MODULE 75 / 39: EXTERNALITIES AND PUBLIC POLICY

The purpose of this module is to study how negative externalities can be regulated with environmental standards, emissions taxes or tradable permits. The module also shows how both positive and negative externalities lead to deadweight loss as either too little, or too much, of a good is being supplied by a market that does not recognize the externalities in the equilibrium quantity or price.

Student learning objectives:

- How external benefits and costs cause inefficiency in markets.
- Why some government policies to deal with externalities, such as emissions taxes, tradable emissions permits, and Pigouvian subsidies, are efficient, although others, including environmental standards, are not.

Key Economic Concepts For This Module:

- Pollution is a form of negative externality. It can be lessened with environmental standards, emissions taxes, and/or tradable emissions permits. The taxes and permits tend to reduce pollution more efficiently as they equate, for all producers, the marginal cost of the next ton of pollution emitted.
- When consumption of a good generates external benefits to third parties, it is said to provide a positive externality.
- The market will under-produce a good with a positive externality because the marginal social benefit is greater than the marginal private benefit. This outcome creates deadweight loss that could be eliminated with a Pigouvian subsidy equal to the marginal external benefit.
- The market will over-produce a good with a negative externality because the marginal social cost is greater than the marginal private cost. This outcome creates deadweight loss that could be eliminated with a Pigouvian tax equal to the marginal external cost.

Common Student Difficulties:

- Students understand how taxes reduce pollution, but find it more difficult to follow how a system of tradable permits would reduce pollution. They will often ask incredulously, "why does the government issue a polluter *the right* to pollute?" Remind the students that, with no regulation, the firms will maximize pollution to potentially dangerous levels. The permit system first reduces pollution by limiting the number of permits to safer levels, and then allows them to be traded. Over time the government gradually reduces the number of permits as abatement technology improves, cleaning the environment in the process.
- Get the students to think about positive and negative externalities at their most localized level: their classmates. Does someone ever do something that you enjoy (holding the door open, doing you a favor, wearing a nice perfume)? That's a positive externality. The examples of negative externalities are going to be easier for the students to identify.
- Help the students to see that the *MPB* curve is really the demand curve that we have been studying throughout the course. Until now, we assumed that the only persons who benefited from consumption along the demand curve were those paying the price and consuming the good. Thus the *MPB*=*MSB* because there were no external benefits. When there are third parties that benefit, there is a break between the *MSB* and *MPB*.
- Likewise, show the students that the *MPC* curve is just the supply curve that we have been studying throughout the course. Until now, we assumed that the only persons who incurred cost from production along the supply curve were those hiring inputs and producing the good. Thus

the *MPC*=*MSC* because there were no external costs. When there are third parties that incur cost, there is a break between the *MSC* and *MPC*.

In-Class Presentation of Module and Sample Lecture

Suggested time: This module can be covered in two to three one-hour class sessions.

I. Policies Toward Pollution
  - **A.** Environmental Standards
  - **B.** Emissions Taxes
  - **C.** Tradable Emissions Permits

II. Production, Consumption, and Externalities
  - **A.** Private versus Social Benefits
  - **B.** Private versus Social Costs
  - **C.** Network Externalities

I. Policies Toward Pollution

Major pieces of environmental legislation in the U.S. have only been around since the early 1970s. Recent laws have incorporated more market-based incentives to reduce pollution and gain economic efficiency.

Note: for more historical background of the EPA and important laws, see this site: http://www.epa.gov/history/

A. Environmental Standards

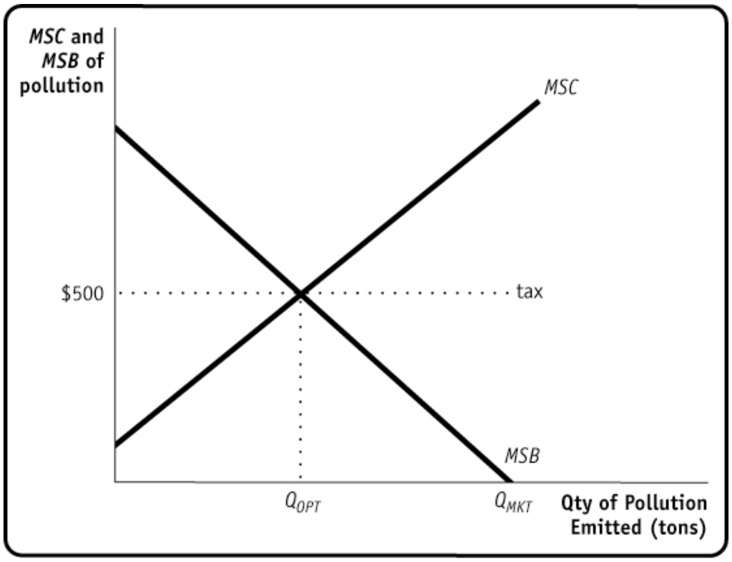
Early legislation was written with a heavy dose of "thou shalt not" pollute more than _____ amount of gunk in the air, water, and/or soil. This was a vast improvement on the unregulated, and heavily polluted, situations that led to the environmental movement, but was seen by economists as an inefficient way to tackle the problems. These environmental standards are also known as "command and control" measures for reducing pollution.

Example: Many cities require autos to pass emissions inspections before the license plate can be renewed.
Sewage must be treated before it can be released back into the environment.

B. Emissions Taxes

Economists have long known that if you want someone to do less of something, all you need to do is raise the price of doing it. Harness the power of the law of demand and the profit motive!

We'll bring back the graph that shows the *MSB* and *MSC* of pollution from the previous module.
The socially optimal quantity of pollution Q_{OPT} is where *MSB*=*MSC* and suppose this corresponds to $500 per ton.
The unregulated marketplace would produce Q_{MKT} tons of pollution and the government would like to reduce pollution back to Q_{OPT}.



The government is about to impose a tax on every ton of pollution emitted. This gives the firm a simple choice: spend money on pollution abatement for that ton, or pay the tax on that ton.

Note: remind the students that the benefit of the next ton of pollution, or the next ton removed, is represented by the *MSB* curve. Pollution removal measures are called "pollution abatement" and if $1 million is required to reduce pollution by one ton, $1 million is not being used in its next best alternative. Thus if the one ton of pollution is allowed to exist, society receives $1 million of marginal benefit.

So long as the tax is above the *MSB* curve, it will be cheaper for the firm to spend money on abatement measures than it would be to pay the tax.

Refer back to the graph above. If the tax is set at $500, firms will spend money on abatement measures from Q_{MKT} all the way back to Q_{OPT}. So if the tax is set at the point where *MSB*=*MSC*, pollution will be reduced to the socially optimal amount.

By putting a price (the tax) on each ton polluted, the government gives the firms a financial incentive to reduce pollution.

Why is this better than a strict environmental standard?
Both polices can reduce pollution to Q_{OPT}, but the tax can do it more efficiently than the standard.

To see how, let's create a simple example.
Polluting firms all have different mechanisms for reducing their pollution. These differences are seen as differences in the costs of implementing pollution abatement, which means that some older firms will need to spend more money to reduce their pollution than a newer firm would need to spend.

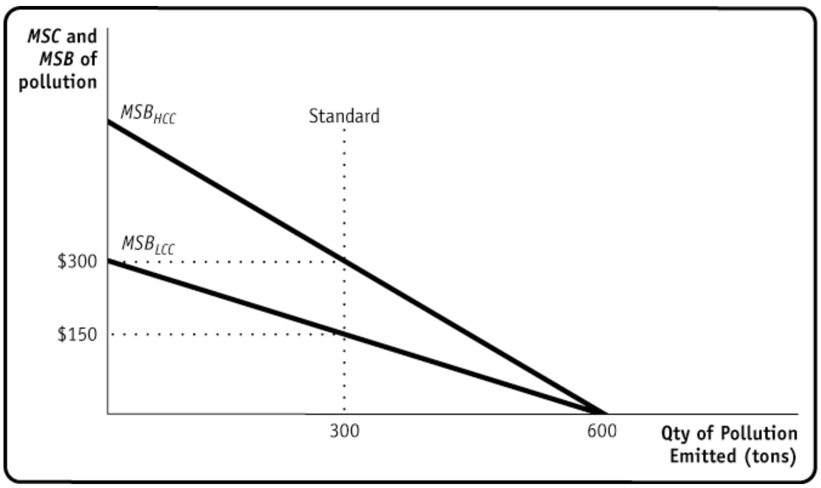
> **Example:** Note: this is an expansion of the example used in the textbook.
> There are two polluting firms in town, and each emits gunk into the environment. High Cost Carbon (HCC) is a factory built nearly 50 years ago and hasn't adopted very much "green" technology over the years. Low Cost Chemical (LCC) was built recently with state-of-the-art pollution controls. If each firm needed to reduce pollution by one more ton, it will cost LCC much less to install more pollution abatement than it would cost HCC.
> We can see this difference in the *MSB* curves.

If there were no pollution regulations, each firm would produce 600 tons of pollution where each *MSB*=0; thus a total of 1200 tons would be emitted into the environment.

Environmental Standard

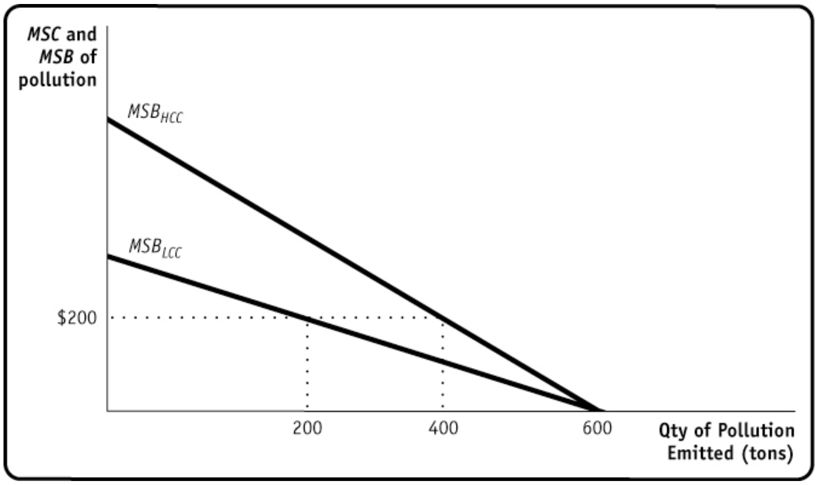
Each firm must cut pollution in half to 300 tons. This removes half of the pollution from the environment, but it is twice as costly for HCC to reach the standard as it is for LCC. We can see in the graph that MSB_{HCC} = \$300 for the 300th ton, while MSB_{LCC}=\$150 for the 300th ton.

We can also see in the graph the total cost of abatement measures as the area of the triangle under each of the *MSB* curves.
Total abatement cost for HCC = ½*(\$300)(300 tons) = \$45,000
Total abatement cost for LCC = ½ *(\$150)(300 tons) = \$22,500
Total cost to reach the standard of 600 tons = \$67,500



Emissions Tax

Now the government is considering imposing a tax on each ton of pollution that is emitted, and sets the tax such that a total of 600 tons will be emitted. If the tax is set at \$200 per ton, LCC will reduce pollution even more (to 200 tons) than under the standard while HCC will reduce pollution by less (to 400 tons) than they would under the standard.
We can see this in the graph below.



Again, we can see the total cost of pollution abatement as the triangles under the respective *MSB* curves.
Total abatement cost for HCC = ½*($200)(200 tons) = $20,000
Total abatement cost for LCC = ½ *($200)(400 tons) = $40,000
Total cost to reach the standard of 600 tons = $60,000

So the tax policy achieves the same goal of 600 tons of pollution but does so at a lower cost to society.

- When each plant values a unit of pollution equally, there is no way to re arrange pollution reduction among the various plants that achieves the optimal quantity of pollution at a lower total cost.

C. Tradable Emissions Permits

Let's go back to the outcome we saw with the environmental standard. Each firm was required to emit only 300 tons of pollution.

Suppose that HCC and LCC meet for pancakes one morning.
President of HCC says, "Hey, this pollution standard is killing me! It costs me $300 to reduce that last ton of pollution and it only cost you $150 to reduce your last ton of pollution. How about if I pollute one more ton and you pollute one less ton?"
President of LCC says, "Sure, but reducing my pollution by one more ton will cost me a little more than $150, so I'll need at least that much payola to agree to this deal."
President of HCC is giddy, "No problem! See, polluting one more ton will *save* me a little less than $300, so we can agree to a price between $300 and $150 that makes us both happy."

And thus two firms were trading pollution. The high cost firm saved money by polluting more, but had to pay the low cost firm to pollute less. The same total amount of pollution was emitted.

A system of tradable pollution permits works like this.

- The government would issue (or auction) 600 permits, each allowing the holder to emit one ton of pollution. This removes 600 tons of pollution from the environment, because 1200 would have been emitted without the permit system.
- If a firm found that they needed to pollute more, they would buy permits from a firm that found they could pollute less.
- The firm buying permits (like HCC) knows that it's cheaper to buy a permit than it is to install costly abatement equipment, so it profits from this transaction.
- The firm selling permits (like LCC) knows that it's cheaper to install abatement equipment, so it sells excess permits and profits from the transaction.

- When there are no more mutually beneficial transactions to be made, an equilibrium price is set for permits.

II. Production, Consumption, and Externalities

The production and consumption of most goods creates some form of pollution, or external cost, upon society. Even the simple act of using electricity to operate my laptop computer is contributing to the burning of coal in the Ohio River Valley.
Not all production and consumption creates a negative externality, sometimes a positive externality exists. If one person spends money to beautify her house and yard, it benefits the homeowners nearby with higher property values. The property is also pleasant to those who drive or walk past.

We will see that when external benefits exist from the production and consumption of a good, that the market will under-produce that good. In other words, society would benefit from more, but the market produces less.

We will also look again at the issue of external costs, like pollution, when a good is produced and consumed. We will see that the market over-produces such goods. Society would benefit from less, but the market produces more.

A. Private versus Social Benefits

When the production and consumption of a good provides benefits to third parties, that good is said to provide positive externalities to society.

Example

- I consume a chocolate bar. This provides me with private benefit, but my friends, neighbors or fellow citizens of the world receive no benefit from my actions.
- But if I consume a flu shot or chickenpox vaccine, my friends, neighbors and fellow citizens of the world are going to receive some of the benefit because these two viruses just became less likely to be carried by me.
- If Sue spends lots of money improving the value of her home, she receives private benefit. But the improvement of her home has a spillover benefit to her neighbors by raising the value of *their* homes.

So in the case of home improvements, there is a difference between the private benefits that Sue receives and the external benefits that her neighbors receive. Economists like to sum all of the benefits, both private and external, to get the total benefits received by society.

Total Social Benefit = Total Private Benefit + Total External Benefit.

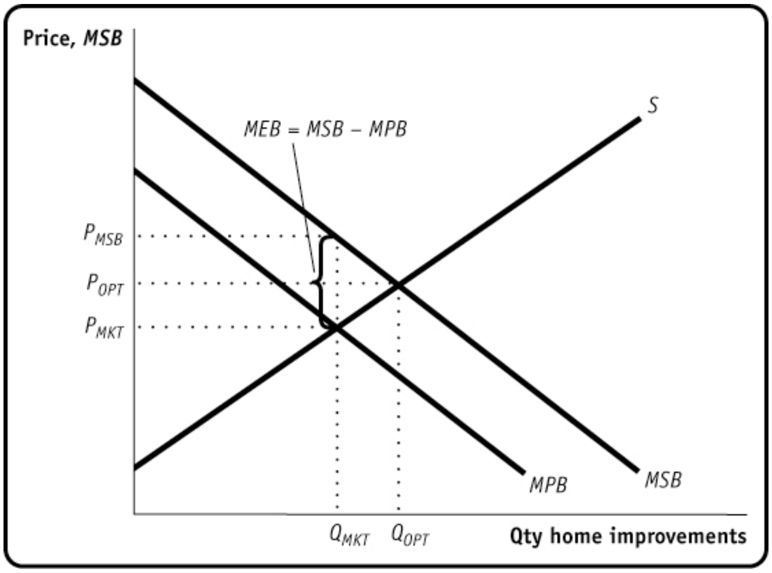
On an incremental basis, the next unit of home improvements (or the next flu shot), provides marginal social, marginal private, and marginal external benefits.

Marginal Social Benefit = Marginal Private Benefit + Marginal External Benefit.
Or,
$MSB = MPB + MEB$
We can safely state that $MEB>0$ because Sue's neighbors see an increase in their property values when Sue consumes home improvement goods.

Earlier in the course we learned that marginal benefit declines as more of a good is consumed. The same is true here. The first unit of home improvement provides the greatest marginal benefit, but this marginal benefit declines. The downward sloping *MB* curve is also the demand curve for the good. In order to consume more units as the *MB* falls, the price must also fall.

In the graph below we show that the marginal private benefit (*MPB*) declines. This represents the private benefits that people like Sue receive with more consumption of home improvements and the private market demand curve for the good. But Sue's neighbors also benefit so when we add the positive amount of *MEB* to *MPB*, the *MSB* curve lies above the *MPB* curve.

For now we assume that the supply of the good doesn't generate any external benefits or costs, so we show a typical upward sloping market supply curve for home improvements.



Market outcome:
Equilibrium occurs where the supply curve intersects *MPB* (private demand) and Q_{MKT} is produced at price of P_{MKT}. This is the same outcome we have seen throughout the course. But the *MPB* only reflects the benefits received by the actual consumers of home improvement goods; it does not reflect <u>all</u> of the benefits like those received by the neighbors. When we include the external benefits, the price society would be willing to pay for Q_{MKT} is higher at P_{MSB}.

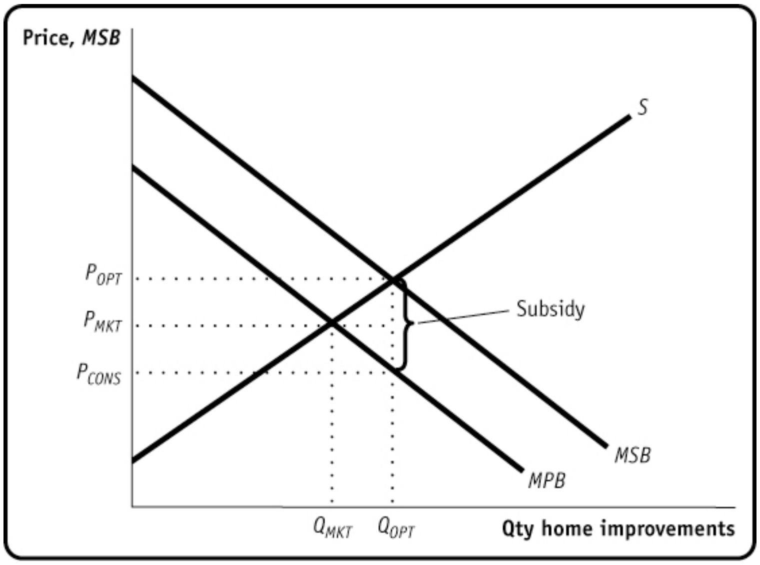
Socially optimal outcome:
If the external benefits are considered, the socially optimal outcome is where the supply curve intersects the *MSB* curve and Q_{OPT} is produced at a price of P_{OPT}. At this point the marginal cost of producing home improvements (from the supply curve) is equal to the marginal benefits society receives from consuming them.

Note: stress that the socially optimal outcome is where *MSB*=*MSC*.

The difference between the market outcome and socially optimal outcome:
We can see that the market under-produces goods that generate positive externalities. In other words, we don't get enough of a good thing.
Is this a big deal? Well, it's inefficient and produces deadweight loss just like price controls and monopoly. This represents benefits that would be enjoyed by society if the socially optimal, not the market, output was produced.
The area of the deadweight triangle is above the supply curve, with base of ($Q_{OPT} - Q_{MKT}$), and height of ($P_{MSB} - P_{MKT}$),

How could policy eliminate the deadweight loss?

We could provide a subsidy (called a Pigouvian subsidy) on each unit of home improvement goods demanded by people like Sue. Maybe the government provides a voucher to each consumer that is redeemable for home improvement goods. This increases each person's private willingness to pay for each unit of the good. If the subsidy was equal to MEB, it would shift the *MPB* upward so that it was located on the *MSB* curve. This would increase output to Q_{OPT} and increase the price suppliers receive to P_{OPT}, but the price P_{CONS} consumers pay would be (P_{OPT} – Subsidy), which is actually lower than the original price P_{MKT}. We can see this in a simplified version of the graph above.



B. Private versus Social Costs

We have seen that when firms produce goods, they incur production costs. These are private costs of production. But when production of a product generates external costs, a negative externality, on society it means that third parties are also incurring costs and these costs must be added to the private costs to reflect the total costs of producing a product.

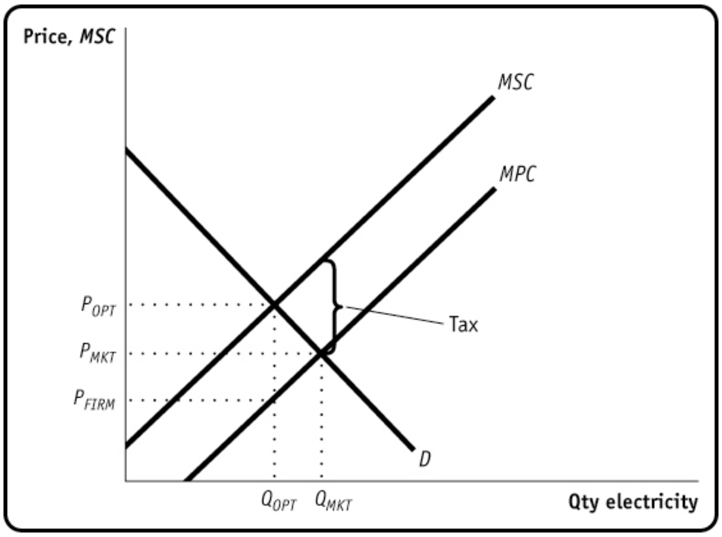
Note: the discussion below closely follows the discussion of positive externalities. If the students follow the difference between *MSB* and *MPB*, they will find this topic to be familiar.

> **Example** As discussed in previous modules, most forms of electricity production produce pollution as a byproduct.
>
> So in the case of home electricity production, there is a difference between the private costs incurred by producers and the external costs that citizens bear. Economists like to sum all of the costs, both private and external, to get the total costs incurred by society.
>
> Total Social Cost = Total Private Cost + Total External Cost.
>
> On an incremental basis, the next unit of electricity provides marginal social, marginal private, and marginal external costs.
>
> Marginal Social Cost = Marginal Private Cost + Marginal External Cost.
> Or,
> $MSC = MPC + MEC$
> We can safely state that $MEC>0$ because pollution from the power plants cause health problems for people and the environment downwind from the plant.

Earlier in the course we learned that marginal cost rises as more of a good is produced. The same is true here. The upward sloping *MC* curve is also the supply curve for the good. In order to produce more units as the *MC* rises, the price must also rise.

In the graph below we show that the marginal private cost (*MPC*) increases. This represents the private costs that power plants incur with more production of electricity, and is the private market supply curve for the good. But the environment also incurs cost, so when we add the positive amount of *MEC* to *MPC*, the *MSC* curve lies above the *MPC* curve.

For now we assume that the demand for the good doesn't generate any external benefits or costs, so we show a typical downward sloping market demand curve for electricity.



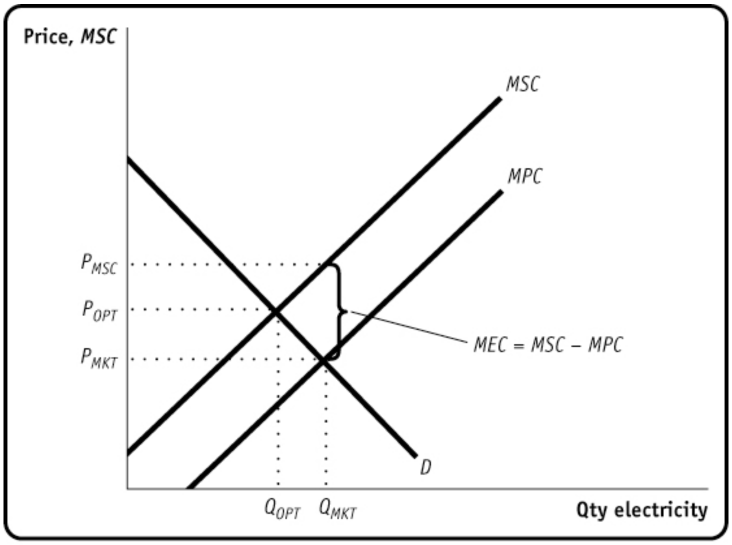
Market outcome:
Equilibrium occurs where the demand curve intersects *MPC* (private supply) and Q_{MKT} is produced at price of P_{MKT}. This is the same outcome we have seen throughout the course. But the *MPC* only reflects the costs incurred by the actual producers of electricity; it does not reflect <u>all</u> of the costs like those borne by the surrounding environment. When we include the external costs, the price society would be willing to pay for Q_{MKT} is higher at P_{MSC}.

Socially optimal outcome:
If the external costs are considered, the socially optimal outcome is where the demand curve intersects the *MSB* curve and Q_{OPT} is produced at a price of P_{OPT}. At this point the marginal benefit of consuming electricity (from the demand curve) is equal to the marginal costs society incurs from producing it.

Note: Again, stress that the socially optimal outcome is where *MSB*=*MSC*.

The difference between the market outcome and socially optimal outcome:
We can see that the market over-produces goods that generate negative externalities. In other words, we get too much of a bad thing.
Is this a big deal? Well, it's inefficient and produces deadweight loss just like price controls and monopoly. This represents additional costs that would not be incurred by society if the socially optimal, not the market, output was produced.
The area of the deadweight triangle is above the demand curve, with base of ($Q_{MKT} – Q_{OPT}$), and height of ($P_{MSC} – P_{MKT}$),

How could policy eliminate the deadweight loss?
We could provide a tax (a Pigouvian tax) on each unit of electricity supplied by the power plants. This increases each firm's private marginal cost of each unit of the good. If the tax was equal to *MEC*, it would shift the *MPC* upward so that it was located on the *MSC* curve. This would decrease output to Q_{OPT} and increase the price consumers pay to P_{OPT}, but the price P_{FIRM} firms receive would be (P_{OPT} – Tax), which is actually lower than the original price P_{MKT}. We can see this in a simplified version of the graph above.



Of course producers don't appreciate receiving a lower price, after the tax is paid, on each unit of electricity that they produce. But this provides an excellent incentive to develop better ways of producing electricity so that less pollution is created and fewer dollars are spent paying taxes.
Consumers don't enjoy paying higher prices for the electricity they grown accustomed to buying at very low rates. Of course consumers have been receiving a discount on that electricity because the market price didn't reflect all of the costs we incur from generating the electricity. So the new higher price reflects all of society's costs and sends consumers a powerful incentive to use less electricity.

C. Network Externalities

A network externality exists when the value to an individual of a good or service depends on how many other people use the same good or service.

When more people use Facebook or Twitter, it becomes more valuable to you. When more people have cell phones with Verizon service, it means your Verizon phone can call more people at lower prices.

If you buy an electric car, you will need recharging stations so that you can get a charged battery when yours is low. If there are more people driving electric cars, more of these recharging stations will emerge, making it more convenient for you (and the other drivers) to "fill up".

In-Class Activities and Demonstrations

Practice the Externality FRQs.
In the last few years, the AP Microeconomics exam has included more and more questions from this section of the curriculum. It's highly encouraged that the instructor use recent FRQs to help prepare the students for similar challenges.

A Cap and Trade Simulation
The website below takes you to a simulation at MSNBC.com that illustrates how a tradable permit system is intended to work. The students can experiment with several variables to see whether their program would create the right set of incentives for firms to reduce emissions and invest in cleaner technology.
http://www.msnbc.msn.com/id/18288820/ns/business-going_green/

A Mercury Cap and Trade Game
Note: I have not tried this game in my own classroom, but it looks useful and doable for inexperienced instructors to try.
http://www.pbs.org/newshour/extra/teachers/lessonplans/economics/mercury_econ.html