



DE-FE0032104

**Carbon Capture and Utilization for Protein
and Fatty Acids**

Global Algae Innovations

08/07/2024





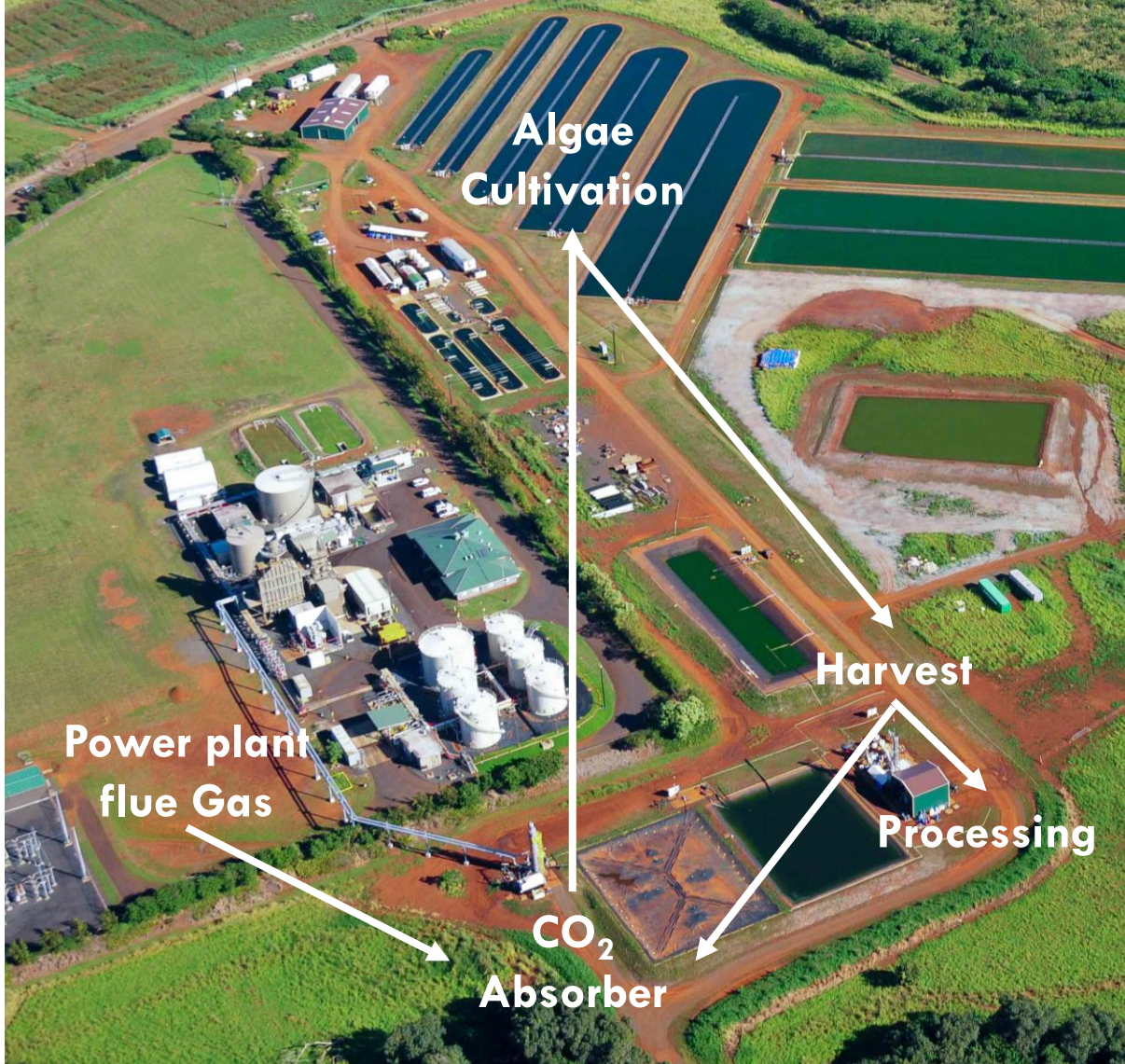
GLOBAL ALGAE

Creating an abundant & sustainable world

Founded in 2013 with the Vision to:

harness the unparalleled productivity of algae to provide food and fuel for the world, dramatically improving the environment, economy, and quality of life for all people. .

Project Summary



Consumer Products



Algae Oil



Mono unsat. ↑

Oil Fractionation

Sat. →

Jet fuel, diesel, and gasoline

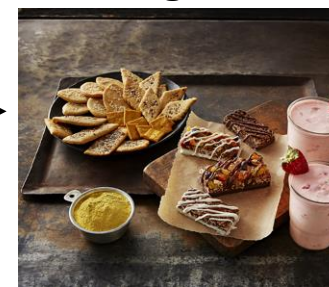


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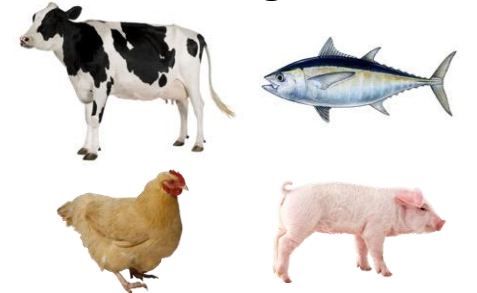
Protein Meal



Food Ingredients



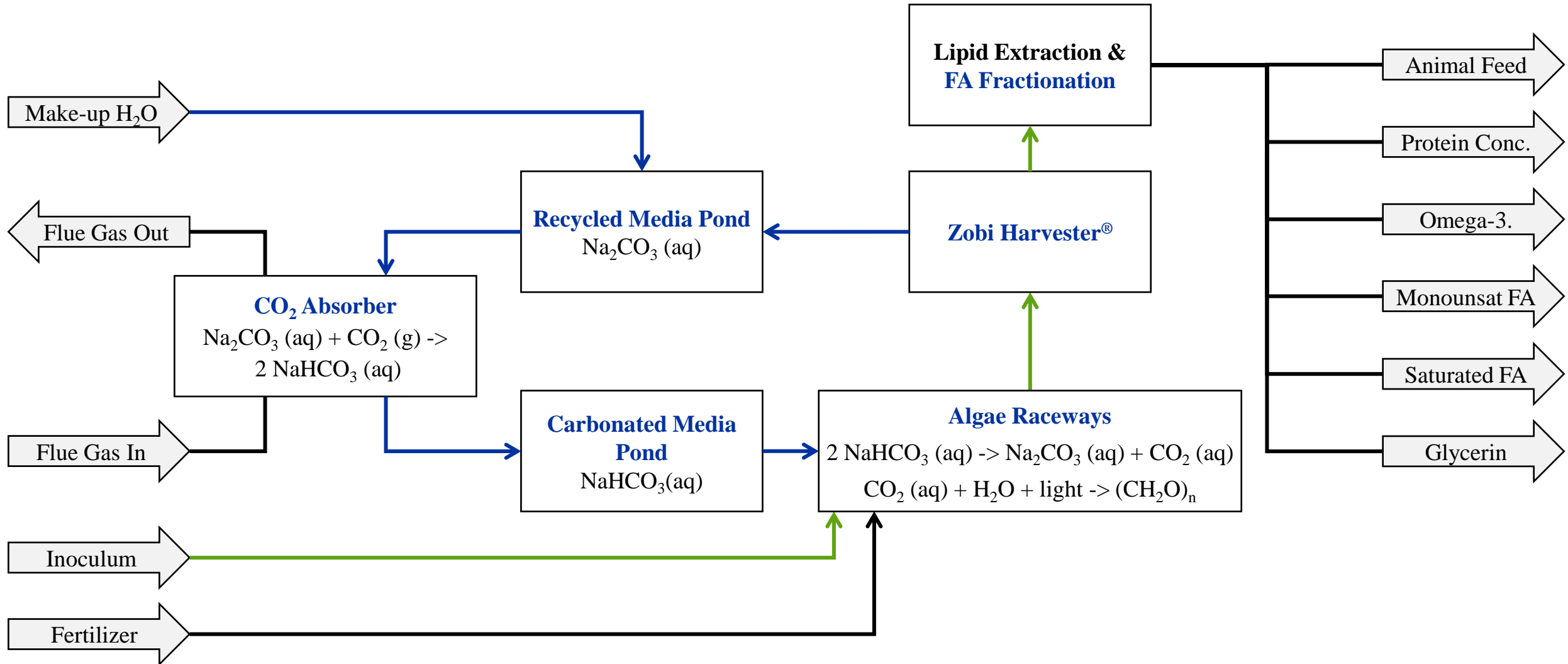
Feed Ingredients



Project Objectives

1. Complete field testing that demonstrates parameters listed in the state table for
 - a. carbon capture and utilization efficiency;
 - b. cultivation and harvesting;
 - c. extraction;
 - d. fatty acid fractionation; and
 - e. product suitability.
2. Accurately quantify economic and environmental benefits of the target products through techno-economic analyses (TEA) and life cycle analyses (LCA) informed by the field testing results that: (a) validate the net decrease in CO₂ emissions; and (b) validate required selling price for the products with a carbon price of \$0/ton.
3. Achieve a 10% **increase in peak and average algae productivity** over the baseline

Simplified Block Flow Diagram



CO₂ supply system advantages

- 24 hour per day CO₂ capture
- Storage of CO₂ to account for variable demand
- Very low energy: 2.5" water pressure drop on flue gas
- No ground level flue gas emissions, i.e., can be permitted
- Eliminates need for gas distribution or controls to raceways
- Low cost, \$25-50/ton captured, stored, and delivered to the raceways
- High capture efficiency, 70-90%
- High utilization efficiency, 90-100%

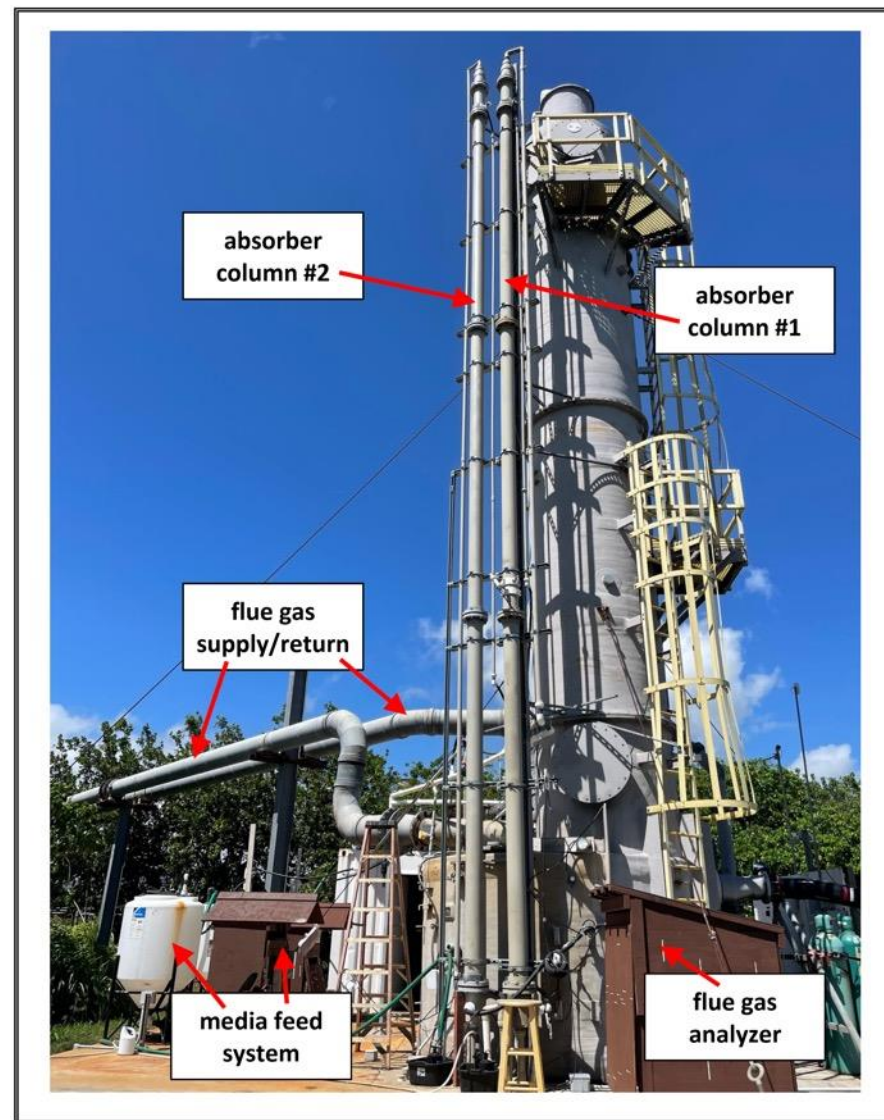


New absorber and tanks integrated into the Kauai Algae Farm



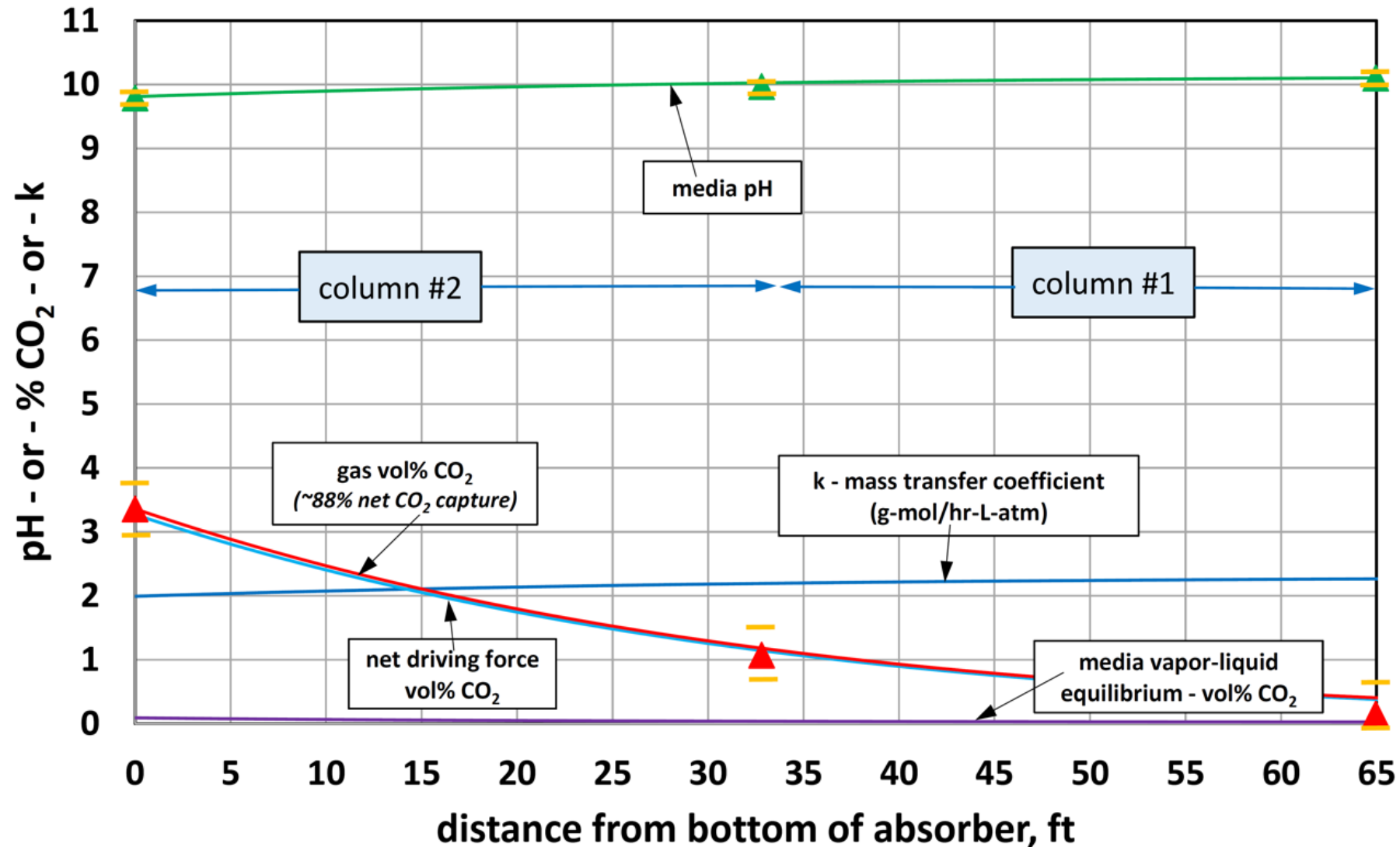
CO₂ Capture and Supply System Exceeds Targets

- Parametric study completed with flue gas for capture efficiency from flue gas slip stream
 - Consistent with process model predictions
- Integrated operation with algae cultivation
 - Completed two of four campaigns
 - 88% and 90% capture efficiency from 4% CO₂ flue gas
 - Exceeded project goal of 60% capture efficiency

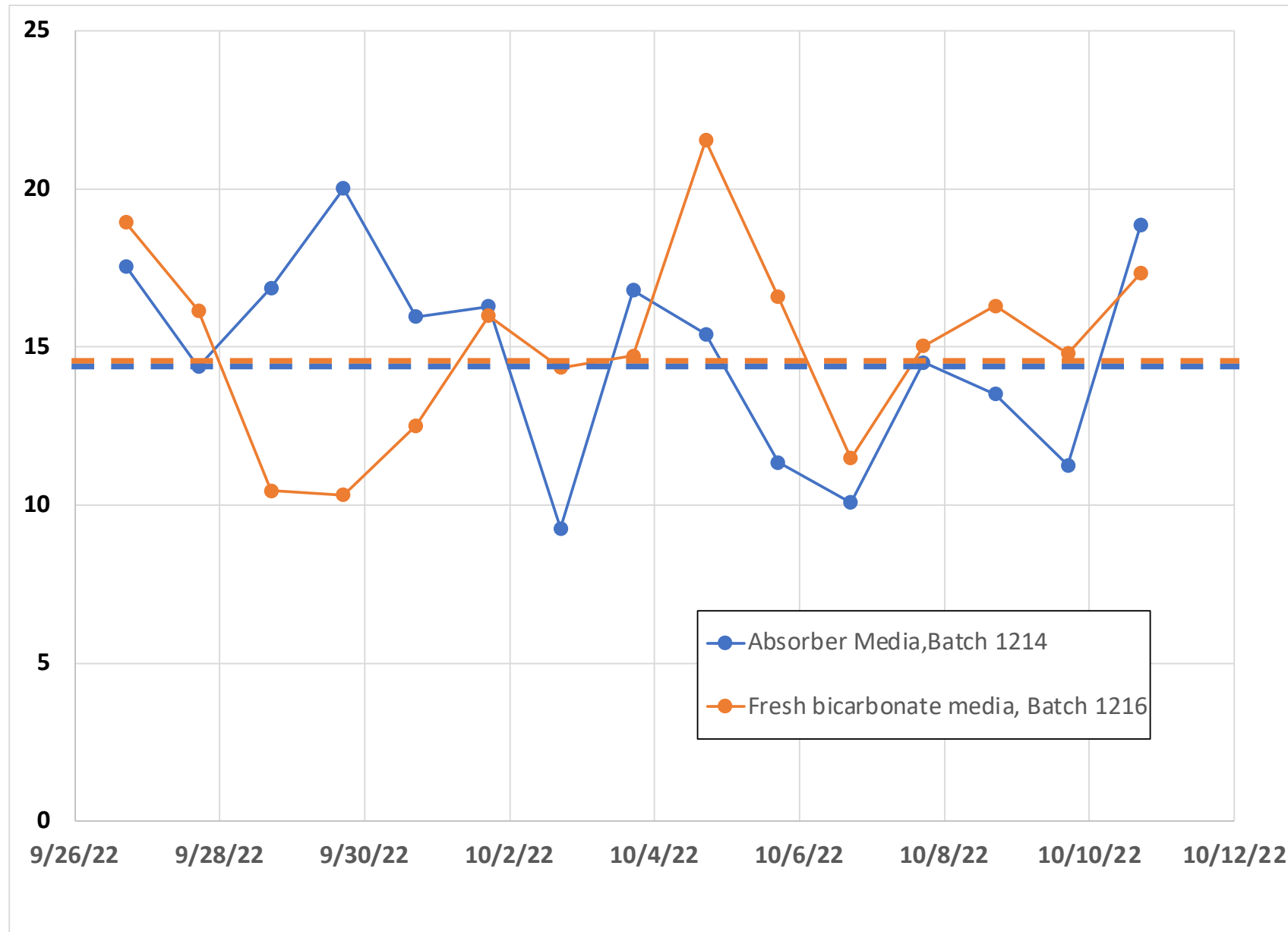


Absorber Test Results

Consistent with Process Model Predictions



Productivity is the Same with CO₂ from Fresh Bicarbonate and CO₂ Absorbed from Flue Gas



Integrated cultivation and harvesting campaigns

- Completed two of four campaigns for annual averages
- Composite productivity for growth and lipid formation phases
 - Quarter 1 2024: 17.0 g/m²d
 - Quarter 2 2024: 19.4 g/m²d
 - Exceeded project goal of 18.6 g/m²d peak productivity
 - On-track to exceed project goal of 16.6 g/m²d annual average
- Carbon utilization efficiency
 - Quarter 1 2024: 102%
 - Quarter 2 2024: 112%
 - Exceeded project goal of 100% utilization efficiency
- Harvested with Zobi harvester®



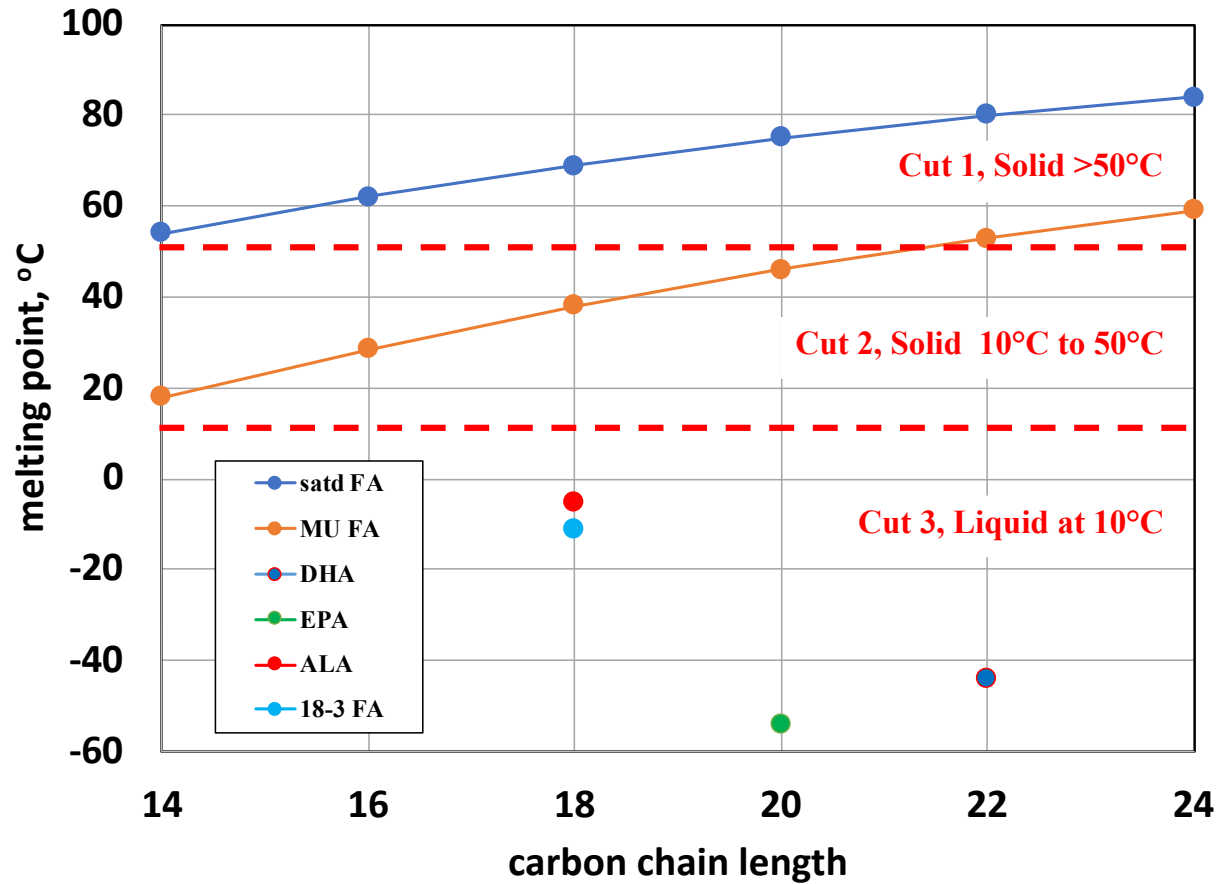
Extraction and fatty-acid separation

1. Extracted two batches, one with ethanol and one with hexane
 - Ethanol: 4.3 kg fatty acid lipids; 94% extraction efficiency relative to Soxhlet
 - Hexane: 4.2 kg fatty acid lipids; 95% extraction efficiency relative to Soxhlet
2. Subcritical water hydrolysis to convert to fatty acid
 - System verified with simulant
 - Hydrolysis of algae oil later in August
3. Distillation of fatty acids
 - To be performed at Pope Scientific
4. Omega-3 fatty acids to shrimp feed trials
5. Separate saturated and mono-unsaturated
 - Mono-unsaturated to polyurethane production
 - Saturated to sustainable aviation fuel

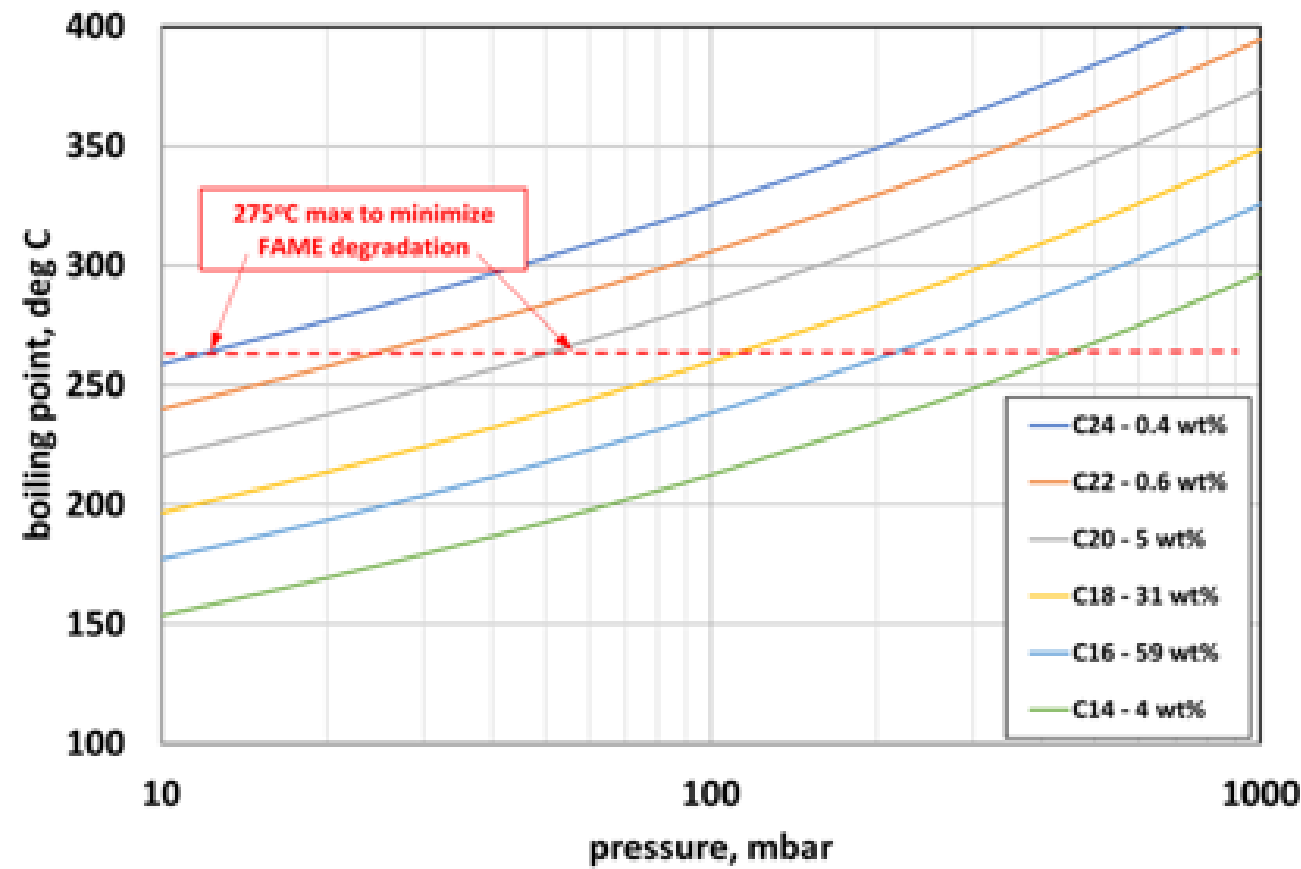


Lipid Fractionation

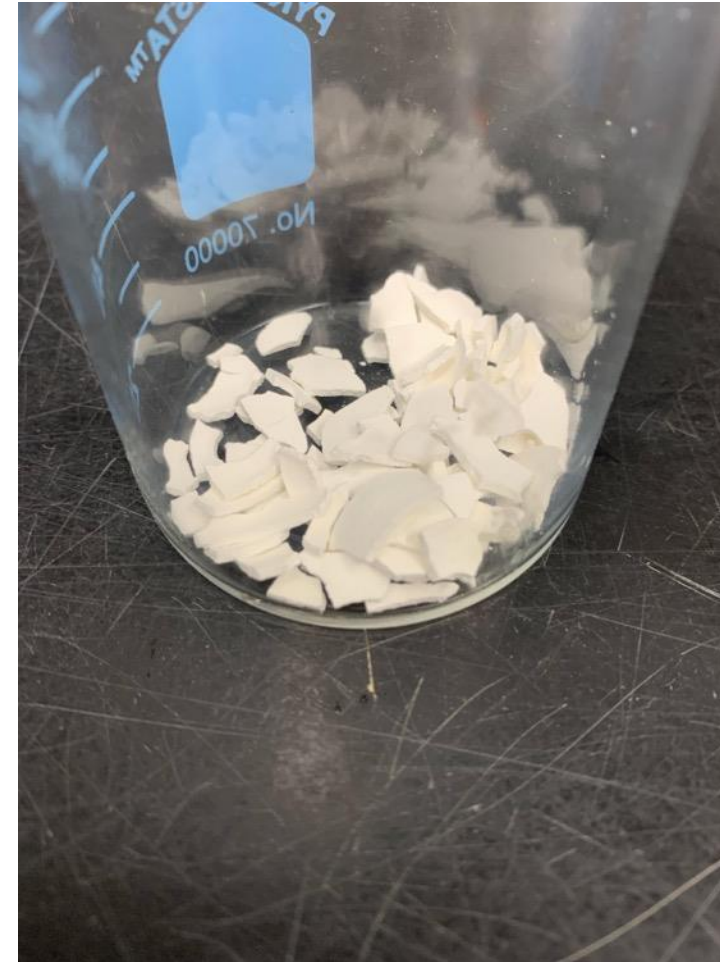
Winterization (new equipment)



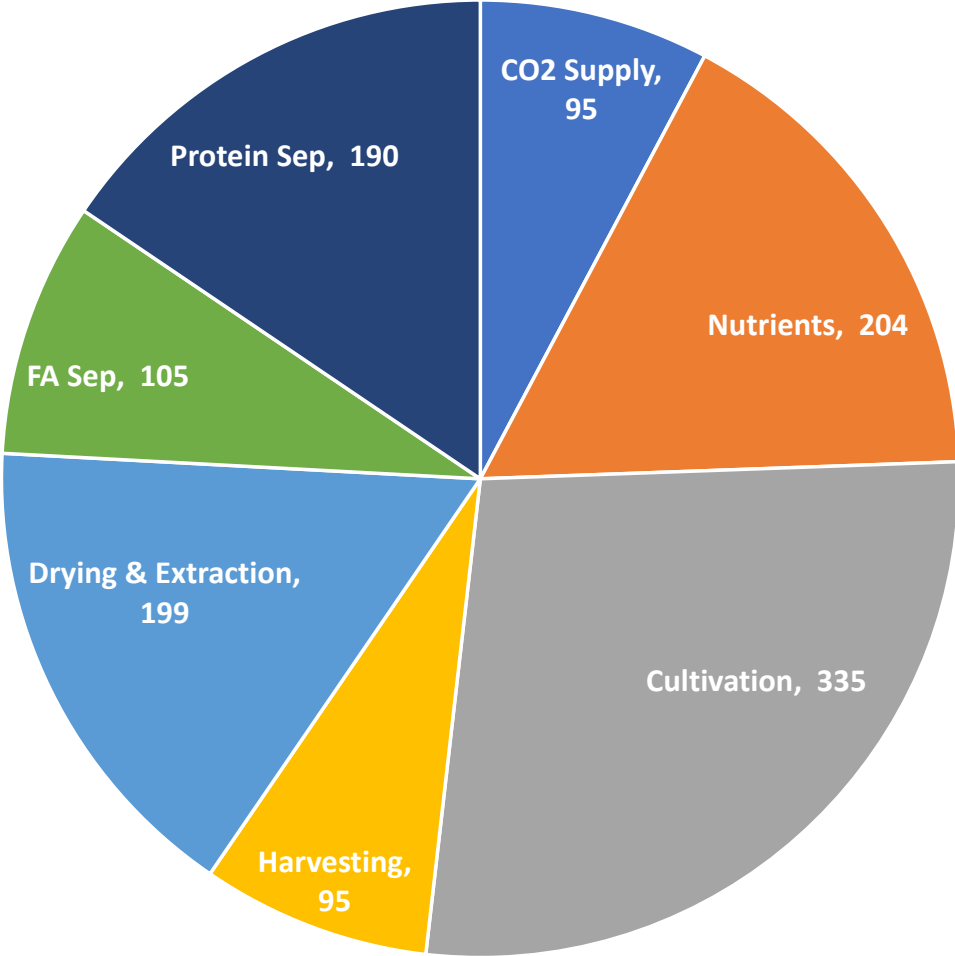
Vacuum Distillation (vendor site)



Separation Into Solid and Liquid Lipids



Costs and product values updated to 2023 \$



Product	% of AFDW	Value (\$/mt)
Protein concentrate	12%	1800
M. unsat. fatty acid	17%	2300
Sat. fatty acid	17%	1400
Omega-3	6%	4200
Glycerin	5%	1100
Protein meal	43%	570
Composite price	100%	1400

Projected cost \$1224/mt (2023\$, 8% unlevered IRR)