J. ENVIRONMENTAL SYSTEMS, Vol. 5(4), 1975

POLICY CHOICES FOR AIR QUALITY GOAL ATTAINMENT

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ABSTRACT

The four major air quality attainment policies—emission control regulations, emission control subsidies, emission charges, and emission rights—are respecifications of air resource property rights. Among these, regulations and subsidies are allocatively and dynamically inefficient. The choice between emission charges and emission rights depends on an empirical assessment of their associated transactions costs, although emission rights appear more promising. The proper evaluation of emission control policies requires better techniques for estimating transactions costs and for assessing the deleterious effects of various specific pollutants. Ultimately, environmental policymakers have to confront the choices of air quality goals, of the final distribution of pollution abatement costs, and of regional variations in air quality as normative political issues, despite substantial inputs of scientific information concerning these issues.

Introduction

One of the most important emerging problems regarding the economics of air quality is the increasing political concern with the growing cost of emission abatement applications. One author has projected that environmental protection expenditures will increase from their current levels of about 1.5 per cent of GNP to 3 per cent by the turn of the century and to more than 5 per cent of GNP within the following two decades. By comparison, the United States in 1970 allocated about 2.5 to 3 per cent of GNP on fuels and about 7 to 8 per cent for education and a similar amount on medical services. In part, these pessimistic projections of environmental protection costs result from the physical properties of the

doi: 10.2190/EVYF-H3JC-0E6X-2XFT
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air and water. As the natural waste assimilative capacities of these fluids are pressed by increasing industrial growth and potential emissions, the aggregate cost of maintaining current environmental quality grows nonlinearly [1, pp. 951-2]. The analysis summarized in this paper purports that at least part of the growing magnitude of these projections results from the policy choices that are assumed in estimating the future costs of attaining current air quality goals. In particular, regulatory approaches to the achievement of air quality have to a large extent themselves become identified as the major policy mechanism. Many apparently attractive alternative policies, such as emission charges and air rights schemes, appear to offer substantial savings in the resource costs of environmental protection. Yet these policies have received relatively little attention at the policymaking level. In view of the expected growing relative magnitude of environmental protection costs, it seems incumbent on environmental policymakers to pay especial attention to the efficiency properties of the policy tools that are employed.

The purpose of this paper is to review the major policy alternatives available to achieve air quality. This review is conducted in the context of the realignments of property rights that are implicit in the policy alternatives. In one section property types are classified; then each of four major air emission control policy options—emission control regulations, emission control subsidies, emission charges, and emission rights—is discussed in terms of the type of air resource ownership it confers on emitters. Also several advantages and disadvantages of each are discussed. Another area addresses several policy issues related to the choice of allocatively efficient emission control policy options.

Property Rights and Environmental Policy

Although economics is the science that studies the processes by which scarce resources are allocated, the air resource largely escaped analysis until the last decade. This inattention was likely due to the fact that until recent years air was as good an example as economists could devise to illustrate a free good, i.e., a good that is infinitely available at a zero price. The increasing demands on the waste assimilative capacity of the air have made it rather obvious that, if not air, then certainly air quality is a scarce resource. However, the fact that changing economic conditions redefined air as a scarce resource is not peculiar to air. For example, in historical perspective, the private ownership and control of land is a relatively new development in many parts of the North American continent. Indeed, in Antarctica the convention of enforcing surface ownership rights has not yet emerged.

The attributes peculiar to the air resource are its physical properties of mobility and indivisibility. As J. H. Dales has pointed out, these characteristics in a resource identify it as a common property resource in the absence of an interventionist policy which somehow assigns rights-to-access [2, 3].

This section develops the notion that the alternative policy tools devised to achieve and maintain air quality are simply administrative devices designed to bring about realignments of property rights to the air resource. It is contended here that none of the known administrative tools for achieving air quality goals is intrinsically superior. Rather, if the policymaker accepts the criterion of allocative efficiency, it is the overall resource costs implied by each alternative specification that ought to be the ruling determinant of the desirability of each.

An elaboration of the alternative property rights structures within which alternative policy tools follows.

A CLASSIFICATION OF PROPERTY TYPES

The concept of property rights is particularly relevant to an analysis of the air pollution problem because the emergence of property rights is likely when the gains from internalizing the air pollution externalities become larger than the costs of internalization [4, p. 350]. Internalization, of course, refers to the process that enables the harmful (or beneficial) effects associated with the exercise of individual property rights to bear on all interacting persons.

This section summarizes the major types of property ownership and indicates, in general terms, the associated degree of internalization. This framework then allows, in the following sections, an analysis of the major policy options for air quality attainment and their expected properties of allocative efficiency. The four major types of ownership classified here follow Dales description [2, p. 795-6].[1] These four types are: common-property, restricted common-property, status-tenure, and full ownership.

Common-property—Common-property basically implies nonownership. A common-property resource is defined as any

[1] Demsetz specifies an alternative three-way classification: communal, private, and state ownership. This classification is not fundamentally different from that given by Dales [4, pp. 354-6].

resource that can be accessed an unlimited number of times at a zero price. The air, until recently, and ocean resources are traditional examples of common-property resources. H. Scott Gordon's classic work on the ocean fishery showed that common property ownership will in the long run imply economically inefficient use of the asset [5].

Restricted common property—This is, as the name implies, common property for which the types of uses are restricted. Nonetheless, for the specified uses there is no limit on the degree of access. Examples of restricted common property are such resources as national forests (for camping, hiking, etc.), freeways (for driving specified vehicles), and public beaches (for swimming and sunbathing). Generally, although the restrictions on the common property may avoid depletion in the physical sense, such resources are nonetheless often deteriorated in quality by congestion problems which arise because of the lack of limitations on access.

Status-tenure—The third type of ownership, which Dales refers to as status-tenure ownership, is especially important to the analysis of environmental policies. This ownership arrangement assigns exclusive rights-of-access to those authorized to use the property, but the user's rights are not transferable. Typical examples are land owner-tenant arrangements or, similarly, apartment owner-tenant relationships. The previous two examples are cases where the rights to use the property are transferred at a positive price. However, there is another entire class of status-tenure ownership arrangements wherein the rights-to-access are granted at an apparent zero price. These consist of the large set of valuable property rights that are transferred to individuals and firms via the regulatory branches of government.[2] Although the inability to transfer these property rights prevents an explicit assessment of their value, they are nonetheless usually very valuable rights and as such become evident in the appearance of implicit prices. For example, the restrictions on tobacco acreage in the Southeast effectively reduced the supply of that commodity and resulted in higher prices. Hence, the anticipation of continued restrictions led to the capitalization of the status-tenure ownership of tobacco allotments into the price of the tobacco producing land. As elaborated below, many environmental laws also basically imply a status-tenure system of ownership,

[2] See Charles A. Reich for a discussion of specific examples of the impact of regulatory function on property rights and values [6].

which is likely deficient in coping effectively with the air quality problem.

Full ownership—Full property ownership implies the right to transfer the owned resource at an explicit price, just as the existence of an explicit price implies full ownership. This type of ownership allows the maximum internalization of the side effects of exercising the property rights. We are most familiar with full ownership because it tends to emerge in a free society for resources which are both relatively immobile and divisible and which are increasing in economic value over time. Because of the allocative efficiency that accompanies full ownership, imaginative policies which exploit its economic properties in achieving air quality goals are likely to reduce substantially the associated resource costs.

ENVIRONMENTAL POLICY INSTRUMENTS

This analysis of the instruments that are candidates for environmental policies presumes the answers to several questions that some authors may regard as most critical. Specifically, it is assumed that the political system answers the following three questions:

1. How much pollution should be allowed?
2. Where should pollution be allowed? and
3. How should pollution and emissions be measured?

These questions are addressed later in this paper.

A paradigm of the setting assumed here might be something like the following. An environmental policymaking authority is asked to select from among alternative policy instruments that one which appears to require the smallest level of aggregate resources for meeting an already specified level of air quality, stated as the maximum level of pollution concentrations that may obtain at any time within the region over which the policy is to be administered. The aggregate level of resource costs is assumed to include not only the expenditures of individual firms on pollution abatement but also the total costs associated with the government's administration of each policy instrument. These latter costs are loosely defined as transactions costs.[3] Furthermore, it is assumed that each emitter is stationary, that each is emitting a single pollutant which is the only

[3] Krier and Montgomery define transactions costs as ". . . the costs of interacting parties identifying each other, informing each other of a willingness to deal, carrying out and memorializing negotiations, and enforcing the resulting agreement." In this particular case the interacting parties would be the government owner of the air resource and the individual emitter [7, p. 95].

one under consideration, that all emission rates are easily measureable, and that the relationship between individual emission rates and pollution concentrations at all points in the region is identical for all emitters.

Alternative Policy Options

EMISSION CONTROL REGULATIONS

The regulatory approach has, almost uniformly, been the policy prescription to achieve air quality goals. The emission control regulation is basically a status-tenure property right that is assigned to any potential emitter. Under this system the emitter has a non-transferable right to emit up to the constraints specified by the regulation. The constraints take on many different forms but are usually denominated as functions of such production parameters as process weight, heat input, fuel characteristics, etc. This right to emit is normally transferred at a zero price through the administrative mechanisms of the government environmental authorities. Normally, the regulations apply uniformly to all emission sources within specified industries among all regions under the control of the agency. This contrasts with an approach that applies uniformly to all emission sources within specified regions but not necessarily across regions for specified industries.

The property right specification that is implicit in the imposition of emission control regulations has both advantages and disadvantages. The most obvious advantage is that emitters are given a fixed set of constraints which are understandable in an engineering sense. There is relatively little apparent uncertainty about the emitters present and future obligations under such a policy. Thus regulations have a pragmatic appeal [7, p. 103]. Because of the way they are specified one can readily understand the way in which regulations operate and exactly how the regulations relate to the engineering parameters of production.

Another potentially positive feature of a uniform emission control regulation is that the agency may require less information to enforce them. Hence, there may be lower overall transactions costs than under alternative policies. In reality this feature appears largely illusory, because the type of emission control regulation that discriminates among sources within each region basically implies a set of tailored, individually specified regulations.

A third advantage of regulations is that they do not involve the significant transfer of financial resources away from emitters that are implicit in, for example, a uniform emission charge scheme. From the viewpoint of society as a whole these transfers, like income taxes, do not represent a net loss to society because they are simply channeled into the treasury for public expenditures. However, from the viewpoint of individual emitters or emitting industries, these potential transfers loom as dangerous threats to their viability, since there is little assurance that the emitters will eventually recoup their losses through retransfers back to themselves.

Unfortunately, the disadvantages of regulations are substantial. The most important objection to uniform regulations is that they are allocatively inefficient. Different industrial and plant sources have widely different marginal abatement costs. Therefore, even while each emission source within a region meets the applicable regulation, the cost of avoiding the marginal (last) unit of emissions is invariably much greater for some emitters than for others. Hence, there would be a net abatement cost savings to society if regulations were individually designed and enforced to equalize marginal abatement costs among emitters. But that is virtually asking the impossible because, even in a world of static relative input prices, the investment in information that would be required is staggering. Then, even if the abatement cost functions could be estimated properly, the environmental authorities would be constantly faced with dynamic shifts in those cost functions as the relative prices of such inputs as fuel or abatement devices changed.

Despite the fact that the received system of regulations does not, in any significant way, account for marginal abatement cost differences, it still retains some of the negative features of an attempt at such an approach. In particular, as mentioned above, the current system of regulations is applied on a source-by-source basis. Hence, in point of fact, one of the potential advantages of regulations, i.e., the information cost savings attributable to uniform specifications, is forfeited.

A final disadvantage of regulations is that they are designed to satisfy air quality goals in only a static sense. Hence the apparent certainty implicit in regulations is also forfeited in the long run if a fixed air quality goal is to be maintained. Because the environmental authority makes no attempt to specify the location or absolute magnitude of allowable emissions, the status-tenure commitment of the government to both current and future potential emitters is essentially open-ended. For example, so long as an existing emitter shows that his emissions do not exceed those prescribed by the "process weight rate regulation" he faces, he may increase that rate, and hence emissions, as much as he chooses. This increase may occur as a result of an expansion of the polluting facility at the existing location or as a result of new industrial growth. Consequently, the Environmental Protection Agency has devised the Air Quality Maintenance Plan concept, whose purpose and design is intended to cope with this dynamic problem. In regions where emissions are already at the maximum rates consistent with air quality goals, the ultimate operational significance of those plans has to be that emission control regulations will become more stringent over time.[4] Some may argue that this consideration is not a significant problem in the near-term future because older existing facilities will be replaced by new emission sources that will have to comply with the relatively more stringent New Source Performance Standards. The counterargument is that, although that point may be valid, it only postpones the day of reckoning.

EMISSION CONTROL SUBSIDIES

Emission control subsidies involve the payment of public funds to emitters to clean up. The existence of a subsidy mechanism is an implicit recognition that emitters, not the government, possess unabridged rights-to-access the air resource and hence control the extent of waste disposal to that medium. The subsidy payments are basically incentives to those who use the waste assimilative capacity of the air to reduce the harmful effects of pollutants on those who access the air resource for life-support and amenity purposes.

The subsidy scheme appears unimportant initially because it is an apparently little-used approach. However, emission control subsidies are more ubiquitous than they may appear at first blush. Basically many of the pollution control-related tax preference schemes that have been legislated in recent years are implicit subsidies. For example, the rapid amortization schemes for pollution control equipment as well as exemptions of pollution control facilities from local property taxes are effective transfers from the public treasury to emitters. Similarly, no-interest or low-interest loans made available by revenue bond financing impose additional tax burdens on the general taxpayer and hence represent an effective subsidy. Although these partial emission control subsidies are used in conjunction with emission control regulations and, as such, do not constitute the sole policy mechanism for

[4] It should be noted that land use planning schemes which outrightly proscribe new emission sources in parts of a region simply constitute a special case of this point.

achieving air quality, many of the comments that are made below regarding subsidies apply equally well to those partial subsidies.

The major advantages claimed for subsidies is that emitters will not be forced to raise their prices to consumers of their products. Only regional or national taxes will have to be increased. This is really a spurious argument because it avoids the more important question regarding the total resource requirements of meeting air quality goals under this scheme and chooses to focus on the far less important distributional questions. Nonetheless, subsidies are obviously financially advantageous to emitters.

The disadvantages of subsidy approaches are likely even greater than those of regulations. First, if the subsidy is set at a fixed rate per unit of emissions, the emitter would abate emissions up to the point at which the marginal cost of emission reductions equals the subsidy rate. If, for all emission rates in excess of that equilibrium emission rate, the marginal abatement cost is less than the subsidy rate, the emitter will earn rents which will ultimately imply that the relative price of his output will fall *because* he is an emitter. This will in turn result in an effective increase in the demand for the products each emitter produces and iterative increases in public expenditures on emission control subsidies because of the inappropriate price signals that are fostered by this type of air resource ownership.

Another problem related to this is that the subsidization approach does not provide any incentive to choose or develop low emission production methods. There is even a contrary incentive for the emitter to increase his *potential* emission rates to collect a subsidy. However, to maximize the rents he earns from the subsidy there is a continuing incentive in the subsidy approach to develop efficient abatement devices.

The second problem with subsidies is that they encourage the overstatement of potential emission rates to maximize the revenue potential of the subsidy scheme. Any attempts to alleviate this problem would require intensive investments in engineering information that may well exceed the requirements of regulations.

Subsidies are additionally inefficient because environmental authorities would have to experiment with the subsidy rate over time to find the level at which the air quality goal is met. Thereafter, the rate would have to be varied periodically to deal with the problem of regional and industrial growth that was discussed above with respect to regulations.

EMISSION CHARGES

Emission charges basically constitute an alternative status-tenure ownership arrangement between the government-owner of the air resource and individual emitters. Under this arrangement the environmental authority transfers an unlimited right-of-access to the air resources for waste disposal purposes, but at a uniform, positive price per unit of emissions.

The theoretical advantages of the emission charge approach far outweigh those of either regulations or subsidies. Most importantly, emission charges are allocatively efficient, in a static framework. That is, the imposition of a uniform marginal emission charge sufficient to achieve the air quality goal in a given region will automatically achieve the air quality goal at minimum total resource cost to all emitters combined. This result follows theoretically from the simple assumption that all emitters wish to provide whatever output levels they select at minimum cost to themselves [8, p. 319]. For example, a preliminary empirical assessment of the inefficiency of emission control regulations vis-a-vis emission charges showed that the control of sulfur emissions sufficient to meet air quality goals in St. Louis, Missouri, would cost 70 per cent more under regulations than under uniform emission charges [9]. A comparable estimate of 28 per cent was developed for Cleveland, Ohio.

Although this result is both important and compelling, there are some important disadvantages to emission charges. First, uniform emission charges imply significant financial transfers away from emitters. For example, in the above-mentioned study the transfer of financial resources away from emitters (which results in no net social cost) was estimated to cause the net private costs of emission charges in St. Louis, for example, to be 37 per cent lower under regulations than under the uniform emission charge. This problem, however, can be dealt with quite easily by specifying alternative types of emission tax structures that incorporate some type of redistributive scheme.[5]

A second deficiency that is leveled against emission charges is not dealt with so lightly. This argument basically states that the practical aspects of any real world application of emission charges cause important deficiencies [10, 11]. These problems are largely induced by both the static and dynamic information requirements of any charge scheme. For example, like the subsidy scheme, the environmental authority would have to experiment with the tax rate initially to find that one at which total emission rates correspond to those consistent with the air quality goal. Then in the longer run, as industrial and regional growth continue, the charge rate would have to be raised to continue meeting the air quality

[5] A representative listing of these alternatives are summarized in chapter 2 of Bingham and Miedema [9].

constraint. As Rose-Ackerman points out, this experimentation and iteration is a poor approach to achieving air quality for the very basic reason that pollution abatement is capital intensive [10, p. 523]. In all the static theoretical models this is no problem because the implications are derived from the models under long-run equilibria. But the problem of experimenting to find the correct tax rate is by nature a short-run problem. The misallocative effects of this experimentation procedure derive then from two related sources:

1. the fixity of the capital intensive abatement processes and
2. the induced uncertainty in the capital outlays that will be required either to pay emission charges or to purchase abatement devices.

Another disadvantage of a uniform emission charge is that, with a uniform emission charge that is supposedly set equal to the marginal damage cost, the total emission charge payment will always exceed the social cost of the remaining externality so long as the marginal benefit curve is falling (or the marginal damage schedule is rising) [10, p. 513]. This argument, almost the reverse of the argument that subsidies induce economic rents, implies that the uniform emission charge would impose negative rents and the emitting industries would bear net total (not marginal) private costs that exceed the true social costs of all the resources they employ, including air. This result implies a higher long-run average cost for emitters and hence the emission charge may suboptimally drive some emitters out of business. However, this theoretical problem can be avoided by emission charge schemes that account for this distributional problem [9, chapter 2]. Nonetheless, these considerations encourage a more intensive analysis of an alternative property rights specification that avoids some of these problems of emission charges while retaining their static efficiency attribute.

EMISSION RIGHTS

The idea of an auction market in which the rights to emit are freely traded was first proposed in the mid-sixties [2, 3, 12] and has recently received more intensive analysis by Montgomery and Tietenberg [13, 14]. Although some authors distinguish between emission rights and pollution rights—the latter assumes that rights are adjusted for varying emission-related pollution concentrations which result from meteorological differences and changes—this analysis assumes that emission rights are the subject of study because of our earlier assumption that all emission sources affect air quality equivalently.

The emission right is defined as the right to emit a unit mass of a specified pollutant over a specified time interval. These rights are fully transferable in an emission rights market. Therefore they come as close as any of the policy options to exploiting the allocative efficiency properties of full ownership rights. The number of emission rights is initially set and fixed at that number which just satisfies the air quality goal.

Because of their transferability, emission rights retain the overall cost minimizing properties of emission charges.[6] This is an intuitively appealing property because it seems logical that an individual profit-maximizing emitter would sell his emission rights whenever their market price exceeds his marginal abatement cost. This property implies that the environmental authority will have much lower information requirements about emitters and abatement processes than those which would obtain under a system of regulations that attempt to discriminate among emitters on the basis of their marginal abatement costs.

A second major advantage of emission rights is that they prevent the degradation of air quality over time. Hence they avoid one of the major problems inherent in both emission taxes and regulations. To the extent that the demand for the waste assimilative capacity of the air resource is increasing over time, this gets reflected in the price of a right because the supply of rights is fixed. It should be noted, however, that unless emission rights have a perpetual duration they may share an attribute of taxes, i.e., unanticipated transfers of financial resources away from emitters. However, a futures market in these rights would alleviate this problem and there is no reason why one should not emerge.

Thirdly, emission rights may utilize the market system to resolve conflicts over the competing amenity and waste disposal uses of the air resources [3]. The ownership of an emission right does not require that they be used. Therefore, environmental groups could vote with their dollars instead of through the political system. A potential problem with this proposed resolution is what is generally called the free-rider problem. To the extent that environmental group purchases of these rights cannot exclude nonparticipants from enjoying the increased air quality which results from their purchases, this mechanism for resolving conflicting values will result in an underprovision of air quality.

[6] This point is rigorously developed by Montgomery [13].

Finally, emission rights may potentially remove much of the emitter uncertainty inherent in other pollution control policies. For example, if emission rights were marketed in several series whose dates of expiration varied up to five years or more, individual emitters could assure for themselves the right to emit at the rate allowed by the purchased rights for a long, fixed period. This kind of policy flexibility would likely reduce the above-mentioned misallocations that result from the effects of uncertainty on investment in pollution abatement devices.

Some Related Issues

ESTIMATION OF TRANSACTIONS COST

Several unresolved issues are related to the choice of air quality management policies. One of the most important empirical issues concerns the estimation of transactions costs. Most empirical assessments of air quality control policies compare only the emission abatement costs that would obtain under alternative policy instruments. What is now required is a complete operational approach to estimating aggregate resource costs including transactions costs because, as Demsetz has shown, the case for any particular realignment of property rights must essentially reduce to an empirical case based on the *total* resource requirements, and savings, of the realignment. Some allocative inefficiency in abatement costs, such as those embodied in regulations, can obviously be tolerated if there are compensating savings in transactions costs.

AIR QUALITY GOALS

A second unresolved issue is the choice of air quality goals. In theory, air quality goals themselves should emerge from an application of economic analysis. Specifically, the theoretically optimum level of air quality is that at which marginal pollution reduction costs equal marginal benefits from the pollution reduction. In practice, it may be argued that the state-of-the-art in economic analysis precludes the proper valuation of many benefits from air pollution control. Imponderables such as determining the value of aesthetics and the assignment of dollar values to human life must enter such benefit calculations. There is no generally agreed upon technique to do that even if we had accurate estimates of the effects of changes in air quality on such variables. Although the tools of economics can be helpful in many areas of benefit assessment, it would seem reasonable that on the whole the proper choice of air quality is fundamentally a political issue that must be resolved iteratively over time as emitter and receptor interests interact in the political arena. It is important, however, that while this political interaction occurs, all interests be shown accurate estimates of the costs of various levels of air quality so, at least, they can make an intelligent value judgment about the appropriate level of air quality. Based on the above-mentioned empirical evidence, it appears that a large portion of the costs of regulations result from their allocative inefficiency. To the extent that is true, interacting political interests are receiving poor information about the costs of air quality. The upward bias in the costs of air quality due to the allocative inefficiency of regulations may therefore eventually cause a suboptimal air quality level.

EQUITY AND ABATEMENT COSTS

A third issue is the matter of equity and the final incidence of the costs of pollution abatement. It is important for emitters to be aware of the opportunity cost of the air resource that is implicit in the air quality goals. That awareness is not achieved by subsidizing emitters to pay their abatement costs. However, this argument does not imply that the property rights to the air resource should maximize financial transfers away from emitters. Rather, so long as each emitter within the defined region faces the same marginal cost, there is a good argument for minimizing financial transfers in the interest of getting least-cost policy options implemented. Some variants of the pricing schemes already mentioned do in fact minimize these transfers. Two examples are the emission charge scheme with an exemption level and the direct, free endowment of emission rights. Other arguments about the distribution of pollution abatement costs among industries, individuals, geographic regions, and generations are valid concerns on which research can provide important inputs. However, it would appear that once these data are weighed the ultimate decision must be a value judgment that, too, has to be resolved by the political system.

REGIONAL VARIATION IN AIR QUALITY

Another general problem area is that of subdividing the nation into geographic regions and then determining the air quality that should obtain in each region. This is a difficult question on which some economists have argued for the "separate facilities" concept, i.e., basically the nondegradation argument that dirty subregions should be allowed to get dirtier and pristine regions ought to stay that way [2, 3, 15]. This issue too is really a normative one—sometimes involving intergenerational equity issues—that has to be resolved in the political system, which somehow has to decide on the extent of control landowners *should* have in developing new (emitting) industry. Yet it should be noted that the answer to the regional mapping question is critical because all policy options are applied under the assumption that the regional air quality goal is well defined.

AIR QUALITY MEASUREMENT

A related issue is the whole problem of defining and measuring air quality. In the discussion of policy options it was assumed that we were dealing with a single, well-defined pollutant. In practice, that is unrealistic. Therefore, scientists have to improve on their judgments about the equivalence of emission rates for separate pollutants. It can be argued that these improvements are among the most important products of the research on physical responses to pollution dosages. Some may argue that a good table of equivalents for separate pollutants will never be achieved, but any improvements are important. Indeed current pollution control policies implicitly incorporate our naive understanding of such equivalents already. Specifically, for policy purposes environmental authorities infer from the published air quality goals some weighting scheme which essentially implies a way to add up various pollutants. Solving this "additivity problem" is really critical to the way in which alternative policy options are specified. For example, given a solution, an emission rights system could be denominated as a single equivalent emission rate rather than as a separate rights specification for each pollutant.

The ultimate resolution of many of the issues addressed in this section requires a substantial volume of scientific inputs. Yet, in the final analysis, many of the solutions must be based on normative judgments. This is a critical consideration because it delineates the point at which science leaves off and the resolution of differing value judgments through the political process begins. It is also important because it sets the proper stage for an analysis of alternative policy instruments and their attendant efficiency properties.

Summary

This paper has presented the argument that the rising value of the waste assimilative capacity of the air resource has resulted in an increased demand for a realignment of the property rights associated with the air resource. The resulting realignments imply four major alternative policy options—emission control regulations, emission control subsidies, emission charges, and emission rights—

which are basically alternative respecifications of the rights-to-access the waste assimilative capacity of the air resource. To develop an efficient program to achieve air quality goals, i.e., a program which minimizes the sum of pollution abatement costs and transactions costs, special attention must be paid to the cost properties of the policy options. Although the final determination of an optimal policy is basically an empirical question, there are sound a priori reasons, in addition to some preliminary empirical evidence to encourage a movement away from emission control regulation approaches and to avoid subsidy schemes altogether. The choice between emission charges and emission rights will depend to some extent on the actual cost of administrative devices to implement and enforce each, although the emission rights scheme has very positive properties that avoid the dynamic misallocative properties of emission charges while retaining their least-cost advantage.

The proper evaluation of emission control policies requires better techniques for estimating transactions costs and for assessing the deleterious effects of various specific pollutants. Ultimately, environmental policymakers have to confront the choices of air quality goals, of the final distribution of pollution abatement costs, and of regional variations in air quality as normative political issues, despite substantial inputs of scientific information concerning these issues.

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