

**ARPA-E “Novel Bioreactors for Photosynthetic and  
Electrofuels-based Systems” Workshop  
March 27, 2012  
Washington, DC**

**Objective**

Identify technological whitespace, new research directions, and opportunities that could enable biofuel systems at-scale with the following characteristics:

1. Simplified downstream processing with reactor productivity greater than 2 g/L-hr
2. Efficient energy conversion in excess of 20%

**Agenda - Tuesday, March 27, 2012**

8:00 AM – 8:15 AM	Continental Breakfast
8:15 AM – 8:30 AM	Welcome and Opening Remarks (Dane Boysen, ARPA-E)
8:30 AM – 8:45 AM	Workshop Overview and Objectives (Rob Conrado, ARPA-E)
8:45 AM – 10:00 AM	Morning Introductions
10:00 AM – 10:15 AM	Break
10:15 AM – 12:00 PM	Morning Breakout Sessions
12:00 PM – 12:45 PM	Lunch and Breakout Reports
12:45 PM – 1:00 PM	Break
1:00 PM – 2:45 PM	Afternoon Breakout
2:45 PM – 3:00 PM	Coffee Break
3:00 PM – 3:30 PM	Breakout Summary and Wrap Up

**Ground Rules**

In the interest of time, the following topics will not be discussed:

1. Regulations, policies and subsidies
2. Genetic engineering of microbes
3. Demonstration projects with existing technologies

**Breakout Room Assignments**

AM Group 1 (VCS): *Photobioreactors*

AM Group 2 (Rockstar): *Electrobioreactors*

PM Group 1 (Rockstar): *Photobioreactors*

PM Group 2 (VCS): *Electrobioreactors*

## **Group 1: Photobioreactors**

### **ARPA-E's goals are to:**

1. Validate or improve our strawman metrics to be technically audacious but possible with sufficient stretching
2. Identify and understand potential new designs, materials, and fabrication processes that could result in dramatically more efficient and productive bioreactors 5-10 years from now.

### **AM Questions**

1. What approaches offer the greatest opportunity? Light manipulation? Increasing surface area to volume ratio? Improving material lifetime, stability, and reducing degradation?
2. What are the technical and economic barriers?
3. What novel/unique approaches could be enabling for this technology? What materials and engineering challenges, if overcome, would make this possible?
4. What is the ultimate optical system for collecting, manipulating, and delivering light to a photobioreactor? Within a reactor?
5. How would bioreactor designs change if this light delivery system was possible?
6. What is the power density needed, at each stage, to drive down the cost of these systems? What power density is possible if active cooling strategies are employed?
7. What is the optimal way to deliver and remove gases to these systems? Is it possible to achieve  $k_{La} > 250$  in this system?
8. What is the trade-off between high power density and available materials? Is there a way to integrate thermal management into optics/bioreactors without evaporating water?
9. Can these reactor systems be stably operated for week, months? How can one design to avoid contamination? What are the major contaminants?
10. Draw picture(s) of several promising reactor setups?

### **PM Questions**

1. Where is the ARPA-E white space? Are there new technologies that can put us on new learning curves? Long term, why might this be successful?
2. What are the high level techno-economic metrics necessary for commercial adoption? What fundamental materials and process performance metrics are necessary for success?
3. What can be done with \$3-4M, 2-3yrs? What is the largest prototype that could be built under this budget? Is there any value to funding seedlings <\$1M? What are appropriate targets 1-yr? 3-yrs?
4. What advances/breakthroughs (if any) have there been in the last 10 years that might make this possible now? What are the most promising classes of materials, optical systems, coatings, bioreactor designs?

## **Group 2: Electrobioreactors**

### **ARPA-E's goals are to:**

1. Validate or improve our strawman metrics to be technically audacious but possible with sufficient stretching
2. Identify and understand potential new designs, materials, and fabrication processes that could result in dramatically more efficient and productive bioreactors 5-10 years from now.

### **AM Questions**

1. What approaches offer the greatest opportunity? Electrode development? Microbial coatings? Increasing surface area to volume ratio? Improving material lifetime, stability, and reducing degradation?
2. What are the technical and economic barriers?
3. What novel/unique approaches could be enabling for this technology? What materials and engineering challenges, if overcome, would make this possible?
4. What is the ultimate system for delivering electricity to an electrobioreactor? Within an electrobioreactor?
5. How would bioreactor designs change if this electricity delivery system was possible?
6. What steps are necessary to deliver  $>1 \times 10^6$  Amps ( $>10$  BOE/day) into a bioreactor? What power electronics, materials, and thermal management strategies are necessary?
7. What is the optimal way to deliver and remove gases to these systems? Is it possible to achieve  $k_L a > 250$ ?
8. What is the trade-off between high power density and available materials? Is there a way to integrate thermal management into the electrical system/bioreactor without evaporating water?
9. Can these reactor systems be stably operated for week, months? How can one design to avoid contamination? What are the major contaminants?
10. Draw picture(s) of several promising reactor setups?

### **PM Questions**

1. Where is the ARPA-E white space? Are there new technologies that can put us on new learning curves? Long term, why might this be successful?
2. What are the high level techno-economic metrics necessary for commercial adoption? What fundamental materials and process performance metrics are necessary for success?
3. What can be done with \$3-4M, 2-3yrs? What is the largest prototype that could be built under this budget? Is there any value to funding seedlings  $< \$1M$ ? What are appropriate targets 1-yr? 3-yrs?
4. What advances/breakthroughs (if any) have there been in the last 10 years that might make this possible now? What are the most promising classes of materials, electrical systems, coatings, bioreactor designs?