Climate Engineering Teaching Module
Lesson 3: Climate Engineering Designs

Grade Level: 6-12

Estimated Time for Activity: 90 minutes

Learning Outcomes and NGSS

	Content Knowledge	**Skills**
Expected Learning outcome	Students will apply knowledge from current climate engineering research to improve their personal designs Students will be required to adjust their design to meet specific criteria	Students will learn how to develop engineering schematics/blueprints to illustrate their technology and its features. Students will develop their engineering thinking.
NGSS	**MS-ESS3-3.** Apply scientific principles to design a method for monitoring and minimizing human impact on the environment. **MS-ETS1-2 Engineering Design.** Evaluate competing design solutions using a systematic process to determine how well they meet the criteria and constraints of the problem. **HS-ESS3-2 Earth and Human Activity.** Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios. **HS-ESS3-4.** Evaluate or refine a technological solution that reduces impacts of human activities on natural systems. **HS-ETS1-3 Engineering Design.** Evaluate a solution to a complex real-world problem based on prioritized criteria and trade-offs that account for a range of constraints, including cost, safety, reliability, and aesthetics as well as possible social, cultural, and environmental impacts.	

Materials:

White Poster board (one sheet per student (or per group), ~22”x28”), multiple colors of colored pencils

Key Terms:

Engineering Schematics/Blueprints, engineering thinking

Background:

From Lesson 1 and Lesson 2, each student will have three geoengineering technology designs, knowledge of climate engineering being researched today such as Marine Cloud Brightening (MCB) and its potential benefits, limitations, and risks. This lesson requires the students to further develop a climate engineering design from Lesson 1 to meet more specific criteria.

This lesson is designed to have the students think more critically about the design and function of their technology; yet, still maintaining that the students are in the "driver's seat". From Lesson 1, only two criteria were established for the designs: 1) each design must modify or work with an existing environmental system and 2) each design's intent is to slow global warming. In this lesson, students will need to consider many other criteria as they design their final climate engineering technology. To be considered are the costs and resources needed, ability for the technology to scale from a small, testable version to large-scale deployment, potential unintended negative consequences of deploying the technology, whether the technology a short- or long-term solution to global warming and/or climate change, the consequences if the technology breaks, and whether any countries or demographics will benefit more, or be harmed more, by the use of the technology.

In selecting and developing their final designs, students will work collaboratively within their groups (3-5 students). It is an important part of the engineering design process to have others assess their own design critically and offer suggestions for improvement. Furthermore, engineering projects almost always are completed by a team working together, rather than lone individuals.

The output of this lesson is an Engineering Blueprint. This task introduces the students to a design medium that is commonly used in engineering. Furthermore, the blueprint is a great medium to display and engage with as the students present their designs to an audience in the culminating event of this Teaching Module (Lesson 5). Despite additional criteria, students should still be encouraged to develop their wild ideas and teachers should provide space for the students' creativity and storytelling.

Engineering blueprints/drawings are "a rich and specific outline that shows all the information and requirements needed to manufacture an item or product. It is more than simply a drawing; it is a graphical language that communicates ideas and information." More information about engineering blueprints can be found here: How to Read Engineering Drawings – a Simple Guide | Make UK, and here is a Youtube video: https://youtu.be/aYZn018E2Ok

Activity 1 – Selecting the best climate engineering design:

This lesson begins by summarizing MCB in the accompanying PowerPoint. It is important to review how MCB works by utilizing environmental systems (clouds and seawater) to reduce incoming solar radiation, how the technology (sea salt sprayers) is deployed, and some of the limitations and risks associated with MCB. The PowerPoint also contains a slide to review environmental systems as well as the impacts of global warming and climate change.

Next, the students will be required to select one of their three designs that best meets the more specific criteria as described in the Decision Matrix, shown in the PowerPoint and on the student Worksheet 1. To aid with this decision, the Decision Matrix quantifies six criteria that the final design should meet. If possible, students should be given the opportunity to research information that will help them score the six criteria. This is a good opportunity for students to use technology and practice research skills. Students should be encouraged to select the design with the highest point total and to consider whether combining a feature or two from their other designs will help their selected design score even higher. Combining ideas is a great way for students to refine (but not disregard!) their wild ideas to achieve practicality and usefulness. This is a good time to have the students talk with their group members to help with their decision-making process – you may also decide to have the group members score each other's designs to increase objectivity and teamwork. Furthermore, you may wish to have each group select one design and work together on the technology specifics and blueprint. One method for students to share their feedback on other designs is for each student to place one sticky note at each station that includes a "glow" remark (compliment), "grow" remark (suggestion), and "question" remark (to clarify the design or its use). This will provide valuable feedback before finalizing their design idea and creating the blueprint.

Activity 2 – Creating an Engineering Blueprint:

Once students have selected their final design (and have considered any modifications necessary to better meet the criteria), they are assigned to create an Engineering Blueprint. Each blueprint must contain a title, a descriptive subtitle, drawings of the technology from at least two perspectives, labels and a table of important features, and labels and a table of the size of the technology (see example and checklist in the PowerPoint. The checklist is also included in Worksheet 1). Remind the students to consider the criteria listed in the Decision Matrix as well as the questions on the worksheet as they begin to create their blueprint. The blueprint should be completed on a large poster board, ~22x28" will work well (encourage the students to draft their blueprint on a blank 8.5x11" paper first). Blueprints are typically drawn with one color, but multiple colors can be used for this assignment to enforce creativity. If students need to take their blueprints home to work on, it would be best to roll the drawings and hold them with a rubber band rather than folding.

Demonstration, discussion, and reflection (with Worksheet 2)

In this section, teachers can facilitate a demonstration of the blueprints with discussion of

- What is your geoengineering technology and how does it work? Why is it important?
- How did they embody the big idea into technologies?
- Why did they choose this design over others?
- What challenges did they have when choosing, making, and drawing the design?
- What improvements do they want to make if they do it again?

The purpose of this part is for students to experience and talk through the engineering process explicitly. For developing the engineering thinking, teachers can help the students realize that the engineering process is

- not linear
- iterative
- teamwork
- driven by social needs
- involves a lot of failure
- emotional and its ok to feel frustrated sometimes

Gear up: **A storytelling demonstration**. Teachers can help each group document their thinking and decision-making process. Encourage students to write down what they are thinking while discussing design ideas and store those notes in a Ziplock bag. Each group can use the document bag to tell the story of how they came to the blueprint they show.

Gear down. A simple class discussion and reflection proved to be necessary and effective for students to develop their engineering thinking. Teachers can talk about the relevant engineering process aspects as mentioned above explicitly with the students.