Climate Change Lesson 3: *The Engineer*
Educator's Lesson Plan

Objective

In this *The Engineer* activity, students will:

1. Analyze data from a variety of graphs in order to evaluate:
    - US greenhouse gas emissions.
    - Sources of greenhouse gas emissions.
    - Human population growth rates.
2. Calculate and analyze individual carbon footprints.
3. Research a leading source of greenhouse gas emissions and design a solution to decrease the carbon footprint associated with this source.

Time Required: 200 minutes

Materials Required	Safety Considerations	Science & Engineering Practices
• Computers for research and/or digital presentation • Poster paper • Colored pencils/markers • Variety of materials for student models, including materials such as cardboard, pipecleaners, solar cells, elastic bands, paper, etc.	None	• Analyzing and Interpreting Data • Constructing Explanations or Arguments From Evidence • Designing Solutions • Communicating Findings/Design (Oral Presentation)

Inquiry Scale: Leveling Information

Level 1: most teacher-driven (*recommended for grades 4-5)*
Lead students through the graph interpretation as a whole class discussion: project the graphs on the board and ask students what they see and what it means. Answer the questions as a class.
Demonstrate how to use the carbon footprint website. Discuss results as a class.
Choose which source of greenhouse gas emissions you would like the class to focus on for their research (see Appendix A). Recommended sources for this level include electricity, transportation, or students' own homes (residential). Project the Source Card for students to give students ideas. Students can work in small groups to complete their final projects.

Level 2 (*recommended for grades 5-6)*
Lead students through the graph interpretation as a whole class discussion: project the graphs on the board and ask students what they see and what it means. Think-pair-share the questions: have students answer the questions with a partner and then share with the class to check for understanding.
Demonstrate how to use the carbon footprint website. Discuss results as a class.
Students can work in small groups to complete their research and final projects. Choose three different Source Cards from Appendix A for the class to focus on and on which student groups can choose to base their projects.

Level 3 (*recommended for grades 6-7)*
Students will analyze the graphs in small groups and answer the questions with their group. Guide student discussions as needed. Review as a class to check for understanding.
Discuss student answers to the carbon footprint questions as a class.
Students can work in small groups to complete their research and final projects. Cut Appendix A into strips along the rows and let each group choose from a bag to determine their source.

Level 4: most student-driven (*recommended for grades 7-8)*
Students will independently complete all aspects of the activity, including analysis of graphs, independently completing carbon footprint calculations, choosing and researching sources of greenhouse gas emissions, and creating solution models or campaigns. Allow students to choose their source from Appendix B. As the facilitator, check in on group progress. Provide suggestions and support to individuals or specific groups, as needed.

Agenda

I. Show PowerPoint to introduce *The Engineer* Activity (10-15 minutes)
The PowerPoint will review essential concepts learned in *The Solve* and provide context for the students' upcoming *Engineering* challenge.

PowerPoint Slide Guide

Slide 1: Introduction

Slide 2: Why has Earth's global temperature risen by 1 degree Celsius since 1880?

1. Think-pair-share
2. Students share out answers
3. Steer conversation to emphasize how human population and technology has increased over the years. Since the Industrial Revolution (which took place from the eighteenth to nineteenth centuries), Earth's global temperature has continued to steadily rise due to increased amounts of greenhouse gases entering the atmosphere from the burning of fossil fuels

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Slide 3: The Greenhouse Effect

1. Ask students to reflect on Mosa Mack's Mystery on Climate Change as they were shown in *The Solve*.. How are greenhouse gases creating a "greenhouse effect" on Earth?
2. Explain the greenhouse gas diagram to students to help them understand how greenhouse gases work to trap heat in our atmosphere

Emphasize to students that greenhouse gases are gases that are released into the atmosphere as a result of biological processes as well as human activity. These gases trap heat in the atmosphere. During the day, the sun shines through the atmosphere, warming the earth. At night, the earth's surface cools, releasing heat back into the air. Greenhouse gases prevent some of the heat from escaping, thus trapping heat in our atmosphere and warming the earth. These gases comprise carbon dioxide, methane, nitrous oxide, and fluorinated gases. They are emitted as a result of the burning of fossil fuels such as coal, oil, and natural gas, as well as from livestock, which release organic waste into the environment.

Slide 4: What are sources of greenhouse gases?

1. Think-pair-share
2. Students share out answers
3. Emphasize to students that the images shown on this slide show only **some** of the sources emitting greenhouse gases. Source #1 is transportation

Answer: According to EPA data from 2015, transportation accounts for 27% of all greenhouse gas emissions, releasing primarily carbon dioxide into the atmosphere from the combustion of petroleum-based products like gasoline. Source #2, agriculture, accounts for 9% of all greenhouse gas emissions. Agricultural practices, including the use of fertilizers, release nitrous oxide into the atmosphere, while livestock release methane into the atmosphere as part of their natural digestive process. Source #3 relates to the generation of electricity, accounting for 29% of all greenhouse gases. The burning of fossil fuels in order to generate electricity releases carbon dioxide, methane, and nitrous oxide into our atmosphere.

Slide 5: Why such concern?

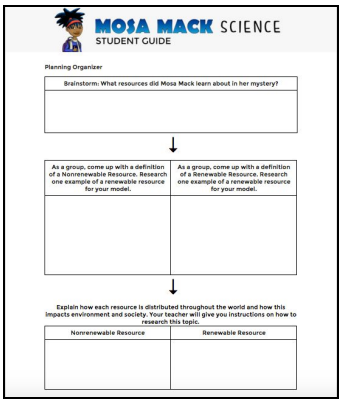
1. Why are scientists so concerned about global warming and the release of greenhouse gases into our atmosphere?
2. Think-pair-share
3. Students share out answers

Answer: With the increase in global temperatures, scientists are concerned about the rate of polar ice cap melting and the rise in sea levels. Continual greenhouse gas emissions have also caused climate change, leading to more unpredictable and extreme weather patterns, including destructive hurricanes, severe drought, and prolonged and more damaging wildfire seasons.

Slides 6-8: Your Challenge

1. Steps to the Activity
2. Group roles
3. Any questions?

II. *The Engineer* Activity (160 minutes)


MOSA MACK SCIENCE
STUDENT GUIDE

Planning Organizer

Brainstorm: What resources did Mosa Mack learn about in her mystery?

As a group, come up with a definition of a Nonrenewable Resource. Research one example of a renewable resource for your model.

As a group, come up with a definition of a Renewable Resource. Research one example of a renewable resource for your model.

Explain how each resource is distributed throughout the world and how this impacts environment and society. Your teacher will give you instructions on how to research this topic.

Nonrenewable Resource	Renewable Resource

As guided by the organizer, students will:

1. Interpret graphs to learn about greenhouse gases and human population growth. See Answer key in Appendix C.
2. Calculate their own carbon footprint. An example of a completed answer is shown in Appendix D.
3. Research* one source of greenhouse gases and explain:
    a. The type and percentage of greenhouse gases being emitted by this source.
    b. The environmental impact resulting from greenhouse gas emissions produced by the source.
    c. Current solutions being used to decrease the production of greenhouse gases produced by this source.

    **Based on your preference, have computers with internet access available to reference EPA data link provided, or printed EPA data resource packets available for student research.*
4. Design a solution model or campaign to help reduce greenhouse gas emissions being produced by their researched source.
5. Present their solution model or campaign to a peer audience.

III. Presentation (30-40 minutes)

Student teams will each have five minutes to present their researched greenhouse gas source and solution (model or campaign) to a peer audience.

***The Engineer* Assessment:** Project Grade and Rubric Score Sheet – Climate Change

Project Submitted by _____

Climate Change *The Engineer* Checklist: Content Concepts and Practices

Your Challenge: Research a leading source of greenhouse gas emissions and design a solution to decrease the carbon footprint associated with this source.

Project Completion:

- ❑ Completion of all aspects of Engineering Planning Guide including:
  - ❑ Gas Emission and World Population graph analysis questions completed and answered thoroughly.
  - ❑ Carbon footprint graph and data completed along with corresponding analysis questions.
  - ❑ Research on greenhouse gas source and environmental impact
  - ❑ Planning template for design solution
- ❑ Option A: Model includes:
  - ❑ Title
  - ❑ Greenhouse gas source researched facts
  - ❑ Environmental impact researched facts
  - ❑ An explanation of how model works and how it will help to reduce greenhouse gas emissions produced by source
  - ❑ A convincing argument as to why the public should use solution to reduce greenhouse gas emissions
  - ❑ Sketch/blueprint of model showing proper dimensions
  - ❑ Explanations of all parts and how they contribute to the product
- ❑ Option B: Campaign includes:
  - ❑ Title
  - ❑ Greenhouse gas source research facts
  - ❑ Environmental impact research facts
  - ❑ An explanation of how solution works to reduce greenhouse gas emissions produced by your source
  - ❑ A convincing argument using evidence as to why the public should use solution(s) to reduce greenhouse gas emissions
  - ❑ One or more graphic displays of data included in presentation (greenhouse gas emission data, environmental impact data, etc.)

DCI Standards Checklist:

- ❑ Accuracy of graph interpretation and analysis for all relevant graphs regarding greenhouse gas emissions, world population and carbon footprint
- ❑ Accurate understanding and communication of relevant data regarding researched source of greenhouse gas and environmental impacts
- ❑ Design solution is realistic, relevant and could accurately be used to alleviate greenhouse gas source and environmental impacts.
- ❑ Informative explanation of how design solution works to limit greenhouse gases produced by source
- ❑ Presentation convinces audience members to adopt solution in order to help reduce their own carbon footprints and improve the environment

Science & Engineering Practices Rubric

	Emerging (1)	Developing (2)	Proficient (3)	Advanced (4)
Analyzing and Interpreting Data	Constructs data tables or graphs that do not display all data. Analyzes data with major misconceptions or omissions.	Constructs data tables or graphs that displays all data, but does not analyze relationships. Analyzes data with minor misconceptions.	Constructs data tables or graphs that displays all data and makes simple connections between variables. Analyzes data to provide evidence for a phenomena.	Constructs data tables or graphs that displays all data and makes complex connections between variables. Analyzes data to provide evidence for a phenomena and acknowledges limitations.
Constructing Explanations or Arguments From Evidence	Constructs an explanation with no clear sources of evidence.	Uses scientific principles and/or data from at least one source to construct or evaluate an explanation, but explanation contains minor misconceptions.	Uses accurate but incomplete scientific principles and/or data from multiple sources to construct or evaluate an explanation.	Uses accurate and complete scientific principles and/or data from multiple sources to construct or evaluate an explanation.
Designing Solutions	Applies no scientific principles and/or data to design, construct, and/or test a design of an object, tool, process, or system.	Applies minimal scientific principles and/or data to design, construct, and/or test a design of an object, tool, process, or system.	Applies adequate scientific principles and/or data to design, construct, and/or test a design of an object, tool, process, or system.	Applies complete scientific principles and/or data to design, construct, and/or test a design of an object, tool, process, or system.
Communicating Findings/Design (Oral Presentation)	Findings/design are incompletely and inaccurately communicated. Or no evidence of using appropriate eye contact, adequate volume, or clear pronunciation.	Findings/design are completely communicated with some misconceptions. Or uses minimal eye contact, inappropriate volume, or inconsistent pronunciation.	Findings/design are completely communicated but lacking depth and complexity. Or often uses eye contact and engaging and appropriate volume and pronunciation, but is inconsistent.	Findings/design are completely communicated with depth and complexity. Or mostly uses eye contact and engaging and appropriate volume and pronunciation.

Teacher Comments:

Final Score: Final Grade:

Appendix A: Engineering Source Cards (Inquiry Levels 1, 2 or 3)

Source of Greenhouse Gas Emissions	Percentage of Total Greenhouse Gas Emissions produced by source	Potential Solutions to Reduce Greenhouse Gas Emissions (Build Into Model or Explain in Campaign)

Electricity 	29%	• Using Renewable Energy Resources to generate electricity such as:
		  ○ Wind power
		  ○ Hydroelectric power
		  ○ Solar power
		  ○ Geothermal power
		• Carbon capture from power plant stacks and rerouting carbon emissions underground

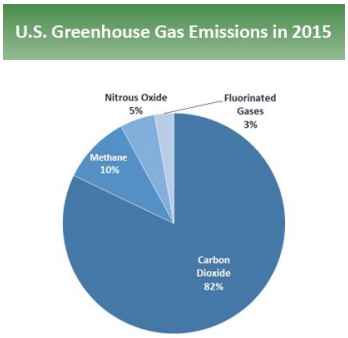
Transportation 	27%	• Biofuels • Hybrid or electric cars • Solar powered car model • Wind turbine car model • Carpooling or taking public transportation
Industry 	21%	• Plant-derived plastics • Recycling steel and scrap aluminum • Energy efficient machinery • Energy efficient building heating • Solar building model
Commercial/Residential 	12%	• Energy efficient buildings (solar panel installation) • Solar home model • Better insulation and efficient windows to prevent heat loss • Efficient fluorescent lighting • Energy efficient appliances • Recycling programs and waste reduction techniques to reduce landfill waste
Agriculture	9%	• Fertilizing crops with exact amount of nitrogen • Improved breeding practices to improve efficiency of livestock • Containing and storing manure in an anaerobic environment. Then capturing methane to use an an energy substitute

Appendix B: Engineering Source Cards (Inquiry Level 4)

Source of Greenhouse Gas Emissions	Percentage of Total US Greenhouse Gas Emissions
Electricity 	
Transportation 	

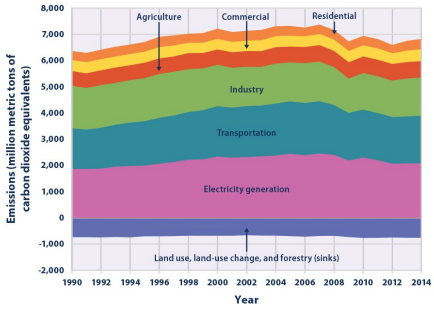
Industry 	
Commercial/Residential 	
Agriculture	

Appendix C: Part 1 Answer Key



U.S. Environmental Protection Agency (2017). *Inventory of U.S. Greenhouse Gas Emissions and Sinks: 1990-2015*.

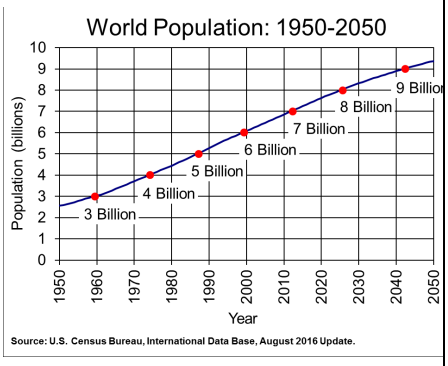
In the US, which greenhouse gas has the highest emissions? *Carbon dioxide*



Source: U.S. EPA, 2016

What is our greatest source of greenhouse gas emissions? *Electricity generation*

How do you predict these greenhouse emissions might change as the human population increases? *Answers may vary. Potential answers include: as human population increases, greenhouse gas emissions will also increase.*



How has the human world population changed over time? *The human world population has increased over time.*

How much did the population increase between 1960 and 2000? *The population increased by 3 billion people between 1960 and 2000.*

According to this graph, what is the current human population? *About 7.5 billion*

How do you predict the population will change in the future? *Answers may vary. Students may predict that the population will continue to increase.*

Appendix D: Part 2 Answer Key

Use the *Lehigh University Environmental Initiative* website to calculate your carbon footprint.

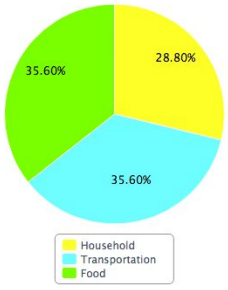
**Carbon footprint is the amount of greenhouse gases produced due to your daily activities.*

http://www.ei.lehigh.edu/learners/cc/carboncalc.html

Once completed, answer the following questions.

Create a pie chart to show your carbon emission data.

Example pie chart:



Record the average US emission data in each category.

Household: 40.60% Transportation: 44.30% Food: 15.10%

How does your carbon footprint data compare with the average US emission data? Explain.
Student answers will vary. Potential student answers could include: According to the generated data, my carbon dioxide emissions produced by food are easily double the average US emission data in this category as my levels are 35.60% as compared to the US average of 15.10%. Transportation and household emissions are less than the average US emission data as shown by the comparative graphs.

What actions could you take to reduce your carbon footprint? Explain. *Student answers may vary. Potential student answers could include: My carbon footprint data is significantly higher than the US average in the category involving food. In order to reduce my carbon footprint associated with food, I could eat less meat and fewer dairy products, reducing my demand for animal-related products that release methane into the environment.*