Recreate Energy: Energy for a Brighter Future

Team Members: Santiago Buitron, Shaun Kim, Erica Stoll, Rene Valencia

Sponsor: Daniel Vega

Speaker: Rene Valencia

Project Overview

- Existing oil crisis has led to the search of alternative fuels over the years
- As technology advances, the use of algae for biofuel has been able to grow but it is still a work in progress
- The goal of this project is to turn micro algae into crude oil for commercial use
- Recreate Energy is attempting to create a solution where advantages from open and closed systems are combined to successfully grow algae
- 3 subteams have been created to take on specific design considerations for this project

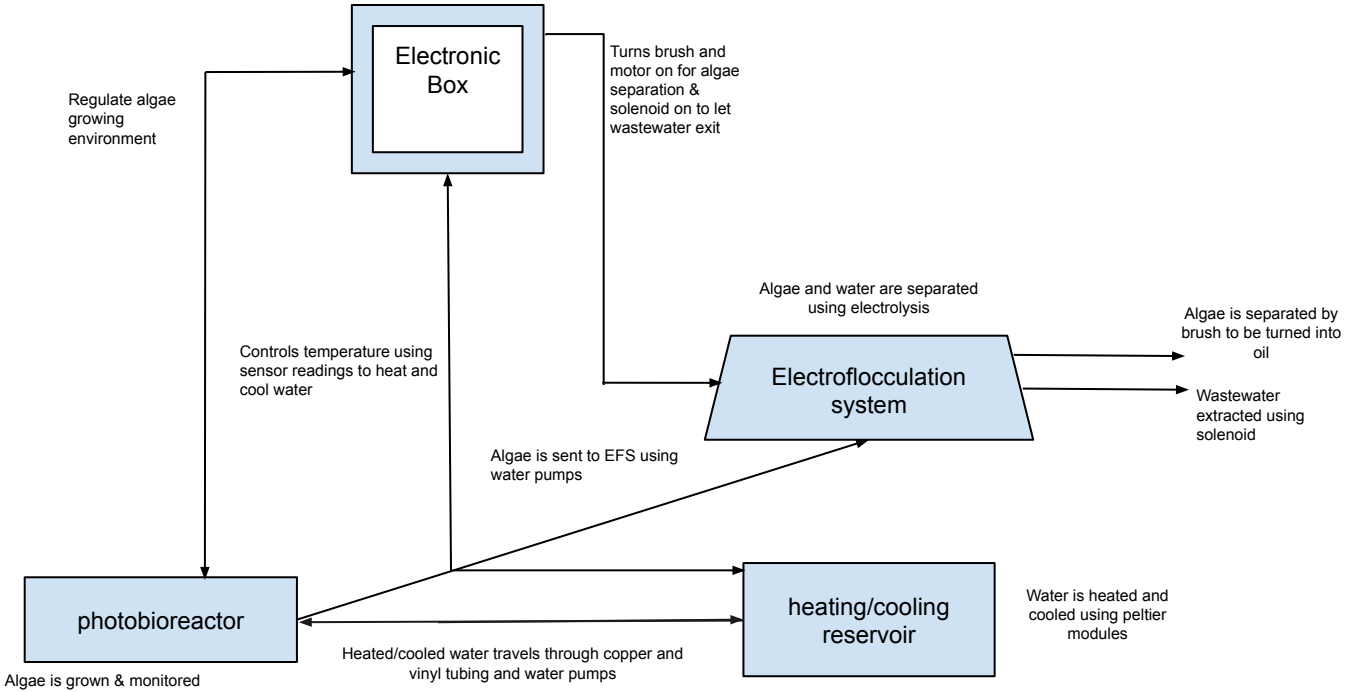
Speaker: Rene Valencia

Design Attributes and Requirements

- Heating/Cooling System: Establish a thermoelectric system that uses Peltier modules to heat and cool the system.
- Electronic Box: Designing a case that properly fits the electrical components and can be placed outdoors.
- Electroflocculation System: Ensure that algae can be separated from the water and extracted.
- Reducing cost, reducing energy consumption, weather resistance, and compatibility need to be considered for every system.

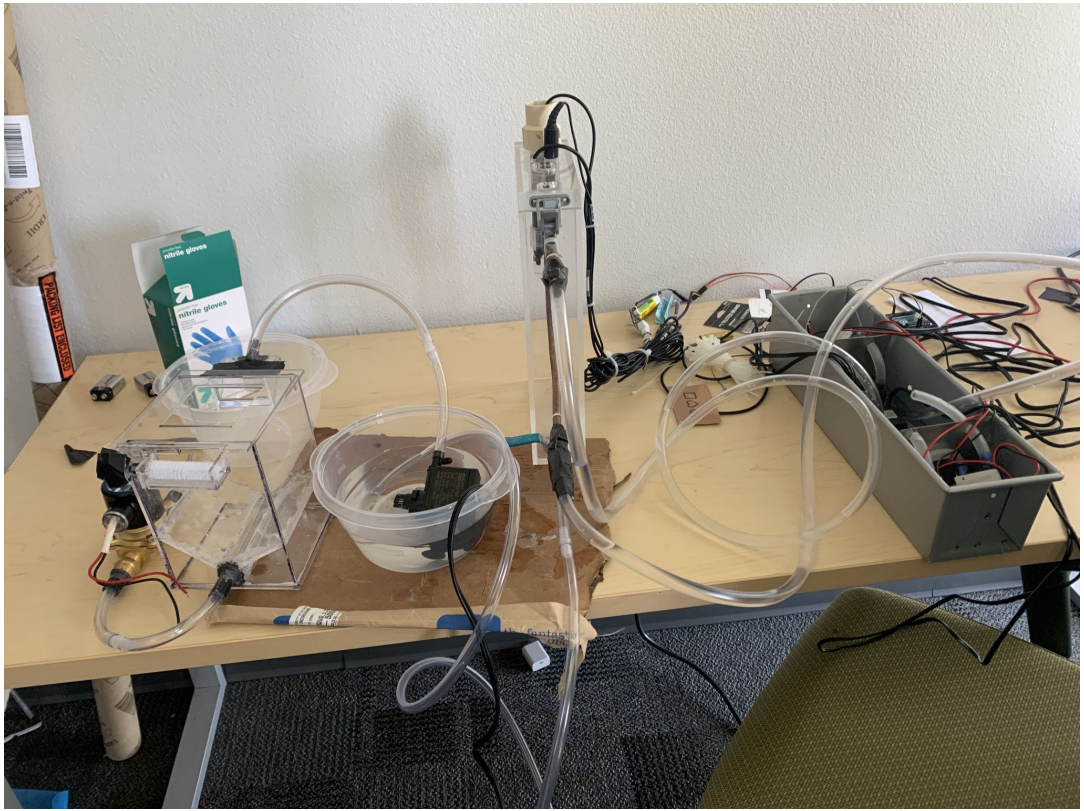
Speaker: Rene Valencia

Integration of Systems Diagram



Speaker: Erica Stoll

Integration of Systems Picture



Speaker: Erica Stoll

Electronic Box

Speaker: Erica Stoll

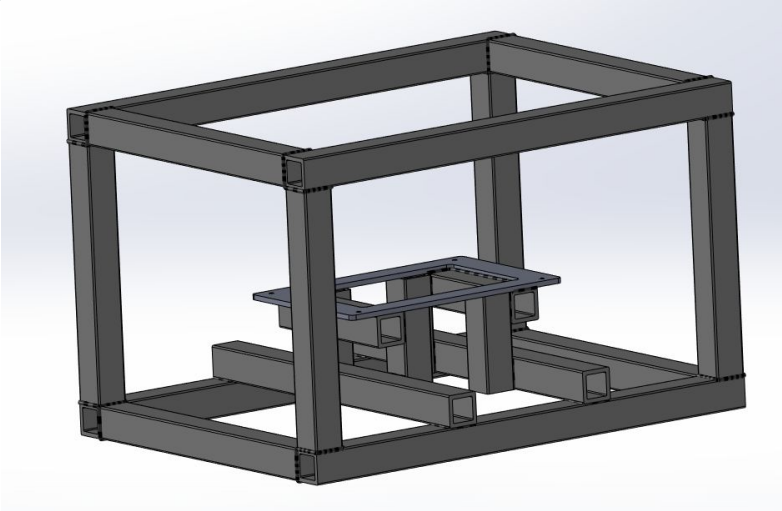
Design Attributes and Requirements

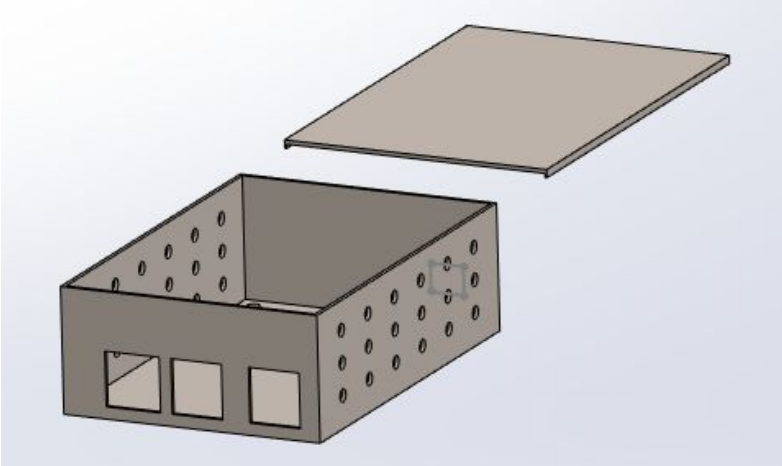
- Keep temperatures below 70°C (max operating temperature for arduino is 75°C)
- Protect from rain & condensation
- Budget of $300
- Ability to modify the sensor inputs

Speaker: Erica Stoll

Design

- Dual case
  - Tight fit inner case to protect from the elements
  - Outer case to protect from physical abuse
  - Cases mount together and are removable
- Key features
  - Air flow
  - Aluminum for thermal conductivity
  - Steel for strength (+ rust inhibitor)
  - Mounting ability
  - Multiple connections available for sensors





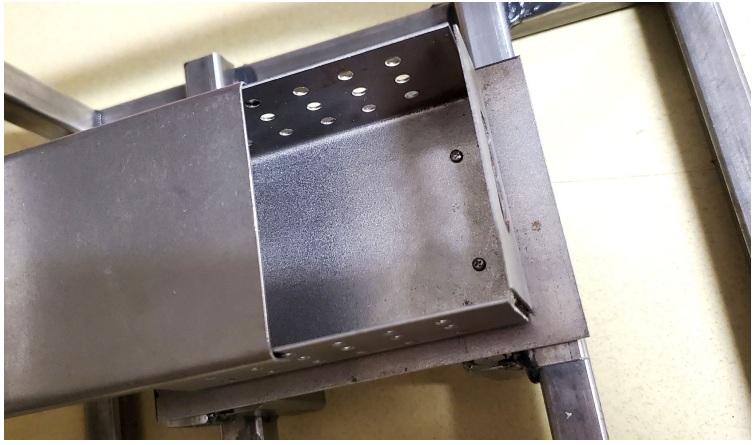
Speaker: Erica Stoll

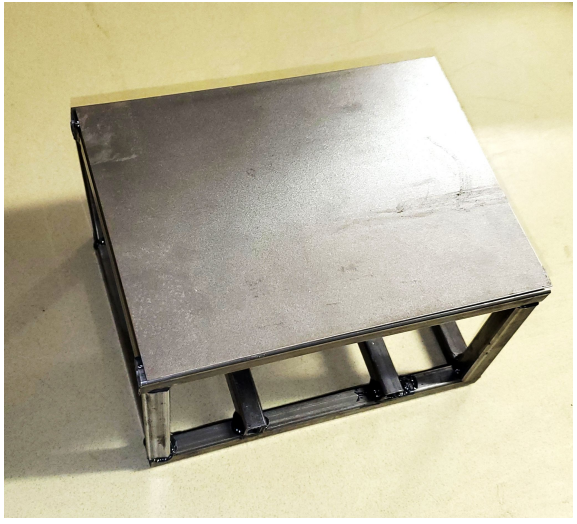
Bill of Materials

Item Description	Quantity	Price per item
22-Gauge Plain Sheet Metal	2	$7.51
1/2in Plain Steel Square Tube	2	$13.83
Steel Reinforced Epoxy	1	$14.79
Stainless Steel Woven Wire Mesh	1	$11.77
18-8 Stainless Steel Phillips Screw 0-80 Thread	1	$6.30
18-8 Stainless Steel Hex Nut 0-80 Thread	1	$7.43
Rust Inhibitor Black Paint	1	$13.25
Total		**$96.22**

Prototype

- Production:
  - Manufacturing is complete
  - Construction is almost complete -> waiting to paint before assembling with electronics
- Challenges:
  - Rust concern -> ordered anti rust paint, still waiting for PO to arrive so we can paint





Speaker: Erica Stoll

FMEA Analysis

Process Step/Input	Potential Failure Mode	Potential Failure Effects	SEVERITY (1 - 10)	Potential Causes	OCCURRENCE (1 - 10)	Current Controls	DETECTION (1 - 10)	RPN	Action Recommended
What is the process step, change or feature under investigation?	In what ways could the step, change or feature go wrong?	What is the impact on the customer if this failure is not prevented or corrected?		What causes the step, change or feature to go wrong? (how could it occur?)		What controls exist that either prevent or detect the failure?			What are the recommended actions for reducing the occurrence of the cause or improving detection?
Corrosion & material degeneration	*Rusting of the steel frame*	*unable to withstand impact*	*2*	*exposure to the elements and moisture*	*9*	*visual inspection*	*4*	*72*	*coat steel with a rust inhibitor or change materials*
Thermal regulation	*Overheating*	*electronic malfunctuion & system failure*	*8*	*large temperature range & cooling system*	*2*	*preemptively check outdoor temperatures*	*3*	*48*	*add sensor inside the box to monitor temperature*
Electronics accessibility	*Small size and cramped layout*	*unable to easily access the electronics*	*2*	*large temperature range & cooling system*	*7*	*physical and visual inspection*	*1*	*14*	*make the top panel removable*

Speaker: Erica Stoll

Future Recommendations

- Cooling system
  - Add fans or water cooling system
  - Self regulate with sensors
- Material selection
  - Weld instead of using epoxy
  - Use aluminum bars instead of steel to avoid rusting

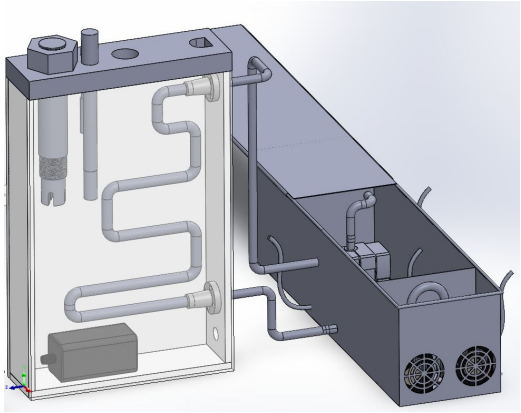
Only used ⅓ of budget

Heating & Cooling

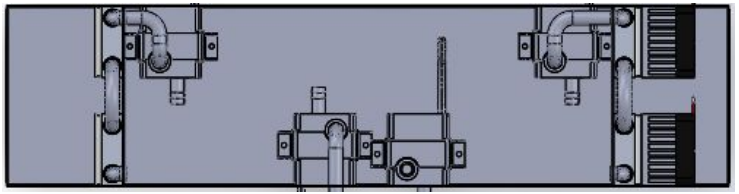
Speaker: Santiago Buitron

Heating/Cooling Subteam

- Provides an external heating/cooling system that does not interfere with micro-algae production
- Aluminum structure helps maintain temperature, while also being cost effective
- The total cost was $272.46 and is under the budget of $320.



Fully constructed view with photobioreactor (left) and isolated view of reservoir design (right)



Speaker: Santiago Buitron

Budget - $320

Item Description	Quantity	Price per item
Aluminum Box	1	$22.89
Sliding Lid	1	$17.88
6061 Aluminum Sheet	1	$8.00
AlumBond Chemical Welding Solution	1	$25.46
Water Blocks (40mm x 40mm)	4	$5.50
Peltier Modules (TEC1-12706)	4	n/a
Heatsinks (40mm x 40mm)	4	$2.00
Fans	2	$11.59
Heatsinks (40mm x 40mm)	1	$7.90

Speaker: Santiago Buitron

Budget - $320 (contd.)

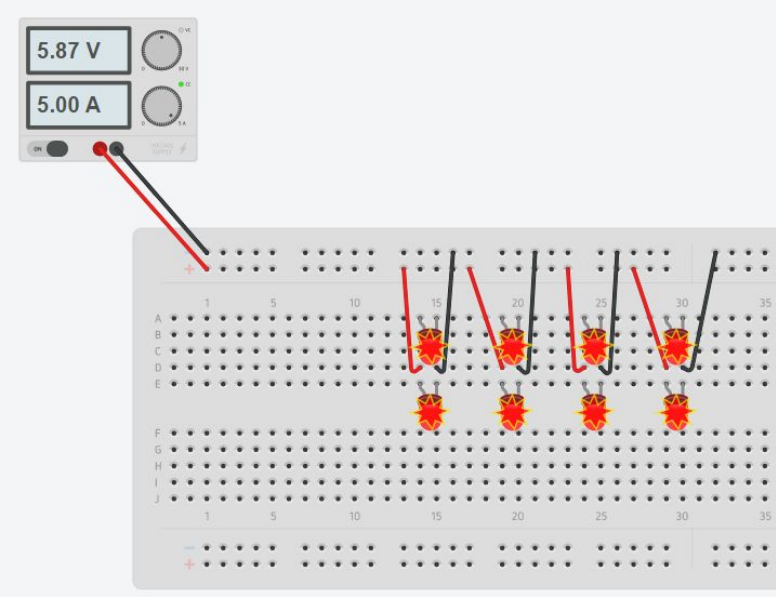
Item Description	Quantity	Price per item
PVC Piping	1	$12.36
Mini Water Pumps (50 GPH)	4	$4.74
Mini Water Pumps (240L/hr)	2	$9.95
Waterproof Digital Temperature Sensors	1	$13.99
Peltier Modules	1	$19.99
Power Supply	1	$41.99
Total	**29**	**$272.46**

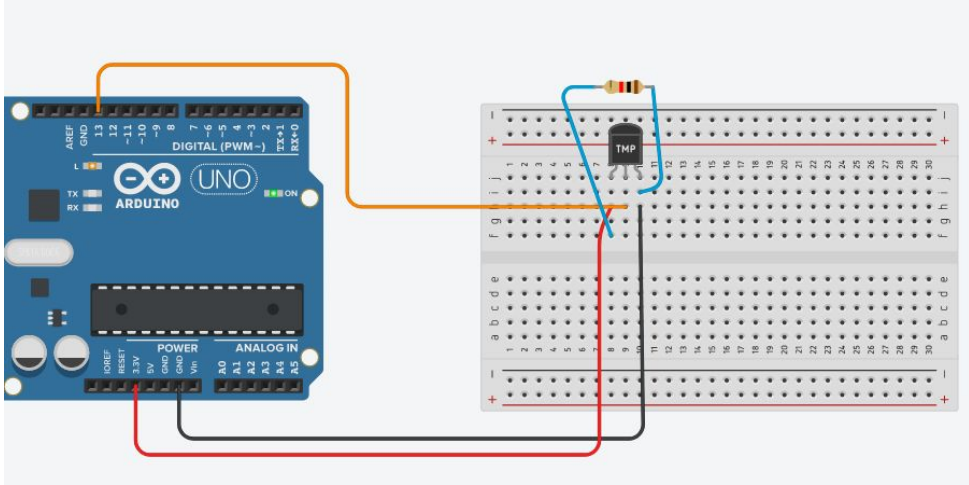
Heating/Cooling Subteam - Review of Final Design

- Component Details:
  - 16”x 4” aluminum box with sliding lid
  - Aluminum sheet dividers to separate components from water
  - 8 TEC1-12706 peltier modules
    - Applied with thermal paste
  - Main water reservoir has 2 water pumps to pump the water from the water blocks to the main tank
  - Will integrate another pump to transport water from the tank to the photobioreactor

Speaker: Santiago Buitron

Peltier Module Setup Compared to the Temperature Sensor Setup

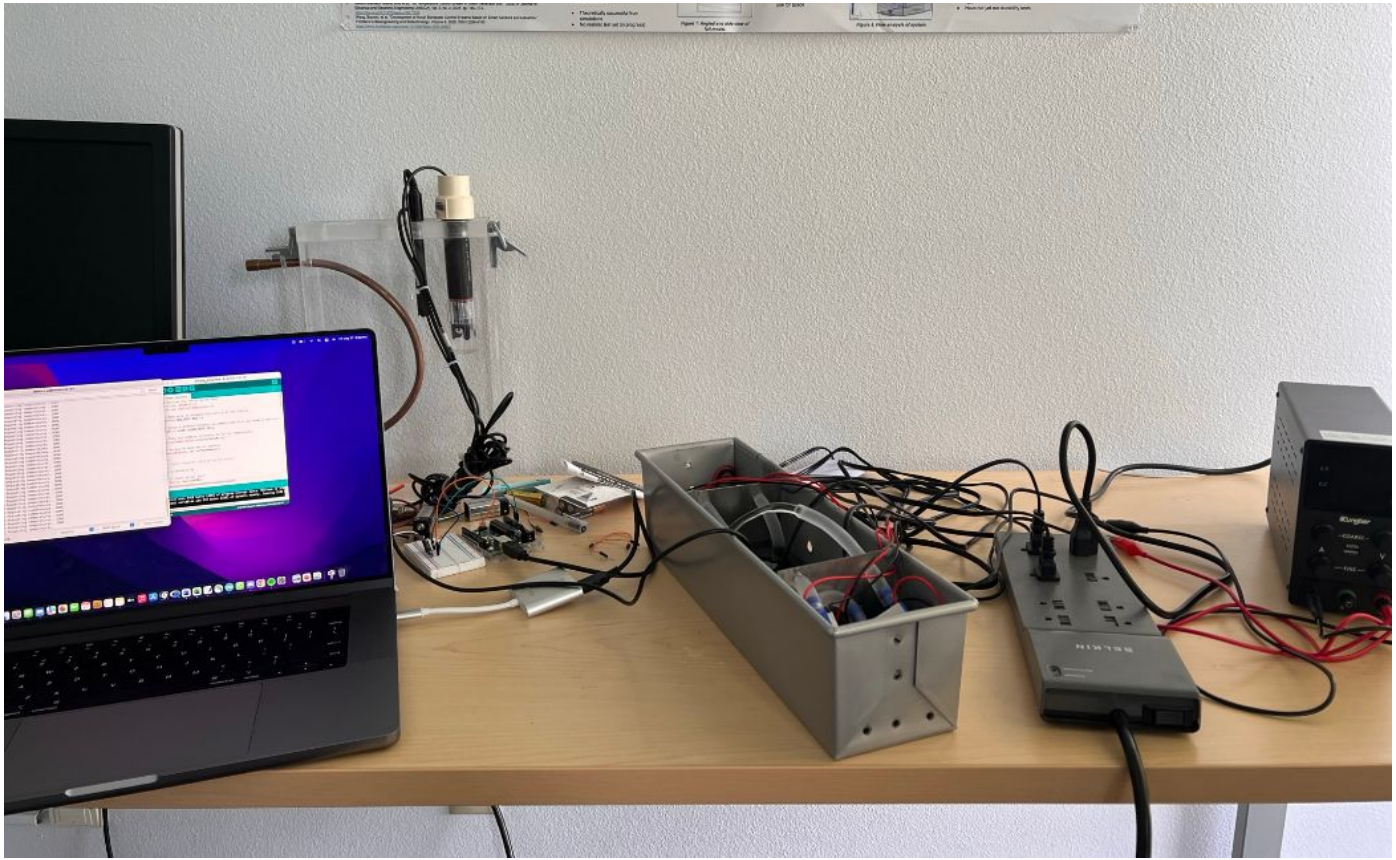




Note: TinkerCAD does not offer peltier modules, LED bulbs were used as a substitute

Speaker: Santiago Buitron

Finalized Model with Operational Temperature Sensors, Peltier Modules, Pumps, etc.



Speaker: Santiago Buitron

Heating/Cooling Subteam

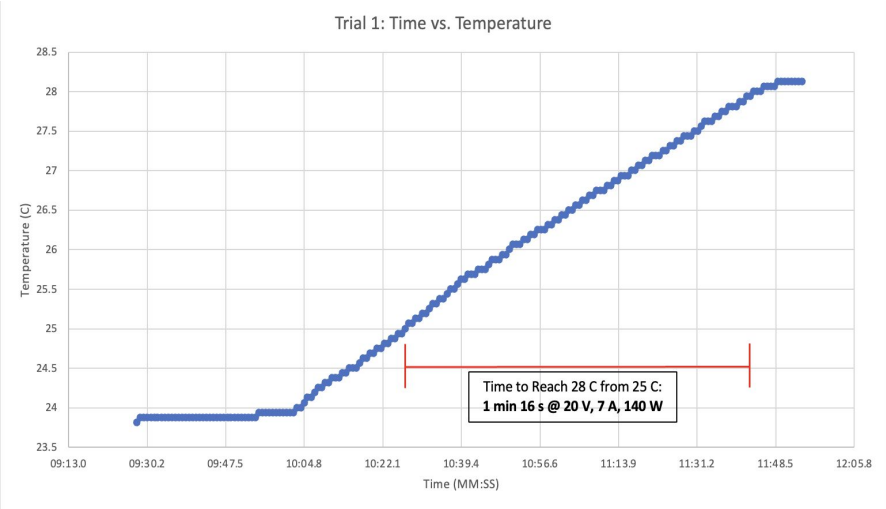
- Finalized design
  - All peltier modules are functional and operational
  - System is successfully able to heat to desired temperature
- Current challenges:
  - Cooling of water
    - Peltier modules are too strong, heat sinks are not enough

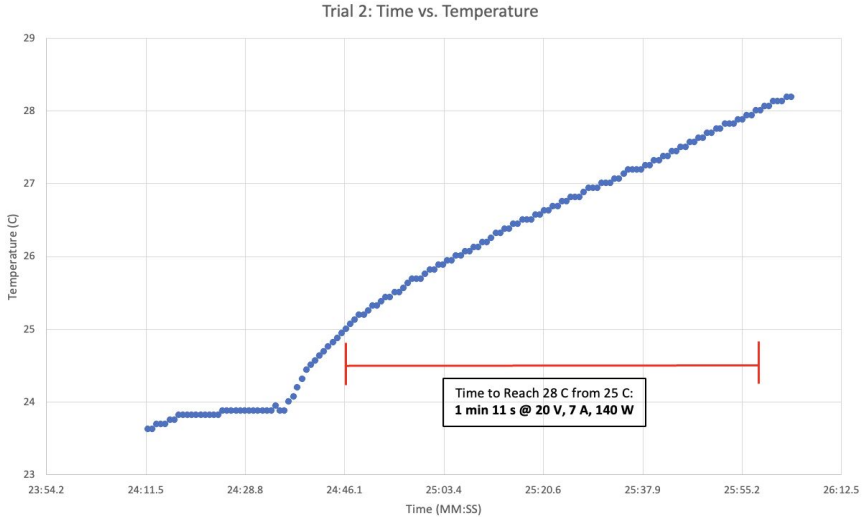
Speaker: Santiago Buitron

Demonstration

Speaker: Santiago Buitron

Results





Speaker: Santiago Buitron

FMEA Risk Assessment

FMEA									
Process Step/Input	Potential Failure Mode	Potential Failure Effects	SEVERITY (1 - 10)	Potential Causes	OCCURRENCE (1 - 10)	Current Controls	DETECTION (1 - 10)	RPN	Action Recommended
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Copper tubing	*Toxicity from tubing harming algae*	*Kills algae and stops entire process*	*8*	*Copper is a toxic material to algae*	*8*	*Visual Inspection*	*4*	*256*	*Coat tubing with non-toxic material*
Peltier Modules	*Could reach temperatures that burn through wires*	*Stops entire process due to no connection*	*8*	*Current wires are too thin and may melt due to high temperatures*	*4*	*Visual inspection, controlling power supply wattage*	*2*	*64*	*Purchase thicker wires to manage melting*
Wires	*Lots of loose wires that could potentially make its way into the water*	*Could lead to system failure due to failure of wires*	*8*	*Wires slipping into water reservoir*	*6*	*Manually making sure wires are not in tank, using zipties*	*2*	*96*	*Wire organization involves longer wires and improving cable organization*
Peltier Modules	*Peltier modules have an average lifetime of 5 years*	*Modules could become weaker or lose power, resulting in less efficiency*	*4*	*This system will put modules under constant loads, may decrease life expectancy*	*1*	*Temperature sensors to test heating*	*2*	*8*	*No action as of now, will need to regularly check on modules*

Speaker: Santiago Buitron

Future Recommendations

- Expand cooling system by incorporating fan cooling or liquid cooling (commonly seen in PC's)
- Purchase thicker and longer wires
- Coat copper tubing in photobioreactor
- Integrate with software team to automate heating and cooling

Speaker: Santiago Buitron

Electro-Flocculation

Speakers: Rene Valencia, Shaun Kim

EF : Design Attributes and Requirements

Requirements

- Capacity must be around 1 L or greater
- Must successfully allow separation of algae biomass from liquid slurry (both electroflocculation system and output)
- Allow ventilation of H_2 gas
- Budget of $300 (total cost was $236.22)
- Compatible with Arduino

Design Attributes

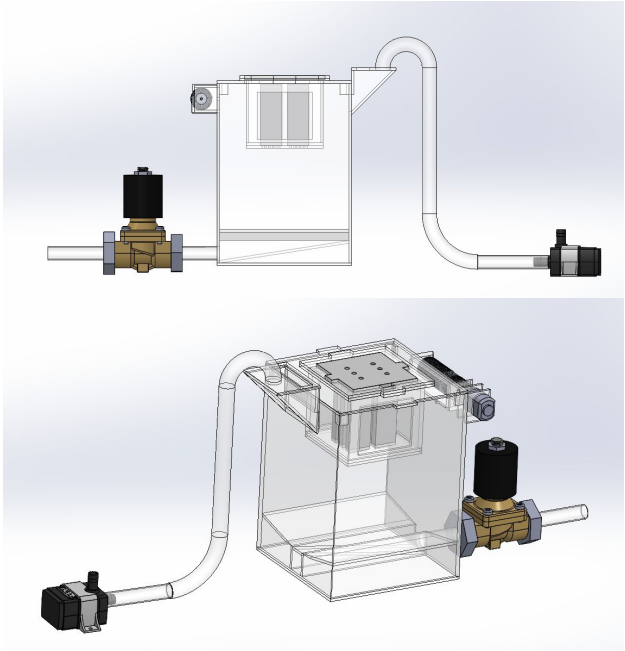
- Casing made from durable and waterproof material
- Electroflocculation system use effective metal/alloy
- Separator for algae and slurry

Speaker: Rene Valencia

EF Subteam - Review of Final Design

- **Key Components:**
  - 3 Aluminium-6101 and 3 Carbon electrode configuration
  - Detachable lid and electrode case for easy access
  - Slanted floor to allow wastewater to exit
  - Tube brush and motor are used to separate algae slush
  - ABS cover for wires and access to electrodes
  - Solenoids and water pumps to move fluid
  - Electrode residue will sit at the bottom of the case

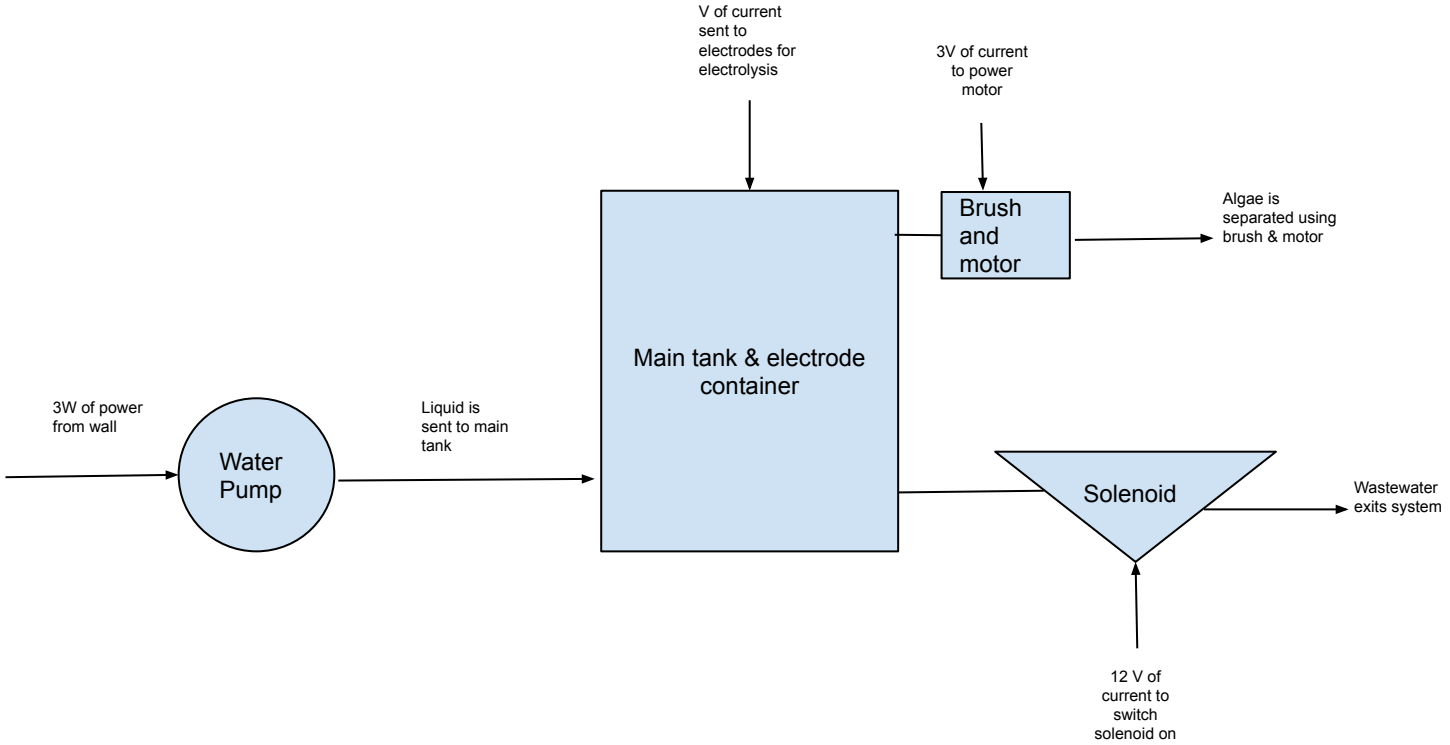
- **Project objectives:**
  - Material selection of Al alloy reduces cost and increase efficiency
  - Acrylic casing for low cost, weather resistance, and viewing accessibility



Side view (top) and angled view (bottom) of full tank assembly

Speaker: Rene Valencia

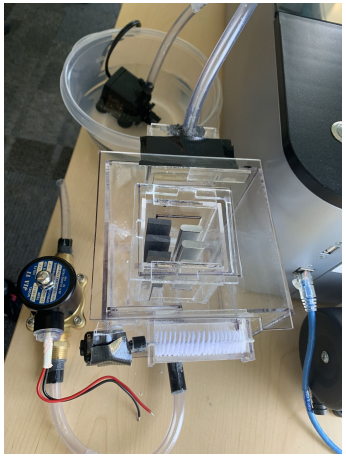
EFS System Diagram



Speaker: Rene Valencia

Prototype-EFS

- Current production:
  - System is completed
  - Tank holds ~1L of liquid
  - Water is able to enter and exit system
  - Electrolysis is successful (H_2 gas is produced)
  - Brush is functional
- Current challenges:
  - System is compatible with Arduino but automation of system has not been tested(pumps plug into wall)
  - Arduino might not be able to automate solenoid (12V)



Main assembly top view (top left), front view (top right), and side view (bottom)

Speaker: Rene Valencia

Budget-$300

Item Description	Quantity	Price per Item
Extruded Acrylic Sheet (400 X 330 X 3 mm)	2	$8.05
6101 Aluminum Bar (¼ X ¾ X 5 in)	2	$13.23
Flat Carbon Electrode	3	$12.77
DC 1.5-3V Mini Electric Motor	1	$6.99
Drinking Straw Brush Pipe (8in rod, 2.5 X 0.7 in brush)	1	$5.99
WELD-ON 4 Acrylic Adhesive [4 Oz]	1	$19.35
20 pack of Alligator clips with wires	1	$7.99

Note: Budget excludes shipping costs but include tax

Speaker: Shaun Kim

Budget- $300 cont.

Item Description	Quantity	Price per Item
10 ft long Vinyl Tubing [5/16 ID, 7/16 OD in]	1	$7.99
5V 4 Channel Relay Optocoupler Isolation	1	$8.99
Brass normally closed electric solenoid valve [1/2" female port] 12V	2	$21.99
10-piece pack Plastic Hose Barb Fitting Mender Joint [5/16" x 5/16"]	1	$10.99
12 piece Metals Brass Pipe Fitting (Male and Female Thread Pipe) [1/2" x 1/2"]	1	$22.79
Cold-Weld Cold-Weld Steel Reinforced Epoxy [2 oz.]	1	$5.13
Imagitarium Power Head water pump	1	$24.99
TOTAL	**$236.22**	

Speaker: Shaun Kim

EFS Subteam - FMEA Risk Assessment

- Greatest value: 120 - electrolysis & pump

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The tank	*Leakage - The biomass slurry will leak out of the tank and into the environment*	*Decrease in efficency to generate power & increase cost in maintenance*	*9*	*The joints of the tank are not properly aligned; the sealant between joints are not set properly*	*2*	*Visual Inspection - Tank made up of clear acrylic; Epoxy/silicon seal the joints of plates*	*2*	*36*	*Regular check of device when in use. If leaks, empty out and reapply sealants to affected areas*
The electroflocculation process (electrolysis)	*The electrode may contact eact other causing a short circuit*	*Failure to separate algae from biomass slurry properly; Threaten safety with electric shock; May cause fire with short circuit*	*10*	*The electrodes are not properly secure in place and flowing water may force them to touch; The power of the electrodes are high at a range of 8 -12 V*	*6*	*Thermal paste is attached to the bottom of each electrode to the electrolysis case; Grooves are fitted into the casing to eep the electrodes aligned and strlaght*	*2*	*120*	*Regular maintance and visual of device; if occur more regualrly, may get item to stick between electrode to secure spacing of electrodes*
The pump	*Clogged - The slurry might halt the flow in the pump and cause it to break down*	*The entire flow is halted & there might be dnager with a broken down pump*	*6*	*The pump is not properly maintaned and check in case of blockage*	*4*	*It may not be as obvious when looking at it from direct sight but can be detecte by seeing the flow of the slurry through the output pipe*	*5*	*120*	*Regular check of both the pump and output pipe. If blockage occur, remove offender and check if pump still functional. If not need replacement.*
The solenoid	*Clogged/Leak - The biomass stops the flow or escapes from the flow*	*The flow will be reduced/halted, therefore decreasing the efficency and causing additional cost in terms of mess*	*6*	*The sluury particulates gather within the solinoid and build up over time, which eventually cause a blockage and malfunction*	*3*	*Visual Inspection of the output pipe to see if flow is continuing. There also audiable indication of the value opening and closing with a large clack noise*	*4*	*72*	*Regualr check and maintance. If blockage does occur, dislodge offender. If can not, then get replacement*
The pipes	*Leakage - The slurry may escape through from the flow*	*The efficency of the whole device is decreased and the cost increase due to reduced efficency and mess produced*	*4*	*The slurry escape through cracks of the joints where pipes comnnect*	*3*	*The pipe is made of clear vinyl which makes it easy to indicate where the slurry is heading. Any leaks would be easy to spot*	*2*	*24*	*Regular check by sight. If present, then plug offender with sealant. IF repeats then replacement may be needed*

Speaker: Shaun Kim

Demonstration

Speaker: Shaun Kim

Future Recommendations

- Integration of solenoid that uses less voltage to run
  - Current usage - ~8 - 12 V
- Automation of system
  - Current completed tests to system only focus on functionality
- Testing electrolysis with algae
  - All testing done only used water
- Minimizing leakage
  - Multiple components had a little bit of leak

Speaker: Shaun Kim

Thank You

Any Questions?