U.S. DEPARTMENT OF ENERGY | Energy Efficiency & Renewable Energy

Biomass Basics: The Sustainability, Climate Change, and Bioenergy Nexus

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Agenda

- Overview of Bioenergy
- Biomass to Biofuels Life Cycle
- Importance of Bioenergy
- Bioenergy and Climate Change
- 2016 BioenergizeME Infographic Challenge

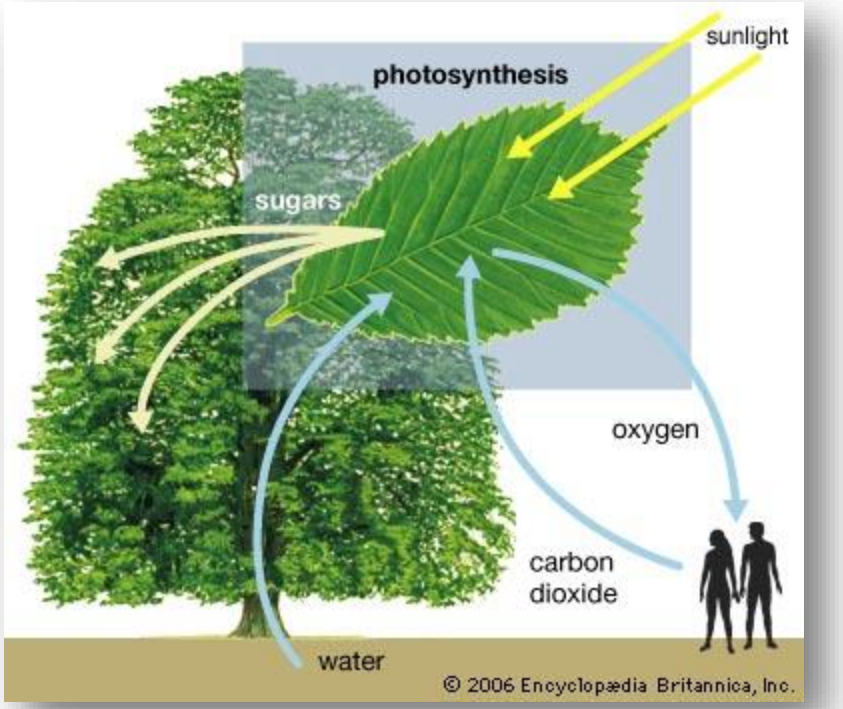
What is Bioenergy?

Bioenergy is a form of renewable energy derived from biomass to generate heat and electricity (biopower), biofuels (transportation fuels), biochemicals, and other energy-related bioproducts that are produced from biomass.

Photos courtesy of USDA and NREL

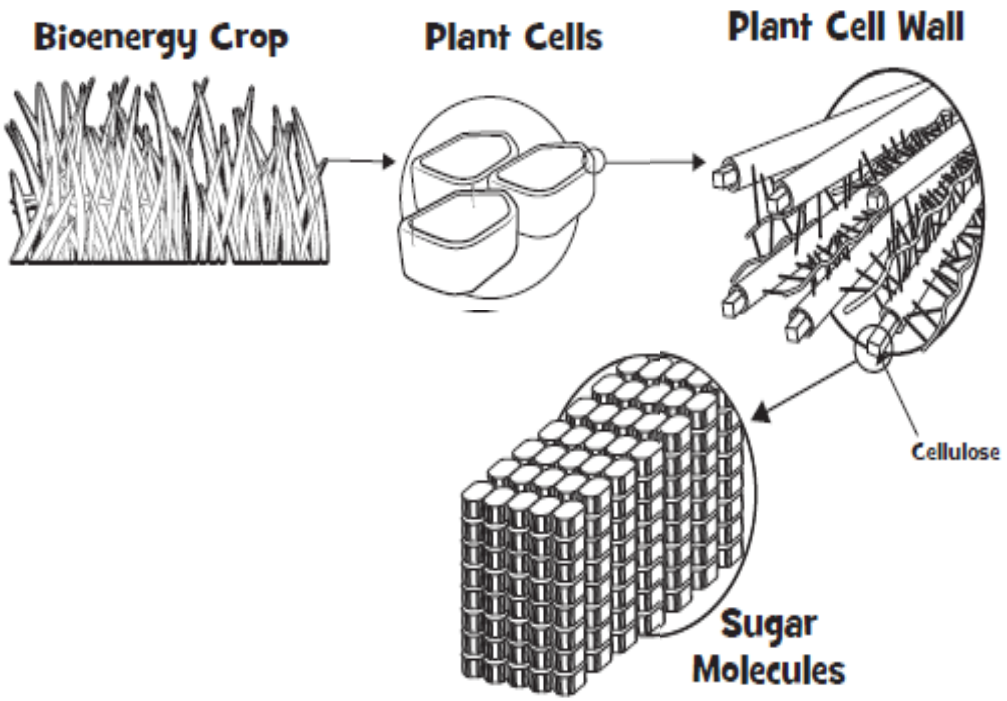
What is Biomass?

Biomass: any organic (living/once living) material that has stored sunlight in the form of chemical energy (sugars like cellulose)



Photosynthesis = Light + water + carbon dioxide → sugars

What is Biomass?



Cellulose is the main component of plant cell walls. Made from sugar molecules, the **cellulose serves as a structural frame** (steel beams) for the cell wall.

Sustainable Feedstocks

Agricultural Residues: Plant parts left in the field after harvest are commonly called agricultural residues. This plant matter and secondary residues like manure and food processing wastes can be useful feedstocks. *Photo: iStock/6710081*

Forest Residues: Leftover wood or plant material from logging operations, forest management, and land-clearing are available feedstock resources. Secondary residues like mill wastes supplement this category. *Photo: NREL/04190*

Energy Crops: Fast-growing trees and perennial grasses are specifically grown for energy uses. Trees and perennial grasses can often be grown on land that is less suitable for conventional crops and can stabilize the soil. These crops have high biomass production potential. *Photo: iStock/4373820*

Algae: Many macroalgae, microalgae, and cyanobacteria carry out photosynthesis to drive rapid biomass growth. Algae biomass can contain high levels of oil, making it a promising feedstock for biofuels, including renewable gasoline, diesel, and jet fuel. *Photo: NREL/01726, 19549*

Municipal Solid Waste: MSW has potential as a gasifier feedstock. Its near-term availability and pre-existing collection and transport infrastructure make it a particularly attractive resource. *Photo: iStock/14910937*

What can Biomass Produce?

POWER AND HEAT

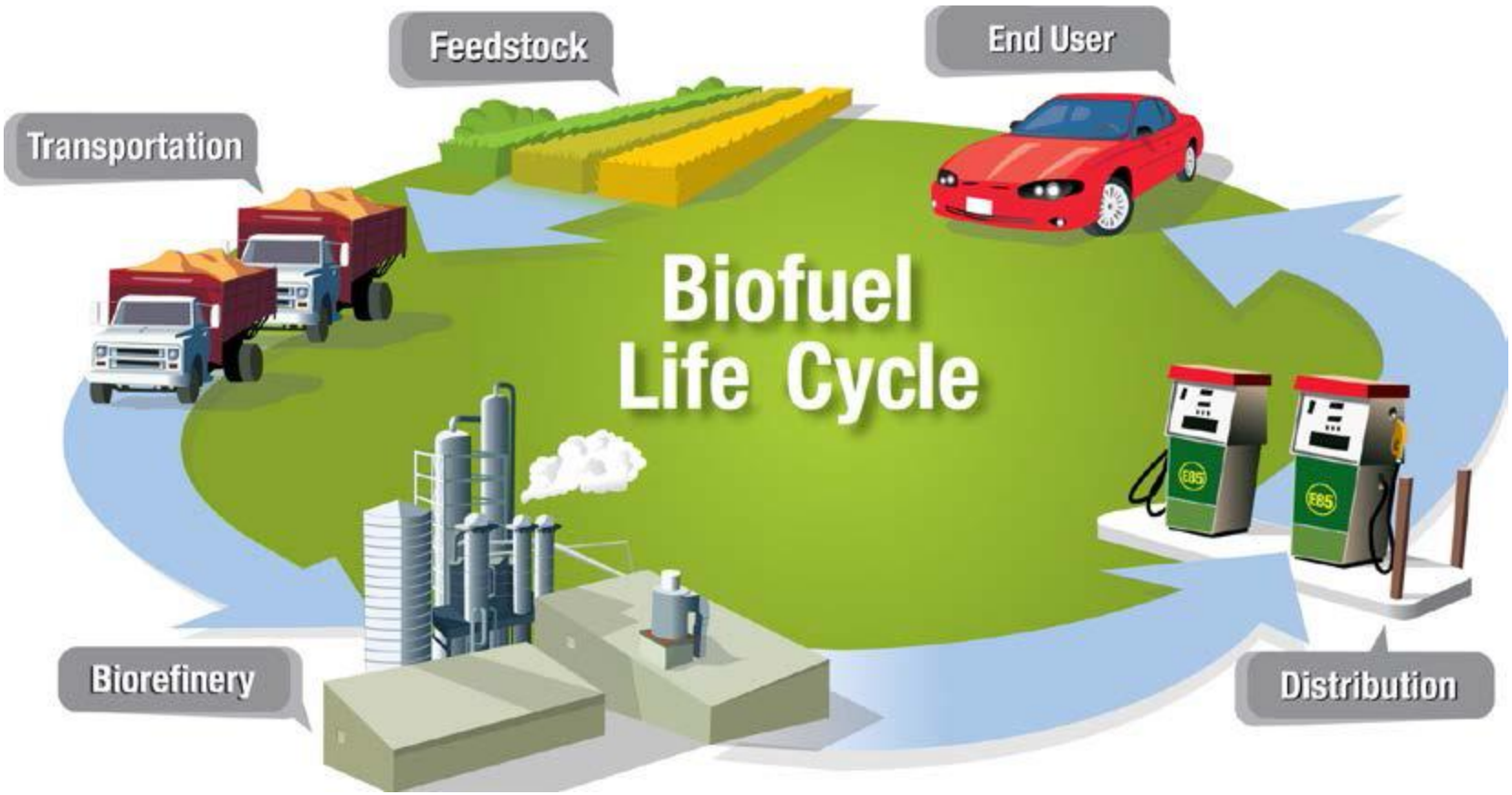
FUELS

BIOMASS

PRODUCTS

Photos courtesy of NREL

How Biomass is Turned into Bioenergy



Feedstock Supply and Transport

Plant-based renewable biomass is harvested, chopped into small pieces, or rolled into bales. Processed biomass is transported to a storage site at a biofuel plant or biorefinery.

Pictures courtesy of AGCO, Auburn University, INL

Feedstock to Biorefinery

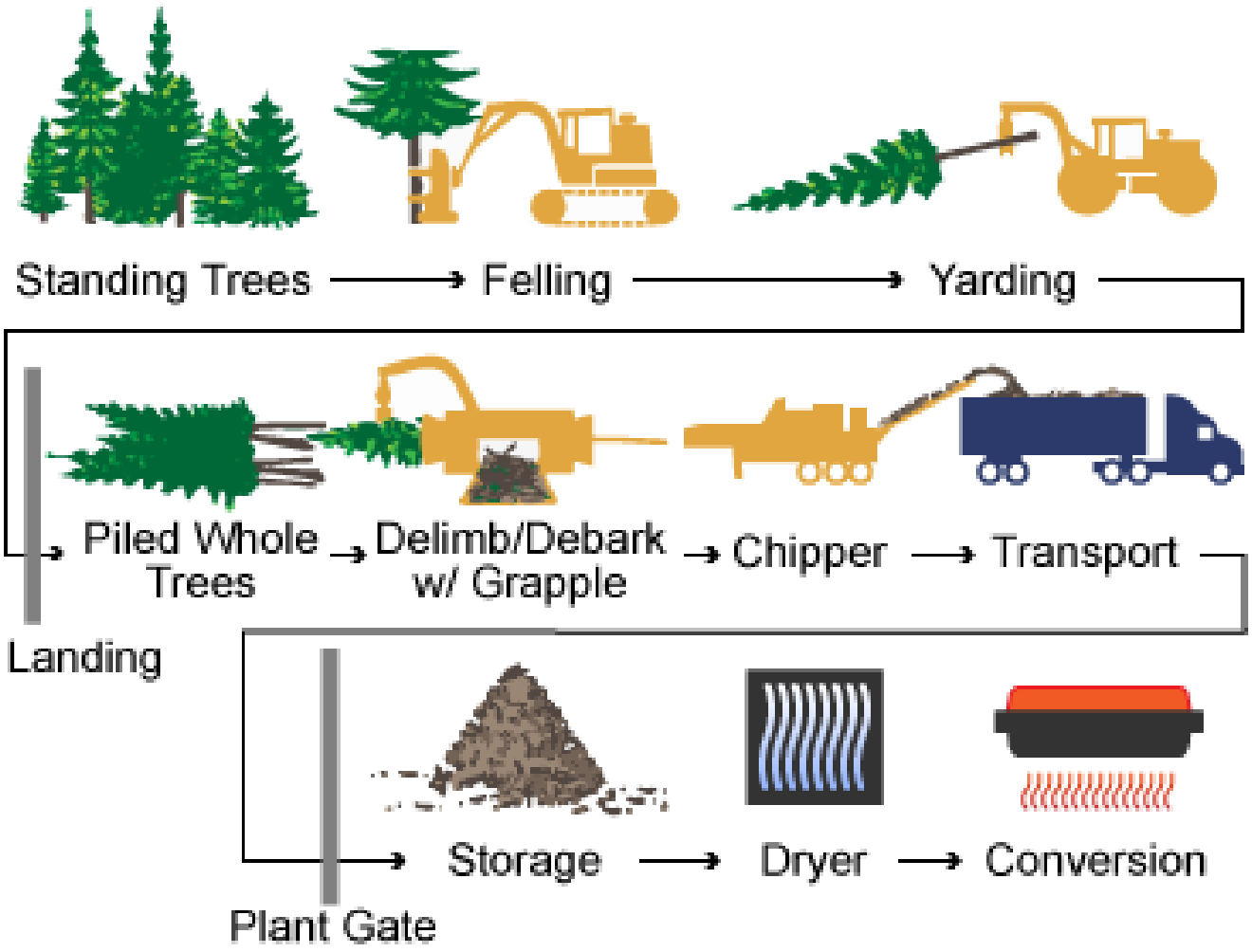


Photo Credit: INL

How Does a Biorefinery Operate?

Processed biomass is treated with heat and chemicals

Enzymes break down cellulose into sugar

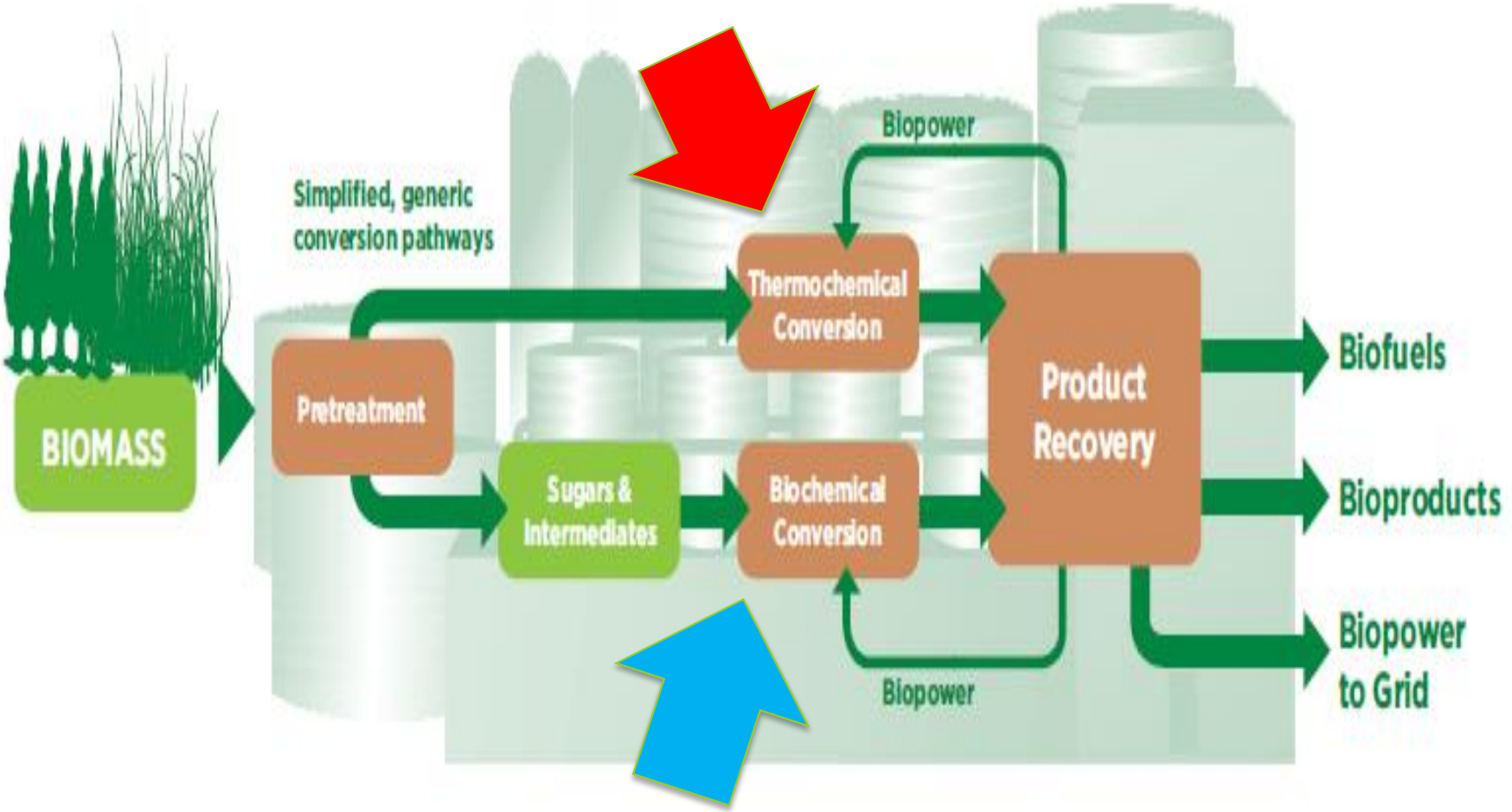
Biorefinery

Microbes ferment sugar into ethanol

Ethanol is purified and prepared for distribution

Photos courtesy of NREL

At the Biorefinery: Step-by-Step Process



Distribution: Fuels Travel to Consumers

Where can Biofuels be Used?

Photos courtesy of NREL

What are the Benefits of Bioenergy?

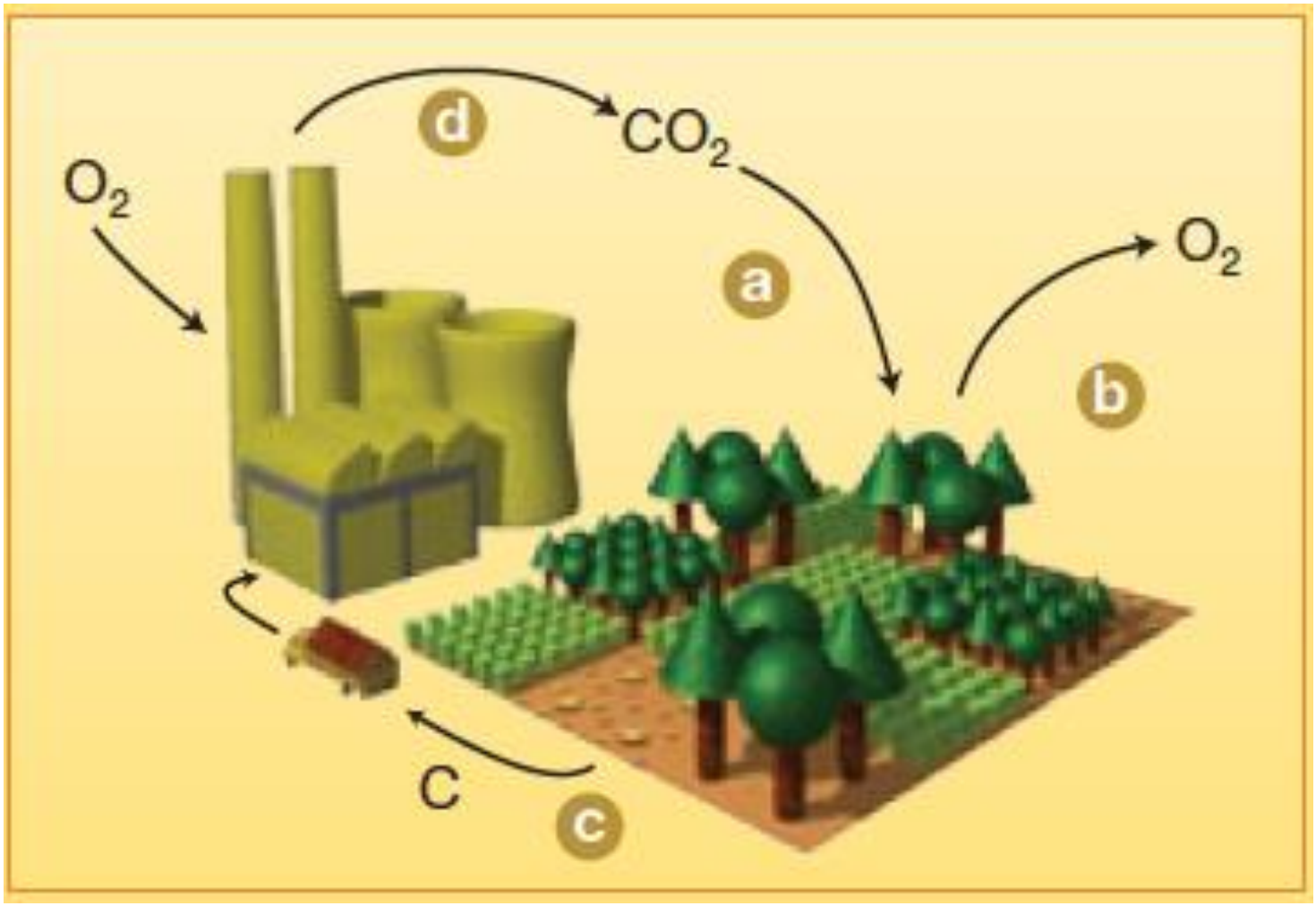
- Improved national energy security
  - Biofuels can be grown, harvested, and produced domestically
- Increased economic growth
  - Biofuels create domestic jobs and increase economic activity
- Broad-based environmental benefits
  - Reduce greenhouse gas (GHG) emissions and increase land conservation

Bioenergy and Climate Change

- Bioenergy offers significant potential to mitigate climate change by reducing life-cycle greenhouse gas (GHG) emissions relative to fossil fuels.

- Although producing and burning biomass-based fuel releases carbon dioxide, biomass absorbs carbon dioxide from the atmosphere as it grows.

- In contrast, using fossil fuels releases carbon that has been sequestered for millennia, adding significant volumes of newly released carbon to the atmosphere. The burning of fossil fuels causes a net positive increase in atmospheric carbon.



Source: IEA Task 38 FAQ

Sustainability Considerations of Bioenergy

Climate Change and Air Quality

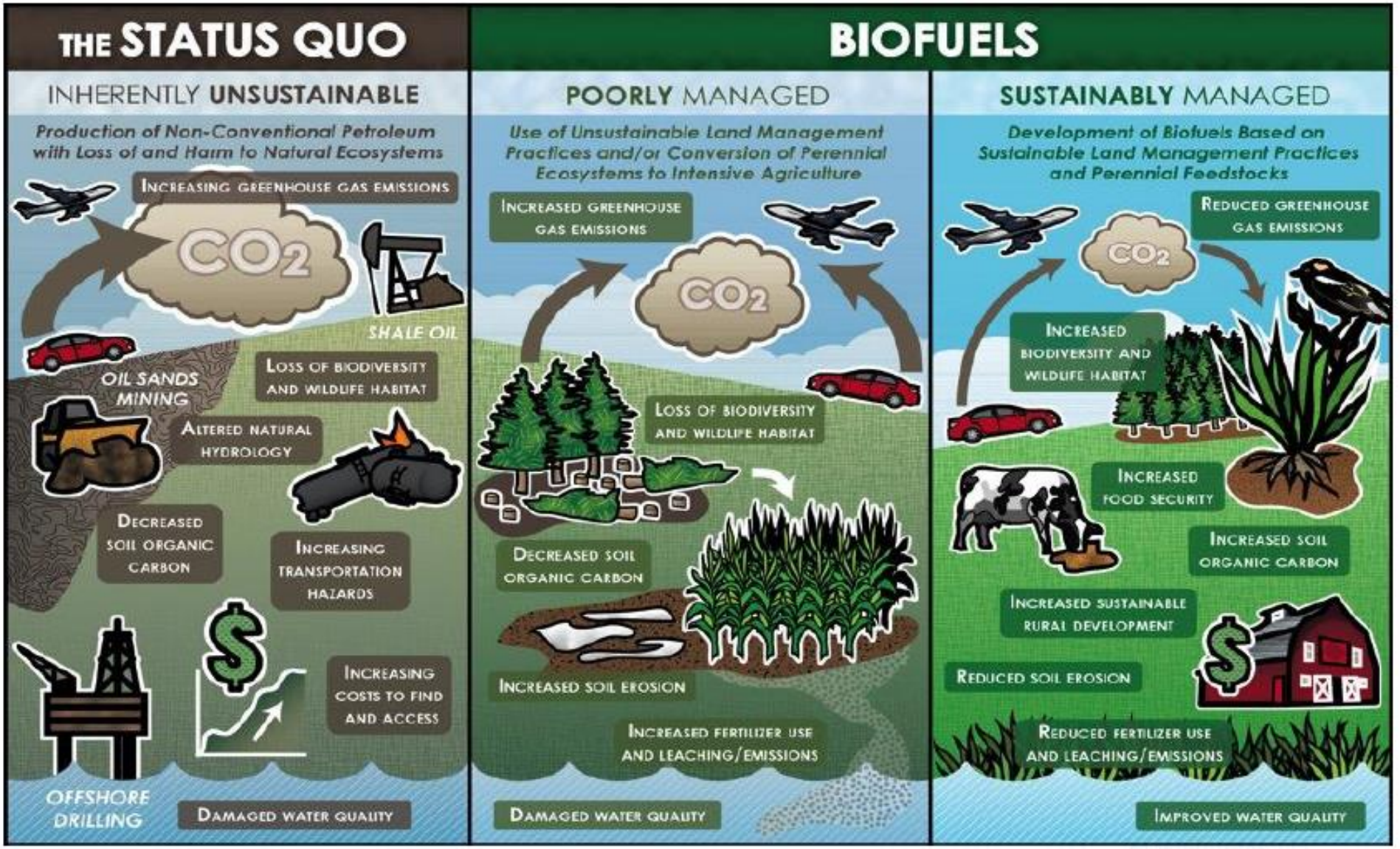
Soil Quality

Land Use and Productivity

Water Quantity and Quality

Biological Diversity

Management of Biofuels can Support Goals



Dale Bruce et al. (2014) *Environmental Science & Technology* 48: 7200-7203.

OAK RIDGE National Laboratory

For more information, please watch: [DOE-BETO WEBINAR: BIOFUELS FOR THE ENVIRONMENT AND COMMUNITIES]

Obama Administration's Climate Action Plan & Bioenergy

- 17% CO2 reduction by 2020 from 2005 levels.
- Outlined a strategy that focuses in part on Building a 21st Century Transportation Sector and Developing and Deploying Advanced Transportation Technologies.
- Promoted partnerships between the private and public sectors to deploy cleaner fuels.

Summary

- Bioenergy has the potential to deliver large GHG savings if replacing fossil fuel-based energy sources, **IF** sustainable management practices are used.

- Bioenergy is an important mitigation strategy of the US Climate Action Plan to address climate change, as well as an important topic of discussion in international forums.

- The challenge posed to is how to improve the awareness of governments and society of the potential benefits of bioenergy while limiting the negative impacts.

BioenergizeME Infographic Challenge

Purpose

- Provide an engaging virtual venue for 9-12th-grade participants to gain foundational knowledge about bioenergy and to educate others about what they have learned.
- Their enhanced energy literacy will enable them to be better consumers of energy information and to dispel energy myths they encounter in the media and from other sources.

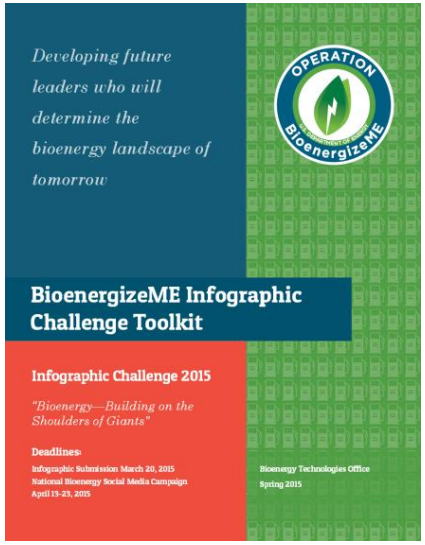
Challenge Activities

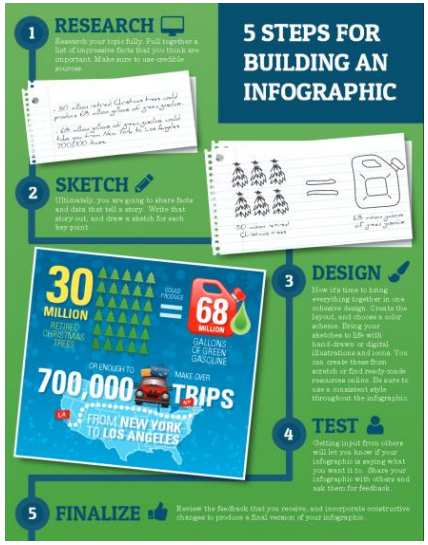
- Student teams research bioenergy topics and report their findings in an infographic.
- Selected teams promote their infographic in an 11-day social media challenge.
- Winners are selected in two categories: quality of infographic and effectiveness of social media campaign.

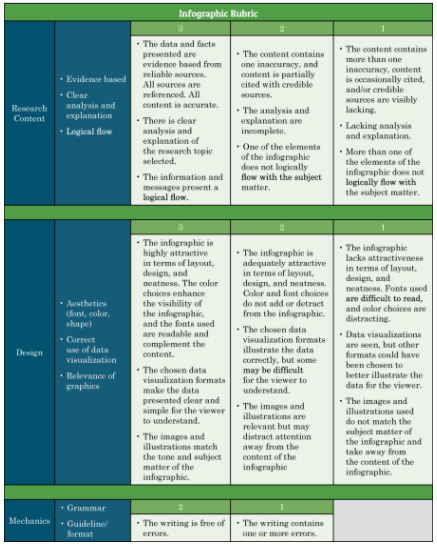
Classroom-Ready Support Materials!

BioenergizeME resources provided

- Challenge rules, research topics and prompts, evaluation rubrics
- Guidance on doing research, creating infographics, and developing a social media campaign
- Research references, search phrases, and links to government-funded publications
- Easy for educators and fun for students!







2016 Challenge Topic Areas

1. Bioenergy History
2. Workforce and Education
3. Science and Technology
4. **Environmental Impacts**
   - **Compare/contrast the environmental impacts of bioenergy and fossil energy, such as greenhouse gas emissions, water usage, energy balance, soil productivity, biodiversity, etc.**
   - **Explore the role of our current transportation system as it relates to energy consumption, environmental conditions, and the national/global economy. Is it sustainable?**
   - **How would you define sustainable transportation? How can sustainable bioenergy technologies help meet sustainable transportation goals?**
   - **How are researchers and scientists addressing concerns about the potential environmental impacts of bioenergy in the future?**

Spring 2015 Finalists

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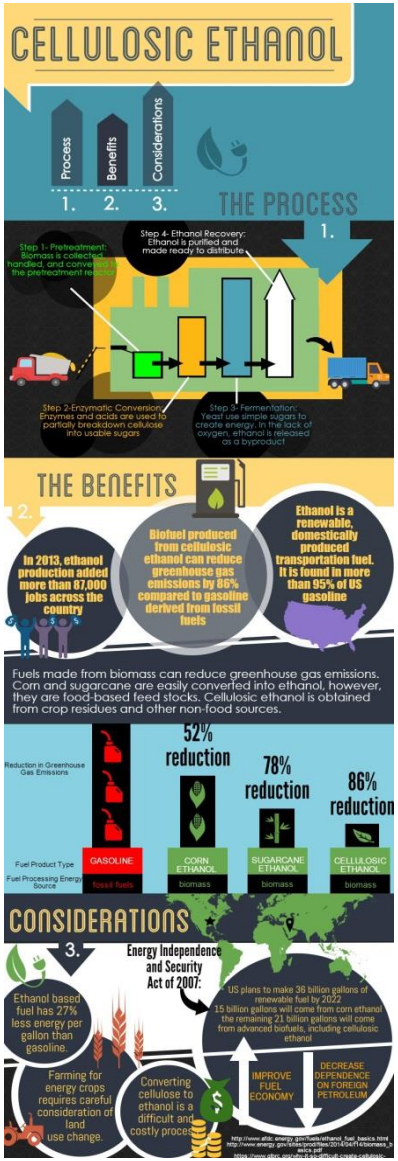
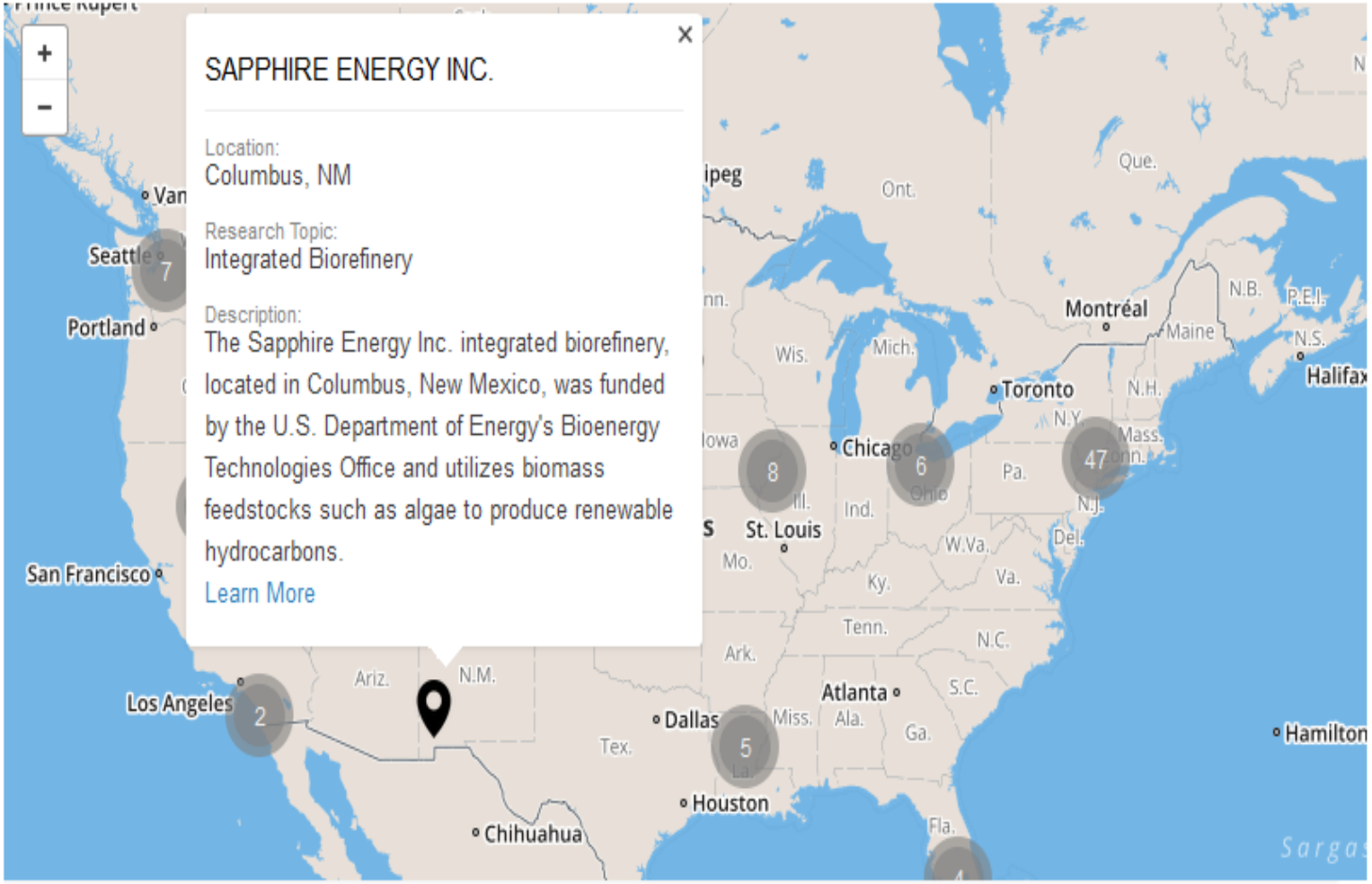


Put Your School/Organization on the Map!

BIOENERGIZEME INFOGRAPHIC CHALLENGE MAP

- Bioenergy Home
- About the Bioenergy Technologies Office
- Research & Development
- Education & Workforce Development
- Financial Opportunities
- Information Resources
- News
- Events
- Contact Us



Thank you for your attention!

Questions? Email us:

BioenergizeME@ee.doe.gov

More Information:

http://www.energy.gov/eere/bioenergy/

Sources of information on the connections among Climate Change, Bioenergy, and Sustainability

- Souza, G.M., Victoria, R., Joly, C. & Verdade, L. (Eds). (2015). *Bioenergy & Sustainability: Bridging the gaps* (Vol. 72, p779). Paris: SCOPE. Available at: http://bioenfapesp.org/scopebioenergy/index.php/chapters/table-of-contents
- Matthews, R. & Robertson, K. (Eds) (2015). *Answers to ten frequently asked questions about bioenergy, carbon sinks, and their role in global climate change*. Prepared by IEA Task 38 "Greenhouse Gas Balances of Biomass in Bioenergy Systems." Available at: http://www.task38.org/task38faq.pdf
- Berndes, G. (Eds). (2011). *Bioenergy, Land Use Change and Climate Change Mitigation. Report for Policy Advisors and Policymakers*. Prepared for IEA Bioenergy. Available at: http://www.globalbioenergy.org/uploads/media/1012_IEA_Bioenergy_-_Bioenergy__land_use_change_and_climate_change_mitigation_01.pdf
- Global Bioenergy Partnership
- IEA Task 38: Climate Change Effects of Biomass and Bioenergy Systems