

**STEM ACTIVITY:**  
**Life Cycle of Energy in Aviation**

Grades 9–12

[www.nasa.gov](http://www.nasa.gov)



# LIFE CYCLE OF ENERGY IN AVIATION

## SUMMARY

Students will be given various forms of information about sustainable aviation and sources of energy. Using the claim, reasoning, and evidence method (CER), students will create a presentation to a simulated NASA panel on ways to make aviation more sustainable using alternative energy sources.

## OBJECTIVES

Students will:

- Compare and contrast energy life cycles to determine how aviation can be more sustainable.
- Present a claim to a simulated NASA panel about making aviation more sustainable using the claim, evidence, and reasoning (CER) method.

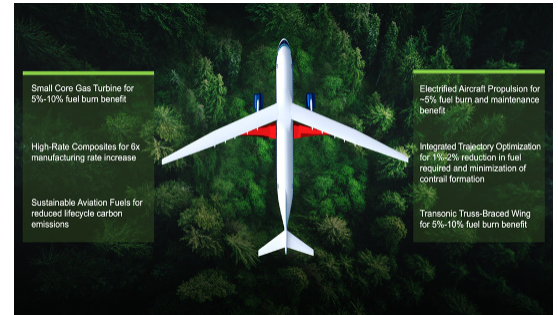
## SAFETY NOTE

Students should be aware of their surroundings and carefully move throughout the room when viewing other teams' work.

# BACKGROUND

## Sustainable Aviation

NASA innovates for the benefit of humanity. Sustainable aviation is one such benefit. Sustainable aviation is the concept of improving the environmental and societal impacts of air transportation. One of its goals is to help industry reduce harmful emissions. NASA is starting with an aircraft that would help contribute to the White House's U.S. Aviation Climate Action Plan's goal of net-zero carbon emissions by 2050. The purpose of the Sustainable Flight Demonstrator project is to engage with industry, academia, and other government organizations to identify, select, and mature key airframe technologies – such as new wing designs. Other advanced technologies will be introduced onto the demonstrator to help achieve fuel consumption and emissions reductions of up to 30%. The Sustainable Flight Demonstrator will improve the aviation industry's knowledge of responsible aviation with the most current technologies onboard. The demonstrator aircraft is one aspect of the multifaceted Sustainable Flight National Partnership that NASA has embarked on with industry and is part of NASA's Integrated Aviation Systems Program.



A picture showing an airplane and how it is constructed for lower emissions.

Credit: NASA

This new area of sustainable aeronautics is being led by NASA. Each year, aircraft emit up to 4% of global carbon dioxide emissions. Currently, jet engines are powered primarily by kerosene, a fossil fuel. As a result of burning kerosene, pollutants such as carbon dioxide ( $\text{CO}_2$ ), nitric oxide ( $\text{NO}_x$ ), sulfur oxides ( $\text{SO}_2$ ), and soot are produced. How do these emissions cause problems?

Water vapor and soot particles are present in traditional jet engine exhaust. Water vapor condenses as it cools. Supercooled water can form ice crystals when it interacts with exhaust soot or even particles naturally present in the air, which can affect the way the Earth is heated and cooled. A cleaner-burning jet fuel or the use of no fuel usage while flying in the atmosphere reduces the impact of aviation on climate change.

## Life Cycle of an Energy Source

One energy source rarely functions as the only energy source. Different products require different sources or combinations of energy. In fact, one energy source may even rely on another. For example, currently, raw materials for a lithium battery are mined with, heavy machinery that runs on diesel fuel. Therefore, the lithium battery's life cycle includes items that depend on diesel fuel. The life cycle includes every step in its life from the beginning to the end. All energy sources have a potential for social, economic, or environmental impact. The steps in the life cycle usually include material extraction, manufacturing and production, transportation, use, and disposal. The environmental impacts can be lessened at each stage and NASA is looking for those sustainable energy sources, one which creates close-to-zero carbon emissions, to lessen the environmental impacts in aviation.



A diagram showing the example of the life cycle of lithium battery.

As a threat to operations and missions in 2005, NASA identified ‘regional climate variability’ as a risk. As part of NASA’s Climate Action Plan (CAP), published in 2021, NASA presented a vision for adapting to climate change impacts on its mission, facilities, infrastructure, natural lands, and other assets today and in the future. This sustainability is leading to a revolutionary era of aeronautics where under the Sustainable Flight National Partnership, NASA is enabling the use of high-blend sustainable aviation fuels and deploying operational improvements to maximize the efficiency of the next generation of single-aisle aircraft while reducing the amounts of pollutants in the atmosphere.

## INSTRUCTIONS

**Work In a small group to answer the following questions:**

- What is energy?
- What items do you use on a daily basis that need energy?
- What is the energy source needed for the items that you use daily?
- Is there one energy source that is the best?

Watch the video: [NASA’s X57 Maxwell Powers Up](#)

**Answer the following questions that you learned from the video:**

- What energy source is being used by the X-57?
- Do you think this is the most sustainable energy source for aviation? Why or why not?
- If not, what would be the most sustainable energy for aviation?

Research “environmentally sustainable aviation” to get a basic understanding of this concept. Then research “sustainable energy sources” to determine what energy source or what combination of energy sources can be used to make aviation more sustainable. Keep in mind that most aircraft use multiple energy sources. During your research, **create a graphic organizer** that will show the energy type, the waste products, emissions, and environmental impacts, as well as the pros, and cons of each energy source.

Here are just a few resources to get you started but you will need to look further than just these links:

- [NASA’s X57 Maxwell Powers Up](#)
- [NASA, Boeing Gather Data to Aid Sustainable Aviation Fuel Adoption](#)
- [X-57](#)
- [New Mexico Energy – NASA DEVELOP Summer 2018](#)
- [Renewable and Alternative Energy](#)

**Compare which energy sources have more environmental impact and which have less and explain.**

- Are there any energy sources that do not have any waste, emissions, or environmental impact anywhere in their lifecycle?
- Based on what you have learned, what energy source would you choose to ensure aviation is sustainable? Explain why.

**Use the information you just learned to create two life cycles of energy (pictures and labels).**

Remember, as you create your life cycles you are looking for an energy source that will make aviation more sustainable. An example of a life cycle can be found in the background information.

**Once the energy cycle is complete, compare life cycles. Here are some questions to help compare the life cycles:**

- What is the best source or combined sources of energy for an aircraft? Why?
- How can you conserve energy on an aircraft?
- What can the aviation industry do or not do to conserve energy and contribute to sustainable aviation?

**You will now use all the information you have gathered for your Claim, Evidence, Reasoning (CER) worksheet. Review the CER worksheet and rubric.**

- Your team will have the following claim: How can aviation be more sustainable? Teams will be using the information that you have gathered as evidence and then connect each piece of evidence to the claim.
- After your CER worksheet has been approved, then you can move to the next section.
- Your team will place your CER worksheet around the room.
- As a team, you will evaluate other teams using the CER rubric.
- As your team evaluates, do not only circle numbers but include questions about the CER handout if there is a concept that is not developed well.

**After your team has completed and evaluated CER handouts, your team will present your claim, evidence, and reasoning as a presentation to a simulated NASA panel.**

- Presentations can be in any form indicated by the educator but must include the energy sources life cycles and the CER information. It also must explain to the panel an idea of how aviation can be more sustainable using the energy sources life cycle.
- Think about the following questions as your team creates its presentation:
- What were your team's struggles during this process?
- What types of evidence did you use?
- Do you think the solution you presented to NASA is something that is feasible or may take time to develop? Why?
- What have you learned about sustainable aviation that you did not know before?

## DIFFERENTIATION AND GOING FURTHER

- Give students the types of energies that you want them to research.
- Give students a limited number of energies to research.
- Have the graphic organizer premade for some students, you may even want to put the names of the energies that they research in the column.
- To conserve time, research as a class and give each group a different type of energy to research and then share information.

### Extension

[Think Green – Utilizing Renewable Solar energy](#)

See how you can be involved with a [citizen science project](#).

## STANDARDS

### Next Generation Science Standards

#### Disciplinary Core Ideas

- HS-ESS3-4 Earth and Human Activity
- HS-LS2-7 Ecosystems: Interactions, Energy, and Dynamics
- ESS3.C: Human Impacts on Earth Systems
- LS4.D: Biodiversity and Humans

#### Crosscutting Concepts

- Systems and system models
- Energy and Matter

#### Science and Engineering Practices

- Developing and using models
- Constructing Explanations and Designing Solutions

# CLAIM, REASONING, AND EVIDENCE HANDOUT

Student Data Sheet 1

Student Name: \_\_\_\_\_ Date: \_\_\_\_\_ Period: \_\_\_\_\_

<p><b>Claim:</b> I believe that by _____ aviation can be more sustainable.</p>	
<p><b>Evidence:</b> Sufficient, Appropriate, and Observation-driven</p>	<p><b>Reasoning:</b> (Why is this evidence important?)</p>
<p><b>Student Data Sheet: A</b> 1. 2. 3.</p> <p><b>Student Data Sheet: B</b> 1. 2. 3.</p> <p><b>Student Data Sheet: C</b> 1. 2. 3.</p>	<p><b>Student Data Sheet: A</b> 1. 2. 3.</p> <p><b>Student Data Sheet: B</b> 1. 2. 3.</p> <p><b>Student Data Sheet: C</b> 1. 2. 3.</p>

Student Data Sheet 1

Student Name: \_\_\_\_\_ Date: \_\_\_\_\_ Period: \_\_\_\_\_

<p><b>Claim:</b> I believe that by _____ aviation can be more sustainable.</p>	
<p><b>Evidence:</b> Sufficient, Appropriate, and Observation-driven</p>	<p><b>Reasoning:</b> (Why is this evidence important?)</p>
<p><b>Student Data Sheet: A</b> 1. 2. 3.</p> <p><b>Student Data Sheet: B</b> 1. 2. 3.</p> <p><b>Student Data Sheet: C</b> 1. 2. 3.</p>	<p><b>Student Data Sheet: A</b> 1. 2. 3.</p> <p><b>Student Data Sheet: B</b> 1. 2. 3.</p> <p><b>Student Data Sheet: C</b> 1. 2. 3.</p>

## My NASA Data: 6–8: Seasonal Science: Building Claims from Evidence

Student Name: \_\_\_\_\_ Date: \_\_\_\_\_ Period: \_\_\_\_\_

**C-E-R Rubric**

Description	3 Points	2 Points	1 Point	0 Points
<b>Claim</b>	Makes an accurate and complete statement linking independent and dependent variables	Makes an accurate but incomplete claim addressing only one variable	Makes an inaccurate claim	Does not make a claim
<b>Evidence</b>	Provided appropriate and sufficient evidence to support claim using qualitative and quantitative observations of both the independent and dependent variables	Provide appropriate but insufficient evidence to support claim	Provides inappropriate evidence. The evidence does not support the claim	Does not provide evidence
<b>Reasoning</b>	Provides reasoning that connects each piece of evidence to the claim. Uses scientific principles to explain why the evidence supports the claim.	Provides appropriate but incomplete reasoning. Each piece of evidence is not supported by a line of reasoning.	Provides inappropriate reasoning.	Does not provide reasoning.
<b>Total</b>				

Student Name: \_\_\_\_\_ Date: \_\_\_\_\_ Period: \_\_\_\_\_

**C-E-R Rubric**

Description	3 Points	2 Points	1 Point	0 Points
<b>Claim</b>	Makes an accurate and complete statement linking independent and dependent variables	Makes an accurate but incomplete claim addressing only one variable	Makes an inaccurate claim	Does not make a claim
<b>Evidence</b>	Provided appropriate and sufficient evidence to support claim using qualitative and quantitative observations of both the independent and dependent variables	Provide appropriate but insufficient evidence to support claim	Provides inappropriate evidence. The evidence does not support the claim	Does not provide evidence
<b>Reasoning</b>	Provides reasoning that connects each piece of evidence to the claim. Uses scientific principles to explain why the evidence supports the claim.	Provides appropriate but incomplete reasoning. Each piece of evidence is not supported by a line of reasoning.	Provides inappropriate reasoning.	Does not provide reasoning.
<b>Total</b>				



National Aeronautics and Space Administration

**Headquarters**

300 E Street SW

Washington, DC 20546

**[www.nasa.gov](http://www.nasa.gov)**