

Chapter 5: Analysis and Sustainability

Sustainability Indicators

Convener: Matthew Atwood

Discussion:

The National Academies of Science issued a DOE-funded report⁷ outlining environmental sustainability indicators for algal biofuels. They identified “concerns of high importance” (water, nutrients, land area, energy return on investment, and GHG emissions). Some companies are not taking enough interest in addressing these indicators, and the DOE is not doing enough to stress their importance within a commercial approach. There needs to be a more honest conversation at the beginning of the industry to look at these issues holistically.

Some companies choose their processes based on these sustainability indicators, for example using wastewater and closed PBR systems. Water availability is one of the largest concerns for the start of this industry. Sustainability has to be part of the conversation on commercialization. How should DOE apply it to their funding strategy as companies look at scaling?

DOE could facilitate companies in the navigation of regulatory concerns and permitting imposed by the EPA. There is no precedent for this scale of algae cultivation and so the regulatory framework is ambiguous and inconsistent. Permitting discharge points and other requirements under the National Environmental Protection Act (NEPA) are major commercialization hurdles. Because of these regulations, the reality is that the first commercial projects are not going to be in the U.S.

How would companies measure open air capture of CO₂ rather than flue gas CO₂ for purposes of mitigation credits?

In contrast to the idea of focusing on initial environmental concerns, DOE could also conduct trade-off analyses to avoid picking winners when companies could later meet sustainability issues in the long run even if they have trouble within the current regulatory framework. If algal biofuels are going to succeed, there needs to be a critical mass of companies that are able to succeed. There is an urgent need to replace fossil fuels, and other environment problems can be taken one at a time. The DOE needs to evaluate these metrics and vet them with the stakeholders, rather than dictating what sustainability means. How does DOE set these metrics?

There could be R&D systems out there that are flawed from the beginning. First generation biofuels (corn ethanol) presented environmental deal-killers, even though the concept was co-opted from the environmental community. The logistics were not evaluated in terms of the long run.

⁷ National Research Council. Sustainable Development of Algal Biofuels in the United States. Washington, DC: The National Academies Press, 2012.

What is the marketability of algal biofuels if it is not “green”?

Guiding Questions:

1. What is the time horizon for this topic or issue; will this impact algal biofuel production in the near, mid, or long term?
 - Sustainability indicators inherently are examining long-term impacts, but companies need to focus on these issues in the near term to ensure sustainability.
2. Has this topic been included in the National Algal Biofuel Technology Roadmap; and if not, should it be?
 - The Algae Roadmap does address some, but not all, of the sustainability indicators.
3. What is the BETO Algae Program role in furthering this topic or addressing this issue?
 - The DOE could facilitate a workshop to pull together the right sustainability metrics.

Poster:

High Importance

- Water
- Nutrients (CO₂)
- Land Area
- EROI
- GHG Lifecycle

Medium Importance

- GMOs
- Land use changes
- Air Quality emissions
- Pathogens from WW
- Algae release to environment
- Waste products
- Effects on local climate

1. Sustainability as honest part of the conversation/direction (especially water)
2. Support development of mid- and long-term goals with key metrics in these areas

GMO Algae and Environmental Assessments

Convener: Justin Flory

Discussion:

What are the regulatory barriers to genetically modified (GM) alga? GM algae biofuels will most likely overcome regulatory barriers more easily than GM foods, with regards to Environmental Assessments (EAs), because they will be combusted rather than consumed.

How will regulators test the possible consequences of GMO? The industry should think about this subject proactively and not wait until an industrial accident happens before the risks are discussed. What would be required in possible monitoring plans; what information will be needed to make sure you are still compliant? What do you monitor and test for, and how much will it cost/who will pay for it. What is DOE's role in this issue?

The USDA did not fund the outdoor release of GMO regulation proposal. The USDA could not decide if algae were a crop, and they are not interested in making determinations on hypothetical situations because their focus is on pre-commercialization. There is an outstanding need for a plan on how a company could show that their GMO strain is safe, or how to evaluate the potential risks of GMOs. The GMO algae regulations are a near term problem, and it is important to build a framework now so that it is easier for companies to implement a GMO.

There is also a need to develop health and safety guidelines for this industry, beyond environmental risk assessments, including the potential health consequences to humans exposed to GMO. There are different pathways for GMO to come into contact with humans such as skin contact and inhalation. Natural water bodies could possibly be contaminated by nearby GM algae, and the potential impact of this contamination is unknown. Determining how best to design mitigation solutions and where these mitigation barriers should be placed will result in more regulatory issues.

What agency will take the lead on GM algae, and who will coordinate this effort? DOE can influence this process, but it is not a regulatory agency. DOE can act as an active facilitator to clarify regulations, and help identify roles and responsibilities of the various agencies. DOE could potentially influence regulatory bodies by preparing a programmatic EA statement that would address these issues; not just for algae, but all GMO crops used for bioenergy. DOE could sponsor a study to assess impacts of the different regulatory policies, including regulatory impact scenarios on technoeconomic analysis. Government agencies will oversee the analysis of the regulatory process, but the industry will need to supply some of the information to perform the policy analysis. Businesses hate uncertainty, and so they would have a vested interest in informing the bounds of regulation, and a possible framework on how best to proceed. A standard federal regulatory framework will reduce uncertainties in the industry on this issue.

The Algae Roadmap should include information on how to test for GMOs and what equipment will be needed to detect modified genes. Science-based policy is sound policy. It is not the

agencies' place to choose industry winners or losers. GM strains will be used in the industry, and so these issues need to be addressed.

GM algae should be an element of the DOE Algae Roadmap. The Algae Program should think about the message they want to deliver in 5-10 years and then fund the research right now that would support their message.

Guiding Questions:

1. What is the time horizon for this topic or issue; will this impact algal biofuel production in the near, mid, or long term?
 - The GMO algae regulations are a near term problem, and it is important to build a framework now so that it is easier for companies to implement a GMO.
 - This issue requires near-term work that would have a long-term impact.
 - The most urgent need is reducing uncertainty. Fuels are in the future, but co-products produced with GMO algae are happening right now.
2. Has this topic been included in the National Algal Biofuel Technology Roadmap; and if not, should it be?
 - The Algae Roadmap should include information on how to test for GMOs, and what equipment will be needed to detect modified genes. Science-based policy is sound policy. It is not the agencies' place to choose industry winners or losers; GM strains will be used in the industry and these issues need to be addressed.
3. What is the BETO Algae Program role in furthering this topic or addressing this issue?
 - DOE can act as an active facilitator to clarify regulations and help identify roles and responsibilities of the various agencies.
 - The DOE could prepare a programmatic EA/EIS statement that would address these issues in order to help other agencies that are more regulatory – answering what are the genetic factors for testing, and how to develop a testing protocol to show that; monitoring and testing protocols for all organisms; standards. What are the environmental impacts, quantitative risk metrics for possible escape/impact if something did escape?
 - BETO should sponsor and coordinate research to address the uncertainties and help support sound science-based regulations. This research funding could fill knowledge gaps that would lead to clearer guidelines for deploying GMO algae in the field and identify the needs to transition GMO algae to commercial use.
 - DOE could write a white paper to identify a TEA of regulatory impacts.
 - BETO could develop a testbed facility to help quantify risks for different organisms.

Poster:

<u>ACTIVITY</u>	<u>TIME</u>
DOE → Proactive facilitator to: <ul style="list-style-type: none">• Streamline and clarify regulations• Define roles of various agencies• Regulatory impacts on TEA	Now! Short term
Sponsored Research regarding: <ul style="list-style-type: none">• Monitoring /testing protocols• Coordinated research in support of regulations	Now to Mid-term

LCA and TEA Development and Validation

Convener: Byard Wood

Discussion:

There need to be more interactions across the supply chain to among analysts in order to keep TEA/LCA models accurate and relevant. Partnerships and data sharing are key in this field, and the DOE could play a role in facilitating these relationships.

What are the real issues in using LCA/TEA? There is a need for data on feedstock costs and system performance. Predictions of algae production are extremely varied due to seasonal and environmental variable assumptions. Modelers in the public domain must use assumptions. The testbed projects could compile data, with corrections, to provide baseline data for modelers. Though estimating the net carbon/carbon balance would be difficult. There is also a need to refine scaling factors.

What are the highest uncertainties?

- How much productivity can be achieved?
- Lipid production
 - Can scan parameters and determine sensitivities
- Harvestability
- CO₂ delivery (flue gas)
- Determining the absolute maximum productivities
 - Maybe simplify (1 gal/acre/year)
 - Timeframes
- Strain
- Pond design

Is it possible for experimental system developers and model developers to communicate?

- Tornado plots might be the closest indicator; a large range that indicates an issue area
- GREET model may help bridge the communication
- Harmonization cost summary sheets
- ASPEN simulations
- Pathway dependence makes it difficult to re-simulate models
- Model transparency and accessibility
 - Plug and play models are extremely difficult
 - Models used: GREET, ASPEN Plus
 - TRANSIS (Wisconsin made it for solar) plug and play
 - Plug and play has issues; algae is complex - separations, heat transfer, biology
- Models might need to change based on outcomes in short timeframes

Guiding Questions:

1. What is the time horizon for this topic or issue; will this impact algal biofuel production in the near, mid, or long term?
 - Models are required in the near term (1-2 years).
2. Has this topic been included in the National Algal Biofuel Technology Roadmap; and if not, should it be?
 - The issue is in the Algae Roadmap, but DOE could make a prioritization of what are the most significant issues to be resolved.
3. What is the BETO Algae Program role in furthering this topic or addressing this issue?
 - DOE could provide a modeling toolset for individuals.
 - DOE can expand model integration; beginning an iterative process to determine how changes affect full loop.
 - There is a need for reverse engineering/sensitivity analyses, probability charts, and user interfaces, validations, facilitation of user groups.
 - Model accessibility is a need, but it may not be helpful for early TRLs.

Poster:

1. Short-term, 1-2 years
2. Roadmap, incorporate recent learnings
3. Expand integration of resource assessment, LCA and TEA, and continue model integration. Fund user-interface and model delivery. DOE's current role is going well. DOE can encourage and leverage their investments for modeling and testbeds.

Include in work to incorporate modeling of experimental work.