

Advanced, Low-Cost, System for Algae Dewatering

Ashok Damle
Techverse, Inc.

Poster presentation
Algae Biomass Summit
October 24-26, 2016



U.S. DOE SBIR Phase II Project

- Project Duration – August 1, 2016 – July 31, 2018
- Project Partners -

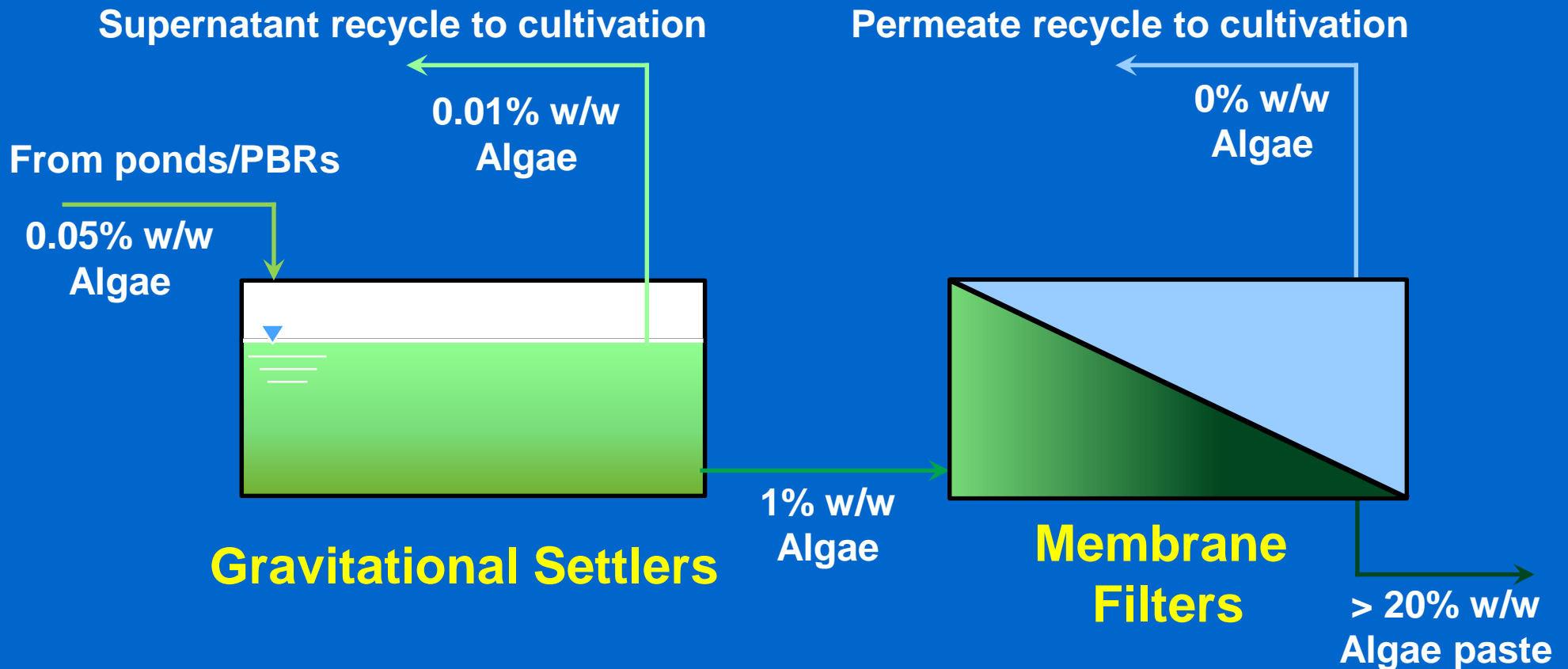
Techverse, Inc.
Advancing Energy Technologies



Phase II Project Objectives

- Develop a two-stage algae dewatering system for >20 % w/w algae paste from 0.05% w/w algae feed
- Achieve >30% capital cost reduction and >20% energy reduction compared to DAF/centrifuge
- Demonstrate concentration of 1% w/w algae to >20% w/w paste in a continuous membrane process
- Develop methodology for algae pre-concentration by gravitational settling (<0.05% w/w algae to >1% w/w)
- Different algae species of interest – Chlorella, Nanno.

Proposed Algae Dewatering Process

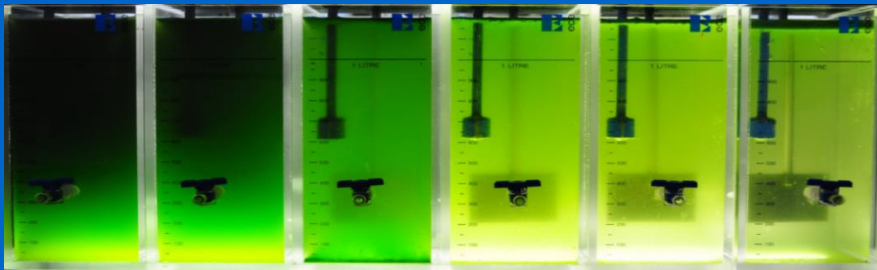


Phase II Project work Plan

- Task 1 - Gravitational settling studies (AzCATI)
- Task 2 – Design/Fabricate a 3-stage membrane dewatering skid to process 100 L/hr of 1% w/w algae feed to produce 5 L/hr of >20% w/w algae paste. (SmartFlow/Techverse)
- Task 3 – Skid Testing at AzCATI with 1% w/w pre-concentrated algae from raceway ponds at AzCATI. (Techverse/AzCATI)
- Task 4 – (Year 2) Skid Testing at AFS BioOil with 1% w/w pre-concentrated algae from PBRs at AFS BioOil. (Techverse/AFS)
- Task 5 - Process design for large algae flow rates with lowest possible cost as well as energy use (Techverse/SmartFlow)
- Task 6 - Techno-economic analysis (Techverse lead)

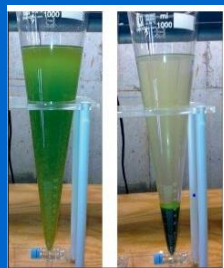
Task 1 Gravitational Settling Studies

- Bench-scale screening for settling studies will be conducted with a jar testing apparatus similar to that shown below and different algae/conditions can be evaluated for flocculation/settling behavior.

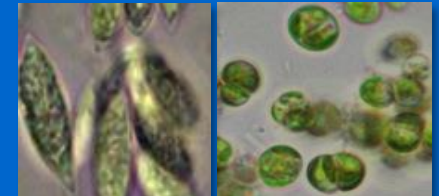


- In addition, standard settling velocity will be evaluated with simple settling testing using an Imhoff cone, in particular looking at total suspended and settled solids as a function of time.

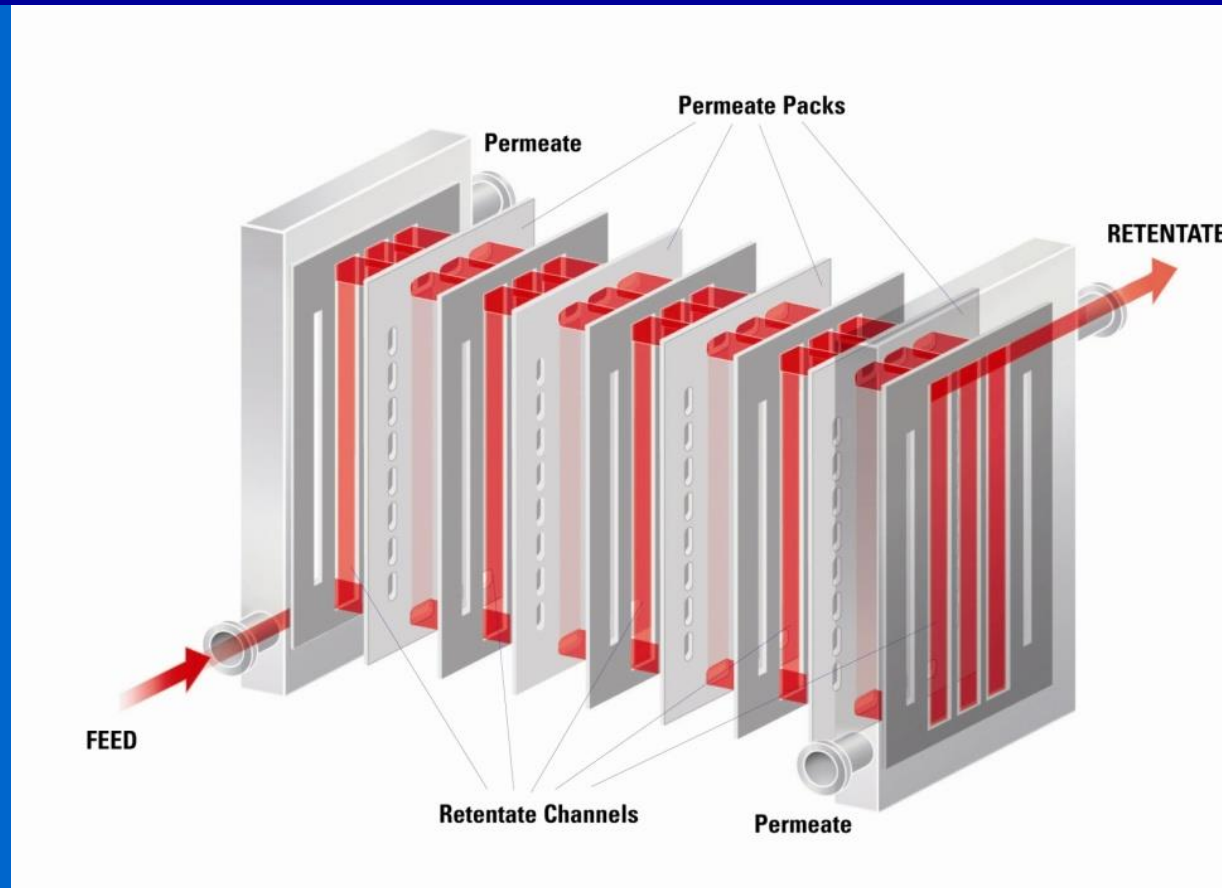
Imhoff cones



- Primary algae strains of interest for the bench-scale testing will include commercially relevant algae species and include:
 - *Scenedesmus* sp.
 - *Chlorella* sp.
 - *Nannochloropsis* sp.
 - *Desmodesmus* sp.
- Range of cultivation/physical parameters will be explored that are known to affect settling behavior:
 - Freshwater or marine
 - Different size/shape algae (some natural settlers)
 - Auto-flocculation vs. coagulants
 - Nutrient replete vs. deplete (i.e., stressed) algae cultivation
- Develop general methodology for algae pre-concentration by gravitational settling (<0.05% w/w algae to >1% w/w algae concentrate)



SmartFlow's Patented "Open Channel" Membrane Module Technology



<http://www.smartflow-tech-biofuels.com/consepadvancedsolutions.html>

Advantages of SmartFlow Membrane Module

- Uniform flow pattern throughout the membrane module
 - Utilizes 100% of membrane surface area
- Equal fluid path length in all flow channels - Equal flow resistance
 - Avoids channeling and dead spots
- Uniform flow velocity over all of the membrane surfaces
 - Creates equal shear at all locations
 - Avoids deposits and fouling prone areas
- Patented rib design - uniform retentate channels (no porous spacer)
 - Easily handles fluids with high solids content, high viscosity
 - Allows producing high solids content algae concentrates

Task 2 – Membrane Algae Dewatering Skid



To be tested at AzCATI soon

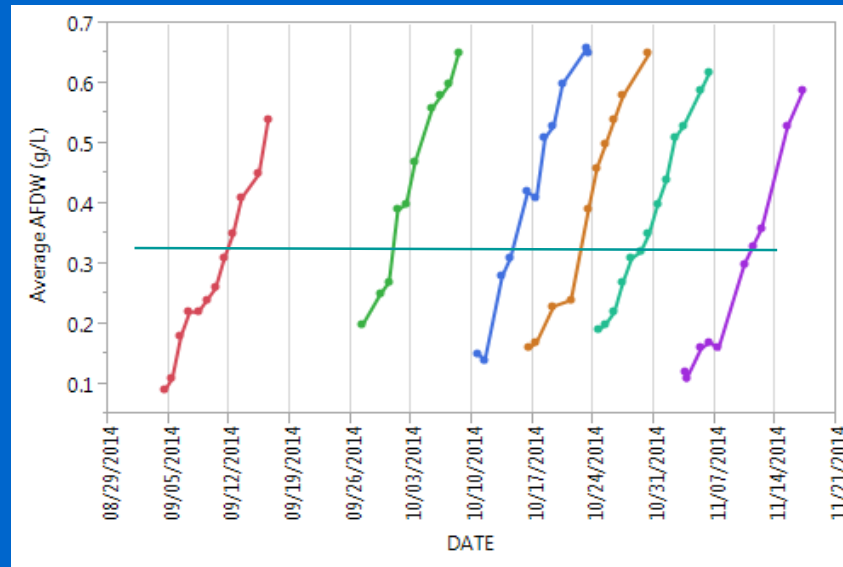
- Feed rate - 100 L/h
- Feed conc. - 1% w/w
- Continuous dewatering
- Concentrate - 5 L/h
- Product - >20% w/w
- # of stages – 3
- Total membrane area
 - 3.6 m²



Task 3: Skid Testing at AzCATI



Twin 60 m² raceways with a culture volume 15 m³ per pond will be used for algae cultivation scale up for skid testing of the Techverse/SmartFlow membrane filtration pilot.

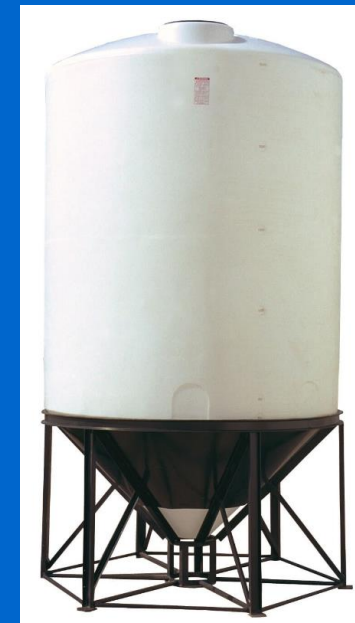


Typical growth curves (fall season) for *Nannochloropsis* sp. cultivation in 60 m² raceways at AzCATI.

- Target culture density at harvest: minimum of 0.5 g/L (0.05% w/w)
- Ponds will be operated in “semi-batch” mode
- 20 m³ of culture volume from duplicate raceways (10 m³ per pond) will be harvested, combined, and pre-concentrated using membrane filtration to a final volume of 1 m³ at 1% w/w.
- Pilot trials will be conducted on the Techverse/SmartFlow pilot skid using the 1% w/w conc.
- Up to 4 strains/conditions will be tested at the pilot scale

Task 3: Skid Testing at AzCATI

- For pilot studies, membrane filtration will be used as proxy to achieve 1 wt % target for pilot testing (1000L of culture volume)
 - If appropriate conditions identified, pilot trials with one or more algae pre-concentrated through gravitational settling may be run through the Techverse/SmartFlow pilot to simulate target large scale 2 stage dewatering.
 - AzCATI has large settling tanks suitable for this task



Phase I – Single stage systems



Front view

Side view

Lab-scale system – 0.1 m² module



Field System
0.8 m² module



Photos of Algae Paste Discharge – Phase I



Videos of Algae Concentration and Paste

- https://youtu.be/_U-xKDeyiko - Algix pond algae – Phase I
- <https://youtu.be/pT4-PAnftkA> - AFS BioOil PBR – Phase I
- <https://youtu.be/DKz1HzP6zgc> - Marine Algae – Phase I
- <https://youtu.be/nry1FInEXkU> - Marine Algae – Phase I
- <https://youtu.be/bzwTvuJNB6o> - Chlorella Algae – from DAF
- <http://youtu.be/RjjRTH2hDjM> - Chlorella Algae – from PBRs
- <http://youtu.be/O1tf8RM1VbE> - Fermented Algae
- <https://www.youtube.com/watch?v=phIJDQZ86sk> Tomato Juice
- <http://youtu.be/fO2SwWbLt6k> - Potato starch

More information? Questions?

Contact:

Dr. Ashok Damle

Techverse, Inc.

919-454-8461

techverse@hotmail.com