

# Seventh Grade Lesson

## *Greenhouse Gas Emissions*

### **Description**

Students will learn about Earth's atmosphere, its chemical composition and changing trends. Students will research an advanced manufacturing company initiative and make a proposal to reduce its greenhouse gas emissions.

### **Advanced Manufacturing Jobs**

environmental engineer, pollution control engineering technician, quality control inspector



### **Essential Vocabulary**

**Atmosphere:** a thin layer of gases surrounding the Earth.

**Carbon footprint:** refers to the greenhouse gas emissions caused, either directly or indirectly, by a person, organization, event, service or product.

**Combustion:** chemical process involving the burning of different types of fuel and causing pollution.

**Greenhouse effect:** ability to trap sun's heat inside of the atmosphere.

**GHGs:** abbreviation for greenhouse gases which trap heat in the atmosphere.

**Manufacturing:** making something on a large scale using machinery.



Math Standards	Standards for Math Practice
<p>7.EE.B.3 Solve multi-step real-world and mathematical problems posed with positive and negative rational numbers presented in any form (whole numbers, fractions, and decimals).</p> <p>7.EE.B.3a Apply properties of operations to calculate with numbers in any form; convert between forms as appropriate.</p>	<p><input type="checkbox"/> MP1: Make sense of problems and persevere in solving them.</p> <p><input type="checkbox"/> MP2: Reason abstractly and quantitatively.</p> <p><input type="checkbox"/> MP3: Construct viable arguments and critique the reasoning of others.</p> <p><input checked="" type="checkbox"/> MP4: Model with mathematics.</p> <p><input checked="" type="checkbox"/> MP5: Use appropriate tools strategically.</p> <p><input checked="" type="checkbox"/> MP6: Attend to precision.</p> <p><input type="checkbox"/> MP7: Look for and make use of structure.</p> <p><input type="checkbox"/> MP8: Look for and express regularity in repeated reasoning.</p>

Science Standards	Sci. & Eng. Practices	Crosscutting Concepts
<p>7.ESS3: Earth and Human Activity</p> <p>1. Graphically represent the composition of the atmosphere as a mixture of gases and discuss the potential for atmospheric change.</p> <p>2. Engage in a scientific argument through graphing and translating data regarding human activity and climate.</p> <p>7.LS2: Ecosystems: Interactions, Energy and Dynamics</p> <p>1. Develop a model to depict the cycling of matter, including carbon and oxygen, including the flow of energy among biotic and abiotic parts of an ecosystem.</p>	<p><input type="checkbox"/> Asking Questions/Designing Problems</p> <p><input checked="" type="checkbox"/> Developing &amp; using models</p> <p><input type="checkbox"/> Controlled investigations</p> <p><input checked="" type="checkbox"/> Data analysis &amp; interpretation</p> <p><input type="checkbox"/> Math &amp; computational thinking</p> <p><input type="checkbox"/> Constructing explanations &amp; designing solutions</p> <p><input checked="" type="checkbox"/> Engaging in argument from evidence.</p> <p><input type="checkbox"/> Obtaining, evaluating &amp; communicating information</p>	<p><input checked="" type="checkbox"/> Pattern</p> <p><input checked="" type="checkbox"/> Cause and effect</p> <p><input type="checkbox"/> Scale, proportion, and quantity</p> <p><input type="checkbox"/> Systems and system models</p> <p><input type="checkbox"/> Energy and matter</p> <p><input type="checkbox"/> Structure and function</p> <p><input checked="" type="checkbox"/> Stability and change</p>

### Task Background Knowledge

1. Students should have an understanding of the Earth’s atmosphere, its chemical makeup and function.
2. Students should have an understanding of human activities that alter the Earth’s atmosphere balance.



### **Student Misconceptions:**

1. Students think that air around the Earth is mainly warmed by energy transferred directly by sunlight.
2. The greenhouse effect is due to human activity.

### **Pre-Assessment:**

Teacher will use formative assessments to determine the student's prior knowledge and skills related to the lesson. For example, a teacher can use a self-assessment probe to ask students to reflect and comment on their level of knowledge and skill across a range of items.

### **Engage:**

Students will brainstorm on what they already know about Earth's atmosphere.

Possible questions:

1. What is Earth's air made of?
2. What gases do we need to survive? Explain

Show students two videos. Students will revisit these two questions and compare their previous knowledge about the atmosphere with the information presented in the videos. Students will write questions they still have after seeing the videos. See Engage Atmosphere Student Handout.

YouTube Video: Learn About Planet Earth - Earth's Atmosphere (5:41 min)

[https://www.youtube.com/watch?v=fyfN9t\\_E0w8](https://www.youtube.com/watch?v=fyfN9t_E0w8)

You Tube Video: Atmosphere (2:18 min) <https://www.youtube.com/watch?v=ZyhsVX-bsik>

### **Explore**

**Infer:** How is the Earth's atmosphere changing?

**Part I:** Students will explore website "Our Atmosphere" by going to

[http://sunshine.chpc.utah.edu/Labs/OurAtmosphere/atmosphere\\_main.html](http://sunshine.chpc.utah.edu/Labs/OurAtmosphere/atmosphere_main.html)

After exploring the website, students will list the gases that makeup the Earth's atmosphere in descending order and create a pie chart representing the Earth's atmosphere's chemical composition. Model how to draw a pie chart using the data table below, making the appropriate conversions and calculations. Students will need a protractor for graphing. Students will also

answer questions on the importance of the atmosphere and the greenhouse effect.

See *Explore Atmosphere Student Handout*.

Gas	Percent in Atmosphere	Change Percent to Decimal	Multiply by 360	Angle Size in Pie Chart
Nitrogen	78.08%			
Oxygen	20.95%			
Argon	0.93%			
Carbon dioxide	0.038%			
Trace Gases	0.004%			

**Part II:** Students will explore the “Atmosphere Design Lab”, an interactive website explaining the roles of gases in the atmosphere. For the Atmosphere Design Lab, go to

<http://forces.si.edu/atmosphere/interactive/atmosphere.html>

After exploring the interactive website, students will complete the following data table identifying the role of chemicals normally found in the atmosphere and their primary sources. Students will also document possible chemical changes and their effects. See *Explore Atmosphere Student Handout*. Below are some teacher notes.

Important Details:	Oxygen- O <sub>2</sub>	Carbon Dioxide- CO <sub>2</sub>	Ozone (gas composed of 3 oxygen atoms)
Role	Combined with sugar, it produces energy, CO <sub>2</sub> and H <sub>2</sub> O; allowing us to live	Warms planet by retaining heat from sun; part of greenhouse gases	Protects from Ultraviolet radiation from the sun
Source	Released by plants during photosynthesis	Burning fossil fuels, automobiles exhaust, power plants, decaying plants and animals, etc.	Accumulated in Earth's atmosphere
Effects of Higher Levels	Too much can make things turn into flames	Making the planet too hot and unbearable	Block too much of the UV radiation needed to produce Vitamin D
Other	Since Earth was formed 4.6 billion years ago, oxygen levels have risen making 1/5 of the Earth's atmosphere	Makes less than 1% of atmosphere; but vital to keep planet warm	Some chemicals caused a reduction in the ozone. Once these were banned, the ozone layer expects to be repaired in 40 to 50 years.

### Explain:

Explain the concepts using a PowerPoint or other presentation forms. Emphasize the

importance of the Earth's atmosphere and how its gases form the greenhouse effect. Explain that scientists are investigating the effects of human activities and manufacturing emissions on the atmosphere. Make a cross-curricular connection with social studies by explaining how the Industrial Revolution changed the work place by incorporating machines able to do work faster and more efficiently. However, machines burn fossil fuels generating gas emissions into the atmosphere. Share data from American Chemistry Society explaining the increasing trend of greenhouse gases. Additional information can be found at

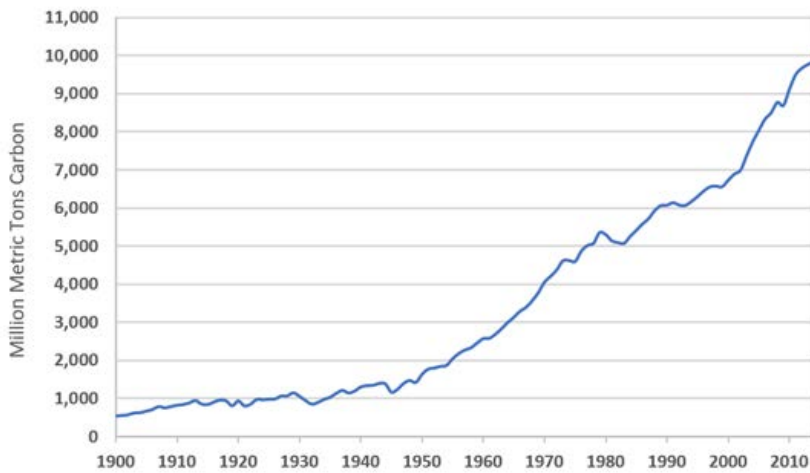
<https://www.acs.org/content/acs/en/climatescience/greenhousegases/industrialrevolution.html>

Explain in addition to scientists, government agencies such as the U.S. Department of Energy and the Environmental Protection Agency (EPA) are monitoring the manufacturing companies, their energy usage and emissions to the atmosphere. New advanced manufacturing processes use large amounts of energy produced mostly by burning fossil fuels creating large amounts of gas emissions. Over many years, the gas emissions have increased and accumulated in the atmosphere. Scientists believe that the accumulation of gas in the atmosphere is affecting the perfect balance known as the greenhouse effect and causing a climate change. According to the EPA, industry's direct or indirect gas emissions in 2015 accounted for 29 percent of the total United States gas emissions, making industry the largest contributor to greenhouse gases. Government agencies are continuously monitoring gas emissions and hope to slow down its accumulation in the atmosphere by making manufacturing companies and all involved stakeholders aware of the situation. Additional information on industry emissions can be found at <https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions>

**Part I:** Students will analyze the global and United States emissions and answer the following questions:

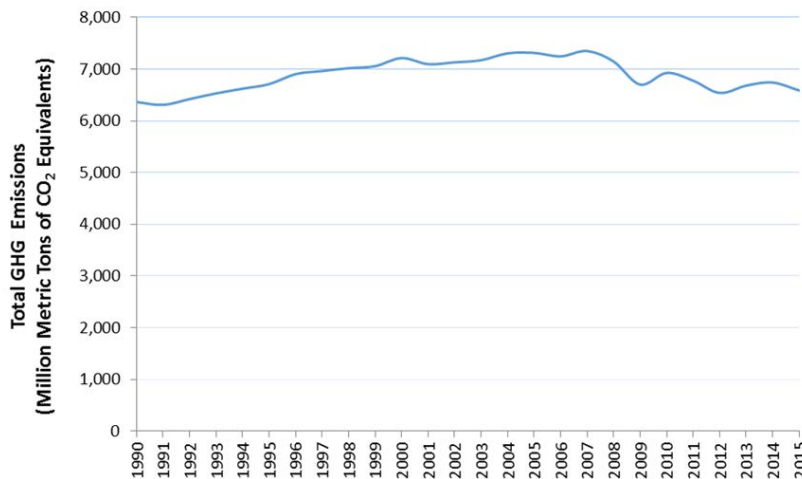
1. What trends do you observe in the Global Greenhouse Gas Emissions graph?
2. What trends do you observe in the U.S. Greenhouse Gas Emissions graph?
3. How do these two graphs compare?
4. What could be the causes of these trends?

### Global Carbon Emissions from Fossil Fuels, 1900-2014



Graph from EPA website: <https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data#Trends>

### Total U.S. Greenhouse Gas Emissions, 1990-2015



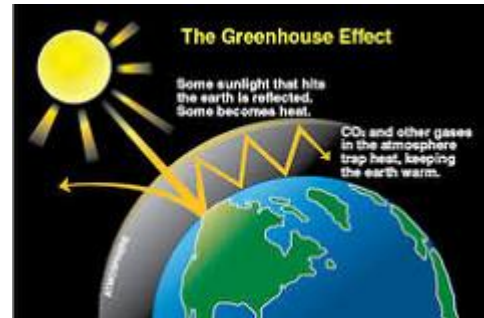
Graph from EPA website: <https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions>

Teacher Note: Students should infer that United States regulations are helping control the gas emissions.

**Part II:** Students will analyze the Global Carbon Atlas map for 2016 CO<sub>2</sub> Emissions at <http://www.globalcarbonatlas.org/en/CO2-emissions> and answer the following questions:

1. What differences do you observe among the circles on the map?
2. Which countries or continents have the highest number of circles?
3. Which countries have the higher emissions? Go to the right toolbar and click on Chart View. List the top 10 countries with the highest emissions in descending order.

Country	Emissions in MtCO <sub>2</sub>
China	10151
US	5312
India	2431
Russia Federation	1635
Japan	1209
Germany	802
Iran	656
Saudi Arabia	634
South Korea	595
Canada	563



4. How do China and United States compare in their emissions from 2000 to 2015? Click on the right toolbar and go to Time Series.
  - a. What trend do you notice for China?
  - b. What trend do you notice for United States?
5. Infer: Why is it important for US citizens to be aware of the emissions of other countries?

### Elaborate

Share with students an overview presented by the United States Environmental Agency stating that human activities are responsible for the excessive accumulation of greenhouse gases in the atmosphere. The largest source of greenhouse gas emissions from human activities in the United States results from burning fossil fuels for electricity, heat, and transportation. Manufacturing processes produce goods and raw materials that we all use every day. These processes, directly produced 21 percent of gas emissions. But when taking into account the use of electricity, the direct and indirect combined gas emissions for industry rise to 29 percent, becoming the largest contributor of greenhouse gases.

**Essential question:** How do progressive towns support existing manufacturing companies



and promote the establishment of new ones, while preventing an increase of greenhouse gases that ultimately could alter the Earth's atmosphere's balance?

**Part I:** Students will research and build a model explaining how carbon moves through the atmosphere and is used by living and non-living factors such as manufacturing companies and other processes. For more information on the carbon cycle, students may go to <https://scied.ucar.edu/carbon-cycle>

See *Part I: Carbon Movement Model Student Handout*. Using their own model, students will answer:

1. What will be the effects of carbon overproduction by any of the processes part of the model?
2. What process can counterbalance the overproduction of carbon? Explain.
3. Why is carbon dioxide vital in maintaining the perfect balance of the greenhouse gases? Use a mathematical model to justify your answer.

**Part II:** Students will research the EPA website: <https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions> and learn about the United States greenhouse gas emissions and analyze its sources. For a deeper understanding of the industry role, students should click on the Industry tab and read about the progress in reducing emissions. See Part II: Student Task on Industrial Greenhouse Gases Effects Handout.

Students will analyze the information provided and answer the following questions:

1. What trend do you observe in the industry emissions?
2. How much have the industry emissions decreased since 1990?
3. What are ways for the industry sector to reduce even further their emissions? Explain each opportunity:
  - a. Energy efficiency
  - b. Fuel switching
  - c. Recycling
  - d. Training and awareness





**Part III:** As a leading advanced manufacturing country, the United States will continue having higher energy demands and possibly an increase in greenhouse gas emissions. To protect Earth's atmosphere and maintain its perfect balance, industries must be aware of their effects on the atmosphere and the many ways in which they can reduce their impact. Research different industries using the EPA Greenhouse Gas Reporting Program at <https://www.epa.gov/ghgreporting/ghg-reporting-program-data-sets> Students may research specific advanced manufacturing companies within our state and identify their current initiatives for reducing greenhouse gas emissions.

**Student Task:** Choose a local or national company and research their practices to reduce emissions. Then create a proposal for a local industry. In your proposal be sure to include:

- a. the industry's main product(s), location and 2016 gas emissions,
- b. rationale for the existing problem of excessive greenhouse gas emissions,
- c. possible future consequences if the emissions are not controlled and/or reduced, and
- d. two or more ways to reduce their emissions without affecting their productivity.

*See the Emissions Proposal Rubric.*

### **Evaluate:**

Teacher may choose to administer a standard-based assessment and determine the students' mastery level after completing the task.

### **Resources:**

#### **Handouts:**

Engage Earth's Atmosphere

Explore Atmosphere Design Lab

Explain Global and US Gas Emissions Data Analysis

Elaborate Part I- Carbon Movement Model

Elaborate Part II and III: Emissions Proposal Student Task

#### **Rubric:**

Emissions Proposal (attached)

#### **Videos:**

Learn About Planet Earth - Earth's Atmosphere

[https://www.youtube.com/watch?v=fyfN9t\\_E0w8](https://www.youtube.com/watch?v=fyfN9t_E0w8)

Atmosphere <https://www.youtube.com/watch?v=ZyhsVX-bsik>

## References:

American Chemical Society. (n.d.). What are the Greenhouse Gas Changes Since the Industrial Revolution? Retrieved on December 8, 2017, from <https://www.acs.org/content/acs/en/climatescience/greenhousegases/industrialrevolution.html>

Astrophysics Science Project Integrating Research and Education. (n.d.). Our Atmosphere. Retrieved on October 15, 2017, from [http://sunshine.chpc.utah.edu/Labs/OurAtmosphere/atmosphere\\_main.html](http://sunshine.chpc.utah.edu/Labs/OurAtmosphere/atmosphere_main.html)

Global Carbon Project. (2016). Global Carbon Atlas. Retrieved on October 18, 2017, from <http://www.globalcarbonatlas.org/en/CO2-emissions>

Smithsonian Institution. (n.d.). Atmosphere Design Lab. Retrieved on December 9, 2017, from <http://forces.si.edu/atmosphere/interactive/html/index.htm>

United States Environmental Protection Agency. (n.d.). Global Greenhouse Gas Emissions Data. Retrieved on December 8, 2017, from <https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data#Trends>

United States Environmental Protection Agency. (n.d.). Greenhouse Gas Reporting Program Data Sets. Retrieved on December 9, 2017, from <https://www.epa.gov/ghgreporting/ghg-reporting-program-data-sets>

United States Environmental Protection Agency. (n.d.) Sources of Greenhouse Gas Emissions- Industry. Retrieved on December 8, 2017, from <https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions>

University Corporation for Atmospheric Research. (2007). The Carbon Cycle. Retrieved on December 9, 2017, from <https://scied.ucar.edu/carbon-cycle>

## Engage: Earth's Atmosphere A Different Approach to KWL

	Activity:	Student's Notes
K	Brainstorm: What do I know about the Earth's atmosphere? What is air made of? What gases do we need to survive?	
L	You Tube Video Learning: Learn About Planet Earth - Earth's Atmosphere? <a href="https://www.youtube.com/watch?v=fyfN9tE0w8">https://www.youtube.com/watch?v=fyfN9tE0w8</a>	
L	You Tube Video Learning: Atmosphere <a href="https://www.youtube.com/watch?v=ZyhsVX-bsik">https://www.youtube.com/watch?v=ZyhsVX-bsik</a>	
W	Reflect: What questions do I still have about the atmosphere?	

# Explore- Atmosphere Design Lab Student Handout

**Infer:** How is the Earth’s atmosphere changing?

**Part I:** Explore website “Our Atmosphere” using this link:

[http://sunshine.chpc.utah.edu/Labs/OurAtmosphere/atmosphere\\_main.html](http://sunshine.chpc.utah.edu/Labs/OurAtmosphere/atmosphere_main.html)

After discovering information on the website, answer the following questions:

1. What gases make up the Earth’s atmosphere?
  - a. List gases in descending order.
  - b. Create a pie graph to represent the gases that make up the Earth’s atmosphere.

Gas	Percent in Atmosphere	Change Percent to Decimal	Multiply by 360	Angle Size in Pie Chart	Earth Gases Pie Chart

2. Why do we have an atmosphere?

3. What is the greenhouse effect?

4. Why is it important?

**Part II:** Explore the “Atmosphere Design Lab”, an interactive website explaining the roles of gases in the atmosphere. For the Atmosphere Design Lab, go to <http://forces.si.edu/atmosphere/interactive/atmosphere.html>

1. After exploring the interactive website, complete the following data table.

Important Details:	Oxygen- O <sub>2</sub>	Carbon Dioxide- CO <sub>2</sub>	Ozone (gas composed of 3 oxygen atoms)
Role			
Source			
Effects of Higher Levels			
Other			

2. Summarize your findings: How is the chemical composition of the atmosphere changing?

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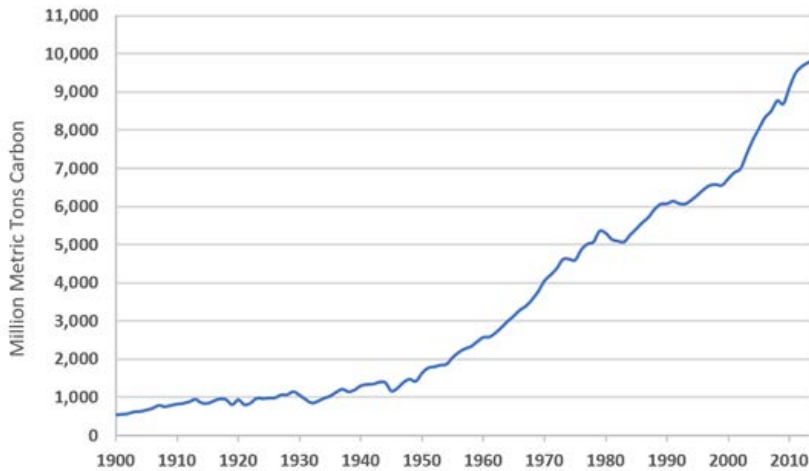
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# Explain: Global and US Gas Emissions Data Analysis

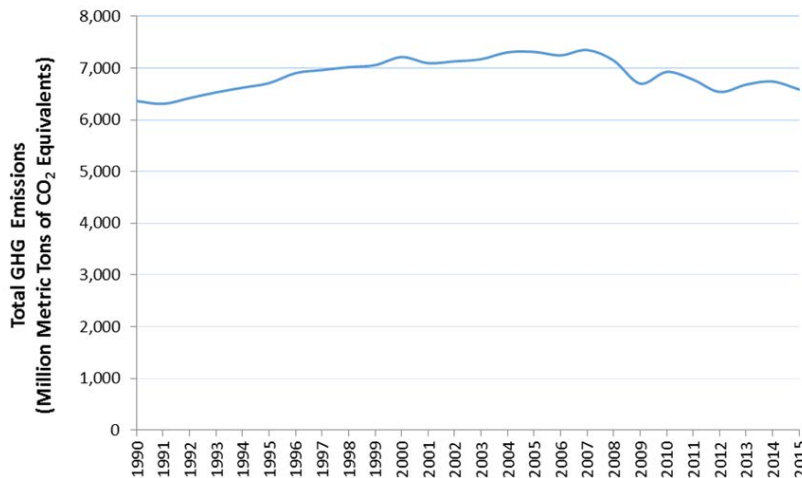
Part I: Analyze the two graphs below and answer the following questions:

Global Carbon Emissions from Fossil Fuels, 1900-2014



Graph from EPA website: <https://www.epa.gov/ghgemissions/global-greenhouse-gas-emissions-data#Trends>

Total U.S. Greenhouse Gas Emissions, 1990-2015



Graph from EPA website: <https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions>

1. What trends do you observe in the Global Greenhouse Gas Emissions graph?
2. What trends do you observe in the US Greenhouse Gas Emissions graph?
3. How do these two graphs compare?
4. What could be the causes of these trends?

**Part II:** Analyze the Global Carbon Atlas map for 2016 CO2 Emissions at <http://www.globalcarbonatlas.org/en/CO2-emissions> and answer the following questions:

1. What differences do you observe among the circles on the map?
2. Which countries or continents have the highest number of circles?
3. Which countries have the higher emissions? Go to the right toolbar and click on Chart View. List the top 10 countries with the highest emissions in descending order.

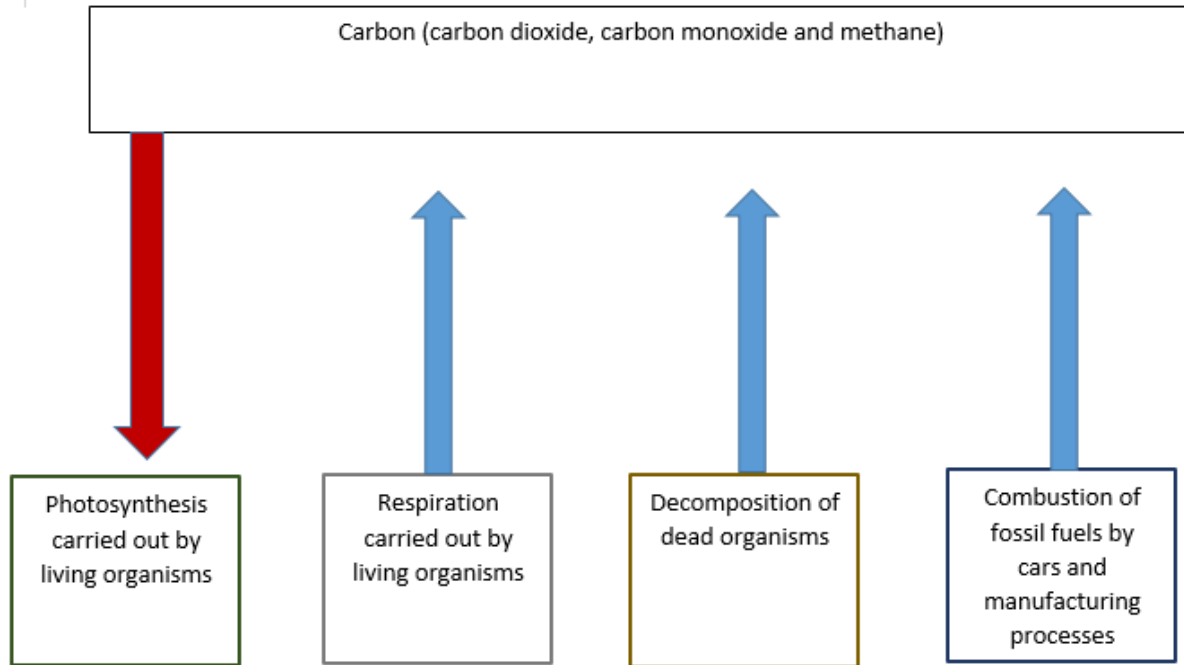
Country	Emissions in MtCO2

4. Go to the right toolbar and click on Time Series. From 2000 to 2015,
  - a. What trend do you notice for China?
  - b. What trend do you notice for United States?
5. Infer: Why is it important for US citizens to be aware of the emissions of other countries?



# Elaborate Part I- Carbon Movement Model

Research the movement of carbon through different processes including manufacturing and develop a model. An example is provided below:



Using your model, answer the following questions:

1. What will be the effects of carbon overproduction by any of the processes part of the model?
2. What process can counterbalance the overproduction of carbon? Explain.
3. Why is carbon dioxide vital in maintaining the perfect balance of the greenhouse gases? Use a mathematical model to justify your answer.

## **Elaborate- Part II and III: Student Task on Industrial Greenhouse Gases Effects**

**Part II:** Research and analyze data provided in the Environmental Protection Agency website (<https://www.epa.gov/ghgemissions/sources-greenhouse-gas-emissions> ). For a deeper understanding of the role of industry, click on the Industry tab and read about the progress in reducing emissions.

Analyze the information provided and answer the following questions:

1. What trend do you observe in the industry emissions?
2. How much have the industry emissions decreased since 1990?
3. What are ways for the industry sector to reduce even further their emissions? Explain each opportunity:
  - a. Energy Efficiency
  - b. Fuel Switching
  - c. Recycling
  - d. Training and Awareness

**Part III-Student Task:** As a leading advanced manufacturing country, the United States will continue having higher energy demands and possibly an increase in greenhouse gas emissions. To protect Earth's atmosphere and maintain its perfect balance, industries must be aware of their effects on the atmosphere and the many ways in which they can reduce their impact. Research different industries using the EPA Greenhouse Gas Reporting Program at <https://www.epa.gov/ghgreporting/ghg-reporting-program-data-sets> You may also research specific advanced manufacturing companies within our state and identify their current initiatives for reducing greenhouse gas emissions. What are your recommendations for them?

**Student Task:** Choose a local or national company and research their practices to reduce gas emissions. Then create a proposal for your chosen industry. In your proposal be sure to include:

- a. industry's main product(s), location and 2016 gas emissions,
- b. rationale for the existing problem of excessive greenhouse gas emissions,
- c. possible future consequences if the emissions are not controlled and/or reduced, and
- d. two or more ways to reduce their emissions without affecting their productivity.

# Evaluate- Emissions Proposal Rubric

Evaluate Emissions Proposal using the following indicators:

<b>Task Components</b>	<b>3 Above the Expectations</b>	<b>2 Met Expectations</b>	<b>1 Below Expectations</b>
<b>Industry Product(s) and Emissions Data</b>	Proposal thoroughly describes the industry's main product(s), includes its emissions data and makes a connection between the both.	Proposal describes the industry's main product(s) and includes its emissions data. A brief connection between the two is made.	Proposal does not describe the industry's main product(s), neither/nor includes its emissions data. A brief statement of the industry is made.
<b>Rationale for Excessive Emissions Problem</b>	Proposal includes a complete rationale of the current existing problem with excessive emissions in United States and other countries. The rationale is supported with emissions data including United States and other countries.	Proposal includes a rationale of the current existing problem with excessive emissions in United States. The rationale is supported with some emissions data.	Proposal does not include a rationale of the current existing problem with excessive emissions. A general statement is made about the current problem.
<b>Future Consequences</b>	Proposal clearly explains the damaging consequences if emissions are not controlled and/or reduced and provides one or two examples.	Proposal explains the consequences if emissions are not controlled and/or reduced and provides one example.	Proposal does not explain the consequences if emissions are not controlled and/or reduced. A general consequence is mentioned without details.
<b>Ways to Reduce Emissions</b>	Proposal includes two or more ways to reduce emissions without affecting the company's productivity. Each recommendation has detailed explanation and justification.	Proposal includes one way to reduce emissions without affecting the company's productivity. Each recommendation is well explained.	Proposal includes no specific ways to reduce emissions without affecting the company's productivity. A vague recommendation is included without details.