**Design an algae production facility for a small community in NM**

**Introduction**

In the past decade, the US Department of Energy alone has invested millions of dollars into the research and development of biofuels derived from algae. This is in addition to the investment made by industrial entities who wish grab a share of the market in this promising field. So why such a push?

First of all, biofuels represent a preferred alternative to traditional fossil fuels. Unlike fossil fuels which are net emitters of carbon, algae ultimately pull carbon from the atmosphere creating a carbon neutral energy source. In fact, most of the fossil fuel deposits we mine from the earth today began as algae in various water systems, so the process of deriving biofuels from algae simply allows a much more rapid jump from the carbon source to energy [1]. The process of growing, harvesting, and converting algae to fuel is also something that can be done domestically, which is strategically preferred to foreign dependence on fossil fuels.

Still, with so many potential sources for biofuel, why algae? For example, corn is currently the largest source of biofuel in the US and is used to produce ethanol. But where each acre of corn can be harvested only once a year, portions of the algae grown in an acre-sized pond can be harvested every day [1]. Certain species of algae can be composed of 50-70 percent oil by mass which makes it an ideal source for producing biodiesel [2].

One of the major challenges facing biofuel production from algae is being able to grow algae at a quick enough rate to make the process profitable [3]. While algae may seem to grow rapidly in a natural environment, such as a pond, the rate isn’t actually sufficient enough for fuel production and is limited by the amount of nutrients that are accessible to the algae from the natural environment.

A small rural community in New Mexico relies on the local dairy farms to support its economy. One of the problems with these dairy farms is they produce a large amount of wastewater. One of the ways that we can mitigate the amount of wastewater is to use it to support a large scale algal biofuel production facility, with added benefit of increased economic stability.

Your tasks are to grow, harvest, and extract oil from a chosen algal species. For this endeavor to be successful, 30 grams of algae must be grown per square meter per day.

**Student Learning Outcomes**

Students should be able to research the key unit operations currently used for micro-algae based biofuel production and produce a process flowchart

Students should be able to identify issues with large scale production

Students should be able to propose a production facility for algae within constraints

Students should be able to complete a mass balance on the production facility and determine overall conversion of algae carbon into fuel

**Project Constraints**

Temperature range for algae growth 15 -25C

Algal growth must take place 24 hours per day

Water sources should not be shared with farm irrigation and drinking consumptions

Land area should be valuable farmland for food supply

Selected NM community should have a population size – less than 10,000

Selected carbon dioxide source must have low cost

**Project Roles**

Three Teams Including:

Team Champion – this person is responsible for team deliverables at the end of the challenge. The champion will coordinate with their team to propose their piece of the overall challenge. Someone with strong presentation skills should be considered for this role.

Scribe – The scribe is in charge of documentation. Your groups will meet outside class on occasion and this person will make sure everything that is said and contributed will be documented. Someone who has excellent organization skills would be best utilized here.

Team Strategist – responsible for managing timeline and keeping group on task with deliverables and due dates.

Coordinator – This person, not to be confused with the scribe, who compiles group notes, will take those notes and construct them in a way that the champion can deliver.

These group roles are meant to guide you with getting your project done to the best of your ability and in a timely manner. Due to class size, there may be instances where there are two people assisting in one role. The only person that will be solitary is the Team Champion. This mimics a real professional setting with management and the hierarchy below them.

**Project Timeline and Deliverables**

|  |  |  |
| --- | --- | --- |
| Deliverable | Due Date | Points |
| Proposal   * Two-page proposal containing the following:  1. Background information 2. What do you propose to do? 3. What are the benefits of your project? 4. Identify the key constraints 5. What specific measurable metrics will you use to know if the project is successful. | WK 1 |  |
| Progress Check   * What is your motivation/goals, any changes in goals of the project? * What is the status is the project, do you have any results or decisions so far? | WK 2 |  |
| Annotated Bibliography   * Minimum 6 sources cited in the MLA style citation. * 1 paragraph for each source   Sample Process Calculations   * Identify important process variables, i.e. density, flow rate, etc. where applicable. * Show that you are utilizing the knowledge that you are using in class. * Propose a minimum of two calculations. | WK 3 |  |
| Progress check   * What is your motivation/goals, any changes in goals of the project? * What is the status of the project, do you have any results or decisions so far? | WK 4 |  |
| Process Description with Flow Chart   * Write a description of your process. Document each material stream, flow rates, components etc. * Describe each process (unit) operation in the process. Propose labels for each step. * Flowsheet should be easy to follow with descriptions guiding the reader to what is going on. | WK 5 |  |
| Final Presentation   * 10 minute oral presentation per champion with 5 minutes of time for peer questions. * Prepare a video using any medium you wish. For example, camcorder, iphone, computer, etc. This video will show your learnings from the project, what did you take away from the challenge, and what was the challenge? | WK 6 |  |
|  |  |  |

**References**

[1] This American Land, 2014, https://www.youtube.com/watch?v=d5laQZbJ2mg

[2] University of Kansas, 2014, https://www.youtube.com/watch?v=Ve1tBAc1fss

[3] Our Ohio, 2012, <https://www.youtube.com/watch?v=pA4a_I-rb3Q>

**Growth Phase Worksheet: Location and Sourcing**

For each of the following categories, list your team’s choice and write a paragraph or two explaining your choice. Include any information that illustrates the benefits or limitations of each choice.

**Community:** Name the New Mexico community which falls within the project constraints where your team has chosen to build your algae facility (fill out the decision matrix below to help reach your community decision).

|  |
| --- |
|  |

**Population:** What is the size of your community?

|  |
| --- |
|  |

**Land:** Describe the land upon which your team proposes to build your algae facility and show that it is not competing with agriculture. Where is it located and what was it previously used for or what was its previous state?

|  |
| --- |
|  |

**Water Source:** Describe the source of water that your facility will use to grow algae. Are there any competing uses for this water?

|  |
| --- |
|  |

**CO2 Source:** Describe the source of or method for producing CO2 that your facility will use to grow algae. Include any data your team has found that supports this as a relatively inexpensive source of CO2.

|  |
| --- |
|  |

**Nutrient Source:** List any nutrients in addition to CO2 that will need to be supplied to your strain of algae for proper growth. Describe your source for these nutrients and include any data you’ve collected that show it to be relatively inexpensive.

|  |
| --- |
|  |

**Other Community Resources:** List any additional resources offered by your chosen community that might aid in your endeavor.

|  |
| --- |
|  |

**Growth Phase Worksheet: Community**

Every community is different. To grow algae, you will need to consider environmental factors that might influence the yield and growth rate of your biomass source. Review your project constraints in the challenge prompt. What are some of those constraints?



In the boxes below, select 3 communities you think fit these needs. Write a short description of each community and the availability of resources for your facility. As always, attach any supporting documents with necessary citations.

**Community 3**

**Community 2**

**Community 1**

Now that you have chosen 3 communities, use a decision matrix to evaluate your team choices.

|  |  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- | --- |
|  | Available Land: | Water Source: | CO2 Source: | Nutrients: | Other Criteria | Other Criteria | Other Criteria | Other Criteria | Total |
| Comm 1 |  |  |  |  |  |  |  |  |  |
| Comm 2 |  |  |  |  |  |  |  |  |  |
| Comm 3 |  |  |  |  |  |  |  |  |  |

|  |  |
| --- | --- |
| **My Choice** |  |
| **Sub Team Choice** |  |

**Decision Making Parley: Facility Type**

To begin the challenge, you will focus your research on exactly how you will grow your algae. For each facility type (Photo Bio-Reactor and Open Pond), what are the strengths and the disadvantages?

When you complete this worksheet **individually**, come together as a team and using a decision matrix (see attached example), compile your criteria to determine the best fit for your needs.

Attach a separate page with any additional information and necessary citations to support your choice.

First: What are the needs and constraints of your facility type?

|  |  |
| --- | --- |
| **NEEDS:** | **CONSTRAINTS:** |

With the above in mind, consider the strengths and weaknesses of growing algae using the methods below.

**Photo Bio-Reactor Tubes**

**PROS:**

**CONS:**

**Open Ponds**

**PROS:**

**CONS**:

|  |  |
| --- | --- |
| **My Choice** |  |

**In Class:**

**Choose a growth method**

With your team, complete a decision matrix to choose a growth method.

As an example, a student used a decision matrix to choose a major. Based on the matrix, she chose to major in chemical engineering.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Potential paycheck after graduation | Difficulty of curriculum | Will I need to go to graduate school? | How easy will it be to get a job? | How much do I like the subject matter? | TOTAL |
| **Chemical Engineering** | 3 | 1 | 3 | 3 | 3 | 13 |
| **Biochemistry** | 1 | 3 | 1 | 2 | 2 | 9 |
| **Mechanical Engineering** | 2 | 1 | 3 | 3 | 1 | 10 |
| **Mathematics** | 1 | 2 | 1 | 1 | 1 | 6 |

1 = worst /lowest 2 = moderate 3 = best/highest

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Replace with criterion 1 | Replace with criterion 2 | Replace with criterion 3 | Replace with criterion 4 | Replace with criterion 5 | TOTAL |
| **Photo Bio-Reactor Tubes** |  |  |  |  |  |  |
| **Open Ponds** |  |  |  |  |  |  |

**You might change your mind as you decide which method to use. With each step, record your decision.**

|  |  |
| --- | --- |
| My Choice |  |
| Sub Team Choice |  |
| Jigsaw Choice |  |
| Team Choice |  |
| Class Choice |  |

**Decision Making Parley: Strain of Algae**

For this part of the challenge you will select, as a class, the strain of algae you will use for the facility. Every strain of algae is different, and some strains are better equipped than others to serve as biomass for fuel.

**Before Class:**

To begin, **individually** refer to the previous worksheet and revisit your facility needs and constraints. What are some important criteria that you can use to evaluate whether a particular strain meets those needs? List those below.



Considering the criteria above, look at 3 different strains and research how best they fit to your criteria. What are the benefits and drawbacks? Which strain would you choose? Attach any research notes with necessary citations.

.

**Strain 3**

**Strain 2**

**Strain 1**

|  |  |
| --- | --- |
| **My Choice:** |  |

**In Class:**

With your team use a decision matrix to decide which strain you think you should use.

As an example, a student used a decision matrix to choose a major. Based on the matrix, she chose to major in chemical engineering.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Potential paycheck after graduation | Difficulty of curriculum | Will I need to go to graduate school? | How easy will it be to get a job? | How much do I like the subject matter? | TOTAL |
| **Chemical Engineering** | 3 | 1 | 3 | 3 | 3 | 13 |
| **Biochemistry** | 1 | 3 | 1 | 2 | 2 | 9 |
| **Mechanical Engineering** | 2 | 1 | 3 | 3 | 1 | 10 |
| **Mathematics** | 1 | 2 | 1 | 1 | 1 | 6 |

1=worst / lowest 2=moderate 3=best/highest

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Add Criteria 1 | Add Criteria 2 | Add Criteria 3 | Add Criteria 4 | Add Criteria 5 | Total |
| Strain 1 |  |  |  |  |  |  |
| Strain 2 |  |  |  |  |  |  |
| Strain 3 |  |  |  |  |  |  |

**With each step you might change your mind on which strain to choose. Record your decision along the way.**

|  |  |
| --- | --- |
| My Choice |  |
| Sub Team Choice |  |
| Jigsaw Choice |  |
| Team Choice |  |
| Class Choice |  |

**Decision Making Parley: Source of Carbon Dioxide**

For this part of the challenge you will select, as a class, the source of carbon dioxide.

Algae consume carbon dioxide for normal growth during photosynthesis and adequate supply is needed to help realize large scale production. Recall, your plant is located in Vado, New Mexico. The plant size is 13000 ft2 and stream factor 0.9 (i.e. 324 days for the year).

# Before Class:

Keeping in mind the algae facilities needs and constraints, what are some important criteria that you can use to evaluate whether the selected source is viable? List those below.

Considering the criteria above, look at 3 different sources and research how best they fit to your criteria. What are the benefits and drawbacks? Which source would you choose? Attach any research notes with necessary citations.

**Source 1**

**Source 2**

**Source 3**

**My Choice:**

# In Class:

matter?

With your team use a decision matrix to decide which source you think you should use.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Add Criteria 1 | Add Criteria 2 | Add Criteria 3 | Add Criteria 4 | Add Criteria 5 | Total |
| Source 1 |  |  |  |  |  |  |
| Source 2 |  |  |  |  |  |  |
| Source 3 |  |  |  |  |  |  |

**With each step you might change your mind on which source to choose. Record your decision along the way.**

|  |  |
| --- | --- |
| My Choice |  |
| Sub Team Choice |  |
| Jigsaw Choice |  |
| Team Choice |  |
| Class Choice |  |

**Harvest Worksheet 1**

When you think of a harvest, thoughts of fall, threshers, and bushels come to mind. Harvesting algae, however, is a more delicate process. You need to separate the algae from the water and dry it in preparation for extraction. This can be an energy intensive process, so your job is to design a process that is energy efficient.

Research different processes to harvest your algae below, and with each evaluation comment on energy use, cost, and how well you can integrate it within your facility constraints. Use citations when necessary.

**Process 2**

**Process 1**

**Process 3**

Using a decision matrix, evaluate your choices for harvest method.

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | Enter Criteria | Enter Criteria | Enter Criteria | Enter Criteria | Enter Criteria | Total |
| Method 1 |  |  |  |  |  |  |
| Method 2 |  |  |  |  |  |  |
| Method 3 |  |  |  |  |  |  |
| Method 4 |  |  |  |  |  |  |
| Method 5 |  |  |  |  |  |  |

|  |  |
| --- | --- |
| **My Choice** |  |
| **Team Choice** |  |

**Extraction Worksheet 1**

Extraction of oil from Algae is one of the costlier processes in the overall conversion of algae biomass into fuel. It seems simple enough to get the oil out of the algae, but the plants themselves are very resilient. You need a process that is efficient and cost effective to be considered sustainable.

What are some important criteria to consider when looking at extraction methods?



Use the above criteria to evaluate some methods of extraction. What are the benefits and drawbacks in each process?

**Extraction Method 4**

**Extraction Method 3**

**Extraction Method 2**

**Extraction Method 1**

**Use a decision matrix to evaluate your chosen methods.**

|  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- |
|  | Criteria | Criteria | Criteria | Criteria | Criteria | Criteria | Total |
| Process 1 |  |  |  |  |  |  |  |
| Process 2 |  |  |  |  |  |  |  |
| Process 3 |  |  |  |  |  |  |  |
| Process 4 |  |  |  |  |  |  |  |
| Process 5 |  |  |  |  |  |  |  |

|  |  |
| --- | --- |
| **My Choice** |  |
| **Sub Team Choice** |  |

**Annotated Bibliography**

An annotated bibliography is a list of references to books, articles, and documents. Each reference is followed by a brief descriptive and evaluative paragraph, the annotation. The purpose of the annotation is to inform the reader of the relevance, accuracy, and quality of the sources cited.

**Content**:

Sources for the annotated bibliography should be critically chosen. Be sure to evaluate the authority or background of the author, consider the intended audience of the source, compare each work with others that you have already chosen, and consider how each work illuminates your bibliography topic.

**Format**:

* Include at least 6
* Use Times New Roman 11.5 font size for main text.
* Use Times New Roman 12 font for all section headings.
* 1- inch margins all around, 1.5 line spacing and JUSTIFY text.
* Sentence construction and punctuation: Use proper grammar. There are many guides available on this. The biggest mistakes include run-on sentences, sentences that are missing a verb, subject or direct object, and sentences that just don’t make sense. Many of these problems could be easily caught by actually reading the report (preferably a hard copy) before handing it in!
* Spelling! At a minimum, use a spell checker. Unfortunately, many of the problems involve words that are spelled correctly but not the right word – catch these by carefully reading a hard copy before turning in.

**Algal Biofuel Project Proposal**

Each team shall prepare a project proposal. It should be presented as a document that can stand on its own and use formal tone. The tone should suggest that the document is intended to be read by potential investors. A length of 2 pages is expected. Important content to include is summarized below. It should be concise, clear, informative and aimed at a well-educated audience. The audience should be able to acquire information it needs without referring to the entire report. It highlights the nature of the process, important findings, and constraints of the project. There are also no pictures or figures in the project proposal.

**Content**:

* Background: Briefly describe the history and development of this field. Justify your team’s reason for investigating this field.
* Proposal: What are you doing and why? Objectives need to be clear here along with measurable goals.
* Scope: Describe and/or list the constraints and assumptions under which you will work.
  + *Constraints*: These are restrictions that limit what you can achieve and how and when you can achieve it.
  + *Assumptions*: These are statements about how you will address uncertain information as you conceive, plan, and perform your project.

**Format:**

* Use Times New Roman 11.5 font size for main text.
* Use Times New Roman 12 font for all section headings.
* 1- inch margins all around, 1.5 line spacing and JUSTIFY text.
* Sentence construction and punctuation: Use proper grammar. There are many guides available on this. The biggest mistakes include run-on sentences, sentences that are missing a verb, subject or direct object, and sentences that just don’t make sense. Many of these problems could be easily caught by actually reading the report (preferably a hard copy) before handing it in!
* Spelling! At a minimum, use a spell checker. Unfortunately, many of the problems involve words that are spelled correctly but not the right word – catch these by carefully reading a hard copy before turning in.

# Self and peer evaluation of algal biofuel design challenge

|  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- |
|  | | **B) Fill in your name and your sub-teammates names. Divide the points across members—including yourself—as you think they deserve. Remember, everyone has strengths and weaknesses. Your scores should reflect this.** | | | | |
| **A) How did your subteam perform on this aspect?**  **90-100: Truly exceptional (rare)**  **70-89: Okay, just minor/few issues**  **40-69: Lots of challenges**  **0-39: Utter failure**  **Total points you think your sub team deserves:** | | **Your name:** | **Subteam name 1:** | **Subteam name 2:** | **Subteam name 3:** | **Subteam name 4:** |
| *Example aspect 1* | *75* | *20* | *20* | *5* | *20* | *10* |
| *Example aspect 2* | *60* | *5* | *5* | *5* | *35* | *10* |
| 1. Completed **quality** work |  |  |  |  |  |  |
| 2. **Quantity** of participation—was willing to do a fair share of the work |  |  |  |  |  |  |
| 3. Was prepared in a **timely** fashion |  |  |  |  |  |  |
| 4. Dealt with difficulties effectively |  |  |  |  |  |  |
| 5. Open-minded, **respectful** when disagreeing |  |  |  |  |  |  |
| 6. Encouraged everyone to contribute ideas |  |  |  |  |  |  |
| 7. Showed concern for the feelings of other team members |  |  |  |  |  |  |
| 8. Acquired knowledge or skills as needed to meet requirements |  |  |  |  |  |  |
| 9. Made sure we understood each other |  |  |  |  |  |  |
| 10. Adapted to new ideas |  |  |  |  |  |  |
| 11. Was a positive influence in group discussion / decisions |  |  |  |  |  |  |
| 12. **Listened** well to team members |  |  |  |  |  |  |
| 13. Contributed **creative** ideas |  |  |  |  |  |  |
| 14. Gave constructive feedback |  |  |  |  |  |  |
| 15. Responded well to critical feedback |  |  |  |  |  |  |
| ***C) Overall Effectiveness***  ***Sum the total points given for each line (max of 1500!)*** |  |  |  |  |  |  |

Yes No Explain why in the space below.

In what ways did your subteam work well together?

How did you deal with issues or challenges you faced as a subteam?

My group functioned well together.

The group project was a valuable component of the course.

|  |  |  |  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- | --- | --- | --- |
| **Self & Peer Evaluation** | | **B) Fill in your name and your sub-teammates names. Divide the points across members—including yourself—as you think they deserve. Remember, everyone has strengths and weaknesses. Your scores should reflect this.** | | | | | |  |
| **A) How did your subteam perform on this aspect?  90-100: Truly exceptional (rare) 70-89: Okay, just minor/few issues  40-69: Lots of challenges  0-39: Utter failure (rare)   Total points you think your sub team deserves:** | | **Your name:** | **Subteam name 1:** | **Subteam name 2:** | **Subteam name 3:** | **Subteam name 4:** | check your math! | | |
| *Example aspect 1* | ***75*** | *20* | *20* | *5* | *20* | *10* | 75 | | |
| *Example aspect 2* | ***60*** | *5* | *5* | *5* | *35* | *10* | 60 | | |
| 1. Completed **quality** work |  |  |  |  |  |  | 0 | | |
| 2. **Quantity** of participation—was willing to do a fair share of the work |  |  |  |  |  |  | 0 | | |
| 3. Was prepared in a **timely** fashion |  |  |  |  |  |  | 0 | | |
| 4. Dealt with difficulties effectively |  |  |  |  |  |  | 0 | | |
| 5. Open-minded, **respectful** when disagreeing |  |  |  |  |  |  | 0 | | |
| 6. Encouraged everyone to contribute ideas |  |  |  |  |  |  | 0 | | |
| 7. Showed concern for the feelings of other team members |  |  |  |  |  |  | 0 | | |
| 8. Acquired knowledge or skills as needed to meet requirements |  |  |  |  |  |  | 0 | | |
| 9. Made sure we understood each other |  |  |  |  |  |  | 0 | | |
| 10. Adapted to new ideas |  |  |  |  |  |  | 0 | | |
| 11. Was a positive influence in group discussion / decisions |  |  |  |  |  |  | 0 | | |
| 12. **Listened** well to team members |  |  |  |  |  |  | 0 | | |
| 13. Contributed **creative** ideas |  |  |  |  |  |  | 0 | | |
| 14. Gave constructive feedback |  |  |  |  |  |  | 0 | | |
| 15. Responded well to critical feedback |  |  |  |  |  |  | 0 | | |
| ***C) Overall Effectiveness Sum the total points given for each line (max of 1500!)*** | **0** | **0** | **0** | **0** | **0** | **0** | 0 | | |
| 16. Would you want to work with this person again? (Yes/No) | | |  |  |  |  |  | | |
| 17. In what ways did your subteam work well together? | Your response here | | | | | | |  |
| 18. How did you deal with issues or challenges you faced as a subteam? | Your response here | | | | | | |  |