Carbon Capture

Carbon Removal Purchase Application

General Application

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

Company or organization name

CarbonCapture Inc.

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

Los Angeles, CA, USA

Name of person filling out this application

Jonas Lee

Email address of person filling out this application

[redacted]

Brief company or organization description

We offer CDR offsets generated by our DAC + sequestration projects

1. Overall CDR solution (All criteria)

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

In conjunction with a sequestration partner in Wyoming, we are launching a large-scale DAC-based carbon removal as-a-service project. This project will sell permanent carbon removal credits that consist of DAC-based atmospheric carbon removal plus geological sequestration in an approved Class VI well. Note that we expect negotiations with our sequestration partner will be finalized in late May 2022. Capture and sequestration operations are expected to begin in mid-2003.

With respect to our DAC technology, we have successfully demonstrated a low-cost process to remove CO_2 from the atmosphere in a lab-scale, TRL 5 prototype that utilizes commercial zeolites in an energy-efficient, low-pressure drop temperature vacuum swing adsorption (TVSA) process.

Low-silica zeolites with the FAU framework topology are commercially available at a low cost; they are amongst the most commonly used adsorbents in industrial gas adsorption and separation. However, the main issue that has impeded the use of zeolites for DAC is its high affinity for water and the related energy needed for desorption. To address this issue, we have successfully developed and demonstrated a process that can remove more than 90% of the water content in air with no thermal energy input. This is critical as it considerably reduces the energy requirements of a zeolite-based DAC system.

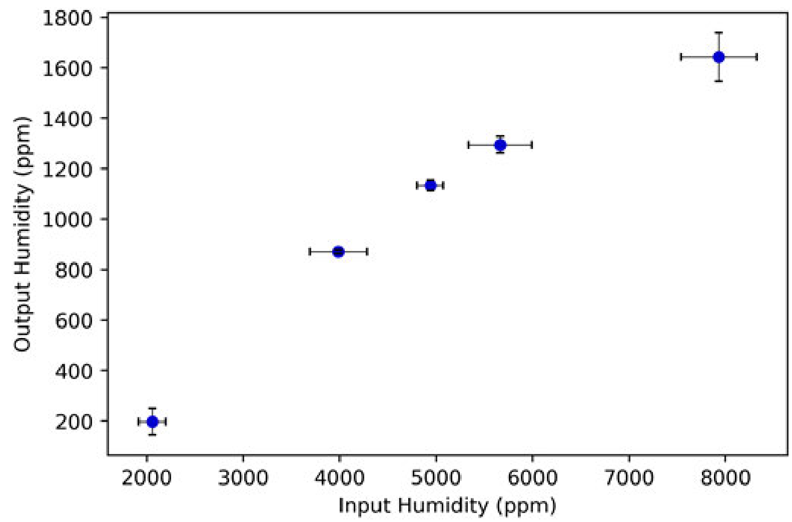


Figure 1 shows the humidity content in the stream leaving the pre-processing unit as a function of ambient condition. Dry air then enters the zeolite bed for CO2 adsorbtion.

The use of zeolites allows our DAC systems to achieve a number of important design goals, including:

- *Modularity: zeolite-based DAC systems can be built with smaller reactors in order to be cost effective, enabling a modular design approach. Each of our DAC modules is the size of a standard 40' shipping container and will be capable of removing 0.5 to 1.5 ton-CO_2/day. This modular design enables off-site manufacturing, inexpensive transport, and rapid deployments that can start with a single module and expand to thousands with demand.*

- *Scalability: zeolites are currently commercially manufactured in very large volumes; by accessing the existing global supply chain for zeolites, this technology removes the scaling bottlenecks associated with exotic adsorbents that are not easily manufactured in mass quantities.*

- *Low temperature: With a relatively low desorption heat and temperature of under 300°C, a number of renewable thermal energy sources are applicable, including solar, nuclear, geothermal, and industrial waste heat.*

Figure 2 shows a conceptual rendering of our container-sized DAC module as it is being installed in a cluster formation, which is itself part of a larger array.

Current DAC development status and notes:

- *We have completed steady state, parametric, and transient tests in our laboratory scale prototype over a 6-month period in order to quantify performance under various conditions.*
- *We are in the process of commissioning a system that can remove approximately 1 kg of CO_2/day from the atmosphere.*
- *The next prototype, currently being constructed, will be operational by YE 2022 and will remove 50 to 100 kg CO2 per day-.*
- *Thereafter, the first commercial module will be built and deployed by mid Q2 2023 at a scale of ~500 CO2 per day.*
- *The Global CO2 Initiative's verification of our technology is available upon request.*

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.)*

The major participants in this project are:

- *CarbonCapture Inc.: a technology and project development company that is developing, manufacturing, financing, and deploying our modular DAC systems as well as selling the offsets that our project generates*
- *Geologic storage partner: a company with an extensive operating history in Wyoming (to be announced in Q2, 2022) will be providing CO_2 compression services using existing equipment and permanent geological CO_2 storage via sequestration. A Class VI well license has been filed by this organization and is*

anticipated to be granted by YE 2022

- *Other supporters of this project include: The Nature Conservancy: an NGO responsible for advising on project siting and land usage*
- *Wyoming Business Council: a state agency responsible for advising on local permitting, land use, and potential revitalization activities*

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

- *Availability and scaling of the supply chain for DAC materials*
- *Availability and scaling of renewable or zero carbon energy sources*
- *Passing of proposed enhancements to 45Q*

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

CCI has filed provisional applications on the new processes involved for pre-drying the air and utilizing zeolites for DAC. The applications are pending review and are not publicly available.

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

We currently have a team of 34 individuals working on the development, commercialization, and deployment of our DAC technology. Our leadership includes:

Bill Gross, Chairman. Bill is Co-founder and Chairman of CarbonCapture. He's also Founder and Chairman of Idealab Studio, a leading technology incubator. Over the last 23 years, Idealab has created and operated more than 150 companies and had more than 45 successful IPOs and acquisitions, including pioneering climate technology companies such as Heliogen and Energy Vault.

Adrian Corless, Chief Executive Officer and Chief Technology Officer. Adrian has spent over 25 years developing and commercializing products in the cleantech industry. From 2013 to 2018, he was the CEO of Carbon Engineering, where he successfully developed the company into a recognized global leader in direct air capture, piloting industrial scale systems in less than two years.

Saeb Besarati, Dir. Of Systems Engineering. Saeb holds a PhD degree in Chemical Engineering and a Master's degree in Thermal Mechanical Engineering. He has more than 12 years of experience in developing technologies to address climate change. Saeb is a certified project manager by the Project Management Institute (PMI).

Peter Ciulla, VP Operations. Peter has 20 years of experience developing and scaling products in the aerospace, commercial, and industrial sectors. He's skilled at evaluating product-market *fit, leading cross functional teams to develop and commercialize products.*

Steve Hamblin, VP Product Engineering. Steve has significant engineering experience and engineering leadership experience, most recently at Virgin Galactic, where he led the Vehicle Design team in the developing space vehicles and high-altitude aircraft.

Jonas Lee, Chief Commercial Officer. Jonas leads the commercial team, responsible for structuring partnerships, developing client relationships, and deploying projects. His background is in the commercialization of early-stage technologies.

In addition to the 34 employees we currently employ, we are in the process of hiring an additional 20 individuals by the end of 2022. Most of these hires will be engineers, scientists, and specialists with expertise in materials science, product development, manufacturing, and other fields that support the deployment of DAC projects; adding top-flight talent in these areas is our most urgent need.

Our unfair advantages in building and deploying our DAC solution include:

- *A strong scientific and engineering team that has generated, and will continue to generate, significant materials and systems-level intellectual property related to DAC*
- *A highly experienced, well-funded management team that is focused on rapid deployment at megaton scale*
- *A focused strategy that emphasizes modularity, materials interoperability, rapid cost reduction through scale*

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 2022 - Jun 2023. The end of this duration determines when Stripe will consider renewing our contract with you based on performance.*	*Our initial modules are intended to operate for 30 years, but our offer only reflects volumes from Year 1 of our deployment.*
When does carbon removal occur? *We recognize that some solutions deliver carbon removal during the project duration (e.g. DAC + injection), while others deliver*	*July 2023 – July 2024. Note that carbon removal and launch of the project happen simultaneously and there is no delay between the two.*

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 2022 - Jun 2023 OR 100 years.*	
Distribution of that carbon removal over time *For the time frame described above, please detail how you anticipate your carbon removal capacity will be distributed. E.g. "50% in year one, 25% each year thereafter" or "Evenly distributed over the whole time frame". We're asking here specifically about the physical carbon removal process here, NOT the "Project duration". Indicate any uncertainties, eg "We anticipate a steady decline in annualized carbon removal from year one into the out-years, but this depends on unknowns re our mineralization kinetics".*	*As soon as we begin operations in mid 2023, we will be capturing and sequestering CO2.* *Note that we plan to expand aggressively, growing from 3,150 t/CO2 in year one; 30,000 in year two; 150,000 in year three; 725,000 in year four; 3,000,000 in year five and 5,000,000 per year thereafter*
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.*	*At least 1,000 years*

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

Permanent geological sequestration has a lower bound estimate of 1,000 years; multiple sources suggest very little risk of leakage, providing upper bounds of at least 10,000 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.)*

Our expectation is that the CO2 injected into a Class VI well will remain sequestered for at least 1,000 years. The IPCC supports this estimate, considering it likely that 99% or more of injected CO2 will be retained for 1,000 years:
https://www.energy-transitions.org/wp-content/uploads/2022/03/ETC-CDR-Report-Mind-the-Ga

p.pdf

As part of the Class VI well permit, the proper authorities (in our case the Wyoming Department of Environmental Quality (DEQ)) will review sub-surface assessment of the site, including seismic data and any nearby wells that have not been properly closed, which, if any, must be identified and corrected prior to the start of operations in order to ensure the security of geological storage.

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?

A substantial body of research indicates that it is likely that 99% or more of the injected CO2 will be retained for 1,000 years, with only minimal risks occurring during injections and well closures. While seismic activity could affect geological sequestration, the research done for the Class VI permit of this sequestration site shows negligible seismic risk.

Our geologic storage partner significant has substantial experience with sub-surface characterization and injection. We are confident of their technical capability to safely and securely store and monitor injected CO2. Further, we believe that the Wyoming DEQ will only issue a Class VI permit to an organization that has sufficiently demonstrated the capacity to safely and securely store CO2 as well as provide the requisite financial guarantees.

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.)*

As per Class VI requirements, our geologic storage partner will be utilizing multiple monitoring wells to track injected CO2.

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	*1,400 tons/year gross removal*

Do not subtract for embodied/lifecycle emissions or permanence, we will ask you to subtract this later	
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	*N/A*

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

*Each of our Gen-1 modules will remove at least 0.5 a ton of CO2/day (we expect future modules to expand that capacity to 1.5 tons/day). Our initial module clusters will consist of 18 modules, with a total carbon removal capacity of more than 9 ton-CO2/day. Assuming 350 days of operations, that's 9 tons-CO2/day * 350 operating days/year = 3,150 tons/year gross removal. We are offering Stripe 1,400 tons of this capacity.*

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, our DAC technology is TRL5-6. As such we have not deployed any commercial systems in the field. In our first year of field operations (mid-2023 to mid-2024), however, we plan to deploy a DAC cluster that consists of 18 of our container-sized modules. This cluster will capture approximately 3,150 tons a year. *By the end of our second year of operations, we plan to expand capacity at this same site to*

over 30,000 tons/year by deploying additional DAC clusters. From there, we anticipate very rapid growth, reaching 5.0 megatons of capacity by YE 2027.

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.)*

We have completed steady state, parametric, and transient tests in our laboratory scale prototype over a 6 months period to quantify performance under various conditions. The process has been demonstrated live to the Global CO2 Initiative (GCI). The data collected from the experiments as well as the underlying assumptions for the techno-economic model were reviewed and verified by the GCI.

Figure 3. Inlet and outlet CO_2 concentrations and bed temperature during adsorption

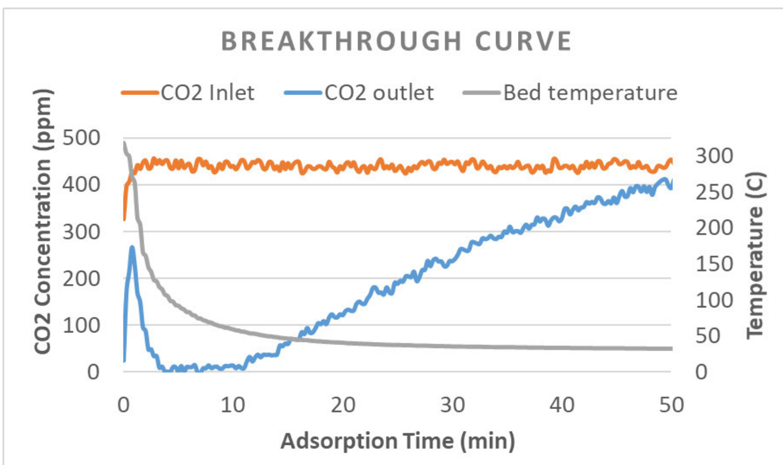
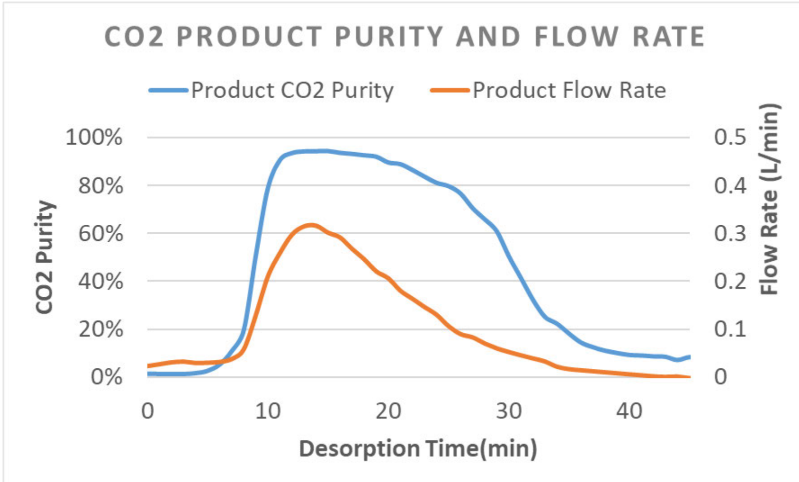


Figure 3 depicts the adsorption process within a single cycle. The orange line represents the inlet CO2 concentration while the blue line shows the CO2 concentration in the flow exiting the reactor. The cooling and adsorption steps are combined to improve cycle time. This results in a spike in the outlet concentration at the beginning of adsorption, which is mainly due to high bed temperature.

Figure 4. CO_2 purity and flow rate during desorption



The CO2 purity and flow rate of the outlet stream from the prototype during the desorption process is in Figure 4.

Based on the data collected from the tests, we developed high fidelity processes and techno-economic models. In parallel, we leveraged the extensive experience of our mechanical design engineers to develop a system that embody reactors and other required components.

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.

- *A rendering of the proposed modular DAC system can be seen here: https://vimeo.com/691924234*

- *We are forwarding a letter from the Global CO2 Initiative outlining their review of the technology in a separate email*

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	*1,400 ton CO_2*

Gross project emissions	*200 ton CO_2*
Emissions / removal ratio	*14.3% for Gen 1 module*
Net carbon removal	*1,200 ton CO_2*

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

Figure 5. Carbon flow diagram for first CCI’s commercial module

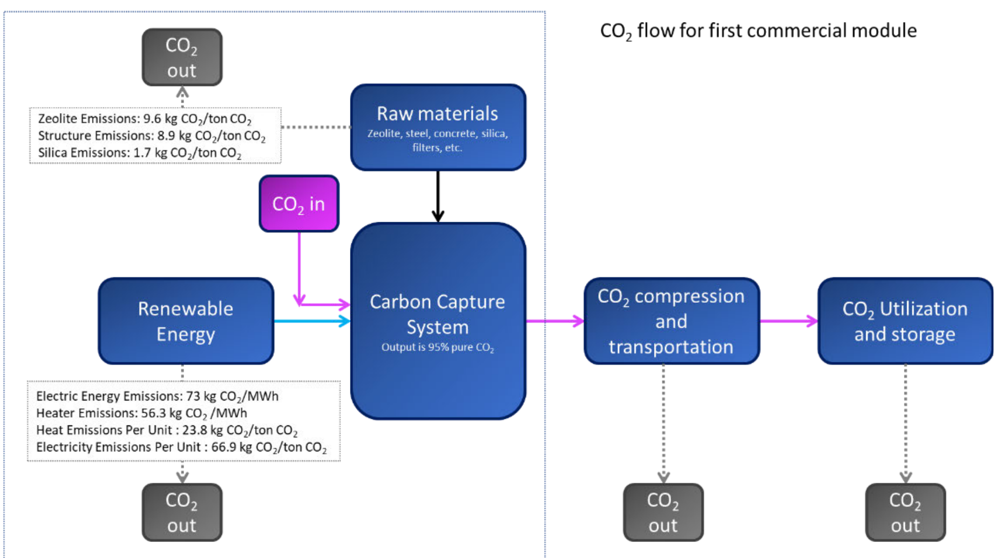
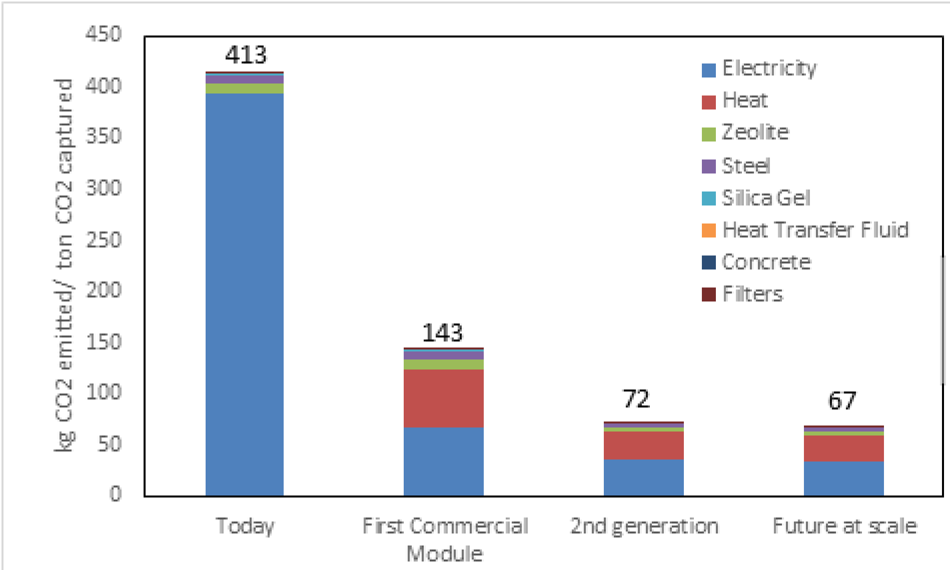


Figure 6. Life cycle analysis for different generations of CCI technology



We will have the Global CO2 Initiative perform a full LCA when we have selected our sequestration partner.

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?

In our LCA we include the energy used to perform direct air capture. We also include the carbon footprint of the materials used for constructing the unit (concrete and steel), the CO2 sorbent, desiccant system, and other consumables (replacement parts, filters, etc.).

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](#).

This is proprietary data and can not be shared publicly.

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.

As part of our completed technical review with the Global CO2 Initiative they reviewed our data and believe our technical assumptions to be justified. We also have submitted our LCA under the approval of the University of Illinois at Urbana-Champaign for a department of energy grant.

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

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

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

We will be deploying our first set of container-sized (40'x8'x9.5') modules in clusters of 18. Eventually, we will deploy as many clusters as the sequestration site can accommodate, limited primarily by the market demand for CDR credits and our ability to manufacture and deploy systems.

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

Year	Units deployed (#)	Unit cost ($/unit)	Unit gross capacity (tCO_2/unit)	Notes
2022	*N/A*			<50 words
2021	*N/A*			<50 words
2020	*N/A*			<50 words
...				

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

Our costs have been stable because we're still in the first cycle of deployment.

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)
8 modules	*175 tCO_2/unit*

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

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

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

For our lab prototype, the current estimated cost is $1946/ton CO2.
The cost for offered CDR units is anticipated to be $715 per ton as described below.

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

The $1946/ton CO2 captured is based on lab-scale, but this is not relevant for commercial costing. The model assumes a cost of renewable energy (both heat and electrical) at $0.08/kWh.

Beyond the lab scale prototype, the first generation systems ($715/ton CO2) will be built as prototypes in our facility and will be deployed incorporating renewable heat from a concentrated solar power plant and be designed to recover about 25% of the sensible heat each cycle, with potential to achieve up to 70% recovery in future generations. These advancements will significantly reduce energy costs. Furthermore, with direct use of heat combined with improved technology, the carbon removal efficiency, representing the impact of life cycle emissions, will increase from 59% today to 86% in the first commercial module and 93% in future generations. Our Gen-1 estimate for the capex/opex ratio is roughly 40%/60% with respect to levelized costs.

Our second generation systems will incorporate cost reductions for streamlined production at large scale, and will include improvements in sorbent or reactor technology that are currently in the R&D phase. Our Gen-2 estimate for the capex/opex ratio is roughly 50%/50% with respect to levelized costs.

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

This is proprietary data and can not be provided publicly.

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

The main cost drivers in the current system are:

- *Energy. Costs will first be reduced by using renewable heat directly (as opposed to using electricity). In second generations, costs will be reduced by using higher-capacity sorbents and improving the thermal efficiency of the reactor*
- *O&M costs. Costs will primarily be reduced thought extended the lifetime of the sorbents and introducing remote monitoring, automating basic operating functions, and by focusing on particulate filtration to improve sorbent lifetime. In second generations, we anticipate introducing more robust sorbents with longer lifetimes*
- *Equipment costs. By moving into commercial production, we expect significant cost reductions. in the customized CCI reactor, which will similarly be reduced at scale with improved design for manufacture and supply chain management*

Reaching $100/ton requires further advancements in the areas below:

- *Energy. We anticipate that the cost of 24x7 renewable electrical energy will fall from $0.08 to $0.035/kWh. It is also anticipated that the cost of heat will be reduced below $0.01/kWh or that inexpensive waste heat can be used, which could even further reduce costs*
- *O&M costs. We believe there are substantial cost reductions to O&M for large scale deployments (over one megaton) due to logistics and staffing efficiencies*
- *Equipment costs. Whereas equipment costs in the near term are projected to be upwards of 400% of raw materials, in the long run, at very high volumes, we anticipate acquiring or building equipment in-house at roughly 30% to 70% above the cost of raw materials (as is done by Tesla and other high volume car manufacturers). To achieve this, we will 1) develop in-house manufacturing of valves, controls, and other high-cost equipment, 2) reduce parts count through integration of functions, and 3) increase our use of advanced volume manufacturing process including automation, castings, and the use of stamped parts*
- *Cost of capital. A capital recovery factor of 10% is the default in the TEA above; it is assumed improved project financing will reduce that figure to 6.7%. This is the rough cost of capital for well-managed, large industrial companies; we anticipate that the DAC industry at gigaton scale will support the development of multiple large industrial companies*

Analysis based on 2022 dollars

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

In terms of the cost difficulties mentioned above:

- *Owned vs leased land. We are currently working with sequestration partners who have sufficient land to host our DAC facility. We do not see this as a risk in our target project locations in Wyoming*
- *Renewable electricity costs. The assumptions made in the TEA for the first commercial module are highly realistic, e.g. a sensible heat recovery of only 25%*
- *Higher vendor equipment costs. We are focused on developing the supply chains for all strategic components including the adsorbents and key process equipment*
- *Deployment site adjustments. We are leveraging existing developments in Wyoming which are already committed to deploy Class VI wells*
- *Technical performance optimization. Our technology and product delivery teams understand the KPI's critical to meeting our technical and commercial goals. We continue to support extensive additional advanced development programs on materials and systems to ensure we will meet or exceed or stated goals*
- *Supporting plant infrastructure. We are partnering with experienced partners who have developed and implemented industrial CCS projects in the past*
- *Construction overruns. We are working with our EPC partner to manage this risk*

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

Milestone #	Milestone description	Why is this milestone important to your ability to scale? (200 words)	Target for achievement (eg Q4 2021)	How could we verify that you've achieved this milestone?
1	*Finalize the partnership with an engineering firm and sequestration site to build a cluster of 18 modules with a capacity of removing about 3200 ton-CO2/year*	*Allows timely construction and commissioning of the project. Also, securing a site with class VI sequestration well is critical for permanent storage of CO2*	Q2 2022	*We can provide commitment letters from each party*
2	*Demonstrate a unit removing 50*	*This is 10% scale of the final module size. A successful*	Q4 2022	*We will provide a report presenting system design,*

	kg-CO2/day	*demonstration will be an important step for de-risking the technology at scale*		*tests results, and lessons learned*
3	*Complete engineering the commercial size module*	*The engineering activities for the commercial size module, 0.5+ ton-CO2/day, is completed*	Q4 2022	*We will provide a report presenting system design and equipment selection*

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	*N/A*		
2	*1 kg CO_2/day*	*50 kg-CO_2/day*	*Scaled up unit*
3	*50 kg-CO_2/day*	*500 kg-CO_2/day*	*Scaled up unit*

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

Milestone #	Anticipated cost/ton prior to achieving milestone (ranges are acceptable)	Anticipated cost/ton after achieving milestone (ranges are acceptable)	If those numbers are different, why? (100 words)
1	*N/A*		
2	*N/A*		*The milestone is important for de-risking the technology and cost reduction is not the objective*
3	*$2,000*	*$715*	*Cost is expected to be significantly reduced by integrating thermal energy instead of electric heaters, including heat recuperation, and optimizing the use of valves and instrumentations*

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

We would ask Larry Fink of the investment firm BlackRock to incentivize public companies to fill 5% to 10% of their net zero commitments through the purchase of DAC-based carbon offsets. Doing so would rapidly drive scale up and costs down.

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

We will be looking to hold community engagement sessions in Wyoming in June. We would love to have Stripe participate in those sessions to raise awareness and community support for our DAC project.

7. Public Engagement (Criteria #7)

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

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

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

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

External stakeholders. External stakeholders include environmental groups; local and state government agencies; community groups concerned about revenues for education and public good; and clean energy advocates. We are currently engaged with the Wyoming chapter of The Nature Conservancy, the Wyoming Business Council, The University of Wyoming, and the Wyoming Energy Authority. These groups will help us build out our full engagement plan over the next several months.

Location of external stakeholders. The majority of the groups with which we will be engaged will be within the state of Wyoming.

Process used to identify stakeholders. We are working with The Nature Conservancy, the Wyoming Business Council, and The University of Wyoming to map out local stakeholders for engagement and to hold joint educational sessions. We will create a formal stakeholder engagement plan and a local steering committee for the project to address any concerns raised throughout the process.

Discussion of the communities engaging in or impacted by our project.
We have been working closely with The Wyoming Energy Authority and the Wyoming Business Council on the development of our Wyoming DAC project. We expect a local support staff from the Wyoming Business Council to be assigned to us to ensure we are connecting with relevant local government resources. This is in addition to our community engagement plan described above.

We also note that the proposed site is not adjacent to any native lands. There are certainly considerations as this land may be home to wildlife; will collaborate with local stakeholders to ensure as little disruption as possible.

We believe that our Wyoming DAC site is likely to be the largest in the US by YE 2027; we recognize the tremendous responsibility to the local community and the DAC industry itself that this project represents.

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

At this early stage, our interactions have been primarily with The Nature Conservancy, the Wyoming Business Council, The University of Wyoming, and the Wyoming Energy Authority. We may consider working with external consultants with more direct environmental justice experience as we move forward. As described above we plan to work through a full engagement plan and begin educational sessions this summer. Given the low ratio of people to land in Wyoming and its history of extractive activity, we believe the support for this project will be much stronger than we would find in most other states.

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?

We have learned from The Nature Conservancy that some land deployed for renewable energy was done without consideration of wildlife impacts. We will look to avoid these mistakes by ensuring that our facilities do not impede migrations. Further, we anticipate using previously disturbed land for our activities.

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?

Our land use at the outset will be minimal, but as we expand, land needed for both the DAC installation and zero-carbon energy deployment will rapidly increase. Mapping out where to place structures to have the least environmental impact will be a critical part of our community engagement.

8. Environmental Justice (Criteria #7)

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

Our project is expected to be located in an area of WY where 14% of the population lives below the poverty line (well above the national average of 12%). We anticipate that the development of a large-scale DAC industry in Wyoming will help address some of the economic challenges faced by the state brought on by the job losses in the extractive industries brought on by the energy transition process.

We are currently working closely with The Nature Conservancy and the Wyoming Business Council to identify key stakeholders with respect to environmental justice concerns.

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

We are committed to working with business and community leaders in the state to ensure that the community's environmental justice concerns are fully addressed as we deploy our large-scale DAC and renewable energy facilities. To date, we have identified the following considerations:

- *We believe our project could encourage additional renewables deployment, which has stalled as some are concerned about the displacement of fossil fuel-based power*
- *We will be placing structures on land that has already been disturbed, which has less opportunity for nature-based regeneration*
- *We will be spacing and elevating our DAC clusters to allow for migratory animals*
- *By locating a large-scale DAC facility in an area with substantial job losses in the extractive industries brought on by energy transition process, we hope to improve the economic position of the local community*

9. Legal and Regulatory Compliance (Criteria #7)

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

We have hired legal counsel to advise us on our project. While our sequestration partner will be responsible for a Class VI permit required to permanently sequester our CO2 underground and the associated liability, we will ensure through our own compliance with the appropriate regulation as well. In specific, we have retained counsel with specific expertise in 45Q credits.

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

Our proposed sequestration partner has already submitted a Class VI well application to the Wyoming Department of Environmental Quality (DEQ). We plan to lease land from that same sequestration partner who has current land rights. As we build out our project, we will require the build out of zero carbon electricity and thermal energy, which may require additional permits.

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

No

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

The legal framework in both the United States and Wyoming regarding capturing and sequestering carbon is fairly advanced. There is not considerable contract precedence for DAC-based capture and sequestration, but by using other contracts related to sub-surface injection, we feel comfortable with legal requirements and our ability to manage any related liability.

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

We have not yet received any government compliance programs to-date. We plan to receive, however, 45Q credits as part of our DAC-based carbon removal and geological storage project in Wyoming.

10. Offer to Stripe

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

	Offer to Stripe

Net carbon removal *metric tonnes CO_2*	*$1,200*
Delivery window *at what point should Stripe consider your contract complete?*	*July 2022 – July 2023*
Price ($/metric tonne CO_2) ***Note on currencies:** while we welcome applicants from anywhere in the world, our purchases will be executed exclusively in USD ($). If your prices are typically denominated in another currency, please convert that to USD and let us know here.*	*$800. This is 12% higher than our direct costs in order to cover administrative expenses*

Application Supplement: DAC

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

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

Physical Footprint (Criteria #1 and #2)

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

Year	Land Footprint (km^2)
2021	*N/A*
2022	*N/A*
2023	*0.00072 km2 for a cluster (18 modules, arranged in stacks of 3)*

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

Year	Contactor Footprint (m^3)
2021	*N/A*
2022	*N/A*
2023	*Each contactor measures 1.0m x 1.2m x 1.5m. There are 8 contactors per 40ft module and 18 modules (total usage = 259 m3)*

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

1. What sorbent or solvent are you using?

Commercially available zeolites as well next-generation zeolite sorbents being developed by

our materials science specialists

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

The equilibrium adsorption capacity is 1.8 wt% at 25C and dry condition. Under inlet condition of 2000 ppm water and 25 C, the working capacity is about 1 wt%. However, zeolites perform exceptionally well in cold and dry climates. Given that the average annual temperature at Evanston, WY is 6 C, we would expect a working capacity of 2.6 wt%.

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

Please see the response above

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

We consider our sourcing activities a trade secret. Note that the core features associated with zeolites include:

- *Low cost*
- *Very high availability (billions of tons manufactured annually)*
- *Inorganic and non-toxic*
- *Highly tunable/adjustable*
- *Low manufacturing emissions footprint*

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

We employ a temperature vacuum swing (TVSA) process to regenerate our material. The thermal and electric energy input for our first commercial module is estimated as 13.5 GJ and 3.3 GJ, respectively.

The energy requirements are expected to significantly decrease for the second-generation module due to better heat recovery, system integration, and sorbent performance. The estimated thermal and electric energy will be 6.2 GJ and 1.8 GJ, respectively.

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

We are in negotiations with different parties to provide renewable heat and electricity to our system. Assuming electricity is provided by 50% solar and 50% wind with battery storage, the carbon intensity is 73 kg CO_2 /MWh. Also, assuming heat is provided by solar energy the carbon intensity is 15 kg CO_2 /MWh (please see the LCA section for references).

We have assumed an initial electricity cost of $0.08/kWh and heat cost of $0.01/kWh in our TEA analysis. However, given the historical trends as well as recent developments in the cost of renewable power generation and storage, there is strong consensus that the costs will be considerably reduced before the end of the decade. We are also collaborating with Heliogen, Inc. to develop and integrate low-cost renewable heat into our system (https://www.gasworld.com/heliogen-carboncapture-combine-expertise-for-dac-technology/2022436.article)

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

We do not consume water or other resources in our process.

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

N/A

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

Our cycle time is between 90 to 120 minutes.

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

Zeolites are known in industry for their stability and longevity. With proper filtration, we expect a minimum lifetime of 5 years, which has been confirmed by industrial experts. We are also working on developing advanced filtration techniques to improve zeolite lifetimes; they can theoretically last indefinitely if protected from fouling.

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

Lifetime assumption for our material is at least 5 years.

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

Zeolite adsorbents are inorganic and non-hazardous, presenting minimal safety hazards in field use or upon disposal.

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

The advantages of our project can be divided into strategic and technical components:

- *Strategic:*
    - *Large scale. The goal of our Wyoming project is to get to 5 megatons of DAC capacity by YE 2027. We believe this is key to rapidly achieving the cost reductions that are necessary for broad adoption of DAC. At present, there are no visible limitations to hitting this goal (i.e., permitting, land use, energy, or injection limitations) at our Wyoming site*
    - *Modular deployment. A modular strategy is an important factor in rapidly scaling and reducing costs as it allows us to 1) very rapidly permit, finance, and deploy initial units, which in turns allows us to sell additional capacity and grow along with demonstrated demand, 2) use high-volume, factory-based manufacturing techniques and global sourcing to quickly ride down the experience curve (aka learning curve), and 3) rapidly introduce new sorbents and systems technologies without 'betting the farm"*
    - *Sequestration storage. We believe this will be the first major DAC + sequestration project; it is important to the development of the DAC industry to demonstrate the viability of such a project at scale*
    - *US-focused. We believe it is strategically important to focus our first major project at a site in Wyoming, a state that is being significantly impacted by the energy transition.*
    - *No EOR. We will never pursue projects, partners or sites that include EOR*

- *Technology:*
    - *Low-cost adsorbents. Zeolites are cheaper by at least an order of magnitude in comparison with advanced sorbents being utilized in existing systems*
    - *Highly available adsorbents. Zeolites are already commercialized at scale; there is a reliable supply chain to meet high-volume demand*
    - *Long lifetime adsorbents. Zeolites are known for their longevity and stability as they don't suffer from presence of oxygen or other gasses*
    - *No water loss. There is no water loss associated with our system. Instead, our system can be tuned to produce water as a part of the process*

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?

The CO2 is compressed until it liquifies

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 geological setting is deep depleted oil and gas reservoirs, trapped by multiple shale layers. The MRV plan includes multiple monitoring wells. In addition, the State of Wyoming has recently legislated to take permanent liability 10 years post-injection.

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 VI

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

The injection well will have capacity of up to 20,000 mcfd. At the end of the first year, we will be injecting an equivalent of 2,250 tons per quarter at our facility.

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?

While historically there have been concerns related to CO2 contaminating drinking water, these concerns are mitigated through the extensive initial due diligence and sub-surface characterization that goes into a Class VI application. This characterization demonstrates the security of the associated pore space for geological sequestration and that the appropriate "seals" exist to keep it separated from any water resources.

Concerns about leakage or seismic activity are also addressed by documenting 1) any seismic activity in the associated geological formation and 2) characteristics that will keep the CO2 permanently trapped, both nature-based (good cap-rock) and human-based (uncapped or mismanaged wells).

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

The key uncertainty is whether there are sufficient economic incentives to justify permanent sequestration. There are few, if any, technical uncertainties (including scaling up operations) as downhole gas injection has been a part of normal hydrocarbon extraction operations for decades.