GENERATE: The Game of Energy Choices

Teacher's Guide: High School

High School Instructional Support Document

Overview:

The objective of Generate: The Game of Energy Choices is to engage students in grappling with the complexities of our energy challenges in order to cultivate a deep and layered understanding of these challenges. The game serves as a dynamic platform for teaching players about the considerations involved in deciding what type of energy generation to build, as well as the costs (financial and otherwise) involved in providing electricity. It examines impacts on the environment, including how different mixes of electricity can affect emissions of carbon dioxide (CO_2) and water use. The game also has the potential to explore different energy contexts specific to geographic regions as well as socio-political considerations.

This game, which is a powerful engagement strategy to begin a deeper examination of energy issues, is appropriate for use with a variety of age groups including middle school, high school, and college/university. The game is played in a variety of rounds, and teachers should select the rounds that are appropriate to age group and course standards. The game aligns with Next Generation Science Standards as well as North Carolina Essential Standards for a variety of subjects and levels; below is a sampling. *Additions and clarifications relevant to the game are shown in italics*.

Alignment to North Carolina Essential Standards for Earth/Environmental Science:

1. EEn2.8.1: Evaluate alternative energy technologies for use in North Carolina.
2. EEn2.8.3: Explain the effects of uncontrolled population growth on the Earth's resources.
3. EEn1.1.3: Explain how the sun produces energy which is transferred to the Earth by radiation *(accomplished with extension piece on solar photovoltaic).*
4. EEn2.2.2: Compare the various methods humans use to acquire traditional energy sources (such as peat, coal, oil, natural gas, nuclear fission, and wood).
5. EEn2.4.1: Evaluate human influences on freshwater availability *(with water usage round(s))*.

Alignment to North Carolina Essential Standards for World History:

1. WH.H.8.4: Analyze scientific, technological and medical innovations of postwar decades in terms of their impact on systems of production, global trade and standards of living (e.g., satellites, computers, social networks, information highway).
2. WH.H.8.5: Explain how population growth, urbanization, industrialization, warfare and the global market economy have contributed to changes in the environment (deforestation, pollution, clear cutting, ozone depletion, climate change, global warming, industrial emissions and fuel combustion, habitat destruction, etc.).

Alignment to Next Generation Science Standards:
Engineering, Technology, and Applications of Science:

1. HS-ETS1-1: Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.
2. 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.
3. 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.
4. HS-ETS1-4: Use a computer simulation to model the impact of proposed solutions to a complex real-world problem with numerous criteria and constraints on interactions within and between systems relevant to the problem.

Human Impacts on Earth Systems

1. HS-ESS3-1: Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity. [Clarification Statement: Examples of key natural resources include access to fresh water (such as rivers, lakes, and groundwater), regions of fertile soil such as river deltas, and high concentrations of minerals and fossil fuels.]
2. HS-ESS3-2: Evaluate competing design solutions for developing, managing, and utilizing energy and mineral resources based on cost-benefit ratios. [Clarification Statement: Emphasis is on the conservation, recycling, and reuse of resources (such as minerals and metals) where possible, and on minimizing impacts where it is not. Examples include developing best practice for mining (for coal, tar sands, and oil shales), and pumping (for petroleum and natural gas). Science knowledge indicates what can happen in natural systems- not what should happen].
3. HS-ESS3-3: Create a computational simulation to illustrate the relationship among management of natural resources, the sustainability of human populations, and biodiversity. [Clarification Statement: Examples of factors that affect the management of natural resources include costs of resource extraction and waste-management, per-capita consumption, and the development of new technologies. Examples of factors that affect human sustainability include levels of conservation and urban planning]. [Assessment Boundary: assessment for computational simulations is limited to using provided multi-parameter programs or constructing simplified spreadsheet calculations.]
4. HS-ESS3-4: Evaluate or refine a technological solution that reduces impacts of human activities on natural systems. [Clarification Statement: Examples of data on the impacts of human activities could include the quantities and types of pollutants released, changes to biomass and species diversity, or areal changes in land surface use (such as for urban development, agriculture and livestock, or surface mining). Examples for limiting future impacts could range from local efforts (such as reducing, reusing, and recycling resources) to large-scale geoengineering design solutions (such as altering global temperatures by making large changes to the atmosphere or ocean).

Essential Objectives for High School

- Understand and evaluate the different sources of electricity generation, and the trade-offs between their cost and their environmental impact [comparison of different pieces].
- Identify potential improvements in energy technologies that could mitigate the trade-offs [how to reduce cost of renewables and reduce CO_2 and water impact of fossil fuels].
- Create, evaluate, and refine competing design solutions for the electricity mix based on total system cost, which includes the financial cost and the cost of the environmental (climate, water, etc) damages [comparing grid solutions throughout consecutive rounds].
- Analyze and describe the complexities of designing a cost-effective and environmentally-friendly electricity mix.
- Explain the impact of constraints in resource availability [such as limited wind, solar, natural gas] or the ability to use different technologies [constraints on nuclear or coal] on designing optimal electricity mixes.
- Evaluate the impact of energy efficiency on design solutions in terms of system cost, environmental impact and competitiveness of renewables, and describe the relevancy of their own actions [benefits of energy efficiency measures].

Materials

- This Instructor's Guide*
- Game Board and Pieces* (1 game board and 1 bag of pieces per team, 5 teams, see table below)
- Full-size Game Boards – (optional) this can be used for printing and mounting on foam board*
- Separate energy efficiency pieces to pass out for later rounds (4 small and 2 large pieces per team)
- 1 Score Card per team*
- Introductory presentation slides*
- Excel spreadsheet for scoring and team rankings (see website below for instructions on accessing)
- Computer and Projector that can display presentation and Excel Spreadsheet
- Set of Red Light, Green Light, Yellow Light cards for each team (optional, see explanation under "Differentiation")
- Calculators for each team (optional)

*Printable PDFs located at: https://www.epa.gov/air-research/air-quality-and-energy-choice-stem-activities-educators

Assembly of Team Materials

The printable boards and pieces provided on the website are designed for 5 teams. There may be some extra pieces for each type of energy. The number of pages that need to be printed for each type of energy are shown at the top of the page. For example, for the sheet of Nuclear pieces, "Print x2" means print 2 sheets of the Nuclear pieces. This will produce 6 total pieces to be distributed to teams as shown below. Additional teams can be created by simply printing additional pieces and boards. For assembly, use one quart or gallon-sized plastic zipper storage bag per team (and a bag for the extra pieces). Print the team piece lists below, cut them out, and include the list in the storage bag for reference. Store the energy efficiency pieces separately.

Pieces can be printed on letter-size printer paper. For more durable versions, it is recommended to print on cardstock and possibly laminate the pieces as well as the boards. The score cards and calculation sheets can also be printed/laminated so that students can use dry erase markers on them.

TEAM 1		TEAM 2		TEAM 3	
Nuclear	0	Nuclear	2	Nuclear	1
Coal	8	Coal	6	Coal	5
Coal - Existing	5	Coal - Existing	4	Coal - Existing	6
Coal - CCS	5	Coal - CCS	5	Coal - CCS	9
Natural Gas	11	Natural Gas	9	Natural Gas	6
Wind Small	7	Wind Small	12	Wind Small	10
Wind Large	4	Wind Large	5	Wind Large	5
Wind with Battery	2	Wind with Battery	4	Wind with Battery	4
Solar Small	10	Solar Small	9	Solar Small	8
Solar Large	6	Solar Large	5	Solar Large	4
Solar with Battery	6	Solar with Battery	4	Solar with Battery	2
TEAM 3		**TEAM 4**		**TEAM __ ***	
Nuclear	1	Nuclear	0	Nuclear	
Coal	5	Coal	8	Coal	
Coal - Existing	4	Coal - Existing	3	Coal - Existing	
Coal - CCS	5	Coal - CCS	9	Coal - CCS	
Natural Gas	10	Natural Gas	7	Natural Gas	
Wind Small	11	Wind Small	12	Wind Small	
Wind Large	6	Wind Large	7	Wind Large	
Wind with Battery	6	Wind with Battery	3	Wind with Battery	
Solar Small	10	Solar Small	10	Solar Small	
Solar Large	5	Solar Large	5	Solar Large	
Solar with Battery	5	Solar with Battery	2	Solar with Battery	

*For additional teams, you can duplicate a team or create your own distribution of pieces!

Student Preparation for Activity

For the high school level of instruction, students are expected to enter the activity with a *basic* understanding of the types of and differences between fossil fuels, non-fossil and renewable energy sources. They should also have an understanding of carbon dioxide (CO_2) emissions from fossil fuel combustion and the linkage of anthropogenic CO_2 emissions to climate change and it's impacts. As the game can be played at a variety of levels, teachers may decide that students need more preparation to play more complex rounds. The middle school instructional support document provides some of that additional background.

Duration: 90-minute block period or two 45-minute shorter periods; options to extend.

Procedure

1. Divide students into teams of 4-5 students. Present each team with a game board, bag of pieces, and student score card. Depending on your goals, you may also allow use of a calculator.

2. **Prior to playing the game, use the <u>PowerPoint presentation</u> to review or introduce the U.S. Energy System**. Actively engage students in the review or introduction, asking question such as:
    a. Show the slides available here: https://www.epa.gov/air-research/air-quality-and-energy-choice-stem-activities-educators
    b. **Slide 2**: Energy can take many forms. Primary energy resources including fossil fuels as well as renewables. We use energy in residential and commercial buildings (homes, offices, stores, etc), industrial facilities and in the cars and trucks we drive as passengers and heavy duty freight. In between, we have to convert those primary resources to useable forms, like electricity, gasoline, and diesel. Is there a form of energy that we both convert to electricity but often use directly in our homes for space heating, water heating, and cooking? [Answer, natural gas].
    c. **Slide 3**: This diagram is called a Sankey diagram, and it connects all of our resources from primary resources to end use. The width of the connecting flows represents the relative amounts of energy. All flows of energy are represented here. What do we start with, all the way to the left? [The actual primary energy resource]. What do we have, all the way to the right? [End-use demand sectors, or how and where we use that energy]. What do we need, in between the energy resource and end use, to enable us to flip a switch and have the light turn on? [Technologies to convert the energy into useable resources, i.e., electric power plants to make electricity].
    d. Stay on slide 3: Each colored line on this infographic represents one of the energy sources listed on the bottom of the slide. Which does the dark green represent? Why? How or where is this energy source used? How can that end use inform us of what type of energy it may be? Now, turn and talk with a neighbor for 2 minutes. Try to match the remaining energy forms with the colors on the graphic. After 2 minutes, bring the class together again and quickly move through the list of colors, asking students to call out their findings. Let's check and see if you're correct. [Answers on next slide].
    e. **Slide 4**: What do you notice is happening with the thick gray lines, particularly on the upper right area of the slide? [rejected or wasted energy]. How much is actually used versus wasted? Which types of energies currently contribute to more rejected energy? Why do you think this is? [Answer is: efficiency losses in converting energy from one form to another, a good example is a lightbulb, the heat is considered rejected energy since that is not meeting an energy demand, what we really want is lighting, measured as lumens]. This slide introduces the concept of efficiency. Some of the later rounds of the game include energy efficiency pieces.
    f. **Slide 5**: Prior to advancing the slides, ask: Now let's think about environmental impact. In what ways do energy extraction, conversion, and use impact the environment? [air pollution, greenhouse gas emissions, water use]. What percentage of these things do you think are related to our energy use? Advance the slide and share information. Ask students, do these percentages surprise you?

3. Now you are ready to **introduce the game.** The PowerPoint should remain projected as the slides continue to walk students through how to play.
    a. **Slide 6**: Explain that the Energy Game is a simple simulation of our energy system, using values derived from engineering costs of building and operating electricity generating units. We are

mainly focusing on electric power generation. *The purpose of the game is to not to tell us the "right answer" but to help us understand the challenges and tradeoffs involved in making energy and policy decisions.* Each team has the same "electric grid" size and the same total energy (area of pieces), but teams do not have the same mix of energy types. The goal, in each round, is to completely fill the grid with energy pieces in order to achieve the lowest total score, or cost, that fulfills the parameters of the round. Pieces may not overlap, and pieces may not extend past the grid or be placed sideways. Your score is determined by adding up the one-time purchase cost, 30 years of annual operating costs, and 30 years of total CO_2 costs for all of the pieces you choose.

b. **Slide 7**: This is the grid. The name of the game is Generate because we are looking at how to produce, create or "generate" electricity. Generation means to convert one form of energy (chemical, mechanical, etc.) into another (electrical).

c. **Slide 8**: Show the pieces. Ask students to compare piece sizes. Why is piece size significant? How would you use that to compare the cost per square on the grid, or cost per unit of energy? [Answer: the larger the piece, the more of the grid it covers and the more energy it provides. The largest nuclear piece is 64 squares, the large coal pieces are 32, natural gas and renewables are 16, and the smallest wind and solar are 4]. What units are used in real-life for selling and purchasing electricity? [Our electricity bills measure kilowatt-hours, and we pay in cents or dollars per kilowatt-hours, e.g., $/kWh]. How do we buy liquid fuels like gasoline and diesel [dollars per gallon, or $/gal]?

d. Stay on slide 8: Students should have some basic background on fossil fuels, renewable energy, and energy efficiency. Review the different types of energy pieces.

   i. Why are there three types of coal pieces?

      1. "Coal" could be a new coal power plant, while "Existing Coal" would be power plants that are already built and operating, so only annual operating costs are needed.

      2. What is "Coal with Carbon Capture and Storage (CCS)"? How is it different? This is coal with technology to capture CO_2 emissions so that they can be stored instead of emitted to the atmosphere. How do the CO_2 emissions differ? Is it cheaper or more expensive than the other coal power plant pieces?

   ii. What other fossil fuel pieces are there? Answer: natural gas.

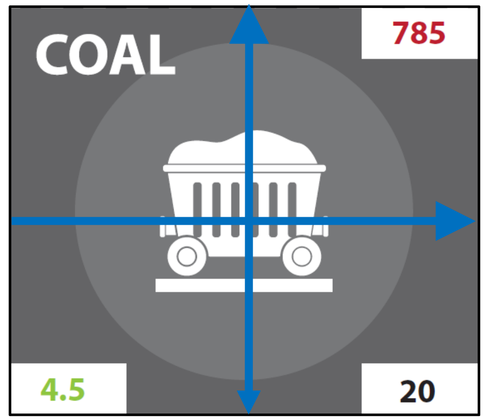
   iii. Why is nuclear so large? Does it have CO_2 emissions? Why not? There is no fuel combustion to produce CO_2.

   iv. There are also different types of renewables: wind and solar.

      1. Some have battery technologies and a higher cost. Why do renewables need batteries to store power? Renewables are sometimes called intermittent. Their electricity generation is not continuous, but depends on when the sun is shining and the wind is blowing. They need batteries to store electricity for when it's needed at different times of day.

      2. Also, some renewable energy installations may be large, and some may be small (think of a solar farm with acres of solar panels compared to smaller solar panels on rooftops of individual homes).

e. **Slide 9**: Explain the parts of the pieces and how to calculate the score. The **size** is the amount of energy it produces. Point out that the one-time **purchase cost** is in red, located on the upper right-hand corner. Make the analogy that this is similar to the up-front cost of purchasing a car. What else does it take to run a car? [Answer: gasoline or diesel, maintenance, insurance, registration and taxes, inspection]. These are similar to the annual costs to operate a power plant. Point out that the **annual cost** is noted in black, located on the bottom right-hand corner. If the power plant functions for 30 years, what would you multiply this number by to get its lifetime cost? Point out that **CO_2 emissions** are located on the bottom left-hand corner in green. These annual CO_2 emissions will also be multiplied by 30 years. However, we will then put a cost on the emissions, to reflect environmental damages or possible policy decisions. This is done as a CO_2 multiplier, which is set by the instructor on the Excel Spreadsheet for each round and will also need to be multiplied by a specific CO_2 cost given in each round.



f. Slide 9 also shows the full equation, and how it would calculate for one coal piece. Remember, these all last for 30 years so annual costs and emissions are multiplied by 30.
Cost per piece = Purchase cost + (Annual Cost x 30) + (CO_2 emissions x 30 x CO_2 cost)

4. **Slide 10: Let's play the game!** For round one, assign a CO_2 multiplier of 0, so CO_2 costs are not factored into this round. Remind students that their goal is to achieve the lowest possible score. Instruct students to write down how many pieces of each type they used on the score sheet. Minimize the PowerPoint and project the spreadsheet. Be sure that the CO_2 cost (highlighted in yellow) is set at 0. Instruct teams to send up a representative with the score sheet, as they finish, so that you can begin plugging in their chosen energy mixes into the spreadsheet. Once all teams have finished and been ranked, ask them to compare. The spreadsheet will show TOTAL COST of their electricity mix. They will be ranked according to the lowest cost for the full board. For the teams ranked 1 and 2, what does your energy mix look like? [Existing coal favored, natural gas]. For those of you ranked toward the bottom, how is your mix different? [more renewables, perhaps nuclear, less existing coal]. Were some teams given an unfair advantage for this round? [Yes, those with more existing coal and natural gas are at an advantage in this first round]. That advantage will shift as we start considering CO_2. What challenges did you encounter? [Had to diversify so that coal, even if you had enough, was not completely covering the board (note that the grid is created in a way that forces diversification)]. Why do you think the grid is created in order to force diversification? What made you use the smallest pieces [Answer: it can represent state or regional energy policies, for example, many states have standards for minimum amounts of renewable electricity, sometimes called Renewable Portfolio Standards, which may require a percentage of electricity to come from wind, solar, and possibly biomass, hydropower or geothermal].

* Please note that you may choose to delete or expand upon some of the rounds below based on student needs/standards. In order to introduce an understanding of trade-offs, at least one round of CO_2 cost and one round of energy efficiency should be played.

5. **Round Two**: Inform students that they will play another round. This time, they will have to take CO_2 costs into effect, and thus, they must rethink their strategy. Their goal is still to achieve the lowest score. Set the CO_2 cost multiplier at 1 on the spreadsheet. Let the students see how their total costs and even rankings change even before redoing their grid. Now, let them redo their strategy to take into account both the purchase and operating cost, but now the CO_2 cost as well. Remind them to multiply their annual CO_2 emissions by 30 years and then multiply by the CO_2 cost. Debrief: Compare the new team rankings. What do the cheapest energy mixes now look like? [Existing coal is no longer up there, wind is very competitive]. What about the teams with higher costs that are ranking toward the bottom?

   Student may want to discuss what the CO_2 cost multiplier represents. Ask them for any examples of impacts related to climate change [Some examples include sea level rise and storm surges along coastal areas, changes in temperature and precipitation patterns, changes in the frequency of droughts, stronger storms, etc.]. How could these impacts lead to economic costs (some examples, impacts on agricultural production, human health, transportation and other infrastructure). The CO_2 cost reflects the damages associated with climate change, and calculates those additional damages for each additional unit (e.g., ton) of CO_2 emissions.

6. **Round Three**: Change the CO_2 cost again, this time to 2, 3 or 4. Changing the number and letting the students see how the rankings change lets them see the tipping points. Don't forget to change the CO_2 cost on the spreadsheet. Additional rounds can be played increasing the CO_2 cost, depending on time. Make sure with each round the students look at how their total score was affected by the cost to build and cost of CO_2. Maybe they had a grid that was expensive to build and operate but with a low CO_2 cost. Or, alternatively, their grid was cheap but their CO_2 cost was high. Let the students discuss the different strategies they used to reduce CO_2 emissions.

7. **Round Four**: Energy Efficiency. Prior to beginning play for this round, hand each team 2 large energy efficiency pieces and 4 small energy efficiency pieces. Tell the teams to leave their existing pieces in place on their grid. Keep the CO_2 multiplier set at the same level as the last round. Instruct students that they are to again seek the lowest score, this time substituting energy efficiency for some of the power plants on the grid. Note: they should only be replacing pieces with energy efficiency pieces, not making other changes to the mix at this point. Debrief: Look at the projected score sheet. What types of energy tended to be replaced by the energy efficiency?

8. **Round Five**: Water Use. This is an optional round. Water use is only for nuclear (74), existing and coal and coal (16), coal with carbon capture and storage (CCS) (43) and natural gas (4). Looking at the water use levels on the Excel spreadsheet can inform where to set a water limit to force change. Setting the total water use at 100 will force some teams to change their mix; more change will occur by lowering the limit to 80, 60, and so on.

Extensions

Pure Optimization**:** Distribute the pieces equally among all teams. Then one or more rounds are played (with or without CO_2 costs), to determine which team can arrive at the optimal solution. Do they all reach the same solution? Are there ways to achieve the same lowest cost solution with different energy mixes? Are there some solutions that are "close" in total cost but very different CO_2 emissions? Can they look to some real-world examples of how different states, countries, or regions have reduced their CO_2 from their electric sector using different energy strategies? Why did they make those choices, and what was the role of resource availability or other economic, social, political or environmental considerations?

Energy Traders**:** Players may swap pieces between their teams, they can do any number of types of pieces, as long as both teams agree to the trade. A single player should be assigned to be the team trader. Teams are allowed one chance to trade *before* each round. This can be done any time after the first round of play.

"Give and Take" or Change Cards: "Give and Take" either adds new technologies (from the extra pieces), takes away certain types of technologies, or increases or reduces the relative costs. For an additional round, each team can draw a chance card before choosing their mix. *See chance cards below.*

Budget Breakers**:** The game facilitator can set an upper limit on the cost of purchasing and running the electricity grid. This only includes the purchase and annual operating and maintenance costs, not the CO_2 cost. This can be set to anywhere between 8,000 or 10,000. At lower levels, certain teams may not be able to reach this cost. However, it can also be combined with Energy Traders, and lower costs can be set.

Carbon Cap**:** The game facilitator can set an upper limit for the CO_2 emissions on the score sheet. Does this lead to different solutions for reducing CO_2? How does setting a cap affect the total costs?

Thirsty Energy**:** Another approach to incorporating water use is to include it in all rounds. The game facilitator can set an upper limit for water use using the graph on the score sheet. Multiple rounds can be played but the teams that run out of water (or exceed the upper limit) will be eliminated. Keep in mind that nuclear and coal with carbon capture and storage (CCS) are very water intensive. Renewables are virtually water free!

Number Crunchers: This game is based on a simplified version of the cost of electricity based on capital or purchase costs and annual costs for operating. The goal is to be accessible to students and to be able to rapidly calculate multiple rounds. However, the real-world calculations of metrics such as the "levelized cost of energy" (LCOE) are more complex. One extension following the game play can be for students to research different metrics for energy prices and cost of energy. The Energy Information Administration has good resources to discuss this. For example, there are tables with the LCOE for future electricity generation plants. How do these numbers compare to the game? What is the LCOE? Tax credits were not included in the numbers for this game. How much can those affect costs? https://www.eia.gov/outlooks/aeo/pdf/electricity_generation.pdf

Calculations and Differentiation

The supporting calculations can be handled in a variety of ways. Students can be required to calculate their total scores prior to submitting their mixes in each round, or the teacher can calculate by plugging the numbers into the spreadsheet. The benefit of the spreadsheet is the ability of all teams to see each other's energy mix and scores. It is also a useful exercise to have the students watch the scores and ranks change as the CO_2 cost on the spreadsheet is increased to see how the different teams scores and rankings are affected.

Some students simply guess what the cheapest pieces are based on the relative costs. Other students will compare the pieces of the same size (comparing the different coal pieces, or comparing natural gas to large wind or solar) and compare smaller pieces to large pieces (four small wind or solar compared to natural gas). This will give students a quick sense of the cheapest pieces. Other students may try to add up the cost of the entire board, and then readjust and recalculate, which can be time consuming.

The most accurate approach is for students to calculate -- for each energy type – the cost per square and compare all pieces. Then students would use the low cost pieces first, then the second lowest cost, and so on. This will be more time consuming for the first round. But, in the following rounds, the cost per square will only change for the pieces that have CO_2 emissions (natural gas and coal). Because the CO_2 emissions for wind, solar and nuclear are zero, the CO_2 cost does not affect their cost per square. Students can be reminded of this or left to discover it on their own.

$$Cost\ per\ square = \frac{(Purchase\ Cost)\ + 30 \times (Annual\ Cost) + 30 \times (CO2\ Cost) \times (CO2\ Emissions)}{Squares\ per\ Piece}$$

For example, a natural gas piece (which covers 16 squares) would cost 26.4 at a CO_2 cost of 0.5.

$$Cost\ per\ square = \frac{(105)\ + 30 \times (10) + 30 \times (0.5) \times (1.2)}{16} = 26.4$$

If the rounds move quickly, it may be a struggle both for students that are unsure how to approach the math, as well as for students who want to do the math in detail for every round. The instructor can determine how much guidance to give on the approach to calculations, or give feedback to individual teams (e.g., "are you sure that's the cheapest medium-size piece?")

Teachers can select how many rounds and which rounds to assign based on the needs of their classes. They may choose to take more time and only run three rounds, only adjusting carbon. They may choose to assign only carbon multipliers that are integers rather than using decimals such as 0.5 in order to facilitate easier calculations.

Red, Green and Yellow "Stoplight" Cards: For teams of students who tend to need more help, using these cards is a great way to help students communicate their team's level of frustration and help the teacher quickly see who needs immediate help. Teams can be given red, green, and yellow cards prior to the activity, and can be asked to display one card at all times. The green card signifies that the team is moving along successfully; the yellow card signifies that the team is having difficulty but has not yet come to a complete standstill; the red card means that the team is at a standstill until it receives help.

Resources

To learn more about energy use in the United States, explore the Energy Information Administration's website: www.eia.gov

- State energy comparisons www.eia.gov/state/
- Interactive mapping of U.S. state-level energy resources and facilities www.eia.gov/state/maps
- Open Energy Information http://en.openei.org/wiki/Main_Page

U.S. EPA climate change resources
http://epa.gov/climatechange/ *

- Mapping GHG emissions from large facilities http://ghgdata.epa.gov/
- 30 Indicators for climate change http://epa.gov/climatechange/science/indicators/index.html *
- Students guide to global climate change www.epa.gov/climatestudents/ *

*Please note that the EPA climate change webpages are being updated and are currently not available. Archived versions may be available here: https://19january2017snapshot.epa.gov/climatechange_.html

Additional climate change resources from other U.S. federal agencies and programs.

- NASA Climate Kids: https://climatekids.nasa.gov/
- U.S. Global Change Research Program: http://www.globalchange.gov/

EPA Air, Climate and Energy Research

- Climate Change Research https://www.epa.gov/climate-research
  Air Research: https://www.epa.gov/air-research

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Appendix: GIVE & TAKE CARDS

There has been a major technological breakthrough! Engineers have discovered a way to drive the cost of solar panels way down, while improving their efficiency. Solar manufacturers have cut the price of their technology by half in order to keep up with the market. Cut your solar purchase and annual costs accordingly.

Congratulations! Your team has been working hard to improve energy use and sustainability in your region. Show this card to receive extra energy efficiency pieces! (One large and two small pieces).

CO_2 costs are on the rise as the damages associated with climate change become more severe. ALL teams must now calculate their energy grid with a CO_2 cost of 8.

Although your region has transported and stored used nuclear fuels without any harmful release of radioactive material, there are concerns by citizen about the future of nuclear waste. On the last election ballot, your town voted "NO" to nuclear power. Remove any nuclear pieces you have used/could use, and place them back in your bag.

Talk about going green! Your region is one of the first to pledge zero carbon emissions—and this year is the year! You may only use pieces with zero emissions, so put all of your other pieces to the side.

Your region has been under pressure by surrounding areas (as well as your own population) to take air quality concerns into account. Therefore, you must limit your fossil fuel use. Reduce the amount of fossil-based generation at least HALF of what it was in the previous rounds.

Your region is feeling quite a “blow” to its resources—even though you have a great landscape for on-shore and off-shore wind power, local laws and regulations are making it hard to invest in new wind power. Place all of your wind pieces (both large and small) back in your bag.

Because of issues with initial costs of solar and wind technologies, your regional officials decided that green energy is not the way to go. Please put all of your wind and solar pieces (both large and small) back into your bag. You can only keep 8 small pieces to fill out the grid.

Your region’s proposal to increase solar energy resources was approved. Show this card to gain 2 additional large and 4 additional small solar pieces!

Your region’s proposal to increase wind energy resources was approved. Show this card to gain 1 additional large and 2 additional small wind pieces!

Fossil fuels are becoming cheaper, which means annual costs are decreasing! For all fossil fuel based energy resources, cut the annual costs in half.

The citizens in your region have been researching nuclear energy, and feel the upfront costs of building a new nuclear plant would be justified because they could decrease the region’s dependency on fossil fuels. On the most recent election ballot, your region voted YES to help pay HALF of the purchase cost of nuclear energy. Use a nuclear piece on your grid (if you do not have one, please show this card to your moderator).