Team 9: Hydrogen from microalgae and the collection and sensing systems.

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Sponsors: FIPSEI/UFPR

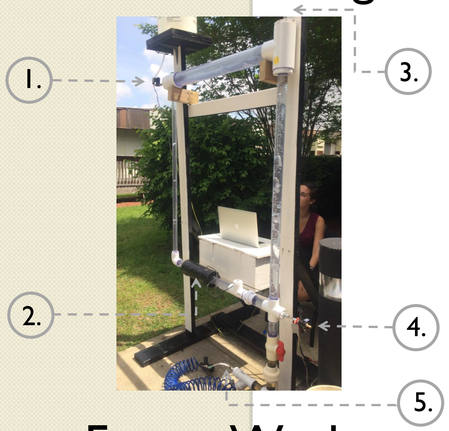
Background

One method of hydrogen production comes from algae. Using sunlight as their energy source, and under the right conditions, algae can produce hydrogen. The research that is currently being done is aimed at two types of algae: Scenedesmus sp. and Chlamydomonas reinhardti.

Objectives

- Design and construct a continuously operating photobiorector for semi-continuous hydrogen production.
- Design and calibrate a hydrogen concentration measuring sensor.

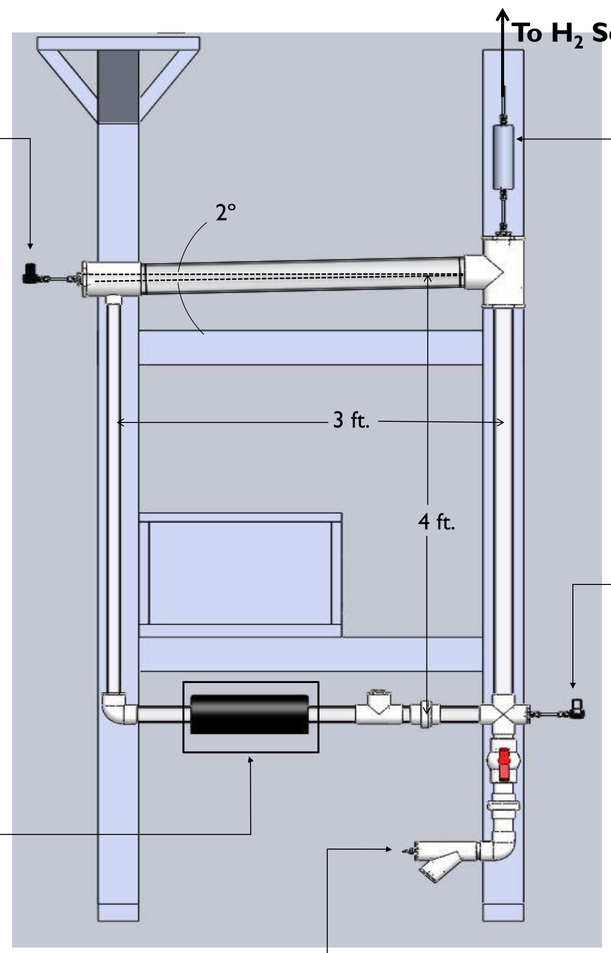
Current Design



Future Work

- Experiment with different growth media.
- Test prototype with algae strains.
- Develop a hydrogen mass flow sensor.
- Large scale implementation based on current design

Photobioreactor System



1. Addition Port

- Gravity fed system
- Works with 12 VDC, 450 mA, normally closed solenoid valve
- C_v = 0.23
- Operating power ~5 W

2. Concentration Sensor

- Master controller of PBR
- 4-LEDs and a Light Dependent Resistor (LDR)
- Increase in concentration reduces resistance and increases voltage through LDR
- Change in voltage converted to 8-bit value

3. H_2 Purifier

- Removal of O_2 and other organic impurities
- Minimum working pressure drop, 0.3 psi
- Removes less than 50 ppb
- 1/4 " Compression fittings
- Disposable when ~ 1200 cubic ft. standard grade H_2 gas

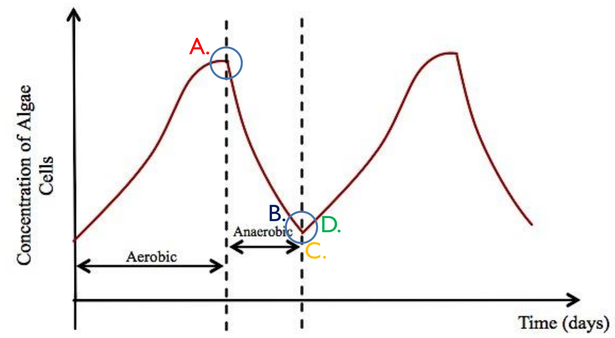
4. Extraction Port

- Gravity fed system
- Works with 12 VDC, 450 mA, normally closed solenoid valves
- Operating power ~5 W

5. Air Input System

- CO_2 mass transfer done with 1 gal. air compressor.
- From $v_{gas} = \dot{V}_g / A_r$,estimated max air volumetric flow rate of 0.076 CFM
- Relay functions as on/off switch for air compressor
- Relay specs:
  - 20 A, 220 VAC Max relay
  - 12 VDC input, 185 mA
  - Controlled through Arduino Uno board

System Function

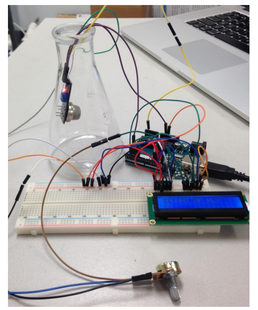


A. C_{max}: Air off → Relay switches OFF.
B. C_{min} : Extraction → Valve opens until empty → Valve closes.
C. Addition: Valve opens until full → Valve Closes.
D. Air ON: Relay switches pump on.

Photobioreactor Specs

- Surface area to volume ratio: V / A = 4 / d = 2.96 in^{-1}
- For large scale implementation the downcomer to riser cross sectional area ratio is: $A_d / A_r = (R_d / R_r)^2 = 0.36$
- Total volume = 2.09 gal (7.91 L)
- Volume with headspace = 1.39 gal (4.95 L)
- Weight: 25 lbs.
- Height: 6 ft.
- Width: 3 ft.

H_2 Concentration Sensor



- Sensitivity ≥ 100 ppm H_2
- Operating voltage = 5 VDC
- Working O_2 concentration between 2% and 21%
- Requires 24 hr. preheat time