stripe

Carbon Removal Purchase Application

General Application

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

Company or organization name

Solugen, Inc.

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

Houston, TX

Name of person filling out this application

Sean Hunt, PhD

Email address of person filling out this application

sean@solugentech.com

Brief company or organization description

Decarbonizing the chemicals industry with computational biology.

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.

Overview:

Founded in 2016, Solugen is a speciality chemicals company focused on developing chemical solutions for customers that are safer to use, more cost effective, and have a lower environmental impact compared to traditional industrial chemicals.

Biogenic carbon dioxide is stored as cellulosic and starch sugars in biomass. These sugars could be dissolved in water and directly injected into Class II water disposal wells or stored in concrete, thereby sequestering atmospheric carbon.

However, the sugars in this state lead to bacterial growth and do not offer any surplus economic benefits beyond carbon sequestration.

Solugen has developed a chemienzymatic process technology that uses air to oxidize sugars to glucaric acid with high yield and energy efficiency. In this form, carbon can be sequestered while also offering surplus performance benefits to concrete manufacturers and Class II disposal operators. By offering dual economic incentives, this can accelerate the large-scale deployment of oxidized sugars as a direct carbon sequestration platform.

Today, the current manufacturing costs and economic benefits of oxidized sugars enable 50 ppm to be disposed of profitably via continuous injection. This lowers the injection pressure by over 200 psig, enabling further efficient sequestration. For a 100,000 bbl/day system, this equates to 0.8 MT/day of carbon sequestration.

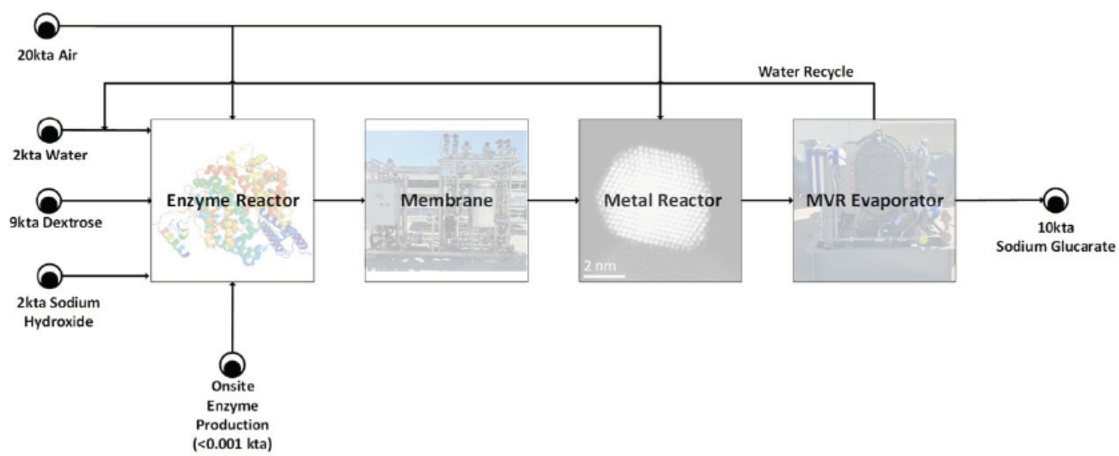
However, these systems could handle up to 10,000 ppm, which would be 160 MT/day of carbon sequestration per system. Although 50 ppm can be injected profitably, it does not maximize carbon additionality.

Today, end-users do not value and pay for carbon benefits at scale. Stripe’s pioneering corporate stance to value and subsidize additional carbon injection will catalyze the widespread adoption of this much-needed corporate behavior. Demonstrated corporate interest in the carbon removal aspect of Solugen’s business will help motivate further investment and purchases.

We feel strongly that combining carbon subsidies with an intrinsically profitable solution is more likely to scale and generate more meaningful climate benefits over time.

In 2021, Solugen is commissioning and starting up its first commercial plant in Houston, TX, targeting a production rate of 10,000 tons per year of sodium glucarate under the tradename BioChelate (TM). Today, the feedstock is dextrose corn syrup, which contains short-cycle biogenic carbon that is recently removed from the atmosphere. By 2040, waste biomass cellulosic sugars are the preferred sustainable feedstock.

In Solugen's process, dextrose is converted to BioChelate(TM) through a coupled enzymatic - metal catalyst reactor technology.



Solugen's BioChelate(TM) product line can be used in many applications, ranging from wastewater treatment to agriculture to concrete. As of today, BioChelate(TM) is primarily sold to customers for use in Class II saline water disposal wells for scale control and iron scavenging purposes. Solugen has discovered that even 50 ppm of oxidized sugars such as glucaric acid can reduce injection pressures by over 200 psig, greatly improving the efficiency of class II disposal wells for sequestering carbon.

Solugen sells BioChelate in ISO tanker trucks with onboard telemetry and level monitoring, enabling Solugen to rigorously track the injection and sequestration of its oxidized sugars. A similar platform will be adapted for concrete where it was found that oxidized sugars slow the set time of concrete, improve workability, and improve the concrete performance.

Solugen will sequester over 1,000 tons of oxidized sugars in 2021 and ramp to 10,000 tons/year of oxidized sugar capacity within 3 years. In 2021, this represents an offering of 1,024 metric tonnes in gross carbon removal. There is an additional 1,700 metric tonnes in carbon offsets from the replacement of incumbent phosphonates.

In 2022, Solugen intends to scale up even further and begin building multiple plants, placed strategically near customer sites. In addition, Solugen is currently developing multiple novel processes to produce current industrial chemicals that follow the same safety, sustainability, and environmentally-friendly standards that are also cost-effective to customers.

Here is an article about Solugen:

https://www.forbes.com/sites/alexknapp/2020/07/06/how-two-young-scientists-built-a-250-million-business-using-yeast-to-clean-up-wastewater/?sh=34de48a47802

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.)*

Solugen is constructing this sugar oxidation asset. Solugen will purchase dextrose, sell its oxidized sugars, and track the quantity of product sequestered by end-users.

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

Solugen is in the process of scaling up its technological platform from pilot plant scale (0.1 kta) to commercial scale (10kta). Scale-ups are inherently risky, but Solugen has rigorously proven that its technological platform is functional and scalable through various benchtop and pilot studies. Solugen's scale-up to its first commercial plant is in its late stages, as the plant will be finished being built within the next three months. Solugen also has customers lined up to purchase BioChelate(TM) from the first commercial plant. At this point in the project, schedule delays during commissioning and startup are the predominant risks. Solugen has a pipeline of future carbon sequestering molecules whereby the predominant risk is speed of market adoption of carbon sequestering solutions.

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

1. [US9890397B1 - Hydrogen peroxide production method, system, and apparatus]
2. [Methods and compositions for the treatment of produced water]
3. [Multifunctional additive for use in wellbore servicing]

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.*	Start: October 2021 Plant Lifetime: 40 years *Demonstration plant is intended to be run for foreseeable future*
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.*	Carbon removal occurs over the duration of plant lifetime from October 2021 through October 2061.
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*	Carbon removal is dependent on how much dextrose is processed through the plant. We anticipate that more and more dextrose will be processed through the plant lifetime as we learn how to optimize plant production. Thus, more carbon will be removed as time passes.

out-years, but this depends on unknowns re our mineralization kinetics".	Over the first year of plant lifetime, Solugen intends to run at 10% of the nameplate capacity (1,000 tons BioChelate (TM)). During the second year of plant lifetime, Solugen intends to run at 50% of the nameplate capacity (5,000 tons BioChelate (TM)). During the third (and subsequent) years, Solugen intends to run at 100% of the nameplate capacity (10,000 tons BioChelate (TM)/yr). Thus, the rate of carbon removal will match this plant ramp rate. More carbon removal will occur when Solugen constructs other assets and deploys its other molecules into the market.
Durability *Over what duration you can assure durable carbon storage for this offer (e.g, these rocks, this kelp, this injection site)? E.g. 1000 years.*	In perpetuity - permanent storage of carbon via BioChelate (TM) use in Salt Water Disposal wells. Once the well is P&A (Plug and Abandoned), BioChelate (TM) is stored and sealed away by impermeable strata.

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

In perpetuity

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.)*

Durability is dependent on the end use of BioChelate (TM). For applications in saline wells, BioChelate (TM) will not degrade when used in scale control. When a well is plugged and abandoned, all of the treated saltwater is sealed away by impermeable strata from above and below.

https://www.epa.gov/sites/production/files/documents/21_McCurdy_-_UIC_Disposal_508.pdf

According to this report on salt water disposal, saline wells are tested for its integrity a minimum of once every five years and pressure tested at least once a month. This ensures that the structural and mechanical integrity of these wells are routinely checked, diminishing the likelihood of failure and increasing the durability of BioChelate (TM) being injected into the well.

https://www.epa.gov/uic/class-ii-oil-and-gas-related-injection-wells

According to the EPA, Class II wells inject brine “thousands of feet below the surface into rock formations isolated from underground sources of drinking water”. BioChelate (TM) is used in permitted, well-established Class II wells, meaning that the BioChelate (TM) is very durable due to direct carbon sequestration.

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?

Over long periods of time (>5000 years), BioChelate (TM) can potentially degrade. In addition, durability risks are contingent upon end-use applications of BioChelate (TM) by customers. For example, leaks in saline wells can cause the release of BioChelate (TM) into the environment. However, regulations of Class II wells (including routine integrity and pressure tests) significantly de-risks the chances of saline well failure.

There are very minimal fundamental uncertainties of using water treatment technologies such as BioChelate (TM) in salt water disposal applications. The use of water treatment technologies in class II saline wells have been utilized for many years. BioChelate (TM) is permanently sequestered thousands of feet below any underground sources of drinking water (https://www.epa.gov/uic/class-ii-oil-and-gas-related-injection-wells).

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.)*

BioChelate (TM) stability will be tracked at customer sites using telemetry to estimate decay rates and product performance. Sampling the returned fluids from these wells are also studied to determine the permanence of the carbon sequestered.

At the end of a salt water disposal’s life, the well is P&A (Plug and Abandoned). Typically, a cement slurry is applied via the tubing and the well is decommissioned. In this case, the carbon is permanently sequestered, as mentioned above.

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	Year 1: 1,024 metric tonnes CO_2 (10% capacity) Year 2: 5,120 metric tonnes CO_2 (50% capacity) Year 3+: 10,240 metric tonnes CO_2/yr (100% capacity) *Numbers based on Life Cycle Analysis for BioChelate (TM) for use in saline well applications* **LCA linked below in Section 2b**
If applicable, additional avoided emissions e.g. for carbon mineralization in concrete production, removal would be the CO_2 utilized in concrete production and avoided emissions would be the emissions reductions associated with traditional concrete production	Year 1: 1,700 metric tonnes CO_2 (1,000 metric tonnes THPS) Year 2: 8,500 metric tonnes CO_2 (5,000 metric tonnes THPS) Year 3+: 17,000 metric tonnes CO_2/yr (10,000 metric tonnes THPS/yr) *Numbers based on Life Cycle Analysis on THPS (current incumbent chemical) for use in saline well applications* **LCA linked below in Section 2b**

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)*

The numbers used for section 2(a) come directly from a life cycle analysis of both Solugen's

BioChelate (TM) product line for use in saline wells for scale control and tetrakis hydroxymethyl phosphonium sulfate (THPS), the phosphonate based incumbent chemical that BioChelate (TM) is replacing. The LCA is located at the link below:

LCA - Solugen GHG Emissions v14.pdf

We assume 100% of the BioChelate (TM) used is sequestered permanently for end-use in saline wells.

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).

Currently, Solugen's technology platform and on-going scale up allows for a gross carbon removal of 10,240 metric tons/yr, operating at full capacity. The BioChelate (TM) that is produced from the plant is sold to customers, mainly for applications of scale control in saline wells. Solugen plans to build larger plants in the near future (within the next 1-5 years), allowing for much more carbon to be sequestered using our current technological platform as well as new technological platforms currently being researched and developed (at least 5X the current gross carbon removal, if not larger). BioChelate (TM) is and will be used in other applications in the future other than Salt Water Disposal, including wastewater treatment, agriculture, concrete, and other industries. The chemicals industry represents 20% of GHG emissions, and Solugen's chemienzymatic platform can enable the biobased manufacturing of a substantial portfolio of high volume chemicals. By 2040, Solugen's deployed portfolio of biobased chemistries presents an opportunity to sequester and offset more than 0.5 Gt/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.)*

Since 2016, Solugen has conducted numerous benchtop experiments to benchmark and develop its chemi-enzymatic technological platform. After vetting enzyme and catalyst viability at benchtop scale, Solugen began conducting experiments at pilot scale, building two reactors that began continuous operation in 2018. The yields and energy efficiency of the pilot plant has been directly measured and translated into the LCA.

Given the late stage nature of Solugen's first commercial plant, its yields and energy usages are known within +/-10% uncertainty as the equipment has already been procured and

installed. In the LCA, comparisons to incumbent petroleum-derived molecules are well understood given the extensive patent and public literature documenting their manufacturing processes. Most incumbent molecules that Solugen is displacing began mass production before the 1980s.

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.

LCA - Solugen GHG Emissions v14.pdf - BioChelate (TM) and incumbent chemicals LCA BioChelate Supplier - Solugen Website

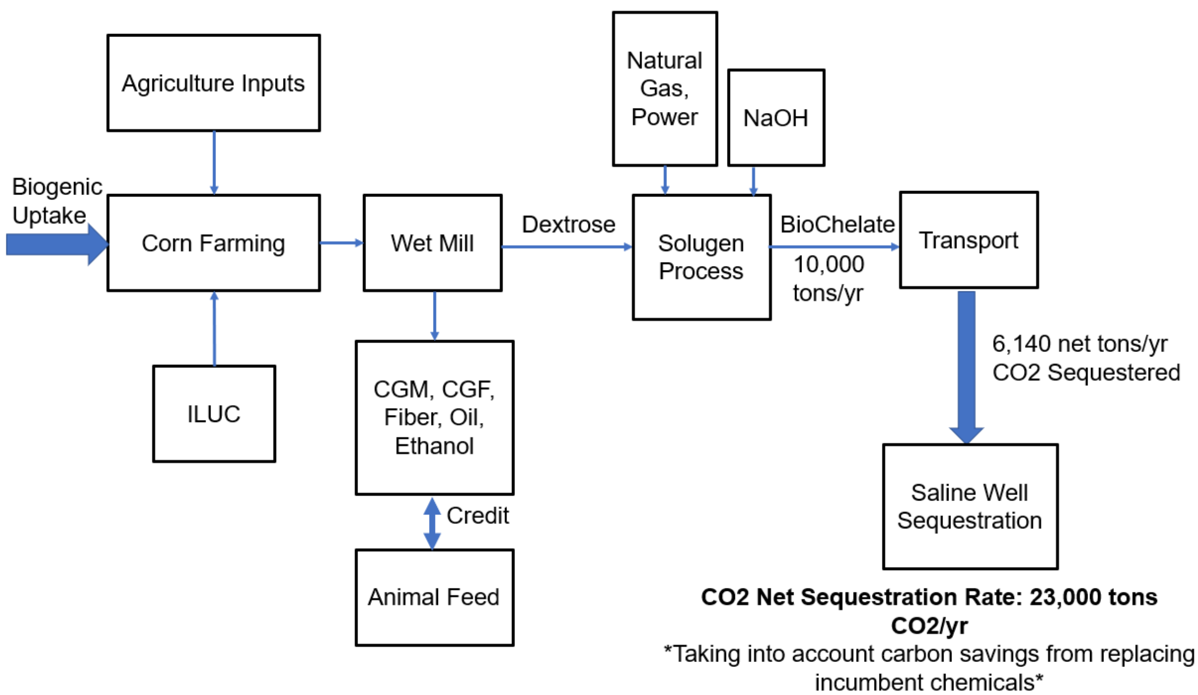
4. Net Capacity / Life Cycle Analysis (Criteria #6 and Criteria #8)

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	Year 1: 1,024 metric tonnes CO_2 (10% capacity) Year 2: 5,120 metric tonnes CO_2 (50% capacity) Year 3+: 10,240 metric tonnes CO_2/yr (100% capacity)
Gross project emissions	Year 1: 410 metric tonnes CO_2 (10% capacity) Year 2: 2,050 metric tonnes CO_2 (50% capacity) Year 3+: 4,100 metric tonnes CO_2/yr (100% capacity)
Emissions / removal ratio	0.40
Net carbon removal	Year 1: 614 metric tonnes CO_2 Year 2: 3,070 metric tonnes CO_2 Year 3+: 6,140 metric tonnes CO_2/yr

	These numbers do not take into account the CO_2 that is not emitted into the environment by incumbent chemicals such as THPS (17,000 metric tonnes CO_2/yr at 10,000 metric tonnes of THPS/yr).

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.



BioChelate(TM) Process Flow Diagram for Saline Well Sequestration. Adapted from LCA.

LCA Link: LCA - Solugen GHG Emissions v14.pdf Future projects will be co-located with waste biomass cellulosic feedstocks that avoid the use of agricultural foodstocks.

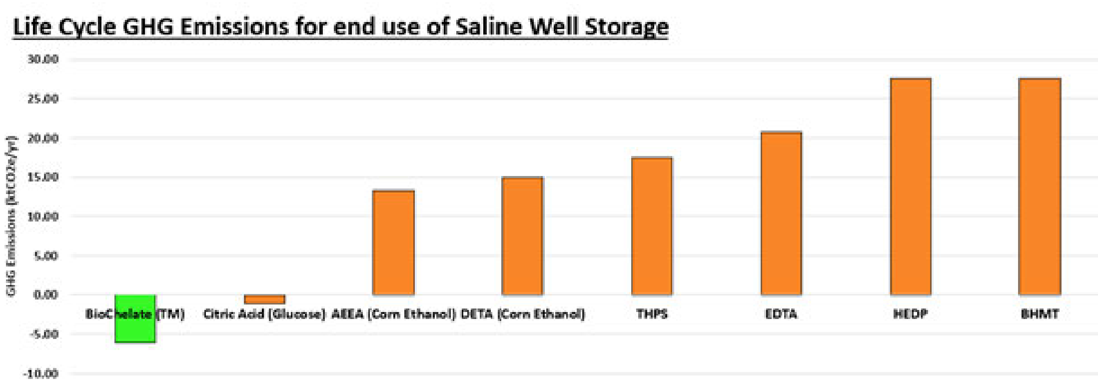
c. Please articulate and justify the boundary conditions you assumed above: why do your calculations and diagram include or exclude different components of your system?

The calculations and process flow diagram for BioChelate (TM) sequestration in saline wells includes every process, transport, and emission streams greater than 1% of the overall mass flow. Thus, every significant stream is accounted for in the overall carbon sequestration calculations.

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.

All of Solugen's numbers used in the diagram above have been measured directly. Since 2017, Solugen has built and operated a pilot plant which is analogous to the first demonstration plant coming online in October 2021. Data from the pilot plant has been used to calculate the numbers in the diagram above.

Additionally, life cycle analysis of Solugen's BioChelate (TM) product line as well as the incumbent chemicals have been performed (LCA - Solugen GHG Emissions v14.pdf). In this analysis, it is very clear that Solugen's BioChelate (TM) line is much more carbon negative compared to incumbent chemicals such as THPS.



BioChelate (TM) GHG Emissions Compared With Incumbent Chemicals For End Use in Saline Well Storage. Adapted from LCA.

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 verifier would confirm that Solugen is already building a commercial plant and aiming to start-up the plant by October 2021. The independent verifier could measure Solugen's emissions and also confirm injection of Solugen's products. The LCA itself will be verified in May 2021 via third party peer review to comply with ISO 14000.

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)*

Solugen's first demonstration plant consists of an enzymatic reactor coupled with a heterogenous metal catalyst reactor followed by downstream purification. Future Solugen plants will follow this same blueprint, with additional unit operations added as new and existing technologies are developed.

Solugen's carbon sequestration progress can be measured in several ways:

1.) Feedstock costs overtime (e.g. moving to cellulosic sugars)
2.) Molecules validated at pilot scale per year
3.) Installed plant capacity per year
4.) Percentage of plant capacity deployed into carbon sequestering end markets
5.) Adoption of carbon subsidies from third parties such as Stripe to end-users over time

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

Year	Units deployed (#)	Unit cost ($/unit)	Unit gross capacity (tCO_2/unit)	Notes
2021	2	N/A	10,240 tons CO_2/unit (100% capacity)	Construction, commissioning, and start-up complete by October 2021. *2nd Unit = Demonstration Plant*
2020	1	N/A	200 tons CO_2/unit	Construction of first demonstration plant

				underway. Benchtop experimentation and piloting continues.
2019	1	N/A	200 tons CO_2/unit	Design of first demonstration plant underway. Benchtop experimentation and piloting continues.
2018	1	N/A	200 tons CO_2/unit	Design of first demonstration plant underway. Benchtop experimentation and piloting continues.
2017	1	N/A	200 tons CO_2/unit	Benchtop experimentation continues. Piloting begins. *1st unit = Pilot Plant*

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.*)

Pilot plants have a more expensive feedstock corn syrup basis (due to the low buying power) as well as the same labor costs as a commercial plant. As Solugen builds more and larger plants co-located with end-users and cellulosic sugars, the economics of carbon sequestration substantially improve.

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)
Solugen will be starting up its first commercial demonstration plant in October 2021. During the first year of operation, Solugen will operate at 10% of the nameplate throughput capacity of the plant before ramping to 50% by the second year. From the third year onward, Solugen will be operating at 100% nameplate capacity, producing 10,000 metric tonnes of	First commercial demonstration plant: 10,240 tCO_2/unit/yr at 100% throughput capacity By 2030: All Solugen "units" (commercial plants) should combine to sequester 10,000,000 tCO_2/yr, with potential to scale up even greater to 0.5Gtpy by 2040.

BioChelate (TM)/yr for prospective customers, directly sequestering a net of 6,140 metric tonnes of CO_2/yr. In addition, by replacing THPS, Solugen is also avoid emitting 17,000 metric tonnes of CO_2/yr (from THPS). Solugen is also planning on building a larger 2nd commercial plant, producing more BioChelate (TM) and thus further sequestering CO_2. By the year 2030, Solugen will have built multiple plants placed strategically near customer sites. The target amount of CO_2 sequestered by all of Solugen's commercial plants will be 10,000,000 metric tonnes of CO_2/yr.	

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?

Solugen is a utilization company whereby the oxidized sugars present a performance benefit to end-users that sequestering sugars or waste bio-oil does not present. As such, Solugen's end-user customers provide for most of the economics today, but only up to 50 ppm of material injection versus the 10,000 ppm that could be injected. By Stripe independently pioneering a corporate behavior that gives monetary value to stimulate the sequestration of carbon, Solugen aims to leverage a procurement partnership with Stripe as an anchoring point with its end users and transition the value of carbon sequestration over time.

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."

Solugen's "in" economics are largely determined by the market pricing of petrochemical incumbents, the cost of biobased feedstocks, CAPEX amortization, labor, electricity, and catalyst costs. Solugen's "out" economics include the R&D cost to develop and demonstrate its chemienzymatic platform.

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	Mechanical completion of Solugen's first commercial demonstration plant.	Mechanical completion marks the end of construction and the plant is ready for commissioning and subsequent start-up. It marks the beginning of Solugen's long term vision of scaling up its unique process technology.	Q2 2021	Come visit the plant.
2	Start-up of Solugen's first demonstration plant to produce BioChelate (TM).	Starting up Solugen's first demonstration plant and producing product *is* scaling up. A successful scale-up validates Solugen's technological platform for future scale-ups as well.	Q3 2021	Come visit the plant. Solugen is producing BioChelate (TM) at the desired production quantities.
3	First delivery of BioChelate (TM) to customer site.	First delivery of product to customer site shows that Solugen is able to produce and sell its products at commercial plant scales. It validates that Solugen's process technology works, is scalable, and is desired for by	Q4 2021	Visit customer saline well site or video capture.

		customers.		

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	200 tons CO_2/yr sequestered.	200 tons CO_2/yr sequestered.	Note: Pilot Plant still operational.
2	200 tons CO_2/yr sequestered.	1,024 tons CO_2/yr sequestered.	Starting up the first commercial plant for the first time, operating at 10% nameplate capacity (100% capacity = 10,240 tons CO_2/yr).
3	1,024 tons CO_2/yr sequestered.	10,240 tons CO_2/yr sequestered.	Note: 100% capacity (10,240 tons CO_2/yr sequestered) achieved after year 3 and beyond.

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	Negotiable	Negotiable	Commercial plant cash flow positive during operation without carbon offset credits. See Section 6(b).
2	Negotiable	Negotiable	Commercial plant cash flow positive during operation without carbon offset credits. See Section 6(b).

3	Negotiable	Negotiable	Commercial plant cash flow positive during operation without carbon offset credits. See Section 6(b).

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?

> The ultimate potential of >0.5GT/y will require billions of dollars of installed capital. We would ask the head of the IMF to approve 90%+ LTV, zero interest project financing to carbon sequestration platforms where the excess IRR is granted to long-term offtake partners, thereby simultaneously incentivizing and financing rapid deployment.

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

> Publicity and brand association with Stripe's pioneering steps in corporate sustainability governance and corporate purchasing behaviors will help enable Solugen to drive new corporate sustainability behaviors from its end-users.

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?

> Our external stakeholders encompass the entire product lifecycle of our carbon negative bio-based chemistries. They include producers of our feedstock (domestic corn growers), transportation providers, end-users of our product (primarily, oil field services providers and

saltwater disposal operators), as well as communities in areas where we operate and where our other external stakeholders operate. We also work closely with industry associations and educational institutions to promote decarbonization of the chemical industry.

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

At Solugen our mission is to decarbonize the chemicals industry. To make our mission a reality we engage with our stakeholders on all levels – through dedicated in-house resources and through external consultants and independent advisors. For example, we teamed up with Invariant, a lobbying group in DC, to promote use of domestic bio-based chemicals by the Department of Defense. We also commit significant in-house resources. For example, our General Counsel completed her certification in Corporate Sustainability from NUY Stern and dedicates a large portion of her time to ESG initiatives, including local community engagement.

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

Through our in-depth engagement with our external stakeholders we learned that there is a lack of knowledge about the availability of domestic bio-based chemistries. End-users have grown complacent and need to be educated and encouraged to improve their business practices. Often customers and vendors do not realize that aligning their operations with ESG objectives delivers significant commercial benefits in addition to environmental benefits.

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?

At Solugen we are relentlessly resourceful. We realize the need to educate local communities and our end-users and plan to increase our community engagement at the local level. We have been successful at constructing small-scale bio-based mini-mills producing basic chemistries. Going forward, we plan to increase the availability of non-hazardous chemistries by constructing mini-mills in close proximity to customer needs.

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

At Solugen we fight environmental racism by making a positive impact on air quality, clean water and a safe environment. We address environmental justice concerns by developing and implementing technology that enables production of bio-based carbon-negative non-hazardous chemicals. In communities we operate we make a positive change by offering green jobs to workers formerly employed in carbon intense industries like oil and gas.

11. Legal and Regulatory Compliance (Criteria #7)

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

We have enlisted the support of industry-specific experts to provide a compliance roadmap based on the market. Each market may require compliance with industry-specific regulatory requirements.

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.

We have obtained construction, air, and water permits. Ongoing communication with our local community exists to address any question the city or surrounding businesses/residential area has regarding our project.

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.

The process is not regulated under OSHA Process Safety Management guidelines. Currently, we have air and water permits for the process that meet the Texas Commission on Environmental Quality (TCEQ) standards.

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)	Year 1: 614 metric tonnes CO_2 Year 2: 3,070 metric tonnes CO_2 Year 3+: 6,140 metric tonnes CO_2/yr

Delivery window (at what point should Stripe consider your contract complete?)	Negotiable - Plant is intended to be online for 40 years
Price ($/metric tonne CO_2) *Note on currencies: while we welcome applicants from anywhere in the world, our purchases will be executed exclusively in USD ($). If your prices are typically denominated in another currency, please convert that to USD and let us know here.*	We would ask that Stripe propose a standard $/tonne price to utilization companies.

Application Supplement: Biomass

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

Feedstock and Physical Footprint (Criteria #1)

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

Dextrose

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

Solugen is procuring dextrose from wet mills in 2021 and purchasing from cellulosic sugars providers from 2023 onwards.

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

	Area of land or sea (km^2) in 2021	Competing/existing project area use (if applicable)
Feedstock cultivation	2900 acres of feedstock	
Processing	0.7 acres	
Long-term Storage	3 acres per injection site for saline wells	

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

	Projected # of km^2 enabling 100Mt/yr	Projected competing project area use (if applicable)
Feedstock cultivation	$2.8 * 10^7$ acres Linear Scale Up. In the future, this would be a mix of starch-derived and cellulosic-derived acreage.	
Processing	70 acres Square Root Scale Up	
Long-term Storage	$2.9 * 10^4$ acres Linear Scale Up	

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

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

> BioChelate (TM) is primarily used for scale control in saline wells. Once BioChelate (TM) is injected into the well, it is sequestered in a stable environment. Saline wells are established permanent assets and have existed for many years. BioChelate (TM) is only injected into stable wells that are well established; thus, the risk that these wells leak or fail are very minimal. Thus, BioChelate (TM) will be permanently sequestered.
>
> Reference: LCA - [LCA - Solugen GHG Emissions v14.pdf]

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

The alternative use of Solugen's 2021 feedstock is human and animal consumption as well as ethanol fuel. Each of these end-uses are net carbon positive. After 2023 with cellulosic sugars, the only alternative for these feedstocks would be incineration, which is net carbon neutral.

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

Solugen's process technology to convert dextrose into BioChelate (TM) is relatively low risk. The technology itself has been optimized and well studied. There seems to be very little negative impacts or important unknowns with the technology itself. Solugen can utilize flexible carbohydrate feedstocks and operates at low temperatures and without the use of flammable processing aids, feedstocks, or solvents. In terms of end-use applications, BioChelate (TM) is intended to be used in pre-existing saline wells for scale control, permanently sequestering the compound. Saline wells are multi-decade permitted wells that have been frequently used. Risks include leaks from these wells, releasing BioChelate (TM) into the environment. However, this risk is very minimal due to the well-established nature of these saline wells.

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

Solugen's proprietary chemienzymatic process is able to convert biomass with high yield and energy efficiency into molecules that can both sequester carbon and serve a useful purpose before sequestration. The process is also capital efficient on a CAPEX/kta and is fully automatable, resulting in a low OPEX delta over the feedstock cost basis. Other solutions are low yield, energy intensive, high CAPEX, and/or produce biomass products that do not serve an economically valuable purpose before sequestration. Fermentation is an established alternative to Solugen's chemienzymatic platform, but 50% of the carbon flux in fermentation is released as CO2 via cellular respiration. Solugen's carbon flux yields approach unity because we do not use living organisms. Pyrolysis is an established alternative to Solugen's chemienzymatic platform, but the high CAPEX/kta throughput and high temperature conditions result in substantial primary CO2 emissions through natural gas burning or biomass incineration to power boilers and furnaces. Solugen's energy requirements are more than 90% supplied by wind-generated electricity with only a small natural-gas fired boiler supporting the 10kta plant for startup steam. This boiler is included in the LCA.

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?

We are injecting an aqueous solution. Other compounds in the injected material include a variety of salts and compounds of produced water.

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 main geologic settings used for this project are Salt-Water Disposal (SWD) Wells. Their primary function is to dispose of high saline fluids which are uneconomical for reuse and or are geographically isolated from a reuse market. SWD's can process produced water and wastewater. Carbon offsets can be calculated based on the following:

A. Carbon dioxide present in the fluids to be disposed which is sequestered upon disposal.
B. Trucking offset where water does not need to be transported to other sites and can be injected from a pipeline source or near the point of end use. Transport Carbon Offset.
C. Substitution of water treatment technologies (WTT) which produce green-house gasses or CO_2 with low carbon emission technologies. BioChelate (TM) replaces Phosphonates such as THPS. The WTT is required due to the high concentration of divalents which can form scale in SWD's and cause premature injection failure. Scale control is the trapping mechanism itself.

Salt water disposal wells have existed for decades and are well designed to ensure that there is no leakage of material over time. These wells are monitored to ensure that there are no leaks and material is not lost over time. In addition, the returned fluids after BioChelate (TM) has been injected are analyzed to ensure that there is no loss of material over time. Thus, the permanence can easily be monitored over time.

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

Class II

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

Usage of BioChelate (TM) can vary from shale, specific geologic water produced, and the effects of corrosion during the recovery process. From Solugen's experience the following could be expressed as a loose average. The primary function of the BioChelate (TM) is to prevent buildup of scale. Iron can be present in the connate water or from corrosion of the metal parts during processing.

As an example:

- 50 ppm of total iron (Ferrous Fe^{2+} and Ferric Fe^{3+}) on 100,000 Barrels of disposal water.
- Average Ferric (most insoluble) would be 10 ppm (primary use for BioChelate).
- BioChelate (TM) on a 100% basis is 3:1 stoichiometrically for Ferric iron
- 126 gallons of 100% BioChelate would be required for 100,000 Barrels of Water (30 ppm)
- At a higher $/ton purchasing price of carbon, Solugen can inject more material beyond what is economically attractive for iron and scale control. >10,000 ppm can be injected while still maintaining asset performance benefits, which translates to over 42,000 gallons per 100,000 barrels.

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?

Solugen is currently and will only be injecting BioChelate (TM) into established wells that have been commissioned and operational for many years. These wells are already consistently monitored and the well contents are routinely analyzed. Solugen will consistently communicate with customers to ensure that these wells are functioning as intended and that BioChelate (TM) is properly controlling scale. The harmful phosphonates and aldehydes that Solugen is displacing represents an environmental hazard reduction.

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

There are no key uncertainties for using and scaling this injection method. Water treatment technologies (including BioChelate (TM)) have been used for many years in saline wells for scale control.