

Saving the Environment with Economic Ideas

Lesson 4: Supply and Demand of Pollution

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Standards and Benchmarks (see page 4.14)

Lesson Description

The lesson shows students how basic supply and demand concepts can be used to analyze the effects of an emissions tax or a cap and trade system. Using supply and demand illustrates how markets can be used to allocate the amount of pollution released into the environment.

NOTE: Students need a basic understanding of supply and demand, the factors that cause increases or decreases in supply and demand, and the results of increases or decreases in supply and demand on market equilibrium.

Grade Level

High School

Concepts

Cap and trade system

Emissions tax

Objectives

Students will be able to

- describe cap and trade system and emissions tax,
 - use supply and demand analysis to find the equilibrium level of pollution, and
 - describe the effects of growth in the economy or improved pollution control technology on the equilibrium level of pollution.
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Compelling Question

How can markets be used to solve pollution problems?

Time Required

45 minutes

Materials

- PowerPoint Slides 4.1-4.9
 - Handout 4-1, one copy for each student
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Introduction

Market-based systems are increasingly being used as methods to control pollution. These systems use price incentives (either taxes or permit systems) to encourage firms to reduce pollution. Economists advocate market-based systems because these systems are efficient in reducing pollution. For example, the U.S. SO₂ trading program was successful in reducing the quantity of pollution at a low cost to the power plants that emitted SO₂.¹ The program's additional benefit was the reduction in the amount of particulates released. Currently, a carbon tax is being championed as a way to combat climate change.² This lesson demonstrates how these environmental tools work using simple supply and demand analysis, which opens the door to introducing environmental policies early in a high school economics course.

Procedure

1. Introduce the topic by discussing the following:
 - Why do firms pollute when they produce products? (*Answers may include that waste is created during production and needs to be released somewhere.*)
 - Why don't firms either (a) clean up the pollution from the environment, (b) prevent it from escaping into the environment, or (c) use technology that results in less pollution? (*Answers may include that it is expensive to do any of those alternatives.*)
 - Is there a cost to society for releasing pollution into the environment? (*Yes, pollution damages people's health and property, among other things.*)
2. Explain that the goal of this lesson is to understand the balance between allowing harmful pollution into the environment and keeping a firm's costs of cleanup low. The lesson will use supply and demand analysis to help them understand how pollution can be managed in a market economy. To analyze pollution through a market lens, they must understand that firms create waste when they produce goods and services. Firms need someplace to dispose of that waste.

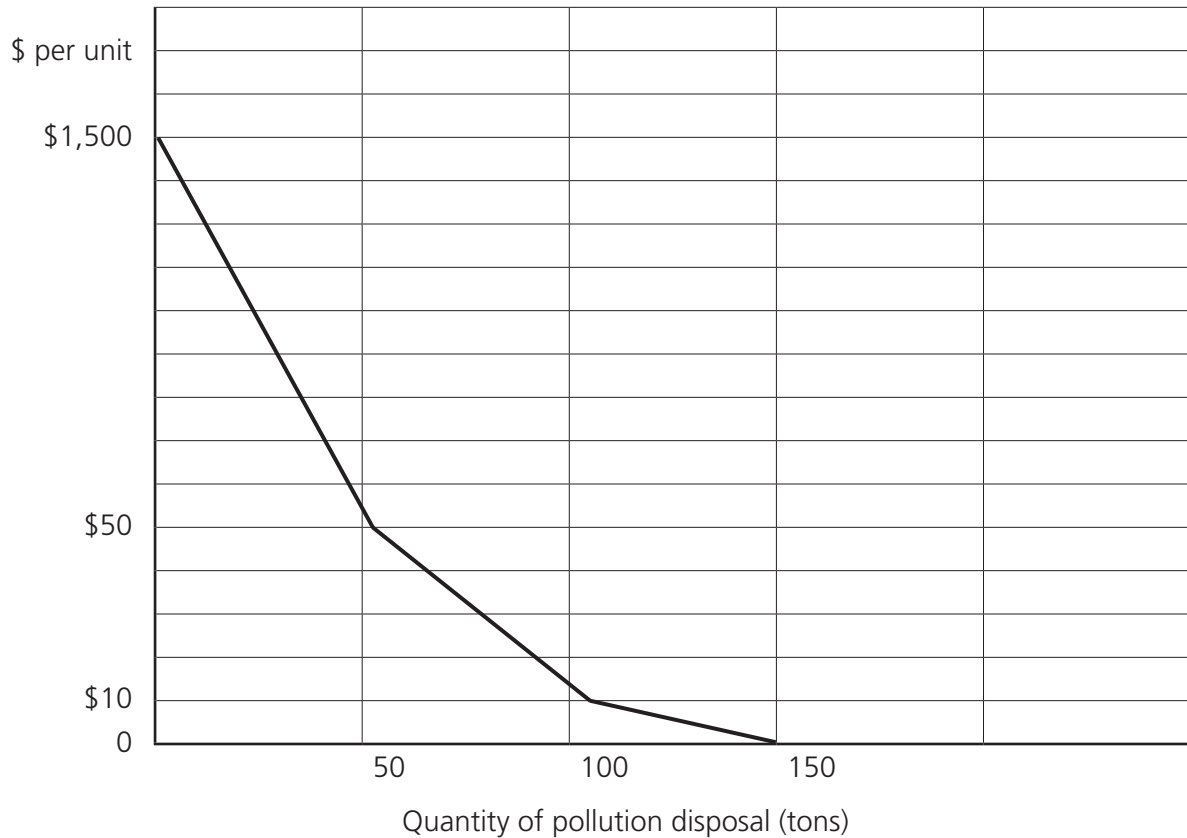
¹ See Schmalensee and Stavins, 2013.

² See Climate Leadership Council.

3. Tell the students that it is helpful to think of pollution control markets as providing pollution disposal “services” instead of merely a place to dump pollution. For example, if a firm wants to emit smoke (particulates) into the air, the firm is making use of the air as a place to dispose of its smoke. So if the air is viewed as a service that the firm views as “pollution disposal,” then this disposal service can be thought of as something demanded by firms. Ask the students who demands “pollution disposal.” (*Firms who produce products and want to release pollution into the environment*) Tell the students that the demand for pollution services is the relationship between the prices firms must pay to dispose of their pollution in the environment and the quantities of pollution they will emit into the environment.
4. Explain that you will use the example of CO₂ as a pollutant that contributes to climate change.³ The question is how pollution might be controlled in a market setting. Discuss the following:
 - If firms do not have to pay to dispose of pollution in the environment, will firms pollute a lot or a little? (*Answers may include that firms will undoubtedly pollute a lot. Some students may suggest that goodwill on a firm’s behalf may limit the amount it pollutes.*)
 - If firms had to pay \$1,500 per ton of CO₂ they released (students may not really know if this is a high or low value, but they will probably infer that it is high), how much would firms pollute? (*Answers may include close to no pollution, but certainly less than if no charges were assessed.*)
 - What might firms do to reduce the amount of CO₂ they release into the environment? (*Answers may include that firms either use production techniques that do not emit so much CO₂ pollution or clean up the CO₂ pollution created instead of disposing of it into the environment. Firms may also reduce production of the good.*)
5. Tell the students to note that firms have to decide between either disposing of pollution in the environment or taking actions to reduce the amount of pollution they produce.
6. Display Slide 4.2. Tell the students that the graph shows firms’ demand for pollution disposal services—that is, the quantities of pollution firms will want to put into the environment at various prices. Note that the endpoints of the demand for pollution are at a price of \$1,500 for zero pollution and a price of \$0 for a large quantity of pollution (the graph shows 150 tons). Tell them that as the price of pollution disposal increases, firms reduce the amount of pollution disposed of. This is the demand for pollution disposal.
7. Discuss the following:
 - Based on the graph, how much CO₂ would firms dispose of into the environment if they had to pay nothing to do so? (*150 tons*)

³ See Intergovernmental Panel on Climate Change (IPCC), 2018.

Demand for Pollution Disposal

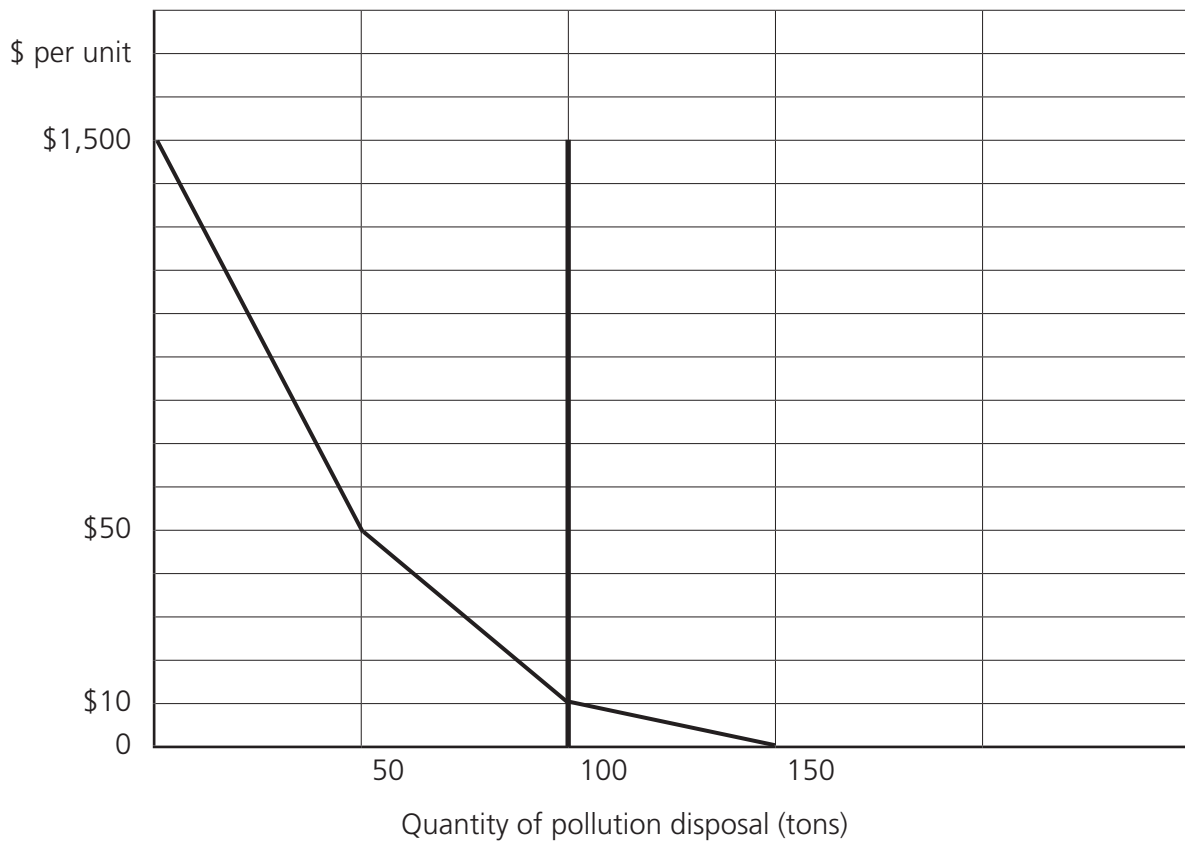


- What do you think about this “free to dispose of pollution” approach? (*Answers may include that the emissions cause harm to people and the environment and should be reduced.*)
 - Why would governments allow any pollution? (*Answers will vary. The students should realize that we want the goods produced by firms, so allowing no pollution might result in no goods.*)
8. Tell the students that one of the roles of government in a market economy is to intervene when markets aren’t able to fix a problem such as pollution. Pollution is an externality. When an externality is not corrected, markets are inefficient. Discuss the following:
- The government must decide how much firms should be allowed to pollute. Ideally, the government would use cost-benefit analysis to decide how much pollution (CO₂ in this example) should be allowed into the environment.

- In other words, the government becomes the supplier of pollution disposal services. Through laws, the government decides how much pollution is allowed to be disposed of into the environment and/or at what price.
9. Explain that the laws of local, state, or federal government provide the supply of pollution disposal. The supply of pollution disposal includes the quantities of pollution available at various prices. While many ways of providing “pollution disposal services” exist, tell the students that you will talk about two market-based systems—a tax system and a **cap and trade** system. These systems are called market based because firms are not told how to manage their pollution. Specifically, they are not told what technology to use or to reduce their output. Instead, they are given incentives to reduce emissions and then must decide on their own how to respond to the incentives.
 10. Display Slide 4.3. Tell the students that one way to cap the amount of pollution at a fixed amount is for government to issue permits (say one ton of pollution per permit) and then allow businesses to buy and sell the permits among themselves. The price of a permit is determined in an open market. This system is known as cap and trade. Review the advantages of a cap and trade system as follows:
 - The quantity of pollution emitted is known and equal to the amount given by the permits.
 - Firms whose cost of controlling pollution is high can buy permits from firms whose cost of controlling pollution is low. This means high-cost firms don’t have to spend a lot to control pollution and low-cost firms are rewarded by being able to sell permits.
 - A firm is free to choose whichever method or technology it finds best to meet its cap. Firms have an incentive to reduce pollution by adopting new technologies because this would allow them to sell their excess permits.
 - The government can earn revenue if the permits are initially sold at auction. (However, many times existing firms are given allocations of permits for free.)
 11. Display Slide 4.4. Have the students think about what the supply of pollution disposal graph would look like under a cap and trade system. (Encourage them to think about how the quantity of pollution disposed of is fixed no matter what the price. This means a vertical supply curve.) Tell the students that the supply curve is what economists call perfectly inelastic—the quantity does not change when the price changes. Ask the students what the graph would look like if 50 units of pollution were allowed under a cap and trade system. (*The curve would shift to the left.*)
 12. Display Slide 4.5. Tell the students that this graph has both the supply and the demand for pollution illustrated. With a cap and trade system, a market for pollution is created. The market determines the price of pollution: In the graph, this is the price at which supply and demand cross. Ask the students what the price of permits will be. (*\$10*)

13. Explain that if the government auctions off the permits, the amount the government would earn would be \$1,000 (Price x Quantity of permits). Tell the students that with a cap and trade system, sometimes permits are given for free to businesses. In this case, firms receive the money from the sale of their permits or benefit from not having to buy permits if they save the permits for their own use.⁴ The good thing about tradeable permits is that even if the government gives the permits to firms that don't need them (because they can control their waste at a low cost), firms can earn revenue by selling their permits to firms who can't cheaply reduce their waste. In this case, low-cost firms will trade their permits to high-cost firms, restoring the market to equilibrium and ensuring that the most efficient firms are the ones that reduce their waste.

Supply and Demand for Pollution Disposal with Cap and Trade

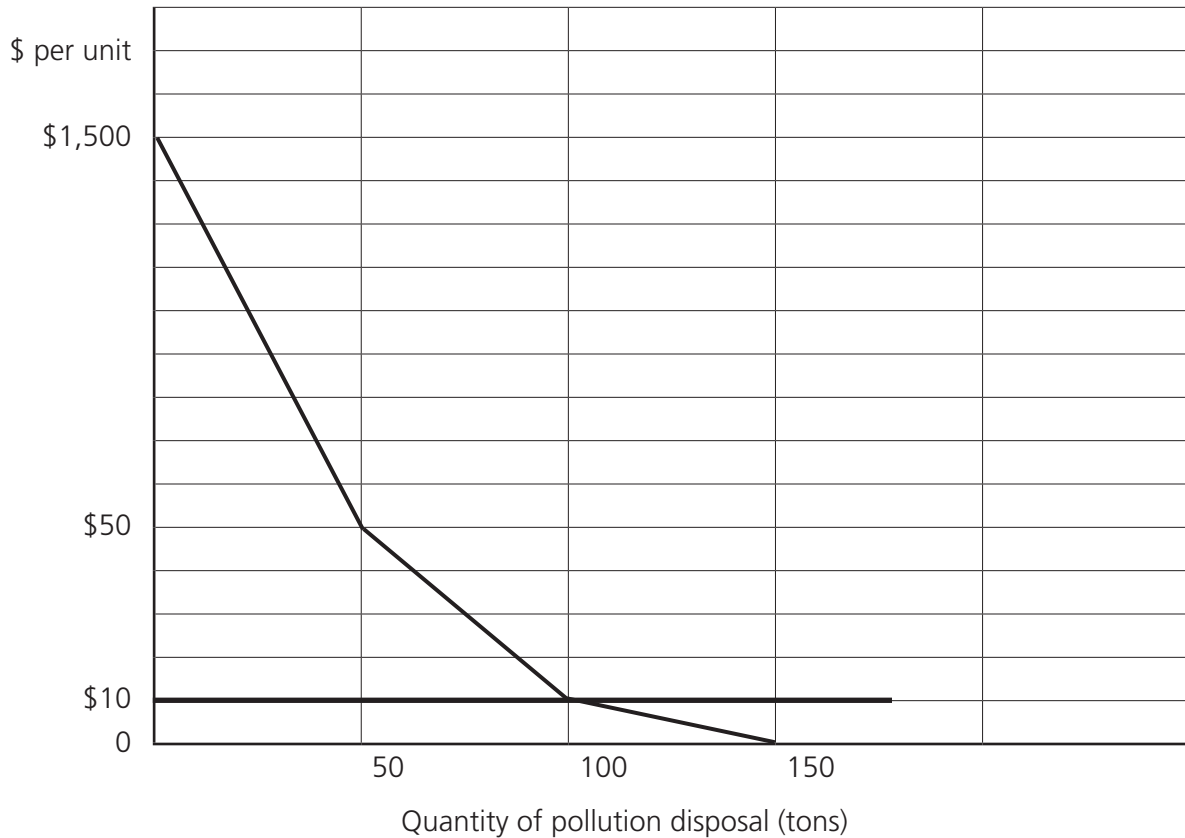


14. Display Slide 4.6. Tell the students that a second way to limit the disposal of pollution emissions into the environment is to tax pollution emissions. With this type of option, firms can pollute as much as they would like as long as they pay the tax for each unit of pollution. This system is described as an emissions tax. Review the advantages of an **emissions tax** as follows:

⁴ See Weber, 2002.

- The cost of pollution disposal (the amount of the tax) is known to businesses, and it provides some security in planning for the costs of doing business in the future.
 - Firms whose cost of controlling pollution is high can pay the tax and pollute. Low-cost firms can control their emissions and avoid paying the tax for pollution disposal.
 - Firms are free to choose whichever method or technology they find best to avoid paying the tax. Firms have an incentive to adopt new technologies to reduce pollution and avoid the tax.
 - The government will earn revenue from the tax. From an efficiency standpoint, implementing an emissions tax, if done properly, will improve efficiency. If the government uses the revenue from the emissions tax to lower taxes that might cause inefficiencies (for example, lowering income taxes to encourage working), then overall efficiency can be improved. This is called the “double dividend” of fixing pollution problems.
15. Tell the students to assume the tax to dispose of pollution into the environment is \$10 a unit. This means the government will allow (supply) firms as many units of pollution as they want at the price of \$10. Ask the students what they believe the supply curve looks like in this example. (*A horizontal line at the \$10 mark*) Explain that this is a perfectly elastic supply curve.
16. Display Slide 4.7. Ask the students how much pollution will be released based on the graph. (*100 units*) Remind the students that the demand for pollution disposal is based on the fact that cleaning up or avoiding creating the pollution costs firms money. The cleaner the environment, the more expensive it is to continue to clean up. Discuss the following:
- If firms did not have to pay to dispose of pollution into the environment, how much would they release? (*150 tons*)
 - Why do firms reduce pollution from 150 units to 100 units when the tax is imposed? (*It is cheaper to reduce emissions than to pay the tax; the demand curve is below the tax amount.*)
 - How high would the tax have to be to have a firm not dispose of any pollution into the environment or, in other words, have the quantity of pollution disposal services used be equal to zero? (*\$1,500*)
 - Why does the price have to be so high—\$1,500—to get firms to not dispose of any pollution? (*It is very expensive for firms to adopt technologies where nothing is emitted into the environment.*)
17. Point out that in this example, the \$10 tax and the permit system with 100 permits are equivalent. The price in the permit system is \$10 and the quantity in the tax system is 100. However, the differences between the two systems become apparent when the demand for pollution changes.

Supply and Demand for Pollution Disposal with Cap and Trade



18. Explain that the demand curve can shift if the cost for firms to reduce pollution is lowered. If the cost is reduced, the amount of pollution that needs to be disposed of is lowered, and firms will not need to demand as much pollution disposal. Ask the students how the following might shift the demand for pollution by firms:
- An innovation in pollution technology that makes it cheaper for firms to reduce pollution (*It would shift the demand for pollution to the left; it decreases demand for pollution disposal.*)
 - Growth by firms in the production of the good they produce (*It would shift the demand for pollution to the right because more production will result in more pollution to dispose of; it increases demand for pollution disposal.*)
19. Draw a demand curve and a supply curve for pollution disposal with a cap and trade system on the board (or doc cam). Discuss the following, shifting the curves as answers are given:

- What happens to the amount of pollution and the price of permits if the technology for reducing pollution emissions improves? (*The demand curve shifts to the left. As a result, the price decreases; the same quantity is emitted.*)
 - What happens to the amount of pollution and the price of permits if the demand for a product that firms produce increases? (*The demand curve shifts to the right. As a result, the price increases; the same quantity is emitted.*)
20. Draw a demand curve and a supply curve for pollution disposal with an emissions tax on the board (or doc cam). Discuss the following, shifting the curves as answers are given:
- What happens to the amount of pollution and the “price” firms pay if the technology for reducing pollution emissions improves? (*The demand curve shifts to the left and the price [the tax] is the same; the quantity decreases.*)
 - What happens to the amount of pollution and the “price” firms pay if the demand for a product that firms produce increases? (*The demand curve shifts to the right and the price [the tax] is the same; the quantity increases.*)
 - Suppose the government decides that too much pollution is being disposed of into the environment. What would be a solution? (*Increase the tax, which would shift supply vertically and result in less pollution*)

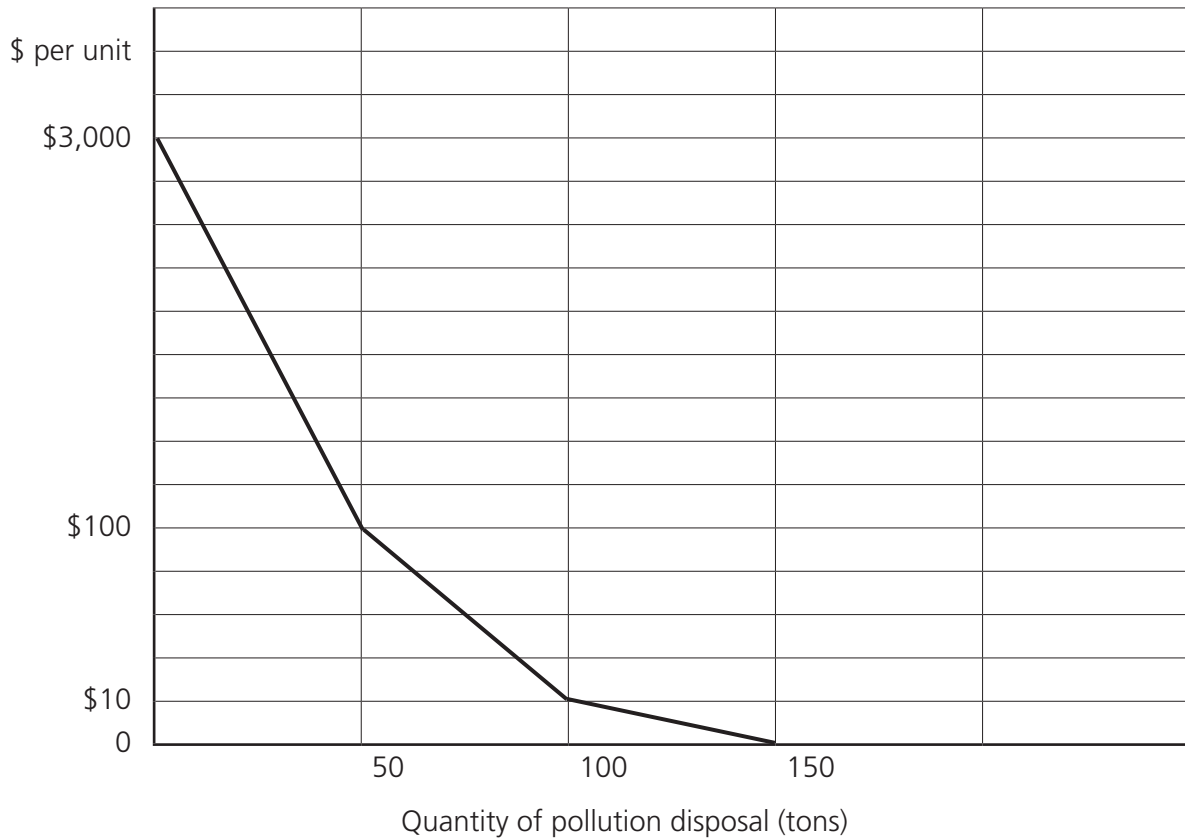
Closure

21. Conclude the lesson by projecting Slide 4.8. Tell the students that the United States does not currently control CO₂ emissions. However, many other examples of cap and trade exist, including the following:
- U.S. Acid Rain Program, SO₂ trading (<https://www.epa.gov/airmarkets/acid-rain-program>); SO₂ levels are now low, so prices are almost zero.
 - California’s Cap-and-Trade Program for carbon (<https://www.arb.ca.gov/cc/capandtrade/capandtrade.htm>)
 - European Union Emissions Trading System for many pollutants (https://ec.europa.eu/clima/policies/ets_en)
22. Also, note that some countries (and some U.S. states) are taxing carbon as a method to reduce CO₂ emissions. See Slides 4.9 and 4.10, from World Bank and Ecofys, 2018.
23. Ask the students what the main advantage of a market system is as opposed to government regulations that specify the technologies firms must use to control pollution. (*In a market system, firms can use whatever technology or method they wish to reduce pollution. Or, if they decide to do so, they can pay more to pollute more—either the tax or the price of the permit. This allows firms to figure out what is the cheapest thing for them to do.*)

Assessment

24. Distribute a copy of *Handout 4-1: Assessment* to each student. Allow time for the students to work and then review the answers as follows:

Multiple Choice



1. Suppose the government allows 50 units of pollution into the environment. The cap for a cap and trade system should be _____ tons. An equivalent method would be to charge a tax of \$_____ on pollution.
 - a. 50; 100
 - b. 100; 50
 - c. 50; 50
 - d. 100; 100

2. As an industry grows, the demand for pollution disposal will _____. Under an emissions tax system, the quantity of pollution emitted will _____.
 - a. *increase; increase*
 - b. *increase; stay the same*
 - c. *decrease; decrease*
 - d. *decrease; stay the same*

3. As pollution control technology improves, the demand for pollution will _____. Under a cap and trade system, the quantity of pollution emitted will _____.
 - a. *increase; increase*
 - b. *increase; stay the same*
 - c. *decrease; decrease*
 - d. *decrease; stay the same*

Short Answer

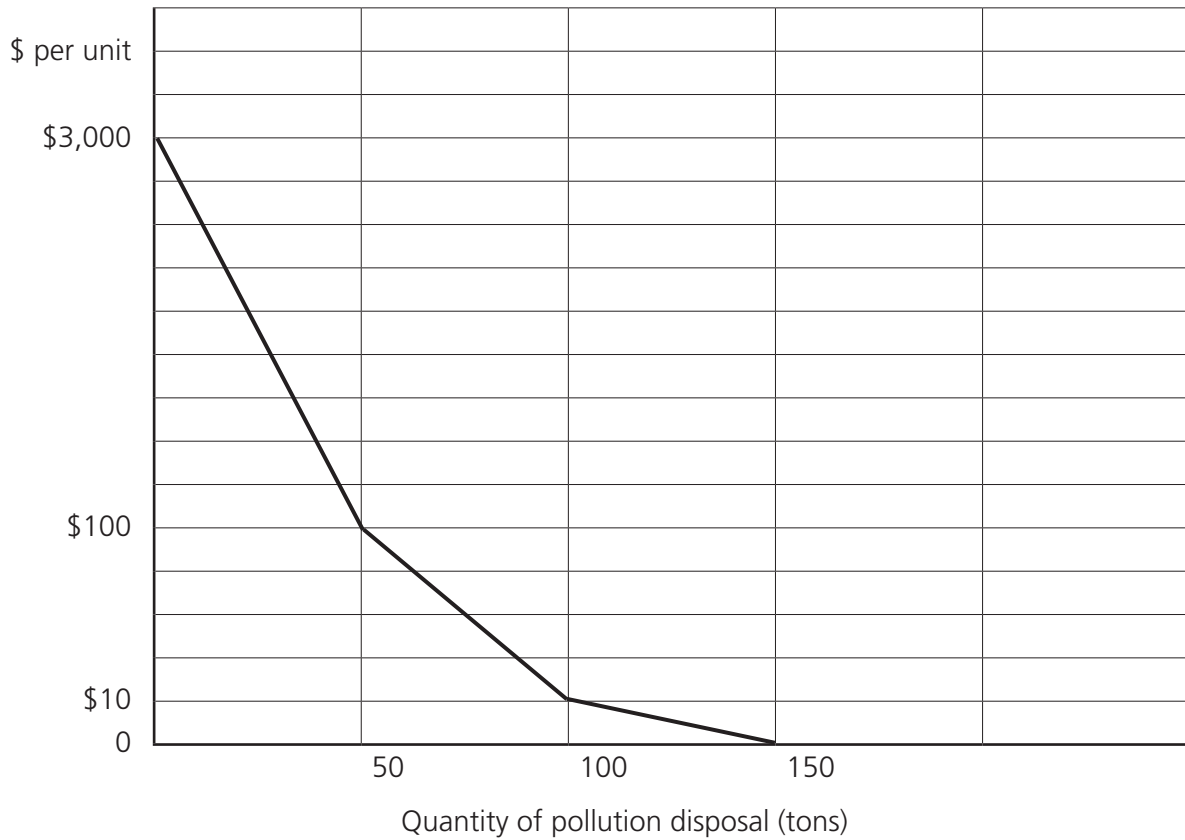
4. Recommend either a tax on pollution or a cap and trade system in which the permits are auctioned to firms by the government for the following scenarios:
 - You felt the environment’s capacity was at a “tipping point” where increases in pollution might result in a large amount of damage. (*Cap and trade*)
 - You want to provide firms with predictability in their costs of pollution control. (*Tax*)
 - You want to allow firms an opportunity to grow without increasing pollution control costs. (*Tax*)
 - You want pollution to shrink as pollution-control technologies improve. (*Tax*)

Handout 4-1: Assessment (page 1 of 2)

Multiple Choice

Directions: Select the best answer for each of the following questions.

- The diagram below shows the demand for pollution disposal services by firms. Use the diagram to answer the questions that follow.



- Suppose the government allows 50 units of pollution into the environment. The cap for a cap and trade system should be _____ tons. An equivalent method would be to charge a tax of \$_____ on pollution.
 - 50; 100
 - 100; 50
 - 50; 50
 - 100; 100

Handout 4-1: Assessment (page 2 of 2)

2. As an industry grows, the demand for pollution disposal will _____. Under an emissions tax system, the quantity of pollution emitted will _____.
- a. increase; increase
 - b. increase; stay the same
 - c. decrease; decrease
 - d. decrease; stay the same
3. As pollution control technology improves, the demand for pollution will _____. Under a cap and trade system, the quantity of pollution emitted will _____.
- a. increase; increase
 - b. increase; stay the same
 - c. decrease; decrease
 - d. decrease; stay the same

Short Answer

Directions: Write responses to the prompt below.

4. Recommend either a tax on pollution or a cap and trade system in which the permits are auctioned to firms by the government for the following scenarios:
- You felt the environment’s capacity was at a “tipping point” where increases in pollution might result in a large amount of damage. _____
 - You want to provide firms with predictability in their costs of pollution control. _____
 - You want to allow firms an opportunity to grow without increasing pollution control costs. _____
 - You want pollution to shrink as pollution-control technologies improve. _____

Standards and Benchmarks

Voluntary National Content Standards in Economics

Standard 2: Decision Making

Effective decision making requires comparing the additional costs of alternatives with the additional benefits. Many choices involve doing a little more or a little less of something: few choices are “all or nothing” decisions.

Standard 4: Incentives

People usually respond predictably to positive and negative incentives.

Common Core State Standards

CCSS.ELA-Literacy.RH.11-12.7: Integrate and evaluate multiple sources of information presented in diverse formats and media (e.g., visually, quantitatively, as well as in words) in order to address a question or solve a problem.

Notes

Climate Leadership Council; <https://www.clcouncil.org/economists-statement/>.

Intergovernmental Panel on Climate Change (IPCC). “Summary for Policymakers,” in Masson-Delmotte, Valérie; Zhai, Panmao; Pörtner, Hans-Otto; Roberts, Debra; Skea, Jim; Shukla, Priyadarshi R.; Pirani, Anna; Moufouma-Okia, Wilfran; Péan, Clotilde; Pidcock, Roz; Connors, Sarah; Matthews, J. B. Robin; Chen, Yang; Zhou, Xiao; Gomis, Melissa I.; Lonnoy, Elizabeth; Maycock, Tom; Tignor, Melinda and Waterfield, Tim, eds., *Global Warming of 1.5°C: An IPCC Special Report on the Impacts of Global Warming of 1.5°C Above Pre-Industrial Levels and Related Global Greenhouse Gas Emission Pathways, in the Context of Strengthening the Global Response to the Threat of Climate Change, Sustainable Development, and Efforts to Eradicate Poverty*. Geneva, Switzerland: World Meteorological Organization, 2018.

Schmalensee, Richard and Stavins, Robert N. “The SO₂ Allowance Trading System: The Ironic History of a Grand Policy Experiment.” *Journal of Economic Perspectives*, 2013, 27(1), pp. 103-22; doi: 10.1257/jep.27.1.103.

Weber, David W. “Pollution Permits: A Discussion of Fundamentals.” *Journal of Economic Education*, 2002, 33(3), pp. 277-90; doi: 10.1080/00220480209595192.

World Bank and Ecofys. “State and Trends of Carbon Pricing 2018 (May).” World Bank, Washington, DC, 2018; doi: 10.1596/978-1-4648-1292-7.