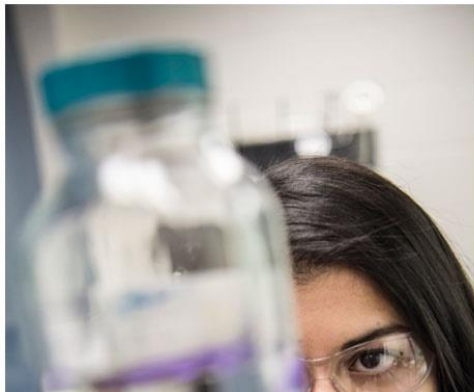
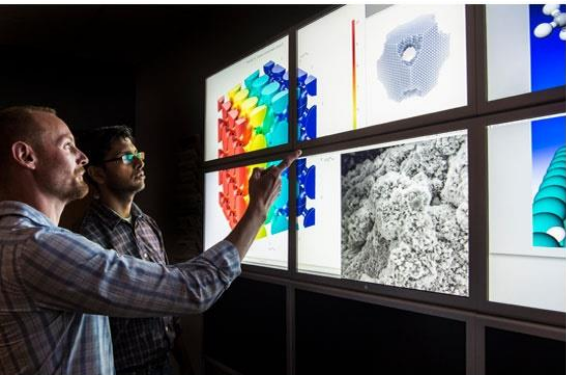


<https://tinyurl.com/betobridges24>

## BIOENERGY RESEARCH AND EDUCATION BRIDGES PROGRAM

### Bioenergy Case Studies from the Department of Energy for Community College Classrooms

Kelly Sturner | STEM Education Program Lead | Argonne National Laboratory | [kmoran@anl.gov](mailto:kmoran@anl.gov)





## KELLY STURNER

STEM Education  
 Program Lead  
 Argonne National  
 Laboratory



# BETO BRIDGES IS A NATIONAL TEAM EFFORT FOR BIOENERGY EDUCATION



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# BIOENERGY – RENEWABLE ENERGY ALL AROUND

- Did the Olympic Torch catch your eye? It was powered by biopropane.
- Did you fly into Kansas City? According to the [International Civil Aviation Organization](#) (ICAO), over 360,000 commercial flights have used sustainable aviation fuel (SAF) at 46 different airports largely concentrated in the United States and Europe.
- Did you drive a hybrid or gas car? Nearly all U.S. car fuel is 10% ethanol by volume.
- Hate plastic pollution and its carbon footprint but still need stuff? Bioproducts! Circular economy!



A large industrial facility, likely a wood processing plant, is shown. A yellow crane bucket is suspended in the air, dumping a stream of wood chips into a large pile of wood chips. The background features a large, multi-story building with a corrugated metal facade and a series of windows. The foreground is dominated by a large, textured pile of wood chips.

## WHY WAS BETO BRIDGES CREATED?

*Photo by iStock*

# Today's Session:

- What's included in the BRIDGES toolkit
- Access to the toolkit with guided demonstration
- Dive into a case study
- What's next and how to reach us

JET FUEL  
MAX. PRESSURE  
50 P.S.I.  
MAX. SUCTION  
11 P.S.I.  
0.8 BARS

Photo by iStock



## FACT SHEETS AND PRIMER

**U.S. DEPARTMENT OF ENERGY**  
Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

**Municipal Solid Waste-to-Energy: Traditional Ecology and Environmental Justice** | Bioenergy Research and Education Bridge (BRIDGES) Program Case Study Fact Sheet

According to the Environmental Protection Agency (EPA), we generate 290 million tons of trash and up to 100 million tons of landfills. Image from Idaho National Laboratory.

**Sustainable Solutions for a Waste-to-Biofuels Challenge**

Students will be introduced to the challenges of managing municipal solid waste, opportunities for turning these products into usable energy sources, and exciting careers in the bioenergy field.

Students will explore the challenges associated with any community designing a sustainable waste management strategy, and the unique challenges experienced by an over-burdened and underserved community. Students will focus on the ways that science and technology can inform potential solutions + culturally responsive.

In this case study, students introduced to the Shoshone Tribes, located on the Fort Reservation in southeastern Idaho. Like many communities, the challenge of identifying practices to deal with their solid waste (MSW), also known as landfills waste.

Students will assume the role of a chemical engineer at Idaho National Laboratory, who will assist the Youth Council in exploring solutions for managing waste-related career paths.

**U.S. DEPARTMENT OF ENERGY** Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

**Bioenergy Research and Education BRIDGES Program Prepares a National Bioenergy Workforce**

**What is BRIDGES?**  
The Bioenergy Technologies Office within the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy supports the research, development, and demonstration of technologies aimed at reducing domestic greenhouse gas emissions for the production of greenhouse gas emissions across the U.S. economy.

Bioenergy can help create an economically sound and secure future while reducing environmental impacts by:

- Developing affordable domestic fuels and products
- Advancing clean energy sources
- Generating domestic jobs to support the growth of the U.S. bioeconomy

**Get Involved!** For more information about the BRIDGES program or to access BRIDGES materials, visit [energy.gov/BRIDGES](http://energy.gov/BRIDGES), or email [BRIDGES@energy.gov](mailto:BRIDGES@energy.gov).

**What is BRIDGES?**  
The U.S. Department of Energy (DOE) Bioenergy Technologies Office (BETO) Bioenergy Research and Education Bridge (BRIDGES) is an educational development program designed to assist education in teaching bioenergy topics to help prepare the future bioenergy workforce.

The bioenergy-themed case studies are based upon foundational bioenergy research at DOE national laboratories. Specific goals for the BRIDGES program include:

- Translating DOE scientific research for the classroom setting
- Creating awareness of bioenergy topics and careers
- Accelerating the transition from academia to industry
- Providing equitable access to high-quality bioenergy learning materials.

Argonne | BRIDGES | INEL | Idaho National Laboratory

For more information, visit [energy.gov/bridges](http://energy.gov/bridges)  
08.10.2024 | Page 2/22

Image credits from the National Renewable Energy Laboratory, the Idaho National Laboratory, and Argonne.

## TALK TO YOUR NEIGHBORS!

- What courses or programs could these case studies be a fit for?
- Where could they go in your curriculum?



GO TO BRIDGES WEBSITE NOW

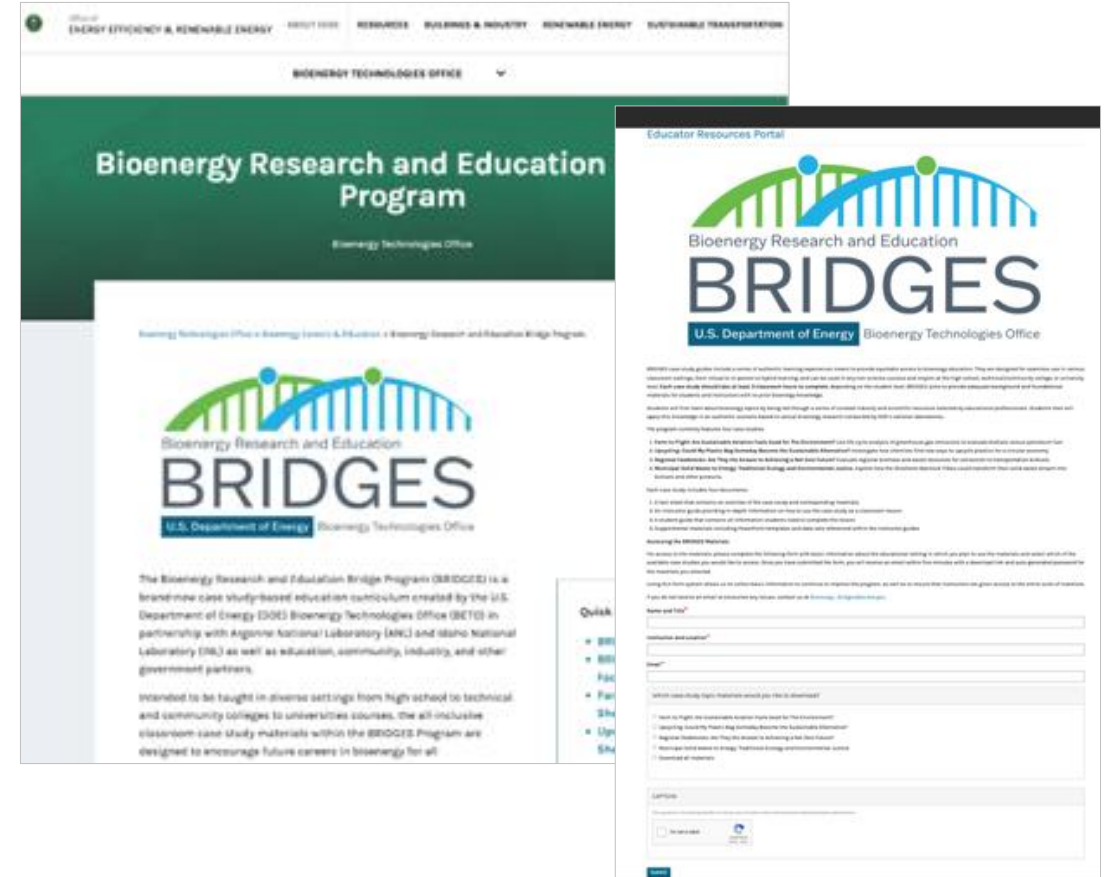


<https://tinyurl.com/betobridges24>

OR

<https://www.energy.gov/eere/bioenergy/bioenergy-research-and-education-bridge-program>

WEB PORTAL FOR DIGITAL DOWNLOAD



The screenshot displays the Bioenergy Research and Education BRIDGES website. The main header features the program name and the Bioenergy Technologies Office logo. Below this, there is a section titled "Educator Resources Portal" which includes a list of resources and a search bar. The page also features a navigation menu at the top with categories like "ENERGY EFFICIENCY & RENEWABLE ENERGY", "RESEARCH", "BUILDING & INDUSTRY", "RENEWABLE ENERGY", and "SUSTAINABLE TRANSFORMATION".

# INSIDE A BRIDGES CASE STUDY...



Topic Introduced with Authentic Scenario



Students Explore Resources



Students Demonstrate Learning



Career Exploration

# Overview

U.S. DEPARTMENT OF ENERGY  
Office of ENERGY EFFICIENCY & RENEWABLE ENERGY

Bioenergy Research and Education  
**BRIDGES**  
U.S. Department of Energy Bioenergy Technologies Office

## STUDENT GUIDE

Farm to Flight: Are Sustainable Aviation Fuels Good for the Environment?

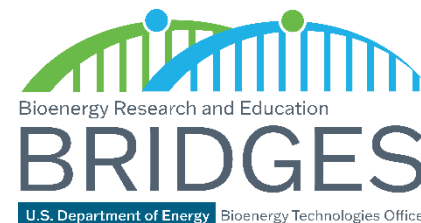
Bioenergy Research and Education Bridge (BRIDGES) Program



**ABSTRACT**  
Students will be introduced to the challenges and benefits of bioenergy, as well as to exciting careers within the industry. Students will take on the role of a sustainability specialist in the cutting-edge biofuel industry to compare the use of sustainable and petroleum jet fuels, including their greenhouse gas emissions.

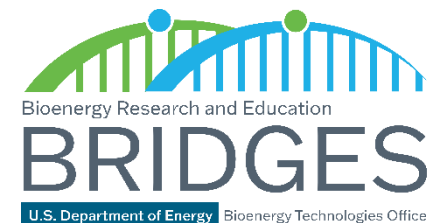
# Learning Goals

- Describe what bioenergy and sustainable aviation fuels are and how fuels are evaluated for environmental impact (metrics: energy, water usage, air pollutants, and greenhouse gas emissions).
- Explain life cycle analysis and describe the well-to-wake jet fuel pathways of petroleum jet fuels and biofuels from two example feedstocks (waste and biomass).
- Explain what a computational model is, as well as system boundaries, processes, inputs, and outputs.
- Compare the greenhouse gas emissions of petroleum jet fuel and sustainable aviation fuel using data from the GREET model.
- Describe the role and skills necessary for a sustainability specialist in the bioenergy industry.



## Quick Start Guide for Students

- Before you begin, please read or skim through the student guide to get an idea of what to expect.
- Pay special attention to the Background Information section. It is highly recommended that you take the time to review it before you begin, as it will save you time in the end.
- You will be working in small groups, and tasks should be delegated to group members.



# TOPIC INTRODUCED WITH AUTHENTIC SCENARIO

- Students play role of a sustainability specialist
- Phone call comes in from an airline CEO saying the board of directors is concerned
- The board requires an expert analysis... are sustainable aviation fuels good for the environment?



A long train of black tanker cars is visible on a track, stretching into the distance. The train is positioned next to a lush green cornfield. The sky is clear and blue. The text "SAFs = SUSTAINABLE AVIATION FUELS" is overlaid in white on a semi-transparent dark blue band across the middle of the image.

**SAFs = SUSTAINABLE AVIATION FUELS**

*Photo by iStock*

## Preparation (Student Guide)

- You and the other sustainability specialists have just been assigned this project by your supervisor.
- Provide information on the environmental impact of SAFs to the airline's board of directors as a presentation.
- Educate the board on SAFs and conduct a life cycle analysis of their greenhouse gas emissions to present, as well as other factors affecting SAF sustainability

## Instructor Notes

- This portion sets up the goals of the case study in line with the scenario.



## Tasks and Questions (Student Guide)

- What are SAFs and how do they differ from petroleum jet fuels? Why do scientists, engineers, industry, and government organizations suggest that SAFs are the best option compared to other decarbonization investments one might use to make the airline industry more green or sustainable?
- What are the environmental benefits of switching from petroleum jet fuel to SAFs?
- Qualitatively compare the use of SAF and petroleum jet fuel, making sure to include, but not limited by, the following:
  - Greenhouse gas (GHG) emissions.
  - 1–2 other types of air pollution emissions – Choose based on research comparing petroleum jet fuels to SAFs.
  - 1–2 other environmental impacts – Consider the environmental impacts of sourcing the feedstock and how you would measure those impacts.

## Instructor Notes

- Tasks and questions help students fill in their background knowledge while also answering the questions that were brought up by the board
- All resources are available as background reading and information in the case study. Students can also look these up elsewhere.

### Terminology List

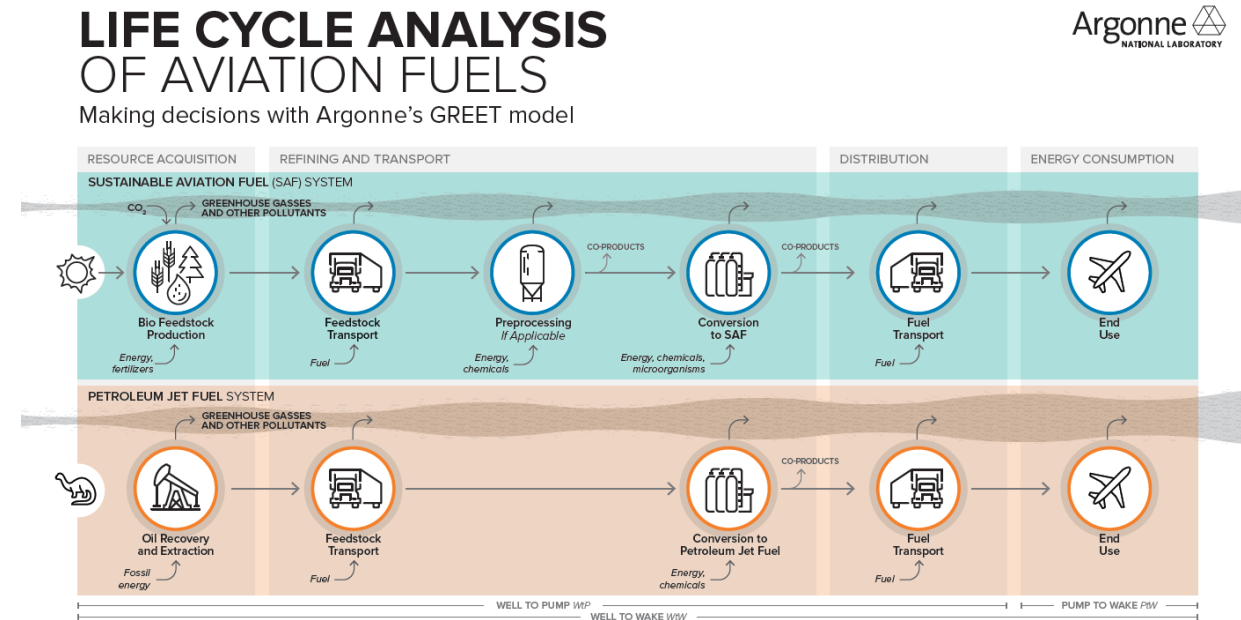
Term	Definition
Bioenergy	The energy produced from biomass; includes biofuels, bio-based products, and biopower.
Biofuel	Fuel produced from biological resources (plant or animal material)
Biomass	An energy resource derived from waste and food waste. It includes agricultural residues (such as waste from food crops fuels and animal manures), forest resources, purpose-grown energy crops (such as perennial grasses and woody energy crops), urban wood waste, and food waste.
Carbon dioxide equivalent (CO <sub>2e</sub> )	Used to measure and compare emissions from greenhouse gases based on how severely they contribute to global warming. Metrics for CO <sub>2e</sub> would show how much a particular gas would contribute to global warming if it were carbon dioxide.
Carbon footprint	The net amount of carbon dioxide emissions attributable to a product or service (emissions from production and combustion, minus absorption during plant growth). For fossil fuels, the absorption of carbon dioxide occurred millions of years ago, so their carbon footprint is simply 100% of their carbon output.

### Feedstock Summary Table<sup>1</sup>

	Description	State of Development	Emission Reduction Factor (ERF)
<b>Wastes</b>			
Municipal solid waste (MSW)	Following sorting to remove any recyclable components, typical organic MSW can be processed into SAF.	Substantial quantities of MSW exist globally that are not used for energy production, and nearly all end up in landfills. A number of MSW feedstock plants are under construction, with the first major facility close to completion.	Current ERF: 70%
Forestry waste residues		Opportunities are substantial but tend to be linked to specific regions (such as the Nordics) that have an existing timber or paper industry.	Current ERF: 70%–80%

## More Tasks and Questions (Student Guide) Instructor Notes

- What are the main categories of SAF feedstock? Give examples of each. Briefly mention the main benefit and drawbacks of each.
- Explain the concept of life cycle analysis of greenhouse gas emissions using the following LCA diagrams for both petroleum jet fuel and SAFs as a guide. Make sure to include the following:
  - Explain the terms well to pump (WTP), pump to well (PTW), and well to wake (WtW). Make sure to point out and explain what processes are contributing to each of these stages.



# PART 2: Working with a Computational Model to Conduct a Life Cycle Analysis

- Introduction to GREET (Greenhouse gases, Regulated Emissions, and Energy use in Technologies (GREET) model designed by the Systems Assessment Center at Argonne National Laboratory and the Well to Wake Calculator

Argonne GREET Model  
greet.es.anl.gov

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AWARE-US Model  
FD-CIC Tool  
Refinery Products VOC  
GREET Building Module

**GREET® Model**  
The Greenhouse gases, Regulated Emissions, and Energy use in Technologies Model

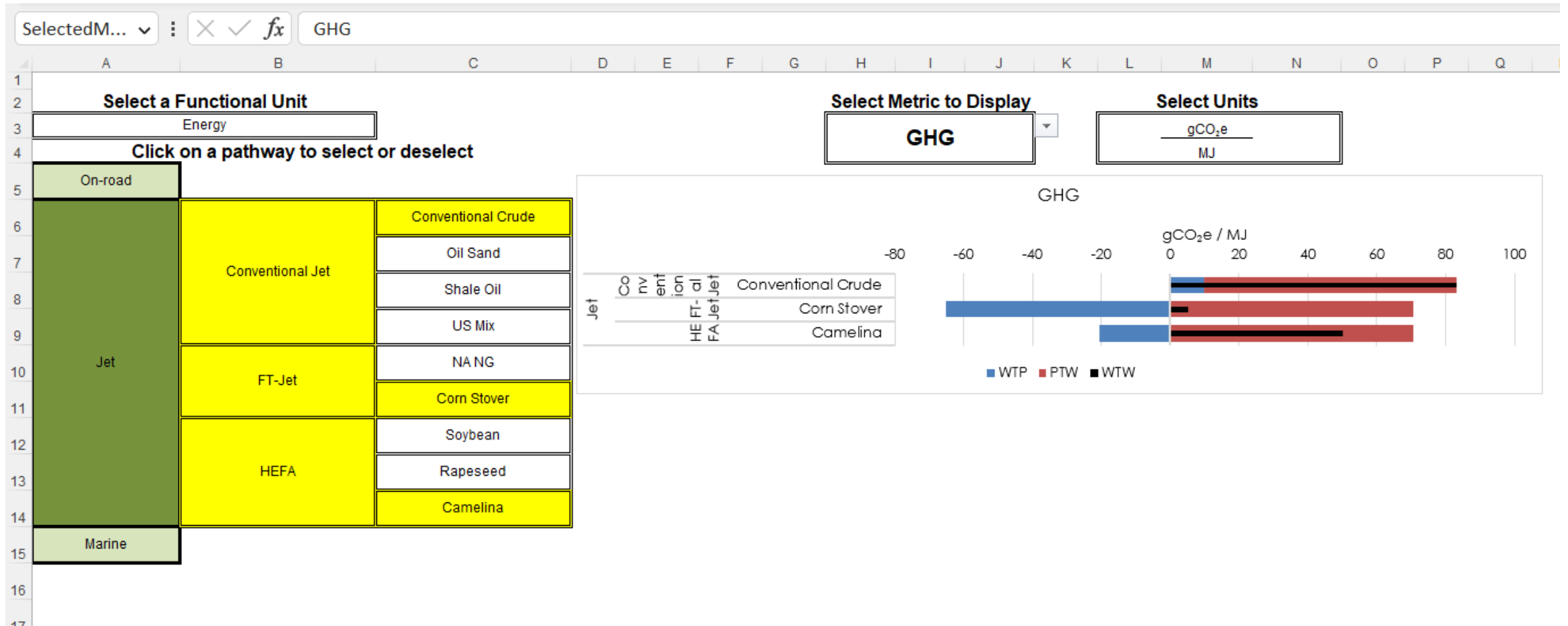
The GREET model is a one-of-a-kind analytical tool that simulates the energy use and emissions output of various vehicle and fuel combinations. Sponsored by the U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy, GREET offers two free platforms to use: the GREET.net model and the GREET Excel model.

To get a complete picture of the energy and environmental impacts of a technology, it is important to consider the full life cycle – from well to wheels for fuels and from raw material mining to vehicle disposal for automobiles.

VEHICLE CYCLE (GREET 2 Series)  
RECYCLING OF MATERIALS  
FUEL TO WHEELS  
WHEELS TO WHEELS

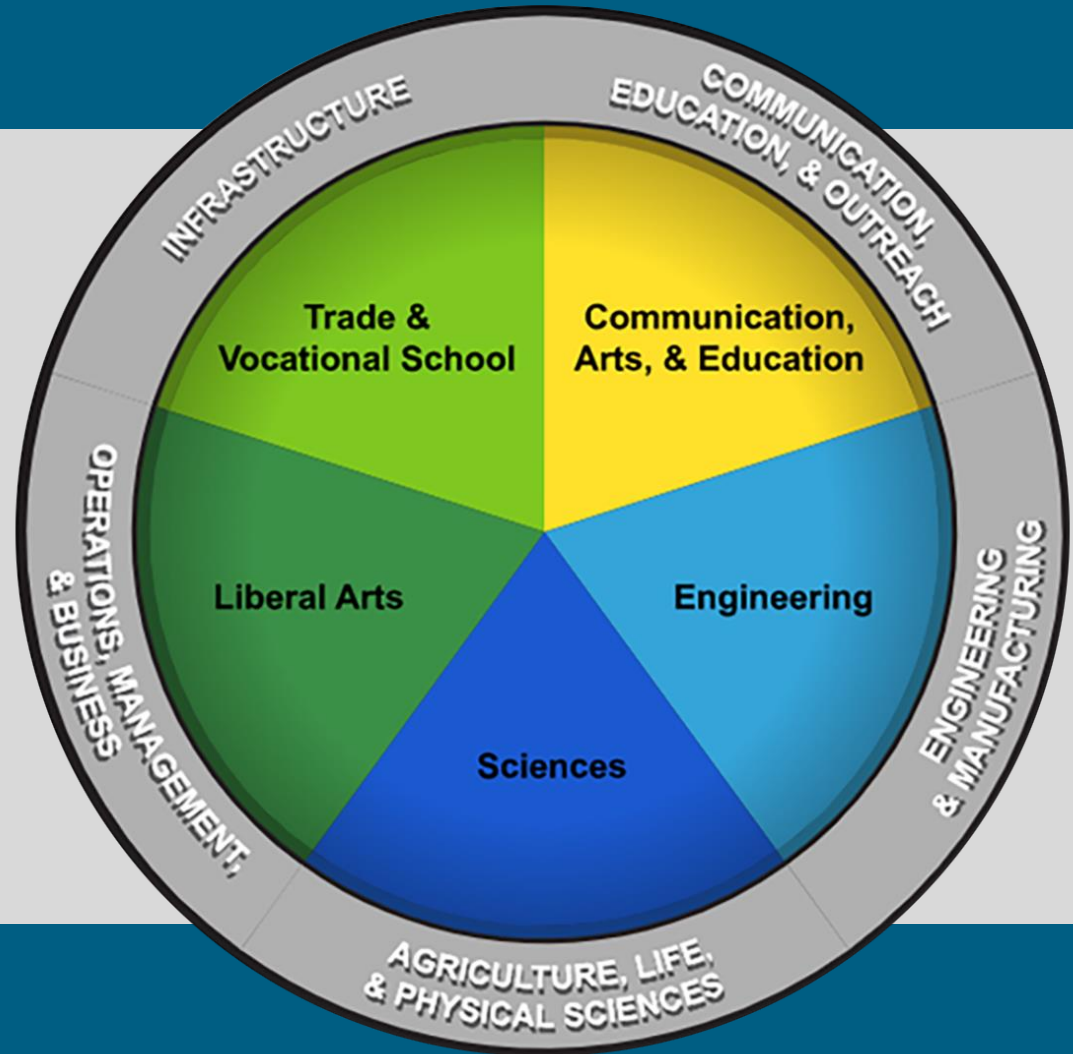


# REET Well to Wake Calculator



## CAREER HIGHLIGHT SUSTAINABILITY SPECIALIST

- Average salary
- Common majors for this position
- Responsibilities of a sustainability specialist
- Students then explore the career wheel to identify a career of interest to them



## ASSUMES NO BIOENERGY BACKGROUND

- Case study introduction/background
- Learning objectives
- Prerequisite knowledge
- Classroom implementation strategies
- Rubrics
- Example answers to background questions
- Additional resources



# EXAMPLES OF INSTRUCTOR RESOURCES

## Rubric

Instructors may choose to use the following rubric. Percentage breakdowns of each category have been included as suggestions to assist in the grading of the project. Instructors may also choose to share the rubric with their students ahead of time.

### Infographic Rubric

	Beginning	Developing	Accomplished	Exemplary
Pictures/Graphics 15%	Pictures/graphics are not clear or relevant	A few of the pictures/graphics are not clear or relevant	Most of the pictures/graphics are clear and relevant	Pictures/graphics are clear and relevant
Data/Results 20%	Data and results included are not significant	Most significant data and results are included; there may also be some unnecessary data or results included	All significant data and results are included, along with some unnecessary data or results	All significant data and results are included; no unnecessary data or results are included
Organization of Data and Results 15%	Results are disorganized, poorly recorded, or do not make sense; not enough data were included to justify results	Data and results are unclear, missing labels, do not show obvious trends, or are disorganized, but there are enough data to show experiment was conducted	Data and results are clearly recorded and labeled; trends are not obvious, or there are minor errors in the organization	Data and results are clearly recorded and organized so it is easy for the reader to see trends; all appropriate labels are included

## Guiding Questions

### Part 1

- What are SAFs made from? **Feedstocks—typically waste or biomass**
- What other non-GHG emissions do SAFs reduce? **Particulate matter (PM), sulfur dioxide (SO<sub>2</sub>), nitrous oxides (NO<sub>x</sub>)**
- Define “sustainable” in this context. **See terminology chart for definition**
- Define “feedstock” in this context. **See terminology chart for definition**
- What are the main categories or types of sustainable aviation fuels? **Fats, oils, and greases (FOG); biomass; waste (agricultural, forest, municipal solid); power-to-liquid**

### Option 1: Face-to-Face Class, One-Class Meeting

#### Homework: Assign Part 1

If the case study is completed in one 90-minute period, students should be assigned Part 1 as homework to be completed either individually or in assigned small groups. Depending on the instructor’s goals, students may be allowed to generally search the internet or be given the handout [Sample Sources of Information for Student Research](#) at the end of this instructor

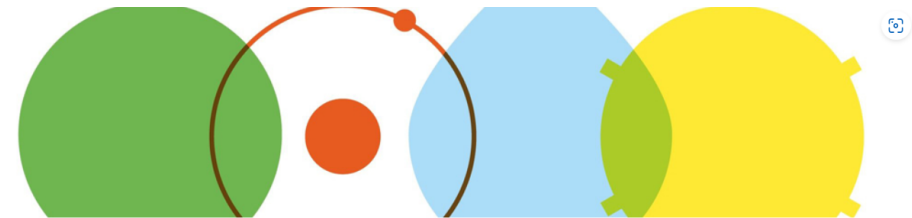
# UPCOMING EVENTS TO SUPPORT EDUCATORS IN TEACHING BRIDGES CASE STUDIES



For more information or support, email  
[Bioenergy\\_BRIDGES@ee.doe.gov](mailto:Bioenergy_BRIDGES@ee.doe.gov)

## Office Hours (registration only)

- **AUGUST 8**
- **AUGUST 22**
- **SEPTEMBER 5**
- **SEPTEMBER 19**



**NATIONAL COLLABORATIVE FOR RESEARCH ON FOOD, ENERGY, AND WATER EDUCATION (NC-FEW)**  
A hub of innovation for research on FEW-Nexus educational programming

Department of Energy BRIDGES Bioenergy Case Study

Can Plants Help Clean Up Watersheds *and* Supply Renewable Energy?  
Explore a U.S. Department of Energy BRIDGES Bioenergy Case Study

Thursday, September 12, 2024

10am - 11:30am PT | 11am - 12:30 pm MT | 12pm - 1:30pm CT | 1pm - 2:30pm ET

The registration deadline is Tuesday, September 10, 2024.

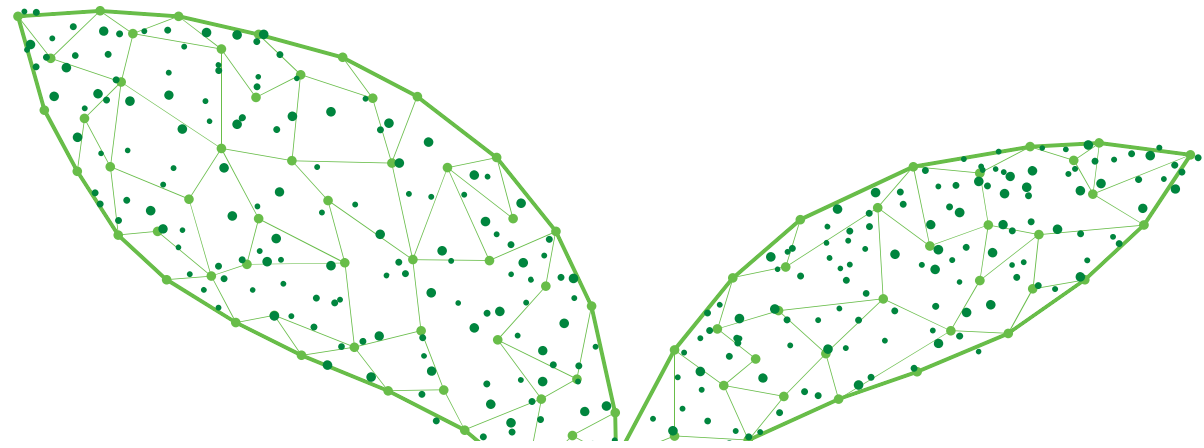




<https://tinyurl.com/betobridges24>

# Thank you!

Contact us with additional questions & comments: [Bioenergy\\_BRIDGES@ee.doe.gov](mailto:Bioenergy_BRIDGES@ee.doe.gov)



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Feedstock



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