

How Much Does Carbon Cost?

Students begin with a simulation to understand limits imposed by environmental regulations. They compare 2 structural solutions to regulate carbon emissions, then play a cap and trade game that explores ways to reduce emissions in the most cost-effective manner.



Adapted from “The Cap and Trade Game” by Ava Erickson, Seattle Girls School



Inquiry/Critical Thinking Questions

- What are some examples of ways that businesses and industries are regulated to reduce carbon emissions?
- How does a cap and trade system work?
- What are the benefits and drawbacks of different types of environmental regulations?

Objectives

Students will:

- Calculate the economic efficiency of 2 systems designed to regulate carbon emissions
- Participate in a cap and trade game
- Determine which regulatory system reduces CO₂ emissions most effectively

Time Required

50 minutes

Key Concepts

- Structural solutions
- Cap and trade system
- Environmental regulations

Subject Areas

- Social Studies (Economics, World History, Civics, Contemporary World Problems)
- Science (Environmental)
- Mathematics
- Business/Finance

National Standards Alignment

National Science Education Standards (NSES)

- Standard F: Science in Personal and Social Perspectives

National Council for the Social Studies (NCSS)

- Strand 6: Power, Authority, and Governance
- Strand 7: Production, Distribution, and Consumption
- Strand 8: Science, Technology, and Society
- Strand 9: Global Connections



Vocabulary

- **cap and trade**—rather than placing a cap (maximum allowable amount) on each individual CO₂ emitter (power plant, factory, or other business), this system places a cap on industry overall; each emitter is given a certain number of CO₂ allowances per year, and can trade with other emitters to acquire more allowances or sell off excess allowances
- **environmental regulation**—a law passed that is intended to protect or enhance the environment; often people or businesses are required to follow certain rules to limit their environmental impact
- **structural solution**—a way in which a component of a system can be changed in order to alleviate a problem (vs. a personal solution, which is a way in which an individual can act to alleviate a problem)

Materials/Preparation

- Handout: Costs of Environmental Regulations, 1 per student
- (Optional) Teacher Master: Costs of Environmental Regulations
- Handout: Cap and Trade Balance Sheet, 1 per group of 3-4 students
- Dice, 1 per group of 3-4 students
- (Optional) Play money, \$1000 per student group

“Many companies are taking steps to reduce their carbon footprints, often by using renewable energy or energy-efficient technology.”

Activity

Introduction

1. Begin this activity by asking students how their lives would be affected if they could only make 5 phone calls each week. If they make fewer than 5 phone calls, they can sell their extra phone calls to classmates; or, they may buy phone calls from classmates if they need to make more than 5 calls. Ask students how they would respond to this new limit placed on their phone calls.
2. Now explain that one way to fight climate change is to set limits. A government or other entity may limit, or regulate, emissions produced by companies. Students will soon play a game to explore 1 climate change regulatory mechanism.
3. In order to prepare for the game, first work through the handout, Costs of Environmental Regulations. Have students work either individually or in pairs, and then discuss results as a class.
4. After finishing the worksheet, ask students which option (Individual Limit or Cap and Trade) seems to be best for each company. If you were AllStuff and you knew the government was going to impose regulations, would you prefer Individual Limit or Cap and Trade? Why?

Steps

1. Divide the class into groups of 3-4. Give each group a Cap and Trade Balance Sheet and a die.
2. (Optional) Give each group \$1000 in play money so that they can actually gain or lose dollars during each transaction.
3. First, students will create their company name. What does the company do? What is it called?
4. Instruct all groups to roll their die twice and add up the numbers, then multiply by 10. This is their CO₂ emissions in tons per year. Have them write that number on their balance sheet.
5. Now have them roll the die once and multiply by 10. This is the cost to their company to reduce emissions by 1 ton of CO₂. Have them write that number on their balance sheet.
6. Depending on their total emissions, students may have extra allowances, or they may need to reduce their emissions. To reduce emissions, companies may pay to reduce emissions themselves (through conservation, improved efficiency, or new technology). They may also buy allowances from companies with extra allowances; this may be cheaper and faster.



7. Tell students to circulate in the class to meet other companies. If a company has extra allowances, it will want to sell them for the most money it can get. If a company needs to reduce its emissions, it needs to do so for the least amount of money. Each company will have to decide if it is cheaper to make the reductions themselves or buy allowances from another company.
8. Have students record each transaction, making sure not to exceed the total amount of money they started with. Continue the game for 10-15 minutes, or until everyone has had a chance to make at least 2 transactions. For an extra challenge, introduce a second year of trading with fewer allowances.
9. At the end of the game, poll the class to see who was able to sell extra allowances for the most money. Also, who purchased allowances for the least money? Conclude with the following reflection questions.
4. Do you think a cap and trade system is a good way to reduce overall CO₂ emissions? Is this a good climate change solution? Are there other solutions that you think would work better to reduce the impact businesses have on climate change? (Other environmental regulations include performance standards, mandating use of best available technology, and pollution taxes.)
5. How might businesses be persuaded to reduce CO₂ emissions without regulations? How could businesses benefit by saving energy?
6. How do you think the impact of these types of structural solutions (environmental regulations) compares with personal solutions (e.g., reducing energy use, using “cleaner” technology)?

Reflection

1. Did anyone reduce emissions on their own rather than buy allowances? If so, why?
2. How do you think businesses whose emissions exceed the maximum number of allowances would feel about a cap and trade system? Why?
3. How do you think businesses whose emissions are below the maximum number of allowances would feel about a cap and trade system? Why?

Additional Resources

Websites

- <http://www.worldwatch.org/node/3949>—In this question and answer site maintained by the Worldwatch Institute, ideas are offered for how businesses and governments can work toward climate change solutions.
- <http://www.theclimategroup.org>—The Climate Group is a nonprofit organization dedicated to advancing business and government leadership on climate change. Click on Low Carbon Solutions to learn about ways that businesses and governments can lower their CO₂ emissions.

Costs of Environmental Regulations

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WE WILL USE OUR MATH skills to learn more about 2 types of environmental regulations: Individual Limit and Cap and Trade.

Let's suppose there are only 2 carbon dioxide (CO_2) emitters in the world: the ElectroGen power plant and the AllStuff factory. Each company can reduce its emissions by improving efficiency or installing new technologies. Following are the emissions and costs for reducing CO_2 for both companies.

COMPANY	CO_2 EMISSIONS PER YEAR	COST TO REDUCE CO_2
ElectroGen	120 tons	\$20 per ton
AllStuff	90 tons	\$15 per ton

Individual Limit

THE GOVERNMENT TELLS ELECTROGEN AND AllStuff that each emitter (power plant or factory) is allowed to emit only 100 tons of CO_2 per year.

1. By how many tons will ElectroGen have to reduce their emissions?
2. By how many tons will AllStuff have to reduce their emissions?
3. ElectroGen calculates that it will cost \$20 to reduce their emissions by 1 ton of CO_2 per year. How much will it cost ElectroGen each year to reduce its total emissions to 100 tons of CO_2 ?
4. It costs AllStuff only \$15 to reduce its emissions by 1 ton of CO_2 . How much will it cost AllStuff to reduce its total emissions to 100 tons of CO_2 ?
5. Imagine that you are the President of ElectroGen, and the government announces that you cannot emit more than 100 tons of CO_2 per year. How would you respond?
6. Now imagine that you are the President of AllStuff, and the government announces that you cannot emit more than 100 tons of CO_2 per year. How would you respond?

Cap and Trade

THE GOVERNMENT DECIDES THAT TOTAL emissions for ElectroGen and AllStuff combined must be capped (limited) at 200 tons of CO₂ per year. Each company is given 100 allowances. (An allowance is the right to emit 1 ton of CO₂.) They can make the reductions themselves, or they can trade allowances with each other.

7. By how many tons will ElectroGen and AllStuff combined have to reduce their emissions?
8. How many additional allowances does ElectroGen need?
9. How many extra allowances does AllStuff have?
10. ElectroGen is emitting more CO₂ than it has allowances for. It wants to meet the regulations in the cheapest way possible. In a cap and trade system, companies can buy allowances from each other. ElectroGen decides to buy AllStuff's extra allowances. What is the most that ElectroGen would pay for them?
11. If ElectroGen buys all of AllStuff's allowances, how many more will ElectroGen need?
12. To reduce its remaining 10 tons of CO₂, ElectroGen could install new technology that will cost \$20 per ton to reduce emissions. But that's pretty expensive. It's cheaper for AllStuff to reduce its emissions (\$15 per ton), so ElectroGen and AllStuff strike a deal.
 - a. AllStuff decides to reduce its emissions by 10 tons, so that it is only emitting 80 tons of CO₂ per year. What is the total cost to AllStuff for that reduction?
 - b. How many extra allowances does AllStuff have now?
 - c. ElectroGen offers to buy the allowances from AllStuff. What is the least amount of money per allowance that AllStuff will accept?
 - d. What is the most amount of money ElectroGen will pay AllStuff for extra allowances?
 - e. Suppose they compromise in the middle. How much will ElectroGen pay per allowance?
 - f. How does this benefit both companies?
13. Suppose you are the President of ElectroGen. How would you respond if the government was to impose this cap and trade limit of CO₂ emissions to 100 tons per year?
14. Suppose you are the President of AllStuff. How would you respond if the government was to impose this cap and trade limit of CO₂ emissions to 100 tons per year?

Costs of Environmental Regulations

Teacher Master

1. 20
2. 0 (they are below the limit)
3. \$400 ($\20×20 tons)
4. \$0 (they do not need to reduce emissions)
- 5.
- 6.
7. 10 ($120 + 90 = 210$)
8. 20
9. 10
10. \$20/ton (\$400 for 20 tons)
11. 10
12.
 - a. \$150 ($\15×10 tons)
 - b. 20
 - c. \$15
 - d. \$20
 - e. \$17.50
 - f. AllStuff makes money on each allowance sold to ElectroGen.
ElectroGen can save money by paying AllStuff to reduce CO₂ emissions.
- 13.
- 14.

Cap and Trade Balance Sheet

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TEAM MEMBERS _____

COMPANY NAME _____

DESCRIPTION OF COMPANY (What product or service to you provide?)

Starting Information:

Starting Money	Allowances (tons of CO ₂ you can emit)	CO ₂ Emissions per Year (roll die twice; add the numbers and multiply by 10)	Cost to Reduce Emissions by 1 Ton (roll die once and multiply by 10)	How many extra allowances do you have?	How many extra allowances do you need?
\$1000	65				

IF YOU NEED TO REDUCE YOUR EMISSIONS, find a company willing to sell you allowances for LESS than it would cost you to reduce CO₂ emissions by 1 ton.

IF YOU HAVE EXTRA ALLOWANCES TO SELL, try to make as much money as you can by selling the allowances. In some cases, it may be best to pay to reduce your CO₂ emissions even more and then sell the allowances gained for MORE than you paid.

