Hydrogen from Microalgae

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Background

- Collaboration with the Federal University of Parana (UFPR)
- Continuation from the 2012 and 2013 senior design projects
- 2012:
  - Optimize amount of algae to be extracted from a PBR
  - Algae and CO_2 concentrations
  - Mass flow
- 2013:
  - Design a continuous PBR
  - Addition/Extraction Units

Objectives

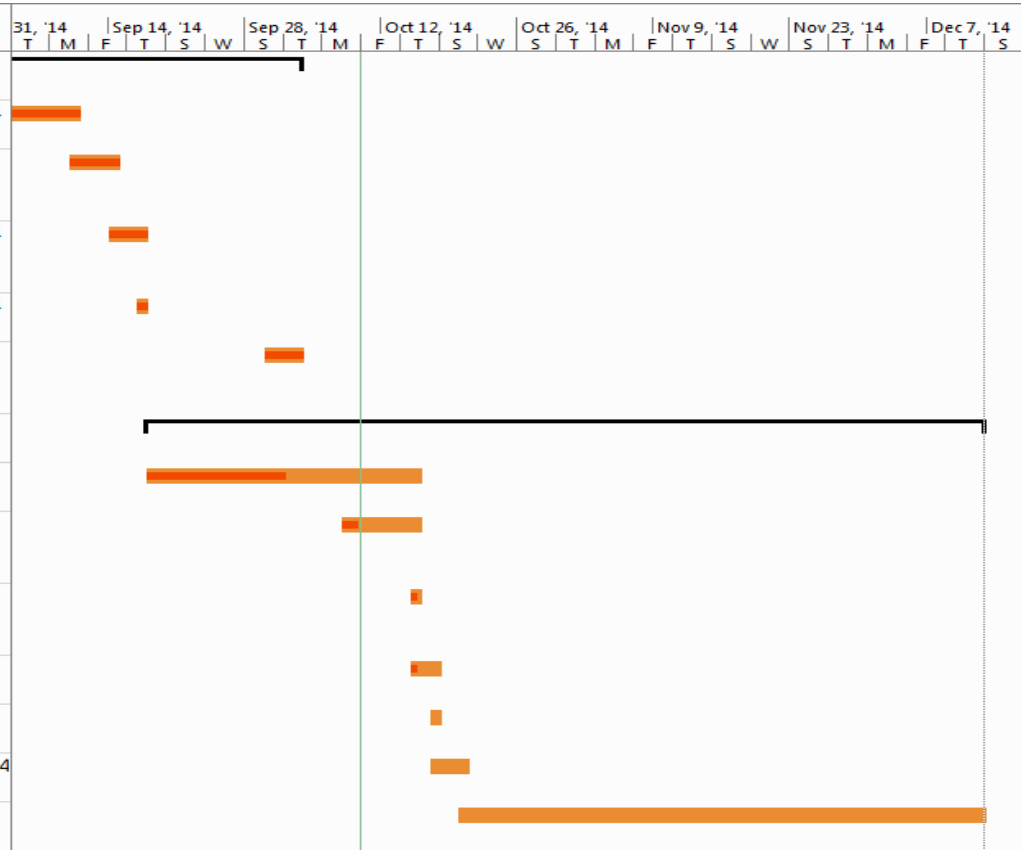
- Hydrogen, H_2 , producing photobioreactor system
- Electronic H_2 mass measuring sensor
- Produce enough biofuel to be tested
- Drawings of bioreactor and sensor design
- Invention disclosure (U.S.) and patent (Brazil)

Potential Challenges

- Appropriate bioreactor
- Sustainment of cultivation and productivity of algae
- Reduction of cell damage to microalgae
- Product and fabrication costs
- Maintenance
- Expansion to an industrial sized scale

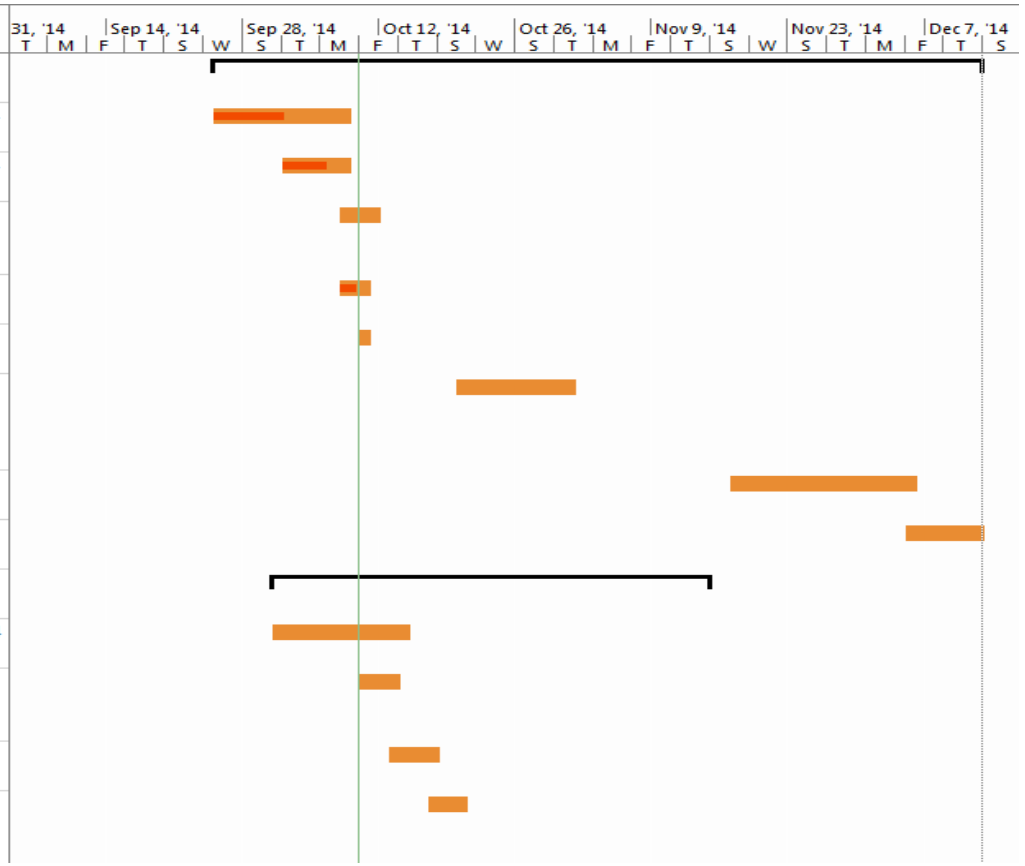
Gantt Chart

ID	Task Mode	Task Name	Duration	Start	Finish
2		**Initial Planning**	**22 days**	**Thu 9/4/14**	**Fri 10/3/14**
3		Development of Project Goals	5 days	Thu 9/4/14	Wed 9/10/14
4		Development of Project Responsibilities	3 days	Wed 9/10/14	Sun 9/14/14
5		Assignment t of Project Responsibilities	3 days	Sun 9/14/14	Wed 9/17/14
6		Sponsor Meeting	1 day	Wed 9/17/14	Wed 9/17/14
7		Development of Project Methodology	4 days	Tue 9/30/14	Fri 10/3/14
8		**Microalgae Growth**	**62 days**	**Thu 9/18/14**	**Fri 12/12/14**
9		Algae Growth Research	20 days	Thu 9/18/14	Wed 10/15/14
10		Evaluation of Equipment Needed	6 days	Wed 10/8/14	Wed 10/15/14
11		Evaluation of Equipment Available	1 day	Wed 10/15/14	Wed 10/15/14
12		Cost Analysis	3 days	Wed 10/15/14	Fri 10/17/14
13		Work Order for Supplies	1 day	Fri 10/17/14	Fri 10/17/14
14		Microalgae Set U	2 days	Fri 10/17/14	Mon 10/20/14
15		Growth Maintenance	40 days	Mon 10/20/14	Fri 12/12/14



Gantt Chart continued...

ID	Task Mode	Task Name	Duration	Start	Finish
16		**Hydrogen Sensor Development**	**57 days**	**Thu 9/25/14**	**Fri 12/12/14**
17		Hydrogen Sensor Research	10 days	Thu 9/25/14	Wed 10/8/14
18		Sensor Design Development	5 days	Thu 10/2/14	Wed 10/8/14
19		Evaluation of Equipment Needed	3 days	Wed 10/8/14	Sat 10/11/14
20		Cost Analysis	3 days	Wed 10/8/14	Fri 10/10/14
21		Work Order for Parts	1 day	Fri 10/10/14	Fri 10/10/14
22		Sensor Development/ Reprogramming/ Calibration	10 days	Mon 10/20/14	Fri 10/31/14
23		Sensor Testing	15 days	Mon 11/17/14	Fri 12/5/14
24		Testing Anaylis	6 days	Fri 12/5/14	Fri 12/12/14
25		**Photobioreactor Development**	**33 days**	**Wed 10/1/14**	**Fri 11/14/14**
26		Photobioreactor Research	10 days	Wed 10/1/14	Tue 10/14/14
27		Evaluation of Current Bioreactor	2 days	Fri 10/10/14	Mon 10/13/14
28		Development of Modifications	5 days	Mon 10/13/14	Fri 10/17/14
29		Evaluation of Equiptment Needed	2 days	Fri 10/17/14	Mon 10/20/14

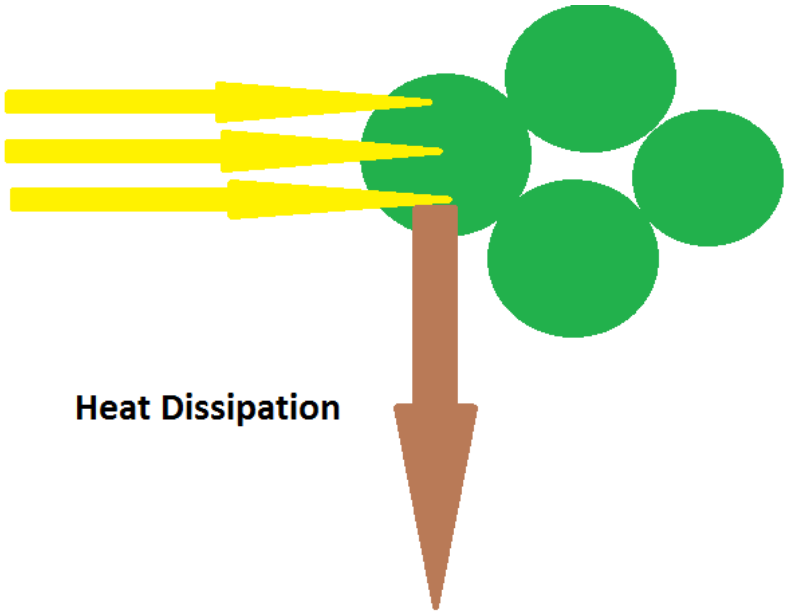


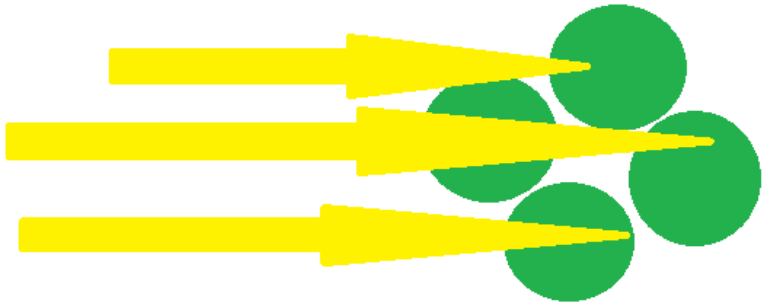
Microalgae for Biofuel

- Rapid growth rates
- High oil content
- Require raw materials that are abundant
- Grow in adverse conditions
- Efficient energy converters

Algae Species

- Chlamydomonas reinhardtii (strain CC-125)
  - Mutant Strains (CC-4170)
  - Increased H_2 Production
- Scenedesmus sp.





Growth Mediums

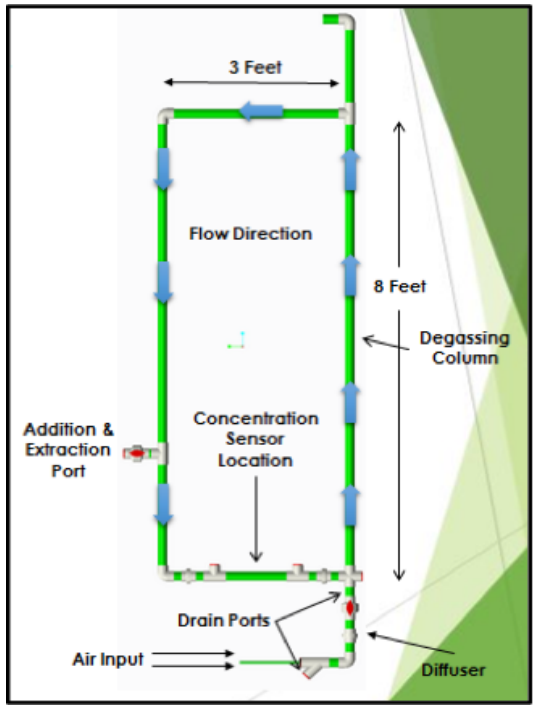
- Copper Enriched and Sulfur deprived
- Both have similar effects on algae
  - Block creation of enzymes
  - No photosynthesis without enzymes
  - Anaerobic environment promotes H_2 production
- Cu best at producing H_2 continuously

Open Ponds vs. Photobioreactors

- Open Ponds
  - Contamination
  - Limited locations available
  - Light limitation
  - Cheap
  - Fouling
- Photobioreactor
  - Control environment
  - Minimal contamination
  - Can be used anywhere
  - Expensive

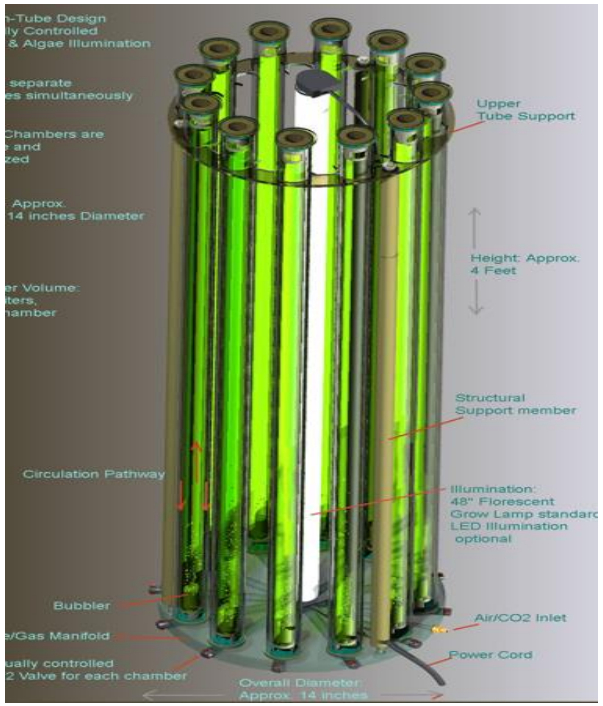
Photobioreactor

- PBRs are used to control growth environment of algae
- Basic components include:
  - Housing Container
  - CO2 Supply
  - Light Source
- Various types of PBRs in use today include:
  - Tubular Systems
  - Airlift or Bubble Systems
  - Raceway Ponds
- Previous senior design team chose to use an airlift system
- System could be used by us to measure hydrogen output



Design Concept

Chamber PBR



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Straight-Line PBR

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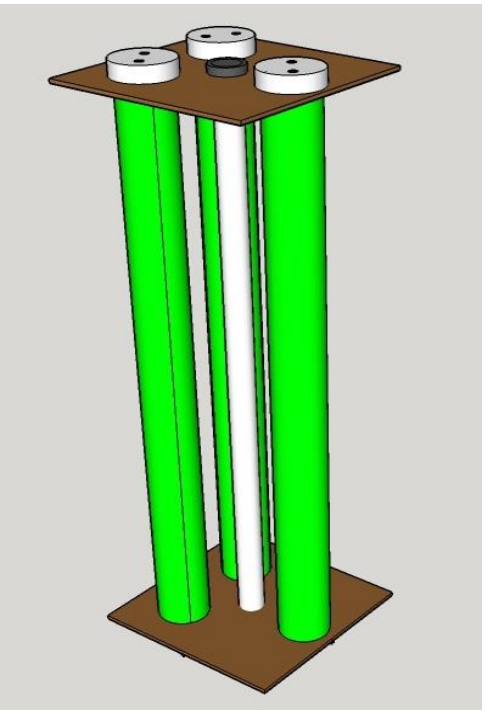


Group 9

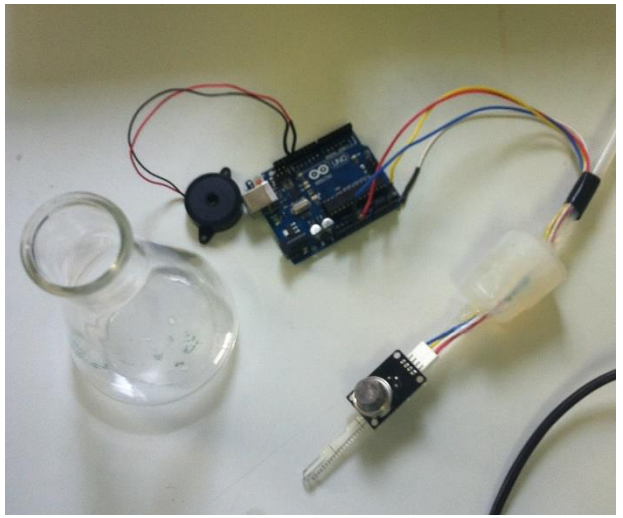
Jonatan Elfi

Hydrogen Sensor

- Sensors are commercially available
- Various Modes of operation:
  - Palladium Sensors
  - MOS Sensors
  - Infrared Sensor
- Cost varies according to type
- Advantages:
  - Digital readout
  - Accuracy
  - Calibration

Hydrogen Sensor

- Team in Brazil has been working on the sensor
- Main components include:
  - MQ - 4 Gas Sensor (MOS)
  - Anduino Uno Board
- Advantages:
  - Inexpensive
  - Simple design
  - High Sensitivity
- Disadvantages:
  - No direct readout of concentration
  - Calibration Required
  - Time Intensive



Summary

- Scenedesmus Sp. and Chlamydomonas Reinhardtii and possibly a mutant variation for higher H2 output
- Chamber airlift photobioreactor design
- Sensor assembled and is currently being programmed, calibrated, and tested
- Challenges include:
  - Sustaining algae
  - Programming H2 sensor
  - Large scale implementation

Questions/Comments?