Lesson 5: Solutions to Climate Change

Phenomenon:

There's a lot you can do to make a difference about climate change.

Introduction:

One goal of teaching students about climate change is to foster resiliency. Resilience has multiple facets including understanding the problem and finding solutions. Previous lessons in the unit have presented the problems posed by climate change. Students could be concerned that nothing can be done to address these problems. This lesson provides students with a strategy for making a difference going forward.

This lesson, like the last one, is place-based. The game presented in this lesson is based on what is often called the "wedge strategy". This is the idea that no single alternative energy solution can adequately replace fossil fuels, but a strategy that combines alternative energy resources can. What makes this place-based is that different strategies may be more successful in different regions. Geothermal energy could provide a good alternative in some areas, but not others. Wind is a more viable option in areas where there are stronger sustained winds. Solar power may eventually replace fossil fuels, but it will take time to build enough solar panels, so other strategies must still be used over the next few decades to help communities move away from dependence on fossil fuels for their energy needs.

Conservation, decentralization of the power grid, carbon capture, and changing how we produce and consume resources may also be part of your strategy. The **Supplemental Folder** will provide examples of **NCSE Ambassador Teacher** lessons as well as additional activities and links you can use to personalize your lesson.

Lesson Outline:

Age Level	This lesson is designed for high school biology or environmental science. Options for 5th, middle, and AP applications are provided in the Supplemental Document.
Time Needed	One 60 minute period
Vocabulary	• **Carbon emissions:** emitting carbon dioxide into the atmosphere from the burning of fossil fuels. • **Mitigation:** attempts to reduce the effects of human activity, usually by reducing carbon emissions. • **Stabilization:** stopping our carbon emissions per year from

	increasing. • **Stabilization wedge:** dividing the amount of stabilization into smaller wedges of alternative energy sources. • **Wind power:** technology that generates electricity by harnessing the kinetic energy of the wind that rotates the blades of a wind turbine. • **Photovoltaic solar power:** technology that converts solar radiation directly into electricity using semi-conductors. • **Concentrated solar power:** Technology that uses mirrors to concentrate sunlight to heat a fluid to extremely high temperatures, used to generate electricity. • **Carbon capture and storage (CCS):** technology that captures carbon dioxide produced from coal plants and stores it in the Earth.
Student Learning Outcomes	• Students will learn to analyze complex real-world problems by specifying qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
Disciplinary core ideas	• HS-ESS3.A: Natural Resources • HS-ESS3.D1: Though the magnitudes of human impacts are greater than they have ever been, so too are human abilities to model, predict, and manage current and future impacts. • HS-ETS1.B1: When evaluating solutions, it is important to take into account a range of constraints, including cost, safety, reliability, and aesthetics, and to consider social, cultural, and environmental impacts. • HS-PS3.A2: At the macroscopic scale, energy manifests itself in multiple ways, such as in motion, sound, light, and thermal energy.
Performance expectations	• HS-ESS3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems. • HS-ETS1-2: Design a solution to a complex real-world problem by breaking it down into smaller, more manageable problems that can be solved through engineering. • HS-ETS1-3: 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.
Educator Prep	• Responding to climate change - https://cleanet.org/resources/45148.html • World Climate: Climate Change Negotiations Game - https://cleanet.org/resources/43001.html • 68 alternative energy activities on CLEAN - https://cleanet.org/clean/educational_resources/collection/index.html?search_text=alternative%20energy • FLICC: Five characteristics of science denial • Read through Lesson 9 at explainingclimatechange.ca to

	understand background and operation of the Stabilization Wedges Game.
Fact	There are multiple strategies to reducing carbon emissions, and there are realistic paths to preventing climate change if we try many solutions at once.
Myth	Renewables like solar or wind are not enough to solve climate change.
Fallacy	**Cherry picking:** focusing on just one or a few possible solutions ignores that solving climate requires a multi-pronged strategy.

Engage

Myth: Renewables like solar or wind are not enough to solve climate change.

Our industrial society was built on easy to use, energy-rich, CO_2 emitting fossil fuels. This has allowed us to build an economy based on easy access to energy. It is expected that our demand for energy will increase in the coming decades as new technologies are developed and a growing global population continues to become more prosperous. In order to address the threats posed by climate change we need to find alternative sources of energy. Currently, renewable resources, including solar, geothermal, and wind, represent our best chance to produce the energy we will need and offset the problems associated with our current energy production. But what will it take to accomplish this? What infrastructure must be built? Where will the money come from? Decision makers in the future will need to balance these considerations to balance the maintenance of our societal norms with efforts to improve the environment and reduce climate change.

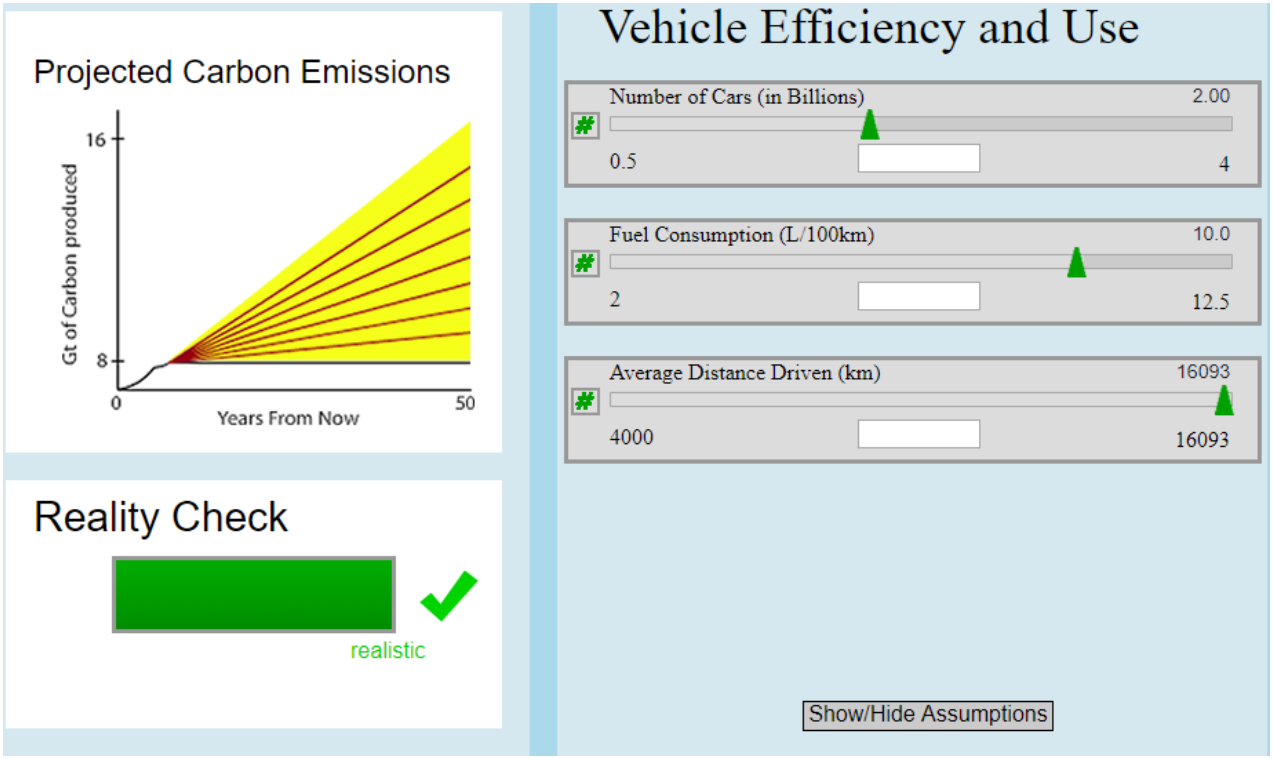
Engage your students with the challenge of replacing fossil fuels within the next 50 years. **What's the best strategy for our community?** As an introduction you may want to show the Ted Ed Video, "Climate change: Earth's giant game of Tetris:"

https://ed.ted.com/lessons/climate-change-earth-s-giant-game-of-tetris-joss-fong

Explore

CHALLENGE: The Stabilization Wedges Game offers a simulation that allows you to test various strategies for replacing fossil fuel use with alternative energy sources. The game shows the potential increase in carbon emissions over the next 50 years and allows you to test various technologies.

The image below shows an example of a strategy for testing automobile usage. It shows the the parameters that can be adjusted, Projected Carbon Emissions (yellow), and a Reality Check (green).



Visit the Stabilization Wedges Game and hit start. You can change the parameters using the menu at the top. Preview these options before starting the game.

Your job is to adjust the sliding green arrows for the different parameters that are most important for your community to find the best balance of strategies. These are all factors that will influence Carbon Emissions. The goal is to reduce the **yellow wedges** to the minimum level while maintaining a level of "**realistic**" on the Reality Check for the 50 year time period.

Remember that changes you make to one wedge can also affect other wedges.

RECORDING YOUR DECISIONS

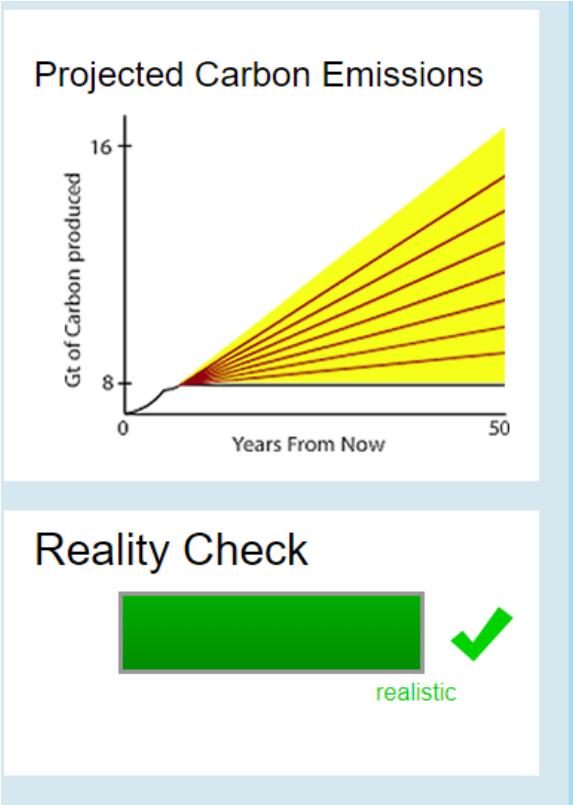
Each row below represents a parameter that you can adjust. In the "SLIDER" column, draw the location you placed it in the simulation. You do not need to write the numbers. If you need to adjust levels to maintain your "Realistic" value, just redraw the slider and circle your final value.

Also - write a short statement explaining your decision or describing what the parameter is measuring. Click on the “Show/Hide Assumptions” to help.

PARAMETER	SLIDER	EXPLANATION
Vehicle Efficiency and Use		
Number of Cars		
Fuel Consumption		
Average Distance Driven		
Coal Power Generation Efficiency		
Efficiency of Coal Plants		
Amount of Power Produced by Coal Plants		
Efficient Buildings		
Number of Lights		
Percentage of Lights that are Fluorescent		
Increase in Efficiency of Newly Constructed Buildings		
Decarbonization of Power		
Wind Power for Coal Power		

Photovoltaic Solar Power for Coal Power		
Concentrated Solar Power for Coal Power		
Coal Power Replaced by Nuclear Power		
Carbon Capture for Coal Plants		
Geothermal Power Generation		
Decarbonization of Fuels		
Biofuels Number of Cars		
Percentage of Cars Using Biofuel		
Forests and Agricultural Soils		
Deforestation Thousands of square km deforested annually		
Conservation Tillage Conservation Tilled Farmland		

Finally, when you have completed the simulation - use colored pencils to modify the image to the right to represent your final "PROJECTED CARBON EMISSIONS" and "REALITY CHECK."



CONCLUSIONS:

- How successful were you? Were you able to reduce the Carbon Emissions all the way down?
- Describe the process you went through to make your final determinations for each parameter.
- How often did you have to reset due to the "Reality Check" dropping too far?
- How does this activity contradict those that say that using renewable energy sources will not be enough to lower our impact on the environment and also cover our energy needs?

Extend

Visit the Project Drawdown website (http://www.drawdown.org/solutions-summary-by-rank) and identify 2 things they could personally do and 1 other solution that would help slow the pace of climate change in your area.

Project Drawdown

- Describe two ways you can help reduce carbon emissions
- Describe one large scale effort that would reduce carbon emissions

Explain

The Laboratory for Atmospheric and Space Physics provides a lot of information on the parameters of the wedge game in their lesson: http://lasp.colorado.edu/home/wp-content/uploads/2011/08/Stabilization-Wedges.pdf

The U.S. Energy Information Administration website also provides descriptions of each kind of alternative energy: https://www.eia.gov/energyexplained/?page=renewable_home

This site from The Solutions Project provides an interactive map that shows what clean energy could look like in 2050 by city: http://thesolutionsproject.org/why-clean-energy/#/map/cities/

This site from the U.S. Department of Energy provides an interactive map of renewable energy production by state: https://www.energy.gov/maps/renewable-energy-production-state

This site from Solar Industry Magazine also provides state by state statistics: https://solarindustrymag.com/state-state-view-u-s-renewable-energy-2017/

Evaluate – FLICC

Spot the fallacy exercise

This lesson began with the fallacy that solar and wind cannot solve the problems of climate change alone, so we shouldn't rely on alternative energy sources. You could have the students discuss how this is an example of "**cherry picking**", and challenge them to find other examples.

But you might also challenge the students to expand the parameters of this misconception.

Students realized through this lesson that we can find alternative energy strategies for our communities in the U.S. But what about the developing world? Surely it isn't fair to force them to use alternative energy? After all, we've enjoyed the benefits of energy from fossil fuels for over a century. Don't developing countries need to use fossil fuels to catch up?

Watch this video from **Global Weirding** with Katharine Hayhoe:

https://www.youtube.com/watch?v=h687bvUB5jI&t=1s

Have a class discussion about the best strategies for replacing fossil fuels globally.

You could have your students work in teams to explore the challenges different countries face and then have a "global climate summit" to share what they find. Have the teams write a short paragraph for each of the questions below:

- What are the expected impacts of global climate change in your country?
- To what extent can climate change impacts be mitigated by alternative energy strategies?
- What is the best strategy for your country?

You might also want to have your students discuss how one country's strategy might be at odds with another country.

- Should all countries be held to the same standards?
- Should richer countries do more to mitigate climate change since they are primarily responsible for the problem?

Guide your students to an agreement similar to the Paris Accords.