

## **Output-Based Refunding of Emission Payments: Theory, Distribution of Costs, and International Experience**

Thomas Sterner and Lena Höglund

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Resources for the Future  
1616 P Street, NW  
Washington, D.C. 20036  
Telephone: 202-328-5000  
Fax: 202-939-3460  
Internet: <http://www.rff.org>

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## **Abstract**

In this paper, we discuss the effect of refunding environmental charges. Taxes often are resisted by polluters because they imply both abatement and tax costs. We show that when charges are refunded, the incentives for abatement are essentially the same as for a tax, but the output reduction that often accompanies a tax scheme is forgone. We describe and examine the refund emissions payment (REP) scheme as a policy instrument for emissions abatement and compare it with taxes and permits with regard to allocative properties, distribution of costs, property rights, and, consequently, the politics of implementation. As an empirical example, the Swedish charge on nitrogen oxides is analyzed.

Key Words: refunded charge; incentive-based environmental policy; air pollution

JEL Classification Numbers: Q28, Q25, H23

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## Symbols Used

$\Pi_j$	Firm $j$ 's profit
$\Phi_j$	Firm $j$ 's environmental effectiveness
$c'_e$	Marginal costs with respect to emissions
$c'_a$	Marginal costs with respect to production
$c_{a,j}$	Firm $j$ 's abatement cost when production and abatement costs are separable
$C_j$	Total supply costs, including costs of production and taxes, refunds, etc.
$c_j(e_j, q_j)$	Production costs for firm $j$ to produce output $q_j$ with emissions $e_j$
$c_{y,j}$	Firm $j$ 's production cost when production and abatement costs are separable
$E$	Total emissions ( $\sum e_j$ )
$E/Q$	Average rate of emissions ( $r$ )
$e_j$	Firm $j$ 's emissions of single pollutant
$\bar{e}_j$	Allocation of emissions permits to firm $j$ in a permit scheme
$N_j$	Firm $j$ 's net refund
$p$	Market price of output
$p^{\text{tax}}, p^{\text{rep}}$	Supply curve/marginal cost/market price of output for firms regulated by a tax or refunded emission payment scheme, respectively
$P^{\text{lep}}$	Price of emissions permits
$Q$	Total output ( $\sum q_j$ )
$q_j$	Firm $j$ 's output of a single product ( $i = 1, \dots, j, \dots, n$ is firm index)
$r$	Average rate of emissions ( $E/Q$ )
$s_j$	Firm $j$ 's market share
$t$	Payment or tax level per unit of emissions

# Output-Based Refunding of Emission Payments: Theory, Distribution of Costs, and International Experience

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## Introduction

In this report, we analyze the properties of a refunded emission payment (REP) scheme in which polluters pay a charge on pollution and the revenues are returned to the *same collective of polluters* as refunds in proportion to output. We review the relevant literature, present an overview of the REP mechanism, describe the Swedish experience with the abatement of nitrogen oxide (NO<sub>x</sub>) emissions from stationary sources as one example of an REP system, and suggest policy implications for the REP scheme.

At its introduction in 1992, the Swedish REP scheme targeted all large combustion plants producing at least 50 GWh of useful energy per year.<sup>1</sup> The charge is 40 Swedish kronor (SKr; about US\$5) per kilogram of NO<sub>x</sub>, and the nearly entire revenue of about 600 million SKr (\$80 million) per year is refunded in proportion to output of energy.<sup>2</sup> The Swedish Environmental Protection Agency (SEPA) manages the scheme at a small administrative cost of about 0.2–0.3% of revenues [17].

Although the Swedish REP scheme is the clearest example we have found, it is worth pointing out that many developing and formerly planned economies such as those in Colombia and China have quite extensive systems of environmental charges that are at least partially refunded [22].<sup>3</sup> The main obstacle to instituting taxes is often the power of the polluters—and their threat of relocating or going out of business. The timing of payments may be crucial, because the pollution tax costs tend to be the highest the first couple of years after a tax is introduced, when firms also pay for abatement investments. Policymakers therefore may abandon charges for permits, but we know from Weitzman [23] that price-type instruments such as charges are sometimes preferable to quantity-type

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<sup>1</sup> Roughly 200 plants were targeted at introduction in 1992. In 1996 and 1997, limits were lowered to 40 and 25 GWh/year, respectively, bringing about 170 new plants into the scheme [16].

<sup>2</sup> Useful energy produced has been accepted as a way of finding a reasonably neutral yardstick for measuring output when comparing paper mills, power plants, and other heterogeneous activities that use large boilers.

<sup>3</sup> Refunding is typically tied to the financing of abatement; for more information, visit the World Bank Web site (<http://www.worldbank.org/nipr/>).

instruments. In such cases, REPs may represent smaller costs to the polluters than a tax and thus incite less political opposition.

Permits are property rights to the environment and can be allocated in different ways to reflect different concepts of ownership, which imply different distributions of cost. They usually are allocated in proportion to past emissions (grandfathered) but can be auctioned or allocated in proportion to other criteria, including output (as in the U.S. Environmental Protection Agency's phase-out of lead program in which the lead content of gasoline was to be controlled; see References 10 and 12 for more information about the lead program and Reference 8 for more information about the theory of output allocation). Emission payments have traditionally been taxes but could be (partly or wholly) refunded depending on who—the polluter or society—has ownership rights to the environment. If polluters hold these rights, or if they simply have too much power for a tax to be politically feasible, then REPs introduce a price-type alternative to tradable emission permit (TEP) schemes. Tax refunds assure polluters overall financial neutrality in a way similar to the distribution of free permits. Thus, REPs offer a new option to policymakers.

Any emissions payment scheme must be not only reasonably efficient from a social welfare point of view but also politically viable. Different policy instruments impose different cost distributions and therefore can cause widely varying degrees of opposition. Cost distributions raise ethical questions and can, in the spirit of Coase [3], be seen as a question of how to define property rights to the environment. A tax implicitly assigns property rights to society, whereas grandfathered permits assign them to the polluters. However, taxes and permits are not the only options: REPs impose a cost distribution between polluter and society and among polluters that is different from that of a tax- or permit-based system (see Table 1).

Table 1 shows two ways of distributing property rights and, thereby, cost burdens. When society has ownership, the polluter has to pay the equivalent of a market price for the right to use “environmental services.” The price-type instrument is a tax, whereas auctioned TEPs constitute the quantity-type analogy. When the polluter has ownership, the polluter has the right to use the environment or resource free of charge but must maintain it in some acceptable condition.<sup>4</sup> This distribution of

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<sup>4</sup> The polluter may have more exclusive ownership rights so that if society wants a clean environment, it has to pay, either by abatement subsidies (a price-type instrument) or through publicly financed cleanup (a quantity-type instrument), such as municipal trash management. These options are excluded to keep the Table 1 simple. Intermediate forms of ownership and instruments are also conceivable, such as permits that are grandfathered up to some level and then auctioned or *partially* refunded emission payments. In some countries, taxes go to environmental funds with different (regional or other) scopes and mandates. Many other hybrids exist, such as grandfathered permits with a charge. For example, the U.S. permits for chlorofluorocarbons and halons were taxed by the U.S. Congress to limit the windfall accruing to the permit recipients [21].

responsibility implies payment for a reasonable level of abatement but not for the pollution caused at that level. The traditional policy instrument for achieving this goal has been tradable permits (grandfathered or output allocated). Our purpose in this paper is to make the point that there is a price-type alternative as well: the REP scheme.

Often, it is desirable to target an instrument to a subset of polluters. These polluters may cause more environmental damage than others do (depending on location or size), or, as in the case of the Swedish NO<sub>x</sub> scheme, monitoring and control costs may be too high to motivate the inclusion of small producers. A tax would be difficult to implement because it would distort the relative competitiveness between large and small producers. Exempting small polluters would create a perverse incentive to run small plants, and in such a case, the REP is a convenient scheme.

### **Refunding, Tax Subsidies, and Other Two-Part Mechanisms**

Traditionally, economists have not focused strongly on the proceeds of environmental taxes; however, experience from implementation shows that great interest in these proceeds may determine the political feasibility of a policy instrument. Lately, much has been written about double dividends (which we view as a separate but related issue) and the use of the tax proceeds. However, our concern here is not with this form of general recycling but a recycling of tax proceeds within a group of polluters. The purpose of the REP scheme is not to improve on the general tax system per se but to provide an incentive for polluters to internalize damage that is still feasible in situations where an ordinary tax would not be.

Two-part price instruments are combinations of tax and refund or tax and subsidy, and are often motivated by monitoring concerns. For example, Fullerton and Kinnaman [9] analyzed waste dumping when no monitoring is available. They showed that the second-best policy is not taxes but subsidized waste treatment combined with a tax on the potential polluter through a tax on goods that lead to pollution. This instrumental design is clearly related to deposit–refund systems [2] and to “presumptive taxes.” In the absence of monitoring in developing countries, presumptive taxes are suggested [4] on inputs or outputs that are complements to pollution, while allowing some polluters to claim refunds by proving themselves less polluting than others. This system shifts the burden of proof to the polluters and reduces the administrative costs for the regulators. The polluters who have installed cleaner technology will monitor and report, and those who have not are presumed to be polluting.

An early example of a two-tier price mechanism is found in Porter [15]. Each period, polluters pay an “entry” tax on baseline emissions but receive a refund for the amount of pollution abated. Similar ideas can be found in Kohn [13]. Disclosure is the main idea behind the mechanisms put forth by Porter and Kohn. Reporting of both anticipated and actual emissions makes deception more difficult. The firm still pays for actual emissions—but the tax has a clever disclosure mechanism. Yohe and MacAvoy’s suggested simultaneous tax on emissions with a subsidy for proven abatement [25] is similar.

Another interesting topic in the literature that is close to the REP scheme is found in Pezzey [14]. Polluters are assigned property rights to a “baseline” emission level set by the regulator. They pay a charge per unit of emissions above the baseline and receive a subsidy per emission “saved” whenever emissions are below the baseline. In the quantity-type analogy, the units of emission above or below

the baseline are traded in the market. Recently, Farrow [6, 7] explored a similar mechanism in which emission payments were refunded (wholly or partially) relative to emissions during a base year. As the author pointed out, these tax credits are targeted at the existing polluters.<sup>5</sup>

### The REP Scheme: Design and Some Properties

Assume we have  $n$  profit-maximizing firms ( $i = 1, \dots, j, \dots, n$ , where  $j$  is an arbitrarily chosen firm among the  $n$  firms) with production costs  $c_j(e_j, q_j)$  to produce output  $q_j$  with emissions  $e_j$ . We assume  $c_j$  is sufficiently well behaved to give an interior solution. An REP scheme imposes a charge of  $t$  per unit of emission and refunds revenues to the firms proportionally to output. The firms now face total supply costs of operation  $C_j = c_j(e_j, q_j) + t[e_j - \sum_i (q_j / \sum_i q_i) e_i]$ . If we assume that firms take the market price of output ( $p$ ) as a given, then they maximize the profit function (Equation 1), giving first-order conditions (Equations 2 and 3):

$$\Pi_j = pq_j - c_j(e_j, q_j) - te_j + t \underbrace{\frac{q_j}{\sum_i q_i} \sum_i e_i}_{N_j} \quad (1)$$

$$-c'_e = t(1 - s_j) \quad (2)$$

$$c'_q - t(E/Q)(1 - s_j) = p^{\text{rep}} \quad (3)$$

where total emissions ( $E$ ) is  $\sum e_i$ , total output ( $Q$ ) is  $\sum q_i$ , and firm  $j$ 's output share ( $s_j$ ) is  $q_j/Q$ . For a firm in an REP scheme, the net refund ( $N_j$ ) consists of the two tax terms of Equation 1. They can be written  $N_j = te_j(1 - \Phi_j)$ , where  $\Phi_j = s_j/(e_j/E)$  is relative environmental effectiveness. When  $\Phi_j > 1$ , firm  $j$  receives a net refund and is a winner in the scheme; however, if  $\Phi_j < 1$ , firm  $j$  is a loser. For an average firm,  $\Phi_j = 1$ , and the net payment is zero. To compare this calculation with a tax, we drop the refund term in Equation 1, and the corresponding first-order conditions are

$$-c'_e = t \quad (4)$$

$$c'_q = p^{\text{tax}} \quad (5)$$

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<sup>5</sup> Organized competitions in which the “losers” pay the “winners” have some similar traits. To improve cost-effectiveness in NO<sub>x</sub> abatement, the U.S. Environmental Protection Agency recommends states to create trading programs for the power industry. Power plants and other sources that reduce more emissions than required can sell their excess allotment as “credits,” and facilities unable to meet their goals can buy credits [20].



In a TEP scheme with grandfathered or auctioned permits, each firm is given an exogenous number of permits ( $\bar{e}_j$ ) that may be related to historic emissions but not to anything the firm can influence (if permits are auctioned, then  $\bar{e}_j = 0$ ). If we assume that the permits are traded competitively and that the number of permits is appropriate, then marginal abatement costs will be equalized, and permit price  $P^{\text{tep}}$  will correspond to the tax  $t$ . The profit function when TEPs are grandfathered then becomes

$$\Pi_j = pq_j - c_j(e_j, q_j) - P^{\text{tep}}(e_j - \bar{e}_j) \quad (6)$$

Because  $\bar{e}_j$  is a constant, it is easy to see (and well known; see Reference 24) that the first-order conditions will correspond to the case of a tax (compare Equations 2 and 4) with  $P^{\text{tep}}$  instead of  $t$ .

In an output-based TEP scheme, each firm is given  $\bar{e}_j$  permits relative to production share—that is,  $e_j = q_j E/Q$ , where  $E$  is the optimal total emission level. Note that current output affects the number of permits obtained. The profit function when tradable permits are allocated in proportion to output is given in Equation 7, which is analogous to Equation 1:

$$\Pi_j = pq_j - c_j(e_j, q_j) - P^{\text{tep}}(e_j - q_j E/Q) \quad (7)$$

The first-order conditions are again equivalent to Equations 2 and 3 with  $P_T$  instead of  $t$ , and the net payment that polluters make or receive  $N_j = P^{\text{tep}}(e_j - e_j) = P^{\text{tep}}e_j(1 - \Phi_j)$ . As in the REP scheme, the determining factor for being a net buyer or seller is again the firm's relative environmental effectiveness ( $\Phi_j$ ).

### **Choice of Abatement Level and Output**

Table 2 summarizes the similarities and differences between tax and REP schemes. The difference in incentive with respect to abatement due to refunding (or output allocation of permits) is a factor that reflects the firm's market share. With many small firms,  $s_j$  approaches 0, and the marginal cost of abatement ( $-c'_e$ ) approaches  $t$  for all firms. In this case, a refunded charge levied on all firms will imply practically the same abatement level as a tax. With large output shares, the factor  $(1 - s_j)$  could be more significant; however, with small shares, it is small compared with the general uncertainty about abatement and damage costs.

The purpose of the second row of Table 2 is to show output effects. Under an environmental tax, the marginal cost of production or supply curve ( $p^{\text{tax}}$ ) is given as  $c'_q$ . The marginal cost of production when using a tax will normally be higher than in the unregulated case because the tax leads to abatement, implying a higher market price and a smaller level of production.<sup>6</sup> With REPs, the

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<sup>6</sup> With the general function used, this difference is not easy to see, but if we had assumed additive separability between production and abatement costs  $c_j(e_j, q_j) = c_{y,j}(q_j) + c_{a,j}(e_j, q_j)$ , then the first order

marginal cost curve ( $p^{rep}$ ) is given by  $c'_q - t(1 - s_j)E/Q$ . The costs of production are lower because of the rebate, thus the supply curve will be lower than the corresponding curve for the tax case. Disregarding the factor  $(1 - s_j)$  (which is close to 1 when many small firms are targeted), the supply curve will be lower by an amount  $rt$ , where  $r$  is the average rate of emissions ( $E/Q$ ). This amount can be seen as the tax cost for the average firm of an extra unit of production. If and only if this amount is large relative to the marginal production costs ( $c'_q$  in Equation 3) will the output effect be empirically important. (So far, we have discussed the supply curve; the effect on clearing prices and quantities will also depend on the slope of the demand curve.)

The output effect is somewhat akin to the classical difference between subsidies and taxes (for instance, see Reference 1). With all refunds coming from payments by the (polluting) firms in the industry, there is no aggregate subsidy from society to the industry compared with the unregulated case. It is forced to abate but not to bear the costs of unabated pollution; hence, the output effect. In an REP system, costs of abatement increase and output is reduced overall compared with the unregulated case. However, compared with a *tax* case, the output will be higher.

### The Swedish Experience with an REP Charge on NO<sub>x</sub>

For many (but not all) real-world cases, the environmental tax payment is quite a small share of production costs. Environmental tax costs are typically escaped by investing in abatement rather than reducing industry output. The fact that the REP scheme lacks an output effect will therefore not make much practical difference. However, the fact that polluters are more likely to accept REPs than taxes may be a decisive factor for the political viability of the regulation. An NO<sub>x</sub> tax, corresponding to the current Swedish NO<sub>x</sub> charge level of \$5,000/ton, would constitute a share of less than 10% of the cost of energy production<sup>7</sup> [16]. Consequently, a tax level of \$5,000/ton would have given an output effect

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conditions would have given  $p = c'_{y,j}$  for the unregulated case,  $p^{tax} = \partial c_{y,j} / \partial q_j + \partial c_{a,j} / \partial q_j$  for the tax case, and  $p^{rep} = \partial c_{y,j} / \partial q_j + \partial c_{a,j} / \partial q_j - t(1 - s_j)E/Q$  for the REP case.

<sup>7</sup> Using observed emission rates of 0.3 kg NO<sub>x</sub>/MWh on average, a tax of US\$5/kg would imply an extra cost of \$1.5/MWh. This amount is less than 10% of the production cost of fossil electricity in Sweden (where production cost is assumed to correspond to the retail price of electricity). For pulp and paper, chemical and other industries with greater value added, the cost share of a NO<sub>x</sub> tax would be even lower than for the energy industry.

of only 2–3% of total current output.<sup>8</sup> Regarding the abatement effect, emissions rates have been reduced rapidly during the course of Sweden's REP program and vary significantly between plants. The least environmentally effective of the 372 plants targeted in 1997 emits 30 times more per energy unit produced than the most effective plant [17]. This variance may indicate that further reductions can be expected as a result of cleaner technology and lower emission rates as technology and management practices spread. In this example, the output effect is much less important than the abatement effect.

Because the criterion for inclusion in a payment scheme is output, which the firms can control, problems might arise related to perverse incentives for entry to (to cash in on the refund) or exit from (to avoid the charge) the system. In the Swedish NO<sub>x</sub> scheme, the right to entry is determined by SEPA. Zero-emission energy producers, such as nuclear power plants, are not allowed to participate, because the purpose of the scheme is to promote abatement at large combustion plants. However, in the Swedish NO<sub>x</sub> scheme, a certain number of plants may exit (or fail to enter) the scheme. Plants that are very close to the threshold production level for inclusion in the scheme and are relatively environmentally inefficient may exit by producing just under that threshold output. Evidence from the Swedish case is that although some plants have left the scheme, the effect has been only limited.<sup>9</sup>

We cannot fully evaluate the environmental efficiency of the Swedish NO<sub>x</sub> scheme here,<sup>10</sup> but we can present some evidence to support our position. Between 1992 and 1998, mean emission rates were

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<sup>8</sup> If we assume the short-run price elasticity of electricity demand to be  $-0.3$ , a 10% increase in price would, in turn, give a 3% reduction as the output effect.

<sup>9</sup> In 1996, when the boundary was lowered from 50 to 40 GWh per year, fifteen new plants entered the scheme that were producing in the range of 50–55 GWh per year [16]. Some of these firms may have been running at just below 50 GWh beforehand to stay out of the scheme. Still, these plants accounted for only 1.7% of total targeted output and 2.2% of targeted NO<sub>x</sub> emissions [11]. With the periodic lowering of the boundary, this problem is hardly a major one in the Swedish case.

<sup>10</sup> A detailed study would ideally compare the Swedish scheme with that of another country that uses a tax or other policy, but no countries have comparable policies. (France has a tax, but its level is less than 1% of the Swedish level). Good data is needed, but there is little monitoring of plants outside this scheme. Plants may use sporadic measurements or rule-of-thumb estimates. Experience from the Swedish plants shows large variations due to fine tuning, which suggests that such data is questionable. See Höglund [11] for a study of 114 targeted plants.

reduced by 40% for the roughly 200 plants initially targeted by the charge. This reduction is substantial because technically, NO<sub>x</sub> abatement is considered relatively difficult.<sup>11</sup> Detailed figures show that not only the average but the most and least polluting plants per unit of output have improved by roughly the same margins [16]. Data from newcomers to the system in 1996 and 1997 reinforce the impression that emission reductions are mainly due to the REP scheme (see Figure 1). Their emission rates on entry into the scheme are similar to those of the original plants on entry in 1992, but they immediately start to fall in response to the charge.

SEPA has investigated the reasons for the reduction in emissions [17]. It found that reductions of 14,570 tons of NO<sub>x</sub> were due to investments in equipment and an additional 4,000 tons were due to fine-tuning the combustion process to minimize the NO<sub>x</sub> creation during combustion. With quantitative plant limits only, emission reductions would have been (according to the estimates) only 5,960 tons per year. This finding may be questioned because most plants were operating well below their legal limits, and the REP scheme may be considered the main cause of the observed reductions.

The U.S. Environmental Protection Agency [5] has compared NO<sub>x</sub> emissions from selected plants with similar technology (coal-fired boiler plants with selective catalytic reduction [SCR]) in different countries, including a plant from Sweden. The Swedish plant had about half the emission rates of the plants in the other countries. The report ascribes this discrepancy largely to the REP scheme.<sup>12</sup>

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<sup>11</sup> From 1980 to 1996, Sweden reduced total SO<sub>2</sub> emissions by 81% but total NO<sub>x</sub> emissions (including transport) by only 22% [18]. One of the reasons for the small reduction is that NO<sub>x</sub> emissions are only partly due to nitrogen emissions from fuel. A major factor is the effect of temperature and supply of oxygen on the creation of NO<sub>x</sub> from the nitrogen content of the air. SO<sub>2</sub> emissions are derived exclusively from the sulfur content of the fuel, and a sulfur tax based on fuel content (with refunds for abatement) is an appropriate instrument (compare Yohe and MacAvoy [25]). For NO<sub>x</sub>, actual monitoring is required both for outside inspectors and, indeed, for plant managers so they know emissions levels and therefore which measures are successful.

<sup>12</sup> “The Swedish retrofitted unit, in contrast, demonstrates that NO<sub>x</sub> levels well below the Swedish standard (and also below the German or United States standards) are achievable. ... The Swedish regulatory system, incorporating an economic incentive, clearly motivates [the Swedish plant] to achieve minimal NO<sub>x</sub> rates rather than just comply with the applicable emission standard.” [5, p. 37].

### ***Distribution of Environmental Charges and Refunds***

Several reasons were behind Sweden's decision to adopt a refunded charge scheme [17]. A price-type instrument was favored because abatement costs were thought to vary considerably between firms, and advantages to scale and rapid development in abatement technology were expected. Second, a tax on all point sources of airborne NO<sub>x</sub> emissions was not feasible because monitoring was too expensive for small units. A tax levied only on large units would be perverse, encouraging the operation of small and potentially less efficient units rather than big ones. Presumptive taxes on all NO<sub>x</sub> emissions would have been an alternative but would have engendered considerable resistance and put Swedish firms at a competitive disadvantage to foreign producers. These problems highlight the importance of the distribution of costs between society and the polluters.

The net payments of the different sectors are described in annual data from SEPA [16]. The energy sector is always the major net beneficiary of the system; it receives roughly 30 million SKr more than it pays in fees. This scenario does not necessarily mean an overall profit from the scheme, because the energy sector also seems to have invested more heavily in abatement than other sectors. Indeed, in some cases, marginal abatement costs in the energy sector are above the charge level, which can be explained only in terms of green image or other motives unrelated to profit (these companies have a large share of municipal ownership). Metal and manufacturing plants and food industries receive net refunds of about 3–5 million SKr. Waste incineration has paid 10–20 million SKr in some years but managed to break even in 1996. The timber industry's net payments also were close to 0. The pulp and paper industry is the main net "loser," paying about 30 million SKr. It is perhaps characteristic that firms in this group are the only ones to have voiced some measure of discontent by suggesting that each industry should form a separate scheme. Such a scenario would be in their aggregate interest. However, it should be noted that within each and every sector, some firms were net contributors and others were net beneficiaries of the scheme.

### **Conclusions and Policy Implications**

The REP scheme offers a new option to policymakers who must choose a policy instrument to regulate environmental pollution. The REP scheme is the price-type counterpart to the output-based allocation of TEPs. One empirical example is the Swedish charge on NO<sub>x</sub>, which has contributed to a 40% reduction in emission rates in seven years. A tax of this size would not have been politically feasible or fair, because only large polluters were to pay (because too-high monitoring costs prevented the targeting of small polluters).

The REP scheme seems to be a promising alternative for many situations, for example, when the distributional consequences of taxes are unacceptable or the opposition to taxes is too strong. It also offers an interesting alternative to permits, particularly when the regulator wants a price-type instrument (maybe because of a steep cost curve for marginal abatement) but does not want to place the full cost burden on the polluters. The REP scheme also can target subsets of polluters and thereby

limit perverse incentives to exit<sup>13</sup> the scheme. For a small open economy in which competitiveness is an issue, refunding makes political sense.

Naturally, the REP scheme has its limitations. As with all price-type instruments, setting the optimal payment level is a tricky task. The basis of refunding in an REP scheme requires a common output, which can be hard to define. For small numbers of firms (oligopolies) with large output shares, the abatement incentive would be weakened by the refund. Compared with taxes or permits, the REP scheme also lacks the output effect, which may or may not be a cause for concern depending on a couple of key variables. The output effect presumably also implies that emissions of unregulated pollutants will increase (unless they are complements to the pollutant subject to the charge). The output effect will be less of a concern if the cost share of the fee is low, the demand elasticity of the product is small, and the technical abatement possibilities are large. In the case of the NO<sub>x</sub> charge scheme implemented in Sweden, these conditions were fulfilled; however, in other cases, such as with greenhouse gases, the output effect may be very important. The REP scheme does not follow the “polluters pay principle” with respect to the cost of unabated pollution (but neither do standards and other regulations).

Although pure REP schemes are rare—in fact, the Swedish NO<sub>x</sub> charge described in this report is rather unique—other similar schemes have included elements of refunding to the polluters. Water and sewage charges sometimes have some of the characteristics of schemes described here, as do some energy efficiency policies [19]. In our opinion, the REP scheme has more potential than current alternatives.

Environmental economists who have worked in transitional or developing countries know full well that the political aspects of how to use the revenues collected from environmental charges are a central topic of discussion. In many countries, revenues from environmental (and other) charges are traditionally earmarked for specific purposes, which not only raises concerns about the efficient use of public funds but also reflects local political concerns that need to be taken into account. We believe that the REP scheme may be particularly attractive in developing countries. In developing countries, regulators typically lack the power to directly confront all the polluters at once, and the polluters’ threats of bankruptcy carry more political weight than in richer countries. Therefore, it is important to enlist the support of at least some of the polluters when introducing environmental regulations. At the same time, some sort of economic incentive for the adoption of cleaner technology is urgently needed in many developing countries.

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<sup>13</sup> As already noted, some smaller incentives for exit and entry still exist.

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## References

1. Baumol, W. J., and W. E. Oates. 1988. *The Theory of Environmental Policy*. Cambridge, U.K.: Cambridge University Press.
2. Bohm, P., and C. Russell. 1985. Comparative Analysis of Alternative Policy Instruments. In *Handbook of Natural Resource and Energy Economics, Volume 1*, edited by A. V. Kneese and J. L. Sweeney. Amsterdam, the Netherlands: Elsevier Science Publishers.
3. Coase, R. H. 1960. The Problem of Social Cost. *Journal of Law and Economics* 3:1–44.
4. Eskeland, G. S., and S. Devarajan. 1996. Taxing Bads by Taxing Goods, Pollution Control with Presumptive Charges. *Directions in Development Series*. Washington, DC: World Bank.
5. U.S. EPA (Environmental Protection Agency). 1998. *1997 Compliance Report—Acid Rain Program*. Washington, DC: U.S. EPA.
6. Farrow, S. 1995. The Dual Political Economy of Taxes and Tradable Permits. *Economics Letters* 49:217–20.
7. Farrow, S. 1999. The Duality of Taxes and Tradable Permits: A Survey with Applications in Central and Eastern Europe. *Environment and Development Economics* 4:519–35.
8. Fischer, C. 2000. *Rebating Environmental Policy Revenues: Output-Based Allocations and Tradable Performance Standards*. Mimeo. Washington DC: Resources for the Future.
9. Fullerton, D., and T. Kinnaman. 1995. Garbage, Recycling, and Illicit Burning or Dumping. *Journal of Environmental Economics and Management* 29:78–91.
10. Hahn, R. W., and G. L. Hester. 1989. Marketable Permits: Lessons for Theory and Practice. *Ecology Law Quarterly* 16:361–406.
11. Höglund, L. 1999. Abatement Costs in Response to the Swedish Charge on Nitrogen Oxides. Unpublished paper. Göteborg, Sweden: Göteborg University, Department of Economics.
12. Holley, J., and P. Anderson. 1989. Lead Phasedown—Managing Compliance. Memorandum. Washington DC: U.S. EPA, Field Operations and Support Division.
13. Kohn, R. E. 1991. Porter's Combination Tax and Subsidy or Controlling Pollution. *Journal of Environmental Systems* 20:179–88.
14. Pezzey, J. 1992. The Symmetry between Controlling Pollution by Price and Controlling It by Quantity. *Canadian Journal of Economics* 4:983–99.

15. Porter, R. C. 1974. The Long-Run Asymmetry of Subsidies and Taxes as Antipollution Policies. *Water Resources Research* 10:415–17.
16. SEPA (Swedish Environmental Protection Agency). 1993–98. Memorandum 733-3720-93 Mt, 733-4143-94 Mt, 733-6828-95 Mr, 733-4238-96 Mr, 733-4677-97 Mr, 713-3713-98 Rt. Stockholm, Sweden: SEPA.
17. SEPA (Swedish Environmental Protection Agency). 1997. *Svavelskatt och NO<sub>x</sub>-avgift—utvärdering*. Report 4717. Stockholm, Sweden: SEPA.
18. Statistics Sweden. 1997. Utsläpp till luft i Sverige (Emissions to air in Sweden). *Statistiska meddelanden* Na 18 SM 97 01, Stockholm, Sweden.
19. Stavins, R. N. Forthcoming. Experience with Market-Based Environmental Policy Instruments. In *The Handbook of Environmental Economics*, edited by K-G. Mäler and J. Vincent. Amsterdam, the Netherlands: North Holland/Elsevier Science, Section IV.
20. U.S. EPA (Environmental Protection Agency). 1999. *Reinventing Environmental Protection 1998 Annual Report*, March 1999, Washington, DC.
21. Tietenberg, T. H. 1995. Transferable Discharge Permits and Global Warming. In *The Handbook of Environmental Economics*, edited by D. W. Bromley. Oxford, U.K.: Basil Blackwell.
22. Wang, H., and D. Wheeler. 1996. Pricing Industrial Pollution in China. World Bank Policy Research Working Paper 1644. Washington, DC: World Bank.
23. Weitzman, M. L. 1974. Prices vs. Quantities. *Review of Economic Studies* 41:477–91.
24. Xepapadeas, A. 1997. *Advanced Principles in Environmental Policy*. Glos, U.K.: Edward Elgar.
25. Yohe, G. W., and P. MacAvoy. 1987. A Tax Cum Subsidy Regulatory Alternative for Controlling Pollution. *Economics Letters* 25:177–82.



**Table 1. Concept of Rights to Ownership as Related to Kinds of Policy Instruments.**

<i>Kind of instrument</i>	<i>Holder of ownership rights to the environment</i>	
	<i>Society</i>	<i>Polluter</i>
Quantity	TEP (auctioned)	TEP (output-based allocation or grandfathered <sup>a</sup> )
Price	Tax	REP

Notes: TEP = tradable emission permit; REP = refunded emission payment.

<sup>a</sup> Grandfathered permits give the rights to a set of historic polluters, whereas output allocation gives rights to the current polluters.

**Table 2. Abatement and Output Effects of Taxes, TEPs, and REPs.**

<i>Effects of policy instrument</i>	<i>Policy instrument</i>	
	<i>Tax<sup>a</sup></i>	<i>REP<sup>b</sup></i>
Abatement	$t$	$t(1 - s_j)$
Marginal cost of abatement <sup>c</sup> ( $-c'_e$ )		
Output	$c'_q$	$c'_q - t(1 - s_j)E/Q$
Supply curve <sup>d</sup>		

Note: See Symbols Used for definitions of the symbols in this table.

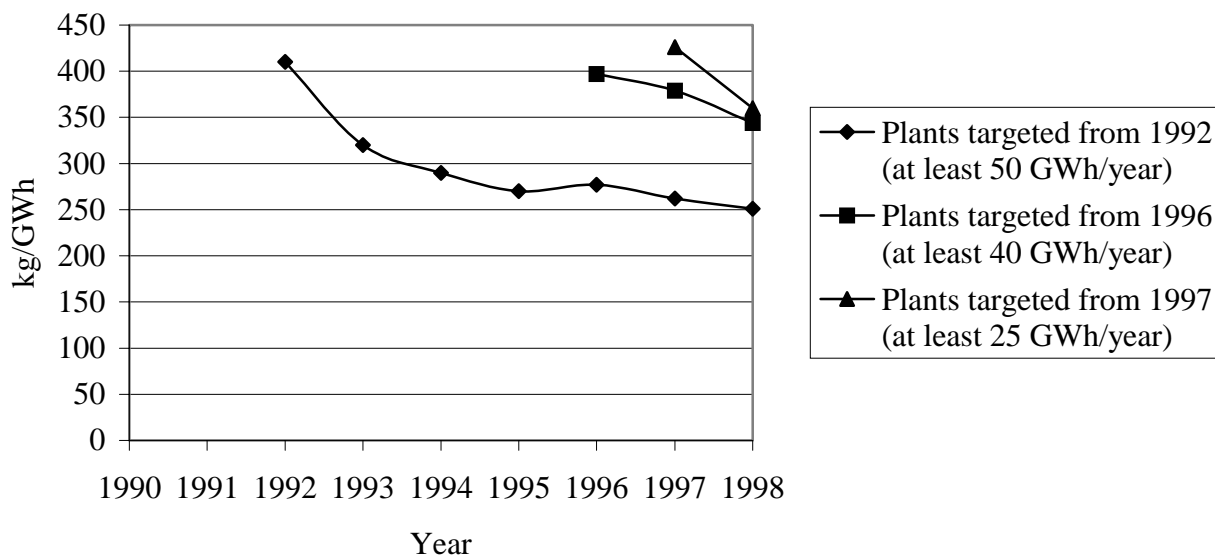
<sup>a</sup> Auctioned or grandfathered permits would have analogous properties, with the price of permits replacing the tax level ( $t$ ).

<sup>b</sup> Similarly in this column, output-allocated permits would have analogous properties, with the price of permits replacing the tax level ( $t$ ).

<sup>c</sup> See Equation 2.

<sup>d</sup> See Equation 3.

**Figure 1. Mean NO<sub>x</sub> emission rates for plants targeted by a NO<sub>x</sub> charge in Sweden, 1992–98.**



Source: SEPA [16].

**Notes**