General Application

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

Company or organization name

CarbonBuilt, Inc.

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

Los Angeles, CA

Name of person filling out this application

Rahul Shendure

Email address of person filling out this application

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Brief company or organization description

Startup commercializing a low-cost, scalable, low-carbon concrete 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.

Our Approach: CarbonBuilt's Reversa™ process directly mineralizes the CO_2 contained in dilute (>3%vol) flue gas or direct air capture (DAC) streams into concrete components such as blocks (concrete masonry units, or CMUs), pavers, hollow-core slabs, and wall slabs - applications that make up 30-40% of the global concrete market. Reversa exploits **portlandite's rapid carbonation in the presence of CO_2**, **without high temperatures, elevated pressures or a CO_2 capture or purification step**. Carbonation converts portlandite (hydrated lime, calcium hydroxide: $Ca(OH)_2$) into limestone (calcium carbonate: $CaCO_3$), permanently mineralizing the CO_2.

Like ordinary portland cement (OPC), the limestone formed in this reaction is a cementation agent that binds aggregates in concrete. The use of portlandite enables a **60-90% reduction in OPC** content and **increased use of low-cost, low-carbon feedstocks** such as fly ash, slag and aggregates, without compromise to material performance. Furthermore, the ability to use low quality feedstocks enables access to billions of tons of material that lies unutilized in landfills.

Using flue gas CO_2, Reversa results in a **10-20% reduction in raw material costs** and a **50-70% reduction in concrete's CO_2 emissions**, approximately ⅓ of which comes from the absorption of CO_2 during curing (with the balance coming from the use of lower carbon raw materials). Absorbed CO_2 makes up 1.5-5% of the concrete's mass after curing.

Portlandite is a readily-available commodity chemical made from limestone at a temperature that is nearly 600°C lower than that required to produce OPC. **Expansion of portlandite's production to support increased use in concrete requires no significant capital investment** as portlandite can be made in cement kilns. Once commercialized, retrofitting a standard concrete masonry line with Reversa will require ~$1 million of investment, and this delivers **very compelling investment economics** (e.g., >30%+ IRR, ~3 yr payback) thanks to the 50%+ profitability improvements that result from material cost reductions and anticipated carbon pricing.

Reversa's adoption by the global concrete industry can deliver a gigatonne scale CO_2 reduction. More specifically, if we assume Reversa is applicable to 100% of the masonry market plus 50% of the non-masonry precast market, 5% CAGR between 2020-2040 (global consumption in 2020: 4.1B tons of cement ~ 41B tons of concrete), and 3.5% CO_2 uptake, it has the potential to utilize and permanently sequester (i.e., remove) 1 gigatonne, and avoid another 1.3 gigatonnes, of CO_2 annually by 2040.

Based on its economics, scalability and product performance, Reversa is the most effective approach that we are aware of to exploit the unmatched permanent CO_2 utilization potential of masonry and precast concrete. Furthermore, Reversa's economics, and its ability to accept dilute CO_2 streams without compression or purification, make it ideally-suited for integration with distributed DAC technologies that are currently under development. Nothing will accelerate the impact of such DAC technologies like an already commercial low-cost process to convert the CO_2 generated by such technologies into concrete, the world's most voluminous synthetic material.

Technology Development: Reversa's development commenced at UCLA in 2013; an initial patent application was filed in 2014. In 2018, the team was selected as a finalist in the NRG COSIA Carbon XPRIZE and separately secured a $3M grant from the U.S. Department of Energy (DOE) to first mature the material formulation strategy and process design, and then build and test a pilot plant capable of curing 13.25 tonnes/day of full size CMUs.

A heavily instrumented "Gen1" pilot plant, consisting of a containerized carbonation curing chamber and a gas processing skid made using off-the-shelf components, was installed at the Wyoming Integrated Test Center (ITC) in Gillette, WY in Q2'20. We produced over 10,000 standard CMUs using flue gas taken directly from ITC's coal power plant (12%vol CO_2). We contracted with a nearby CMU producer for batching (using our mixture design), forming and steam curing; partially cured CMUs were subsequently carbonated at ITC. After testing by two independent labs to confirm that the CMUs fulfilled relevant specifications (ASTM C90), the CMUs were delivered to the Eastern Shoshone Housing Authority, Pine Ridge Reservation, Crazy Horse Memorial and UCLA for use in structural building projects. A video overview is available at https://www.youtube.com/watch?v=h1s-QKaT5Wg.

Detailed analysis of material and energy flows from operations at ITC, independently verified by 350Solutions, confirmed achievement of our technical, environmental and economic objectives. We have just completed a second demonstration, using the same hardware and resulting in the production of >5,000 CMUs, at the National Carbon Capture Center (NCCC) in Wilsonville, AL. Our objectives at NCCC were to successfully operate on a more dilute (4%vol CO_2) flue gas stream from a natural gas-fired plant and reduce energy consumption by 30%. We were successful in meeting both of these objectives.

While our demonstrated pilot performance is sufficient to support commercialization, UCLA and CarbonBuilt are advancing a broad technology portfolio focused on expanding the product portfolio beyond CMUs, improving energy efficiency and using a broader array of low-cost materials (off-spec landfilled or ponded fly ash, bio-ash, and slag; low-carbon portlandite derived without calcination; and DAC-derived CO_2). For example, in 2021-22, with $3M in funding from DOE, we will design, build and test a "Gen2" pilot plant.

Company: CarbonBuilt, which holds exclusive rights to a portfolio of 8 relevant patent families (2 with allowed claims) owned by UCLA, was formed in Nov'20 to commercialize the Reversa platform. CarbonBuilt raised seed financing in Dec'20 from Climate Capital Fund and individual investors hailing from the construction, climate-tech and finance sectors.

CarbonBuilt's near-term focus in developed markets involves partnering with existing masonry and precast concrete producers serving urban markets with a nearby flue gas source (e.g., cement plant, fossil energy, bioenergy, brick production). Flue gas will be piped to the concrete plant, or semi-cured concrete products will be transported to the flue gas source. In high growth markets, such as India, we are partnering with CO_2 emitters who make land available at their facilities to host new precast concrete production plants. Our business model is to share the incremental capital investment and the resulting economic benefits with our partners. Once a few commercial plants are operating, we will tap into third-party, climate-focused infrastructure finance to fuel growth.

Over time, the need for proximity between concrete production and flue gas sources will be managed through:

(1) Improved economics (via technology innovation, learning curves and lower cost financing) will enable an increased radius for piping of flue gas or transportation of semi-cured products;
(2) Concrete producers choosing to locate new capacity adjacent to flue gas sources based on the delivered economic benefits; and
(3) Commercialization of cost-effective DAC solutions that deliver >5%vol CO_2.

Proposed Project: The first integration of CarbonBuilt's technology into an operating concrete masonry plant is being planned for 2022. A detailed economic and environmental analysis, informed by our pilot results, 7+ years of lab testing and extensive discussions with masonry producers ("Partner") and material suppliers, has been prepared for both initial conversion of a single production line and conversion of a plant with 4 lines. CarbonBuilt's technology will reduce net CO_2 emissions of the Partner's masonry products by 57%, with CO_2 removal (as opposed to avoidance) responsible for 31% of the reduction.

Conversion of the entire plant at one time would require $2.5M of capital investment. Combined with very low utilization and avoidance credits of $25 and $5/tCO_2$, respectively, the material cost savings (using portlandite manufactured on-site and off-spec fly ash, net of process costs) delivers 41% margin expansion or 15% IRR. Access to higher CO_2 removal or avoidance credits will allow for some combination of larger returns and DAC integration (both of which fuel faster growth and thus accelerated removal).

Initial conversion of a single production line, as a first step, requires $1.3M in capital, 16% of which is excess contingency because this is CarbonBuilt's first full scale project. On top of the 105% penalty on capital efficiency for operating at smaller scale ($25.77 vs. $12.57/annual tonne of concrete), the low initial volume necessitates using purchased portlandite (transported from out-of-state) and higher cost on-spec fly ash, resulting in an increase (rather than a decrease) in material costs. In order to exceed the Partner's hurdle rate, this initial conversion of a single production line requires a CO_2 utilization credit of $260/tCO_2$ (note: no CO_2 avoidance credit is assumed, since having an initial production line up and running is required for avoidance credit verification). To the extent that operating efficiencies (such as lower cost portlandite or fly ash) are achieved subsequent to construction, this credit can be reduced in future years without impacting the IRR.

In summary, Stripe's purchase commitment will support construction of the first commercial implementation of a gigatonne-scale utilization technology, accelerating its broader adoption and the resultant CO_2 removals.

<1500 words

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.)*

CarbonBuilt owns the intellectual property rights and is the technology provider to the project. Our Partner is providing physical infrastructure, as well as the required supply chain and distribution capabilities, to the project. We will share responsibility for the required capital investment and the resulting economic benefits with our Partner.

=<50 words

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

The most important risk we face is the concrete industry's generally slow pace of innovation, particularly when the economic potential of integrating our technology runs into typical "first plant" issues such as 1) only partial conversion of existing facilities, resulting in inflated CapEx requirements (per tonne of concrete or removed CO_2), and 2) the inability to justify onsite portlandite production given initial (low) volume, necessitating expensive transportation from nearest source.

The second most important risk we face is the long term access to fly ash. Supply of fresh on-spec ash will become more challenging over time due to the decreased use of coal energy. In the near term, our ability to secure access to low-cost landfilled ash is challenged by our initially low volume requirement.

As addressed in the last paragraph of 1a above, a CO_2 purchase commitment from Stripe directly addresses these two risks. More specifically, a purchase price of \$260/tCO_2 allows for the achievement of an IRR in excess of our Partner's hurdle rate despite the capital inefficiency and higher material costs associated with a partial conversion, and more generally with a first commercial plant. \$235/tCO_2 of this proposed \$260/tCO_2 purchase price relates to these issues, while the remaining \$25/tCO_2 is related to achieving an IRR in excess of the hurdle rate in order to incentivize adoption.

The third most important risk we face is customer acceptance of a concrete product made using a new material and a new process. We are addressing this by:

- ensuring full compliance with the existing specifications,
- developing material and product acceptance criteria with the International Code Council's Evaluation Service (ICC-ES),
- third party testing of the products by the National Concrete Masonry Association, and
- promoting the use of blocks from our pilot production in marquee construction projects.

<300 words

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

- ENHANCED CARBONATION AND CARBON SEQUESTRATION IN CEMENTITIOUS BINDERS
- EFFICIENT INTEGRATION OF MANUFACTURING OF UPCYCLED CONCRETE PRODUCT INTO POWER PLANTS
- CO2 MINERALIZATION IN PRODUCED AND INDUSTRIAL EFFLUENT WATER BY PH-SWING CARBONATION
- FACILE, LOW-ENERGY ROUTES FOR THE PRODUCTION OF HYDRATED CALCIUM AND MAGNESIUM SALTS FROM ALKALINE INDUSTRIAL WASTES
- BUFFER-FREE PROCESS CYCLE FOR CO2 SEQUESTRATION AND CARBONATE PRODUCTION FROM BRINE WASTE STREAMS WITH HIGH SALINITY
- FORMULATIONS AND PROCESSING OF CEMENTITIOUS COMPONENTS TO MEET TARGET STRENGTH AND CO2 UPTAKE CRITERIA
- 2 unpublished (process design, distributed DAC)

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.*	Jul 2022 - Jun 2023 *<10 words*
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?* *E.g. Jun 2021 - Jun 2022 OR 500 years.*	During the project duration *<10 words*
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".*	Approximately evenly distributed over the project duration. *<50 words*
Durability *Over what duration you can assure durable*	Tens of thousands to millions of years

carbon storage for this offer (e.g, these rocks, this kelp, this injection site)? E.g. 1000 years.	*<10 words*

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

CarbonBuilt's technology immobilizes CO_2 in the form of calcium carbonate ($CaCO_3$, limestone). Based on both empirical observations, and the geologic record such mineral carbonates are known to be stable over tens of thousands to millions of years.

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.)*

There is extensive evidence in the geologic record of the stability of calcium carbonates in nature (e.g., the Cliffs of Dover) over millions of years, in spite of significant variations in both atmospheric CO_2 concentration and temperature. Furthermore, there is empirical evidence of the durability and structural integrity of structures formed of calcium carbonate (i.e., by lime mortar carbonation) such as Hadrian's Wall, which have demonstrated, in turn, the stability and durability of man-made carbonate materials.

Supporting literature:

*Pytkowicz, R. M. On the Carbonate Compensation Depth in the Pacific Ocean. Geochimica et Cosmochimica Acta **1970**, 34 (7), 836–839.*

*Feely, R. A. et al. Changes in the Aragonite and Calcite Saturation State of the Pacific Ocean. Global Biogeochemical Cycles **2012**, 26 (3).*

*Zevenhoven, R. et al. Chemical Fixation of CO2 in Carbonates: Routes to Valuable Products and Long-Term Storage. Catalysis Today **2006**, 115 (1), 73–79.*

Teir, S. et al. Stability of calcium carbonate and magnesium carbonate in rainwater and nitric acid solutions. Energy Conversion and Management 2006, 47, 3059-3068.

<200 words

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?

Calcium carbonates are thermodynamically, and kinetically stable at ambient pressure, and over a broad range of temperatures, and CO_2 concentrations. The CO_2 that is immobilized in calcium carbonates by CarbonBuilt's technology can only be removed by heating the material to ~800°C at atmospheric pressure. As such, unless exposed to an adverse event (e.g., such as a fire), CarbonBuilt's approach to CO_2 utilization and removal faces no risks, either physical, socioeconomic, or otherwise. *<200 words*

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

We can quantify actual CO_2 utilization in two ways: a) by direct measurements of inlet/outlet (gas-phase) CO_2 concentrations during manufacturing, and b) by post-production assessments of the manufactured concrete products whose CO_2 content is analyzed using thermogravimetric analysis (TGA). This approach allows proper closure of the CO_2 mass balance to ascertain the actual amount of CO_2 that is embedded in concrete products. While the durability of calcium carbonate mineral is well-known (see 2c-2d above), we will additionally carry out random monitoring of the manufactured products using TGA over a period of 5-years to confirm that there are no changes in their embedded CO_2 content to further confirm permanence. *<200 words*

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	992 tCO_2 *E.g. XXX tCO_2*
If applicable, additional avoided emissions e.g. for carbon mineralization in	2,151 tCO_2 (gross) *E.g. XXX tCO_2*

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 2(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)*

For the proposed project, we project 2% uptake of CO_2 by mass of manufactured products (CMUs) based on our lab and pilot plant data. The plant manufactures 198,333 tonnes/year of CMUs and we envision initially retrofitting ¼ of its capacity. 198,333 tonnes/year x ¼ x 2% uptake = 992 tCO_2/year in gross carbon removal. *<150 words*

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).

The capacity of our Gen1 pilot plant is 97 tonnes CO_2/year (at 100% utilization) *# metric tonnes CO_2/yr*

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

The Gen1 pilot plant is capable of carbonating 13.25 tonnes of concrete per day and has

demonstrated 2% uptake of CO_2. At 100% uptime this is equivalent to 97 tonnes of CO_2 removed per year.

We assess CO_2 uptake in our pilot using two independent methods: 1) system mounted CO_2 and flow sensors, and 2) thermogravimetric analysis (TGA) of concrete products following production. We achieved 2% uptake in our ITC demonstration and expect to be able to achieve 3.5% over time with specific advancements in formulation and process design.

<200 words

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.

- CarbonBuilt Leadership & Advisors
- Team Site at Carbon XPrize
- UCLA Institute for Carbon Management
- Technical reference list

Up to 5 links

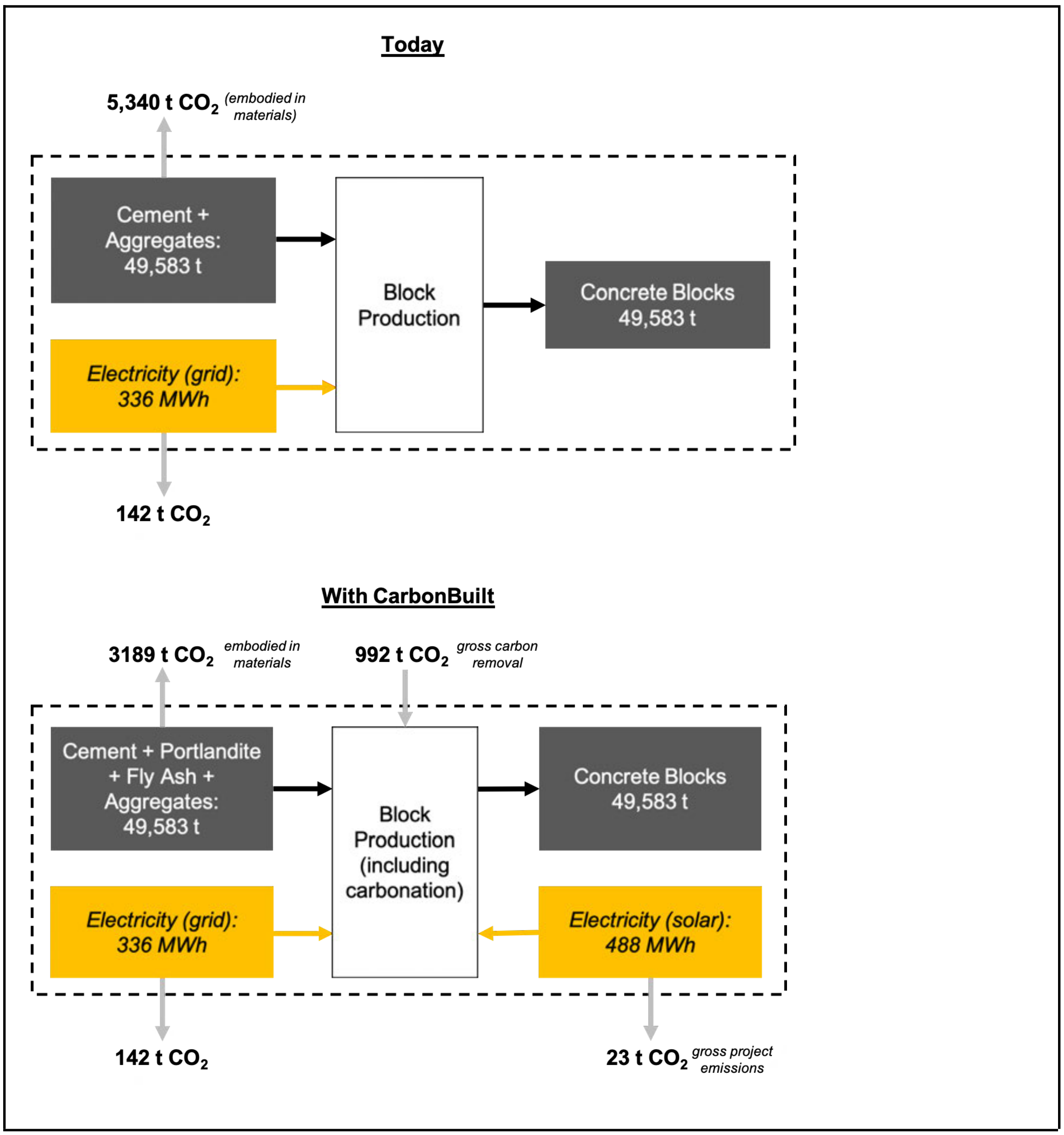
4. Net Capacity / Life Cycle Analysis (Criteria #6 and Criteria #8)

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	992 tCO_2 *Should equal the first row in table 3(a)*
Gross project emissions	23 tCO_2. Project emissions are minimized by purchasing solar electricity from the local utility (negligible costs for a few years, break even in 7 years). *Should correspond to the boundary conditions described below this table in 4(b) and 4(c)*
Emissions / removal ratio	0.02 *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*

Net carbon removal	968 tCO_2 *Gross carbon removal - Gross project emissions*

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?

We do not exclude any system components. As such, the system boundary conditions consider all relevant operations of the concrete plant, CO_2 processing system, and related unit operations. Emissions from grid electricity used for block forming are excluded from "gross project emissions" since this energy use is unrelated to the implementation of our process. Water input (moisture contained in the aggregate; water added to raw materials during batching; water vapor in flue gas) and output (produced during carbonation and available for recycle, reducing requirement for water input) have been excluded for simplicity. *<100 words*

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](#).

Our performance projections for the proposed project are based on measured results from the operation of our Gen1 pilot system over the last 12 months. This system's performance in terms of energy, mass and CO_2 balances has been subject to third party verification over the course of ongoing demonstrations at coal- and natural gas-power plants in Wyoming and Alabama. These demonstrations have been carried out in the course of our participation in the Carbon XPRIZE competition and ongoing technology development contracts that are being fulfilled for the U.S. Department of Energy. We have applied this historical performance to the proposed project, with appropriate modifications made to account for anticipated changes in formulation, energy usage, and scale as we transition from the pilot stage to our Partner's commercial site. *<200 words*

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.)

An independent audit of the mass and energy balances from our Wyoming pilot demonstration was performed as part of the Carbon XPRIZE competition by 350Solutions, a consultancy focused on ISO 14034-compliant carbon verification. We would be happy to make this available for review. *<100 words*

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

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

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

> Unit: Tonnes per day of concrete block production capacity. As our systems are assembled using off-the-shelf equipment, learning curves are expected to be driven both by the cumulative # of conversions or new plants as well as cumulative capacity..*<50 words*

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
2020 - demo	1 (13.25 tonnes concrete/day)	$450,000	0.265 tCO_2/day	Gen1 System operated using real flue gas at coal and natural gas power plants in WY and AL.
2017 - demo	1 (~8 tonnes concrete/day)	$350,000	~0.1 tCO_2/day	Gen0 System operated using simulated flue gas.

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.*)

> The costs have reduced on account of enhanced value engineering, the avoidance of non-recurring engineering costs, and optimal sizing of system components. *<50 words*

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).

stripe

# of units	Unit gross capacity (tCO_2/unit)
1 (187 tonnes concrete/day)	3.74 tCO_2/day* * less than first row in table 3(a) due because actual utilization is less than 100%

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?

CapEx: Unsurprisingly, our Gen1 pilot system (13.25 tonnes/day concrete; stand-alone) is significantly more capital intensive than the proposed project (206 tonnes/day; integrated). Capital intensity ($/tonne of gross CO_2 removed; amortized over 20 years; 100% utilization) is projected to drop by a factor of 5 ($233/$tCO_2$ to $47/$tCO_2$) moving from the Gen1 pilot system to the proposed project (single line conversion) and then again by a factor of 2 (to $23/$tCO_2$) moving from a single line to the full plant.

Operating Savings/Cost: Savings of $79/$tCO_2$ (based on gross CO_2 removal). This consists of material cost reductions, partially offset by carbonation-related electricity costs, after full conversion of our Partner's concrete block plant, with portlandite being produced onsite and by utilizing off-spec (lower quality) fly ash that is well-suited for carbonation processing (but not for use in traditional concrete). This increases to a $86/$tCO_2$ operating cost when portlandite needs to be transported from the nearest existing production facility (~¾ of the swing) and high quality fly ash is used (~¼ of the swing) - both of which are required for the initial block line conversion due to material volumes being too low to justify local (captive) production of portlandite or sourcing of low-cost off-spec fly ash.

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."

CapEx: All equipment required for a full plant retrofit (including engineering and fabrication) plus a contingency allocation (as described above)

Operating Savings/Cost: Raw materials cost reduction (or increase), partially offset by increase in utilities costs

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	Detailed design of single line conversion completed <100 words	Completion required to move forward with construction <200 words	Q4'21	Review Partner acceptance of design package and updated collaboration agreement between CarbonBuilt and Partner<100 words
2	Construction Complete <100 words	Required to start production <200 words	Q3'22	Site visit during commissioning <100 words
3	One year of production<100 words	Required to demonstrate commercial success<200 words	Q2'23	Production logs + monitoring described in 2e above <100 words

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	97 tCO_2/yr *Should match 3(c)*	97 tCO_2/yr	*<100 words*
2	97 tCO_2/yr	992 tCO_2/yr (net of utilization)	Conversion of single line completed *<100 words*
3	992 tCO_2/yr	992 tCO_2/yr	*<100 words*

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	CapEx at 100% utilization: $233/tCO_2$ *Should match 6(a)*	CapEx at 100% utilization: $233/tCO_2$	*<100 words*
2	CapEx at 100% utilization: $233/tCO_2$	CapEx at 100% utilization: $47/tCO_2$	Conversion of single line completed *<100 words*
3	CapEx at 100% utilization: $47/tCO_2$	CapEx at 100% utilization: $47/tCO_2$	*<100 words*

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?

US President Joseph Biden - prioritization of procurement of best-in-class low carbon concrete products by the Federal Government or passage and implementation of legislation that puts a price on carbon.

<50 words

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

Catalyzing distributed DAC (enrichment to 5%vol CO_2) to <$75/tCO_2$ delivered enables the combination (of DAC plus CarbonBuilt utilization) to get to <$100/tCO_2$ sequestered while delivering an attractive 15% IRR to concrete producers.

<50 words

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?

The proposed project will take place on a small fraction of a large plot of industrial land occupied by our Partner. Some materials will be brought in from outside of the facility, but these will not make any meaningful change in the footprint or operations of their suppliers. We consider the communities living near, working at and purchasing from the facilities into which our technology is integrated, as well as the facilities from which key materials are sourced, as external stakeholders for our projects. *<100 words*

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

We have not engaged with such stakeholders to date as this will be our first project taking place outside of technology test centers that are co-located with power plants. *<100 words*

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 *<100 words*

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?

No. At present, we do not anticipate any changes. *<100 words*

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

Utilization of CO_2 and fly ash in concrete permanently locks up these materials within a cemented solid, which is unquestionably the best way to mitigate the potential environmental, public health, ecosystem and justice issues associated with these materials. Extensive scientific evidence indicates that CarbonBuilt's carbonation chemistry is particularly well-suited for this nature of CO_2- and fly ash-immobilization. *<100 words*

11. Legal and Regulatory Compliance (Criteria #7)

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

No legal opinions or decisions are required to implement our solution. Concrete products made with our technology meet existing construction specifications while greatly reducing the emission and accumulation of CO_2 (and other flue gas constituents) into the atmosphere. *<100 words*

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.

Some minor construction permits may be required for flue gas piping and plant retrofits on the CO_2 provider and concrete producer's sites, but based on our ongoing experience such permitting is trivial and requires no more than 3-6 months at the most. *<100 words*

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.

None to our knowledge. *<100 words*

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)	968 tCO_2 *Should match the last row in table 4(a), "Net carbon removal"*
Delivery window (at what point should Stripe consider your contract complete?)	Jul 2022 - Jun 2023 *Should match the first row in table 2(a), "Project duration"*
Price ($/metric tonne CO_2) ***Note on currencies:*** *while we welcome applicants from anywhere in the world, our*	$260/$tCO_2$. As per (6), conversion of a single line (using transported portlandite and high quality fly ash as raw

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.	materials) entails a CapEx of $64/tCO_2$ (amortized over 20 years; net of utilization) and annual OpEx of $86/tCO_2$. The offered price was formulated to deliver a >10% IRR to the entities (the Partner and CarbonBuilt) funding the single line conversion so as to clear the Partner's hurdle rate. Note: our IRR calculations incorporate the depreciation tax shield (7 year life) *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).*

Application Supplement: CO_2 Utilization

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

Feedstock (Criteria #6 and #8)

1. How do you source your CO_2, and from whom?

CarbonBuilt will initially source its CO_2 from industrial emitters such as cement plants, power plants (bioenergy, waste-to-energy, natural gas, coal), and natural gas distribution facilities, directly removing what would otherwise be atmospheric CO_2 accumulations while producing low-carbon construction products. Importantly, this CO_2 utilization occurs without a need for CO_2 capture, concentration, purification, or treatment at ambient pressure and low temperature. To our knowledge, CarbonBuilt is the only CO_2 utilization technology, globally, that is able to utilize dilute CO_2 directly in its mineralization process. *<100 words*

2. What are alternate uses for this CO_2 stream?

At this time, there exist no alternate uses for the CO_2 streams that form a feedstock/input to the CarbonBuilt process. For this reason, CarbonBuilt's technology enables direct and unambiguous removal of CO_2 by beneficially utilizing CO_2 borne in dilute, hard-to-concentrate CO_2 emissions that are emitted by hard-to-abate industrial sectors including cement, steel, and petrochemicals. *<100 words*

3. Do you have a pathway towards sourcing atmospheric CO_2 so as to achieve carbon removal? *(e.g. Future coupling of process to direct air capture)*

CarbonBuilt is working intensively with its academic and technical partners to develop transformative, modular systems for fractional (>5vol% CO_2) DAC that will seamlessly integrate with its CO_2 mineralization systems. Once commercial, this will allow CarbonBuilt to readily utilize atmospherically sourced CO_2 and "cut-the-cord" to classic point-source CO_2 emitters. DAC integration will greatly improve the locational and logistical flexibility of CarbonBuilt's solutions, further enhancing the economics and the scaling potential of the technology. *<100 words*

Utilization Methods (Criteria #4 and #5)

4. How does your solution use and store CO_2? What is the gross CO_2 utilization rate? *(E.g. CO_2 is mineralized in Material at a rate of X tCO_2 (gross) / t storage material).*

CarbonBuilt's Reversa process reacts dilute, gas-phase CO_2 with portlandite ($Ca(OH)_2$) via an acid-base reaction to produce limestone ($CaCO_3$), a cementation agent, in an energy efficient manner, with no requirement for capture, concentration, purification or treatment. The limestone formed binds sand and stone similarly to OPC in traditional concrete. CarbonBuilt's products are functionally, and performance equivalent to traditional concrete with a CO_2 footprint that is up to 70% lower than traditional concrete. On account of the downhill thermodynamics of carbonation, the process is rapid and able to achieve CO_2 mineralization rates ranging between 1.5-5% (by mass of concrete). *<100 words*

5. What happens to the storage material (e.g. concrete), and how does that impact its embodied carbon storage over time? How do you know?

Concrete products produced using CarbonBuilt's Reversa technology will be used in exactly the same ways that conventional concrete products are used. As noted in our answer to question 2(c) in the main application, CO_2 mineralized in these products as calcium carbonate will remain stabilized for tens of thousands to millions of years, as evidenced by the geologic record and humanity's use of lime mortar materials. *<100 words*

6. How do you ensure that the carbon benefits you are claiming through a CO_2 utilization process are not double counted? *(E.g. If sourcing CO_2 from a DAC system, or selling your product to a user interested in reducing their carbon footprint, who claims the carbon removal benefits and how could an independent auditor validate no double counting?)*

In the absence of a rigorous (e.g., blockchain-based) process for tracking carbon benefits from cradle-to-grave, benefits (economic, regulatory and/or marketing) will need to be properly accounted for so that they are not double-counted across the value chain of suppliers, partners and customers. We recognize that norms and policies to prevent double-counting, across the entire spectrum of utilization opportunities, are still being established. Broadly

speaking, we are committed to being an active participant in the cross-stakeholder dialogue that is occurring in this regard, and to making full use of industry-specific best practices. More specifically, we commit to establishing a verifiable methodology (including, for example, contractual arrangements with our Partner, and between our Partner and their customers) to prevent double-counting of benefits for the specific project proposed herein. For clarity, our economic analysis for the project does not include any product price premium that could be derived from marketing the carbon benefits to an end customer nor any “tipping fee” charged to the CO_2 provider. *<200 words*