,000 GWh of electricity annually, the highest in the world per capita. Geothermal is considered a renewable clean energy source but is nevertheless associated with small amounts GHGs of magmatic origin that are carried with the hot fluid powering the turbines. The amount varies between geothermal facilities but the average value in Iceland is 27 tonnes $CO_2$e per GWh and is even lower in those plants where the Carbfix carbon capture and mineralisation technology has been implemented: currently 7.5 g/kWh on-site. |

7. Besides energy, what other resources do you require in cycling (if any), e.g water, and what do they cost? Where and how are you sourcing these resources, and what happens to them after they pass through your system? (You should have already included the associated carbon intensities in your LCA in Section 6) *(100 words)*

A closed-loop humidity circulation system will be integrated into the inlet and outlet of the EDCS unit. Water loss is negligible.

8. Per (7), how much of these resources do you need per cycle?

N.A – we have a continuous electrochemically-based separation process

9. How often do you cycle your sorbent/solvent?

N.A – we have a continuous electrochemically-based separation process

10. Does your sorbent or solvent degrade over time? Is degradation driven primarily by cycling, environmental conditions, or both?

We have a continuous electrochemically-based separation process. We use an ion exchange membrane in very mild conditions (ambient temperatures, low current densities), expected to reach several years of continuous operation.

11. In practical operation, how often do you need to replace your sorbent or solvent material, if at all?

N.A – we have a continuous electrochemically-based separation process

12. Per (11), what happens to your sorbent/solvent at end-of-life? Please note if it is hazardous or requires some special disposal, and how you ensure end-of-life safety.

We expect the EDCS unit to be replaced once every 10 years. The EDCS unit does not include hazardous materials. Most of the materials are recyclable (metals, polymer).

13. Several direct air technologies are currently being deployed around the world (e.g. Climeworks, which Stripe purchased from in 2020). Please discuss the merits and advantages of your system in comparison to existing systems.

| | Carbon Engineering | Climeworks | RepAir |
|---|---|---|---|
| **Technological approach** | Solvent absorption | Solid adsorption | Electrochemical cell |
| **Continuous/batch** | Batch | Batch | Continuous |
| **Heat source** | Yes (900°C) | Yes (100°C) | No (Ambient) |
| **Liquids** | Yes | No | No |
| **Energy consumption** | 7-14 GJ/t$CO_2$ | 7-8 GJ/t$CO_2$ | 1.8-2.5 GJ/t$CO_2$ |
| **Minimal projected cost at scale** | **\$100-\$230/t$CO_2$** | **\$100-\$300/t$CO_2$** | **\$50-\$75/t$CO_2$** |

# Application Supplement: Geologic Injection

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

## Feedstock and Use Case (Criteria #6 and 8)

1. What are you injecting? Gas? Supercritical gas? An aqueous solution? What compounds other than C exist in your injected material?

| |
|---|
| Aqueous solution. Injected mixture consists of fresh water and $CO_2$ - No other compounds present in the mixture. |

2. Do you facilitate enhanced oil recovery (EOR), either in this deployment or elsewhere in your operations? If so, please briefly describe. Answering Yes will not disqualify you.

| |
|---|
| No |

## Throughput and Monitoring (Criteria #2, #4 and #5)

3. Describe the geologic setting to be used for your project. What is the trapping mechanism, and what infrastructure is required to facilitate carbon storage? How will you monitor that your permanence matches what you described in Section 2 of the General Application?

The trapping mechanism is solubility trapping (short term) and mineral strapping (long-term). The $CO_2$ is stored in form of solid carbonate minerals (such as calcite, aragonite, siderite, magnesite, etc.) formed through $CO_2$-water-rock reactions in the subsurface reservoir. The precipitation of these minerals from water-dissolved $CO_2$ takes place rapidly within months, as broadly demonstrated by Carbfix. These minerals are stable over geological timescales so that after the verification of mineralization in a monitoring program, no active management or intervention is necessary. This rapid mineralization distinguishes the Carbfix method from conventional $CO_2$ sequestration processes, drastically improving the long-term storage reliability. The infrastructure required are injection and monitoring wells, as well as pumps, pipelines, well casings and compressors.

In addition to subsurface MMV campaigns, the following parameters are monitored at the surface:
**The accurate amount of $CO_2$ received from the DAC system and injected via the injection system** will be monitored for accurate book-keeping of the transported and injected $CO_2$ and to ensure no fugitive emissions from surface installations and wellheads. Flows, temperatures, and pressures will be monitored continuously at the input from ships, after the vaporisers, and

at each wellhead. Mass balance calculations allow quantification of any fugitive losses until the wellheads.
**Detection of leakages from surface installations and wellheads**, which would affect the overall efficiency of the project**.** Fugitive $CO_2$ emissions from surface pipes will be monitored to ensure efficient operation. $CO_2$ gas detectors will ensure the immediate detection of malfunction of the injection system.
**Ensuring the chemistry of the gaseous $CO_2$ and the water for injection adheres to quality** requirements set out by the project and contamination levels are below those set by operational licences. Sampling valves will enable manual sampling by third parties for verification that impurities do not exceed maximum allowed concentrations. The temperature, pressure and conductivity of injected water will be monitored continuously but its chemical composition will be determined from samples collected manually.
**Ensuring optimal injection conditions:** The optimal injection conditions will be maintained by monitoring physical parameters of the $CO_2$ gas and water flowing to the injection wells. A $CO_2$ and water flow meter will be installed at the wellhead. Pressure sensors in the $CO_2$ gas pipe at the wellhead as well as pressure sensors in the annulus at the wellhead will confirm optimal injection conditions. Any formation of bubbles will cause a deviation in water flow and irregularities in pressure.
**Accounting for use of resources:** Electricity, groundwater, and heat will be monitored using appropriate standard meters (electricity, water flow) and sensors (temperature, pressure).
**Optimisation of injection:** The data on the chemical composition and physical parameters of injected gaseous $CO_2$ and water together with the injectivity of the injection well lay the foundations of the injection system setup such as the mixing depth and setting the ratio of water to $CO_2$ being injected.
**Seismic monitoring** will be continuously monitored.

4. For projects in the United States, for which UIC well class is a permit being sought (e.g. Class II, Class VI, etc.)?

N.A

5. At what rate will you be injecting your feedstock?

~1 t/day

## Environmental Hazards (Criteria #7)

6. What are the primary environmental threats associated with this injection project, what specific actions or innovations will you implement to mitigate those threats, and how will they be monitored moving forward?

The primary environmental risk of induced seismic activity resulting from the injection of water-$CO_2$ mixture underground.

The Icelandic public is aware of the risk of induced seismicity associated with the re-injection of geothermal brine. Although there is no correlation between the earthquakes and injection of water-dissolved $CO_2$, the public does not necessarily distinguish between the two. Carbfix has never caused any Earthquakes but since this is a public concern, we operate under the same traffic light system for injection and have published several scientific papers on the matter. See Hjorleifsdottir et al. 2021 for details.

7. What are the key uncertainties to using and scaling this injection method?

This injection method has already been successfully used for several years in Iceland. The only minor uncertainty to using this injection method may be attributed to utilizing it in other locations other than Iceland. This uncertainty is related to the extent the geological conditions in other locations that were originally spotted by Carbfix will have similar characteristics to allow for effective sequestration in a similar way to the Iceland location.