Carbon BioCapture® Brief

Carbon BioCapture LLC ("CBC") is a Miami-based, minority woman-owned company created to market and deploy its proven and patented "all-terrain" microalgal photobioreactor ("PBR") technology in which naturally occurring photosynthetic microorganisms are adapted to capture and metabolize CO_2 from point-source industrial emissions (or ambient gases) into biomass and oxygen.

CBC exists to:

- Partner with fossil fuel-dependent industries to capture point-source emissions of CO_2 SOx and NOx with our patented, proven, and scalable microalgal PBR technology
- Economically shrink our clients' carbon footprint by capturing and converting CO_2 emissions into biomass
- Deploy our microalgal biosorption technology to help remove sulfur dioxide (SO_2) from smelter emissions and heavy metals from highly contaminated environments
- Develop and patent innovative new PBR designs ("hardware") and microalgal management systems ("greenware") by increasing CO_2 capture efficiency and biomass production yields to drive both CAPEX and OPEX down
- Discover, produce, and market synergistic new products derived from microalgal biomass (e.g. bioplastics, biodiesel, animal feed, spirulina, omega fatty acids, etc.)
- Leverage and grow CBC's infrastructure and expertise for economic, environmental, and social benefit

Management Team

- Andrea Irarrázaval, CEO
- Alfredo Faubel, CFO

Advisory Board

- Prof. Francisco Gracia, Ph.D., University of Chile
- Prof. Francisco De Caso, Ph.D., Principal Scientist at University of Miami
- Roberto Macedo, Technical Director at ERM CVS

Proven Technology

Microalgae synthesize proteins, lipids, and polysaccharides directly from atmospheric CO_2 and water using sunlight, are highly adaptive and are found in all freshwater and saltwater environments.

CBC's point-source Carbon BioCapture® technology is unique in that industrial gases require no pre-treatment; i.e., it works with flue gas diverted via a duct from the stack to the PBR array or "Carbon Farm".

Flue Gas Pipeline Diverting Emissions from Stack to Carbon Farm Location

Unlike other microalgae-based technologies, CBC does not use genetically modified strains. Instead, it selects naturally occurring strains and adapts them to maximize the capture of CO_2, SOx, and NOx from flue gases (or ambient air), as well as the biosorption of heavy metals present in the process water[1]. The oxygen resulting from microalgal photosynthesis is continuously released into the atmosphere.

Custom applications of CBC's technology allow specially curated and adapted microalgae strains to assimilate or bio-accumulate SO_2 and heavy metals present in the gaseous emissions of smelters, effectively acting as a biological sulfur abatement system, and complementing the chemical abatement equipment already in place at the smelter.

[1] According to the EPA, in 2015, the United States had over 735 active carbon combustion residue surface ("CCRS") impoundments, with an average area of 50 acres and depth of 20 feet. Because CCR can contain arsenic, mercury, selenium, boron, and cadmium, these impoundments must be constructed and managed in a manner to prevent potential environmental impacts from leakage or failure. ~ DE-FOA-0002190, p.13

Currently, CBC operates two point-source carbon capture pilot plants: AES's coal-burning power plant in Chile and Argos' cement plant in Colombia. The Chilean plant has been operating for over 11 years with a documented 86% CO_2 capture effectiveness. It also removes over 90% of nitrogen oxides (NOx) and 100% of sulfur oxides (SOx) from the flue gas.

AES Gener: coal-fired plant in Ventanas, Chile

Argos: cement plant in Cartagena, Colombia

The PBR is essentially a batch reactor, and its proprietary design includes thin, vertical, alveolar, acrylic panels that maximize sunlight irradiation per volume of biomass culture medium, and it's guaranteed to last for up to 20 years. At present, up to 12,600 PBR can be deployed per Hectare (Ha). A large array of PBRs is called "Carbon [Capture] Farm".

The energy requirements to operate the carbon farm are relatively low compared to other microalgae systems needing an order of magnitude more power to circulate the growth medium itself through its plug-flow tubular reactors or racetrack ponds. The 6-8 psi (.5 Bar) needed to drive the PBR (i.e., for the gases to overcome the 2m water column pressure) does not require compressors and can be reached with centrifugal blowers, requiring an estimated 500kW/ha.

The biomass is harvested periodically when the concentration reaches 15 g/L. At that point, the PBR is partially emptied and immediately replenished with the water recovered from biomass dewatering. The dewatering process can be accomplished by sedimentation and decanting, or continuously by using a dissolved air flotation ("DAF") system.[2]

The technology works with process water, freshwater, or saltwater. The wet biomass can be readily added directly to degraded soils as a bioremediation agent, or further processed into green, biodiesel, etc., or even animal feed - due to its high omega-3 fatty acid (DHA) content.[3]

[2] DAF visualization: https://youtu.be/8dJOiEyLyfg

[3] Most of the DHA in fish and multi-cellular organisms with access to cold-water oceanic foods originates from photosynthetic and heterotrophic microalgae, and becomes increasingly concentrated in organisms the further they are up the food chain. ~ Wikipedia

Business Model

There are two different applications for CBC's technology: Industrial and Urban. The first is a carbon capture as a service ("CCaaS") business model for point-source emissions, the second is a direct air capture ("DAC") form factor that removes CO_2 from outdoor or indoor ambient air[4].

CCaaS works with large-scale PBR arrays ("carbon farms") to remove a high tonnage of CO_2 from "dirty" emissions from fossil fuels such as coal, which contains 13% CO_2, pollutants like NOx, SOx, and heavy metals, or "cleaner" flue gases from natural gas combustion.

Large Scale PBR Array or "Carbon Farm"

CBC builds, owns, and operates its carbon farms to provide a cleaning (greening) service to its industrial clients: capture their CO_2 and other emissions, for a fixed capture fee proportional to the current prevailing carbon tax[5] times the number of metric tons ("MT") captured - same for SOx and NOx, etc.

Effectively, CBC can provide "carbon insurance" to protect its clients against future regulatory changes imposing a carbon tax of uncertain and growing magnitude on future CO_2 emissions, but also against increased costs of capital and higher insurance premiums.

At present, the CAPEX required to build a carbon farm is about $1,500/PBR and the annual CO_2 capture efficiency varies between 1.5 and 5 MT/PBR, depending on the CO_2 content of the flue gas and environmental conditions (sunlight, water, temperature, etc.)

[4] Outdoor ambient air contains 400 ppm CO2 but indoor air can reach 10,000 ppm.
[5] The carbon tax varies greatly by country: https://www1.compareyourcountry.org/taxing-energy

The client commits to a minimum 10-year carbon capture service contract, provides the land, builds and maintains the flue gas transfer pipeline, and supplies flue gases, water, and electricity at its expense.

The future revenue from the CCaaS contract allows CBC to fund the construction of the carbon farm. The critical factors for CBC are the agreed carbon capture fee, the price of any carbon credits, the 45Q (in the USA only), and the biomass price.

CBC owns the biomass and markets it as feedstock for either bio-fertilizer, bio-fuel, animal feed, bioplastics, etc. Alternatively, the client may purchase the dewatered biomass from CBC as a non-fossil (green) fuel at the then prevailing comparable cost of the equivalent BTU/MT.

Different microalgae strains can be grown in various parcels of the carbon farm to optimize production according to market demand and price for each of the biomass applications. The oxygen resulting from photosynthesis in the PBR is currently vented into the atmosphere and has no commercial value.

For point-source applications, CBC's technology can capture up to 1 million MT of CO_2 per year with a 20-Ha carbon farm. These parameters can be scaled up or down as needed as the technology is modular and easily scalable. The minimum viable carbon farm requires 1 Ha.

CBC's operating expenses for a carbon farm are mostly labor costs associated with managing the microalgae (the "greenware"), mineral nutrients, maintenance, and laboratory supplies. The biologists' salaries don't scale but the other expenses do.

The 45Q tax credit in the US currently allows the "owner of the carbon capture equipment" (i.e., the carbon farm) "$35 per ton of CO_2 captured and put to beneficial uses other than [Enhanced Oil Recovery]". Though the credit is for 12 years, Congress could likely extend this period in future legislation and there's intense lobbying to raise the amount to $90/MT.

CBC offers its clients the option of owning the carbon farm to take advantage of the 45Q tax credit but CBC would remain the operator of the carbon farm. This is due to confidentiality concerns for the technology: the client may acquire the hardware but not the "greenware". In this case, the carbon capture fee per MT would be reduced accordingly.

Before CBC enters into any CCaaS agreement, a "Local Microalgae Feasibility Study" and a six-month-long "Pilot Plant Trial" need to be conducted. The first serves to identify and ascertain the suitability and kinetics (growth characteristics) of the local microalgae strains found in or near the client's location. The latter serves to create enough inoculum to seed the future full-scale carbon farm, to conclusively determine the surface area required for the carbon farm to capture the desired portion of the emissions and the value of the resulting biomass.

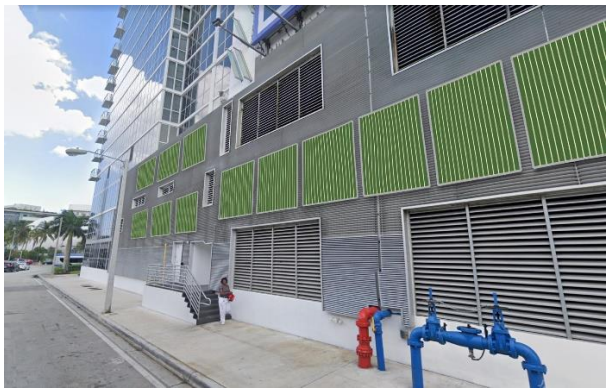
The cost of both the Feasibility Study and the Pilot Plant are initially borne by the client but then credited back by CBC upon the start of operation of the carbon farm.

Direct Air Capture for Urban Environments

The direct air capture application comes in two formats: “Urban [carbon] Capture Tree” and “exterior cladding [façade] array”; these are owned and operated by the client.

An Urban Capture Tree can remove up to 0.5 MT of CO_2 per year from a large hotel or office building. The free-standing structure requires approximately 100 sq ft of open-air space. The PBR façade array mounted on the exterior wall of a building - such as a parking garage - does not have a footprint. The biomass generated belongs to the client and can be used as fertilizer for the property’s landscaping.

Urban [Carbon] Capture Tree



Carbon Capture Façade Array