Carbon Removal Purchase Application

General Application

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

Company or organization name

Methane Oxidation Corporation

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

Los Altos, California

Name of person filling out this application

Rocío Herbert
Peter Fiekowsky

Email address of person filling out this application

rocioherbert9@gmail.com

Brief company or organization description

Oxidize atmospheric methane, financed by carbon offsets

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.

Climate restoration is not geoengineering, just as forest restoration is not geoengineering. Similarly, methane level restoration (enhanced natural methane oxidation) should not be rationally considered geoengineering.

We intend to double the natural rate of atmospheric methane oxidation by increasing the natural concentration of chlorine radicals. The “iron salt aerosol” method has been shown to do this, using naturally occurring iron chloride to transport the chlorine into the lower atmosphere. This project will aerosolize either iron oxide or iron chloride dispersed into ship exhaust.

Salt spray will provide the needed chlorine.

The plumes from these ships will be sufficient to oxidize methane from the whole atmosphere roughly once per four years. This will result in doubling the oxidation rate, and halving the atmospheric methane level, restoring it to roughly its pre-industrial level. This would return global warming to 2005 levels.

We discuss plume modeling here. The modeling is not critical to achieve success because we have designed the system to handle a factor of 100 more or less iron than expected. The iron is the major cost, at $1000/ton. The expected cost per ton CO_2eq is 300 times less than the offset market norm for high quality offsets, so the methane oxidation process should be viable in any imagined circumstance.

As with almost any ocean system there are numerous variables that affect the efficiency, tons of methane oxidized per ton of iron aerosolized. These variables include: aerosol droplet size, pH, available sunlight, humidity, frequency of rain, wind speed and turbulance, plumes from other ships and the starting height of the plume.

Maximizing efficiency will take months or years and affect the profitability of the system. However the goal is to reduce atmospheric methane to preindustrial levels around 0.7 ppm by 2030, and to ensure humanity against a possible Arctic methane burst. Any profitability will be used to accelerate the scale-up of other climate restoration solutions.

Methane Oxidation Corporation (MOC) will design, manufacture, install, and support the aerosolization and reporting equipment on each ship. MOC will also gather and process atmospheric methane data from the ESA Copernicus satellite, and maybe others. That data will verify the amount of methane oxidized, which will be reported to a carbon registry such as VERA or Gold Standard.

The registered carbon offsets are expected to be considered high quality, because they’re additional and relate to verified reduction in atmospheric GHG levels. Companies such as Stripe, Microsoft, and others say they are looking for high quality offsets such as these.

Shipowners will be compensated for the use of their ships with part of the offset revenue.

We intend to have two ships operating and collecting data by the end of 2021, and to contract with about 100 ships by the end of 2022, and 1000 to 10,000 ships by the end of 2023. This should restore atmospheric methane to below 1 ppm by 2030.

Our team includes

- Scientific team at University of Copenhagen doing lab testing and atmospheric modeling, under Prof. Matthew Johnson.
- The scientific team that developed the iron salt aerosol concept in their 2017 paper. That team includes Franz Oeste, Renaud de Richter, Dr. Ming, Clive Elsworth
- The aerosol development team working on marine cloud brightening (MCB) for the Australian Great Barrier Reef project.
- The MOC team: Rocio Herbert, Peter Fiekowsky, Jim Christensen

Specifically:

1. **Physical footprint:** This method takes a few square meters on ships, and no footprint on land.
2. **Capacity**: This method is designed to restore methane to pre-industrial levels, essentially 100% capacity, even as methane emissions increase due to global warming. MOC, by doubling natural methane oxidation, would account for oxidizing half of all methane emissions, 300 MT CH4 per year. With a GWP of 25 this equates to 7.5 Gt CO2e per year.
3. **Cost:** We expect the full cost to be about $1B per year, which comes out to $0.13 per ton CO2e. Because carbon offsets sell for 300 times that, and we cannot risk destabilizing the carbon market, we expect to sell the offsets at market prices. In order to maintain market stability, we may decline to sell all offsets created while restoring methane levels. Our purpose is to maximize climate restoration, not maximizing profit.
4. **Durability:** Once oxidized, the methane stays oxidized. However the methane would oxidize naturally in a few decades. The benefit of enhanced methane oxidation is restoring the climate now. Restoring 2005 warming levels would result in important benefits to humanity and the economy. Methane oxidation also provides insurance against a methane burst which many scientists expect is possible this decade or century as the Arctic ice cap melts.
5. **Verifiability:** MOC will use the ESA Copernicus satellite data (TROPOMI) to verify methane removal from the atmosphere beyond natural oxidation rates.
6. **Additionality:** MOC will remove methane that would ordinarily oxidize over a period of decades. Thus additionality depends on how you look at it. If you consider the benefit to humanity of getting the climate back to where wildfires, category 5 hurricanes, and severe droughts were rare, then methane oxidation is additional. We must acknowledge that these humanitarian and subjective considerations aren't included in traditional emission measures.
7. **Safety and compliance:** The iron aerosols have been designed to be safe, with safety factors around a thousand. Environmental impact assessments are already budgeted. Full compliance with international regulations will be assured.
8. **Net-negative lifecycle:** Since methane turns to CO2 naturally, the net-negative lifecycle is zero. However, if you go beyond the Paris agreement to achieve net-zero emissions, and instead focus on humanity flourishing, this cools the planet now to allow agriculture and humanity as we know it to continue.

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.)*

I am Acting CEO at MOC. Our team includes:

- The MOC team: Rocío Herbert, Peter Fiekowsky (founder & CTO), Jim Christensen (COO)
- Scientific team at University of Copenhagen doing lab testing and atmospheric modeling. They are being funded by foundations.
- The scientific team that developed the iron salt aerosol concept in their 2017 paper. That team includes Franz Oeste, Renaud de Richter, Dr. Ming, Clive Elsworth. This team is being funded through another non-profit.
- The aerosol development team working on marine cloud brightening (MCB) for the Australian Great Barrier Reef project.

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

Risks:

1. **Maintain our social license:** Avoid blindsiding environmentalists who are still looking for emission reductions and consider GHG level reduction a “moral hazard”. We are convening a twice-annual Accountability Council to report to, listen to and respond to concerned stakeholders.
2. **Maintain business “license”**. Avoid threatening incumbent offset sellers whose income we could displace. We will have one on one meetings with relevant competitors and likely convene a “high quality carbon offset roundtable” to ensure communication and collaboration.
3. **Getting funding,** since the Paris agreement encourages funders to promote emission reduction, not the more efficient atmospheric methane oxidation. We don’t expect foundations or governments to fund or support MOC because they consider GHG level reduction to be a moral hazard that can impede their (foolish?) Paris goal of net zero anthropogenic emissions. However a wide range of family offices, committed to the flourishing future generations are likely investors.

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

We have verbal agreements with the patent holders below, and are contracting them to develop the technology

WO/2019/029835, International Application No.: *PCT/EP2018/000253*

- Iron(III) chloride aerosol
- All kinds of chlorine ingredients needed for ISA production
- Different kinds of production methods:

o Nebulization o Pyrolysis ● Application made in 2010 – expires 2030 ● Active in numerous territories Patent applied for in Oct 2020 ● Includes/builds on former patents ● Preferred locations / weather / geographic conditions ● How to provide phytoplankton with additional nutrients to iron ● Expires 2040

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

a. Please fill out the table below.

	Timeline for Offer to Stripe
Project duration	June 2021- December 2023
When does carbon removal occur?	January 2022 - December 2023 (indefinitely as long as needed)
Distribution of that carbon removal over time	Scale-up will occur in 2022-2023. Full scale (300 MT CH_4 per year) is to be achieved by December, 2023, and maintained while needed (probably through 2100)
Durability	The methane stays oxidized forever. However, atmospheric oxidation must continue as long as emissions are high and we wish to insure against a risk of a methane burst.

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

Methane oxidation is permanent

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.)*

Chemistry does not allow significant spontaneous generation of atmospheric methane

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?

There is no known durability risk. Reduced methane is beneficial: It reduces ground ozone which produces significant health benefits

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.)*

There is no known durability risk.

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	0 t CO_2: 7.5 Mt CO_2eq or 300,000 t CH_4 This is 1/1000 of full production after 2023,

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	None officially. In theory the iron could restore additional phytoplankton growth yielding 1 gt CO_2 removal. We will attempt to measure this impact, but do not plan to publish that result because others are pursuing the phytoplankton pathway more directly and efficiently.

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)*

This is 1/1000 of full production after 2023. Full production is 300 Mt CH4/year. 1/1000 of that is 300,000 t CH4/year in 2022. Using GWP of 25, that equals 7.5 Mt CO_2eq. See 3C, 3D below.

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).

0 metric tonnes CO_2/yr today. We plan to oxidize half of global methane emissions at full scale in 2023, and be at 1/1000 capacity during 2022. CH_4 emissions are 600Mt/year.

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

We have designed the system to double natural methane oxidation rates using the iron salt aerosol method. Various calculations indicate that it will require between 100K to 1M tons of iron per year, so we are planning to engage up to 10,000 ships to distribute the iron aerosols. Recent calculations give the lower amount of required iron.

With 10,000 ships and 100,000 tons of iron/year, each ship needs to emit 5 lbs iron per hour, which appears safe. This could be safely increased by a factor of 10x or more in case implementation is less efficient than expected or in case of a methane burst requiring faster oxidation. Fewer ships would be utilized at first.

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.

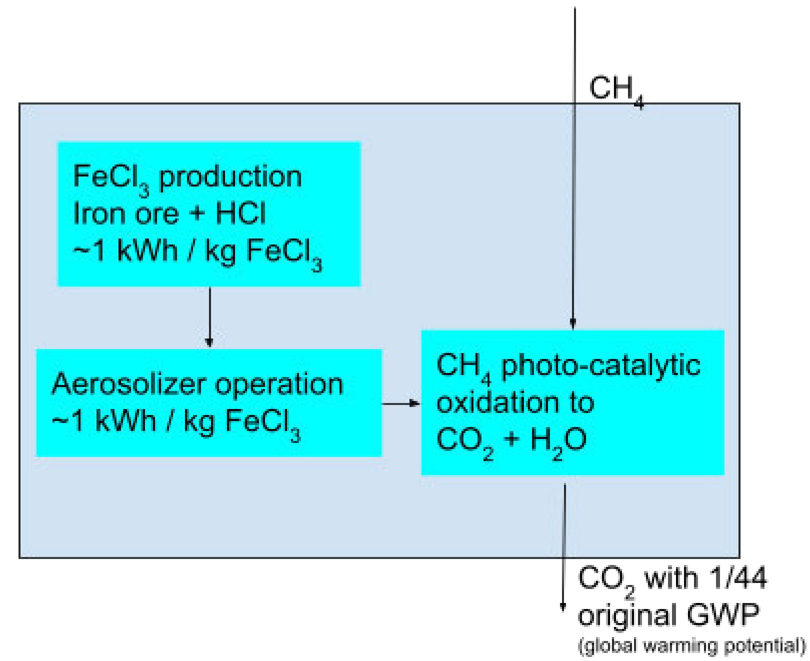
- ISA Plume calculation (ours) https://docs.google.com/presentation/d/1Nb60zX_Z58XwPEZYr4Yyf6iwxmya2yhGYl1Dtnf016k/edit#slide=id.p
- Ming, de Richter, Oeste, Tulip, Cailol (2021) A nature-based negative emissions technology able to remove atmospheric methane and other greenhouse gases *Atmospheric Pollution Research*, https://www.sciencedirect.com/science/article/pii/S1309104221000891#bib20

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	7500 kt CO_2eq
Gross project emissions	170.6 kt CO_2
Emissions / removal ratio	0.023
Net carbon removal	7.3 Mt CO_2eq

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



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

The $FeCl_3$ production facility is usually close to the port, so transportation energy is low or negligible. The marginal shipping energy on the ship for carrying the $FeCl_3$ is negligible. The ship exhaust is already happening, adding our aerosol at the top of the stack does not affect it.
We include the CO_2 produced, which has 1/44 the methane's instantaneous warming potential.

d. Please justify all numbers used in your diagram above. Are they solely modeled or have you measured them directly? Have they been independently measured? Your answers can include references to peer-reviewed publications, e.g. [Climeworks LCA paper](#).

The energy numbers are first estimates, based on interviews with suppliers. We assume 1 kg CO_2 / kWh, which is 1 tCO2 / MWh. In 2022 we expect to use 100 t iron, or 300 t $FeCl_3$. Producing and emitting this would result in 600 t CO_2

e. If you can't provide sufficient detail above in 4(d), please point us to a third-party independent verification, or tell us what an independent verifier would measure about your process to validate the numbers you've provided. (We may request such an audit be performed.)

NA

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)*

We expect full implementation (300 Mt CH_4/yr) . Stripe could be our first customer.

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	0			*<50 words*
2020	0			*<50 words*
2019	0			*<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.*)

NA

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)
10 ships w/ aerosolizers added	750,000 tCO_2eq

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?

NA. We're not in production. Expenses in 2021 will be development, design & manufacturing.

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."

NA

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	Methane Oxidation Measurement System (MOMS) operational.	"What you measure is what you get." Until we measure methane oxidation efficiently, we can't optimize it.	Q3 2021	A report on 1) natural methane oxidation rates and locations; 2) attempt to measure enhanced oxidation from existing ships.

2	Aerosolization test (liquid and / or solid)	Demonstrate we've found the material & aerosolization equip. needed	Q3 2021	Report (maybe on MOC website) on aerosolization
3	Carbon offset protocol approval started	Production funding will require a protocol. This cannot be done without funding	Q3 2021	Verify from Vera or Gold Standard

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	0	0	All milestones are required
2	0	0	
3	0	0	

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	NA		
2	NA		
3	NA		

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?

EDF President, Fred Krup, to publicly commit $2M to MOC for methane oxidation and climate restoration. (EDF is the leading anti-methane nonprofit. It received $100M from Bezos for methane emission reduction work (which is not intended to reduce methane levels, just slow their increase)

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

Publicly commit $2M to the Foundation For Climate Restoration-to promote the idea of leaving a safe and healthy climate for our children and ourselves. We must shift the climate paradigm from net-zero emissions to climate restoration for humanity flourishing. If we don't achieve that, there is no public justification for projects like ours that achieve a survivable climate for future generations.

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?

1) potential carbon offset customers, e.g. Stripe, Microsoft, US Navy, etc.;
2) Anti-geoengineering groups such as WWF, ETC Group; Scientists (most are anti-geoengineering for reputation reasons);
3) Climate engineering governance groups such as Wil Burns' and Carnegie's C2G

Methane oxidation is similar to marine cloud brightening and ocean iron fertilization (sometimes called ocean pasture restoration). The critics of those technologies can be expected to criticise methane oxidation, left to their own thinking. We are framing methane oxidation as simply a good carbon offset--a good "reforestation" product. Those organizations like reforestation.

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

We are organizing a twice annual "Accountability Council" to report and listen. Tentatively starting late Q3 2021. This will include all stakeholders--relevant NGOs, IGOs (IMO, CBD, London Protocol, etc), science orgs, such as the Global Carbon Project.

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?

So far, we have found no organizations opposed to climate restoration or enhanced atmospheric methane oxidation, if done safely and publicly.

d. Going forward, do you have changes planned that you have not yet implemented? How do you anticipate that your processes for (a) and (b) will change as you execute on the work described in this application?

No changes expected until we propose an initial protocol.

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

We think that most EJ groups believe that others will take care of the climate, and they need to care for their constituencies. EJ groups have not been interested in climate restoration to date, and we don't expect them to be--restoration for all humanity is our job. Articulating justice / fairness is their job. We expect climate restoration to benefit their groups and we plan to ask EJ groups to support climate restoration on their websites, and we will contribute some fraction of revenues to EJ groups in exchange.

11. Legal and Regulatory Compliance (Criteria #7)

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

None. Iron is already emitted from ship exhaust; We will seek opinions when the protocol is complete

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.

No known permits required. Our ship captains know of no permits required for iron emission.

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.

We will discuss this with the IMO, CBD, London Protocol when we have details to present.

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)	7.5 Mt CO_2eq
Delivery window (at what point should Stripe consider your contract complete?)	June 2021- December 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.*	$2 to $20 per ton

Application Supplement: Ocean

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

Physical Footprint (Criteria #1)

1. Describe the geography of your deployment, its relationship to coastlines, shipping channels, other human or animal activity, etc.

Airspace above international shipping lanes.

2. Please describe your physical footprint in detail. Consider surface area, depth, expected interaction with ocean currents and upwelling/downwelling processes, etc.
    a. If you've also filled out the Biomass supplement and fully articulated these details there, simply write N/A.

Increased iron in ship plumes will extend over roughly half the tropical and temperate ocean area. Polar regions are excluded because of low sunlight. No interaction with ocean currents, upwelling or downwelling is expected. The plumes generally get "rained out" within a week, so most of the iron will be deposited in the ocean. Iron added to land should add unmeasurably to existing iron, although it could increase plant productivity in low-iron areas.

3. Imagine, hypothetically, that you've scaled up and are sequestering 100Mt of CO_2/yr. Please project your footprint at that scale, considering the same attributes you did above (we recognize this has significant uncertainty, feel free to provide ranges and a brief description).
    a. If you've also filled out the Biomass supplement and fully articulated these details there, simply write N/A.

Our footprint covers most of the tropical and mid-latitude (Northern and Southern hemisphere) oceans at all scales. This is because ships travel everywhere, even when we're starting with one or two ships. We will disable iron emission in polar regions to reduce iron wasted in low-sunlight regions.

Potential to Scale (Criteria #2 and #3)

4. Building large systems on or in the ocean is hard. What are your core engineering challenges and constraints? Is there any historical precedent for the work you propose?

The engineering required is 1) aerosolizers (same as used in MCB); 2) software for measuring methane over oceans from satellite data; 3) software for controlling and monitoring the aerosolizers remotely, from the MOC office. These problems have been solved before, perhaps not to our degree or scale.

Externalities and Ecosystem Impacts (Criteria #7)

5. How will you quantify and monitor the impact of your solution on ocean ecosystems, specifically with respect to eutrophication and alkalinity/pH, and, if applicable, ocean turbidity?

No impact expected on eutrophication and alkalinity/pH, or ocean turbidity.
The addition of about 10 ppt of iron to the ocean surface will not affect those parameters.
A small increase in ocean phytoplankton growth is expected. We don't expect it will be detectable (by satellite)--but we will see. If such phytoplankton growth reduces atmospheric CO_2, we don't plan to quantify or sell it as offsets.

The reduced methane levels will lead to reduced low altitude ozone levels. This ozone reduction will have beneficial health benefits.

Could the iron lead to red-tide events? No-logically:

1. Red-tide events are coastal where there are a lot of nutrients from run-off. Iron concentration in coastal waters is ~1ppm. Iron concentration in ocean is about 3 ppb, about 300,000 times less. Adding 100,000 tons of iron to 300 million km^2 of the ocean, with 10 m mixing could increase iron concentrations by 10 ppb.
2. This is 0.0001% of the coastal iron concentration, thus unlikely to support red-tide.
3. There are no reports of red-tide in the ocean beyond coastal areas.

The chlorine in FeCl should have no measurable impact on the ocean concentrations because the chlorine comes from the ocean sea-salt.

The impact on birds or nearby ships should be unmeasurable because the concentration of aerosols is 1/1000 of typical sea-spray or a typical Chinese city.

The impact of inhaled iron, one hour downwind is one millionth of iron in a normal diet (minimum daily requirement).

Whales and other sea-life will benefit from any increased phytoplankton production, and due to the low iron levels in the ocean, would benefit from any inhaled iron.

An environmental impact assessment will be done when our methodology is mostly settled. We do not know what they might assess.