

# How can air travel produce fewer greenhouse gas emissions?



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## Abstract

When you think about the causes of climate change, what comes to mind? Do you think of gasoline-powered cars? Or do you think about coal and natural gas power plants? It turns out that a big source of greenhouse gas emissions is flying. To prevent Earth from becoming too warm, many countries have set net-zero emission goals. So, the aviation industry needs to make changes. We analyzed the amount of greenhouse gas emissions produced in nine different

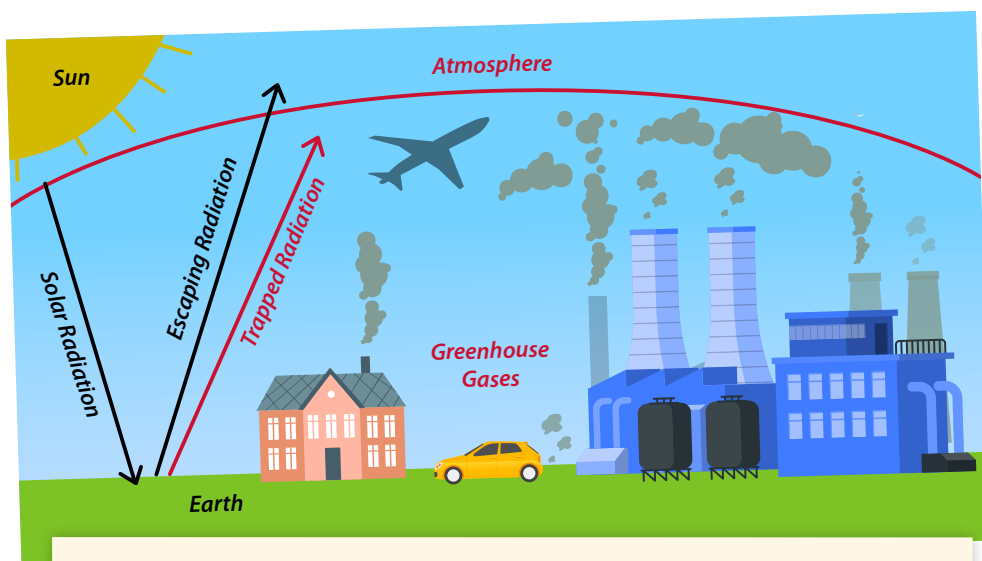
scenarios in the years up to 2050. Each scenario included a change in the demand for flying, a change in the efficiency of the airplanes, and a change in the type of fuel used. We found making changes to these factors can reduce greenhouse gas emissions. However, the aviation industry will also need to invest in carbon dioxide removal from the atmosphere. With these changes, it is possible for the aviation industry to reach net-zero emissions by 2050!

## Introduction

The Earth's temperature is increasing. Many countries do not want the Earth to become too warm. That is why they have set a goal to limit how much the temperature increases. To reach their goal, the world must reach **net-zero greenhouse gas emissions**. That means the amount of greenhouse gases released into the atmosphere is the same as the amount removed from the atmosphere.

The **aviation industry** produces a significant amount of carbon dioxide. This is a **greenhouse gas**. Airplanes use **fossil fuels** as an energy source. Burning fossil fuels releases greenhouse gases (Fig. 1). **Scientists predict that the total greenhouse gas emissions released by airplanes will increase.** That's because more people are traveling by air.

How can the aviation industry reach net-zero greenhouse gas emissions? There are many options. One way is for people



**Figure 1:** Burning fossil fuels releases gases that trap heat in the atmosphere. This causes the average global surface temperature to increase and the climate to change.

to fly less. Another one is to make more efficient airplanes. Another option is to offset the carbon dioxide produced by air travel. That means that the industry pays someone else to remove carbon dioxide from the atmosphere. But this can be tricky if it is not done correctly. The last option is to switch the fuel used by airplanes. Instead of fossil fuels, planes could use a fuel that does not produce greenhouse gases when used.

We wanted to find the best way for the aviation industry to reach net-zero greenhouse emissions. We defined nine different scenarios. Then we analyzed each one to figure out how they would affect greenhouse gas emissions.

## Methods

We developed nine different scenarios in the years up to 2050 (Fig. 2). We used three factors to define these scenarios.

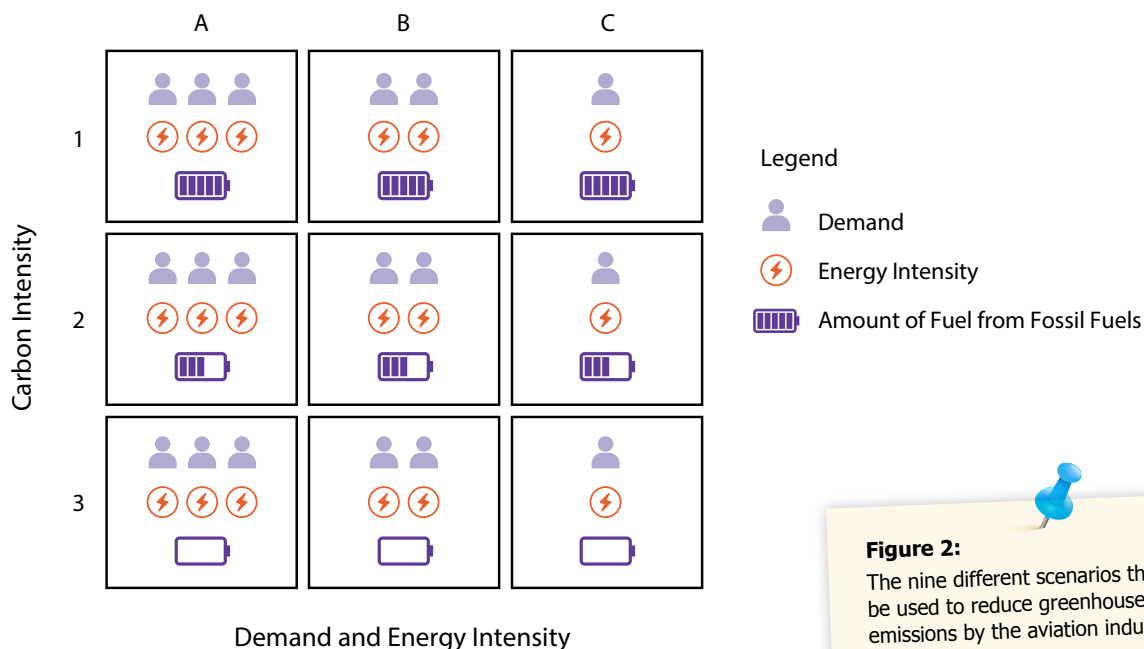
- Demand - how many miles of air travel occur during the given time.
- Energy intensity - the amount of fuel that planes use to travel a certain distance. The lower the energy intensity, the more efficient the airplanes are.
- Carbon intensity - how much of the fuel used by the airplanes is from fossil fuels.

We defined three combinations of demand and energy intensity (A, B, and C). In A, demand and energy intensity

were both high. In B, demand and energy intensity were both medium. In C, demand and energy intensity were both low.

We also defined three levels of carbon intensity (1, 2, and 3). Level 1 had all airplanes using fossil fuels as their energy source. Level 2 had some airplanes using fossil fuels while others used an alternative fuel. Level 3 had all the airplanes using alternative energy.

Each scenario included a demand and energy intensity combination and a carbon intensity level. Then, we calculated the amount of greenhouse gas emissions for each scenario.



**Figure 2:**

The nine different scenarios that can be used to reduce greenhouse gas emissions by the aviation industry.

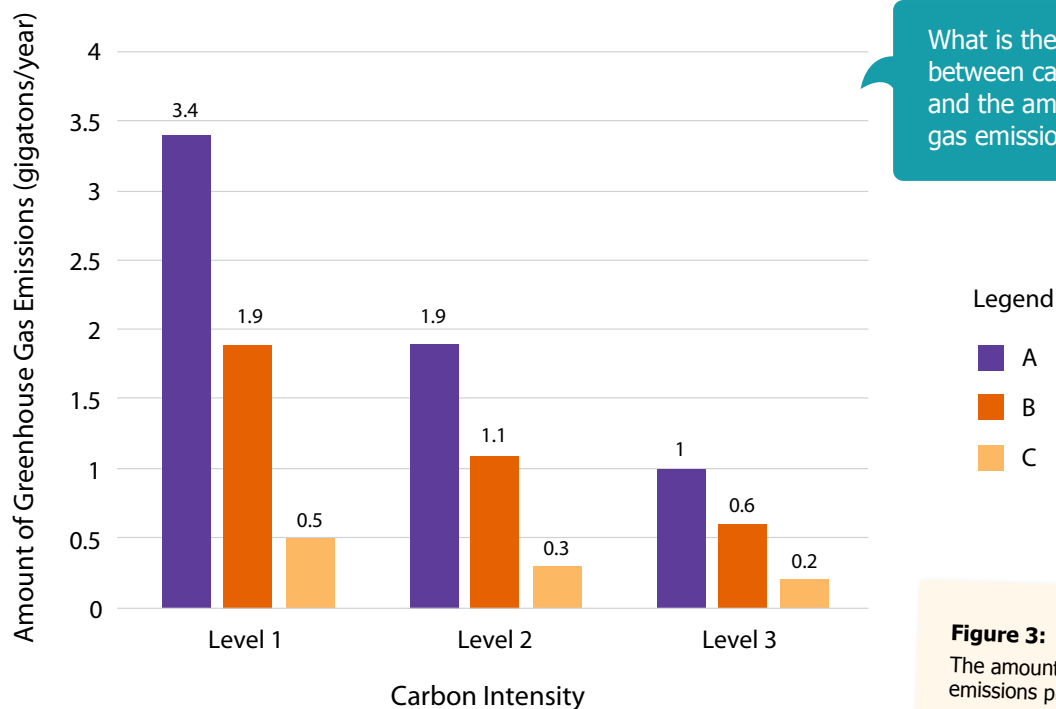
## Results

The scenario that produced the greatest amount of greenhouse gas emissions was A1 (Fig. 3). It produced 3.4 **gigatons** of emissions per year. This scenario had the greatest demand for air travel. It had the least efficient airplanes and the highest use of fossil fuels. **The scenario with the lowest amount of greenhouse gas emissions was C3.**

This scenario had the lowest demand for air travel. **It had the most efficient airplanes, and the highest use of alternative fuels.** It produced 0.2 gigatons of emissions per year.

What is the relationship between demand and energy intensity and the amount of greenhouse gas emissions?

What is the relationship between carbon intensity level and the amount of greenhouse gas emissions?



**Figure 3:**  
The amount of greenhouse gas emissions produced by each scenario.

## Discussion

Our analysis showed that the aviation industry can reduce its greenhouse gas emissions. It also showed that there are different ways to reduce these emissions. But to reach net-zero emissions, some **carbon dioxide removal** is necessary. That is because the scenario with the lowest emission level still produced 0.2 gigatons per year.

But what if there isn't a large decrease in demand and energy intensity? Then the aviation industry will need to switch to alternative fuels. These fuels can include **biofuels** or **synthetic fuels**. One challenge to switching to these

fuels is that there must be enough available. With biofuels, the resources used to make them can include food crops, such as corn. Do we use corn to make fuel or feed the population? Decisions will need to be made on how best to use these resources.

The second challenge to using alternative fuels is cost. The production of these fuels is very expensive. For example, the cost of synthetic fuel is about three times more than the cost of regular jet fuel. Companies will need to compare this cost with the cost of carbon dioxide removal. They may decide

that it is better to pay for removal than to switch fuel types.

It is possible for the aviation industry to reach net-zero emissions by 2050. But there are many questions to answer. Should they update airplanes to be more efficient? Should

they switch to alternative fuels? How much carbon dioxide should they pay to remove? The aviation industry therefore needs to decide how they want to invest their efforts and money.

## Conclusion

Everyone can help the world meet its net-zero emissions goal. How can you help? Reduce the amount of flying you do as much as possible. Choose local vacations over destinations that are far away. Use public transportation whenever possible. Or carpool to help reduce the number of cars on the road. When traveling closer to home, walk

or ride a bike. These options reduce the amount of fossil fuels used to travel from one place to another. And you are helping to reduce the amount of greenhouse gases in the atmosphere!

## Glossary of Key Terms

**Aviation industry** - economic activities that support all aspects of air travel.

**Biofuel** - a fuel derived from living matter, such as plants and algae. Ethanol is an example of a biofuel that is commonly produced from corn or sugarcane.

**Carbon dioxide removal** - a process that takes carbon dioxide out of the atmosphere. There are many methods of carbon dioxide removal including carbon sequestration (storing carbon dioxide in minerals, soil, or the ocean) and the planting of trees.

**Fossil fuels** - an energy source that is formed from the remains of living organisms. The three fossil fuels are natural gas, oil, and coal.

**Gigaton** - a unit of mass that is used for large quantities. One gigaton equals a billion metric tons.

**Greenhouse gas** - a gas in the atmosphere that traps outgoing energy from Earth. This causes Earth's surface to warm. Examples of greenhouse gases include carbon dioxide, nitrous oxide, water vapor, and methane.

**Mile** - a unit of distance commonly used in the USA and UK, equal to approximately 1.6 kilometers.

**Net-zero greenhouse gas emissions** - a balance between the amount of greenhouse gases released into the atmosphere and the amount removed from the atmosphere.

**Synthetic fuel** - fuels that are made using chemical reactions. There are many different processes being explored currently. Many of these processes use hydrogen and electricity to produce the fuel.

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<https://www.footprintcalculator.org/home/en>

## Check your understanding

1 Why is there a world goal of net-zero greenhouse gas emissions?

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2 Why does the aviation industry produce greenhouse gases?

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3 Why is carbon dioxide removal important for reaching net-zero greenhouse gas emissions?

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4 Imagine you have been hired to discuss net-zero greenhouse gas emissions with an airline company. Select one of the scenarios to propose to the company as a way to lower their amount of greenhouse gas emissions. Explain your choice.

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5 Brainstorm a list of ways that your area can reduce greenhouse gas emissions by making changes to transportation systems. Then select the change that you think would be best for your area. What is one thing that would need to occur to make this change successful?

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