

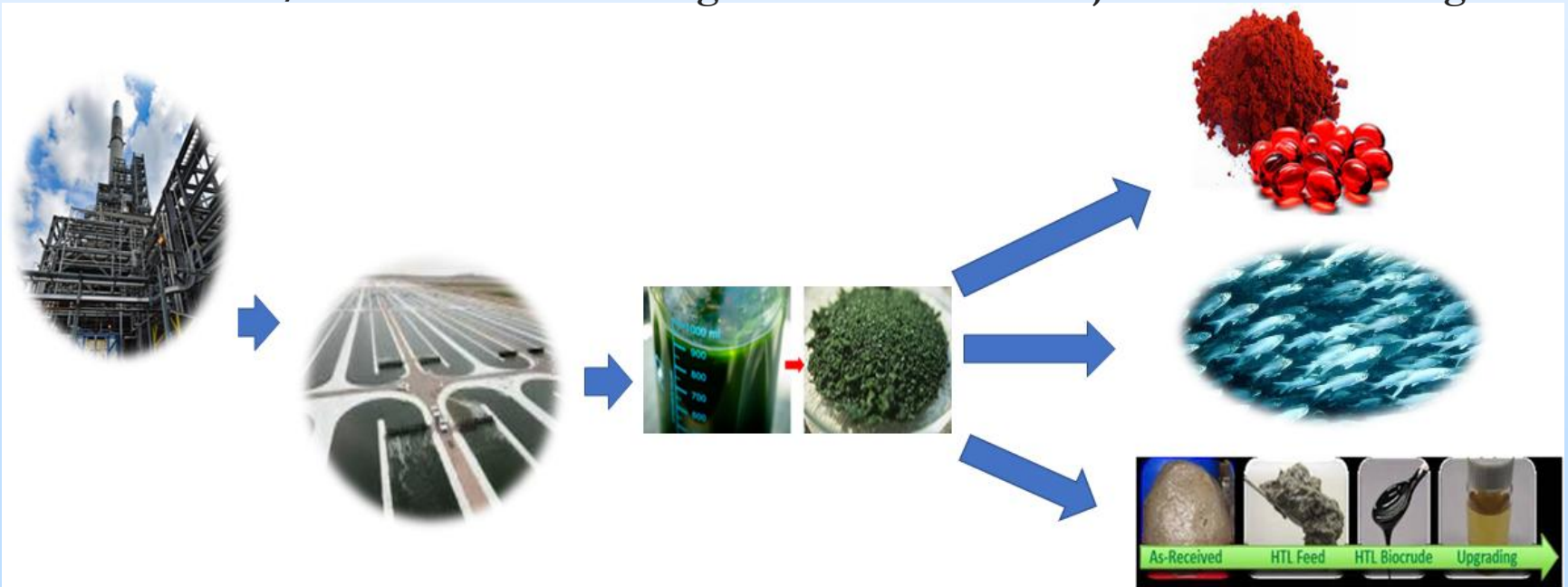
Engineering-Scale Validation of Novel Algae
CO₂ Capture and Bioproducts Technology

Award No: DE-FE-0032103

PI: Dr. Fred Harrington

NETL/DOE Federal Project Manager: Naomi O'Neil

2024 FECM/NETL Carbon Management Research Project Review Meeting



General Project Information

- **Title: Engineering-Scale Validation of Novel Algae CO₂ Capture and Bioproducts Technology**
 - Recipient: Helios-NRG, LLC
 - PI: Fred Harrington, PhD, Chief Scientist
 - Business Mgr: Jim Maloney, VP
 - DOE Federal Project Manager: Naomi O'Neil
- **Project Funding:**
 - **Total: \$2,499,030**
 - **Government Share: \$1,999,228** **Cost Share: \$499,802**
- **Project Period: 10/1/21 – 10/31/25**

Project Partners

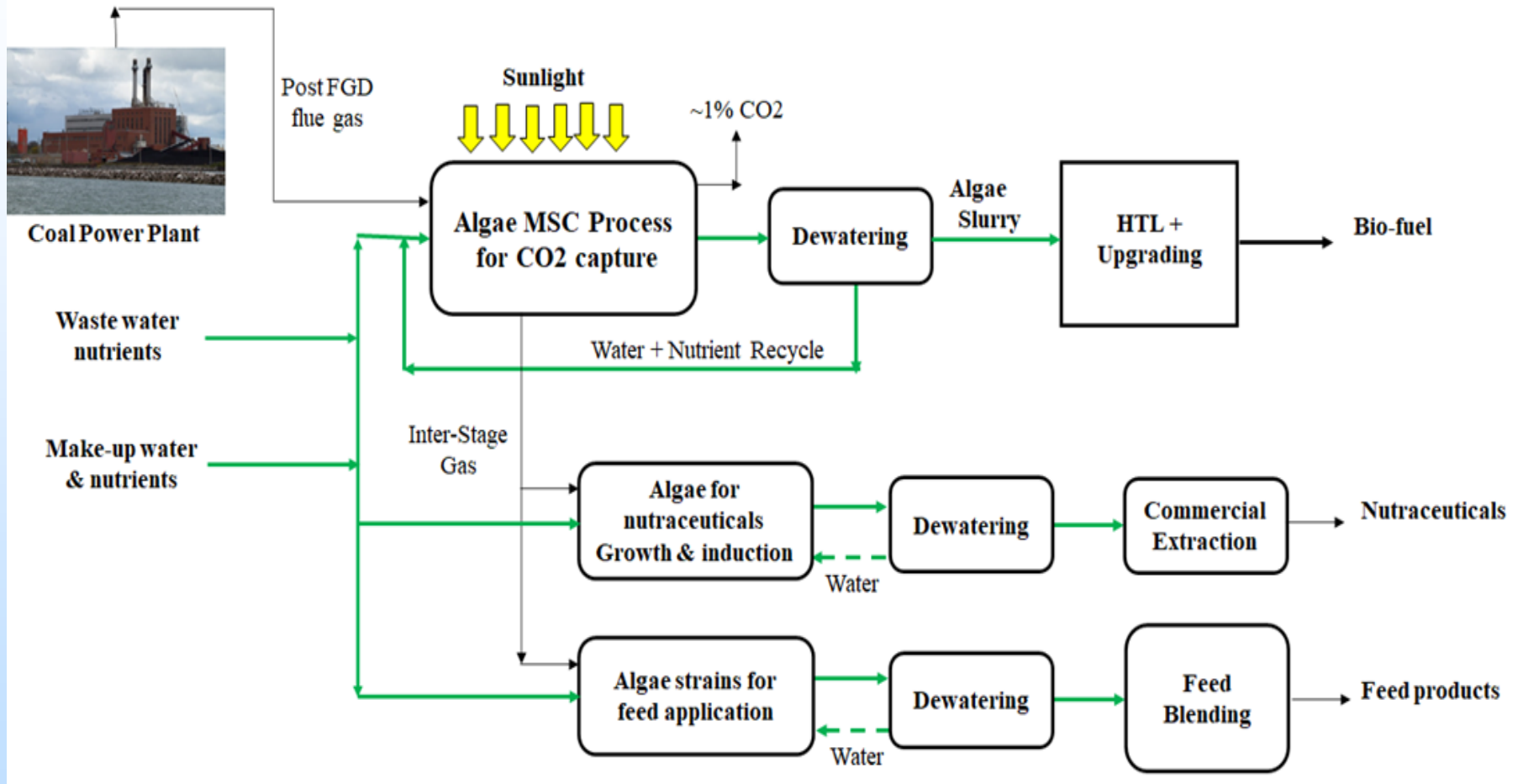
- University of Buffalo-Lin
- University of Buffalo-Bradley
- Bozeman Fish Technology Center
- The Conservation Fund - Freshwater Institute
- National Carbon Capture Center
- Craft Nutrition



Overall Strategy

- *For CO₂ capture to be economically viable, a revenue stream is required to offset cost of capture*
- **Develop algae technology for high CO₂ capture efficiency and high productivity from fossil fuel power plants**
- **Reduce capture cost via operational efficiency, wastewater credits & product revenue**

Process Schematic at Commercialization

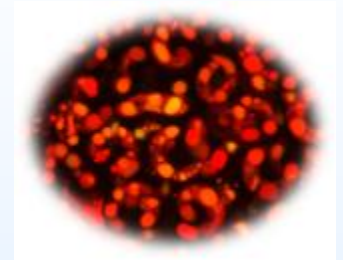


Key Advantages of the Technology

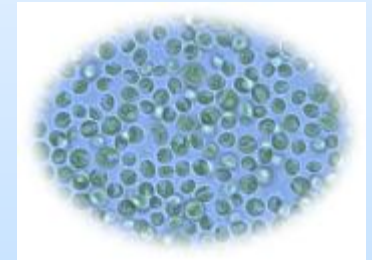
- CO₂ captured as a biomass - avoids gas sequestration
- Sustainable primary energy source (sunlight)
- Capture cost offset by revenue from products
- High productivity + capture efficiency
- Closed system minimizes contamination & water loss
- Continuous scalable process
 - Easier integration with upstream/downstream processes
 - Lower operational cost

Algae Species Selection

- **Primary criteria for CO₂ Capture**
 - High growth rates in presence of flue gas contaminants
 - Can utilize wastewater (Municipal and HTL-aqueous)
 - Adapted naturally occurring species – no GMO's
 - Prior Helios experience & well characterized
- **Capture species selected for project (H-1903)**
 - Backup species available (H-0322)
- **Species are application & product specific**



H-1903



H-0322

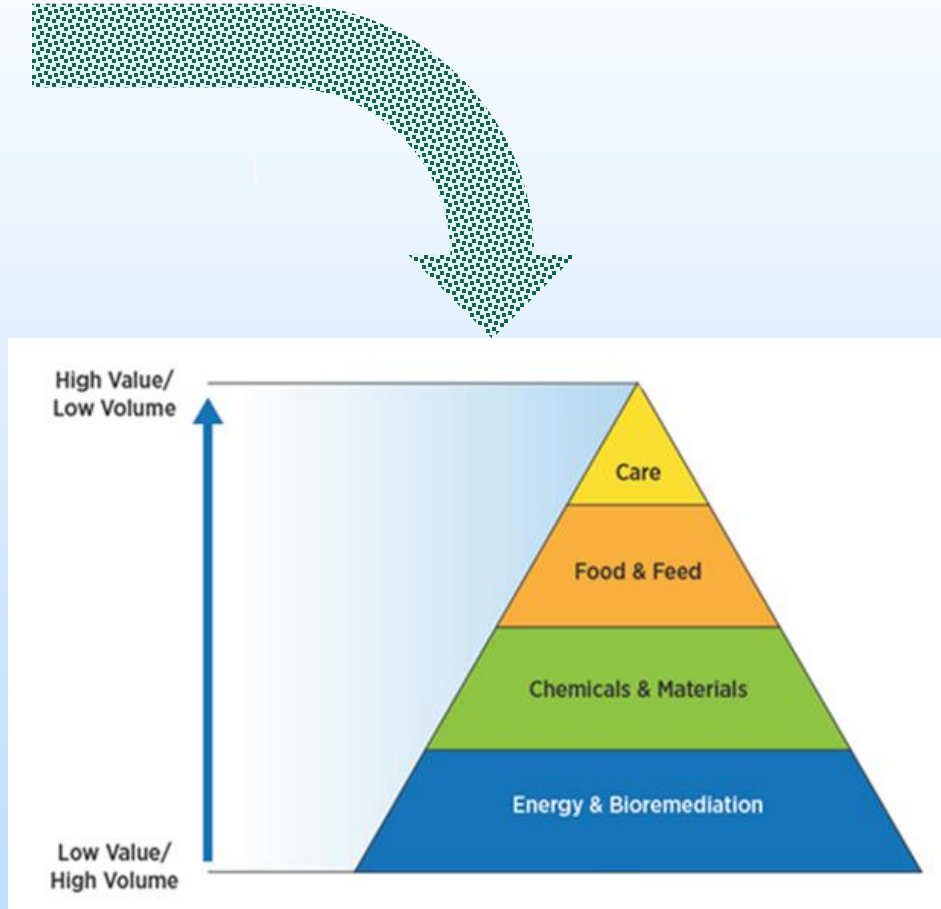
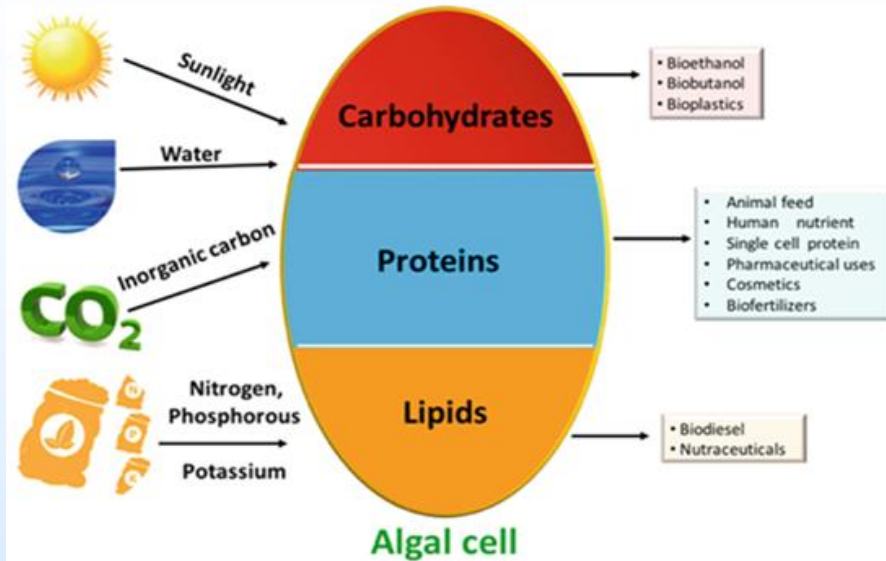
MSC process for Carbon Capture

- **Concept developed using proprietary model**
 - Predictable operation - automated control
 - Top lit closed system
 - High productivity & capture efficiency
 - Various MSC tank designs developed & tested
- **Stability demonstrated in ~100 day outdoor test**
- **MSC operation validated at NCCC test in 2022**
 - Performance exceeded project targets



Location	Sim. Flue Gas Contaminant	Nutr-WW Replacement	Normalized Algae Prod	Avg CO2 Capture
GH-1 Indoor	SOX/NOX + 5HM	50%	92%	59%
Outdoor	N/A	N/A	139%	81%
Outdoor	SOX/NOX + 5HM	80%	141%	76%
Outdoor	N/A	N/A	142%	77%
NCCC'22	NCCC SSTU Flue Gas	N/A	123%	87%

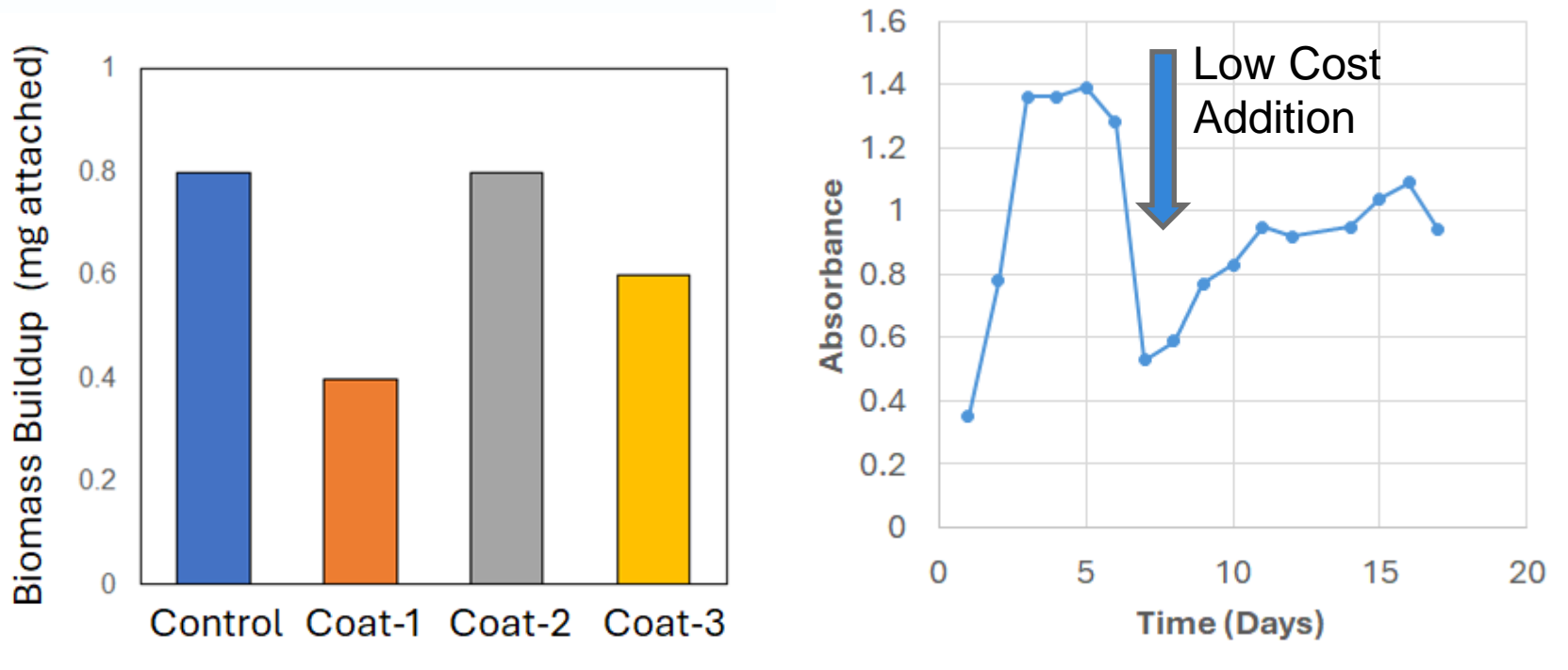
Products from Algae with Existing Markets



Primary Goals of Current Project

- **Develop 3rd Gen MSC to maximize productivity, capture eff & scalability**
 - Improved control system
 - Innovations for scaling
 - Biocontamination control
- **Advance products from algae to increase revenue potential**
 - Fish feed that utilizes valuable components
 - Additional nutraceutical compounds
- **Demonstrate performance in outdoors operation, NCCC**

Bio-contamination control strategy



- Sequencing results indicate primarily predators (e.g., amoeba, ciliates) and bacterial/fungal infection connected to biofilm build up and culture crashes
- Mitigation includes monitoring, process controls, anti-biofilm coatings and low cost chemical additions targeting specific contaminants

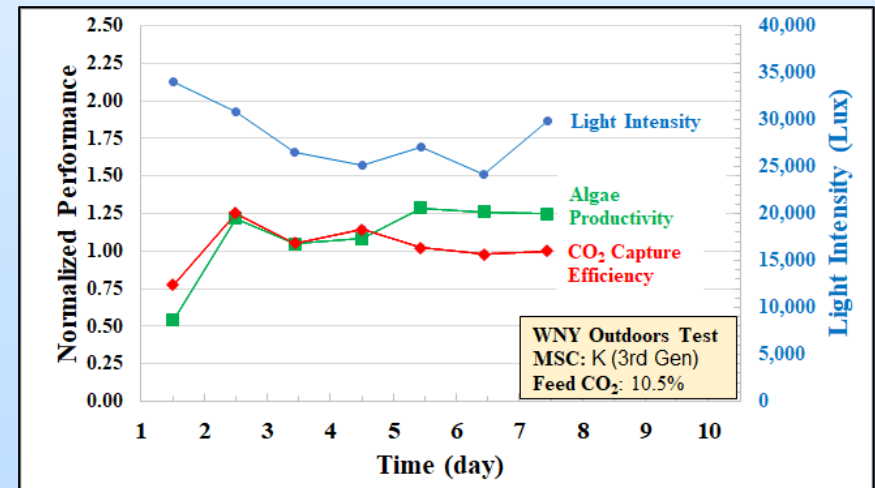
MSC operation for optimal performance

- **Improved MSC system designed & fabricated**
 - Advanced control-system built & being tested
 - Efficient culture circulation
 - Efficient gas-liquid contacting
 - Scalable, low cost seals
- **Integrated multi-stage operation demonstrated**
- **Ongoing tests to demonstrate system functionality**
 - Outdoors test performance exceeds project target

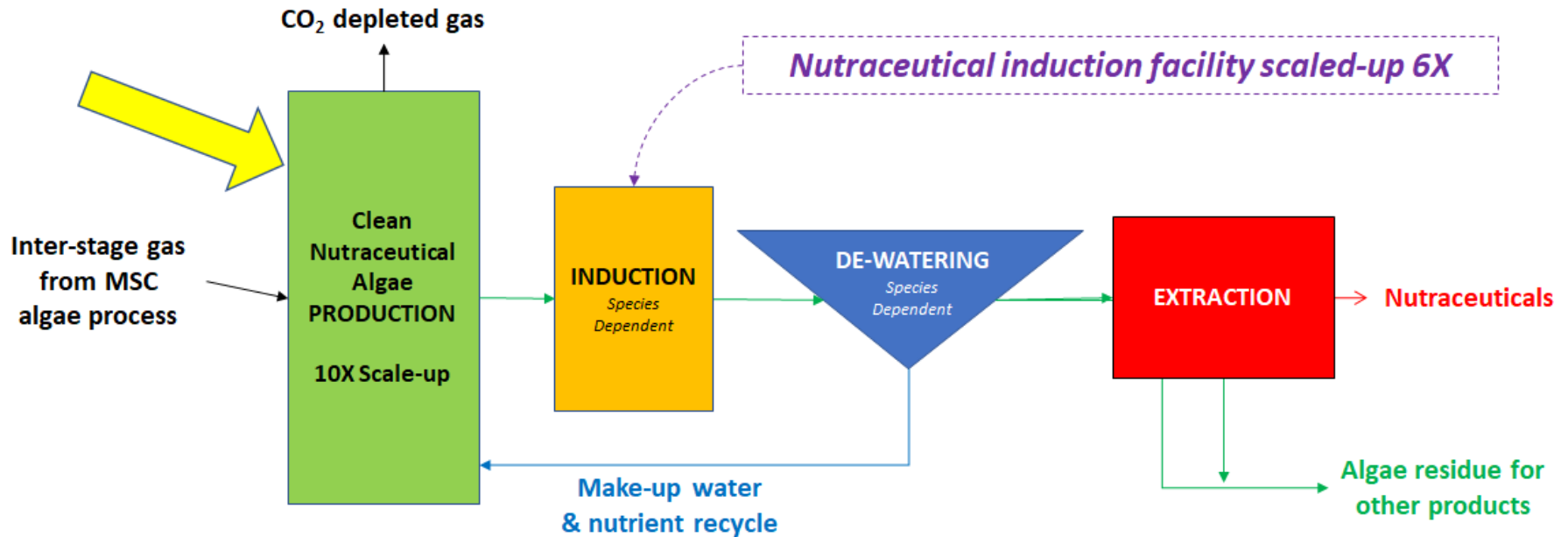
Scalable, sealed raceway design



MSC's Outdoors Performance

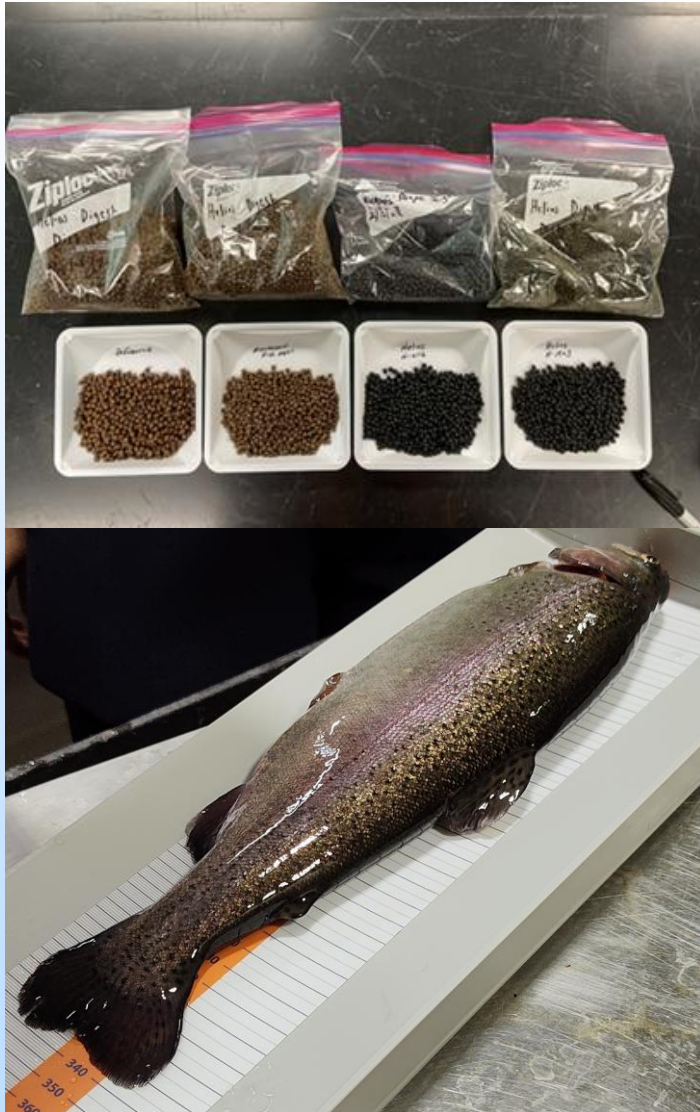


Nutraceutical Production Process



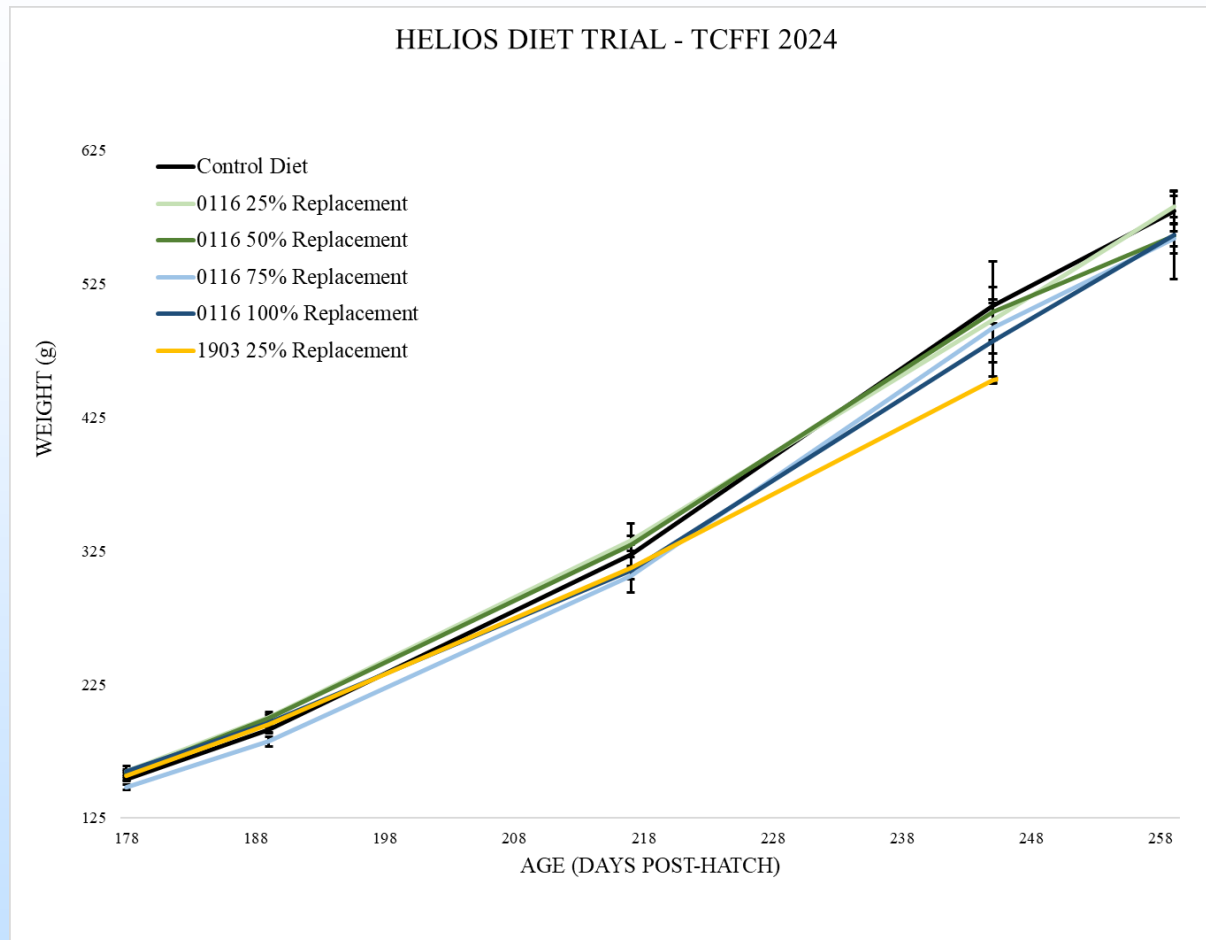
- Two nutraceutical product classes evaluated from two species of algae each
- Pathways advanced towards commercialization looking at current markets and possible future markets

Algae qualification for aquaculture feed blends



- Feed produced with variable rates of fish meal replacement with algae (0-100%) based on digestibility
- Two algae species tested H-1903 and H-0116
- Feed trial conducted in Recirculating Aquaculture System (RAS) with rainbow trout
- Fish growth and health, and the water quality of the RAS monitored over feeding experiment

Algae qualification for aquaculture feed blends



- Fish fed feed with 25 – 100% algae replacement of fish meal grew at similar rates to control

Work In Progress

- **Protocols for biocontamination control & mitigation**
- **Validate improved MSC operation outdoors; NCCC**
- **Advance nutraceutical production towards commercialization**
- **Complete analysis of RAS fish feed study**
- **Perform LCA and TEA**

Plans for future testing/development/ commercialization

- **Implement dynamic process control**
- **Develop in-ground-MSR systems**
- **Implement biocontamination control**
- **Integrate MSR with de-watering and operate with high water/nutrient recycle**
- **Utilize municipal wastewater to replace purchased nutrients - cost reduction + remediation credits**

Summary

Demonstration of:

- **Outdoors testing of MSC dynamic control**
- **Improved bio-contaminant control**
- **Value of nutraceutical products at commercialization**
- **Algae can replace non-sustainable components of fish feed**

Thanks to DOE, NETL and our Partners

Acknowledgement

This material is based upon work supported by the Department of Energy under Award Number DE-FE-0032103.

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