

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

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CLEAN Network Presentation
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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?

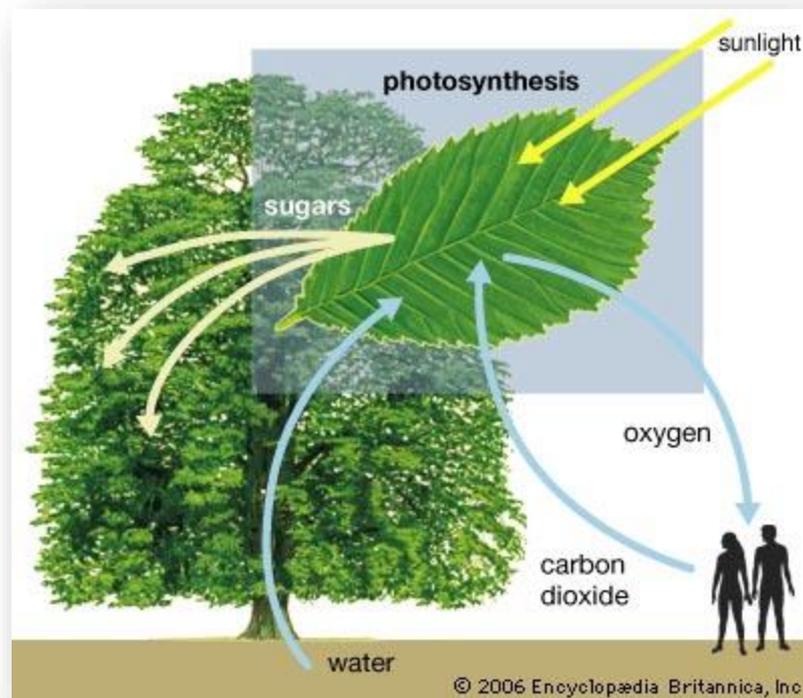
Bioenergy is a form of renewable energy derived from biomass to generate heat and electricity (biopower), biofuels (transportation fuels), biochemicals, and other energy-related bioproducts that are produced from biomass.



Photos courtesy of USDA and NREL

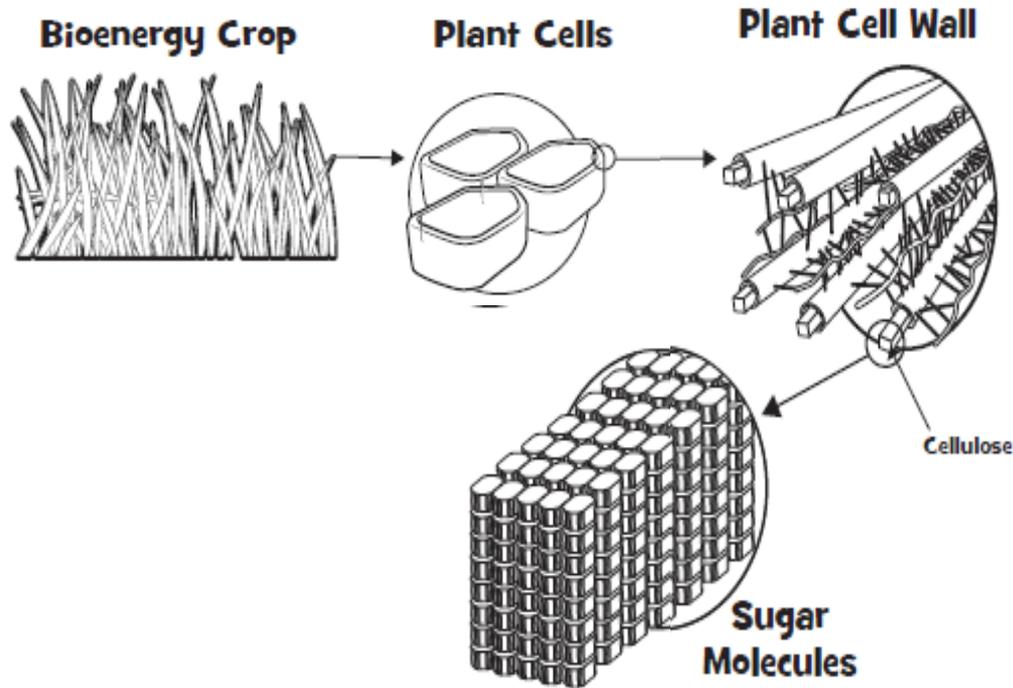
What is Biomass?

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*

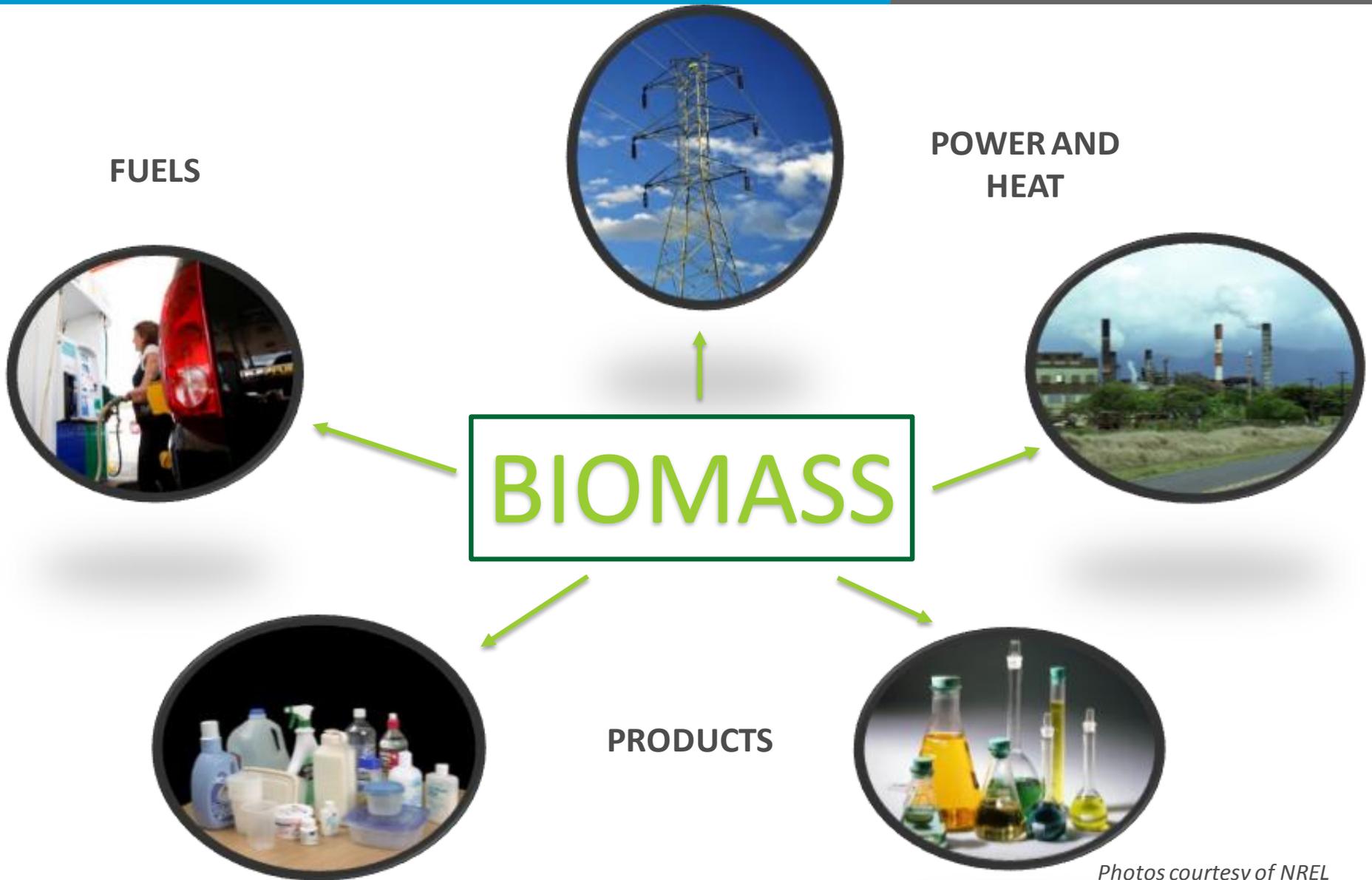


Algae: Many macroalgae, microalgae, and cyanobacteria carry out photosynthesis to drive rapid biomass growth. Algae biomass can contain high levels of oil, making it a promising feedstock for biofuels, including renewable gasoline, diesel, and jet fuel. *Photo: NREL/01726, 19549*



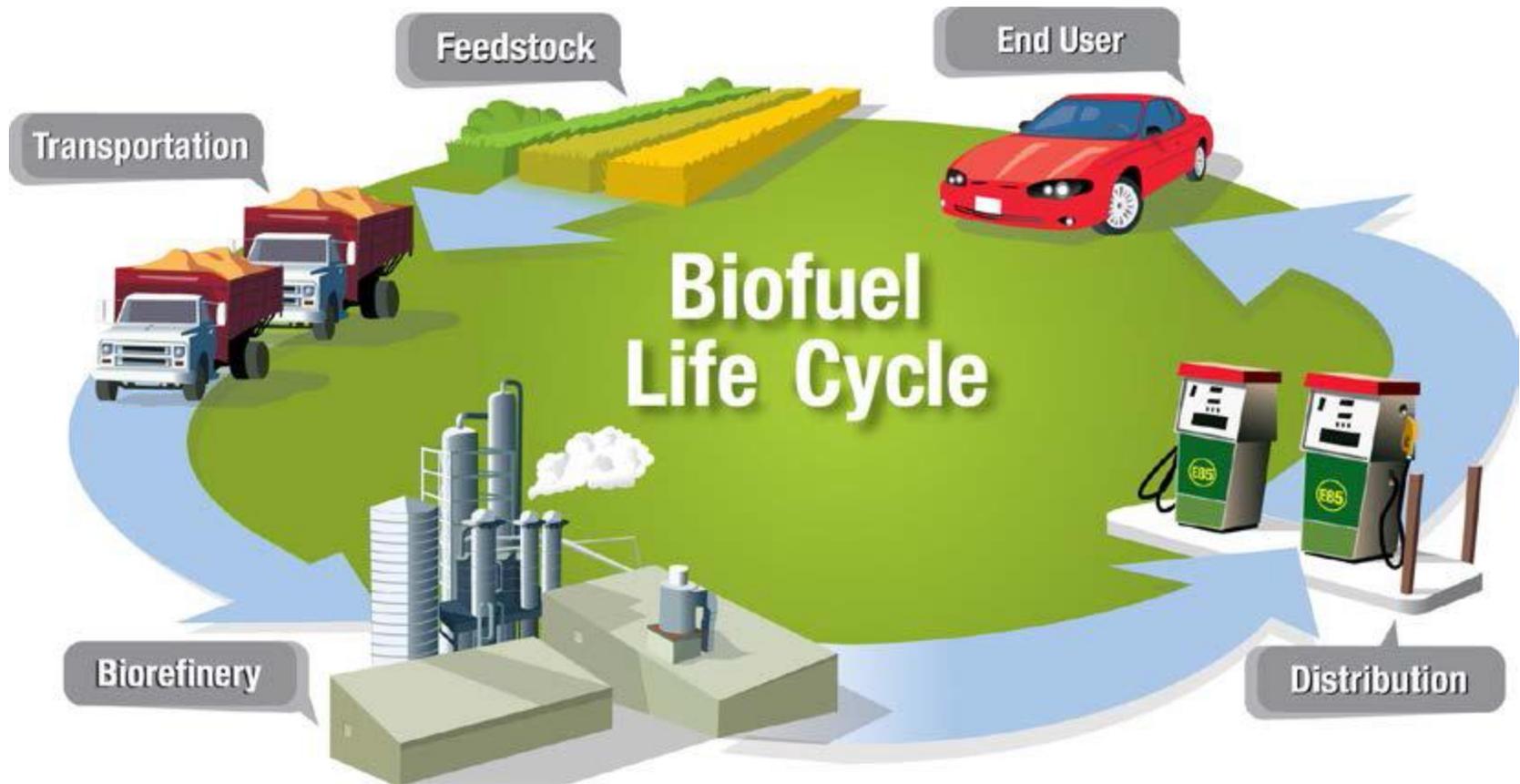
Municipal Solid Waste: MSW has potential as a gasifier feedstock. Its near-term availability and pre-existing collection and transport infrastructure make it a particularly attractive resource. *Photo: iStock/14910937*

What can Biomass Produce?



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.



Feedstock to Biorefinery

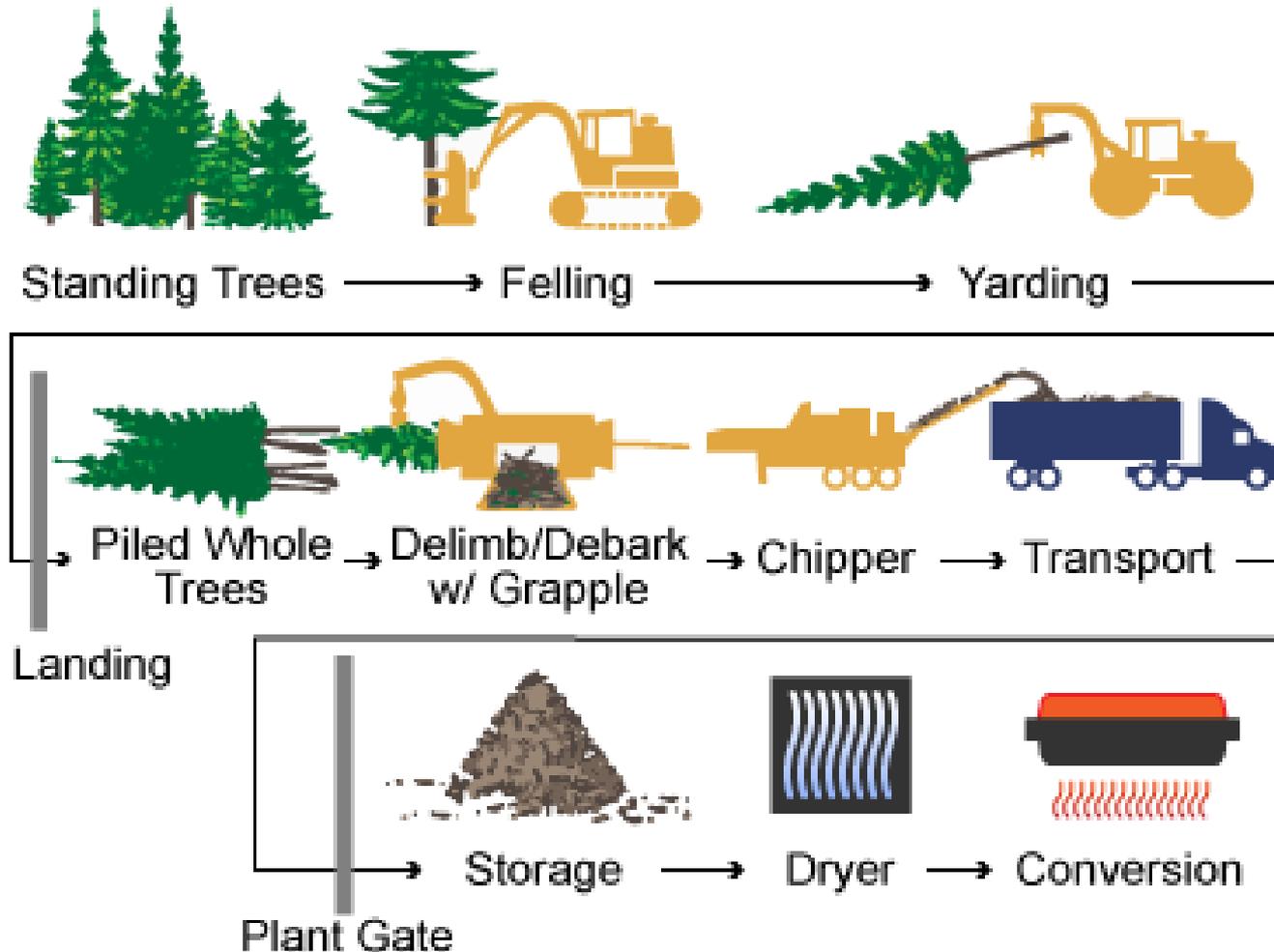


Photo Credit: INL

How Does a Biorefinery Operate?



Processed biomass is treated with heat and chemicals



Biorefinery



Enzymes break down cellulose into sugar



Microbes ferment sugar into ethanol

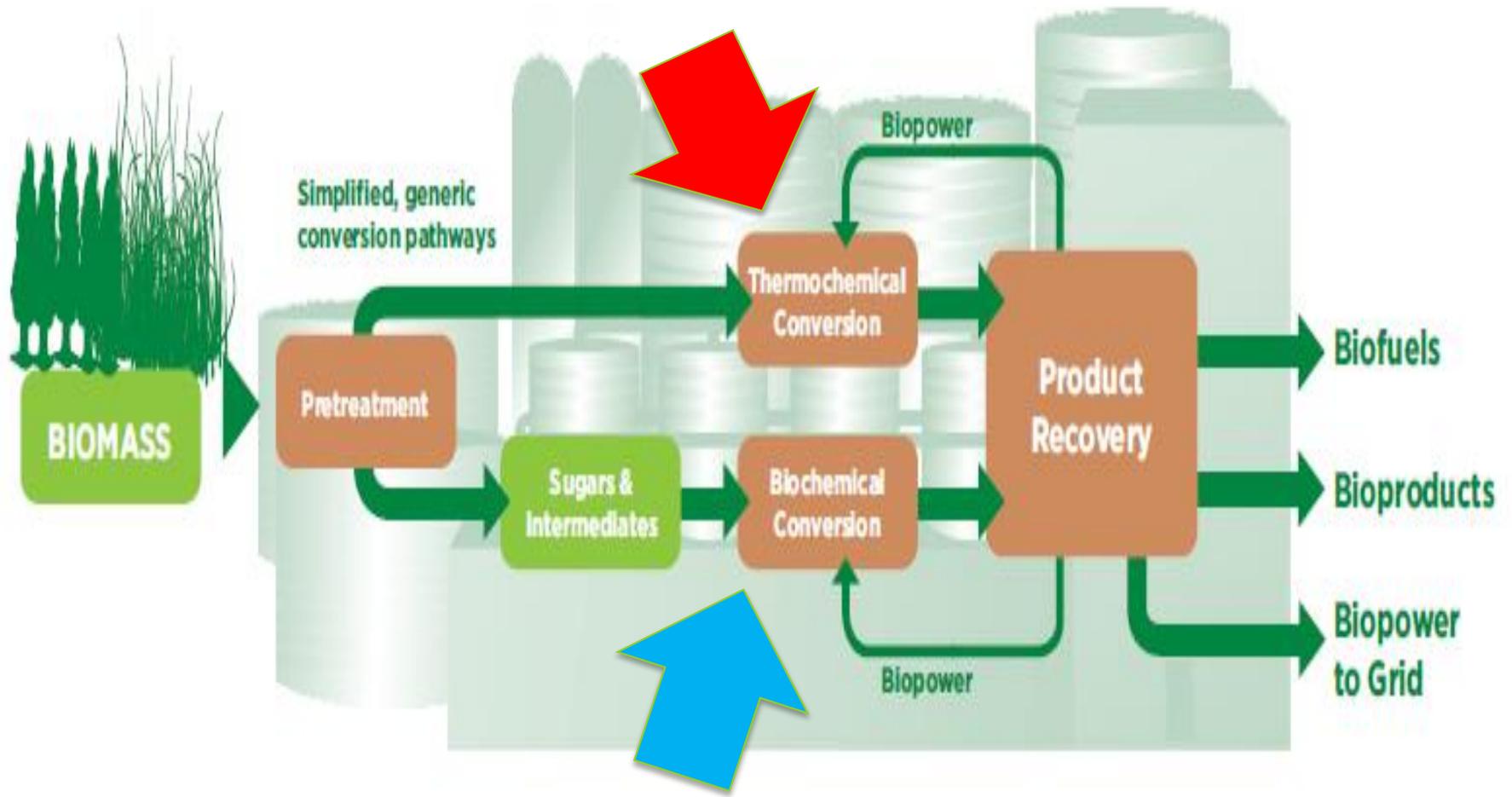


Ethanol is purified and prepared for distribution



Photos courtesy of NREL

At the Biorefinery: Step-by-Step Process



Distribution: Fuels Travel to Consumers



Where can Biofuels be Used?



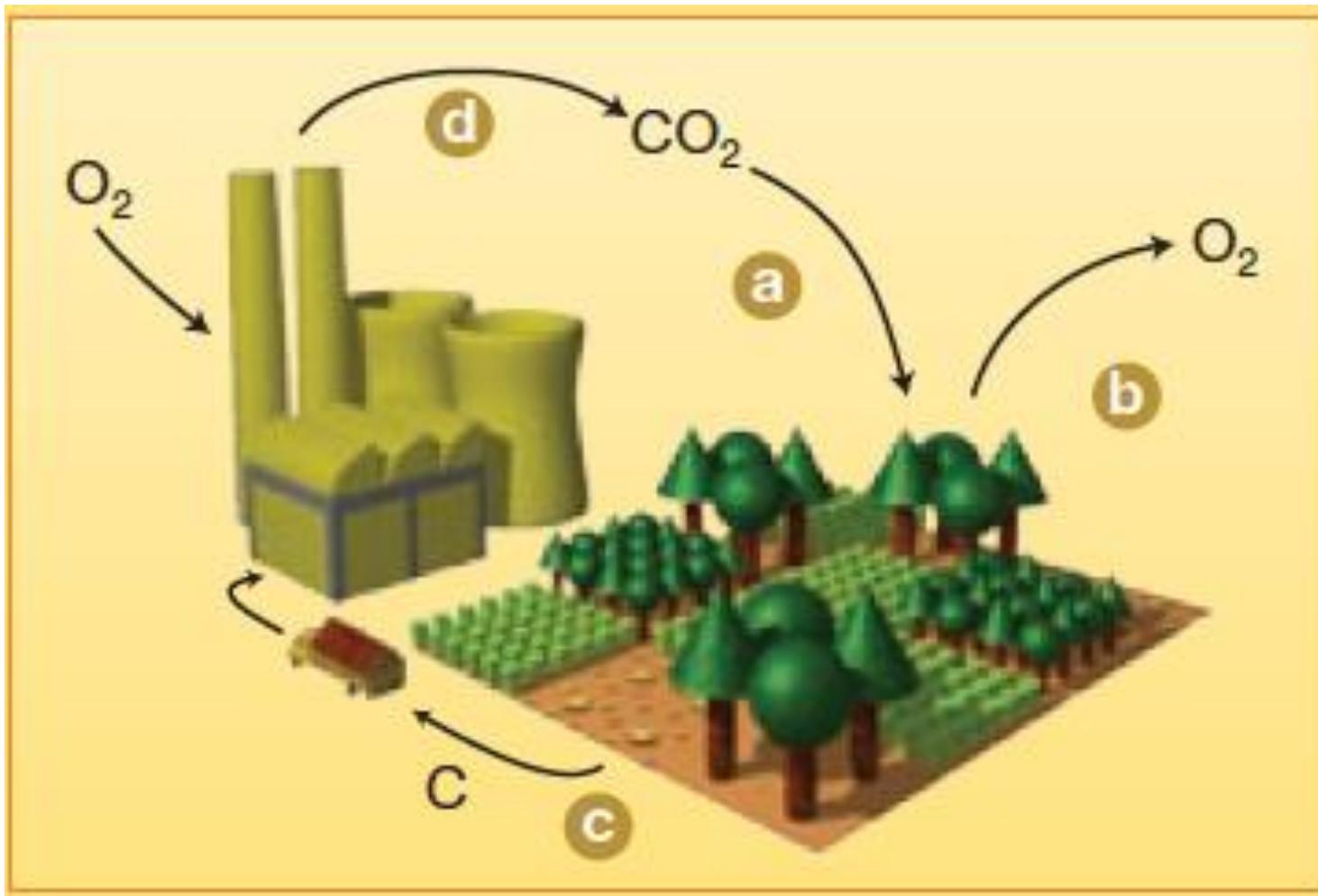
Photos courtesy of NREL

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**

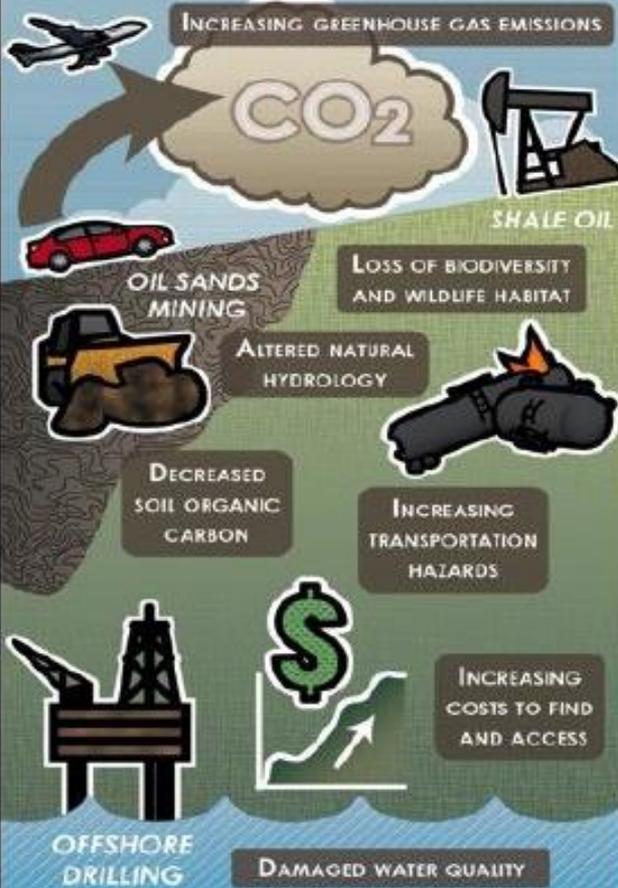


Management of Biofuels can Support Goals

THE STATUS QUO

INHERENTLY UNSUSTAINABLE

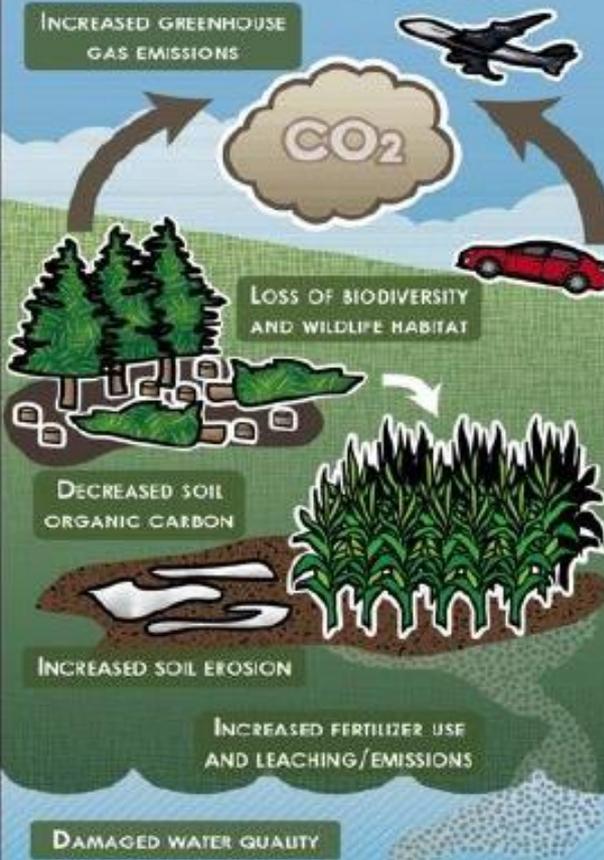
Production of Non-Conventional Petroleum with Loss of and Harm to Natural Ecosystems



BIOFUELS

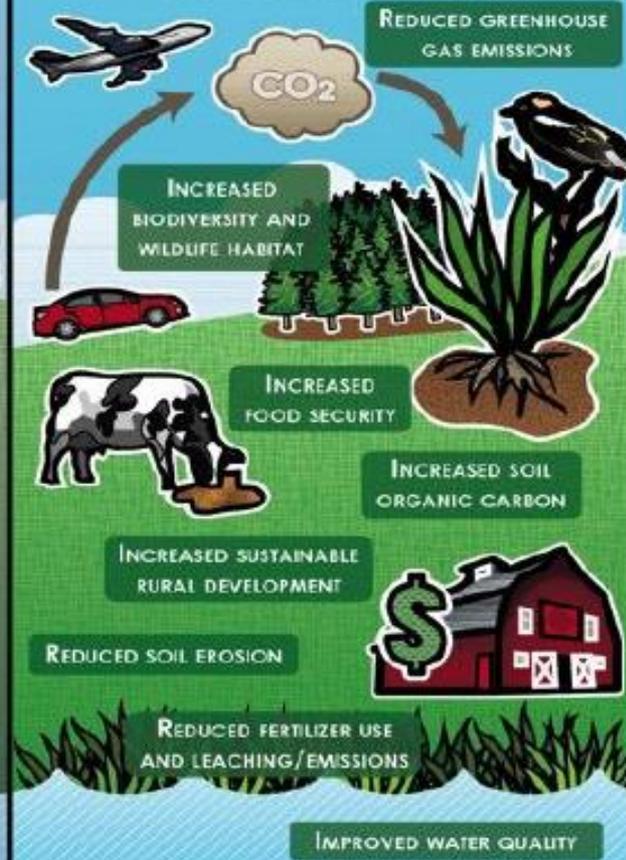
POORLY MANAGED

Use of Unsustainable Land Management Practices and/or Conversion of Perennial Ecosystems to Intensive Agriculture



SUSTAINABLY MANAGED

Development of Biofuels Based on Sustainable Land Management Practices and Perennial Foodstocks



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



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.

— PRESIDENT OBAMA'S PLAN TO —
ADDRESS CLIMATE CHANGE

- ✓ **Reduce carbon pollution from power plants and build cars that burn less fuel.**
- ✓ **Cut energy waste from our homes and businesses.**
- ✓ **Help states and cities prepare for the impacts of climate change.**
- ✓ **Lead global efforts to address climate change.**

Wh.gov/Climate-Change #ActOnClimate

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!

Developing future leaders who will determine the bioenergy landscape of tomorrow



BioenergizeME Infographic Challenge Toolkit

Infographic Challenge 2015

"Bioenergy—Building on the Shoulders of Giants"

Deadlines
 Infographic Submission: March 20, 2015
 National Bioenergy Social Media Campaign: April 13-21, 2015

Bioenergy Technologies Office
 Spring 2015

5 STEPS FOR BUILDING AN INFOGRAPHIC

- RESEARCH**
 Research your topic fully. Pull together a list of impressive facts that you think are important. Make sure to use credible sources.
- SKETCH**
 If possible, you are going to share facts and data that tell a story. Write that story out and draw a sketch for each key point.
- DESIGN**
 Now it's time to bring everything together in one cohesive design. Create the layout and choose a color palette. Bring your sketches, text, and data into a digital illustration and create. You can create by hand or use a computer to create. The goal is to use a consistent style throughout the infographic.
- TEST**
 Getting input from others will let you know if your infographic is easy to read and what you want to do. Share your infographic with others and ask them for feedback.
- FINALIZE**
 Review the feedback that you receive, and incorporate constructive changes to produce a final version of your infographic.



Infographic Rubric		2	1	
Research Content	<ul style="list-style-type: none"> Evidence based Clear analysis and explanation Logical flow 	<ul style="list-style-type: none"> The data and facts presented are evidence based from reliable sources. All sources are referenced. All content is accurate. There is clear analysis and explanation of the research topic selected. The information and messages present a logical flow. 	<ul style="list-style-type: none"> The content contains more than one inaccuracy, and content is partially cited with credible sources. The analysis and explanation are incomplete. One of the elements of the infographic does not logically flow with the subject matter. 	<ul style="list-style-type: none"> The content contains more than one inaccuracy, content is occasionally cited, and/or credible sources are visibly lacking. Lacking analysis and explanation. More than one of the elements of the infographic does not logically flow with the subject matter.
Design	<ul style="list-style-type: none"> Aesthetics (font, color, shape) Correct use of data visualization Relevance of graphics 	<ul style="list-style-type: none"> The infographic is highly attractive in terms of layout, design, and neatness. The color choices enhance the visibility of the infographic, and the fonts used are readable and complement the content. The chosen data visualization formats make the data presented clear and simple for the viewer to understand. The images and illustrations match the tone and subject matter of the infographic. 	<ul style="list-style-type: none"> The infographic is adequately attractive in terms of layout, design, and neatness. Fonts used are difficult to read, and color choices are distracting. The chosen data visualization formats illustrate the data correctly, but some may be difficult to understand. The images and illustrations are relevant but may distract attention away from the content of the infographic. 	<ul style="list-style-type: none"> The infographic lacks attractiveness in terms of layout, design, and neatness. Fonts used are difficult to read, and color choices are distracting. Data visualizations are seen, but other formats could have been used to better illustrate the data for the viewer. The images and illustrations used do not match the subject matter of the infographic and take away from the content of the infographic.
Mechanics	<ul style="list-style-type: none"> Grammar Guideline/format 	<ul style="list-style-type: none"> The writing is free of errors. 	<ul style="list-style-type: none"> The writing contains one or more errors. 	



SOCIAL MEDIA GUIDE

GOAL: Share what you've learned about bioenergy through a 10-day social media campaign!

HOW TO DO IT:

- Assign team roles
- Plan a strategy & timeline
- Start your campaign & monitor progress

Determine what role each person will play in the campaign.

- Team Director**
 Lead and organize your team, keep your team on schedule, and monitor progress (views, likes, and shares) during your social media campaign.
- Content Manager**
 Determine key messages you want to convey to your audience about your infographic, and write catchy text to draw viewers in.
- Engagement Manager**
 Identify the various social media networks (Twitter, Instagram, Facebook, etc.) for your campaign. Engage and respond to questions and comments from followers.

Plan ahead by preparing a strategy and timeline. This is necessary to design a successful campaign.

Tasks

- Choose the social media networks you will use.
- Write content (catchy text—just a sentence or two that promotes your infographic).
- Schedule the days and times your team will post your posts in the various social networks, and make plans about how you'll respond to comments.
- Done. Be sure your schedule does not interrupt your class!

Deadlines

You will have one week to prepare your social media strategy and ten days to carry it out.

Posting Social Media

Be creative to bring attention to your infographic and encourage audiences to share your infographic across their social network.

Responding to Comments

Reply quickly and courteously to comments about your infographic. See how your viewers react and what they are learning about bioenergy from your infographic.

Monitor Progress

Monitor your success by talking, liking, sharing, and commenting, and consider adjusting your outreach strategy based on your progress.

Tip:

- Stay positive and be thoughtful towards your audience: they may not know very much about your topic, or they may be more knowledgeable than you. "Thanks for checking out my infographic" is a good lacking response.
- If you get negative or hostile comments, you may ignore or delete them. If this does not stop a cyberbully, tell a teacher.
- Be active on social media. Like, share, and comment on others' posts, and they may do the same for you.

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

1

CELLULOSIC ETHANOL

THE PROCESS

1. **Step 1: Pretreatment** - Biomass is collected, harvested, and converted into the pretreatment feed.
2. **Step 2: Enzymatic Conversion** - Enzymes and acids are used to partially breakdown cellulose into simple sugars.
3. **Step 3: Fermentation** - Yeast use simple sugars to create energy. In the lack of oxygen, ethanol is released as a byproduct.
4. **Step 4: Ethanol Recovery** - Ethanol is purified and made ready to distribute.

THE BENEFITS

- In 2013, ethanol production added more than 87,000 jobs across the country.
- Biofuel produced from cellulosic ethanol can reduce greenhouse gas emissions by 86% compared to gasoline derived from fossil fuels.
- Ethanol is a renewable, domestically produced transportation fuel. It is found in more than 95% of US gasoline.

Fuels made from biomass can reduce greenhouse gas emissions. Corn and sugarcane are easily converted into ethanol, however, they are food-based feed stocks. Cellulosic ethanol is obtained from crop residues and other non-food sources.

Fuel Product Type	Fuel Processing Energy Source	Reduction in Greenhouse Gas Emissions
GASOLINE	Fossil fuels	0%
CORN ETHANOL	Biomass	52% reduction
SUGARCANE ETHANOL	Biomass	78% reduction
CELLULOSIC ETHANOL	Biomass	86% reduction

CONSIDERATIONS

Energy Independence and Security Act of 2007:

- Ethanol based fuel has 27% less energy per gallon than gasoline.
- US plans to make 36 billion gallons of renewable fuel by 2022. 15 billion gallons will come from corn ethanol; the remaining 21 billion gallons will come from advanced biofuels, including cellulosic ethanol.
- Improving fuel economy and decreasing dependence on foreign petroleum.
- Converting cellulose to ethanol is a difficult and costly process.
- Farming for energy crops requires careful consideration of land use change.

http://www.elle.energy.gov/bioethanol/Fuel_Fuels.html
<http://www.energy.gov/bioenergy/2014/08/15/where-are-we-with-algae-biofuels>
http://www.alle.energy.gov/bioethanol/Fuel_Fuels.html

Algae

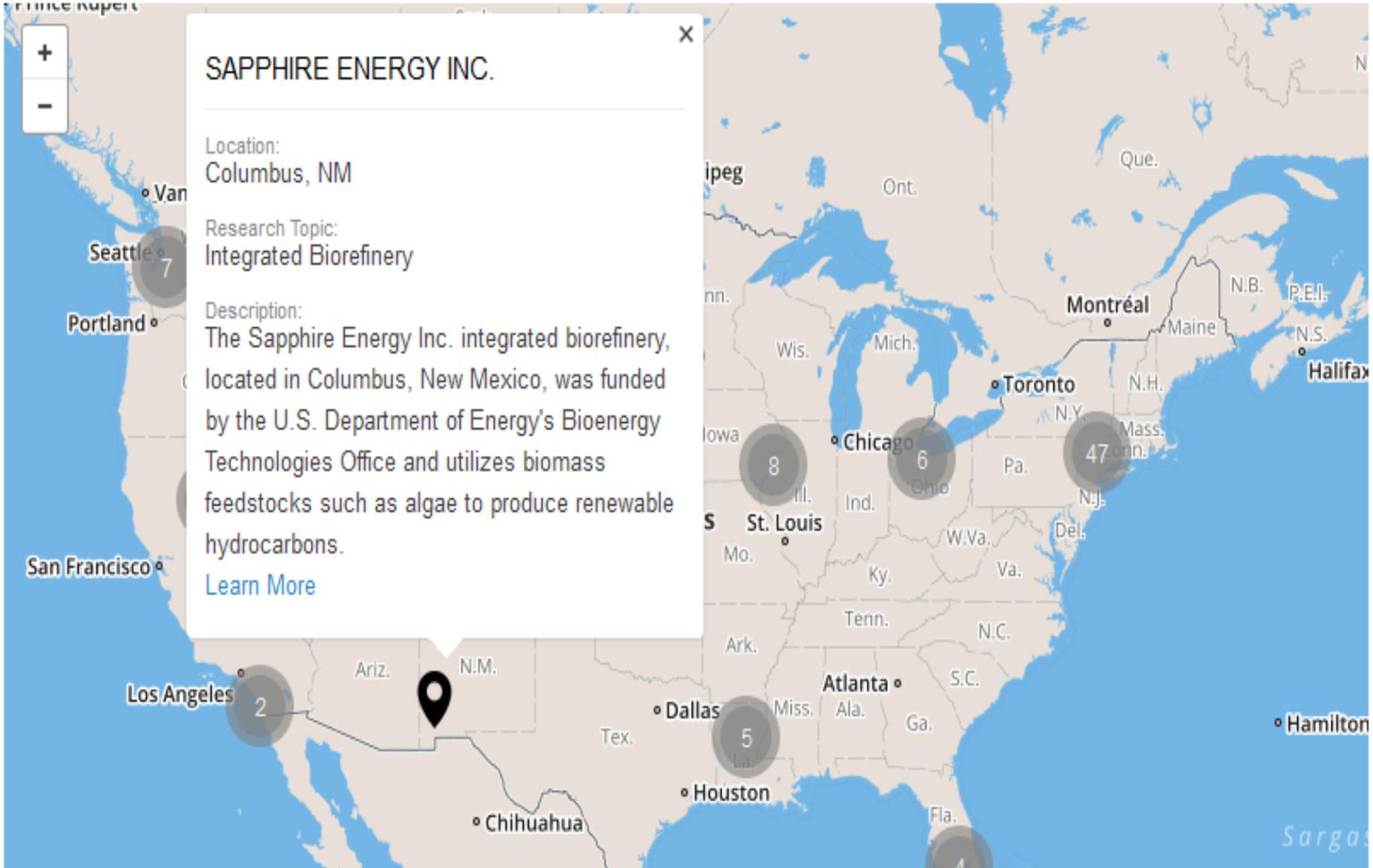
Algae

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 Pittman, Jon K., et al. The potential of sustainable algal biofuel production using wastewater resources. *Bioresour Technology* 102(2010): 17-25.
<https://www.algae.wiki.zoho.com/Chapter-1-Introduction-to-Algae-Biofuels.html>
 Lane, Ben. "Where are we with algae biofuels?" *Biofuels Digest* (13 October 2014).
<http://www.biofuelsdigest.com/bfdigest/2014/10/13/where-are-we-with-algae-biofuels/>

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](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](#)