Bioenergy Research and Education

# BRIDGES

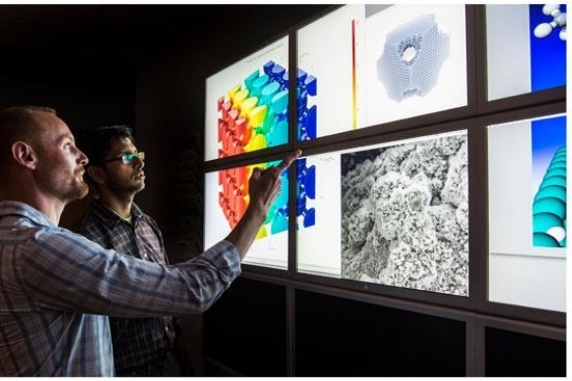
U.S. Department of Energy | Bioenergy Technologies Office

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

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## KELLY STURNER

STEM Education
Program Lead
Argonne National
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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!

# 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

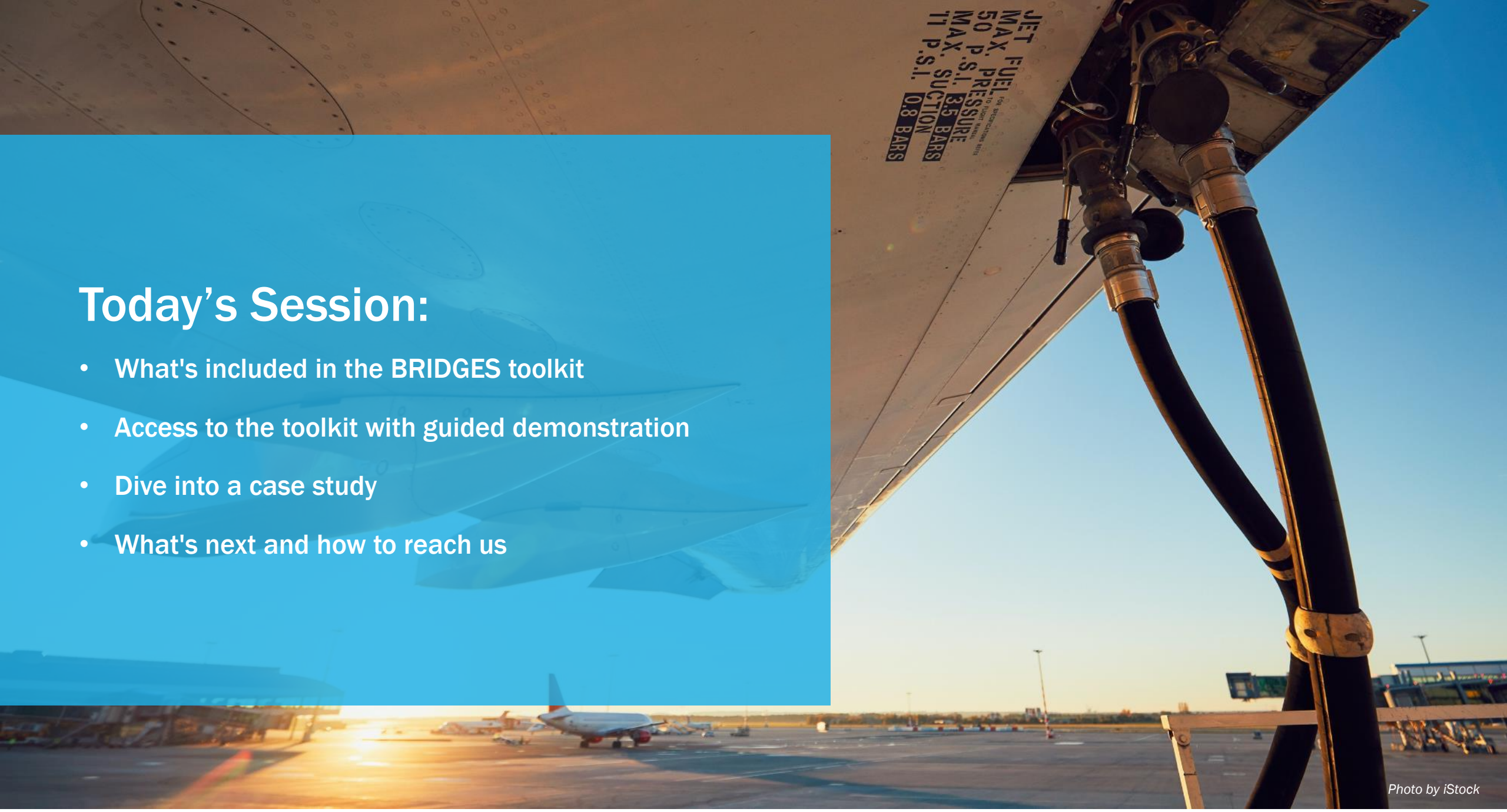
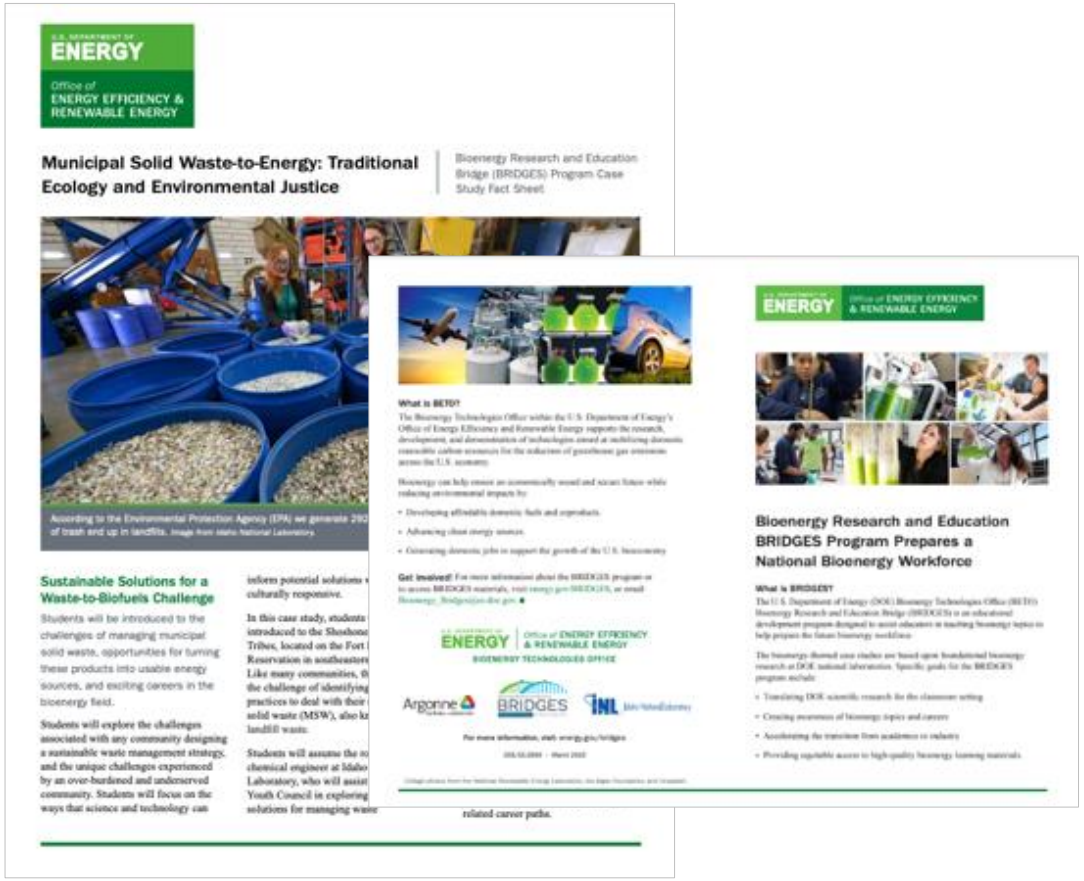



*Photo by iStock*

# MATERIALS THAT SUPPORT BRIDGES

## FACT SHEETS AND PRIMER




## TALK TO YOUR NEIGHBORS!

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

# MATERIALS THAT SUPPORT BRIDGES – HOW TO ACCESS ONLINE

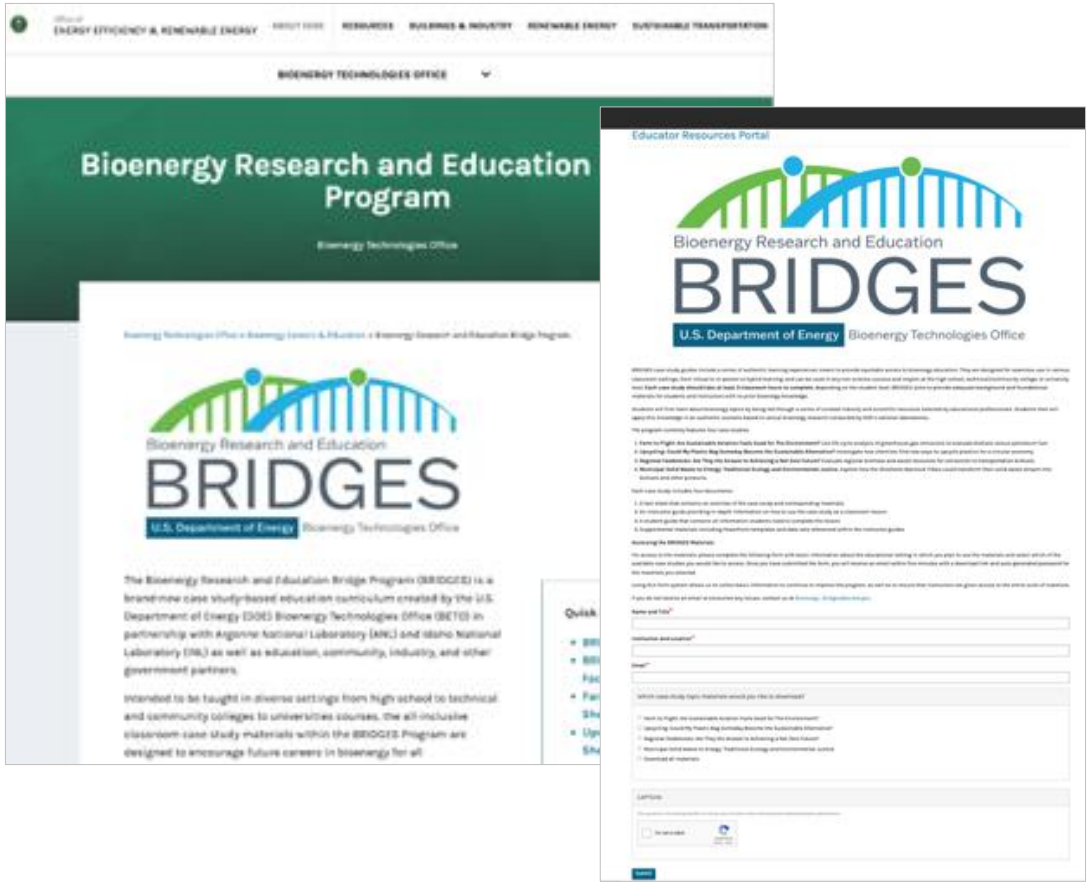
## GO TO BRIDGES WEBSITE NOW

https://tinyurl.com/betobridges24

OR

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

## WEB PORTAL FOR DIGITAL DOWNLOAD

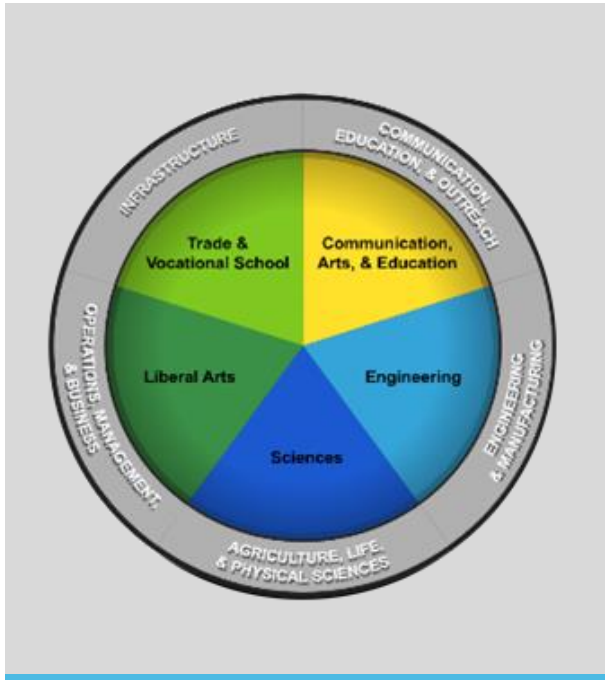


# INSIDE A BRIDGES CASE STUDY…

Topic Introduced with Authentic Scenario

Students Explore Resources

Students Demonstrate Learning




Career Exploration

# Overview


*Photo by iStock*

# 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.

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# QUICK START GUIDE FOR STUDENTS

## 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.

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# 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?

# 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

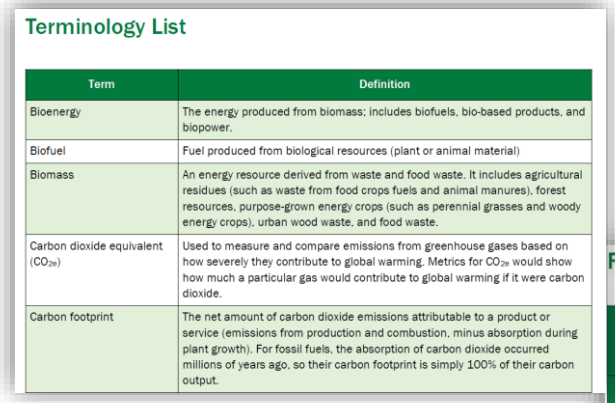
- This portion sets up the goals of the case study in line with the scenario.

## 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.

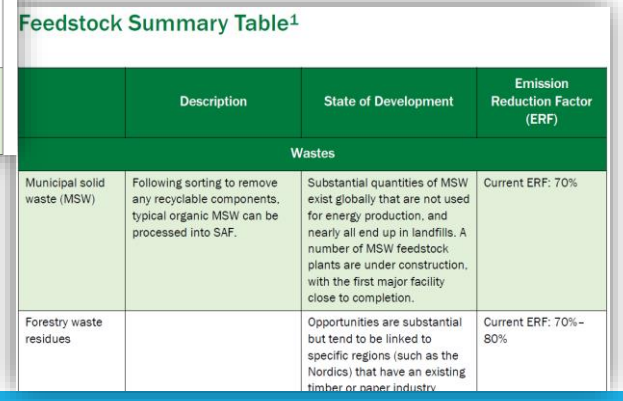
## Instructor Notes

- 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 ($CO_{2e}$) | Used to measure and compare emissions from greenhouse gases based on how severely they contribute to global warming. Metrics for $CO_{2e}$ 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. |



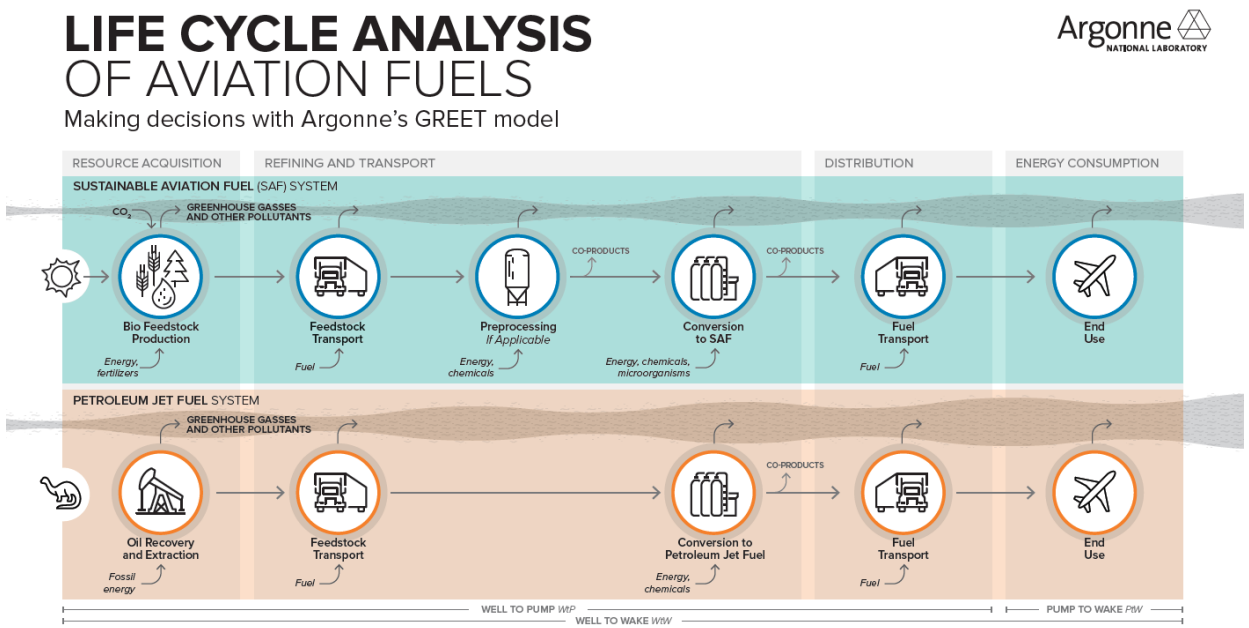
Feedstock Summary Table[1]

| | Description | State of Development | Emission Reduction Factor (ERF) |
|---|---|---|---|
| **Wastes** | | | |
| 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)

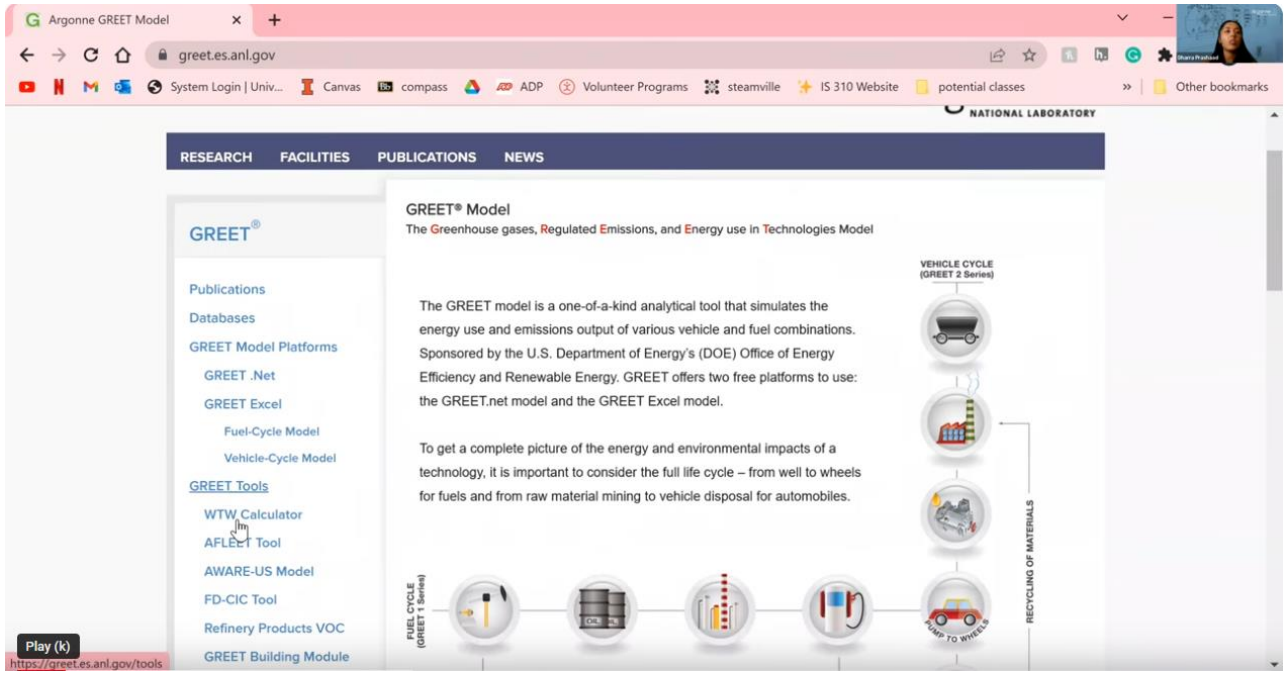
- What are the main categories of SAF feedstock? Give examples of each. Briefly mention the main benefit and drawbacks of each.
- Explain the concept of life cycle analysis of greenhouse gas emissions using the following LCA diagrams for both petroleum jet fuel and SAFs as a guide. Make sure to include 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.

## Instructor Notes



# 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

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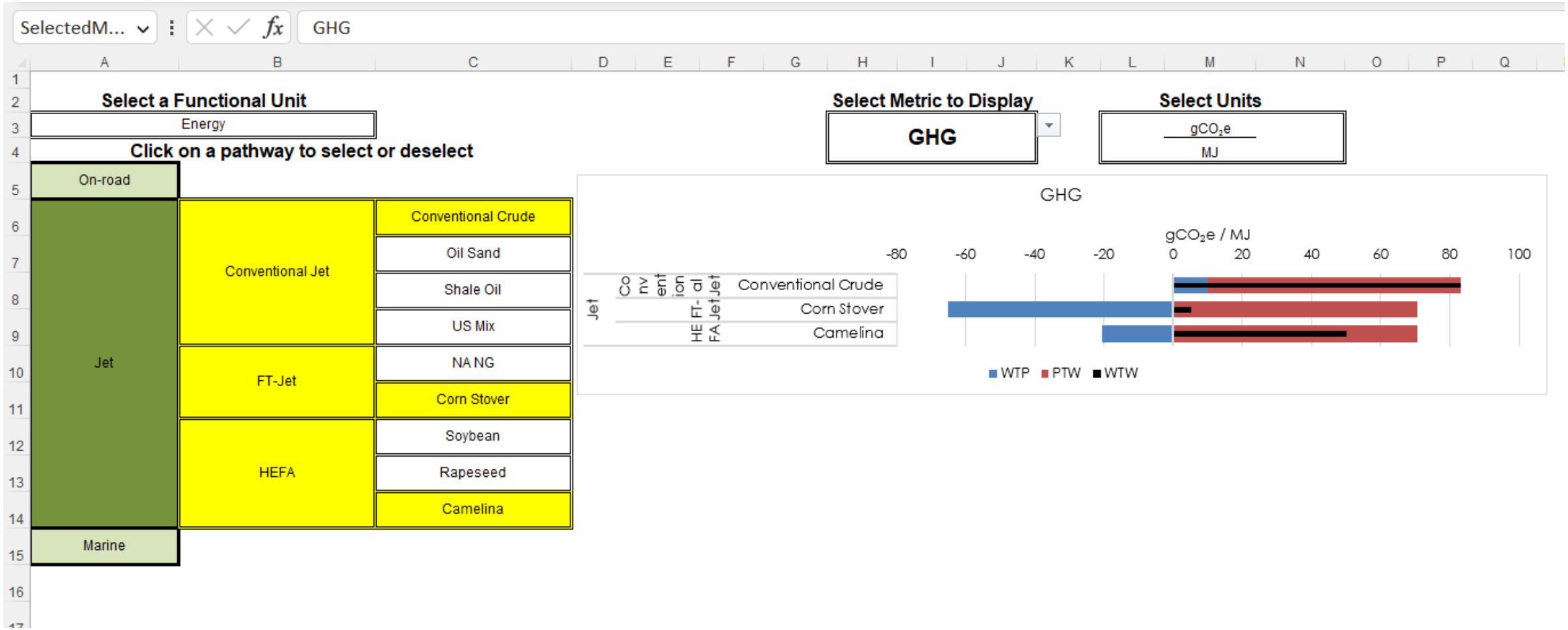
# GREET Well to Wake Calculator

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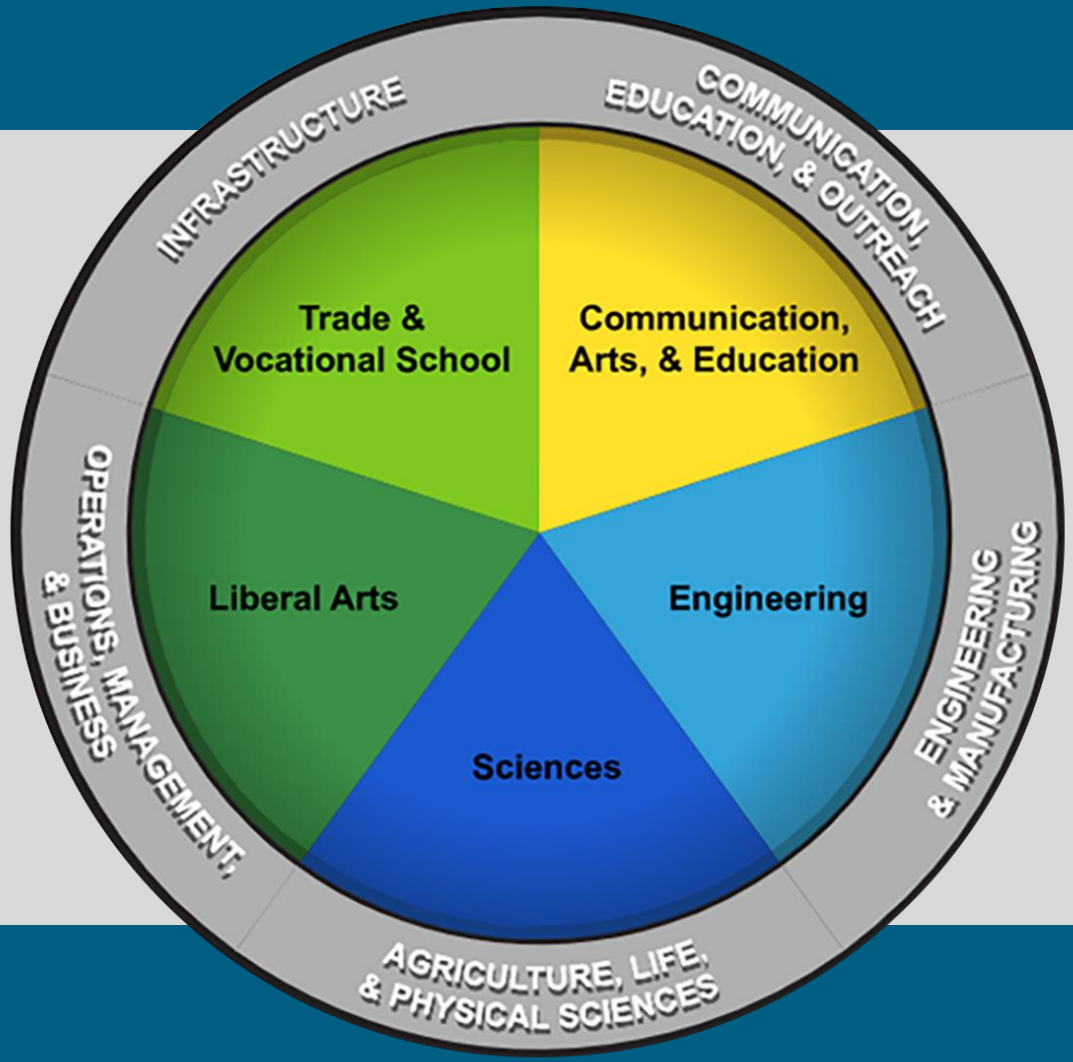
# PART 3: EXPLORE A CAREER IN BIOENERGY

## CAREER HIGHLIGHT
## SUSTAINABILITY SPECIALIST

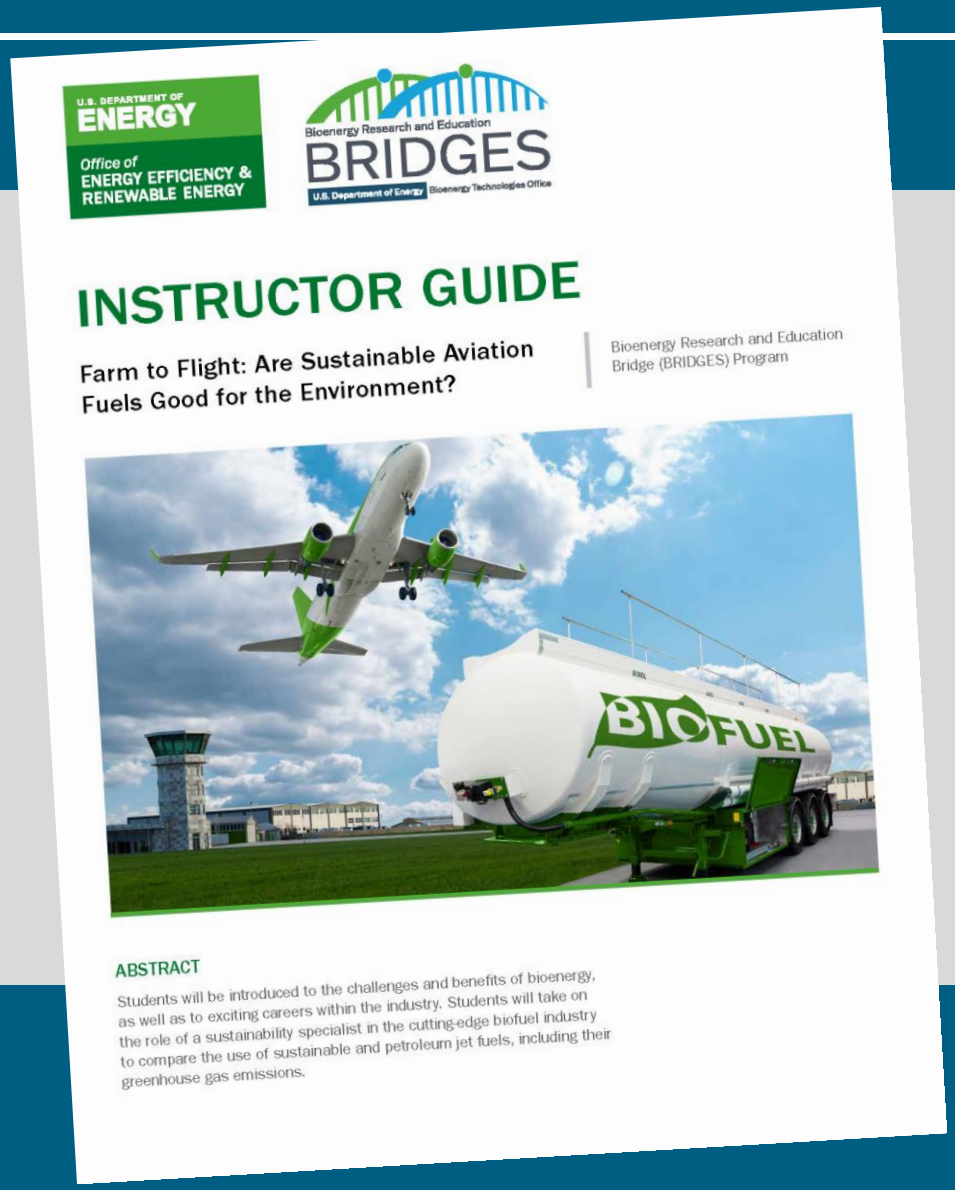
- Average salary
- Common majors for this position
- Responsibilities of a sustainability specialist
- Students then explore the career wheel to identify a career of interest to them



# COMPREHENSIVE INSTRUCTOR GUIDE

## ASSUMES NO BIOENERGY BACKGROUND

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

# 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<br><br>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<br><br>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<br><br>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 ($SO_2$), nitrous oxides ($NO_x$)
- 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

## 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

ıent 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**

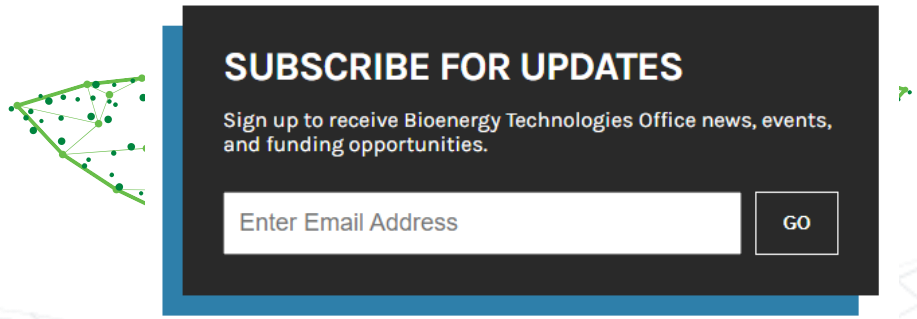
**10am - 11:30am PT | 11am - 12:30 pm MT | 12pm - 1:30pm CT | 1pm - 2:30pm ET**

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




Feedstock | Algae | Conversion | Systems | Data