Technology-Based Emission and Effluent Standards and the Achievement of Ambient Environmental Objectives

The Clean Air Act (CAA)[1] and the Federal Water Pollution Control Act (FWPCA)[2] mandate both ambient environmental quality standards[3] and technology-based emission or effluent standards[4] for certain sources of pollution. This Note demonstrates that the current use of technology-based standards precludes the achievement of ambient standards at least cost. It argues further that, in the context of this mixed regulatory system, technology-based standards fail to promote any important non-economic goals. As an alternative to the current system of dual standards, the Note proposes a zoned marketable pollution rights scheme that would ensure that ambient standards are met at least cost.

Because ambient environmental quality standards limit pollution concentration levels, they are a logical tool for the control of local pollutants, whose harm is directly related to their concentrations in the biosphere.[5] Ambient standards are therefore central to the structure of the CAA,[6] and will play an important role under the FWPCA after 1983.[7] Ideally, these

1. 42 U.S.C. §§ 7401-7642 (Supp. III 1979).
2. 33 U.S.C. §§ 1251-1376 (1976 & Supp. III 1979).
3. An ambient standard sets a maximum pollutant concentration, as measured at a specific location. Tietenberg, *Transferable Discharge Permits and the Control of Stationary Source Air Pollution: A Survey and Synthesis*, 56 LAND ECON. 391, 396 (1980). Under § 109 of the Clean Air Act (CAA), the Environmental Protection Agency (EPA) sets national primary and secondary ambient air quality standards (NAAQS) based on health and public welfare considerations, respectively. 42 U.S.C. § 7409 (Supp. III 1979). In addition, areas with high levels of air quality are subject to ambient standards more stringent than NAAQS under the Prevention of Significant Deterioration (PSD) program. 42 U.S.C. §§ 7470-7479; *see infra* p. 806 (discussing PSD program).

Under the Federal Water Pollution Control Act (FWPCA), water quality standards are established on a case by case basis, pursuant to state laws, 33 U.S.C. § 1313 (1976), or federal statutes and regulations, *see* 33 U.S.C. § 1311(b)(1)(C). There is, in addition, a federal water quality goal, which will come into effect in 1983 and which mandates "fishable/swimmable" waters wherever attainable. *See* 33 U.S.C. § 1251(a)(2); *see also* Homestake Mining Co. v. EPA, 477 F. Supp. 1279, 1285 (D.S.D. 1979).
4. Technology-based standards set quantitative limits on pollutant discharges. These limits are based on the abatement capability of pollution control technology. Freeman, *Air and Water Pollution Policy*, in CURRENT ISSUES IN U.S. ENVIRONMENTAL POLICY 12, 53 (P. Portney ed. 1978). Technology-based standards do not mandate the adoption of any particular technology. *See infra* p. 809; *see also infra* notes 21-22 (discussing CAA emission and FWPCA effluent standards).
5. *See* Tietenberg, *supra* note 3, at 395-96. In contrast, the damage caused by global pollutants depends solely on the aggregate volume of residuals discharged. *Id.* at 395 n.18.
6. All current proposals for the revision of the CAA, including the Reagan Administration's plan, call for the retention of federally set health-based primary ambient air quality standards and welfare-based secondary ambient air quality standards. *See* AMERICAN ENTER. INST. FOR PUB. POLICY RESEARCH, THE CLEAN AIR ACT: PROPOSALS FOR REVISIONS 10-11 (1981).
7. *See supra* note 3 (federal "fishable/swimmable" water quality goal to be implemented in

standards should be set to maximize net social surplus.[8] Setting optimal ambient standards, however, is virtually impossible, because it requires subjective estimates of the benefits of pollution control.[9] Accordingly, this Note limits its scope to the design of an optimal system of environmental regulation consistent with preestablished ambient standards.

I. Economic Considerations

A regulatory system that employs ambient standards is economically optimal if it leads to the attainment of such standards at least cost. Technology-based standards are not cost-effective, either when used as the sole means for attaining ambient standards or when employed as part of the hybrid schemes of the CAA and the FWPCA.

A. *Ambient Standards: Efficiency and Least Cost*

In formal economic terms, there is an efficient degree of pollution control when the marginal cost of pollution abatement is equal to the marginal benefit of abatement.[10] An efficient outcome can be achieved, for example, by imposing a tax upon pollution discharges equal to the marginal net damage produced by those discharges, where net damage is defined as the difference between the total damage to society and the cost to the individual polluter.[11] The current reliance of the CAA and the FWPCA on ambient standards set independently of economic considerations[12] precludes the systematic achievement of an efficient degree of pollution control.

For the purpose of this Note, however, the economic desirability of a pollution control system is determined by the degree to which it allocates discharge units among polluters in a manner that meets ambient standards

1983). The EPA may attach more importance, in the future, to ambient water quality standards. [1981] 12 ENV'T REP. (BNA) 837.

8. Net social surplus is the difference between total benefits and total costs. E. MILLS, THE ECONOMICS OF ENVIRONMENTAL QUALITY 88 (1978).

9. Calculating the benefits of pollution control involves estimating such intangibles as the value of human life, more desirable recreation sites, and breathing discomfort. Experts do not even agree on the methodology that should be used to make such estimates, especially estimates concerning the value of human life. *See, e.g.*, M. BAILEY, REDUCING RISKS TO LIFE 28-47 (1980); Broome, *Trying to Value a Life*, 9 J. PUB. ECON. 91 (1978); Fried, *The Value of Life*, 82 HARV. L. REV. 1415 (1969); Mishan, *Evaluation of Life and Limb: A Theoretical Approach*, 79 J. POL. ECON. 687 (1971).

10. E. MILLS, *supra* note 8. This level of pollution control maximizes social surplus. *Id.*

11. W. BAUMOL & W. OATES, THE THEORY OF ENVIRONMENTAL POLICY 135 (1975). The optimal tax level is not equal to the marginal net damage the activity generates initially, but to the damage the activity would cause if the resulting quantity of pollution had been adjusted to its optimal level. *Id.* at 136.

12. The ambient standards relevant to this Note are based on health effects, *see* 42 U.S.C. § 7409 (Supp. III 1979) (primary ambient air quality standards), welfare considerations, *see id.* (secondary ambient air quality standards), and uses, *see* 33 U.S.C. § 1251(a) (1976) (federal "fishable/swimmable" water quality goals); 33 U.S.C. § 1313 (1976) (state water quality standards).

at least cost.[13] A cost-minimizing allocation will result in ideally efficient pollution control only if the ambient standards themselves satisfy the general conditions for economic efficiency.[14]

The familiar economic condition that marginal cost equalization leads to cost-effective allocations is inapplicable because the environmental impact of a discharge depends on geographical location and inter-regional effects.[15] The equalization of marginal costs of abatement at source points would produce a cost-minimizing solution only if the environmental impact of one unit of discharge were equal for all polluters.[16] Given disparities in impact, the conditions for cost-effectiveness are far more complex.

Compliance with ambient standards can be determined by measuring environmental quality at various points designated as receptor points. The aggregate cost of tightening an ambient standard one unit at a given receptor point is termed the shadow price of pollution at that point. To meet a preestablished ambient standard at least cost,[17] each polluter's marginal cost of abatement must equal the sum over all receptor points of the polluter's effect[18] on environmental quality multiplied by the shadow price of

13. Ways to design cost-effective systems of pollution control consistent with preestablished ambient standards are discussed extensively in the economic literature. *See, e.g.*, W. BAUMOL & W. OATES, ECONOMICS, ENVIRONMENTAL POLICY, AND THE QUALITY OF LIFE 356 (1979); W. BAUMOL & W. OATES, *supra* note 11, at 137-39; J. DALES, POLLUTION, PROPERTY AND PRICES (1968); Tietenberg, *Controlling Pollution by Price and Standard Systems: A General Equilibrium Analysis*, 75 SWEDISH J. ECON. 193 (1973); Walker & Storey, *The "Standards and Price" Approach to Pollution Control: Problems of Iteration*, 79 SCANDINAVIAN J. ECON. 99 (1977). Many economists favor a "standards and prices" approach because it does not require the complex task of estimating the benefits of pollution abatement. *See, e.g.*, W. BAUMOL & W. OATES, *supra* note 11, at 135-37 (determination of marginal net damages of pollution activities is difficult); *cf.* B. ACKERMAN, S. ROSE-ACKERMAN, J. SAWYER, & D. HENDERSON, THE UNCERTAIN SEARCH FOR ENVIRONMENTAL QUALITY 124-35 (1974) (critically evaluating studies of pollution control benefits). *But cf.* A. KNEESE & B. BOWER, MANAGING WATER QUALITY 126-29 (1968) (estimating loss in recreational benefits caused by water pollution).

14. Tietenberg, *supra* note 3, at 395.

15. *See infra* pp. 810, 812.

16. If the marginal costs of abatement for the various polluters are different, and the impact on environmental quality of one unit of discharge from those polluters is equal, the overall cost of achieving a standard can be reduced by shifting one unit of pollution from a high cost to a low cost polluter.

17. In this section, the total cost of pollution control is taken to be the sum of the abatement costs of individual polluters. This approach disregards the effects of pollution control on consumer surplus, and producers' profits that result from changing product mix and output levels. Assumptions of this type are common in economic analysis. *See, e.g.*, Baumol & Oates, *The Use of Standards and Prices for Protection of the Environment*, 73 SWEDISH J. ECON. 42, 52-53 (1971) (ignoring consumer surplus effects); Montgomery, *Markets in Licenses and Efficient Pollution Control Programs*, 5 J. ECON. THEORY 395, 398 (1972) (prices of inputs and outputs not associated with pollution unaffected by measures undertaken to control pollution).

18. The effect of a discharger's impact on environmental quality is determined through the use of a diffusion matrix, which relates the level of discharges released at a polluter's source point to pollutant concentrations at receptor points. *See, e.g.*, Cleveland Elec. Illuminating Co. v. EPA, 572 F.2d 1150, 1160 (6th Cir.), *cert. denied*, 439 U.S. 910 (1978) (describing use of Real-Time Air-Quality Simulation Model to predict plants' effect on ambient pollution); Ackerman & Sawyer, *The Uncertain Search for Environmental Policy: Scientific Factfinding and Rational Decisionmaking Along the Delaware River*, 120 U. PA. L. REV. 419, 436-71 (1972) (discussing effect of biochemical oxygen

pollution.[19] Perfect cost minimization would require estimates of the impact of every discharge source on ambient quality at an infinite number of receptor points. In practice, however, the effect of sources in a given region can be spatially aggregated[20] and compliance with ambient standards can be measured or modeled at only a few receptor points.

B. *The Problems of a Pure Technology-Based Scheme*

Setting emission[21] and effluent[22] standards solely on the basis of available technology without taking into account the costs of compliance will not minimize the costs of achieving ambient standards. Under both the CAA

demand on dissolved oxygen in a stream); Montgomery, *supra* note 17, at 397 (modeling contribution of source emitting nonreactive atmospheric pollutants to pollutant concentration at receptor points).

19. The cost minimization condition can be stated mathematically. Assume that the abatement cost function of a firm at point i discharging pollutants at a level e_i is $C_i(e_i)$. The impact of a discharge e_i on receptor point j is $h_{ij}e_i$, where h_{ij} is a diffusion matrix. The ambient standard at point j is s_j. Then, the cost minimization problem may be stated as

$$\text{Min} \sum_i C_i(e_i)$$

$$\text{s.t.} \sum_i h_{ij}\, e_i \geq s_j \qquad j=[1, \ldots, m]$$

$$e_i \geq 0$$

The Lagrangian function $L(e_1, \ldots, e_n) =$

$$\sum_i C_i(e_i) - \sum_j u_j \sum_i (h_{ij}\, e_i - s_j)$$

where the u_j, $j = 1, \ldots, m$, are Lagrange multipliers. With e_i positive at the optimum, differentiating with respect to e_i leads to the first order conditions for cost minimization:

$$MC_i - \sum_j u_j\, h_{ij} = 0$$

where $MC_i = dC_i/de_i$ is the marginal cost of abatement of firm i.

20. Source points are aggregated by adding, for each pollutant, the emissions of each source in a given region. *Cf.* Tietenberg, *Spatially Differentiated Air Pollutant Emission Charges: An Economic and Legal Analysis*, 54 LAND ECON. 265 (1978) (defining optimal spatial aggregation for effluent fee pollution control system).

21. Under the CAA, EPA sets technology-based emission limitations for new stationary sources and for modifications and reconstructions of existing sources. 42 U.S.C. § 7411 (Supp. III 1979); 40 C.F.R. § 60.15 (1981). These limitations reflect "the degree of emission reduction achievable through the application of the best system of continuous emission reduction . . . ." 42 U.S.C. § 7411(a)(1)(C). In PSD areas, new facilities are subject to stricter technology-based emission limitations. 42 U.S.C. § 7475(a)(4). In addition to these limitations, power plants fired by fossil fuels must achieve a given percentage reduction in emissions over the levels that would have resulted had such fuels not been treated prior to combustion. 42 U.S.C. § 7411(a)(1)(A)(ii).

22. The FWPCA imposes technology-based effluent standards on both existing sources, 33 U.S.C. § 1311 (1976 & Supp. III 1979), and new sources, 33 U.S.C. § 1316 (1976). Since 1977, existing sources have had to meet effluent levels determined by the "best practicable control technology currently available." 33 U.S.C. § 1311(b)(1)(A) (1976). After 1983, this level will be determined by reference to the "best available technology economically achievable." 33 U.S.C. § 1311(b)(2)(A) (Supp. III 1979). New sources must meet a standard determined by the "best available demonstrated control technology." 33 U.S.C. § 1316(a)(1) (1976).

and the FWPCA, however, the costs of compliance are to be considered in setting emission and effluent standards.[23] The consideration of costs could, in theory, lead to a crude equalization of marginal costs in a system in which technology-based emission and effluent standards were the sole means of achieving ambient environmental quality standards. But the current statutory framework, case law, and administrative practice would preclude cost-effective outcomes even in such a system.[24]

1. *Static Analysis*

The CAA and the FWPCA technology-based standards would not promote cost-effective allocations in the short-run, even if they were the sole means of achieving ambient standards.[25] First, these emission and effluent standards are set in the absence of inter-industry cost comparisons.[26] There is thus no explicit mechanism for transferring the pollution abatement burden from an industry with high marginal costs of compliance to

23. Under the CAA, costs must be considered setting all new source performance standards. 42 U.S.C. § 7411(a)(1)(C) (Supp. III 1979). Under the FWPCA, the effluent limitations for existing sources that will apply after 1983 will have to be "economically achievable." 33 U.S.C. § 1311(b)(2)(A) (Supp. III 1979). Similarly, standards of performance for new sources must "take into consideration the cost of achieving such effluent reduction." 33 U.S.C. § 1316(b)(1)(B) (1976). The FWPCA, however, does not provide for an explicit consideration of costs for pre-1983 standards for existing sources. *See* 33 U.S.C. § 1311(b)(1)(A). Under existing case law, however, costs are taken into account in setting such standards. CPC Int'l v. Train, 540 F.2d 1329, 1341 (8th Cir. 1976), *cert. denied*, 430 U.S. 966 (1977); American Iron & Steel Inst. v. EPA, 526 F.2d 1027, 1051 (3d Cir. 1975).

During the House debates on the CAA Amendments of 1970, Representative Ryan proposed that costs of compliance be ignored: "[T]he threat to our environment is so great that, as a matter of public policy, industry should be required to use the most advanced technology regardless of whether or not a particular industry finds it economically feasible." 116 CONG. REC. 19,242 (1970); *see* Portland Cement Ass'n v. Ruckelshaus, 486 F.2d 375, 387 n.47 (D.C. Cir. 1973), *cert. denied*, 417 U.S. 921 (1974) (quoting Representative Ryan). His proposal was rejected. 486 F.2d at 387 n.47.

24. Empirical studies show that the pollution allocations which result from the use of technology-based standards depart significantly from least-cost solutions. *See* Freeman, *supra* note 4, at 56 & n.42. The National Commission on Water Quality estimates that 30-35% of the cost of water pollution control could be saved by the adoption of a cost-minimizing program. Earlier studies estimated these savings at 100-200%. *Id.*

25. Such standards do not promote efficient allocations either. *See supra* pp. 793-94 (distinguishing between cost effectiveness and efficiency). Courts have not required application of cost-benefit tests aimed at efficiency. According to one court, cost-benefit analysis is not required under the CAA because "such a requirement would conflict with the specific time constraints imposed on the administrator," and could not be easily implemented given "[t]he difficulty, if not impossibility, of quantifying the benefits to ambient air conditions." Portland Cement Ass'n v. Ruckelshaus, 486 F.2d 375, 387 (D.C. Cir. 1973), *cert. denied*, 417 U.S. 921 (1974) (footnote omitted). Similarly, a cost-benefit analysis is not required in setting effluent standards for either new or existing sources. CPC Int'l v. Train, 540 F.2d 1329, 1341 (8th Cir. 1976), *cert. denied*, 430 U.S. 966 (1977); American Meat Inst. v. EPA, 526 F.2d 442, 462-63 (7th Cir. 1975); American Iron & Steel Inst. v. EPA, 526 F.2d 1027, 1059 (3d Cir. 1975).

26. "Inter-industry [cost] comparisons . . . are not generally required, or even productive; and they were not contemplated by Congress in . . . [the Clean Air] Act." Portland Cement Ass'n v. Ruckelshaus, 486 F.2d 375, 389 (D.C. Cir. 1973), *cert. denied*, 417 U.S. 921 (1974). Similarly, the FWPCA contains no provision for inter-industry cost comparisons, and these comparisons have not been required by the courts.

one with lower costs.[27] Indeed, as a matter of policy, the EPA may impose stricter regulations on industries with greater financial resources.[28] While this practice may protect sources of employment, it precludes even an approximate equalization of marginal costs, unless it is assumed that industries with greater financial resources also have lower marginal costs of pollution abatement. There is, however, no evidence to support that assumption.

Second, standards are set for categories or classes of polluters;[29] they are not tailored to individual processes and abatement cost functions. Given the variety of such processes,[30] uniform regulations probably impose highly unequal costs of compliance. The pernicious effects of this regulatory approach are particularly severe under section 301 of the FWPCA,[31] which sets uniform effluent standards for plants of widely different ages.[32]

27. *See supra* note 16.

28. L. LAVE, THE STRATEGY OF SOCIAL REGULATION 14 (1981); *cf.* Portland Cement Ass'n v. Train, 513 F.2d 506, 508 (D.C. Cir.), *cert. denied*, 423 U.S. 1025 (1975) (where costs of meeting standards would be greater than industry could bear and survive, such standards could not be implemented by industry regardless of technological feasibility).

29. Under the CAA, new source performance standards are set for categories of stationary sources, and establish "allowable emission limitations for such category of sources." 42 U.S.C. § 7411(a)(1)(A) (Supp. III 1979). To date, the EPA has set NSPSs for 34 categories of sources. *See* 40 C.F.R. §§ 60.40-60.424 (1981). The first subsection of each NSPS defines the "affected facilities," *see* 40 C.F.R. § 60.2 (1981), that is, the types of installations to which each standard applies. For example, the standards of performance for lime manufacturing plants affect all lime kilns and lime hydrators, but do not affect facilities used to manufacture lime at kraft pulp mills. *See* National Lime Ass'n v. EPA, 627 F.2d 416, 426-27 (D.C. Cir. 1980); 40 C.F.R. § 60.340 (1981).

Under the FWPCA, the EPA has the authority to limit discharges by existing plants through industry-wide regulations setting forth uniform effluent limitations. E. I. du Pont de Nemours & Co. v. Train, 430 U.S. 112, 126-36 (1977). This case clarifies an important ambiguity in the statutory language. While 33 U.S.C. § 1311(b)(2)(A) (Supp. III 1979) states that the post-1983 effluent limitations for "*categories and classes* of point sources" will be achieved through the "application of the best available technology economically achievable for *such category or class*," 33 U.S.C. § 1311(b)(1)(A) (1976) speaks of pre-1983 "effluent limitations for *point sources*" (emphasis added). Despite the difference in the language, the Court found that "[n]othing elsewhere in the Act . . . suggests any radical difference in the mechanism used to impose limitations for the 1977 and 1983 deadlines," 430 U.S. at 127, and upheld industry-wide pre-1983 regulations, *id.* at 136. The Court noted, however, that some allowance had to be made for "variations in individual plants." *Id.* at 128. Subsequently, the D.C. Circuit rejected a broad reading of this variance requirement. *See* Weyerhaeuser Co. v. Costle, 590 F.2d 1011, 1031 (D.C. Cir. 1978).

In setting FWPCA standards for new sources, the EPA must publish a list of categories of sources and establish standards of performance in each category. 33 U.S.C. § 1316(b)(1)(B) (1976). While EPA "may distinguish among classes, types, and sizes within categories of new sources," 33 U.S.C. § 1316(b)(2), it may not provide variances in setting pre-1983 effluent standards. *Du Pont*, 430 U.S. at 138-39.

30. If the categories used were reasonably narrow, the setting of standards for categories of sources could be seen as a tradeoff between the compliance costs of individual polluters and the transaction costs of setting individualized standards. The breadth of the categories, however, suggests that the EPA made no such tradeoff evaluation. *Cf.* 40 C.F.R. § 60.60 (1981) (same § 111 standards apply to all types of portland cement plants).

31. 33 U.S.C. § 1311 (1976 & Supp. III 1979).

32. In setting pre-1983 effluent standards, the EPA does consider "age and size of plant . . . energy requirements and costs," but it allows a discharger to secure a permit containing less stringent limitations than those promulgated for his "class" only if he can show "that factors related to the

Third, standards are geographically uniform.[33] This uniformity does not interfere with the equalization of marginal costs at source points, but it precludes a cost-effective allocation of the pollution burden because the impact of a given discharge depends on meteorological factors, topography, and other physical parameters specific to the discharge points.[34]

Thus, technology-based standards preclude a cost-effective allocation scheme among polluters, even though the costs of compliance are considered when these standards are set. In addition, the economic tests applied to measure the costs of these standards—the "exorbitantly costly" test[35] and the "reasonable relation" test[36]—are not designed to yield cost-effective results. The "exorbitantly costly" test constrains the overall economic effect of regulations on an industry by ruling out standards that would impose grave hardships on affected parties.[37] While it protects weak sectors of the economy, it probably does nothing to eliminate the unnecessary costs of compliance with ambient standards.

The "reasonable relation" test is applied by comparing the costs and benefits of abatement, and requiring, in some cases,[38] that the cost of abatement not be "grossly disproportionate" to the corresponding benefit. A simple comparison of cost and pollution reduction yields a ratio, cost per unit of pollution reduction, that represents a polluter's average cost of abatement. Average cost comparisons, however, do not promote cost-minimizing allocations unless the marginal costs of pollution abatement are constant,[39] and typically, marginal costs increase as pollution abatement

equipment or facilities involved, the process applied, or *other such factors* related to such discharger are *fundamentally different* from the factors considered in the establishment of the guidelines." Weyerhauser Co. v. Costle, 590 F.2d 1011, 1038 (D.C.Cir. 1978).

33. *See* 33 U.S.C. §§ 1311, 1316 (1976 & Supp. III 1979); 42 U.S.C. § 7411 (Supp. III 1979).

34. *See infra* pp. 810-12.

35. *See, e.g.*, CPC Int'l v. Train, 540 F.2d 1329, 1343-44 (8th Cir. 1976), *cert. denied*, 430 U.S. 966 (1977) (FWPCA); Portland Cement Ass'n v. Train, 513 F.2d 506, 508 (D.C. Cir.), *cert. denied*, 423 U.S. 1025 (1975) (CAA); Essex Chem. Corp. v. Ruckelshaus, 486 F.2d 427, 433 (D.C. Cir. 1973), *cert. denied*, 416 U.S. 969 (1974) (same).

36. *See* Portland Cement Ass'n v. Train, 513 F.2d 506, 508 (D.C. Cir.), *cert. denied*, 423 U.S. 1025 (1975) (EPA should not require gross disproportion between costs and achievable reduction in emissions).

37. *See* National Lime Ass'n v. EPA, 627 F.2d 416, 433 (D.C. Cir. 1980) (tests used to determine CAA technology-based emission standards should provide "some assurance of the achievability of the standard for the industry as a whole, given the range of variable factors found relevant to the standards' achievability"); CPC Int'l v. Train, 540 F.2d 1329, 1342 (8th Cir. 1976), *cert. denied*, 430 U.S. 966 (1977) (requiring thorough study of initial and annual costs of meeting FWPCA standards and affirmative conclusion that costs can be "reasonably borne" by industry). The "exorbitantly costly" test, however, is not violated, at least under the FWPCA, when a marginal firm within an industry has to close down due to the cost of pollution abatement requirements. Weyerhaeuser Co. v. Costle, 590 F.2d 1011, 1036-37 (D.C. Cir. 1978) (Congress authorized EPA to impose effluent restrictions might shut down paper mills).

38. *See* Portland Cement Ass'n v. Train, 513 F.2d 506, 508 (D.C. Cir.), *cert. denied*, 423 U.S. 1025 (1975).

39. When marginal costs are constant, average costs and marginal costs are equal.

requirements are made more stringent.[40]

In other cases,[41] the "reasonable relation" test requires that the marginal costs of additional abatement not be "grossly disproportionate" to the benefits obtained. In this formulation, the test resembles an efficiency test. The condition for true efficiency, however, is met only when marginal costs are actually equal to marginal benefits.[42] More importantly, an efficiency test is inappropriate. In a mixed system in which ambient standards are set independently of economic considerations, a regulator setting standards for source points should be concerned with cost-effectiveness, not with efficiency; cost-effectiveness requires only that the regulator allocate, among different polluters, the costs of achieving a benefit, which is fixed by the ambient standards.[43] To make this allocation, the regulator needs to consider only marginal costs, not benefits.[44]

2. *Dynamic Analysis*

It is conceivable that a pollution abatement program that is not cost-effective in the short run could produce least-cost long-term results by forcing the development of superior abatement technology, and thereby minimizing the aggregate long-term costs of compliance with environmental regulations.[45] To the extent that technology-based standards under the CAA and the FWPCA have required polluters to reduce their emission and effluent levels, these standards have forced the introduction of previously unused technology.[46] Technology-based standards are not, however, an effective means of forcing technological innovation.[47] Because the introduction of new abatement technologies gives regulators a justification for

40. *See, e.g.*, W. BAUMOL & W. OATES, *supra* note 13, at 213-14 (1979); Dewees, *The Costs and Technology of Pollution Abatement*, in APPROACHES TO CONTROLLING AIR POLLUTION 291, 298-99 (A. Friedlaender ed. 1978).

41. *See* CPC Int'l v. Train, 540 F.2d 1329, 1341 (8th Cir. 1976), *cert. denied*, 430 U.S. 966 (1977).

42. *See supra* p. 793.

43. *See supra* pp. 793-94 (distinguishing between efficiency and cost-effectiveness).

44. If the ambient standards satisfy efficiency conditions, a cost-benefit analysis will identify the cost-effective allocation of the pollution abatement burden. *See supra* p. 794 (establishing converse proposition, that is, conditions under which cost-minimizing allocations are efficient).

45. *See* A. KNEESE & C. SCHULTZE, POLLUTION, PRICES AND PUBLIC POLICY 82 (1975) ("Over the long haul, perhaps the most important single criterion on which to judge environmental policies is the extent to which they spur new technology toward the efficient conservation of environmental quality.")

46. *See, e.g.*, B. ACKERMAN & W. HASSLER, CLEAN COAL/DIRTY AIR 11, 15-16 (1981) (new source performance standards for coal-fired power plants have forced the introduction of scrubbers); Note, *Forcing Technology: The Clean Air Act Experience*, 88 YALE L.J. 1713 (1979) (describing technology-forcing in copper smelting and electric power plants).

47. Comparing such standards to standards not based on technology, effluent charges, sale of pollution permits and subsidies, one commentator concludes that technology-based standards "provide the weakest incentives for . . . abatement technology . . . innovation." Magat, *The Effects of Environmental Regulation on Innovation*, 43 LAW & CONTEMP. PROBS. 4, 21 (1979).

imposing new and potentially more costly pollution control standards, firms have a strong disincentive to develop such technologies.[48]

The only way in which technology-based standards spur innovation is by creating an expanded market for a firm's successful innovation.[49] But the inherent difficulty in appropriating the benefits of new abatement technology, and the lag between the discovery of such technology and its incorporation into regulatory standards, make it unlikely that this incentive will outweigh the powerful disincentive for abatement technology innovation.[50]

C. *The Current Mixed System*

Currently, technology-based standards are only one of the means used under the CAA and the FWPCA to achieve ambient standards. An economic assessment of technology-based standards in this mixed system requires the consideration of a number of factors not relevant to the examination of a pure technology-based scheme.

1. *Setting Air Quality Standards*

Under the CAA, two independent decisionmakers regulate emissions in each air quality control region:[51] the EPA establishes geographically uniform limitations for new sources in the technology-based new source performance standard (NSPS) program,[52] and each state sets individualized

48. A. KNEESE & C. SCHULTZE, *supra* note 45, at 82-83; Ayres, *Enforcement of Air Pollution Controls on Stationary Sources under the Clean Air Act Amendments of 1970*, 4 ECOLOGY L.Q. 441, 476 (1975); Freeman, *supra* note 4, at 57; La Pierre, *Technology-Forcing and Federal Environmental Protection Statutes*, 62 IOWA L. REV. 771, 774 & n.17 (1977); *cf.* Mills & White, *Government Policies Toward Automotive Emissions Control*, in APPROACHES TO CONTROLLING AIR POLLUTION 348 (A. Friedlaender ed. 1978) (incentives for private parties to develop methods for controlling automobile emissions have been badly distorted).

Technology-based standards not only fail to force new technology, they can also produce negative results if they are improperly implemented. First, if their lead times are too short, they will "force" the introduction of quick, costly technologies that have a high probability of success, thus locking in potentially inferior technologies. Second, if the EPA fails to prosecute those who adopt the technology relied on by the agency when it sets the standards, but who do not meet the prescribed emission or effluent standards, it will eliminate incentives for changes in a firm's production technology that could lead to lower emissions but that might make prosecution more likely if the standards are not met. *See* Freeman, *supra* note 4, at 56 (while firms can use alternative technologies to meet effluent standards, enforcement incentives lead them to install technology suggested by EPA). Third, if the standards are also coupled with special requirements, they will further discourage technological innovation. *See* B. ACKERMAN & W. HASSLER, *supra* note 46, at 32 n.19 (percentage treatment requirement for coal-fired power plants discourages development of technologies that meet emission standard but fail to meet specified levels of percentage reduction).

49. Magat, *supra* note 47, at 18.

50. *Id.*

51. The EPA can designate as an air quality control region "any interstate area or major intrastate area which [it] deems necessary or appropriate for the attainment and maintenance of ambient air quality standards." 42 U.S.C. § 7407(c) (Supp. III 1979).

52. *See* 42 U.S.C. § 7411 (Supp. III 1979).

limitations for existing sources in a state implementation plan (SIP).[53] The CAA does not require any comparison of the emission reduction costs for new and existing sources.[54]

This regulatory structure, with its two independent decisionmakers, cannot be cost-effective because there is no adjustment mechanism enabling regulators to amend emission standards when the allocation of the costs of reducing pollution departs from the cost-minimizing solution. The EPA cannot perform this adjustment because it is required to impose geographically uniform NSPS standards.[55] Since the effects of pollution vary geographically,[56] the EPA cannot match the marginal costs of abatement for new sources with the marginal costs of abatement for existing sources.

States are also limited in their ability to set cost-effective emission standards. Pursuant to section 116 of the CAA,[57] states may adopt emission standards for new sources that are more stringent than the NSPSs set by the EPA.[58] Thus, if the marginal costs of compliance are systematically lower for new sources than for existing sources, states can seek to attain cost-effective solutions within their jurisdictions by setting more stringent standards for new sources.[59] But because they do not have the statutory authority to adopt emission standards for new sources less stringent than those imposed by the EPA, states cannot set cost-effective standards when new source marginal costs are not systematically lower than those of existing sources. And when new source marginal costs are systematically higher than those of existing sources, states cannot reduce the unnecessary costs of compliance at all.

In practical terms, section 116 does little to reduce long-term costs. First, empirical evidence suggests that the marginal costs of compliance are typically higher for new sources.[60] Second, since the EPA sets NSPSs at frequent but irregular intervals,[61] attempting to adjust marginal costs would be a continuous and administratively impractical process. Third, states that set standards for new sources more stringent than NSPSs place

53. 42 U.S.C. § 7410 (Supp. III 1979). SIP limitations are not technology-based.

54. The FWPCA also imposes different standards on new and existing sources. *Compare* 33 U.S.C. § 1311, 1316 (1976 & Supp. III 1979) (existing sources) *with* 33 U.S.C. § 1316 (1976) (new sources). But since both sets of standards are imposed by a single decision-maker, the EPA, an explicit comparison of emission reduction costs for new and existing plants could be performed.

55. *See* 42 U.S.C. § 7411(b)(1) (Supp. III 1979).

56. *See infra* pp. 810-11.

57. 42 U.S.C. § 7416 (Supp. III 1979).

58. If an NSPS is in effect, a state "may not adopt or enforce any emission standard or limitation which is less stringent than the standard or limitation under such plan." 42 U.S.C. § 7416 (Supp. III 1979).

59. If marginal costs were systematically lower for new sources, and states did, as a result, make cost-effective adjustments under § 116 for all new sources, there would be effectively one regulator rather than two, a unitary sytem rather than a mixed system.

60. *See* B. ACKERMAN & W. HASSLER, *supra* note 46, at 67.

61. *See* 40 C.F.R. §§ 60.40-.424 (1981).

themselves at a disadvantage in attempting to attract new industry.[62]

2. *Setting Water Quality Standards*

The mixed scheme of the FWPCA is economically undesirable for different reasons. Unlike the CAA, the FWPCA relies on technology-based standards as its primary mode of regulation for both new and existing plants.[63] Adjustments to effluent levels for existing sources are made, pursuant to section 301(b)(1)(C)[64] or 302,[65] only when the resulting water quality fails to meet preestablished ambient standards. The FWPCA scheme is thus closer than the CAA scheme to a pure technology-based system. It still differs from such a system, however, since adjustments result in effluent standards more stringent than the technology-based standards for comparable sources.

These adjustments are not performed in a cost-effective manner. Under section 301(b)(1)(C) there is no mechanism for even attempting a cost-effectiveness analysis.[66] Adjustments under section 302 cannot be implemented if a party affected by the stricter effluent limitation shows that "there is no reasonable relationship between the economic and social costs and the benefits to be obtained."[67] But such a cost-benefit test is inappropriate in this context; it will not yield a cost-effective allocation, or even a cost-effective adjustment. A consideration of benefits in applying section 302 might shed some light on whether the water quality standards are efficient.[68] It could also justify a decision that water quality standards

62. *See infra* pp. 806-08.

63. 33 U.S.C. § 1311(b)(1)(A) (1976) (pre-1983 standards for existing sources); 33 U.S.C. § 1311(b)(2)(E) (Supp. III 1979) (post-1983 standards for existing sources); 33 U.S.C. § 1316 (1976) (new source standards).

64. 33 U.S.C. § 1311(b)(1)(C) (1976). Under this provision, more stringent effluent limitations are adopted when necessary to "meet water quality standards, treatment standards, or schedules of compliance" established under state or federal laws or regulations. *Id.*; *see* Porter County Chapter of Izaak Walton League v. Costle, 571 F.2d 359 (7th Cir.), *cert. denied*, 439 U.S. 834 (1978) (federal standards); Homestake Mining Co. v. EPA, 477 F. Supp. 1279 (D.S.D. 1979) (state standards). These water quality standards are proposed by the states and approved by the EPA. 33 U.S.C. § 1313(a)(1) (1976). If the EPA does not approve the state proposals, and the state refuses to accept the EPA's recommendations, the agency can promulgate its own standards. *Id.*; *see* Mississippi Comm'n on Natural Resources v. Costle, 625 F.2d 1269 (5th Cir. 1980).

65. 33 U.S.C. § 1312 (1976). Adjustments are made pursuant to this provision when the water quality obtained through the imposition of effluent limitations is not sufficient to attain the goals of the FWPCA. *See* Homestake Mining Co. v. EPA, 477 F. Supp. 1279, 1285 (D.S.D. 1979) (§ 302 applies only when implementation of effluent limitations interferes with attainment of federal "fishable/swimmable" goal); *see also* 33 U.S.C. § 1251(a) (1976) (setting out federal water quality goals).

66. Homestake Mining Co. v. EPA, 477 F. Supp. 1279, 1286 (D.S.D. 1979) ("[E]ffluent limitations are established by individual examination of the waterway and . . . [a] hearing . . . to consider costs . . . is not necessary.")

67. 33 U.S.C. § 1312(b)(2) (1976).

68. If the marginal costs of adopting stricter § 302 standards exceed the marginal benefits of higher water quality for all possible allocations of effluent discharges among polluters, those water quality standards are stricter than efficient ones. Conversely, if marginal benefits exceed marginal

should not be met if the cost of doing so is too high. But a cost-benefit test will not, in general, identify the least-cost way of meeting water quality standards.[69] Moreover, such a test is inadequate even as a measure of the efficiency of effluent standards. First, it does not evaluate the efficiency of the effluent limitation itself, but only the efficiency of the departure from the standards that would otherwise be in place. Second, it does not require an equalization of *marginal* costs and *marginal* benefits; a finding that total costs are not exorbitant when compared with total benefits probably satisfies the statutory requirements.[70]

II. Non-Economic Considerations

That technology-based standards do not promote the achievement of ambient standards at least cost does not, by itself, compel the conclusion that technology-based standards are undesirable under the current mixed system. Indeed, non-economic considerations should also play an important role in the choice of environmental policy. Despite the strong claims of supporters, however, technology-based standards are undesirable even from a non-economic standpoint. They are a poor means of supplementing ambient standards, they do not promote the equitable allocation of the pollution burden among states, and they do not ease enforcement problems.

A. *Additional Environmental Protection*

Supporters of the use of technology-based emission and effluent standards in conjunction with ambient standards argue that a mixed system provides greater environmental protection than ambient standards alone.[71] In addition, proponents of technology-based standards argue that such standards provide an additional margin of safety and prevent the deterioration of ambient quality in areas that surpass the minimum level mandated by the national ambient air quality standards (NAAQS).[72]

costs, social welfare could be increased through the implementation of more stringent standards.

69. A determination of cost-effectiveness depends solely on consideration of costs, not on a comparison of costs and benefits. *See supra* p. 799.

70. When similar tests have been applied under the CAA and the FWPCA, however, courts have found pollution control regulations invalid only in cases of gross disparities. *See supra* pp. 798-99.

71. Testimony of David G. Hawkins on Behalf of the National Clean Air Coalition Before the United States Senate Committee on Environment and Public Works 1 (June 2, 1981) (on file with *Yale Law Journal*); Ayres, *supra* note 48, at 470 & n.91.

72. Because they can provide some additional environmental protection, technology-based emission or effluent standards could be used to improve upon the efficiency of ambient standards. Indeed, if it could be determined that making a given ambient standard more stringent would increase social surplus, and if this ambient standard could not tightened because of political considerations, the additional protection provided by technology-based standards might be an acceptable way of increasing social surplus. Assuming that particular industries are concentrated in certain parts of the country, the EPA could impose relatively more stringent technology-based standards on industries located in areas

1. *Margin of Safety*

Former EPA Assistant Administrator David Hawkins claims that "as new well-controlled sources replace old ones," the NSPS program will promote "progress toward known environmental objectives beyond that provided by the ambient standards program."[73] Similarly, Senator Muskie, the sponsor of the CAA, views the technology-based effluent standards as objectives per se, and not as a means to achieve ambient water quality goals.[74]

Technology-based emission and effluent standards are, however, a haphazard means of providing an additional margin of safety. Because they do not limit the number of plants that can be built in areas that meet ambient standards, they do not provide any specific margin of safety in those areas.[75] Moreover, in areas that barely meet or do not meet ambient standards, technology-based standards provide no additional protection. Also, the existence of strict technology-based standards for new sources may allow states to amend their SIPs,[76] relaxing the emission standards for existing sources,[77] while still meeting ambient standards. This posture

in which ambient standards are too lax, thereby increasing social efficiency. There is, however, no evidence that technology-based standards are used to promote this efficiency objective.

73. Testimony of David G. Hawkins, *supra* note 71, at 4. According to Hawkins, the NSPS program provides a "safety net." *Id.* This safety net should not be confused with the margin of safety used in the determination of national primary air quality standards pursuant to § 109 of the CAA, 42 U.S.C. § 7409(b)(1) (Supp. III 1979). That statutory margin of safety is already incorporated into the ambient standard; the "safety net" is intended to provide still further protection.

74. Freeman, *supra* note 4, at 48-49. Given that the "fishable/swimmable" goals of the FWPCA, 33 U.S.C. § 1251(a)(2) (1976), will not come into effect until 1983, and that Homestake Mining Co. v. EPA, 477 F. Sup. 1279, 1284 (D.S.D. 1979), appears to be the only reported case in which the EPA had to include more stringent state water quality standards as part of a National Pollutant Discharge Elimination System (NPDES) permit, Muskie's characterization appears to be accurate. The legislative history of the FWPCA lends support to this view:

> [Section 301] clearly establishes that the discharge of pollutants is unlawful. Unlike its predecessor program which permitted the discharge of certain amounts of pollutants . . . this legislation would clearly establish that no one has the right to pollute—that pollution continues because of technological limits, not because of any inherent right to use the nation's waterways for the purpose of disposing of wastes.

S. REP. NO. 414, 92d Cong., 1st Sess. 42 (1971), *reprinted in* 1972 U.S. CODE CONG. & AD. NEWS 3668, 3709.

75. This inadequacy is implicitly acknowledged by Hawkins: "We will degrade our air quality unless we improve pollution reduction technology at least as fast as we grow." Testimony of David G. Hawkins, *supra* note 71, at 5.

76. SIPs can be amended with relative ease. *See* Train v. NRDC, 421 U.S. 60, 95 (1975) (revision will qualify for approval if it satisfies general requirements applicable to original implementation plans); Mission Indus., Inc. v. EPA, 547 F.2d 123, 125 (1st Cir. 1976) (same); 40 C.F.R. § 51.6(c) (1981) (same).

77. Such a policy was proposed in § 4 of the Energy Supply and Environmental Coordination Act of 1974, Pub. L. No. 93-319, 88 Stat. 256 (1974) (current version at 42 U.S.C. § 7410 (Supp. III 1979)), which encouraged states to loosen limitations for existing sources that might result in emission levels more stringent than those needed to meet NAAQS. *See* Ayres, *supra* note 48, at 469 n.88. *But cf.* Sierra Club v. Ruckelshaus, 344 F. Supp. 253, 254 (D.D.C. 1972), *aff'd sub nom.* Fri v. Sierra Club, 412 U.S. 541 (1973) (invalid to permit states to submit plans which allow pollution levels to rise to secondary ambient standard). In response to *Sierra Club*, Congress established the nondeteri-

could neutralize any environmental benefit that technology-based standards might otherwise have provided.

In fact, technology-based standards under the CAA may actually have perverse effects on ambient air quality. Ackerman and Hassler point out that by increasing the cost of constructing new plants, the NSPS program gives polluters an economic incentive to run their old plants longer than they might otherwise.[78] Since existing plants often pollute a great deal more than new plants, NSPSs that are too strict can thus increase, rather than decrease, total emissions.[79]

Thus, any additional protection that technology-based standards can provide in the short-run by controlling the level of discharges at a given plant will probably disappear in the long-run. If the present ambient standards do not provide sufficient environmental protection, the logical remedy is to modify those standards to provide additional safety. An established optimal margin is preferable to a random and ever-changing one.

2. *Preventing Enviromental Deterioration*

Related to the margin of safety argument is the argument that technology-based standards prevent the deterioration of areas whose ambient quality is better than that mandated by ambient standards.[80] This argument is reflected in the legislative history of the CAA,[81] and is further articulated by Judge McGowan in *National Asphalt Pavement Association v. Train.*[82]

oration provisions of the PSD program. 42 U.S.C. §§ 7470-7479 (Supp. III 1979). Following these amendments to the CAA, SIPs can once again allow pollutant levels to rise in non-PSD areas, and in PSD areas, provided that doing so does not lead to a violation of the allowable increments over emission levels. *See* 42 U.S.C. § 7473 (Supp. III 1979).

78. B. ACKERMAN & W. HASSLER, *supra* note 46, at 68 (discussing "old plant effect").

79. *Id.* For example, coal-fired utilities often produce between three and four times as much sulfur dioxide as new ones. Thus, "[e]ven if a small fraction of old plants are induced to stay on line for an extended period, the overall impact could be quite serious." *Id.* Ackerman and Hassler calculate that stricter 1977 NSPSs forcing all new plants to "scrub" emissions will cause the Midwest to impose 170,000 more tons of sulfur dioxide on the East than it would have under the previous NSPS. *Id. But see* Testimony of David G. Hawkins, *supra* note 71, at 8 (challenging Ackerman and Hassler's estimates of impact of "old plant effect").

80. *E.g.*, Ayres, *supra* note 48, at 470 (without technology-based emission standards, polluters might defile areas with better air quality than that required by NAAQS). Ayres points out, however, that PSD requirements would curb this tendency. *Id.* at 470 n.92.

81. The House Report stated that § 111 was enacted to "prevent the occurrence anywhere in the United States of significant new air pollution problems . . . ." H.R. REP. NO. 1146, 91st Cong., 2d Sess. 31, *reprinted in* 1970 U.S. CODE CONG. & AD. NEWS 5356, 5358. The Senate report presented a similar view: "Maintenance of existing high quality air is assured through provision for maximum control of new major pollution sources." S. REP. NO. 1196, 91st Cong., 2d Sess. 2 (1970). Senator Muskie, one of the bill's managers, stated that "[t]hose areas which have levels of air quality which are better than the national standards should not find their air quality degraded by the construction of new sources." 116 CONG. REC. 32,902 (1970).

82. "[T]he Clean Air Act, and section 111 in particular, was also designed to prevent new pollution problems, especially the deterioration of air quality in areas where existing air quality levels

Despite its initial acceptance, the nondeterioration argument is profoundly flawed. It should be clear that a program that limits the emissions of an individual polluter but does not limit the number of new sources that can be constructed in a given area does not guarantee any specific level of air quality in that area. Indeed, a high industrial growth rate will cause the deterioration of environmental quality despite the presence of strict technology-based standards.

The inability of the NSPS program to prevent significant deterioration was implicitly acknowledged by the EPA when it adopted Prevention of Significant Deterioration (PSD) regulations,[83] and by Congress when it added a specific PSD provision to the CAA.[84] The PSD program reflects Congressional recognition that despite the existence of technology-based standards, the adoption of more stringent ambient standards was necessary to prevent further environmental deterioration.[85]

B. *Equitable Allocation*

Although the geographical uniformity of technology-based standards is a significant impediment to the cost-effective achievement of ambient standards,[86] proponents of technology-based standards argue that uniformity promotes regional equity. In their view, it prevents states from competing for industry by adopting lax environmental standards for new plants.[87] This argument played a central role in the congressional debates that preceded the enactment of section 111 of the CAA.[88]

But geographically uniform technology-based standards do little to pre-

exceed the promulgated air quality standards." 539 F.2d 775, 783 (D.C. Cir. 1976).

83. 39 Fed. Reg. 42,510 (1974).

84. 42 U.S.C. §§ 7470-7479 (Supp. III 1979). The legislative history of the PSD amendments to the CAA also implies that § 111 is inadequate for preventing deterioration: "This section has been developed to provide clearer definition of the nearly decade-old policy . . . that significant deterioration of clean air must be avoided, and to provide more specific congressional guidance as to how this policy is to be implemented." H.R. REP. NO. 294, 95th Cong., 1st Sess. 103, *reprinted in* 1977 U.S. CODE CONG. & AD. NEWS 1182.

85. PSD "allowable increments" are ambient standards. *See supra* note 3; *infra* note 92.

86 *See supra* pp. 798, 801.

87. *E.g.*, Ayres & Doniger, *New Source Standard for Power Plants II: Consider the Law*, 3 HARV. ENVTL. L. REV. 63, 66 (1979).

88. The House Report explicitly stated that "[t]he promulgation of Federal emission standards for new sources . . . will preclude efforts on the part of States to compete with each other in trying to attract new plants and facilities." H.R. REP. NO. 1146, 91st Cong., 2d Sess. 3, *reprinted in* 1970 U.S. CODE CONG. & AD. NEWS 5358. This view was expressed once again in 1977, when Congress considered amendments to the CAA:

> The national new source best technology emission standards were thus intended to meet this need, to avoid situations in which industries could be lured to one State by relaxing emission standards or deadlines and away from other States with stricter standards. Similarly, such national standards requiring use of best practicable control technology were supposed to avoid favoring some areas of the country over others with respect to new sources.

H.R. REP. No. 294, 95th Cong., 1st Sess. 184, *reprinted in* 1977 U.S. CODE CONG. & AD. NEWS 1263.

vent situations in which environmental regulation systematically gives certain regions a comparative advantage over other regions. In the absence of ambient standards, a pure technology-based system allows every region to attract industry that can adhere to the prescribed technology-based standards, but favors those regions in which such standards can be met at a lower cost.[89] The current mixed system produces even more inequities. Technology-based emission and effluent standards merely control the discharges of a given source; they do not limit the number of sources that may be built in a region that meets ambient standards. Regions that barely meet, or do not meet,[90] ambient standards can attract new industry only at the expense of setting more restrictive standards for existing sources.[91] By contrast, regions with high environmental quality can compete more successfully for industry, because they can more easily accommodate new plants.[92]

89. A polluter facing different costs for the attainment of a uniform emission standard will, other things being equal, choose the location where these costs are lower. Thus, a definition of equity based on equal units of emissions rather than comparable costs systematically discriminates against states in which the relevant costs of meeting emission standards are high.

An interesting discussion of the blatant use of new source performance standards to promote regional protectionism is provided in B. ACKERMAN & W. HASSLER, *supra* note 46, at 44-48 (only unambiguous benefit gained by requiring all coal-fired plants to use scrubbers was protection of markets for high sulfur Eastern and Midwestern coal).

90. Under the CAA, a state that is eager to attract new industry but that barely meets ambient standards could amend its SIP to decrease the emissions of existing stationary sources. *See supra* note 77. In contrast, under the FWPCA, states may prescribe effluent standards stricter than those promulgated by the EPA only to attain a higher level of water quality. 33 U.S.C. § 1311(b)(1)(C) (1976). Thus, they may not impose stricter emission standards on existing sources for the sole purpose of setting aside a larger pollution budget for new sources.

In non-attainment areas (areas that do not meet at least one of the NAAQS), new plants may be constructed under the CAA only if the proposed source complies with an emission standard based on "lowest achievable emission rate," and if decreases in the emissions of existing sources are at least as great as the emissions of the new source. 42 U.S.C. § 7503 (Supp. III 1979).

91. It is true that in the absence of uniform NSPSs, such regions could be expected to compete for new industry by setting stringent standards for existing sources and comparatively lax standards for new sources. Existing plants are "captive"; their owners have substantial investments that cannot easily be moved. By contrast, plants still in the planning stage can be transferred from one region to another with relative ease. Hence, regions have an incentive to shift pollution control responsibility to old plants in order to attract new plants. While uniform NSPSs preclude this type of regional competition, other policies, including the market system proposed in this Note, *see infra* pp. 811-12, would also prevent regions that barely meet or do not meet ambient standards from attempting to compete for new plants at the expense of existing sources.

92. It is true that under the CAA, many regions with air quality that exceeds NAAQS are subject to additional PSD requirements. 42 U.S.C. § 7473 (Supp. III 1979). PSD provisions limit the allowable increase in the concentration of pollutants in "clean air" areas. These requirements are thus equivalent to ambient standards more stringent than the NAAQS. Until the entire PSD increment is used, however, even these tougher ambient standards do not act as constraints on regions meeting the NAAQS.

Under the FWPCA, regions with water quality that exceeds ambient standards are not subject to additional constraints. In fact, at present, few ambient standards act as environmental constraints. *See* La Pierre, *supra* note 48, at 807. Once the 1983 "fishable/swimmable" goal comes into effect, however, water quality considerations will constrain emission discharges in many streams. *See* Davis & Glasser, *The Discharge Permit Program under the Federal Water Pollution Control Act of 1972—Improvement of Water Quality through the Regulation of Discharges from Industrial Facili-*

The regional inequities that concerned Congress can be most easily eliminated by establishing more stringent ambient standards in regions that have the comparative advantage of a higher level of environmental quality. Inequities in the allocation of future pollution abatement burdens can be eliminated entirely if ambient standards are set so as to constrain the further deterioration of environmental quality in all regions.[93]

C. *Enforcement*

When Congress passed the CAA and the FWPCA, it believed their technology-based emission and effluent standards would ease the enforcement difficulties[94] encountered under previous pollution control laws,[95] which did not limit individual discharges. But from an enforcement standpoint, any allocation mechanism that specifies the maximum allowable discharges for each polluter is functionally equivalent.[96] In technology-based systems, as in approaches based on the auctioning of pollution permits or on command and control regulations, the enforcing agency must ensure that each polluter's discharges do not exceed permissible levels. Under an effluent fee approach, it must ensure that each polluter computes its fee on the basis of its total discharges. In each case, enforcement depends on monitoring discharge levels.

In practice, technology-based standards may seem to simplify enforcement. The National Commission on Water Quality found that "in many cases, the abatement [technology] which is *actually* being installed is equivalent to the suggested *technologies*, rather than being designed to meet the *limitations*."[97] Firms may reason that, even if they do not meet

ties, 2 FORDHAM URB. L. REV. 179, 223 (1974).

93. This approach has been followed by the PSD program. Ironically, the same House Report that hailed the equity benefits of technology-based standards, *see supra* note 88, conceded that

> [a]bandonment of a policy of prevention of significant deterioration will encourage flight of industry—and jobs—from areas where pollution levels are approaching or exceed the minimum Federal standards to cleaner areas . . . . There exists a strong incentive . . . for industry to "shop around" for States or localities with large clean air resources.

H. REP. NO. 294, 95th Cong., 1st Sess. 133, *reprinted in* 1977 U.S. CODE CONG. & AD. NEWS 1212 (emphasis omitted).

94. *See* EPA v. California *ex rel* State Water Resources Control Bd., 426 U.S. 200, 202-03 (1976) (difficult to enforce standards governing conduct of individual polluters under regulatory approach prior to 1972); Montgomery Envtl. Coalition v. Costle, 646 F.2d 568, 574 (D.C. Cir. 1980) (1972 amendments to FWPCA emphasize direct control of polluting sources); NRDC v. EPA, 478 F.2d 875, 885 (1st Cir. 1973) (effective enforcement of specific emission standards was primary goal of 1970 Clean Air Act Amendments); A. KNEESE & C. SCHULTZE, *supra* note 45, at 39; Ayres, *supra* note 48, at 451.

95. These previous control programs included: Air Quality Act of 1967, Pub. L. No. 90-148, 81 Stat. 485 (1967) (current version at 42 U.S.C. §§ 7401-7642 (Supp. III 1979)); Water Quality Act of 1965, Pub. L. No. 89-234, 79 Stat. 903 (1965) (current version at 33 U.S.C. §§ 1251-1376 (1976 & Supp. III 1979)).

96. *See* W. BAUMOL & W. OATES, *supra* note 40, at 308.

97. *See* Freeman, *supra* note 4, at 56.

effluent limitations, they will be free from EPA prosecution as long as they have adopted the technology used by the EPA in establishing the standards.[98] If the EPA does not bring enforcement actions against such firms, it will ease its enforcement burden, but only at the expense of improperly treating technology-based standards as design standards.[99] When applied according to the requirements of the law, technology-based emission and effluent standards are no easier to enforce than any other scheme that depends upon the monitoring of discharge levels.

III. Transferable Zoned Pollution Permits: An Alternative Means of Meeting Ambient Standards

As demonstrated in the preceding sections, under the CAA and the FWPCA, technology-based standards inhibit the achievement of ambient standards at least cost; they also fail to provide a desirable margin of safety, an equitable regional allocation of the pollution abatement burden, or any special enforcement advantages. The current mixed system of standard setting should therefore yield to a unitary policy that would achieve ambient standards at least cost.

Such a policy could be implemented through direct regulation, the impositon of effluent fees, or the transfer of pollution permits at prices determined by market transactions. Direct regulation, however, can only be cost-effective if the marginal cost functions of all polluters are known.[100] Similarly, setting cost-effective effluent fees[101] also requires knowledge of each firm's marginal cost functions.[102] It is, of course, possible to obtain this information by setting the fee at an arbitrary level, observing the response of polluters, and adjusting the tax until the desired level of dis-

98. *Id.* at 56-57.

99. Design standards, which specify the technology to be used, cannot be applied under the sections of the FWPCA relevant to this Note, and can only be employed under § 111 of the CAA when it is not feasible to prescribe a technology-based emission standard. 42 U.S.C. § 7411(h) (Supp. III 1979). *Cf.* Adamo Wrecking Co. v. United States, 434 U.S. 275, 286-87 (1978) (work practice standard is not emission standard).

100. W. BAUMOL & W. OATES, *supra* note 11, at 139.

101. Effluent fees have been advocated widely in the theoretical literature, especially in the context of water quality control. *See, e.g.*, Brill, Revelle, & Liebman, *An Effluent Charge Schedule: Cost, Financial Burden and Punitive Effects*, 15 WATER RESOURCES RESEARCH 993 (1979); Ferrar, *Progressive Taxation as a Policy for Water Quality Management*, 9 WATER RESOURCES RESEARCH 563 (1973); Upton, *Optimal Taxing of Water Pollution*, 4 WATER RESOURCES RESEARCH 865 (1968); *see also* D. DEWEES, ECONOMICS AND PUBLIC POLICY 133 (1974) (advocating effluent fees to control automobile emissions); Mills & White, *supra* note 48, at 385-400 (same). *But cf.* Rose-Ackerman, *Effluent Charges: A Critique*, 6 CANADIAN J. ECON. 512 (1973) (case for effluent fees has been overstated because of failure to analyze implementation complexities). Effluent fees have not been used in the United States for air or water quality control. W. BAUMOL & W. OATES, *supra* note 40, at 256, 263. A few European countries, however, have instituted pollution control systems based on fees. *Id.* at 256-58.

102. If geographical and inter-regional effects are ignored the optimal tax levied on a unit of discharge is the shadow price of the ambient standard. *See supra* pp. 794-95.

charges is attained.[103] This iterative procedure does not guarantee, however, that the desired standard will ever be achieved.[104] Moreover, even when a cost-effective equilibrium exists, the convergence to the desired solution may be extremely costly.[105] In contrast to both direct regulation and effluent fees, no knowledge of cost functions is required to set up markets for the transfer of pollution permits.[106] Because this strategy places specific limits on discharges, the desired ambient standard can be obtained without the costly iterations often needed to implement an effluent fee schedule.[107]

Ambient quality levels depend not only on the total amount of discharge but also on the geographical location of polluters.[108] For example, depending upon the degree of natural cleansing along the length of a river, a firm that emits waste into the upper parts of that river may do either more or less damage to the community than one that discharges the same amount of effluent downstream.[109] Similarly, a sulfur dioxide emission downwind from a mountain range will have an effect on a far wider area than a similar emission upwind from a physical barrier. Thus, a single market for pollution rights cannot ensure that ambient standards will be met at each point within the region defined by that market,[110] and is therefore inadequate as a strategy to combat local pollution.[111] Moreover, the trading of rights in a single market can lead to systematic trans-

103. W. BAUMOL & W. OATES, *supra* note 11, at 138.

104. Walker & Storey, *supra* note 13, at 100-01.

105. If many trials are required before convergence occurs, "it is likely that for long periods the standard will either be over-achieved, resulting in unnecessary expenditure, or under-achieved, resulting in environmental losses to society." *Id.* at 101. In addition, changes in the tax rate may "lock-in" inferior technologies by altering the relative desirability of available processes, "so that in the ex ante position a different technology would be adopted from the one actually installed; but in the ex post position the expected cost savings do not justify a shift." *Id.* at 103.

106. Rose-Ackerman, *Market Models for Water Pollution Control: Their Strengths and Weaknesses*, 25 PUB. POL'Y 383, 390 (1977).

107. *Id.*

108. W. BAUMOL & W. OATES, *supra* note 11, at 144-47; Rose-Ackerman, *supra* note 101, at 515; Rose-Ackerman, *supra* note 106, at 392.

109. W. BAUMOL & W. OATES, *supra* note 11, at 145. The upsteam emissions may be less damaging than those downstream if the upper part of the river is sufficiently unpolluted to permit natural processes to disperse or degrade a considerable portion of the wastes before anyone is affected by them. Conversely, if there is little natural cleansing of the upstream discharges, they may well be more costly to society than discharges into the lower parts of the river. *Id.*

110. Under the CAA, for example, the air quality within the "entire geographic" area of a state has to meet the NAAQS. 42 U.S.C. § 7407 (Supp. III 1979). *Cf.* United States Steel Corp. v. EPA, 605 F.2d 283, 293-94 (7th Cir. 1979), *cert. denied*, 444 U.S. 1035 (1980) (failure to meet ambient standard at monitoring point justified nonattainment designation for entire area).

111. A single market is adequate to combat the global effects of pollution, that is, effects brought about by changes in the composition of the atmosphere, since it can serve to limit the total level of discharges. Currently, a great deal of attention is focused on one such global problem, acid rain, *see* B. ACKERMAN & W. HASSLER, *supra* note 46, at 66, and a market solution based on the sale of permits has been proposed, *see* [1981] 12 ENV'T REP. (BNA) 837. The current ambient-based environmental policy, however, combats local, rather than global, effects of pollution. Tietenberg, *The Design of Property Rights for Air-Pollution Control*, 22 PUB. POL'Y 275, 281 (1974).

fers to one or more preferred locations, causing the ambient quality in those locations to deteriorate. The transfer of rights among emission locations can thus lead to a violation of ambient standards, even though the total quantity of pollutants emitted within the market area remains unchanged.

The shortcomings of a single rights market can be remedied through a zoned rights system. Under such a system, air and water space would be divided into a number of market regions. A prospective polluter would be required to purchase a quantity of pollution rights, determined by the magnitude of its impact on ambient quality. The polluter would be required to purchase such rights not only in the market region into which it planned to discharge pollution, but in all regions in which its discharges would affect ambient quality. The polluter's impact on ambient quality in each region would be computed through mathematical modeling of the physical processes involved. Such models are already employed,[112] and their accuracy can be expected to improve as their use becomes widespread.[113] As markets within each region reach a competitive equilibrium, the zoned rights scheme should result in the least-cost allocation of the pollution burden that is consistent with a given set of ambient standards.[114]

112. *See supra* pp. 794-95. For the sake of mathematical tractability, most theoretical studies assume a linear relationship between discharges and changes in ambient concentrations. *E.g.*, Montgomery, *supra* note 17, at 397; Tietenberg, *supra* note 111, at 288.

The air quality models upon which a zoned rights program would need to rely have come under considerable criticism, *see, e.g.*, Statement on Behalf of Ohio Power Co. Before EPA 3 (June 18, 1981) (on file with *Yale Law Journal*) (brief for administrative hearing) (effect of emissions on air quality in distant areas is poorly understood), but have been upheld by the courts, *see* Cleveland Elec. Illuminating Co. v. EPA, 572 F.2d 1150, 1161 (6th Cir.), *cert. denied*, 439 U.S. 910 (1978). The possible lack of reliability of these models is not a problem that affects zoned rights schemes alone. Indeed, the same models are currently employed to determine compliance with ambient standards. Statement on Behalf of Ohio Power Before EPA, *supra*, at 1.

113. *Cf.* 215 SCIENCE 881 (1982) (reporting first use in U.S. of trace element analysis to identify distant pollution sources).

114. The cost function of a firm at point *i* discharging pollutants at a level e_i is $C_i(e_i)$. The firm needs to possess a permit that sells in the market at a price p_j for each unit of discharge that reaches region *j*. The cost minimization problem for that firm may be stated as

$$\text{Min } C_i(e_i) + \sum_j p_j e_i h_{ij}$$

$$\text{s.t.} \quad e_i \geq 0$$

The first order conditions obtained by differentiating with respect to e_i are:

$$MC_i - \sum_j p_j h_{ij} = 0$$

where $MC_i = dC_i/de_i$ is the firm's marginal cost of abatement, and h_{ij} is a diffusion matrix. This condition is equivalent to the societal cost-minimization condition. *See supra* note 19. Thus, a marketable permit system can produce a cost-effective allocation.

Given the definition of costs employed in this Note, *see supra* note 17, it follows that the competi-

This scheme differs from other proposed zoned rights systems in that it can take into account not only the differences in a polluter's impact on environmental quality that result from its geographical position, but also the inter-regional effects of pollution that a polluter at a given location can control.[115] For example, by increasing its stack height a polluter will decrease the impact of a unit of discharge on pollutant concentration in the zones immediately adjoining the point of discharge, while it will increase the impact of such a unit on more distant zones.[116] A model that ignores these effects would lead to violations of ambient standards.

If universal compliance with ambient standards were required, a zoned rights scheme would require an infinite number of market regions, each of infinitesimal area. Otherwise, trading could lead to concentrations violating ambient standards. As the universal compliance requirement is relaxed, however, the permissible area of each zone increases. This relationship defines a tradeoff between the transaction costs of setting up markets for the sale of pollution rights and the environmental benefit of uniform ambient levels.[117] Defining optimal size for water or air quality regions is beyond the scope of this Note, but it is assumed that a significant degree of uniformity can be achieved without sacrificing, through increased transaction costs, the advantages of a market system.

A zoned rights scheme can probably be implemented without great difficulty. Indeed, one of its two major components, a permit system, is

tive equilibrium reached under a zoned rights scheme will result in the cost-minimizing allocation.

115. Under Montgomery's pollution license scheme, *see* Montgomery, *supra* note 17, dischargers purchase rights to cause a specified level of ambient pollution. The effect of a unit of emission at a source point on ambient quality at receptor points is determined through the use of a diffusion matrix. Montgomery assumes that this diffusion matrix is an array of parameters over which the polluter has no control. *See id.* at 397-98. Thus, his model does not account for the inter-regional effects that a polluter can control.

Tietenberg proposes a scheme that relates discharges at any point to air quality in a zone that barely meets ambient standards. *See* Tietenberg, *supra* note 111. The quantity of emissions a firm may discharge depends both on the firm's location and on the number of rights it has purchased. This scheme is conceptually equivalent to Montgomery's.

Rose-Ackerman proposes dividing a river into reaches, allocating a fixed number of rights to each reach, and prohibiting rights transfers between zones. *See* Rose-Ackerman, *supra* note 106, at 392-93. This scheme is equivalent to Tietenberg's and Montgomery's only if the ambient standard acts as a constraint at all points in the river. If these standards are not constraining, the number of rights allocated to a given reach has to be recomputed each time an upstream polluter has an impact on that reach.

116. NATIONAL RESEARCH COUNCIL, SULFUR OXIDES 12 (1978) (tall stacks favor long-distance transport of emitted sulfur dioxide). Current law allows sources to emit a greater volume of pollutants if they use tall stacks. 42 Fed. Reg. 57,460 (1977). *But see* 42 U.S.C. § 7423 (Supp. III 1979) (credit for stack height ceases when height exceeds "good engineering practice," defined as 2.5 times the height of source). The incentive to use tall stacks aggravates the pollution problem in areas distant from pollution sources.

117. The transaction costs of setting up markets may be lower than the costs of promulgating technology-based standards. The setting of these standards requires that the regulator, in seeking to define the type of technology on which standards will be based, duplicate industry's search for pollution abatement technologies. This duplication is an inefficient use of scarce bureaucratic resources.

firmly entrenched in the regulatory structures of both the CAA and the FWPCA.[118] The other major component, market transactions, is already utilized to a limited extent under the CAA.[119]

Conclusion

A zoned pollution rights scheme should replace the current technology-based emission and effluent standards as the primary means for achieving CAA and FWPCA ambient standards. Because ambient standards already exist, cost-effective regulations can be implemented without provoking an acrimonious political and scientific debate over desirable environmental targets. While there may be compelling reasons to use technology-based standards to limit discharges of pollutants for which ambient standards have not been set,[120] there is little reason to use them in conjunction with ambient standards.

Both the CAA and the FWPCA may undergo substantial changes in the next few years.[121] In particular, the EPA is apparently considering placing more emphasis on ambient water quality goals.[122] As long as ambient standards are the focus of air and water quality regulation, market strategies such as the one proposed in this Note should be seriously considered as cost-effective means for achieving those standards.

118. Effluent discharges under the FWPCA are enforced by means of NPDES permits. NRDC v. Costle, 568 F.2d 1369, 1374-75 (D.C. Cir. 1977); 33 U.S.C. § 1342 (a) (1976). The CAA contains a similar enforcement strategy. *See* 42 U.S.C. §§ 7410(a)(2)(D), 7475(a)(1) (Supp. III 1979); Roberts & Farrell, *The Political Economy of Implementation*, in APPROACHES TO CONTROLLING AIR POLLUTION 160 (A. Friedlaender ed. 1978).

119. *See* R. STEWART & J. KRIER, ENVIRONMENTAL LAW AND POLICY 494-95 (2d ed. 1978) (offset policy creates market in pollution rights giving existing sources incentive to reduce emissions and sell right to pollute to new sources); Calvo y Gonzalez, *Markets in Air: Problems and Prospects of Controlled Trading*, 5 HARV. ENVTL. L. REV. 377, 399-404 (offsets, banking and bubble concepts create markets in pollution rights); Freeman, *supra* note 4, at 39 (same).

120. For example, toxic pollutants are regulated solely by means of technology-based standards. 33 U.S.C. § 1317(a) (Supp. III 1979) (water quality); 42 U.S.C. § 7412 (Supp. III 1979) (air quality). It may be inappropriate to attempt to define ambient standards for toxic pollutants, since such standards define a maximum concentration level and permit concentrations below that level. *See* Tietenberg, *supra* note 3, at 396. If even minute concentrations of a toxic pollutant can cause appreciable health damage, no concentration level may be acceptable. Thus, this Note does not recommend that all technology-based standards be replaced by market rights schemes.

121. *See* AMERICAN ENTER. INST., *supra* note 6 (CAA revisions); [1981] 12 ENV'T REP. (BNA) 837 (FWPCA revisions). The General Accounting Office has recently proposed a market-based air pollution control scheme. UNITED STATES GEN. ACCOUNTING OFFICE, A MARKET APPROACH TO AIR POLLUTION CONTROL COULD REDUCE COMPLIANCE COSTS WITHOUT JEOPARDIZING CLEAN AIR GOALS (1982). This proposal, however, is flawed because it superimposes a market system on existing NSPS standards, *see id.* at 42, thereby ruling out cost-minimizing solutions in which the emissions of some polluters are higher than NSPS levels and adding the transaction costs of a market scheme to those of the existing technology-based system.

122. *Id.*