University of Connecticut, School of Engineering
Joule Fellows Program 2012
Biomass Pyrolysis Lesson Plan

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Big Ideas:

- The National Science Foundation emphasizes the increasing interest in biofuels production and lignocellulose conversion, highly prioritizing research on biomass pyrolysis [1].
- Biological systems interact, and these systems and their interactions possess complex properties. [2]

Essential questions:

- What factors govern energy capture, storage and transfer between producers and consumers in a terrestrial ecosystem?
- How can energy capture and storage by a producer be measured?
- How is the energy stored in biomass transformed during catalytic biomass pyrolysis?

Background:

Solar energy is necessary for life on Earth. Organisms known as producers or autotrophs capture solar energy and convert it to the chemical energy that is stored in the products of photosynthesis. The products of photosynthesis include energy-rich organic compounds. These organic compounds create **biomass**. On land, plants are the major producers of an ecosystem. Plants can use this biomass as a fuel source so they can meet their own work requirements. Plants can also use the biomass as material to store fuel for future use or to use as building material for their own growth. Gross productivity describes the total quantity of energy captured by a plant in a determined amount of time. In terms of using plant material as a source of biomass for alternative fuel production, the net productivity is of interest. The net productivity represents the amount of energy captured and stored by a plant. Thus, the stored chemical energy becomes available to other members of the community by way of consumption by consumers or decomposition by decomposers. In alternative energy interests, biomass may be converted to useful products such as bio-oils, gases or char. This conversion may occur during pyrolysis which is the thermal decomposition of organic material at elevated temperatures (600C) in the absence of oxygen.

Learning objectives:

Students in the 2012-13 Advanced Research Mentorship class at Glastonbury High School will be able to do the following:

1. Define and describe catalytic biomass pyrolysis after a visit and presentation by UConn graduate student and Joule Buddy, Shoucheng Du and/or Dr. George Bollas, Assistant Professor, Department of Chemical, Materials & Biomolecular Engineering, University of Connecticut.
2. Explain community energy dynamics including energy flow, net primary productivity and primary and secondary producers/consumers
3. Design and construct a diagram to model energy capture and flow through a plant in a terrestrial community.
4. Design and conduct an investigation to sample the biomass of Wisconsin Fast Plants [3] early in the plant's life cycle and then again later in the life cycle.
5. Calculate the average mass of biomass added per plant over the 3-4 week period of growth.
6. Calculate the net primary productivity (kcal) per plant per day.
7. Dry and pulverize the Wisconsin Fast plants to create biomass that can be pyrolyzed (by Shoucheng Du) in the conical spouted bed reactor at Center for Clean Energy Engineering (C2E2) on the Depot Campus of The University of Connecticut.
8. Visit C2E2 in order to observe Shoucheng Du perform catalytic pyrolysis of the Wisconsin Fast Plant biomass students obtained in laboratory investigation at Glastonbury High School.
9. Tour C2E2 to learn about alternative energy engineering opportunities.

Skill development that will be addressed in this lesson

- Growing and maintaining plants through an entire life cycle from seed to seed.
- Keeping and maintaining accurate records of observations and measurements of organisms.
- Posing a scientific question regarding energy dynamics, capture and storage.
- Measuring small mass quantities directly or by combining a number of low mass objects and taking an average
- Constructing an energy flow diagram
- Organizing a work-flow timeline for the overall project
- Reporting findings and conclusions in a peer-reviewed environment

Assessment

Students will emulate communication modes employed by the scientific community. Students will communicate their understanding of concepts learned and skills acquired in this lesson by creating and sharing a scientific poster in a simulated poster session in the Glastonbury High School classroom. The class will be divided into two groups, authors and peer reviewers. The authors will stand in front of their poster and answer questions from peer reviewers about the work. The peer reviewers will use a rubric to evaluate the poster after asking the presenter a number of questions. Authors receive diverse feedback about his/her work and presentation skills. Before the instructor assigns a final grade, the author is encouraged to revise his/her poster based upon feedback from peer reviewers. The two groups (authors and peer reviewers) will switch roles for the second half of the poster session.

Proposed timeline for lesson plan

Approximately eight to ten 45-minute class periods over a 2-3 month span will be necessary to complete all learning objectives listed above. The project is expected to begin in September and will conclude in November of 2012.

References

[1] J Regalbuto, An NSF perspective on next generation hydrocarbon biorefineries, Computers & Chemical Engineering. 34 (2010) 1393-1396

[2] The College Board, AP Biology Investigative Labs: An Inquiry –Based Approach, Teacher Manual

[3] Williams, Paul H., and Curtis B. Hill. Rapid-cycling populations of *brassica*. *Science* 232, no 4756 (June 1986): 1385:1389

*Lesson idea adapted from The College Board, AP Biology Investigative Labs: An Inquiry-Based Approach, Investigation 10, Energy Dynamics.