Frontier

FIRST GIGATON

Carbon Dioxide Removal Purchase Application
Fall 2022

General Application - Prepurchase

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

Company or organization name

First Gigaton Carbon Removal Inc.

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

Philippines and Canada

Name(s) of primary point(s) of contact for this application

Mike Dickhout

Brief company or organization description

Rapid-scaling, People-powered Seaweed-CDR to restore a stable climate (and make your grandkids proud).

1. Project Overview[1]

a. Describe how the proposed technology removes CO_2 from the atmosphere, including as many details as possible. Discuss location(s) and scale. Please include figures and system schematics. Tell us why your system is best-in-class, and how you're differentiated from any other organization working on a similar technology.

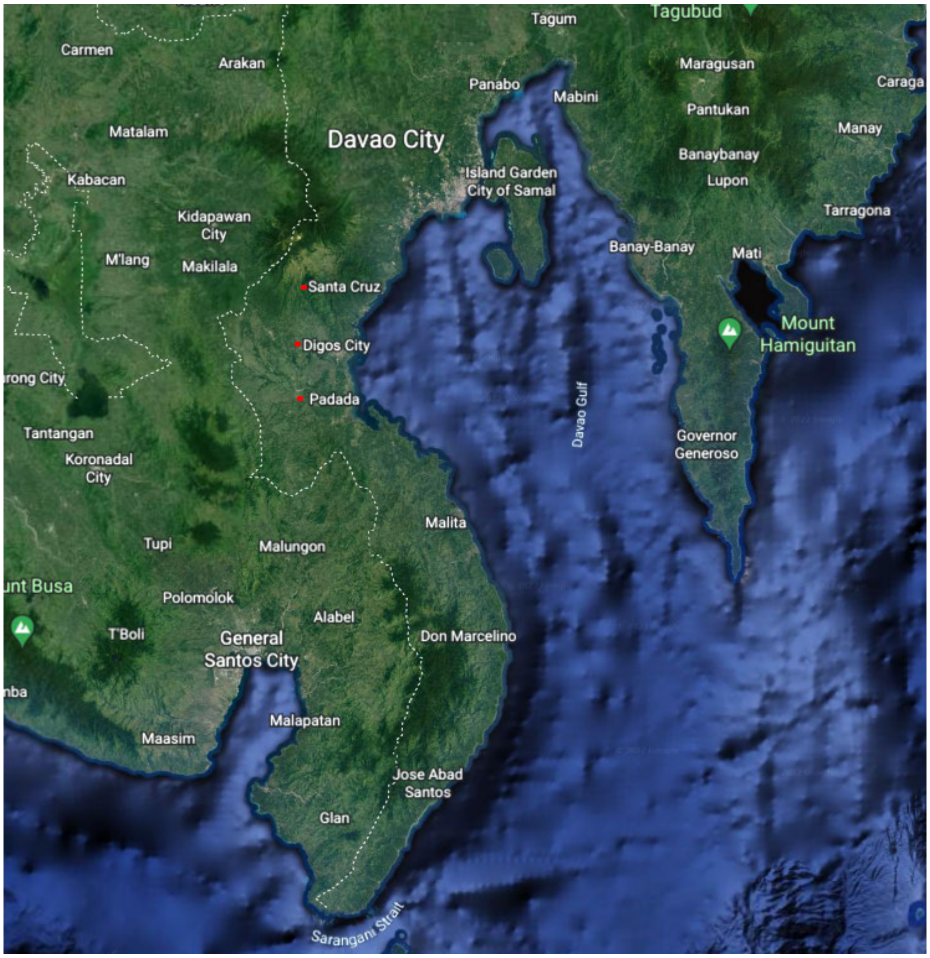
[1] We use "project" throughout this template, but note that term is not intended to denote a single facility. The "project" being proposed to Frontier could include multiple facilities/locations or potentially all the CDR activities of your company.

First Gigaton ("FG") (https://firstgigaton.com and https://firstgigaton.ph) grows seaweed exclusively for Ocean Biomass Sinking.

The surface ocean absorbs CO_2 from the atmosphere (via air-sea gas exchange). Through photosynthesis, our seaweed removes CO_2 from the surface ocean. The company then sinks the harvested seaweed and its captured carbon to depths greater than 1,000 meters. This removes the carbon in the seaweed from the atmosphere, ideally for one thousand years or more. To restore equilibrium, the carbon we've removed is then replaced as the ocean absorbs more CO_2 from the atmosphere. The cycle repeats as we grow and sink more seaweed . . .

Over the next ten years, First Gigaton is building a network of Seaweed-CDR Farms throughout the Global South. In 2032, our farms will collectively sequester more than one billion tonnes (that "first gigatonne") of carbon per year. Equally important, we will secure Climate Justice and Generational Prosperity for some 4 million families in the Global South working hard to remove the Global North's carbon emissions.

FG's first five farms are on the island of Mindanao in the Philippines. For our **Frontier Prepurchase Project** in 2023, FG is scaling to 40 CDR farms in the municipality of **Padada**, Davao del Sur, Mindanao. These farms will remove more than **3,200 tonnes of carbon (gross) by Q3 2024**.



Google Earth

FIRST GIGATON'S SEAWEED-CDR

FG's Seaweed-CDR can be considered a four part process.

I. CULTIVATION: FIRST GIGATON SEAWEED-CDR FARM 1.0

For the purpose of this project, the production unit of First Gigaton's production is "one" Farm, version 1.0.

An FG Farm 1.0 at full capacity is 10,000 meters of line and covers approximately 2 hectares of sea area (100 m x 200m; or 100m per line x 100 lines spaced 2 meters apart).

Current growth data indicates a conservative estimate of 400 tonnes of seaweed per year for each farm or 200 tonnes of seaweed per hectare.

Using a standard conversion rate of 20 percent carbon content, this is the equivalent of **80 tonnes (gross) of Carbon removed per farm per year** (40 tonnes of carbon removed per hectare/year).

While we are proud of this production level, it is far short of the 200 tonnes of carbon removed per hectare per year reported by seaweed farms just across the water in Indonesia. Our objective is to match this capacity (i.e. 200 tonnes of carbon) *per farm* in a safe and sustainable manner (e.g. we'll do it over 2 hectares or more, not one).

FG employs a modified version of the tried-and-true "Hanging Long-Line." That is, we grow our seaweed on ropes (lines). In the Philippines, 1.0 Farms are growing endemic *Eucheuma* strains that are hardier and less prone to theft.

Small seaweed plants (seedlings) are tied to the lines onshore using paid community labour. Each plant is about 120 grams and spaced approximately 15 - 20cm apart (5 - 7 plants per meter).

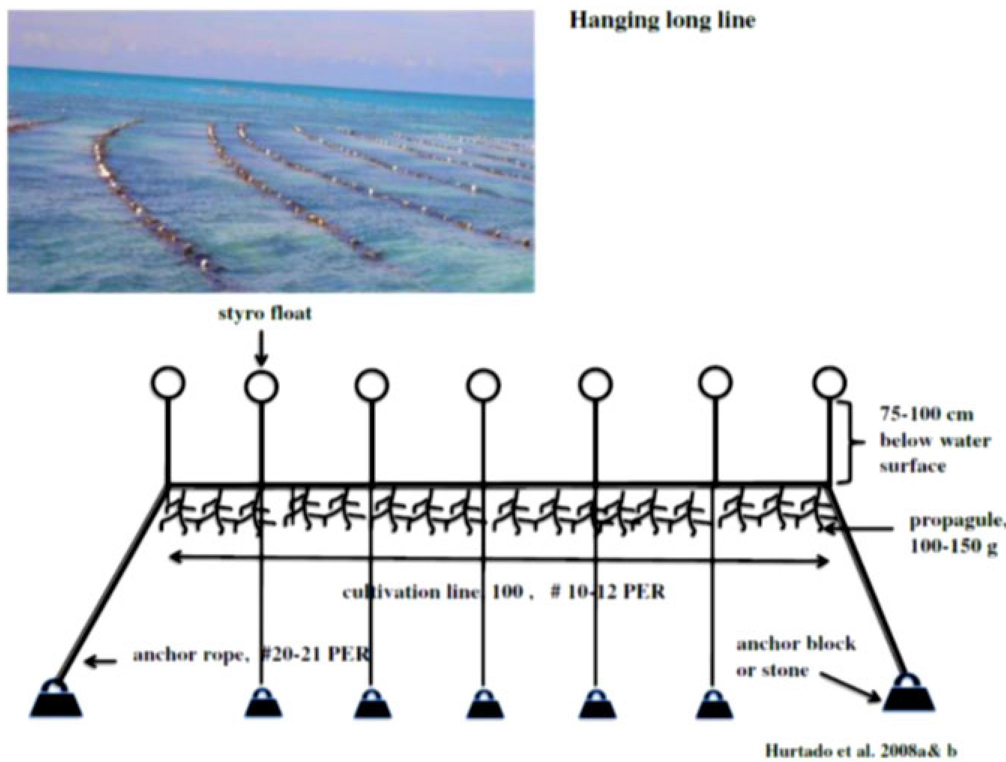


Figure 8: Single hanging longline method (HLL), from Hurtado et al. (2013)

The initial seedlings are sourced from other farmers located in Santa Cruz (Step 1 in the PFD). These seedlings are used in our Seaweed-CDR farms in Padada as well as our own Seedling Farm in Digos (Digos-R) (Step 2 of the PFD).

Once filled with seedlings, the lines are moved to the water. Lines are suspended just below (75 - 100cm) the water surface by buoys/floats. For floats, FG reuses soda bottles recovered by local schools and students.

Each line is attached to the ocean floor with an anchor on each end, and anchors spread along the line as needed. Anchors are made in the community and consist of blocks of cement embedded with one-half of a recycled motorcycle tire.

FG farms are “nearshore;” typically, within one kilometre and in waters no more than ten meters deep. Daily tending, maintenance, and repair are done manually and require no more than an outrigger canoe, a paddle, a knife, and a pair of goggles.

Nearshore cultivation allows for accurate measurements and calculations of carbon captured. It also makes possible daily direct observation of the ecosystem. Combined with a regular sampling of the waters around the farm, direct observation facilitates early detection (and remediation) of potential negative environmental impacts.

Following the MRV Protocol in development by Coastal Carbon Solutions, each farm unit has its own LCA record. All material and energy inputs will be recorded daily for each farm in its LCA. This includes photos and descriptions of materials added to the farm. Fuel will be recorded by volume (litres) at the beginning of every cultivation cycle and every time a fuel tank is filled. A final measurement taken of the remaining fuel at the end of the harvest day.

II. HARVEST

A floating platform, centrally located, is provided for every ten farms. Platforms are used by farmers to take breaks, eat their lunch, and hold meetings.

During harvests, the platforms are used as terminals to collect and weigh the harvested seaweed. Weighing is conducted and crop samples are taken according to the MRV protocol.

On the platforms, farmers compact the seaweed into large sacks. This causes the seaweed in each sack to form a single bundle as the plant’s branches become interlocked. After several trials, we found this to be the best method for the seaweed to be sunk without noticeable shedding, and without the use of baling twine or bags.

Depth-release tags, the number of which will be determined in the MRV protocol, will be attached individual bundles of seaweed. The tags are released and float to the surface when the bundle reaches the desired storage depths, allowing us to determine that the seaweed has reached the ocean floor.

The bagged seaweed is transferred to the sequestration vessel. Currently, we are using an open skiff with a diesel engine capable of hauling five tonnes of bagged seaweed (one tonne of carbon) to the sequestration/deepwater storage site.

III. SEQUESTRATION: NEARSHORE DEEPWATER STORAGE

On the ocean surface above the designated storage site, the crew will remove the seaweed bundles from the bags and deploy them, recording the entire process according to the MRV Protocol.

At this time, FG practices **Nearshore Deepwater Storage** (NDS) where seaweed and its captured carbon is sequestered at depths greater than 1,200 meters but within 20 of the nearshore farm. Our first farms in Padada are within 15 km of 1,200-meter depths.

The Philippines is uniquely suited for Nearshore Deepwater Storage. Much of the country's 38,000 km of coastline is within 15 km (9 miles) of ocean depths greater than 1,000 meters. The country is also suited for offshore deepwater storage with depths exceeding 2, 3, and 4,000 meters within 40 kilometers of shore.

Following the MRV Protocol (again, being developed with CCS), potential deepwater storage sights will undergo an oceanographic survey conducted by the independent third-party Blue Nomads. Storage sites will only be considered if their survey indicates the seaweed can reach the ocean floor (e.g. there are no permanent thermoclines, cross-currents, or upwelling), that the seaweed is not expected to negatively impact local sea lifeup (up to a certain tonnage, TBD), the site's floor is sand or soft bottom sediments and conducive to burying the seaweed, and that any detectable bottom conveyor current or deepwater recirculation is not expected to negatively impact durability.

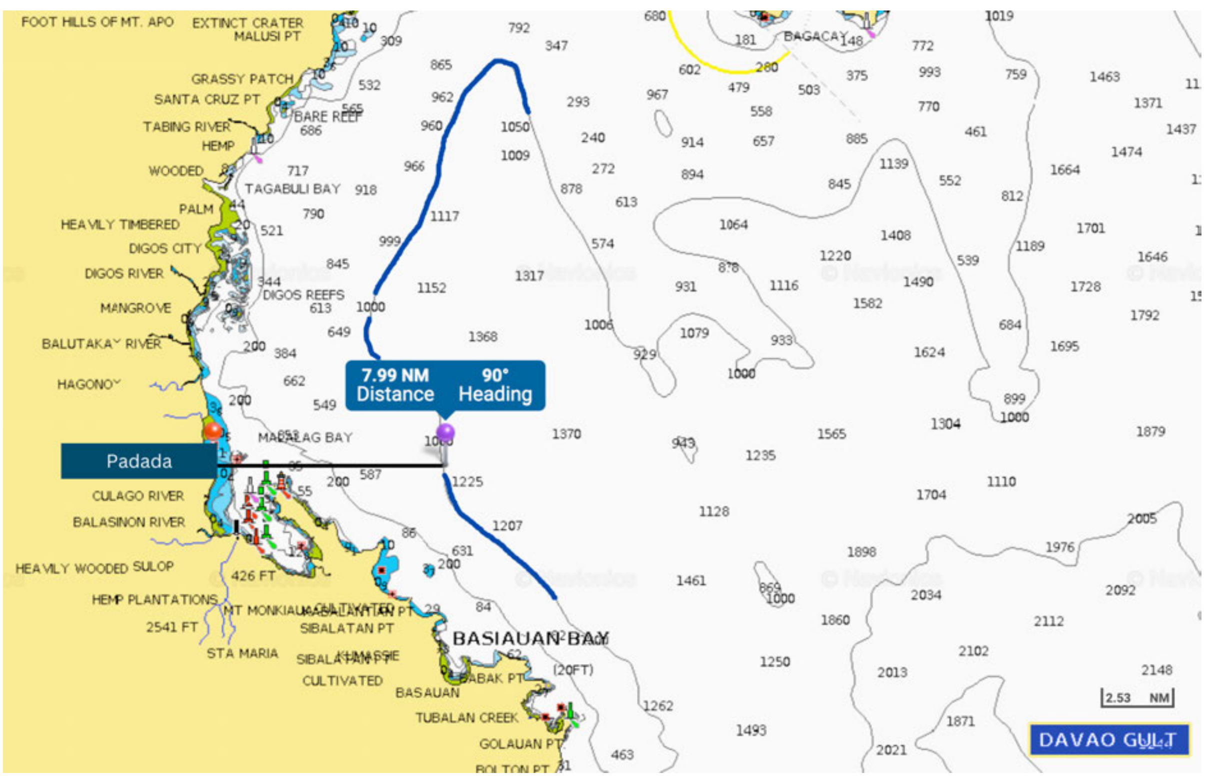


Image provided by Blue Nomads.

While confidence in durability is generally considered to increase with the depth of the storage site, First Gigaton is initially deploying to storage sites at depths of 1,200 meters.

For the short term, First Gigaton is choosing shallower deployment sites (1,200 meters) over deeper sites for four important reasons.

First, shorter distances from shore to deepwater reduce the difficulty, time, and cost of oceanographic surveys to identify sites suitable for sustainable NDS. These surveys help build confidence in the sequestering durability of selected sites.

Second, shorter distances between farms and their NDS site means mean fewer sequestration vessels are needed and less fuel is used by each vessel. This minimizes the associated emissions.

Third, shorter distances to deepwater storage sites allow for the earlier adoption of electric sequestration vessels (which further reduces emissions). As the range of electric marine motors increase, First Gigaton will adopt them across operations and use them to reach storage sites at greater depths (e.g. 4,000 meters) further from shore. This will increase the number of countries and locations in each country suitable for Seaweed-CDR farming. Deeper storage sites also increase confidence in storage durability.

Finally, limiting our initial deepwater storage sites to depths of just 1,200 meters ~ for the short-term ~ delivers advantages critical to MRV and building confidence in Ocean Biomass Sinking. The rationale is that proximity to shore and depths limited to just over 1,000 meters facilitate direct measurement using instrumentation and ROVs. In turn, these measurements lead to more accurate modelling. Well-developed models are essential to building robust MRV and long-term confidence in Ocean Biomass Sinking as a large-scale CDR solution.

The research benefits of Nearshore Deepwater Storage are discussed below as part of what makes First Gigaton the Best-In-Class OBS company.

IV. POST-SINKING MRV

FG’s use of Nearshore Deepwater Storage sites puts the company in a unique position to research the impacts and durability of deepwater storage through direct observation of the sites.

Spreading the cost over thousands of tonnes of carbon, it becomes “affordable” to regularly return to observe the storage site. First Gigaton will employ Blue Nomad’s deepsea Remotely Operated Vehicle (ROV) at depth to directly observe, measure, and sample the stored seaweed and the site’s water column and sediment.

THE FIRST GIGATON ADVANTAGE

Three things make First Gigaton the Best-In-Class among Ocean Biomass Sinking companies.

First, is our unique immediate capacity to scale. Second, is our unique approach to building confidence in Biomass Sinking and Deepwater MRV. Third, is the impact promised by our People-First and Climate Justice Strategy.

1. IMMEDIATE CAPACITY TO SCALE

In 2032, First Gigaton will:

- *Exceed* **One Gigatonne** of annual CDR capacity *and*
- Secure Climate Justice for *more than* **4 million seaweed-farm families** in the Global South (and many more people in their local communities).

Four things directly contribute to FG's unique immediate capacity to scale at this unprecedented velocity:

- Absence of natural constraints.
- Absence of technical roadblocks (no new technology is required).
- Absence of foreseeable supply chain issues.
- A People-First strategy that fuels unlimited growth.

FG's Tech Advantage

Ocean Biomass Sinking companies, including First Gigaton, do not face natural constraints at the global scale to reaching one gigatonne annual CDR capacity. (Local natural constraints, especially concerning sustainability of local operations do exist and must be accounted for). Approximately 48 million square kilometres of the oceans are suitable for seaweed aquaculture (Froehlich, Halley E.; et.al. (2019)). One Gigatonne CDR capacity per year can be achieved using 20,000,000 hectares, or less than one-half of one percent of the suitable area.

However, other OBS companies face substantial technical challenges and roadblocks. Most are developing a remote growing, harvesting, and sinking systems. Their systems must operate without fail for months or years at sea, and they must develop new technology for consistent nutrient supply, as well as autonomous operations and maintenance. R&D is expensive and time-consuming and serious challenges and setbacks are common. (Plus offshore and mid-ocean MRV is a technical nightmare).

Technical roadblocks delay their capacity to scale, and for some, the roadblocks will be fatal.

In contrast, First Gigaton's "technology" consists of . . . ropes, soda pop bottles, and blocks of cement.

Our farmers have been using the same Longline technology to farm seaweed for years, decades, and generations. They've captured thousands of tonnes of carbon. (They just haven't been sequestering it).

While we continue to iterate on the Longline design, First Gigaton does not face any technical or engineering challenges. For us, scaling capacity is incredibly simple:

More lines in the water = More Carbon Removed

As a result, the company's attention, time, and resources are laser-focused on scaling by:

- Increasing the number of farms.
- Increasing the number of lines under management by each farmer.
- Optimizing the carbon capture capacity of each line (e.g. kg of seaweed/meter/year).

We are also working diligently with our partners in MRV (Coastal Carbon Solutions) and Oceanography (Blue Nomads) to develop a world-class Ocean Biomass MRV protocol.

FG's Supply Chain Advantage

CDR companies in all paths have the potential to face problems with their supply chains for critical components, including microchips (not to mention shortages and competition for engineers and technical talent).

First Gigaton reduces supply chain risks by bringing in-house as much of the supply chain as possible.

We've established our own seedling farm in Digos (Digos-S) to minimize the need for an external source of seedlings. Digos-S supplies all existing and expansion farms in Davao del Sur and only needs to refresh its own supply of seedlings from nearby farms three times per year.

In Padada, we are establishing a facility to manufacture the rope used for seaweed lines. The facility uses previously recycled Polypropylene recovered from twine used to tie banana plants. Our facility will supply seaweed lines to existing and expansion farms throughout Davao del Sur.

This will substantially reduce costs and delays from ordering rope from other suppliers and completely eliminate delivery delays. It also benefits the local community by providing training, employment, and opportunities to fill purchase orders from other buyers.

As for buoys, we use soda pop bottles. Local schools and students are paid to collect them on our behalf. We pay full market price (1 PHP per 1-litre bottle) providing the school and students with a fundraising/income opportunity they've never had before. Equally important, we are diverting PPE plastic that would end up in burn pits and pollute the local air, land and water.

Our anchors are already made on-site. Each anchor consists of 10kg of concrete with half a recycled motorcycle tire embedded to attach the ropes up to the seaweed lines. In the unlikely event, we run into a shortage of cement or old motorcycle tires, we are confident that there will be substitutes readily available.

FG's People First Climate Justice Strategy

The absence of natural, technical, and supply constraints pave the way for rapid scaling. However, it's our People-First Climate Justice Strategy that is the rocket fuel unstoppable growth.

In the Philippines, it is not uncommon for local governments, foreign companies, and NGOs to attempt to establish seaweed farms in various areas of the country. However, the farms typically do not survive long due to a lack of technical support, sustainable market access, or sufficient funding to overcome setbacks (storms, disease) when they occur. The general public appears to be aware of these failures which have led to a certain degree of skepticism among local fisherfolk and government officials.

First Gigaton has eliminated this final roadblock of skepticism by doing what past projects do not. FG immediately:

- Hires farmers with instant payment of their first month's salary;
- Supplies farmers with starter seaweed lines and equipment (including the construction of new outriggers);
- Enrols each new farmer in a health insurance program (family members will be added after three months);
- Hires members of the wider community (on a part-time or casual basis) to assist in manufacturing lines, collecting bottles, construction anchors, boat construction, and (the largest expense) tying seedlings to the seaweed lines.
- Sponsors community programs (such as Coastal Clean-ups) by providing meals, drinks, and snacks.

In Padada and other communities, subsistence fisherfolk simply do not have the opportunity to receive an annual salary that comfortably supports their families, let alone a "free" outrigger and medical insurance. Likewise, members of their families and community rarely see regular earning opportunities like the ones FG provides.

Seeing FG's substantial investment and commitment to farmers and the community quickly wins the support of local governments. They secure FG the required permits for seaweed cultivation and deepwater storage and readily offer advice on how we can continue to support the wider community.

Most importantly, word spreads fast. We are approached almost daily by government bodies up and down the coast of Mindanao to "join our program." Pressure and support are building for First Gigaton to expand operations as quickly as possible to neighbouring communities. We already have more applicants (just from Padada) than the 37 open farm positions needed for this Project. Word will spread farther faster as we continue to grow. This creates a flywheel effect, increasing pressure to accelerate our expansion.

2. BUILDING CONFIDENCE IN BIOMASS SINKING AND NEARSHORE DEEPWATER STORAGE

First Gigaton solidifies its Best-In-Class status by spearheading the field research needed to increase confidence levels in MRV for Ocean Biomass Sinking and Deepwater Storage.

All Biomass Sinking companies (including First Gigaton) face significant uncertainties when it comes to quantifying the net carbon removed after sinking the biomass. Unknowns about what happens to harvested macroalgae after it leaves the surface include:

- Beyond depth, what are the characteristics of the ocean floor where the biomass is expected to settle?
- What is the nature of the water column through which the biomass will sink?
- Does the biomass actually reach the ocean floor in the target area?
- What are the immediate and long-term impacts on the ecosystem in the target area?

Storage sites that are hundreds of kilometres from shore and several thousand meters deep make direct measurement and observation prohibitively expensive. The resulting uncertainties are particularly acute for companies choosing to sink their biomass at these locations.

In contrast, First Gigaton's Nearshore Deepwater Storage (NDS) makes possible direct observations of target storage areas before, during, and after sinking.

Confidence levels in durability typically increase with sinking depths. However, for the first few hundreds of thousands of tonnes, First Gigaton will initially use a limited number of storage sites at depths just over 1000 meters (e.g. 1200 meters). The rationale is that proximity to shore and limited depths facilitate direct measurements and the development of more accurate modelling. Well-developed models are essential to building long-term confidence in Ocean Biomass Sinking as a large-scale CDR solution.

Until that time, the proximity to shore of First Gigaton's deepwater storage sites delivers four critically important contributions to building confidence in MRV for Ocean Biomass Sinking.

First, FG will have **Blue Nomads** (https://bluenomads.org), an independent ocean science research group conduct a thorough oceanographic survey of all potential storage sites. First Gigaton will only choose storage sites with surveys that indicate the seaweed can reach the ocean floor (e.g. there are no permanent thermoclines, cross-currents, or upwelling), that the seaweed is not expected to negatively impact local sea lifeup (up to a certain tonnage, TBD), the site's floor is sand or soft bottom sediments and conducive to burying the seaweed, and that any detectable eddies, bottom conveyor current, or deepwater recirculation is not expected to negatively impact durability.

Second, we can directly observe (and record) the sinking of the biomass for tens of meters. This allows us to detect any possible shedding of seaweed as the biomass sinks until it is in free-fall. (Sinking tests FG has conducted to 20 and 40 meters observed no detectable shedding). Depth-release beacons attached to bundles of seaweed will float to the surface to indicate that the seaweed is arriving on the ocean floor.

Third, by spreading the cost over thousands of tonnes of carbon, it becomes “affordable” to regularly return to observe the storage site. First Gigaton will employ Blue Nomad’s deepsea Remotely Operated Vehicle (ROV) at depth to directly observe, measure, and sample the stored seaweed and the site’s water and sediment. The ROV and other instrumentation (e.g. taking BOD light and dark measurements at different depths) will be used to measure Oxygen Usage Rates to ensure we are maintaining an oxic water column as large-scale (Mega - Gigatonne) seaweed deposits decompose and mineralize.

Note: The more seaweed sank, the larger the designated storage area. FG will consult with researchers for a consensus on the ecologically safe capacity of stored seaweed for any given site(i.e. Tens of tonnes, v. hundreds, v. thousands).

Scientists and research organizations are invited to participate. Blue Nomads will collect the data the scientists need to determine what is happening to the seaweed on the ocean floor (e.g. the rate that it is being buried), how fast it is degrading, measure possible impacts on the site’s local sealife, ecosystem, and water column, and determine the impact of deepwater recirculation. The uncertainties associated with biomass sinking will thus be reduced as understanding increases and modelling improves.

Fourth, FG’s MRV partner, **Coastal Carbon Solutions** (https://coastalcarbonsolutions.com) is developing a best-in-class MRV protocol to meet the unique demands of Ocean-Biomass Sinking. CCS’ dedicated protocol will inform the data collected by Blue Nomads ROV operations in order to iterate the protocol and its supporting models.

3. CLIMATE JUSTICE

Our People First and Climate Justice Strategy locks in the company’s Best-In-Class status.

FG delivers Climate Justice to our farmers and their communities in lockstep as we scale CDR capacity. At the Gigatonne scale, we’ll have put over four million families (and more people in their communities) on the path to generational prosperity.

For most of our people, it will be the first time in their lives that they receive a monthly salary that comfortably supports their family, medical insurance for their family, and educational support for their children. (Details of our Climate Justice plan are in the section on Environmental Justice).

We are not aware of any other CDR company (Ocean Biomass or other paths) that even attempt to do this.

b. What is the current technology readiness level (TRL)? Please include performance and stability data that you've already generated (including at what scale) to substantiate the status of your tech.

Currently we are at TRL-7. We've proven Farm 1.0 design (10,000 m) and production capacity (80 tonnes of Carbon/Farm/Year) with 8,000 meters of line across five farms (Digos-S, Padada-R, Padada-1, Padada-2 and Padada-3). We are in the process of scaling 4 farms to 10,000 meters of production each (Padada-R will not exceed 5,000 meters). To transition to TRL-8, we need to establish 37 more full-scale farms and complete and submit an oceanographic survey to identify our first deepwater storage site for final government approval. Scaling to 40 full-scale farms for Seaweed-CDR (not counting Digos-S and Padada-R) is dependent on a Prepurchase Agreement with Frontier. TRL-8 will involve the demonstration of the full Seaweed-CDR process from cultivation to harvest to sequestration. TRL-9 will be achieved with our first post-sinking ROV mission to observe of the storage site.

c. What are the key performance parameters that differentiate your technology (e.g. energy intensity, reaction kinetics, cycle time, volume per X, quality of Y output)? What is your current measured value and what value are you assuming in your nth-of-a-kind (NOAK) TEA?

Key performance parameter	Current observed value (units)	Value assumed in NOAK TEA (units)	Why is it feasible to reach the NOAK value?
Tonnes of Carbon Removed per Farm (10,000 meters of line) per year.	**80 tonnes** (extrapolated from 8,000 meters over 90 days).	**100 tonnes**	The FOAK value of 80 tonnes is for Farm 1.0. This is only 40 percent of 200 tonnes of carbon per hectare reported in Indonesia. https://www.researchgate.net/publication/342150066_Floating_Cage_A_New_Innovation_of_Seaweed_Culture FG Farm 1.0 at 10,000 linear meters is less dense covering approximately 2 hectares compared to the one hectare in the Indonesian report. While 100 tonnes is a 25 percent increase over the FOAK value, it is only 50 percent of Indonesia's reported value. We anticipate 100 tonnes is conservative and readily achievable even while we use the most sustainable farming methods.

d. Who are the key people at your company who will be working on this? What experience do they have with relevant technology and project development? What skills do you not yet have on the team today that you are most urgently looking to recruit?

Mike Dickhout, Co-Founder, CEO
MA in International Affairs; served with Canada's Department of Foreign Affairs and International Trade before becoming an international business development consultant and entrepreneur. Mike is building the company, team, and strategy to restore a stable climate, secure generational prosperity for our farm families, and make all our grandkids proud.

Junie Coscos, Co-Founder, COO
B. Agriculture; expertise and experience in foreign-owned Aquaculture business development and NGO Project Management in the Philippines. Junie is the master-networker and driving force behind FG scaling throughout the Philippines.

Professor Danny Largo, Chief Scientist
B.S. Marine Biology, M.S. Marine Biology, M.S. Aquatic Environmental Science, Ph.D. Aquatic Environmental Science; Full Professor at University of Carlos. Danny is a leading seaweed and blue carbon scientist in the Philippines. He'll ensure FG scales rapidly but sustainably, detecting potential negative impacts early to remediate them before they become serious.
https://www.usc.edu.ph/of-seaweeds-and-climate-change

Jesthony Salomon, Research Farmer (Padada-R)
Jesthony is a Barangay Councilor. He runs our research farm to optimize per meter CDR capacity and our community programs to maximize CJ impact. He is our mover, shaker, innovator and fixer in Padada.

JunJun Anthony, FG Seedling Farmer (Digos-S), Farmer Trainer.
With over ten years on the water growing seaweed, JunJun runs our seedling farm in Digos and trains FG's new farmers on best practices.

NEXT HIRES:
Danny is recruiting a physical and a chemical oceanographer to join the Science Team. As well, he is recruiting PhD and Masters candidates (through FIMFS) to use First Gigaton's resources for their theses research so the company learns first their findings on the company's own research needs including optimizing production, how to mitigate the potential for negative ecosystem impacts (alkalinity/pH, eutrophication) as well as quantifying and monitoring the impact of FG operations on ocean ecosystems and organisms.

e. Are there other organizations you're partnering with on this project (or need to partner with in order to be successful)? If so, list who they are, what their role in the project is, and their level of commitment (e.g., confirmed project partner, discussing potential collaboration, yet to be approached, etc.).

Partner	Role in the Project	Level of Commitment
Coastal Carbon Solutions (https://www.coastalcarbonsolutions.com/)	Third-Party MRV company developing MRV protocol for Ocean-Based Harvested Biomass-Sinking CDR	**Confirmed Project Partner**
Blue Nomads BlueNomads.org	Physical Oceanography and Technical Advisor; providing survey service for potential deepwater storage sites and deepsea Remote Operated Vehicle (ROV) for ocean-floor MRV.	**Confirmed Project Partner**

Mayor's Office, Municipality of Padada	Providing permits and ocean area for Seaweed-CDR farming and sequestration, leadership and support with Municipal, Provincial, and Federal Agencies, and guidance on local community's needs for FG's Climate Justice Program.	**Confirmed Project Partner**
Federation of Institutions for Marine and Freshwater Sciences (FIMFS)	**FIFMS** is a Philippine network of institutions offering programs in Marine Science and Fisheries. We are developing a relationship with them to offer their PhD and Masters students opportunities to participate in FG's oceanographic research needs as part of their theses research, such as biogeochemical processes, euphotic zone and benthic ecosystem dynamics.	Discussing potential collaboration with individual institutional members.

f. What is the total timeline of your proposal from start of development to end of CDR delivery? If you're building a facility that will be decommissioned, when will that happen?

January 2023 to December 2024. Farms established for the project will continue indefinitely.

g. When will CDR occur (start and end dates)? If CDR does not occur uniformly over that time period, describe the distribution of CDR over time. Please include the academic publications, field trial data, or other materials you use to substantiate this distribution.

Seaweed farming for this project will begin in January 2023 with CDR capacity increasing monthly. First sequestration will occur by early Q2 2023. Final sequestration (balance of 3,200 tonnes total gross) will occur before the end of Q2 2024. Any shortfalls remedied and final measurements and verification will be delivered in Q4 2024.

h. Please estimate your gross CDR capacity over the coming years (your total capacity, not just for this proposal).

Year	Estimated gross CDR capacity (tonnes)	Number of Farmers	Farmer increase multiple	CDR Capacity/Farmer/Year (tonnes)
2023	**3,200**	**40**	10	80
2024	**34,000**	**400**	10	85

2025	**400,000**	**4,000**	10	100
2026	**4,800,000**	**40,000**	10	120
2027	**33,600,000**	**240,000**	6	140
2028	**115,200,000**	**720,000**	3	160
2029	**259,200,000**	**1,440,000**	2	180
2030	**460,800,000**	**2,304,000**	1.6	200
2031	**709,632,000**	**3,225,600**	1.4	220
2032	**1,006,387,200**	**4,193,280**	1.3	240

i. List and describe at least three key milestones for this project (including prior to when CDR starts), that are needed to achieve the amount of CDR over the proposed timeline.

	Milestone description	Target completion date (eg Q4 2024)
1	Marine survey and selection of sequestration/deepwater storage site.	**Q1 2023**
2	Expand operations to 40 farmers in Padada.	**Q1 2023**
3	Expand CDR capacity of each farmer 80t CDR/year for a total annual gross CDR capacity of 3,200 tonnes.Begin regular sequestration.	**Q1 2023**
4	Begin regular sequestration.	**Q2 2023**
5	First 1,000 tonnes sequestered.	**Q4 2023**
6	First ROV monitoring/sampling of sequestration site.	**Q4 2023**
7	Expand operations to 200 farmers in Padada and 100 farmers in each of Hagonoy and Sulop.	**Q4 2023**
8	Introduce Farm 1.x to expand CDR capacity of each farmers to 85t CDR/year for a total annual gross CDR capacity of 34,000 tonnes.	**Q1 2024**
9	Balance of total of 3,200 tonnes for the project is sequestered.	**Q2 2024**
10	Second ROV monitoring/sampling of sequestration site.	**Q2 2024**

j. What is your IP strategy? Please link to relevant patents, pending or granted, that are available publicly (if applicable).

No new technology is required for this project. Company research is focused on optimizing seaweed cultivation for carbon removal (increasing seaweed growth/carbon capture per meter and number of lines managed by one farmer), sustainability (e.g density of lines and farms in a given area, optimal safe capacity of sequestration area), and improving confidence in MRV processes (detailed below). Our science team will publish all findings. Additionally, all data will be made public and research groups, academics (including students). Interested parties have an open invitation to observe and participate in our operations. Should we discover/invent anything that could be used commercially, it will be made either opensource or licenseable under generous conditions in order to help other groups remove carbon.

k. How are you going to finance this project?

To date we are self-funded. We have the internal ability to expand and sustain operations “indefinitely” at a certain annual CDR capacity. With a commitment from Frontier we have several options for project (bridge) financing to surpass all production (3,200t/year) and MRV commitments. This includes several private finance companies offering their support and possible support from the **Export Development Corporation** and the **Canadian International Development Agency** of the Canadian government.

l. Do you have other CDR buyers for this project? If so, please describe the anticipated purchase volume and level of commitment (e.g., contract signed, in active discussions, to be approached, etc.).

This project, our offer to **Frontier**, is for 3,200 gross tonnes, which will be completed in 2024. In 2024 we will expand capacity to 34,000 tonnes for other potential buyers such as **Southpole** and **Salesforce**, among others. Of course, **Frontier** will always have *priority* to purchase any additional carbon above and beyond this project's 3,200 tonnes.

m. What other revenue streams are you expecting from this project (if applicable)? Include the source of revenue and anticipated amount. Examples could include tax credits and co-products.

No other revenue streams are anticipated other than the sale of credits to potential buyers in 2024.

n. Identify risks for this project and how you will mitigate them. Include technical, project execution, ecosystem, financial, and any other risks.

Risk	Mitigation Strategy

Severe weather damaging/destroying crops and/or growing arrays.	Our current locations in Davao del Sur are considered low risk for severe typhoons. In the event that severe weather is expected/forecasted, lines and rafts can be moved onshore to prevent damage or loss.
Ice-Ice and other seaweed diseases.	Our chief scientist the world expert in Ice-Ice, the most common seaweed disease in the Philippines. We'll use his expertise to mitigate the risks. Should crops be infected, they still can be harvested, but at reduced growth and therefore reduced carbon content. Case-by-case decisions will be made whether to harvest immediately, sequester, and replant, or continue to grow the line. Risk is also mitigated through geographic and strain diversification.
Geo-Economic Risk.	The war in Ukraine impacts global fuel prices which FG will mostly feel in the costs of chartering sequestration vessels. In the event that the war seriously impacts the global supply of fertilizer and wheat, there may be pressure in the Philippines to grow more seaweed both for fertilizer and food. Should the social need for fertilizer or food be seen by the local community as in its best interest, we will help our community partners develop new, separate farms to serve these markets. This will allow both our local CDR operations to continue uninterrupted and the community to meet local needs and the needs of these new markets. Once the demand for seaweed fertilizer and food products returns to pre-war levels, FG willl be well-positioned to convert the farms exclusively to Seaweed-CDR.
Regulatory challenges regarding deepsea sequestration.	Currently, we are only sequestering within the Philippines' territorial waters. They have no regulations banning this. We've received permission to grow and sequester in the waters of Padada and are awaiting final approval from DENR once a sequestration site is surveyed and selected. When scaling requires the use of international waters, we will ensure we meet all requirements of international agreements, such as the London Protocol. At that time, our track record in the Philippines and other countries' territorial waters will set a strong precedent.

2. Durability

a. Describe how your approach results in permanent CDR (> 1,000 years). Include citations to scientific/technical literature supporting your argument. What are the upper and lower bounds on your durability estimate?

Our projected range for this project is 800 - 4000 years based on the following:

- While it can be assumed "the deeper the better," FG will initially target deepwater sites at "only" 1200 meters in order to facilitate easier surveying of potential sites and post-sinking research by instruments and ROV.

- We are assuming 98 percent reaches the ocean floor. The consensus in the oceanographic community is that, at depths greater than 1000m, seaweed that reaches the ocean floor becomes buried in ocean sediments and mineralizes and is sequestered for thousands of years.

- We assume a 2 percent loss due to shedding and assume none of this seaweed reaches depths of 1000 meters to be sequestered.

- Seaweed that is shed and fails to reach 1000m may be consumed by fauna, in which case the Carbon returns to the surface when it leaves the body of the animal. (The Carbon is not sequestered).

- For Seaweed that is shed and descends below 1000m only to be eaten by deep-sea fauna, the Carbon returns to the water as CO2 after digestion or retained in the animal's body until it dies and decomposes on the ocean floor. (FG does not count this as sequestered).

- Seaweed that descends below 1000m but is not consumed nor does it reach the ocean floor will degrade and dissolve in the seawater as CO2.

- Below 1000 metres, any CO2 from the Seaweed (digested or dissolved) is compressed to a density greater than water. Propelled by deep sea conveyor current, the compressed CO2 will take 800-4000 years (depending on the ocean) to return to the surface and the atmosphere. (FG does not count this as sequestered).

The key assumption is that the seaweed (98 percent of it) reaches the ocean floor. This can be foiled by several oceanographic conditions. For this reason, First Gigaton will:

1. Commission a third party (Blue Nomads) to conduct an oceanographic survey of proposed sequestration sites to increase the confidence and likelihood the full 98 percent reaches the ocean floor. First Gigaton will only choose storage sites with surveys that indicate the seaweed can reach the ocean floor (e.g. there are no permanent thermoclines, cross-currents, or upwelling), that the seaweed is not expected to negatively impact local sea lifeup (up to a certain tonnage, TBD), the site's floor is sand or soft bottom sediments and conducive to burying the seaweed, and that any detectable eddies, bottom conveyor current, or deepwater recirculation is not expected to negatively impact durability.

2. Directly observe (and record) the sinking of the biomass for tens of meters. This allows us to detect any possible shedding of seaweed as the biomass sinks until it is in free-fall. (Sinking tests FG has conducted to 20 and 40 meters observed no detectable shedding).

3. Attach depth-release beacons to bundles of seaweed will float to the surface to indicate that the seaweed is arriving on the ocean floor.

These (and other possible measures developed with Blue Nomads, Coastal Carbon Solutions (our MRV partner), and the wider Ocean-CDR) will be implemented to build confidence that FG's Seaweed reaches the ocean floor.

Finally, we will follow up with (regular) site visits via Blue Nomad's instruments and ROV to directly observe, confirm and quantify the seaweed that has reached the ocean floor, as well as observe exactly what is happening to it. These observations (made easier at depths of "only" 1200 meters) will allow the development of better MRV models.

With these models, and with decreasing costs of electric sequestration vessels, FG will survey and deploy at deeper sites.

Sources:

Krause-Jensen, D., Lavery, P., Serrano, O., Marba, N., Masque, P. & Duarte, C.M. (2018). Sequestration of macroalgal carbon: the elephant in the Blue Carbon room. Biology letters 14, (6):20180236.

https://royalsocietypublishing.org/doi/10.1098/rsbl.2018.0236

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Broecker, W.S. & Peng, T.-H. (1982) Tracers in the Sea. Lamont-Doherty Geological Observatory, Palisades, N.Y., Eldigio Press.

https://www.ldeo.columbia.edu/~broecker/Home_files/TracersInTheSea_searchable.pdf

b. 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?

Oceanographic surveys to choose storage site locations, combined with other measures described above will minimize the risks associated with *sinking* the seaweed. The seaweed that reaches the ocean floor will not be exposed to risks associated with human activity (deeps-sea trolling or mining). Further observation on the sea-floor will determine if there are any other risks (biological or current-related). Such observations will confirm or iterate our models and lead to either a continuation of the site or the selection of an alternative for future storage.

3. Gross Removal & Life Cycle Analysis (LCA)

a. How much GROSS CDR will occur over this project's timeline? All tonnage should be described in **metric tonnes** of CO_2 here and throughout the application. Tell us how you calculated this value (i.e., show your work). If you have uncertainties in the amount of gross CDR, tell us where they come from.

Gross tonnes of CDR over project lifetime	**3,200 tonnes**
Describe how you calculated that value	Gross production of 80 tonnes Carbon per year per Farm x 40 farms.

b. How many tonnes of CO_2 have you captured and stored to date? If relevant to your technology (e.g., DAC), please list captured and stored tons separately.

Approximately **3 tonnes** have been captured since August 2023. Zero tonnes have been intentionally sequestered.

c. If applicable, list any avoided emissions that result from your project. For carbon mineralization in concrete production, for example, removal would be the CO_2 utilized in concrete production and avoided emissions would be the emissions reductions associated with traditional concrete production. Do not include this number in your gross or net CDR calculations; it's just to help us understand potential co-benefits of your approach.

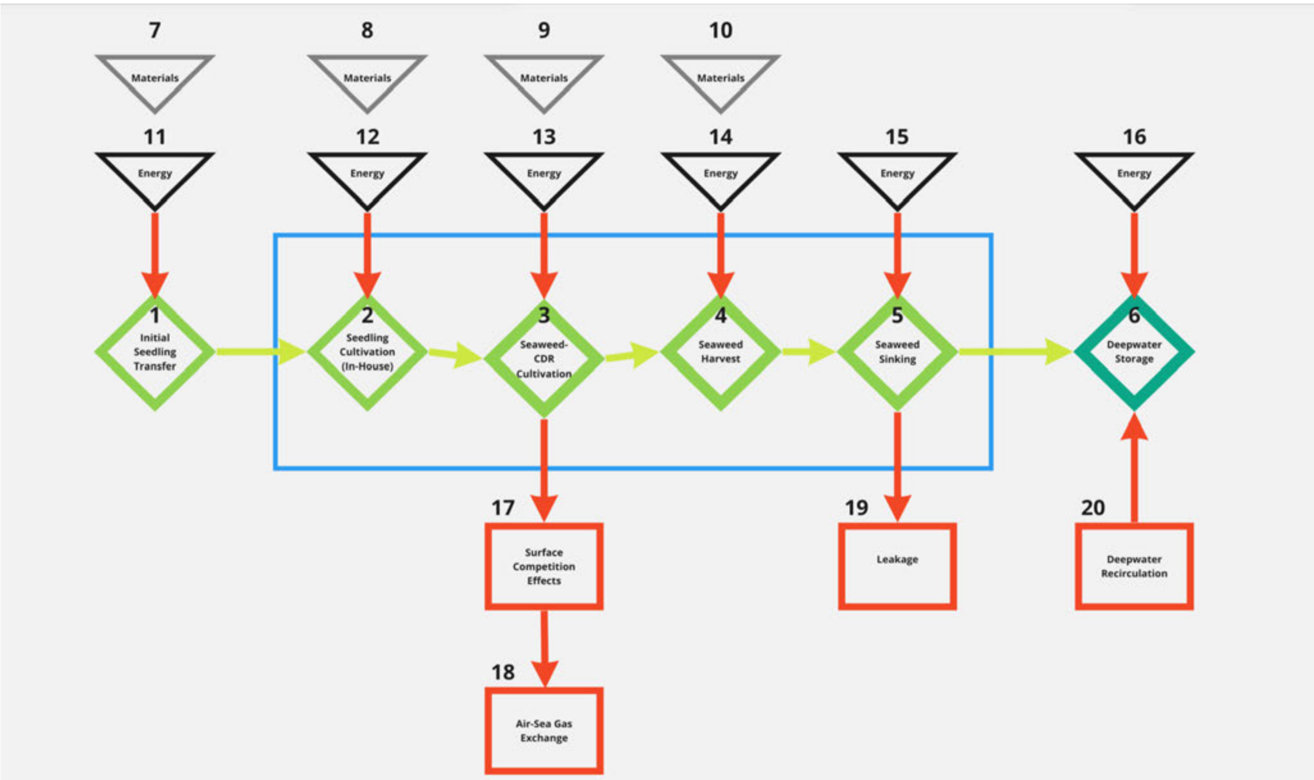
Avoided emissions occur through the intense use of reused and recycled material throughout our process. The results of the LCA are given in the **Figure 2** of the LCA. Most of the materials consisted of reused materials without recycling and as such only their transportation and cleaning (by tap water and manual labour) contributed to environmental impacts. For comparisons, the impacts of equivalent quantities of virgin materials are given in **Table 2** and **3**. **Table 3** displays the comparative environmental benefit obtained by avoiding the use of virgin materials. Please note however that this is also an understatement as a complete environmental benefit would entail the production of specific products such as PET bottles rather than the material only i.e., for instance PET.

d. How many GROSS EMISSIONS will occur over the project lifetime? Divide that value by the gross CDR to get the emissions / removal ratio. Subtract it from the gross CDR to get the net CDR for this project.

Gross project emissions over the project timeline *(should correspond to the boundary conditions described below this table)*	**262.4 tonnes**
Emissions / removal ratio *(gross project emissions / gross CDR–must be less than one for net-negative CDR systems)*	**0.082**
Net CDR over the project timeline *(gross CDR - gross project emissions)*	**2,937 tonnes**

e. Provide a process flow diagram (PFD) for your CDR solution, visualizing the project emissions numbers above. This diagram provides the basis for your life cycle analysis (LCA). Some notes:

- The LCA scope should be cradle-to-grave
- For each step in the PFD, include all Scope 1-3 greenhouse gas emissions on a CO_2 equivalent basis
- Do not include CDR claimed by another entity (no double counting)
- For assistance, please:
  - Review the diagram below from the CDR Primer, Charm's application from 2020 for a simple example, or CarbonCure's for a more complex example
  - See University of Michigan's Global CO_2 Initiative resource guide
- If you've had a third-party LCA performed, please link to it.



f. 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 figures in the LCA do not take into account the impact of Blue Nomad's ships or equipment used for surveying and monitoring (MRV), including the ROV and only account for the fuel consumption. Similarly, periodic maintenance and repair hasn't been accounted for, nor are the end of life impacts for the materials used herein.

Similarly, the overall impact mitigation through the use of waste plastic bottles is anticipated to be significant due to the avoidance of plastic waste disposal activities such as incineration, landfilling and recycling. The results are even more significant if new/virgin plastic bottles are

considered as an input.

g. Please justify all numbers used to assign emissions to each process step depicted 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.

Process Step	CO_2(eq) emissions over the project lifetime (metric tonnes)	Describe how you calculated that number. Include references where appropriate.
1	**Initial Seedling Transfer**	**Step 1** Transfer of initial batch of small seaweed plants purchased from other local seaweed farmers to attach to our lines and begin cultivation. Seedlings were used for both our own Seedling Cultivation and our Seaweed-CDR Cultivation. Energy and Material usage are not directly known, but are assumed to be the same as for our own Seedling Cultivation.
2	**Seedling Cultivation**	**Step 2** One First Gigaton farm (exanding lines as needed) dedicated to growing seedlings for our expansion. Located in Digos (Digos-S).
3	**Seaweed-CDR Cultivation**	**Step 3** Farm 1.0 Plots dedicated to CDR. (40 Farms for this project).
4	**Seaweed Harvest**	**Step 4** Gross tonnage of Carbon Captured. Calculated as 20% of gross fresh seaweed. Production capacity is considered to be 80 tonnes of Carbon per 10,000 meters per year.
5	**Seaweed Sinking**	**Step 5** Process of Sequestering Carbon by sinking the seaweed to depths greater than 1200 meters. Only energy is included, and conisists of two components: 1. Fuel for survey ship to select and survey sequestration site. 2. Fuel for sequestration vessel to transfer seaweed to site.
6	**Deepwater Storage**	**Step 6** Seaweed is deposited on the ocean floor at depths greater than 1200m.
7	**Cumulative Totals for**	**Materials for Step 1**

	7-16 are in the LCA. **https://docs.google.com/document/d/1YeshxqcytWMR1kqbvMN3kPfsffuWZZ1xeAGt8S2WVfE/edit?usp=sharing**	Lines: 140 m (100m on surface) Buoys (Recycled bottles): 30 bottles Cement: 40 kg Used motorcycle tires: 2 tires
8	**Cumulative Totals for 7-16 are in the LCA.** **https://docs.google.com/document/d/1YeshxqcytWMR1kqbvMN3kPfsffuWZZ1xeAGt8S2WVfE/edit?usp=sharing**	**Materials for Step 2** Lines: 14,000 m (10,000m on surface) Buoys: 3,000 bottles Cement: 5,600 kg Tires: 200
9	**Cumulative Totals for 7-16 are in the LCA.** **https://docs.google.com/document/d/1YeshxqcytWMR1kqbvMN3kPfsffuWZZ1xeAGt8S2WVfE/edit?usp=sharing**	**Materials for Step 3** Lines: 560,000 m (400,000m on surface) Buoys: 120,000 bottles Cement: 160,000 kg Tires: 8,000
10	**Cumulative Totals for 7-16 are in the LCA.** **https://docs.google.com/document/d/1YeshxqcytWMR1kqbvMN3kPfsffuWZZ1xeAGt8S2WVfE/edit?usp=sharing**	**Materials for Step 4** Lines: 560,000 m (400,000m on surface) Materials for Step 4 Buoys: 120,000 bottles Cement: 160,000 kg Tires 8,000
11	**Cumulative Totals for 7-16 are in the LCA.** **https://docs.google.com/document/d/1YeshxqcytWMR1kqbvMN3kPfsffuWZZ1xeAGt8S2WVfE/edit?usp=sharing**	**Energy for Step 1** Gasoline for farm boats (30 litres x 3 times per year) 90 litres Gasoline to transport seedlings to FG farms: (5 litres x 3 times per year) 15 litres
12	**Cumulative Totals for 7-16 are in the LCA.** **https://docs.google.com/document/d/1Yes**	**Energy for Step 2** Gasoline for farm boat (30 litres x 1 boat x 12 months) 360 litres Gasoline to transport seedlings from Digos to Padada (10 litres x 12 months) 120 litres

	hxqcytWMR1kqbvMN3kPfsffuWZZ1xeAGt8S2WVfE/edit?usp=sharing	
13	**Cumulative Totals for 7-16 are in the LCA.** **https://docs.google.com/document/d/1YeshxqcytWMR1kqbvMN3kPfsffuWZZ1xeAGt8S2WVfE/edit?usp=sharing**	**Energy for Step 3** Gasoline to transfer material to Digos and Padada (30 litres x 12 months) 360 litres Gasoline for farm boats (30 litres per month x 5 boats x 12 months) 5,400 litres
14	**Cumulative Totals for 7-16 are in the LCA.** **https://docs.google.com/document/d/1YeshxqcytWMR1kqbvMN3kPfsffuWZZ1xeAGt8S2WVfE/edit?usp=sharing**	**Energy for Step 4** Gasoline for farm boats to transfer seaweed to harvest platform (60 litres per month x 12 months) 720 litres
15	**Cumulative Totals for 7-16 are in the LCA.** **https://docs.google.com/document/d/1YeshxqcytWMR1kqbvMN3kPfsffuWZZ1xeAGt8S2WVfE/edit?usp=sharing**	**Energy for Step 5** Marine Diesel for Survey Vessel: 6,000 litres (estimate by Blue Nomads) Standard Diesel for Sequestration Vessel (50 litres per 50 km roundtrip for 5 tonnes of seaweed or 1 tonne of Carbon): 160,000 litres
16	**Cumulative Totals for 7-16 are in the LCA.** **https://docs.google.com/document/d/1YeshxqcytWMR1kqbvMN3kPfsffuWZZ1xeAGt8S2WVfE/edit?usp=sharing**	**Energy for Step 6** Marine Diesel for Monitoring Vessel and ROV 50,000 litres (estimate by Blue Nomads)
17	**10 percent discount**	**Surface Competition Effects - FG estimate**
18	**10 percent discount**	**Air-Sea Gas Exchange - FG estimate**
19	**2 percent discount**	**Leakage (Shedding) - FG estimate**
20	**Not accounted (but minimized through site survey)**	**Deepwater Recirculation- FG Estimate**

4. Measurement, Reporting, and Verification (MRV)

Section 3 above captures a project's lifecycle emissions, which is one of a number of MRV considerations. In this section, we are looking for additional details on your MRV approach, with a particular focus on the ongoing quantification of carbon removal outcomes and associated uncertainties.

a. Describe your ongoing approach to quantifying the CDR of your project, including methodology, what data is measured vs modeled, monitoring frequency, and key assumptions. If you plan to use an existing protocol, please link to it. Please see Charm's bio-oil sequestration protocol for reference, though note we do not expect proposals to have a protocol at this depth at the prepurchase stage.

> First Gigaton is working with **Coastal Carbon Solutions** as our MRV partner and will be working with them on the development of the appropriate protocol. The methodology is still under development. It will contain all of the elements outlined in the CarbonPlan -> Ocean Biomass Sinking (Harvest), will establish the relevant data collection, and data standards, and be part of an ongoing partnership and ongoing MRV effort.
>
> The component parts of the anticipated methodology are outlined in more detail in section 4c. below.

b. How will you quantify the durability of the carbon sequestered by your project discussed in 2(b)? 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.)*

> Our cultivated biomass will be delivered and sunk in an ocean region with an anticipated depth of at least 1,200 m. The biomass will be bundled and observed such that we are confident that it is reaching this depth which is essential for durable sequestration.
>
> We recognize the 1,000 year durability standard established by Frontier and will strive to only offer sequestration activities we believe have satisfied this standard. In the case of ocean biomass this can be difficult to demonstrate as this remains an area of active research and development.
>
> We will consult the available literature and on the expected durability of biomass and carbon sequestered at depth. We recognize that this is highly variable depending on the region and will evaluate our expectations based on our specific area of deployment.

c. This tool diagrams components that we anticipate should be measured or modeled to quantify CDR and durability outcomes, along with high-level characterizations of the uncertainty type and magnitude for each element. We are asking the net CDR volume to be discounted in order to account for uncertainty and reflect the actual net CDR as accurately as possible. Please complete the table below. Some notes:

- In the first column, list the quantification components from the Quantification Tool relevant to your project (e.g., risk of secondary mineral formation for enhanced weathering, uncertainty in the mass of kelp grown, variability in air-sea gas exchange efficiency for ocean alkalinity enhancement, etc.).
- In the second column, please discuss the magnitude of this uncertainty related to your project and what percentage of the net CDR should be discounted to appropriately reflect these uncertainties. Your estimates should be based on field measurements, modeling, or scientific literature. The magnitude for some of these factors relies on your operational choices (i.e., methodology, deployment site), while others stem from broader field questions, and in some cases, may not be well constrained. We are not looking for precise figures at this stage, but rather to understand how your project is thinking about these questions.
- See this post for details on Frontier's MRV approach and a sample uncertainty discount calculation and this Supplier Measurement & Verification Q&A document for additional guidance.

Quantification component Include each component from the Quantification Tool relevant to your project	**Discuss the uncertainty impact related to your project** Estimate the impact of this component as a percentage of net CDR. Include assumptions and scientific references if possible.
Macroalgae harvest	The estimate the carbon percentage of the cultivated seaweeed is determined by obtaining the fresh weight of a volume of seaweed, drying it and measuring the dry weight to get the ratio of fresh to dry weight. We'll send the dry weight seaweed to a 3rd party partner (Department of Science and Technology, Philippines) to evaluate the carbon content of the dry weight seaweed by volume. These measurements will give us an expected ratio of carbon to a volume of seaweed. This process will be repeated with each harvest to evaluate the consistency of this ratio. Through this method, we'll establish our baseline harvest yield. The process involves a degree of uncertainty, but as the potential of error can be in either direction, we will not apply a discount percentage.
Surface competition effects	Macroalgae cultivation requires the use of nutrients that, in the absence of the cultivation activity, might be used to grow other carbon consuming biomass. However, our durability contribution comes from delivering the biomass to be sunk at depth. Without this step, no meaningful, durable carbon sequestration would occur. We believe our actions are entirely additional and not in competition with natural, durable, sequestration activities. **We suggest a 10% discount rate is applied due to this uncertainty.**
Air-sea gas exchange	Macroalgae cultivation draws carbon from the water and (to a lesser extent) from the air. Carbon drawn from the water is replaced from the air (resulting in atmospheric

	CO2 removal) at variable rates while the volume of water circulates near the ocean surface. The rate of actual gas exchange can not be practically measured with current tools and techniques. But, provided the exchange occurs, the rate doesn't have a meaningful bearing on our claims of durable atmospheric carbon removal. There are circumstances where natural downwelling causes water volumes to be removed from the surface layer before the gas exchange can fully occur. We will endeavor to detect and mitigate such occurrences, but also acknowledge an inevitable degree of uncertainty. **We suggest a 10% discount rate is applied due to this uncertainty.**
Macroalgae sinking	Harvested seaweed will be weighed, bundled, and delivered to an ocean drop location where it can be observed being sunk and delivered to depths required for durable sequestration. Prior to sequestration activities, the potential drop site will be surveyed by BlueNomads.org to determine the site's suitability for sustainable and durable sequestration. The drop site will have a minimum depth of 1,200 m, and the location will be shared publicly. The bundling process was designed, after multiple trials with different techniques, to require no extra materials (e.g. no baling twine or bags) while ensuring that the entire biomass sinks to depth. Cameras will be deployed during the delivery to observe and ensure the sinking of the biomass. Nonetheless, there is some risk of biomass leakage during sinking. **We suggest a 2% discount rate be applied to reflect this uncertainty.**
Deepwater recirculation	The deepwater recirculation rate of biomass delivered at depth remains an area of active research. Within the 1,000 year sequestration timeframe there are a number of unknowns. We will utilize the available research and models to ensure maximum durability is achieved with our choice of sinking selection sites. We also hope to work with partners to advance our collective understanding of the durability characteristics of biomass at depth. Our oceanographic survey (conducted by Blue Nomads) for selecting storage sites is intended to minimize the risk associated with, in part, deepwater recirculation. There is considerable uncertainty in this area. It is our understanding that this uncertainty should not be applied to the overall discount rate on this application.

d. Based on your responses to 4(c), what percentage of the net CDR do you think should be discounted for each of these factors above and in aggregate to appropriately reflect these uncertainties?

> Based on the factors above we believe a discount rate of **42%** would be appropriate. The majority of that risk is around potential uncertainty about downwelling events that would interfere with the air-sea gas exchange.

e. Will this project help advance quantification approaches or reduce uncertainty for this CDR pathway? If yes, describe what new tools, models or approaches you are developing, what new data will be generated, etc.?

> We, along with our MRV partners, see this project as a significant opportunity to advance our collective understanding of the ocean biomass sinking as a CDR methodology. We are interested in, and actively pursuing, public-private partnerships and coordination with research institutions to supplement the research and MRV activities around this project. It is likely that the scope and cost of these efforts will exceed the value of the CO2 credits harvested in the early years.
>
> These areas of investigation and cooperation are just beginning to be developed. We hope and expect they will include topics of:
> - Measuring and increasing harvest yield
> - Understanding environmental impacts
> - Measuring and mitigating air-sea gas exchange leakage
> - Understanding the sequestration durability of biomass at depth

f. Describe your intended plan and partners for verifying delivery and registering credits, if known. If a protocol doesn't yet exist for your technology, who will develop it? Will there be a third party auditor to verify delivery against that protocol or the protocol discussed in 4(a)?

> Our MRV partner is **Coastal Carbon Solutions** (CCS). This is a new relationship. Existing comprehensive standards for ocean biomass sinking do not yet exist. We look forward to co-developing a practical MRV methodology that can be used by ourselves and other organizations to measure and verify activity with this CDR pathway. CCS will be responsible for ensuring we comply with the appropriate measurement and data standards. They will package the methodology description and evidentiary data as well as assigning and certifying our volume and durability claims.

5. Cost

We are open to purchasing high-cost CDR today with the expectation the cost per tonne will rapidly decline over time. The questions below are meant to capture some of the key numbers and assumptions that you are entering into the separate techno-economic analysis (TEA) spreadsheet (see step 4 in Applicant Instructions). 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 work with you to understand your milestones and their verification in more depth.

a. What is the levelized price per net metric tonne of CO_2 removed for the project you're proposing Frontier purchase from? This does not need to exactly match the cost calculated for "This Project" in the TEA spreadsheet (e.g., it's expected to include a margin), but we will be using the data in that spreadsheet to consider your offer. Please specify whether the price per tonne below includes the uncertainty discount in the net removal volume proposed in response to question 4(d).

$183/tonne CO_2 without 22% uncertainty discount or MRV-ROV Cost. **Total Cost per Delivered tonne = $297 (includes $113/tonne MRV-ROV costs)**

b. Please break out the components of this levelized price per metric tonne.

Component	Levelized price of net CDR for this project ($/tonne)
Capex	**$12/tonne**
Opex (excluding measurement)	**$172/tonne**
Quantification of net removal (field measurements, modeling, etc.)[2]	**$113/tonne** **(Cost of one ROV visit to Deepwater Storage Site= $193,000)**
Third party verification and registry fees (if applicable)	**N/A**
Total	**$297/tonne**

c. Describe the parameters that have the greatest sensitivity to cost (e.g., manufacturing efficiencies, material cost, material lifetime, etc.). For each parameter you identify, tell us what the current value is, and what value you are assuming for your NOAK commercial-scale TEA. If this includes parameters you already identified in 1(c), please repeat them here (if applicable). Broadly, what would need to be true for your approach to achieve a cost of $100/tonne?

Parameter with high impact on cost	Current value (units)	Value assumed in NOAK TEA (units)	Why is it feasible to reach the NOAK value?
MRV-ROV	$113/tonne	$0	Frequency of visits will decrease over time and costs will be spread across more tonnage. New models that provide sufficient confidence combined with deeper sequestration sites will eventually eliminate the need for regular ROV monitoring.
Farmer Salaries	$51/tonne	$25	Farmer productivity is the main cost

[2] This and the following line item is not included in the TEA spreadsheet because we want to consider MRV and registry costs separately from traditional capex and opex.

			driver. By simply doubling their productivity (mechanization, plus improving yield per meter of seaweed line, plus adding lines) we can halve the cost. In fact, we can realistically quarter it.
Further economies of scale		<$75	After FOAK, substantial cost reductions will occur by bringing line manufacturing, seedline tying, and seedling cultivation 100 percent in-house.
Sequestration Vessel	$50/tonne	$10	Charter and fuel costs associated with sequestration vessels will be substantially reduced by acquiring electric vessels and putting crew on salary.

d. What aspects of your cost analysis are you least confident in?

> Initial costs of MRV-ROV.

e. How do the CDR costs calculated in the TEA spreadsheet compare with your own models? If there are large differences, please describe why that might be (e.g., you're assuming different learning rates, different multipliers to get from Bare Erected Cost to Total Overnight Cost, favorable contract terms, etc.).

> Farmer salaries are a major cost centre. However, cost of farmer (salary) per tonne can be substantially decreased by increasing the productivity of each farm/farmer. This will occur with mechanization, increasing the yield per meter, and adding lines to each farm. We could double productivity and still fall short of per hectare productivity reported by Indonesia.

f. What is one thing that doesn't exist today that would make it easier for you to commercialize your technology? (e.g., improved sensing technologies, increased access to X, etc.)

> Remote sensors for monitoring ocean floor chemistry and currents around sequestration sites.

6. Public Engagement

In alignment with Frontier's Safety & Legality criteria, Frontier requires projects to consider and address potential social, political, and ecosystem risks associated with their deployments. Projects with effective public engagement tend to:

- Identify key stakeholders in the area they'll be deploying

- Have mechanisms in place to engage and gather opinions from those stakeholders, take those opinions seriously, and develop active partnerships, iterating the project as necessary

The following questions help us gain an understanding of your public engagement strategy and how your project is working to follow best practices for responsible CDR project 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 relevant external stakeholders, where are they located, and what process did you use to identify them? Please include discussion of the communities potentially engaging in or impacted by your project's deployment.

> The key stakeholders in our process are our Farmers. Typically, the farmers and members of their community are subsistence fisherfolk. We identify them by travelling to their community and engaging the local barangay councilors and municipal mayor's office.
>
> By establishing our Seaweed-CDR Farms in their community we provide:
>
> - Farmers with a monthly salary that will comfortably support their family.
> - Casual/Part-time employment for other members of the community tying seedlings to line, manufacturing boats, anchors, and helping install lines.
> - Medical insurance for the Farmers and regular (full- and part-time) employees and their families.
> - Educational support (e.g. school and program supplies) for employees' children (primary, secondary, and post-secondary tuition is free in the Philippines; however, supply costs are a burden to many families and often prohibitive for post-secondary programs).
> - Providing full-time employment in our in-house Line (rope) manufacturing facility.
> - Additional fundraising opportunities for community schools and students providing floats for operations (i.e. bottle drives).

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 and Arnestein's Ladder of Citizen Participation for a framework on community input.*

> We hold regular (monthly) activities (such as Beach Clean-Ups and bottle drives) to communicate opportunities in the community and get their input. People come because we always provide food!

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?

> Be generous with the community and they will do anything for you.

d. Going forward, do you have changes to your processes for (a) and (b) planned that you have not yet implemented? How do you envision your public engagement strategy at the megaton or gigaton scale?

> Our approach to community engagement will not vary at any scale. We are on the ground inthe communities to remove carbon (fast) and help the people removing the carbon every way we can.
>
> In addition to existing our engagement programs, we will approach/lobby the Canadian International Development Agency for support for development projects (e.g. water towers, sanitation systems, solar and windpower grids) in each of our farm communities.

7. Environmental Justice[3]

As a part of Frontier's Safety & Legality criteria, Frontier seeks projects that proactively integrate environmental and social justice considerations into their deployment strategy and decision-making on an ongoing basis.

a. What are the potential environmental justice considerations, if any, that you have identified associated with your project? Who are the key stakeholders? Consider supply chain impacts, worker compensation and safety, plant siting, distribution of impacts, restorative justice/activities, job creation in marginalized communities, etc.

> Environmental (and Climate) Justice is at the centre of FG's CDR Solution. It is a core company value that the people most impacted by climate change (the Global South) should be the first ones to benefit socially and economically from climate change solutions.
>
> In FG's CDR Solution, it is the very families working the seaweed farms who receive the bulk of the economic returns for removing the Global North's carbon.
>
> Our first partners are subsistence fisher folk ans seaweed farm families on the island of Mindanao, one of the poorest regions of the Philippines. Many hope to farm seaweed to supplement and/or replace declining livelihoods from fishing. In many areas, fish stocks are depleting due to overfishing, pollution, and increasing water temperatures and acidity from climate change.
>
> For subsistence and small-scale seaweed farmers, failure to find a buyer that pays a fair price for their seaweed puts the well-being of their families at risk. Even when they do receive a fair price, the money earned is never above subsistence. FG provides our partners with a monthly salary paid year-round as well as health insurance for their families. This salary de-risks their farm operations, empowers them to feed their families comfortably and without worry, grow their businesses with our investment, and secure generational prosperity.
>
> However, as stated earlier, Climate Justice is also a good business strategy. It is the surest way to get the eager support of the farmers, their communities, and local and national authorities. We believe the speed of our progress to date is due to our strategy of letting our local partners lead the discussions of what they need from First Gigaton to reap the rewards of Seaweed CDR.

[3] For helpful content regarding environmental justice and CDR, please see these resources: C180 and XPRIZE's Environmental Justice Reading Materials, AirMiners Environmental and Social Justice Resource Repository, and the Foundation for Climate Restoration's Resource Database

b. How do you intend to address any identified environmental justice concerns and / or take advantage of opportunities for positive impact?

> Climate Justice and Social Impact are *the* guiding principles of the company. Our model proves it. By 2032, four million First Gigaton farm families will have secured generational prosperity.

8. Legal and Regulatory Compliance

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

> In January 2022, FG hired a local legal researcher to determine whether we face any legal prohibitions on sequestering seaweed in Philippine waters. Her conclusion was that there were no laws at federal or provincial levels doing so in part because seaweed does not fit the definition of pollution or hazardous materials. Her report indicated that Local Government Units, including coastal municipalities, make regulations regarding the use of the sea and its resources up to 15 km from the shoreline. In Davao del Sur Local sequestration at sea requires a permit from the Municipal Agriculture Office (MAO). The Padada MAO is preparing our permit at this time.

b. What permits or other forms of formal permission do you require, if any, to engage in the research or deployment of your project? What else might be required in the future as you scale? 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.

> In addition to the permit from Padada, we will need a permit from the Department of Environment and Natural Resources (DENR). We are working with Padada MAO and they assure us the DENR permit will come once we provide an oceanographic survey of the proposed sequestration site.

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?

> Initially, the FG Model involves sequestration only within the territorial waters of our partner farms, which currently are the territorial waters of the Philippines under the jurisdiction of municipalities and provinces (e.g. Padada Municipality and Davao del Sur Province). As we scale beyond the Philippines and other countries that qualify as "Nearshore Deepwater Storage," we will need to sequester in international waters. In those cases, we will comply with international legal regimes such as the London Protocol. At this time, it appears the London Protocol is not an obstacle, but we will monitor the situation as it evolves and join with our "offshore" colleagues in lobbying for acceptance of sequestering in international waters.

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.

> Given our received legal opinion and the legal precedent of receiving a sequestration permit from the Padada MAO, we anticipate other jurisdictions (e.g. Digos and Santa Cruz) will quickly follow suit. However, it does remain up to the jurisdiction of local municipalities, so it cannot be guaranteed. This underscores the need to enlist our local partner coops in lobbying/applying for sequestration permits from their own communities. As more municipalities come on board, those that initially refuse will be under increasing pressure to reconsider.

e. Do you intend to receive any tax credits during the proposed delivery window for Frontier's purchase? If so, please explain how you will avoid double counting.

> No Tax Credits are anticipated. However, we will apply for funding from the Canadian Government's CIDA for international development projects for assistance with deploying and scaling operations. In addition, we will help local organizations apply for CIDA grants for community projects (e.g. water towers, sanitation systems, solar and windpower grids) that are separate from FG operations but will have a meaningful and lasting impact on our Farmers' wider communities.
>
> https://www.international.gc.ca/world-monde/funding-financement/funding_development_projects-financement_projets_developpement.aspx?lang=eng

9. Offer to Frontier

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

Proposed CDR over the project lifetime (tonnes) *(should be net volume after taking into account the uncertainty discount proposed in 4(c))*	**2,290 tonnes (includes 22percent uncertainty discount).**
Delivery window *(at what point should Frontier consider your contract complete? Should match 1(f))*	**By Q2 2024**
Levelized Price ($/metric tonne CO_2) *(This is the price per tonne of your offer to us for the tonnage described above)*	**$235/tonne (with no MRV-ROV)**

Frontier

Application Supplement: Biomass

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

Feedstock and Physical Footprint

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

> *Eucheuma* strains of seaweed.

2. How is the biomass grown (e.g., kelp) or sourced (e.g., waste corn stover)? Do you have supply agreements established?

> Initial seedlings have been sourced externally. However, we now have a dedicated seedling farm (Digos-S). This will eventually eliminate the need for external seedlings.

3. Describe the logistics of collecting your waste biomass, including transport. How much carbon emissions are associated with these logistics, and how much does it cost? How do you envision this to evolve with scale?

> Harvested seaweed is weighed and bagged on floating platforms adjacent to the farms. The sequestration vessel docks on the platform to load and transport the seaweed to the sequestration site (approximately 15 km). With scale, chartered diesel sequestration vessels will be replaced with in-house electric sequestration vessels.

4. 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 2022	Competing/existing project area use (if applicable)
Feedstock cultivation	E.g. 1 km2 (floating kelp array) OR N/A (procuring waste biomass)	0.8 km2 consisting of 42 x 10,000 linear meters of seaweed lines.
Processing	E.g. 0.1 km2 (boat yard, manufacturing facility) OR 0.5 km2 (manufacturing facility for mobile biochar plants)	60 m2 (4 x 10m x 5m rafts)

Long-term Storage	E.g. N/A (uncertainty in final state of kelp) OR 2 km2 (ag fields in which biochar is deployed)	On the ocean floor.

Capacity

5. How much CDR is feasible globally per year using the biomass you identified in question 1 above? Please include a reference to support this potential capacity.

Approximately 48 million square kilometres of the oceans are suitable for seaweed aquaculture (Froehlich, Halley E.; et.al. (2019)). One Gigatonne CDR capacity per year can be achieved using 20,000,000 hectares, or less than one-half of one percent of the suitable area.

Additionality and Ecosystem Impacts

6. What are applications/sectors your biomass feedstock could be used for other than CDR? (i.e., what is the counterfactual fate of the biomass feedstock)

The abundance of available sea area for seaweed aquaculture (48 million km2) means there is little need to choose between different "uses" for seaweed. Food companies can grow it for food, fertilizer companies for fertilizer, etc. First Gigaton is growing it exclusively for carbon removal.

The most impactful alternative to FG's Seaweed-CDR for the climate is to grow seaweed to make biofuel. However, one square kilometer (100 hectares) of seaweed grown for biofuel will replace only 1,500 tonnes of emissions per year. That's 15 tonnes per hectare. https://www.frontiersin.org/articles/10.3389/fmars.2017.00100/full

In contrast, one hectare of FG's Farm 1.0 removes 40 tonnes of carbon and we are sure to at least double this number.

Moreover, it costs *substantially* more to manufacture biofuel than it does for us to remove carbon by simply transporting fresh crops a few kilometers out to sea.

7. There are many potential uses for waste biomass, including avoiding emissions and various other approaches to CDR. What are the merits and advantages of your proposed approach in comparison to the alternatives?

One hectare of FG Farm 1.0 will remove 40 tonnes at minimal (and declining) cost.

We are the most cost-efficient, directly measureable means of seaweed-based climate impact.

8. We recognize that both biomass production (i.e., growing kelp) and biomass storage (i.e., sinking in the ocean) can have complex interactions with ecological, social, and economic systems. What are the specific, potential negative impacts (or important unknowns) you have identified, and what are your specific plans for mitigating those impacts (or resolving the unknowns)?

The most important potential impact of seaweed aquaculture is the depletion of nutrients from the local environment. To mitigate against this, on a monthly basis we will use probe-type multi-parameter meter to measure key nutrients like nitrate, nitrite, ammonia and phosphate, together with measurements of water temperature, dissolved oxygen, pH and salinity. Quarterly, we'll take replicated water samples from within the farm and from outside (a kilometer away from the farm as control), and transport the samples to the nearest laboratory.

Should deliterious depletion be detected, FG has several options. We can scale back, suspend or relocate operations (e.g. to eutrophied areas). We may also be able to introduce multi-trophic aquaculture (by adding fish and shell fish operations) with the intent of replenishing/reintroducing nutrients to the local environment.

Additionally, we will measure and record the nutrient content of the seaweed we sequester. This is important as we scale operations to the Mega and Gigatonne scale. We must be extremely cautious to not remove from the global ecosystem a level of nutrients that could have widespread, dangerous impacts. FG will be on top of the science to ensure this does not happen.

Frontier

Application Supplement: Ocean

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

Physical Footprint

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

> Our farm operations are within 1 km of shore in waters less than 10 meters deep. They do not interfere with any other marine activity.

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.

> N/A

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.

> This will require 1,250 Farm 1.0 units of 10,000 linear meters each, or roughly 2500 hectares, or 25 km2.

Potential to Scale

4. Building large systems on or in the ocean is hard. What are your core engineering challenges and constraints (not covered already within 1(n)? Is there any historical precedent for the work you propose?

> Our system is simple: lines, floats, anchors. However, we face growing demand from more and more communities wanting to join our program. Our main challenge is to ensure we scale fast *and sustainably.* Dr. Danny, our Chief Scientist, is a leading expert in sustainable seaweed farming. His job is to ensure FG continues to implement the latest best practices in sustainability across all our operations.
>
> Our largest technical challenge is monitoring the seaweed once it is deployed to the ocean floor. ROVs are the best answer at this time. We are working on it.

Externalities and Ecosystem Impacts

5. What are potential negative impacts of your approach on ocean ecosystems?

In addition to nutrient depletion, potential negative impacts include

- Seaweed cultivated in large scale in shallow habitats can compete with nutrient requirements of corals and other organisms in an oligotrophic environment.
- Activities associated with seaweed farming like physical trampling of existing habitats such as seagrass beds and coral colonies (we locate our farms in deeper water ~ 10 m).
- Largescale seaweed farms with insufficient distances between lines can obstruct water circulation and block sunlight impacting other organisms reliant on photosynthesis.

These impacts can all be avoided by using best practices for sustainable seaweed cultivation.

6. How will you mitigate the potential for negative ecosystem impacts (e.g., eutrophication and alkalinity/pH)? How will you quantify and monitor the impact of your solution on ocean ecosystems and organisms?

We will be regularly sampling waters around the farm, and when possible at sequestration sites using the ROV.