Marine AlGae Industrialization Consortium (MAGIC): carbon capture by and for algae

DOE DE-EE0007091; DE-EE0008518; DE-EE0009278

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Direct Air Capture Kickoff

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Program Overview

- **MAGIC-C - EE0008518**: Carbon Utilization Efficiency in Marine Algae Biofuel Production Systems Through Loss Minimization and Carbonate Chemistry Modification (Oct 2018 – Sept 2022; DOE: $1.5M CS: $0.4M)
- **MAGIC-ABCDE – EE0009278**: Development of high value bioproducts and enhancement of direct-air capture efficiency with a marine algae biofuel production system (*pending negotiation*: Jan 2021 – Dec 2023; DOE:$1.9M CS:$0.5M)

DAC Relevant Project Objectives

- Demonstration of CO_2 conversion and enhancement of CO_2 use efficiency
- Enhancement of natural algal uptake of CO_2 (i.e. nDAC)
- Refinement of DAC technology (towards C supply for algae biofuel)
- Increased efficiency of DAC generated CO_2 through carbon chemistry modification

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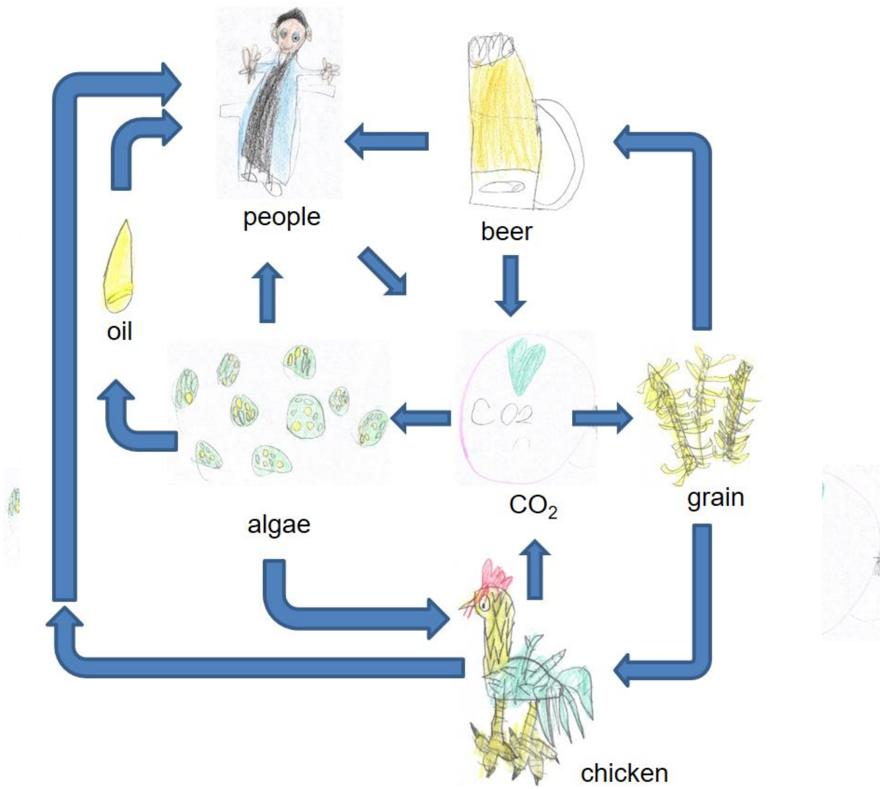
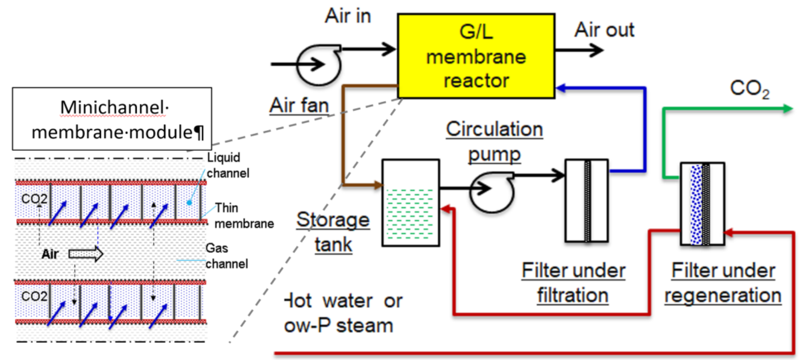
MAGIC-Circular Carbon: Technology Background





DAC innovations: (1) thin micro-porous sheets – CO_2 passes, alkaline solution does not, (2) mini-channel membrane, (3) Ni membrane to collect HCO_3 -> less P and T, less $

DAC Relevant Project Approach

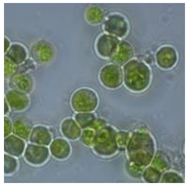
1. Convert CO_2 to bicarbonate using $CaCO_3$ for increased stability/efficiency; lower costs
2. Increase gas transfer through cultivation SA/V optimization
3. Enhance alkaline solution based DAC using with novel membranes/modules
4. Integration of DAC/converter for synergies (e.g. lower [CO_2] generation requirements)

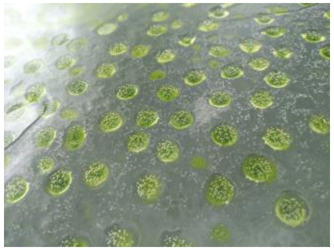
Technical approach / Project Scope

- CO_2 conversion for integration/storage (done, patent#8,828,708)
- Modeling of cultivation redesign (SA/V), ~2022 Q1
- DAC skid for 500 g/d ~2022 Q2
- CO_2 conversion integrated in DAC skid, ~2023 Q4
- DAC+CO_2 conversion used for algae, ~2024 Q3
- LCA/TEA of integrated process, ~2024 Q4

Success is:

- demonstration of nDAC for biofuel algae strain – i.e. reduced (no!) CO_2 supply for algae (i.e. biological "DAC")
- demonstrated DAC of CO_2 (at <$100/t) and conversion to other forms of stable ΣCO_2 for algae use





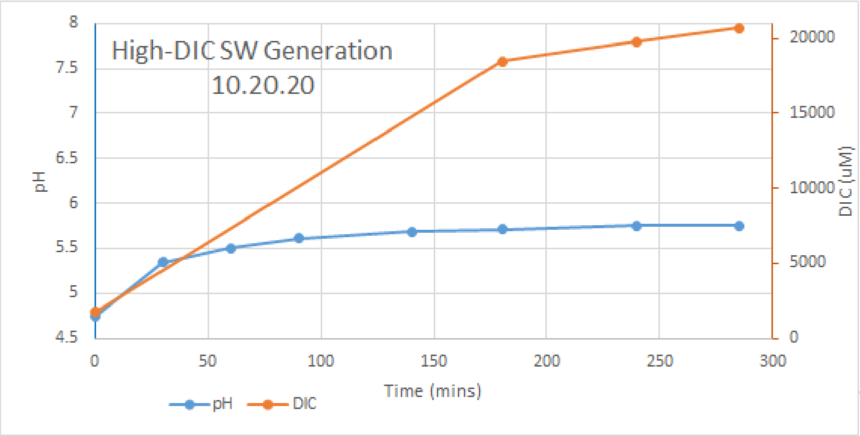
Team and Facilities

6 raceway outdoor pond facility

Team Members: algae, carbon chemistry, membrane/DAC developers (private), TEA, LCA

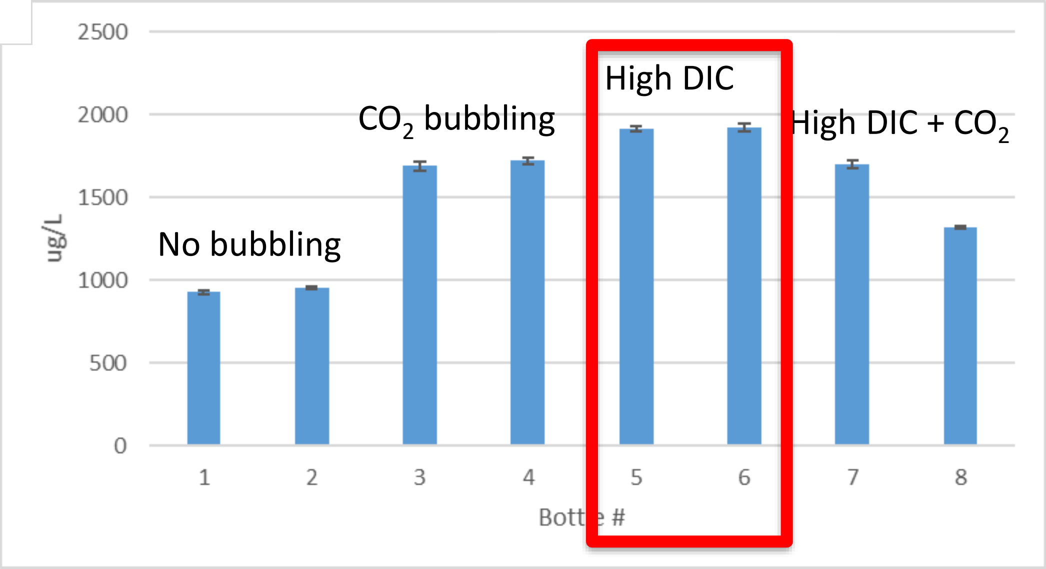
https://www.ml.duke.edu/webcam/algae/

Progress & Current Status



Generation of air stable >20mM ΣCO_2 DAC capture ☺; further optimization ongoing

At least one algae strain does better on high DIC than CO_2 bubbling (pH controlled)



Could uncouple CO_2 delivery from algae farms

Opportunities for Collaboration

Algae cultivation, harvesting, analysis facility - potential testbed for DAC CO_2 use

Advanced membrane fabrication and testing – porous metal, coated, thickness/porosity controllable, etc.

TEA/LCA for multiple CO_2 product streams

Aquatic inorganic/organic chemistry characterization/modeling

Other?

We're a team.

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