Chapter 13

Transferable Emission Permits

An effluent tax requires that some central public authority establishes a tax rate, monitors the performance of each polluter, and then collects the tax bills. It is essentially an interaction between polluters and public authorities in which we might expect the same type of adversarial relationship we get in any tax system. In this chapter we will take a look at a policy approach that, while incorporating economic incentives, is designed to work in a more decentralized fashion. Rather than leaving everything to a centralized public agency, it works through the decentralized market interactions of polluters themselves. It's called the system of ***transferable emission permits (TEPs)***.

General Principles

> ***A transferable emission permit creates a transferable property right to emit a specified amount of pollution.***

In a transferable emission permit system a new type of property right is created. This property right consists of a permit to emit pollutants. Each permit (also known as an *allowance*) entitles its holder to emit one unit (kilogram, tonne, or however the permit is calibrated) of the waste material specified in the right. Rights holders would ordinarily have a number of such permits at any point in time. If a discharger owned 100 permits, for example, it would be entitled to emit, during some specified period of time, a maximum of 100 units of the designated type of pollutant. Thus, the total number of permits held by all sources puts an upper limit on the total quantity of emissions. These discharge permits are *transferable*; they can be bought and sold among anybody allowed to participate in the permit market, at whatever price is agreed upon by the participants themselves. Transferability is a key component of the TEP system. If rights are not transferable, the system is effectively the same as the assignment of an individual standard to each polluter. The regulator would then lose many of the key advantages of a TEP system, as we'll see.

A TEP program begins with a centralized decision on the total number of discharge permits to be put into circulation. These permits are then distributed among the sources responsible for the emissions. Some formula must be used to determine how many permits each source will receive; we will come back to this problem below. An economist would advocate using social efficiency (where marginal damages equals marginal abatement costs) as the criterion for determining the total number of permits (tonnes of emissions) chosen. In actual TEP systems, the total number of permits is set at a target level that may be arbitrary because there is limited knowledge about either the MAC or MD curve (or both) We look in more detail at the issue of uncertainty about the location of these curves in Chapter 14. TEP Regardless of where the target level of total emissions is set, if the total number of permits is less than current total emissions, some or all emitters will receive fewer permits than their current emissions.

Example: A TEP program to reduce sulphur emissions from electric power plants

Suppose there is a national TEP program to reduce the amount of sulphur emitted by electricity-generating power plants.[1] Current total emissions are 120,000 tonnes of sulphur per year, and policy-makers have decided that this must be reduced to 80,000 tonnes/year. Let's focus on the situation of one of the power plants, which we suppose to be emitting 40,000 tonnes of sulphur currently. Suppose each permit allows the holder to release a maximum of 1,000 tonnes of sulphur annually. This plant is initially given 30 discharge permits. The plant manager now has three choices.

[1.] While this is a hypothetical example, Chapter 17 examines an actual market in the United States for sulphur dioxide emissions trading.

1. Reduce the emissions to the level covered by the number of permits the plant was initially given, or 30,000 tonnes/year.
2. Buy additional permits and emit at higher levels; for example, it might buy an additional 10 permits, giving it a total of 40,000 tonnes. In this case it would not reduce its emissions at all from their initial level.
3. Reduce its emissions below the 30,000 tonnes for which it has permits and then sell the permits it doesn't need. For example, if it reduced its emissions to 20,000 tonnes, 10 permits of its original allocation would not be needed; these could be sold.

It may not be obvious that the buying and selling of permits among polluters (and perhaps others) would lead to the distribution of total emissions among polluters in a way that satisfies the equimarginal principle. Figure 13-1 helps illustrate. Assume there are two polluters whose sulphur emissions are uniformly mixed together (non-uniformly mixed emissions are examined below). Panel (a) shows the MAC function for firm A; panel (b) shows the function for firm B. Emissions (E) are measured in thousands of tonnes. To facilitate computations, the functions for these MAC curves are:

$$MAC_A = 120 - 3E_A$$

$$MAC_B = 400 - 5E_B$$

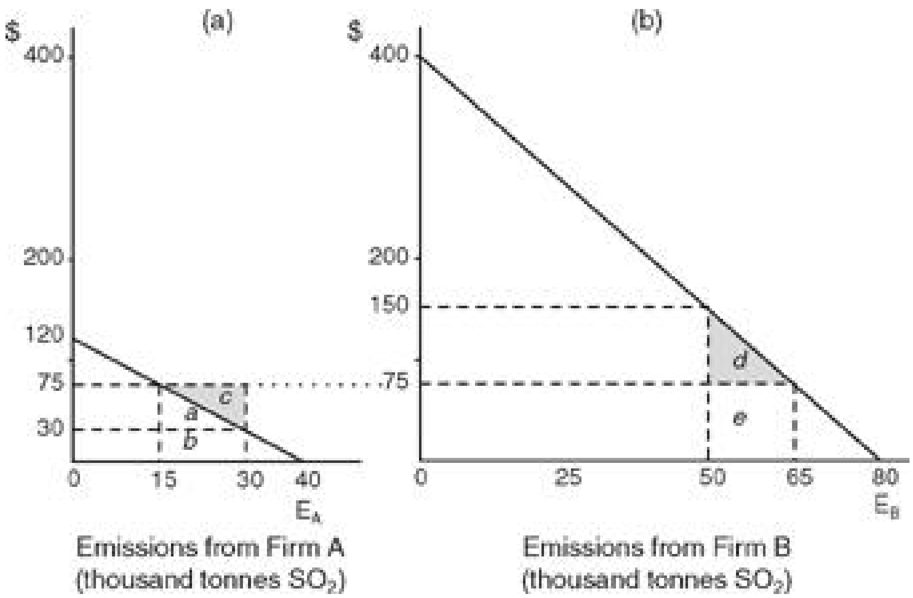
Initial emissions of each firm are found by setting MAC = 0 and solving for $E0$ (as we have done in preceding chapters). Then:

$$E_A^0 = 40{,}000 \text{ tonnes}$$

$$E_B^0 = 80{,}000 \text{ tonnes,}$$

Total E = 120,000 tonnes of sulphur emissions annually.

Figure 13-1: How Transferable Emission Permits Work



A TEP system is introduced to lower sulphur pollution from an initial level of 120,000 to 80,000 tonnes per year. Polluters are given emission permits in proportion to their initial level of emissions (30 to firm A and 50 to firm B). Polluters will have an incentive to trade permits as long as their MACs differ at each one's emission levels. Polluter A will have an incentive to sell permits to B because it can reduce its emissions at lower marginal cost than can B. The cost-effective equilibrium is reached where the MACs of the two polluters are equal and their total emissions equal the target level. A total of 15 permits are traded. Firm A's net gain is area *c*; firm B's is area *d*.

The government regulator has chosen a target level of total emissions to be 80,000 tonnes per year. The regulator creates 80 transferable emission permits, each one of which entitles its possessor to emit 1,000 tonnes/year. ***TEP***The permits are distributed to the two firms, using some agreed-upon allocation rule. The allocation rule for this example is that each is allocated permits roughly in proportion to its current emission rates.[2] Firm A receives 30 permits and firm B gets 50 permits in the original distribution. The firms cannot release any more than 30,000 tonnes and 50,000 tonnes per year respectively unless they trade. Will permit trading occur?

[2.] We have rounded to avoid having fractions of permits.

The basic trading principle is this: A polluter will reduce its emissions and sell its excess permits on the market if the market price is greater than or equal to its MAC at its chosen emission level. A polluter will buy a permit if the price is less than or equal to its MAC of controlling emissions. MAC curves can thus be thought of as a polluter's demand curve for permits (if it is buying) or supply curve (if it is selling).[3] The permit market, if competitive, works like any other market. An equilibrium price and quantity exchanged will be found where supply equals demand.

[3.] The supply curve for a firm selling permits will be the inverse of its MAC curve.

Which polluters will be the buyers and which the sellers? As long as MAC curves differ, there should be trades and the polluter with the lower MAC will be the seller, the one with the higher MAC the buyer. Note in Figure 13-1 that at the initial allocation of permits, firm A's MACs are substantially lower than firm B's ($30 versus $150). This gives firm A the potential to increase its pollution control, not use some permits, and sell them to firm B, if the receipts from the permit sale compensate for A's additional abatement costs. Firm B will want to buy these permits if their total cost is less than it would have had to pay to control the units of sulphur it can now emit. We now illustrate this numerically.

Numerical example of how the permit market works: Computing gains to trading

1. Compute A's net gain (cost saving) if it reduces its emissions from 30,000 to 15,000 tonnes per year and sells its excess permits. Polluter A is the potential permit supplier.

   Polluter A's marginal abatement costs at emissions of 15,000 tonnes per year are given by:

   $$MAC_A = 120 - 3\,(15) = \$75$$

   The change in its total abatement costs if it reduces emissions from 30,000 to 15,000 tonnes is shown by areas ($a + b$) in Figure 13-1. Area $a = \frac{1}{2}[(30 - 15) \times (\$75 - 30)] = \$337.50$. Area $b = [(30 - 15) \times \$30] = \$450$. Area $(a + b) = \$787.50$.

   If firm A now sells its 15 surplus permits to firm B for $75 per permit, it will receive areas $(a + b + c) = \$1{,}125$ in permit revenue.

   Firm A's cost saving is therefore areas $[(a + b + c) - (a + b)]$ = area $c = \$337.50$.

2. Compute polluter B's net gains/cost savings if it buys polluter A's 15 permits and therefore increases its emissions from 50,000 to 65,000 tonnes. Polluter B is the potential permit buyer.

   Polluter B pays A $75 per permit, for a total of $1,125 (area *e* in Figure 13-1).

   B's TACs fall because B increases its pollution. The reduction in TAC equals areas $(d + e) = \$1{,}687.50$.

   Firm B's net gain is therefore [areas $(d + e)$ – area e] = area $d = \$562.50$.

   This proves that both firms would be better off after the trade—their combined gains from trading 15 permits are their cost savings compared to their initial permit allocation. Total cost savings equals areas $(c + d) = \$900$.[4]

[4.] In an actual trading situation the price will be somewhere between the seller's minimum price and the buyer's maximum price, where the minimum and maximum prices are determined by each party's MAC curve. For example, if the firms were to trade two permits, A's MAC at 28 tonnes of emissions is $36, while B's, at 52 tonnes, is $140. The permit price would lie between these two boundaries.

Gains from trade would continue to exist and permits would continue to be traded until marginal abatement costs are equalized. Note from the example above that at 15 permits traded, both firms have the identical MACs of $75 for the last tonne of sulphur emitted. Total emissions still meet the regulator's target of 80,000 tonnes per year. We can solve for this outcome using the same principles established in Chapter 11, where socially efficient individual standards were determined. Recall that a cost-effective equilibrium (satisfying the equimarginal principle) is where

$$\boldsymbol{MAC_A = MAC_B \text{ and}}$$

$$\boldsymbol{E_A + E_B = \text{target level of pollution}}$$

Using the equations above and the target level of pollution = 80,000 tonnes per year, we obtain $E_A = 15$ and $E_B = 65$, with $MAC_A = MAC_B = \$75$ per thousand tonnes.

Note that the TEP system operates like a hybrid between imposing standards or using taxation to reach a target. Because the total number of permits is fixed, there is effectively a standard that cannot be exceeded. But, because the permits are transferable, the market will achieve a uniform price at which polluters' marginal costs of abatement are equal. This is just like a tax, except that the regulator doesn't have to be involved in determining polluters' MAC curves to get just the right tax rate that equates MACs and also meets the target level of emissions. Another key point is that the regulator doesn't even have to know individual polluters' MAC curves—the market does all the work. The trades—permit prices times number of permits traded—reveal each polluter's MAC curve. TEPOf course, in setting a socially efficient emission target, knowledge of the aggregate MAC and MD is still required for a TEP system as well as for all the other regulatory policies we have examined.

How the actual bargaining process takes place will depend on the number of traders, their MACs, and so on. The essential point is that as long as marginal abatement costs are unequal among these sources, they can both become better off by trading permits at some price between these marginal abatement costs. Thus, in the trading of permits and the adjusting of emissions in accordance with their permit holdings, these sources would be led to an outcome that satisfies the equimarginal principle.

When a large number of firms is involved, the TEP system works in the same way, but trading patterns will of course be more complicated. The initial distribution of emission rights will now include many firms, with many potential buyers and sellers. In order for the equimarginal principle eventually to be satisfied in this case, it is obviously necessary that all permit buyers and sellers be trading permits at the same price. What this requires is a single overall market for permits where suppliers and demanders may interact openly and where knowledge of transaction prices is publicly available to all participants. We can then expect that the normal forces of competition would bring about a single price for permits. The permits would in general flow from sources with relatively low marginal abatement costs to those with high marginal abatement costs. Market institutions should develop—and indeed have in the real-world cases of permit trading(see Chapters 17 and 20). In the U.S., there are permit brokers and bankers and emission trading on commodity exchanges, see, for example, the Green Exchange. These markets, if competitive, should work like any other market where the permit price and quantity transacted is determined where the demand for permits equals the supply of permits. The demanders in this market can be new firms that wish to begin operations in the trading area or existing sources that wish to expand their operations and require more permits to cover expected increases in emissions. Supplies of permits would include firms leaving the area or going out of business, and most especially firms who have invested in better abatement techniques and now have excess permits to sell.

The Green Exchange: http://nymex.greenfutures.com/products/

Chapters 17 and 20 examine a number of emission trading regimes operating in the world – in the US, a TEP system covers emissions of nitrogen oxides from stationary sources as well as sulphur dioxide. These markets initially covered only electric utilities, but have now expanded to other sources. The European carbon market covers emissions of carbon dioxide from many countries in the European Union. While there are a number of practical issues that can inhibit the efficient operation of these markets that we explain below, the concept is popular with decision makers because the system creates property rights that can become quite valuable. Unlike effluent tax approaches, which basically make people pay for something they were once getting for free, TEP programs begin by creating and distributing a new type of property right. These property rights will have a market value as long as the total number of permits created is limited. From a political standpoint it is perhaps easier for people to agree on a pollution-control policy that begins by distributing valuable new property rights than by notifying people they will be subject to a new tax. Of course, like any pollution-control policy, TEP programs have their own set of problems that have to be overcome if the programs are going to work effectively. What looks in theory like a neat way of using market forces to achieve efficient pollution reduction must be adapted to the complexities of the real world.

Key points about a TEP policy:

- Like a standard, permits ensure that a target level of pollution is achieved.
- Like a tax, transferable permits that are traded in a competitive market are a cost-effective policy.
- Regulators do not have to know each polluter’s MAC curve to find the right “price” that achieves cost-effectiveness. The market does this automatically, because polluters set the permit price equal to their MAC. If the market clears, the permit price equals the MAC of each polluter.
- Once the target level of pollution is set, the market will reveal a polluter’s MAC curve.
- Trading occurs if the MACs of polluters are sufficiently different so that some will become sellers of permits and the others, buyers.

- The exchange of permits provides each trader with cost savings compared to their initial permit allocation from the regulator.

Issues in Setting up a TEP Market

The Initial Rights Allocation

The success of the TEP approach in controlling pollution depends critically on limiting the number of rights in circulation. Since individual polluters will no doubt want as many as they can get in the first distribution, the very first step of the program is one of potentially great controversy: what formula to use to make the original distribution of emission rights. Almost any rule will appear to have some inequities. Regulators might contemplate distributing them equally among all existing sources of a particular effluent. But this would encounter the problem that firms vary a lot in size. Some pulp mills are larger than others, for example, and the average size of pulp mills in terms of value of output may be different from the average size of, say, soda bottling plants. So giving each polluter the same number of permits may not be fair at all.

Alternatively, a regulator might allocate permits in accordance with the existing emissions of a source. For example, each source might get permits amounting to 50 percent of its current emissions. This may sound equitable but, in fact, it has built-in incentive difficulties. A rule like this does not recognize the fact that some firms may already have worked hard to reduce their emissions. One could easily argue that those firms that have already—out of good conscience or for any other reason—invested in emission reduction should not now be penalized, in effect, by receiving emission permits in proportion to these lower emission levels. This tends to reward firms who have dragged their feet in the past.[5] Incentives could be even more perverse. If polluters believe that permits will soon be allocated on the basis of current emissions, they may have the incentive to *increase* today's emission rate, because this would give them a larger base for the initial allocation of permits.

5. This is just another example of the perverse incentives built into any program that asks everybody to cut their consumption by *x* percent from their current rate. It favours those who have consumed at high rates in the past and hurts those who have consumed less.

Each allocation formula has its problems, and policy-makers must find some workable compromise if the approach is to be widely accepted. Closely related to this issue is the question of whether the rights should be given away or perhaps sold or auctioned. In principle it doesn't matter as long as the permits get distributed fairly widely. Subsequent market transactions will redistribute them in accordance with the relative marginal abatement costs of polluters, whatever the original distribution may have been. What a sale or auction would do, however, is transfer some of the original value of the rights into the hands of the auctioning agency. This might be a good way for public agencies to raise funds that could be used to reduce other fees or taxes (like the double dividend discussed in Chapter 12), but it has to be recognized that a plan like this would create political objections. A hybrid system would be to distribute a certain number of permits free of charge and then auction some number of additional permits, as has been done in sulphur dioxide trading in the United States. Or a small surcharge might be put on permits in the original distribution.

EPA's Clean Air Market Programs: www.epa.gov/airmarkt/trading

Establishing Trading Rules

For any market to work effectively, clear rules must exist covering who may trade and the trading procedures that must be followed. Furthermore, the rules should not be so burdensome that they make it impossible for market participants to gauge accurately the implications to them of buying or selling at specific prices. This implies a "hands-off" stance by public agencies after the initial distribution of the rights. Working against this is the normal tendency for environmental agencies to want to monitor the market closely and perhaps try to influence its performance. The supervising agency, for example, may want to have final right of approval over all trades, so as to be able to stop any trades it considers undesirable in some way. But this intervention in the permits market is likely to be counterproductive. The problem with this is that it is likely to increase the uncertainty among potential traders, increase the general level of transactions costs in the market, and interfere with the efficient flow of permits. The general rule for the public agency should be this: set simple and clear rules and then allow trading to proceed.

One basic rule that would have to be established is who may participate in the market. Is this to be limited to polluters, or may anyone trade? For example, may environmental advocacy groups buy permits and retire them as a way of reducing total emissions? One's first reaction is to say that such groups ought to be permitted to buy permits, because that is evidence that society's willingness to pay for lower total emission levels exceeds the price of the permits, which should be the same as marginal abatement costs. This conclusion is probably valid if we are dealing with a local or regional environmental group whose membership is roughly coincidental with the trading area, and which has raised money specifically to buy discharge permits in that region. There may, however, be problems if large national advocacy groups were to use their resources to buy permits on a regional market for strategic or political reasons that do not reflect the willingness to pay of the people in the region. There is, however, no evidence that this has happened in any of the operating TEP markets.

Non-uniformly Mixed Emissions

Suppose we are trying to design a TEP program to control total airborne SO_2 emissions in a region where there are numerous different sources—power plants, industrial plants, and so on—scattered rather widely around the area. A schematic of this situation is depicted in Figure 13-2. All the emission points are not equally situated relative to the prevailing wind or to the area of highest population density. Some sources are upwind and others are downwind of the populated area. Assume that they are not all equal in terms of marginal abatement costs, but neither are they equal in terms of the impact of their emissions on ambient SO_2 levels over the populated area. They have different transfer coefficients linking their own emissions with damages in the urban area. Having distributed discharge permits, we now allow them to be traded. As long as the number of permits in circulation is held constant, total SO_2 emissions are effectively controlled. But if straight trading is allowed, unit for unit, of permits among all sources, the damage caused by that total could change. For example, if a downwind firm sold permits to an upwind firm, the total number of permits would remain the same but there would now be more emissions upwind of the population and, therefore, more damage. This is sometimes called the ***hot-spot problem***.

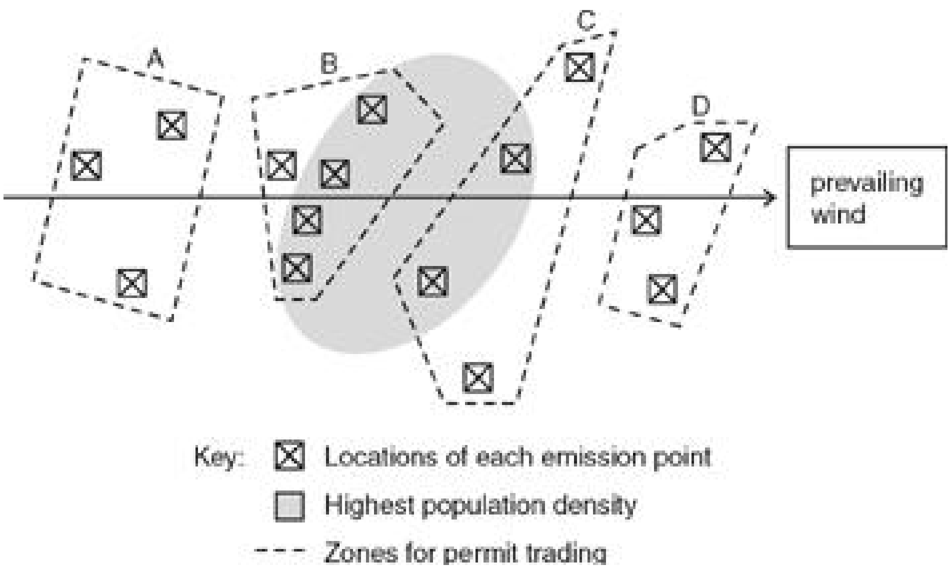
The problem is similar to the one encountered under uniform standards or taxation when pollutants are non-uniformly mixed. If the program were simply to allow trading of permits among all sources on a one-for-one basis, a firm or group of firms with higher transfer coefficients—whose emissions therefore have a greater impact on ambient quality—could accumulate larger numbers of permits and create a hot spot. One way to avoid this problem would be to adjust the trading to take into account the impacts of individual sources. Suppose the emissions from source B were twice as damaging as the emissions of source A simply because of the location of the two sources. Then the administrators of the program might set a rule that if source B is buying permits from source A, it must buy two permits to get one. This is called an ***ambient-based TEP system***. When pollutants are non-uniformly mixed, the ambient system is necessary to achieve a cost-efficient equilibrium. However, it is a very complex type of market to operate. With many sources with different transfer coefficients, authorities would have to determine, for each source, how many permits would have to be purchased from each other source in order for the purchasing source to be credited with one new permit. If there were 5 sources, the regulator has to figure out only 10 trading ratios; if there were 20 different sources, it would have to estimate 190 of these ratios.[6]

[6.] In general, if there were n sources, there would have to be $[n(n-1)]/2$ trading ratios established. It becomes quite obvious that an ambient-based system would be extremely difficult to establish. Regulators then have to look for second-best policies such as zoned systems (or use another policy instrument).

A simpler approach would be to use a zoned system, analogous to the zoned effluent charge discussed in Chapter 12. Authorities would designate a series of zones, each grouping sources that were relatively similar in terms of their location and the impact of their emissions on ambient quality. Four such zones are shown in Figure 13-2.

Regulators could then do one of two things: allow trading by firms only with other firms in the same zone, or make adjustments for all trades across zone boundaries using an ambient-based system. For example, any firm in zone B would have to buy two permits from a firm in zone C if firms in zone B had transfer coefficients twice those in zone C, while those in C would need only half a permit from a firm in B.

Figure 13-2: Non-uniform Emissions and a TEP Program



Non-uniformly mixed pollutants create a dilemma for TEP programs. If permits can be traded anywhere in the region, hot spots can emerge when permit holders are concentrated in area B, close to and upwind of the population centre. A zonal permit trading system shown by the dotted lines groups polluters according to their transfer coefficients. Trades are allowed one-for-one within each zone. This alleviates hot spots, but at the expense of more complexity in the TEP system.

TEPs and Problems of Competition

The question of allowing trading across zone boundaries or, on the contrary, restricting it to within zones has a much wider importance than might first appear. TEP programs work through a trading process, where buyers and sellers interact to transfer title to valuable property rights. Markets work best when there is substantial competition among buyers and among sellers; they work much less well if there are so few buyers or sellers that competitive pressures are weak or absent. In cases where there are few traders, one of them, or perhaps a small group, may be able to exercise control over the market—by colluding on prices, perhaps charging different prices to different people, using the control of discharge permits to gain economic control in their industry, and so on. From the standpoint of fostering competition, therefore, regulators would like to set trading zones as widely as possible, to include large numbers of potential buyers and sellers.

But this may work against the ecological facts. In many cases there may be meteorological or hydrological reasons for limiting the trading area to a relatively narrow geographical area. If we are interested in controlling airborne emissions affecting a particular city, for example, we would probably not want to allow firms located there to trade permits with firms in another city. Or if the concern is controlling emissions into a particular lake or river, we could not allow sources located there to trade permits with sources located on some entirely different body of water. Thus, for environmental reasons regulators may want to have trading areas restricted, while for economic reasons they would want to have trading areas defined broadly. There is no magic rule to tell us exactly how these two factors should be balanced in all cases. We can only look at specific cases as they come up and weigh the particularities of the environmental features with the subtleties of the competitive conditions in the industries where trading will occur.

TEP Programs and Enforcement

As noted above, TEP programs constrain polluters to keep their emissions at a level no greater than the total number of discharge permits in their possession. Thus, an administering agency would essentially have to keep track of two things: the number of permits in the possession of each source and the quantity of emissions from each source. Since the initial permit distribution will be well known, the agency must have some way of keeping track of permit transactions among market participants. Trades could, in fact, become complicated with multiple buyers and sellers, and with different types of transactions like temporary rentals and long-term leases in addition to permanent transfers. Since permit buyers (or renters) would have a strong incentive to have their purchases revealed to the agency, and since all purchases imply sellers, a system of self-reporting, coupled with modern means of information transfer, may be sufficient to provide reliable information on which sources have the permits.

The administrative agency must be able to monitor polluters to see whether emissions at each source exceed the number of permits it holds. If permits are expressed in terms of total emissions over some period of time, a means has to be available to measure cumulative emissions at each source. This is the same requirement as with any policy. If there were reasonable certainty that emissions were fairly even throughout the year, authorities could get a check on cumulative emissions by making spot-checks of instantaneous rates. For most industrial sources of pollution, however, there are considerable daily, weekly, or seasonal variations in emissions, so more sophisticated monitoring would be required.

One desirable feature of TEP programs is that there may be an incentive for sources to monitor each other, at least informally. When, and if, some sources emit more than they have permits for, they are essentially cheating by not buying sufficient permits to cover all of their emissions. In effect this reduces the demand for permits below what it would otherwise be. And this has the effect of lowering the market price of permits. This clearly works against the interest of any firm holding large numbers of permits, which gives it an incentive to see that other firms don't cheat on emissions.

TEPs and the Incentive for R&D

In Chapters 11 and 12, we showed that emission standards did not create a strong incentive to innovate and find cheaper methods of abating pollution, while emission taxes did. TEP programs are identical to the emissions tax, at least in theory. Consider the firm in Figure 13-3. Suppose that a polluter's marginal abatement cost function is MAC_1. Emission permits that entitle the polluter to release one tonne per year sell for p each. The polluter doesn't expect this price to change. The polluter has adjusted its holdings so that it currently owns E_1 permits. Its emissions are therefore also E_1, and its total abatement costs are $(a + b)$. The incentive to do R&D is to find a less costly way of controlling emissions, so the firm can cut emissions and sell the surplus permits. How much would it be worth to get marginal abatement costs shifted to MAC_2? With MAC_2, the firm would shift to an emissions level of E_2. Its total abatement costs here would be $(b + d)$, but it would be able to sell $(E_1 – E_2)$ permits for a revenue of $p(E_1 – E_2) = (c + d)$.

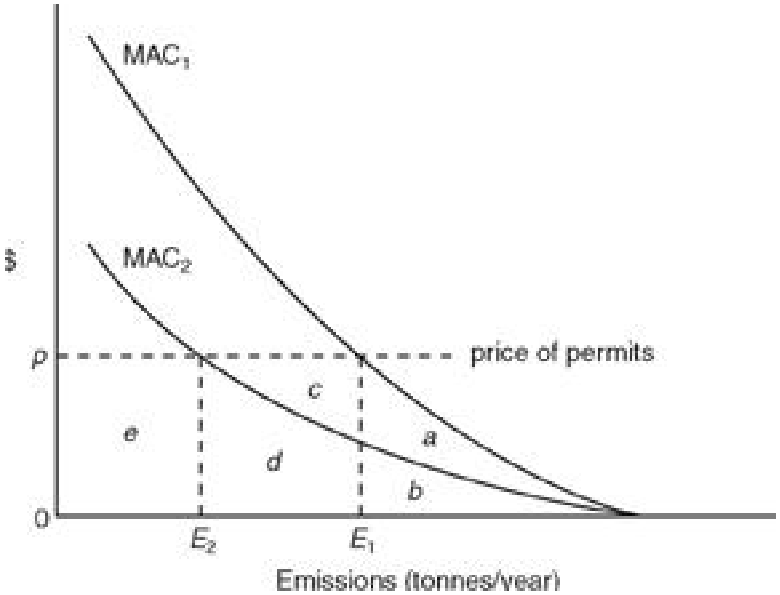
The net gain from the R&D is:

$$(\text{TAC with MAC}_1) – (\text{TAC with MAC}_2) + (\text{Receipts from TEP sales}) =$$

$$(a + b) – (d + b) + (c + d) = (a + c).$$

Compare this with the savings under an effluent tax (see above, pp. 238–40). It is exactly the same. The market price of the permit has the same incentive as a pollution tax; by not reducing their emissions, firms are forgoing the increased revenues they could have obtained by selling some of their permits.

Figure 13-3: TEPs and Technological Change



TEPs create a strong incentive to invest in cost-saving technologies to reduce pollution. A polluter who initially holds E_1 permits has a large incentive to engage in R&D to lower its MAC_1 to MAC_2. With MAC_2, the polluter will reduce emissions to E_2. It can then sell its surplus permits at price p and earn area $c + d$ in permit revenues, for a net gain of area c over its additional TAC from moving from E_1 to E_2, and overall net gain of areas ($a + c$).

SUMMARY

Transferable discharge permits are being used more frequently in North America. Several programs are already in place in the United States; for example, there is a TEP program for SO_2 reduction among electric power producers (see Chapter 17). A world carbon trading system is being investigated by a number of countries (see Chapter 20), and companies are actually engaging in trading carbon in anticipation of this market. TEP programs are being contemplated in Canada for carbon trading, nitrogen oxide, and volatile organic compounds. Canada had a type of TEP program for elimination of chlorofluorocarbons (see Chapter 20). There is the expectation that this approach could give us pollution control at a substantially lower cost than the current system of performance and technology-based effluent standards, and also a sense that, politically, they would be more acceptable than emission taxes.

But TEP programs come with their own set of problems. How the TEP market operates is obviously critical to whether this type of policy will work. There are a host of important factors: who gets the permits at the beginning, the strength of their incentives to minimize costs, the degree of competition in the market, the transaction rules set by the administering public agency, the ability to monitor and enforce compliance, and so on. Nevertheless, the transferable discharge permit system seems to be an idea worthy of the attention it is getting.

Both transferable discharge systems and emission tax systems seek to take the burden and responsibility of making technical pollution-control decisions out of the hands of central administrators and put them into the hands of polluters themselves. It is important to stress the following point: Incentive-based policies such as TEPs and taxes are not aimed at putting pollution-control *objectives* themselves into the hands of the polluters. It is not the market that is going to determine the most efficient level of pollution control for society. Rather, the policy instruments are means of enlisting the incentives of the polluters themselves in finding more effective ways of meeting the overall objective of reducing emissions.

KEY TERMS

Ambient-based TEP system, 252
Emissions-based TEP system, 247
Gains from trade, 248
Hot-spot problem, 252
Transferable discharge permits (TEPs), 245

ANALYTICAL PROBLEMS

1. Using the MAC curves given in the sulphur-permit example in this chapter, calculate the total costs of each firm before any trading occurs, after the cost-effective trade of fifteen permits occurs. Who gains the most from the trade and why?

2. Again, use the MAC equations given in the example. Compute the private versus social costs of a TEP system that initially auctions permits. Contrast this outcome with your solutions to question 1 and explain why any differences occur.

3. Two polluting firms can control emissions of a pollutant by incurring the following marginal abatement costs: $MAC_1 = \$300 - 10E_1$ and $MAC_2 = \$90 - 5E_2$. Assume the *target level of pollution* is 30 units. We do not know if this is the socially efficient level or not.

(a) Compute the level of emissions per firm that is cost-effective for society.

(b) Explain how a tradeable discharge permit system could be applied to achieve the target level of emissions. Assume the regulator initially assigns 15 permits to each polluter. The government gives these permits to the firms without charge. Solve for the number of permits each firm holds after a permit market operates, the price of the permit, and total private costs of the permit system. How would the private costs to each polluter change if the government initially auctioned the permits to the polluters?

4. Which policy instrument uniform standard provides the largest incentive to invest in R&D to lower MACs: individual standard, emission tax, or TEP? Prove your answer graphically.

DISCUSSION QUESTIONS

1. The government has set up a TEP system where it gives away the permits to polluters then lets them trade thereafter. How would this system respond to new firms that enter the industry and have positive levels of pollution? Do you foresee any problems? Explain.

2. What are the pros and cons of letting anybody (e.g., banks, private citizens, environmental groups, government agencies) buy and sell transferable discharge permits, in addition to the emission sources themselves?

3. Suggestions have been made to set up a transferable permit system for wildlife preservation and habitat protection. How might this work?