# Breakout Session

## Siting and Resources

Ron Pate & Anelia Milbrandt

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# Goals and Barriers

- Goal:  Identify needs and role of technical R&D to address algal biofuel production siting & resource issues that fall within the mission space of DOE
- Barriers:
  - Many siting and resource issues and constraints deal with water supplies, land use, and policies that are outside the purview of DOE.
  - Algal biomass and biofuel production is immature, has many pathways, and lacks detailed requirements for siting & inputs
  - Lack of data and objective, detailed T-E assessment of algal biofuels production currently limits quantitative analyses
  - Recent drop in petroleum costs can have negative impact on national interest and support of algal biofuels
  - Algal biofuels is less mature and competes against energy/fuel alternatives with strong advocacy groups and subsidized support

# Technical R&D Needs & Goals

Key challenges are:

- Matching of land, climate/weather, and water resources for sustainable and affordable algae production (function of algal production system options)
- Sustainable and affordable nutrient supply and CO2 sourcing, delivery, and utilization for algae production for biofuels and other coproducts
- Lack of information on brackish groundwater and other resources

- Specific “subgoals” include:
  - Need for improved information, objective assessments, and related educational outreach
  - Need for human resource development & training;
- Strategies to achieve those goals:
  - strategic partnering with agencies and industries who are stakeholders on water, CO2 sourcing, and environmental issues related to algae production
  - R&D investments in assessments and technology development tied to improved CO2 and nutrient sourcing and utilization

# Appropriate DOE Role(s) & Investments Areas

- Areas where DOE mission interests and technologies play a role
  - Provide objective information, technical and economic assessments
  - Develop technologies, systems, and processes requirements and designs matched to various siting/resources options
  - Develop specific technologies and systems appropriate to:
    - Integration with wastewater treatment and/or CO2 emitter industries
    - Smaller scale, distributed vs. larger scale centralized options
    - Synergistic co-location and integration of algal biofuels & coproducts with other product and service industries and market infrastructures
    - Deal with salt management, energy balance, water & nutrient reuse
- Leverage and apply eco-system management techniques, resources and skills to algal biofuels development
- Partner strategically to leverage waste streams (wastewater, CO2, other nutrients) and exploit needs/opportunities for co-location and integration with other industries, infrastructures, and markets
- Partner strategically to enable and facilitate human resource development and address the need for education and training of needed scientists, engineers, and environmental specialists to support development of algal-based biofuels and co-products industries

# Interfaces

- Siting and Resources are cross-cutting issues for most (all?) other breakout groups
  - Very close linkage with utilities and sources breakout
  - Significant interdependencies with algal biology, cultivation systems, policy/regulatory, fuels and co-products breakouts

# Observations and Contentious/Controversial Topics

- Observation:  Many siting & resource issues are not within the mission space of DOE
- Observation & Contentious Issue:  Perception that algae is faced with up-hill battle against other competing biofuel/energy-related interests that are well-funded, subsidized, and have strong advocacy
- Observation:  Development of economically viable algae biofuels will likely involve integration w/ wastewater treatment
- Controversy:  Debate & uncertainty about the relative role of distributed and decentralized algae production vs. large centralized production
- Controversy:  Cost, performance, commercial viability and scale-up potential of inland vs. coastal vs. open ocean siting and operation of algae production
- Controversy:  Debate about the relative importance and constraints (cost, availability) of CO2 vs. other nutrients (N,P,K) for national scale-up of algae biofuel production

# Findings & Recommendations

- Identified challenges tied to siting & resource issues and needs:
  - Nutrient availability, flows, balances
  - Cost of resources (use and compliance w/ discharges)
  - Achieving high CO2 conversion efficiency in algal production
  - Regional variability of sites and resources and need for improved data and analyses of systems performance and impacts
  - Need for Educational Outreach and training information and programs for human resource development (algae specialists, engineers, environmental scientists, etc.)

# Findings & Recommendations

- Need for improved data and information to support modeling assessment of resources, siting, and related systems performance for algal production
- Need for improved technical, economic, and environmental assessments with credible information
- Need to identify and assess opportunities for synergistic co-location of distributed algal production and biorefining with other industries that can provide required inputs (water, CO2, nutrients) and markets for co-products & co-services

# Findings & Recommendations

- Need to develop distributed system approaches and assess the tradeoffs of small distributed vs. large centralized algal production (w/ regional differences)
  - Distributed systems must provide significant biofuel/bioenergy benefit in aggregate
  - Cost/Benefit tradeoffs and potential for system replication in different geographic and climate regions
- Technical R&D needed on flow-through algal production systems that can be integrated with eutrophied water clean-up, wastewater treatment, nutrient capture, and biofuel production
- Technical R&D on options for more affordable $CO_2$ capture/utilization for algal biomass production and more affordable capture and re-use of water and nutrients … including co-location, integration, and co-generation opportunities & requirements

# Findings & Recommendations

- Need to strategically partner with agencies(federal, state, local) and industries (water-related and biofuel end-users) to establish constituency for algae R&D and applications development
  - Joint Studies / Assessments
  - Pilot projects
- Need to develop and disseminate objective authoritative information for other agencies, stakeholders and general public

# Findings & Recommendations

- Need for better assessment and characterization of non-fresh water resources and their suitability for growing algae and impact on operations
- Observation that algae siting and resource issues have heavy intersection with environmental resource management, water resources management, and associated regulatory policies
- Recognition that water loss and salt management are issues that must be better assessed … specific technical R&D within DOE mission space includes reduced water loss algae production systems and lower energy water desalination technology & systems

# Back-up: Flip Chart Notes - 1

- Where does DOE Technology play a role?
  - Technical & Economic Assessments
  - System requirements and designs matched to various siting/resources options
  - Develop specific technologies and systems appropriate to:
    - Integration with wastewater treatment and/or CO2 emitter industries
    - Smaller scale, distributed vs. larger scale centralized options
    - Synergistic co-location and integration of algal biofuels & coproducts with other product and service industries and market infrastructures
- Eco-system management resources and skills are needed and should be applied
- Consider output streams and needs/opportunities for co-location
- Factor in environmental implications of discharges
- Algal residue use and shelf life… and the need for proximity of end-use

# Back-up: Flip Chart Notes - 2

- Need integration of algal production w/ other operations and provision of ecosystem management and services
- CO2 sourcing… co-location with emitters and/or with pipeline infrastructure
- Policy issues … permitting
- Cost and implication of CO2 capture and transport… will be a BIG FACTOR !

# Back-up: Flip Chart Notes - 3

- Nutrient sourcing & balances: where are nutrients (N,P,K) coming from? Where do they go and what impact do they have? Options for nutrient capture & reuse for algal production vs loss to the environment
- NPK loaded water going into waterways… opportunity for algae production and source of cost savings: $200/kg P, $10/kg N (cost numbers from Walter Adey?)
- Policy issue & cost incentive: Nutrient loading reduction in wastewaters and natural waters combined with NPK capture and reuse

# Back-up: Flip Chart Notes - 4

- Apply “Industrial Ecology” principles… match system and process outputs with inputs needed elsewhere… view as closed ecological system
- Need: Look at nutrient requirements for major build-up of algal biofuels production (NPK)
- Energy balance of systems and processes also
- Water capture & reuse needs to be maximized
- Algal blow-down ratio will probably be ~10:1, based on experience with power plants… will need to manage for anti-fouling… if water treatment is required, will be an issue for both cost and energy balance

# Back-up: Flip Chart Notes - 5

- Consider pre-commercial pilot products. Need to ID where, what, with whom, how to enable?
- Barriers:
  - Affordably supplying & maintaining (reuse) nutrients
- Opportunities:
  - Avoid costs for required (mandated clean-up) nutrient load reduction in water supplies
  - Regional examples of nutrient loaded water bodies:
    - Chesapeake Bay
    - Klamath River
    - Salton Sea

# Back-up: Flip Chart Notes - 6

- Need to solicit and evaluate distributed problems/opportunities that could be approached in a collective way for algal biofuels w/ strategic funding support from DOE
- Photoautotrophic vs. heterotrophic/mixotrophic algal biomass production ? … need to consider all
- Factor in co-location of algal biomass starch production with EtOH biofuel production plants
- Need: closer look at challenges & solutions for interfacing CO2 sources with algae production
  - Sparging of CO2 into ponds could be a potential safety problem due to CO2 accumulation… needs consideration
  - Aqueous transfer of CO2 required for efficient utilization at large scale-up

# Back-up: Flip Chart Notes - 7

- High pH operation of open ponds for algae production and improved CO2 use… regulatory problems?
- CO2 uptake efficiency tends to be low in ponds
- CO2-O2 balance and gas management is a key issue for algae production in closed systems
- Algae mat cultivation via flow-through systems (e.g. Algae Turf Scrubber) can improve CO2 use efficiency
- Alternative CO2 utilization approach: Bicarbonate production and distribution to algae facilities as solid material
  - Study done by TVA on bicarbonate scrubber for CO2

# Back-up: Flip Chart Notes - 8

- Allocation of R&D funding for addressing siting and input resource issues… criteria should include:
  - Ability for sustainable operation & replication… not unique one of a kind
  - Suitability for distributed application in different geo-location conditions and regions of the country
  - Nearness to markets for products (fuels & other)
  - Nearness to key inputs (land, water, CO2) without adverse use impacts
  - Leverage of existing facilities & piggybacking on performance of other services: water treatment, CO2 capture/reuse from power plants, etc.
  - Integration that allows co-generation, use of waste heat, etc.
- Partnering & stakeholder group alliances, connected to water in particular (on a watershed scale)
  - EPA, USDA, BLM, Forest Service, State Agencies
- Public-Private Industry-University partnerships needed to attack problems and challenges to algae biofuels in a more integrated way

# Back-up: Flip Chart Notes - 9

- Technical Needs:
  - Quantitative assessments to better understand systems and implications of projects
  - Linkage to state and federal regulations… e.g., wastewater and nutrient discharge, etc.
  - Permitting requirements for algal production tied to wastewater treatment
  - Pros & cons and assessments of open ocean algae cultivation…
    - Technical, economic, and environmental/regulatory viability?
    - Risks to adverse weather and marine environment?
    - Look into past assessments by Gas Research Institute, Japanese, etc.

# Back-up: Flip Chart Notes - 10

- Issue: Salt concentration management in algal biomass growth media and management of high salt content waste streams:
  - How, what, where, & cost of dealing with salt build up?
  - Implications for use of non-fresh water sources and make-up water needs that could require fresh water
  - Treatment options/requirements and the energy implications
- Limitation & need: Education and training of engineers and enviromental scientists
  - Human capital development
  - Essential need for technical training programs & materials
  - Good training materials and teachers are lacking/sparce

# Back-up: Flip Chart Notes - 11

- Saline & brackish water resource information is limited or lacking… needs investment (e.g., funding support for USGS, etc.)
- Need & Criteria for assessments:
  - National algae biofuel production capacity potential? … can it scale up to be significant for meeting national fuel needs?
  - What scale of individual systems are needed?
    - Multiple, smaller, distributed systems that can be regionally and nationally significant in aggregate… tied to other industries & services
    - Fewer, larger, centralized systems
  - Co-products and related issues:
    - Affordable co-product generation and access to co-product markets
    - Matching of co-product volumes to available markets
  - Need to assess technical approaches and systems tradeoffs for the all of the above

# Back-up: Flip Chart Notes - 12

- Need: Investigation of sites and opportunities to provide synergies for algae production for fuels/co-products via integration of
  - Key sources of water, CO2, & NPK nutrients
  - Opportunities for Co-services & Co-Generation
  - Convenient access to markets (fuels & co-products)
  - Co-services include carbon & NPK capture/reuse
  - Paradigm shift: toward more decentralized system solutions
- R&D need: Improved flow-through wastewater treatment and nutrient removal with algae (polyculture) biofuel feedstock production

# Back-up: Flip Chart Notes - 13

- Observation and point of concern: Algae biofuels faces institutional barriers because of competition from other advocacy groups and entities (industry and agencies) that are currently heavily supported with direct funding or incentives (e.g., subsidies, tax credits, etc.)
  - Conventional fuels and energy
  - Agriculture & Forestry
  - Other biofuels (starch & cellulosic EtOH, etc.)
- Downturn in petroleum costs may reduce interest
- Future progress with algal biofuels will depend on:
  - Political will and R&D funding and incentives in the face of lower near-term costs of more conventional alternatives
  - Carbon emissions concerns and role that algae can play

# Back-up: Flip Chart Notes - 14

- Repeat Emphasis: Need to Align and Leverage Strategic Relationships/Partnerships that bring together key stakeholders:
  - Wastewater treatment industry and municipalities
    - WEF, AwwRF, etc.
  - Electric utilities and other industrial CO2 emitters
  - Federal agencies, other organizations & user groups
    - DOE, DOD, EPA, DOI, US Bureau of Reclaimation, BLM, USGS, USDA, Fish & Wildlife, Forestry Service, NSF, State & Local Governments, Aviation Industry, Fuel Industry, etc.
    - Algae biomass & biofuels industry associations
- Example of Biomass R&D Board… need to leverage
  - Government interagency group
  - Includes Five Working Groups
  - Established to inform DOE/EERE-OBP
- Recommendation: Have Biomass R&D Board include algae biofuels into their thinking and work

# Back-up: Flip Chart Notes - 15

- Review of main findings & results
  - Algae biofuels faces challenges with
    - Availability and cost of resources
      - Land, Water, CO2, other nutrients (NPK)
    - CO2 sourcing and efficient utilization with algae
  - Regional variations of suitable siting and resources needs better quantification
    - Improved/updated siting & resource data
    - Improved assessments (GIS and other analysis) tied to appropriate Techno-Economic Models
    - Identification and assessment of distributed co-location opportunities and synergies with other industries and markets for co-products/co-services from algae

# Back-up: Flip Chart Notes - 16

- Review of main findings & results … continued
  - Wastewater treatment, in particular, offers strong synergistic opportunities for algae
  - Recommend that DOE partner with EPA and others tied to wastewater treatment to do studies and pilot projects linked to algal biofuels production
  - DOE should enable/facilitate the development and provision of clear and consistent information on algal biofuels based on objective and credible data and technical and economic assessments
    - Educational outreach
    - Strategic partnering and communications
  - DOE should help address the need for education, training, and human resource development to support the development of algae biofuels, co-products, and related environmental management

# Back-up: Flip Chart Notes - 17

- Areas of Intersection with Day-2 Breakout Session on Utilities and Sourcing
  - Wastewater for non-fresh water and NPK
    - Water treatment utilities
    - Eutrophied water in natural systems
  - Industrial sources of $CO_2$
    - Fossil fired electric power plants
    - Fermentation industries (EtOH plants, etc.)
    - Cement and ammonia plants
  - Agricultural nutrient (NPK) sources & markets
    - Field run-off
    - CAFO (dairies, feedlots, etc.)
    - Nutrient/fertilizer markets
  - Integration of algae production and nutrient capture/reuse with wastewater treatment and/or power utilities operations

# Back-up: Flip Chart Notes - 18

- Areas of Intersection with Day-2 Breakout Session on Utilities and Sourcing … continued
  - Need for more detailed resource assessment and availability for potential algae production
    - Non-fresh water resources
    - CO2 sourcing
    - Nutrients (N, P, K)
  - Need for identification and assessment of algae biomass co-products and markets
    - Biofuel feedstock
    - Nutrient recovery & reuse
    - Water treatment services (tied to nutrient recovery)
    - Animal feed
    - Chemicals & materials
    - Other energy (e.g., combined heat & power)
    - Carbon capture & reuse service
  - Need for Integrated Resources, Infrastructure, and Markets Analysis in support of algae biomass production for biofuels and other products