Strip Mining: A Policy Evaluation

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INTRODUCTION

Wide concern over the environmental injury associated with the strip mining of coal has caused Congress in the past several years to address itself to the task of formulating a national policy on this subject. On two occasions, Congress has passed bills to establish a comprehensive federal-state scheme for regulating strip mining which failed of enactment due to Presidential veto. Further legislative efforts in this area are highly likely.

At stake in the decision on national coal mining policy are a number of important values. Some have argued, for example, that only


1. Coal is not the only mineral subject to surface mining. (For a discussion of the terms "strip mining" and "surface mining" see note 13 infra.) Sand, gravel, stone, clay, and iron are other materials associated with substantial amounts of such mining. See U.S. DEP'T OF THE INTERIOR, SURFACE MINING AND OUR ENVIRONMENT 39-43 (1967) [hereinafter cited as SURFACE MINING]. However, coal surface mining is responsible for the largest amount of land disturbance and also has certain features tending to create especially serious environmental problems, such as acid contamination of water (see text accompanying notes 26-29 infra). In any event, because of the substantial differences perceived between coal and other types of surface mining, major recent Congressional legislation has dealt almost exclusively with the former. See HOUSE COMM. ON INTERIOR & INSULAR AFFAIRS, SURFACE MINING CONTROL AND RECLAMATION ACT OF 1975, H.R. REP. NO. 94-45, 94th Cong., 1st Sess. 78-79 (1975) [hereinafter cited as H.R. REP. NO. 94-45]; S. REP. NO. 28, 94th Cong., 1st Sess. 223 (1975) [hereinafter cited as S. REP. NO. 28].

In this Comment the phrase "strip mining" will be used to refer only to the strip mining of coal.

2. For histories of recent Congressional bills, see H.R. REP. NO. 94-45, supra note 1, at 132-133; S. REP. NO. 28, supra note 1, at 192; G. SIEHL, THE ISSUES RELATED TO SURFACE MINING, S. SER. NO. 92-10, 92d Cong., 1st Sess. 16-17, 249-255 (Comm. Print 1971) [hereinafter cited as ISSUES].

3. S. 425, as reported by a House-Senate conference committee, H.R. REP. NO. 93-1522, 93d Cong., 2d Sess. (1974), was passed by both Houses of the Ninety-third Congress in December, 1974, and was pocket-vetoed. H.R. 25, as reported by a conference committee, S. REP. NO. 94-101, 94th Cong., 1st Sess. (1975) [hereinafter cited as H.R. 25], was passed by both Houses of the Ninety-fourth Congress in May, 1975, and was vetoed by the President on May 20, 1975. 1975 U.S. Code Cong. & Ad. News 786. Voting on June 10, 1975, the House of Representatives failed to override the veto. 121 CONG. REC. 5179-5205 (daily ed. June 10, 1975).

4. See note 37 infra.
by prohibiting all further strip mining can we avoid enormous environmental devastation, while others contend that placing stringent environmental controls on the activity would be needlessly costly and would lead to economic disruption and energy shortages. In the strip mining issue, as in many others, the nation is faced with the difficult problem of making a policy choice which affects multiple and competing interests in complex and imperfectly understood ways. The purpose of this Comment is to present an analysis of the strip mining policy problem which takes account of all of the major values at stake, critically examines the links between those values and policy alternatives, and explicitly identifies and applies a tenable set of evaluative principles in order to determine a preferred policy. The approach is one largely informed by economic thinking, but the intention is to avoid where possible the less defensible aspects of conventional "cost-benefit analysis."

After an introductory description of the nature of the strip mining issue, this Comment will develop the evaluative framework to be used and then analyze in detail the relationships between strip mining and the various social values connected with it. Later sections present the policy conclusions of this analysis as well as considerations going to the effective implementation of the suggested policy. Finally, these results are compared to the approach taken by recent Congressional legislation and recommendations are made for future lawmaking on the subject.

I

OVERVIEW OF THE STRIP MINING PROBLEM

Coal supplies about 17% of the nation’s total energy consumption.


and accounts for 55% of its electric power generation. Although coal's share of the energy market has been declining throughout this century, the future may bring a reversal of this trend. The "fundamental fact" is that "coal represents the largest, most accessible reserve of energy available within the continental United States."

Historically, coal has predominantly been extracted in underground, or deep, mines. In recent decades, however, improvements in earthmoving technology have made it economically increasingly attractive to mine by simply removing the layers of earth which overlie the coal, a method which is usually termed strip mining. While underground mining has stagnated or declined, strip mining, with its generally lower costs, has grown substantially, its output increasing from 108 million tons (24% of total coal production) in 1953 to 290 million tons (49% of total production) in 1973.

9. INDEPENDENCE, supra note 8, at 100. Of the approximately 600 million tons of coal produced in the United States in 1973, 387 million tons, or 64%, were used for power generation. The next largest use category is coking, mainly for steel manufacture, which accounted for 94 million tons. NCA, supra note 8, at 64.

10. INDEPENDENCE, supra note 8, at 99; NCA, supra note 8, at 59.


The reported size of United States coal reserves varies according to the assumptions used concerning economic and physical limits of recoverability, reliability of estimating techniques, etc. By several different definitions, coal reserves have been variously estimated at 390 billion tons, RISSER, supra note 7, at 39; 434 billion tons, COAL, supra note 7, at 5; and 1.5 trillion tons, CONGRESSIONAL RESEARCH SERVICE, supra note 11, at 15; NCA, supra note 8, at 76. Whatever measure is used, it is clear that the amount of coal remaining to be mined is hundreds of times greater than current annual production.

13. Strip mining is usually distinguished from the broader class of "surface mining," which also includes open pit mining, dredging, hydraulic mining, and augering. Aside from a relatively small amount of auger mining, see note 20 infra, these other methods are not ordinarily used to mine coal. See SURFACE MINING, supra note 1, at 33-37.

In this Comment, the terms "surface mining" and "strip mining" will generally be used interchangeably, to encompass both strip mining in the narrow sense and auger mining, except where the context indicates that a distinction is intended between the latter two methods.

14. See text accompanying notes 59-60 infra.

15. NCA, supra note 8, at 82.

Despite the approximately even shares of current coal output attributable to surface and underground mining, reserves recoverable by deep mining methods far outweigh strippable reserves. Deep reserves have been estimated at between 297 billion tons, COAL, supra note 7, at 5, and 1.4 trillion tons, CONGRESSIONAL RESEARCH SERVICE, supra note 11, at 15-18, depending on the definitions used. Strippable reserves have been estimated at between 45 billion tons, BUREAU OF MINES, U.S. DEP'T OF THE INTERIOR, INFORMATION CIRCULAR 8531: STRIPPABLE RESERVES OF BITUMINOUS COAL AND LIGNITE IN THE UNITED STATES 16 (1971) [hereinafter cited as STRIPPABLE RESERVES] and 137 billion tons, COAL, supra note 7, at 5, again depending on the definitions used. See caveat provided at note 12 supra.
It is useful to distinguish between two broad types of strip mining: contour mining, which takes place in hilly terrain, and area mining, which is performed on relatively flat land. In contour mining, earthmoving machinery cuts a section out of a hillside to expose the coal seam and, as the name implies, follows the contour of the seam along the hill. What is left is a long vertical "highwall," sometimes over a hundred feet high, at the point of furthest penetration into the hill, and a horizontal "bench" from which the coal has been removed. In the simplest technique of contour mining, the removed overburden, now "spoil," is placed downslope of the bench as mining proceeds. In area mining, coal is uncovered by digging what is essentially a huge trench. After the coal is removed, another cut is made next to the first, and the spoil from the new one is placed in the previous trench. The process creates a series of huge ridges and furrows—resembling "a gigantic washboard"—with an exposed trench, often a hundred or more feet deep, marking the last cut. In both methods, explosives are commonly used to fracture and loosen the overburden prior to removal.

Coal reserves and production are concentrated in three main areas of the country: Appalachia, the Central region, and the Rocky Mountain-Northern Great Plains regions—"the West." Although about


17. A variant of contour mining which has become widely used in some areas is what is known as mountaintop removal: rather than cutting part way into the hill along the coal seam, the mining operation cuts completely through, thereby removing the whole top of the hill overlying the coal seam. See 2 MATHEMATICA, INC & FORD, BACON & DAVIS, INC., DESIGN OF SURFACE MINING SYSTEMS IN EASTERN KENTUCKY II-23-26, V-3-37 (Prepared for Appalachian Regional Commission & Kentucky Department of Natural Resources & Environmental Protection, 1974) [hereinafter cited as MATHEMATICA].

18. This is not the only method of handling spoil; in certain other techniques, spoil from one portion of the cut is placed in a previously mined section. See, e.g., COUNCIL ON ENVIRONMENTAL QUALITY, COAL SURFACE MINING AND RECLAMATION: AN ENVIRONMENTAL AND ECONOMIC ASSESSMENT OF ALTERNATIVES, S. SER. NO. 93-8, 93d Cong., 1st Sess. 19-23 (1973) [hereinafter cited as CEQ].

19. SURFACE MINING, supra note 1, at 34.

20. In addition to these methods, properly described as strip mining, a relatively small amount of coal is also extracted by another surface mining technique known as augering. In this type of mining, large drills are driven horizontally into a hillside to pull coal out of a seam which is not economically recoverable by contour mining. Typically, auger mining is performed in conjunction with contour mining, after the stripping has cut as far into the hill as is profitable.

In 1973, 15.7 million tons of coal were auger mined, while 276.6 million tons were strip mined. COAL, supra note 7, at 11.

21. STRIPPABLE RESERVES, supra note 15, at 5-19; COAL, supra note 7, at 5-11. The largest amounts of mining in each area occur, respectively, in West Virginia, Pennsylvania-
half of the nation's coal reserves are located in the West,\textsuperscript{22} relatively little coal has actually been mined there until recently because of the distance to major markets. Advances in strip mining and transportation practices,\textsuperscript{23} however, are tending to overcome the West's locational disadvantage, which is offset by a natural advantage in the form of very thick and shallow coal seams, and hence high recovery of coal per acre mined.\textsuperscript{24} Because of topographical differences, strip mining in Appalachia often takes the form of contour mining, while in the Central and Western states area mining is the typical practice.\textsuperscript{25}

The most obvious environmental effect\textsuperscript{26} of strip mining\textsuperscript{27} is the massive direct impact on the land mined, which, in the absence of effective treatment, is left scarred, denuded of vegetation, and practically useless for other purposes.\textsuperscript{28} Water pollution is another major problem associated with surface mining, particularly in the eastern regions, where acid-forming sulfur compounds are often present in the coal-bearing strata. Other adverse consequences of surface mining include erosion, sedimentation, and landslides; increased local flooding; disruption of ground water supplies; and interference with wildlife movements and habitats.

\textsuperscript{ia, Ohio, and eastern Kentucky; Illinois, Indiana, and western Kentucky; and Montana, Wyoming, North Dakota, and New Mexico. In this Comment the term "East" will be used to refer to both the Appalachian and the Central Regions.}

\textsuperscript{22. COAL, supra note 7, at 5; INDEPENDENCE, supra note 8, at 103.}

\textsuperscript{Because Western coal generally has a lower heat value than Eastern coal, somewhat less than half of the energy content of the nation's coal is located in the West. INDEPENDENCE, supra note 8, at 103.}

\textsuperscript{23. See notes 64 and 65 infra and text accompanying.}

\textsuperscript{24. See STRIPPABLE RESERVES, supra note 15, at 10. Another advantage of Western coal is that it is generally low in sulfur content. See text accompanying notes 213-14 infra. In 1973, 64% of national coal production, both underground and surface, took place in Appalachia, 25% in the Central region, and 9% in the West. Of the coal produced by surface mining, Appalachia accounted for 49%, the Central region 31%, and the West 15%. FEDERAL ENERGY ADMINISTRATION, PROJECT INDEPENDENCE BLUEPRINT FINAL TASK FORCE REPORT: COAL 9 (1974) [hereinafter cited as TASK FORCE]; INDEPENDENCE, supra note 8, at 101.}

\textsuperscript{25. CEQ, supra note 18, at 50-51.}

\textsuperscript{26. The environmental consequences of strip mining are further described in the text accompanying notes 83-112 infra. See references cited therein.}

\textsuperscript{27. Underground coal mining, when not adequately controlled, may itself cause substantial environmental problems, such as acid drainage, surface subsidence, and air pollution from mine or refuse pile fires. See, e.g., APPALACHIAN REGIONAL COMMISSION, MINE DRAINAGE IN APPALACHIA, H.R. Doc. No. 91-180, 91st Cong., 1st Sess. (1969); Maneval, supra note 16, at 10, 32-37; PROCESSES, supra note 16; UNIVERSITY OF MARYLAND SCHOOL OF LAW, LEGAL PROBLEMS OF COAL MINE RECLAMATION 27-38, 46-51 (U.S. Environmental Protection Agency Water Pollution Research Series 14010 FZU, 1972). The costs of environmental controls in underground mining are considered at note 60 infra.}

\textsuperscript{28. By 1972, coal surface mining had disturbed 1.7 million acres of land. S. REP. No. 28, supra note 1, at 172.}
With varying success, and at varying cost, the environmental damage from strip mining can be reduced or prevented by the use of what are generally called reclamation techniques, such as regrading the surface of the mined sites, burying the acid-forming material, and revegetating the disturbed area. Moreover, the states in which strip mining occurs generally have enacted statutes imposing various reclamation requirements on surface mining operations. It is widely felt, however, that state regulation has not been sufficiently effective in controlling the harmful effects of these activities. In addition, various aspects of strip mining, both positive and negative, are matters of nationwide concern. It is for such reasons that a national policy on surface mining has been the subject of intensive Congressional consideration for the past several years.

The surface mining bills approved by Congress in 1974 and 1975, and vetoed in each instance by the President, S. 425 and H.R. 25 respectively, were basically similar in approach. The legislation would have established minimum requirements for state programs regulating the surface mining of coal and for a federal regulatory program covering federally-owned lands. The substantive core of the bills was a set of performance standards regulating the environmental impact of mining, which would have required regrading, revegetation, prevention of water pollution, and other measures. In addition, the bills would have prescribed a variety of administrative devices to implement the standards.

It appears likely that further Congressional efforts to control strip
mining will draw heavily on the approach contained in these bills. This approach will be evaluated in section XII of this Comment on the basis of the analysis which follows.

II

FRAMEWORK FOR EVALUATION

The main reason that the strip mining of coal has come to be viewed as a significant problem in our society, warranting governmental intervention, is the environmental damage it causes. However, strip mining also produces real social benefits, the major one being the lower cost of obtaining coal by this method than by the alternative of underground mining. In oversimplified terms, the problem of determining a national policy toward strip mining lies in making the proper choice between these conflicting values. A more complete formulation of the problem must also take into account several other important values which may be at stake.

First, surface mining is safer than underground mining, in terms both of accidents and of disease. The substitution of one type of mining for another would predictably result in more or fewer injuries, illnesses, and deaths among coal miners. Second, because coal is an important energy resource, surface mining policy might have an impact on attempts to increase the nation's energy self-sufficiency. A third value which could be affected is environmental protection of a different sort, the control of air pollution from sulfur compounds, which depends in part on the production of coal with below-average sulfur content. Fourth, government intervention in strip mining has the potential for

37. As of April 1976, for example, efforts were being made in the House of Representatives to discharge from the Rules Committee a bill introduced in the current session, H.R. 9725, which is very similar to the vetoed H.R. 25. 8 NATIONAL J. 450 (1976).

38. The widespread feeling that governmental intervention is needed in strip mining is based on a perception that leaving the activity unregulated, or ineffectively regulated, does not result in a proper balancing among the competing values. This perception is undoubtedly correct, largely because some values (especially environmental ones) are substantially external to the decisions of coal mining businessmen. That is, firms do not fully take the "costs" (in this case, the environmental effects) of strip mining into account in making their economic decisions. This, of course, is just another example of the now-familiar situation where external diseconomies lead to a failure of laissez-faire markets to achieve efficient outcomes. See generally Bator, The Anatomy of Market Failure, 72 Q.J. ECON. 351 (1958); A. FREEMAN, R. HAVEMAN, & A. KNEESE, The Economics of Environmental Quality 71-79 (1973). With respect to strip mining in particular, see Bohm, Lord, & Patterson, Market Imperfections, Social Costs of Strip Mining, and Policy Alternatives, 3 REV. REGIONAL STUDIES 69 (1972-73); Brooks, Strip Mine Reclamation and Economic Analysis, 6 NATURAL RESOURCES J. 13 (1966); Spore, The Economic Problem of Coal Surface Mining, 2 ENVIRONMENTAL AFFAIRS 685 (1973).
influencing the unemployment problems of Appalachia's depressed economy, since coal mining is an important industry in that region. Finally, any analysis intended to inform policy making must concern itself with the costs of administering the policy, which are likely to vary according to the type of intervention chosen. In formulating national policy with respect to strip mining, then, the impact of alternative choices on all of these values needs to be assessed, and the importance of each value weighed against the others.

The general economic approach to such a problem is to quantify the values in money equivalents and thus allow a choice to be made with reference to a single dimension taken to represent social welfare. Where market prices are unavailable for the values in question, as with collective goods and external or "spillover" effects, prices must be imputed by estimating people's subjective willingness to pay, i.e., the maximum amounts of money individuals would be willing to pay in order to obtain each unit of the value. The policy choice may then be made by selecting the alternative which yields the maximum excess of benefits (positive values) over costs (negative values). Suppose, for example (ignoring for the sake of simplicity all values other than strip mining cost savings and environmental damage), that one could associate with each possible set of underground and surface coal mining and reclamation activities a dollar mining cost and a dollar environmental cost.

39. Specifically, what is referred to here is cost-benefit analysis, though this is typically used to evaluate public investment projects rather than public intervention in private economic activities. For a sensitive discussion of cost-benefit analysis and its welfare economics underpinnings, see E. MISHAN, COST-BENEFIT ANALYSIS: AN INTRODUCTION (1971) [hereinafter cited as COST-BENEFIT INTRODUCTION]. On the application of cost-benefit analysis to strip mining, see Brooks, supra note 38; F. SCHMIDT-BLEEK & J. MOORE, BENEFIT/COST APPROACH TO DECISION MAKING: THE DILEMMA WITH COAL PRODUCTION (University of Tennessee Appalachian Resources Project Report No. 23, 1974).

40. Collective, or public, goods are those goods, such as clean air, which cannot be allocated effectively through the private market mechanism because, in essence, one person's "consumption" of the good does not diminish its availability for others. See Bator, supra note 38; Samuelson, Diagrammatic Exposition of a Theory of Public Expenditure, 37 REV. ECON. & STAT. 350 (1955).


42. Alternatively, the question may be phrased as how much money individuals would require as compensation to induce them to give up each unit of the good (or, in the case of a negative value, to tolerate each unit). The results will generally not be the same in both cases, because in effect the individuals' hypothetical wealth differs under each formulation: under one assumption, the person must pay to obtain the value; under the other, he already is entitled to the value and must be paid to relinquish it. See COST-BENEFIT INTRODUCTION, supra note 39, at 125-131.

43. It is also assumed here, for simplicity, that the quantity of coal produced, and therefore the consumer benefits of coal mining, are fixed.
Then the policy prescription would be to choose that set of mining and reclamation activities which involved the minimum sum of mining and environmental costs.

This analytical approach, however, implicitly treats the costs and benefits as affecting society in general, ignoring the manner in which they are distributed among different individuals. It is clear, though, that values at stake in the strip mining problem do not accrue equally to everyone. For example, the occupational hazards of coal mining are obviously not shared in the same degree by all Americans but fall mainly on coal miners themselves. And the benefits of strip mining in the form of cost savings may be shared unequally by owners of mining firms, coal property holders, and various classes of consumers. Evaluating the desirability of policy alternatives which affect different people differently requires making normative judgments about whether, e.g., the gains to person A are "worth" the losses falling on person B. In general, therefore, consideration merely of aggregate "benefits" and "costs" throughout society cannot provide a sufficient guide to making policy choices.

The rationale for using, nonetheless, a simple aggregate net benefits criterion in conventional cost-benefit analysis has both a practical and a theoretical dimension, neither of them wholly persuasive. To begin with, it is very difficult to determine how to take distributional considerations into account. Economists correctly point out that they are no better qualified than anyone else to render the ethical judgments necessary for this task. Moreover, once one constructs a quantitative evaluative procedure based on such judgments—e.g., by assigning different numerical weights to the costs or benefits accruing to various groups of people—only those who happen to agree with the particular comparisons used would find the results meaningful. It is therefore both simpler and seemingly more objective to confine one's economic analysis to aggregate costs and benefits.

The trouble with this approach, aside from its obvious neglect of distributional concerns, is that its apparent neutrality is somewhat illusory.
ry. Whenever costs and benefits are measured by the "dollar votes" people cast for various values, the results depend not only the strengths of their likes and dislikes but also on how many dollars they possess. Hence, the distribution of income and wealth existing in society when a cost-benefit analysis is performed will affect the outcome of the analysis; and this distribution may or may not be thought satisfactory according to fairness or other criteria.

A second possible justification for ignoring distributional concerns is this: if the aggregate benefits from a change or a policy outweigh the aggregate costs, the individuals who enjoy gains could compensate those who suffer losses, thus leaving everyone either better or no worse off than he was originally. To the extent that effective compensation schemes are feasible, then, the initial distributional impact of a policy may be ignored and the policy choice made on the straightforward basis of which alternative produces the greatest excess of all benefits over all costs. The major problem with this concept, of course, is that anything approaching a complete system of compensatory redistribution is difficult to design even in theory, and more difficult still to envision being implemented. Presumably it is of little solace to those who are actually harmed that overall benefits may be great enough to compensate them in theory.

The approach of this Comment will be an attempt to strike a workable, if inelegant, compromise between the impractical and necessarily personal specification of an a priori social welfare function and the morally unsatisfactory alternative of ignoring the distribution of values altogether. Broadly stated, policy evaluation will be made with

49. See note 42 supra; Freeman, The Distribution of Environmental Quality, in ENVIRONMENTAL QUALITY ANALYSIS 243 (A. Kneese & B. Bower ed. 1972); COST-BENEFIT INTRODUCTION, supra note 39, at 132-37.

50. This includes, inter alia, entitlements, such as the right to impose on others certain levels of harm in the process of strip mining, or the right to prevent it. See note 42 supra; Calabresi & Melamed, Property Rules, Liability Rules, and Inalienability: One View of the Cathedral, 85 HARV. L. REV. 1089 (1972); Freeman, supra note 49, at 247-48.

51. This expresses the concept of a "potential Pareto improvement." See Cost-Benefit INTRODUCTION, supra note 39, at 316-21. An actual Pareto improvement is any change which makes at least some individuals better off without making anyone worse off, and a potential Pareto improvement could be transformed into an actual one through appropriate redistribution of the gains.

52. In theory what is required are "lump sum" transfers: redistributions of wealth among individuals which do not in any way effect the perceived incentives to act in economically efficient ways. "It is clear that truly lump-sum measures are extraordinarily hard to devise." GRAAFF, supra note 45, at 78. In addition to this problem are the difficulties in simply identifying those suffering losses, calculating the appropriate compensation, and otherwise administering the redistributions.

53. See note 45 supra.
respect to two criteria, aggregate net benefits and distributional fairness, with the basic goal of maximizing the former subject to the tempering influence of the latter. The relevant values will be examined where possible both in terms of monetary measures of their overall magnitudes and with reference to broad, and probably widely accepted, distributional norms, e.g., it is unfair and undesirable to benefit the richer at the expense of the poorer; it is generally worse for harms (especially if large in relation to one's wealth) to be concentrated on few individuals than to be spread among a large population; and it is generally fair and desirable for the costs of an activity or policy to fall on those receiving its benefits.

To the extent that the distribution of benefits or harms among various groups of recipients appears consistent with these principles, their contributions to aggregate net benefits may, so to speak, be taken at face value. Where, on the other hand, the distribution conflicts with these principles in varying degrees, this will be taken into separate account as a negative factor. In addition, the possibility of compensation mechanisms will be considered in the analysis where such seem feasible. As for the quantification in monetary terms of the various benefits and harms (which will not always be possible), market prices


The statements which follow in the text raise the question of whether the effect of a policy is to harm person A or to avoid benefiting him; to prevent harm to person B or to bestow benefits on him. If, for instance, a new law required increased environmental protection in strip mining operations at some additional cost to coal producers, has this imposed a loss on the prospective strip mining operator and provided a gain for his neighbors? Or has the law merely prevented the operator from receiving some extra gain and protected his neighbors from a potential loss? The answer depends on how the status quo ante is defined, a matter which is necessarily somewhat arbitrary where the allocation of entitlements to the relevant environmental values is not clearly established.

It seems appropriate, and in accord with widely held notions of fairness, to define the environmental aspect of the status quo, for purposes of evaluating strip mining policy, as the situation existing before strip mining occurs. At least with respect to the more direct forms of environmental disruption affecting inhabitants of strip mined areas, such as landslides, flooding, and the destruction of the character of the local environment, people's ordinary expectations surely must support this view of the relevant entitlements. Cf. Michelman, supra at 1235-45 (protection of "fair, or socially useful, expectations"); Cost-Benefit Introduction, supra note 39, at 125-31.

55. More generally, it may be assumed that a dollar of benefit or harm is more significant to poorer than to richer members of society. See, e.g., Calabresi, supra note 54, at 39-41.

56. This proposition is, so to speak, of only prima facie validity, since there are instances where a policy is desired precisely because it redistributes benefits from some groups to others, e.g., programs to aid the poor.
will be used where available unless there appear special reasons relating to distributional norms not to do so.

The aim is, finally, that on the basis of both overall net benefits and fairness considerations, the analysis will reveal some persuasive ordering of the desirability of various strip mining policy alternatives.

III

COAL MINING COSTS

Mining costs vary greatly in both deep and surface mining, depending on such factors as the thickness and depth of the coal deposit, the technology used, the geological characteristics of the overburden, the scale of the operation, and the constraints which may be imposed relating to environmental and occupational safety objectives. On the average, though, it is clear that a ton of coal can be extracted at a significantly lower cost by strip mining than by underground mining.


58. A major reason for the cost differential is greater labor productivity in strip mining, averaging 34.60 tons of coal per man-day in 1973, as compared with 11.20 tons for deep mining. NCA, supra note 8, at 84. (In 1969, prior to the implementation of the Federal Coal Mine Health and Safety Act of that year, 30 U.S.C. § 801 et seq., the comparable figures were 35.96 and 15.61 tons, respectively. Id. It is not clear to what extent the downturn in productivity since the 1969 Act is temporary. See note 60 infra).

Capital costs also appear to be lower in strip mining than in deep mining. See Hearings on the Present and Future Role of Coal in Future Energy Supplies Before the Senate Comm. on Interior & Insular Affairs, 93d Cong., 1st Sess. 525 (1973) [hereinafter cited as Senate Hearings]; 2 National Petroleum Council, supra note 12, at 135. On the other hand, the cost of using land during mining should be greater for surface methods, since they preclude alternative use of the mined area, at least temporarily. However, land costs play a relatively minor role in mining, especially as land values for other uses are quite low in many coal-bearing areas. See, e.g., S. Brock & D. Brooks, The Myles Job Mine: A Study of Benefits and Costs of Surface Mining for Coal in Northern West Virginia 19 (1968); 1 Charles River, supra note 57, at 317; Coal Age, April 1973, at 201.

59. This raises the question of why any coal should be mined by underground methods. There are a number of complementary explanations. For one thing, there is undoubtedly a limited number of unusually rich and accessible deposits of coal which are comparatively cheap to deep-mine. Similarly, some underground mines are advantageously located with respect to transportation facilities. See Task Force, supra note 24, at 29. In addition, a portion of current underground mining is probably a short-run phenomenon reflecting past decisions to open mines at a time when the cost advantage of a strip mining was less; these operations will continue to produce as long as the price of coal
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The best estimates of the average cost differential between surface and underground coal mining in the Central and Appalachian regions are in the range of $3.00 to $5.00 per ton. Because of the availability covers the variable costs of production even if it fails to return the capital investment as originally anticipated. Telephone interview with John J. Schanz, Resources for the Future, Washington, D.C., January 27, 1976 [hereinafter cited as Schanz]. Finally, the quality of deep mined coal (a term which may refer to sulfur, energy, or ash content, or a variety of other characteristics) is often superior to surface mined coal, and higher quality output presumably commands a higher price to cover its cost. Task Force, supra note 24, at 29. The average price of coal at the mine in 1973, for instance, was $10.84 per ton for deep mined coal and $6.11 for strip mined. Coal, supra note 7, at 17.

Although it might seem that such a quality differential should serve to reduce the benefits of strip mining below what is implied by its lower production cost, in part that differential is a result of strip mining's cost advantage. Given the presence of low-cost surface mined coal in the market, it is the underground mines with relatively high grade coal that are best able to survive. Moreover, it appears that certain characteristics of coal which is mined for "high quality" uses, such as steel production, may be less valuable or even counterproductive in other uses, such as power generation. See Congressional Research Service, supra note 11, at 10; NCA, supra note 8, at 15; Strippable Reserves, supra note 15, at 8; Task Force, supra note 24, at 5, 41.

60. These and all other cost and price data contained in this Comment are expressed as nearly as possible in second quarter 1975 dollars, unless otherwise specified.

The $3.00 to $5.00 range is largely based on estimates of the long-run average cost of coal from new mines. Two U.S. Bureau of Mines engineering cost studies, adjusted for input price changes between the earlier and later reports, indicate differentials between typical underground and strip mining operations of between $2.75 and $3.75 per ton. Information Circulars 8535 and 8632, supra note 57. Using similar types of cost studies, the Federal Energy Administration reports differentials averaging $3.57 to $5.95 per ton in Appalachia and $1.49 in the Central region. Task Force, supra note 24, at 31-32. A third estimate of the average cost difference for new mines is $4.92 per ton. Nordhaus, The Allocation of Energy Resources, 3 Brookings Papers on Economic Activity 529 (1973). Finally, one observer has estimated that strip mining costs average 25% to 30% less than deep mining. P. Averitt, Stripping Coal Resources of the United States: January 1, 1970, at 2 (U.S. Geological Survey Bulletin 1322). If one assumes that the average cost of deep mined coal was about equal to its price of $9.70 a ton in 1972 (i.e., before the recent escalation in coal prices), this implies a differential above surface mining costs of $2.42 to $2.91, or $3.05 to $3.67 in 1975 dollars. Coal, supra note 7, at 17.

It is not clear to what extent the above figures take into account the cost of environmental controls or of health and safety improvements under the 1969 Act. The Bureau of Mines and Federal Energy Administration estimates for strip mines included the cost of complying with applicable state reclamation laws, which in the former case apparently was at most 15¢ per ton, or 22¢ in 1975 dollars. Information Circular 8535, supra note 57, at 5. The cost of environmental controls in underground mining, however, appears not to be reflected in the equivalent estimates. The two major sources of this cost are in the prevention of water pollution from acid mine drainage and in the control of subsidence of the surface above mined areas, a phenomenon which may damage structures on the affected land.

The problem of acid drainage is largely concentrated in certain portions of the coal mining regions, notably Pennsylvania, so that potential control costs vary greatly among underground mines. 2 Charles River, supra note 57, at 165-169. See also EPA, Analysis of Pollution Control Costs 5 (EPA-670/2-74-009, 1974) [hereinafter cited as EPA Analysis]. Typical treatment cost have been estimated variously at 6¢ and 20¢ per ton of coal produced (apparently in 1970 to 1972 prices). Dials & Moore,
of very thick and shallow coal deposits in the West, strip mining costs there are as low as one third of the cost of Eastern strip mining.\textsuperscript{61}

\textit{The Cost of Coal, APPALACHIA,} Oct.-Nov. 1974, at 1, 6 (reprinted from \textit{ENVIRONMENT,} Sept. 1974). Another study found a range of between 10\$ and 75\$ per ton (1972 prices), with "the largest proportion" of mines at the low end of this range. \textit{2 CHARLES RIVER, supra note 57, at 165-69.}

A variety of methods are being developed for controlling surface subsidence, a problem which occurs at some but not all deep mines. It is difficult to derive typical per-ton costs in this area. \textit{See EPA ANALYSIS, supra at 347-55.} The figure of 50\$ per ton, though, has been suggested as an average cost based on the technique of backfilling vulnerable mined-out spaces with mine waste or other materials. Dials & Moore, \textit{supra} at 7-8 (apparently in 1971 prices). An alternative long-term solution to the problem may lie in the widespread substitution of a particular deep mining technology, long-wall mining, for the more conventional methods generally used in the United States. Long-wall mining produces uniform subsidence of the surface rather than the variable subsidence associated with traditional "room and pillar" mining, and property damage therefrom is relatively uncommon. \textit{EPA ANALYSIS, supra at 353.} To the extent that the long-wall method is adopted, additional expenditures for subsidence control can largely be avoided.

Implementation of the Coal Mine Health and Safety Act has increased the cost of coal mining, particularly underground mining, because of such factors as reduced productivity and additional equipment expenditures. One survey of deep mining costs in 1972 found increases attributed to the 1969 Act averaging $1.39 to $1.47 per ton ($1.75 to $185 in 1975 dollars) for mines producing under 2.5 million tons per year, and $0.75 per ton ($0.94 in 1975 dollars) for larger mines. \textit{COAL AGE,} Jan. 1973, at 69, 70. However, these changes reflect in part temporary phenomena such as the loss of experienced mine personnel to the Bureau of Mines, an influx of inexperienced workers, and other problems of adjustment to the new constraints. \textit{COAL AGE, supra; M.I.T. Energy Laboratory Policy Study Group, Energy Self-Sufficiency: An Economic Evaluation, TECHNOLOGY REVIEW, May 1974, at 23, 38 [hereinafter cited as MIT].} In addition, a reduction in the prevalence of occupational lung disease among miners should itself eventually contribute to improved labor productivity. \textit{2 CHARLES RIVER, supra note 57, at 180.} Hence the long-run cost increments due to health and safety improvements should be lower than those initially observed, and have been estimated to be in the neighborhood of $0.60 to $0.70 per ton of coal ($0.75 to $0.88 in 1975 dollars) for large and medium scale mines, respectively. Costs will probably be higher at smaller mines. \textit{1 CHARLES RIVER, supra note 57, at 344.} Some of the mining cost studies referred to above have attempted to take account of the impact of the 1969 Act, \textit{see TASK FORCE, supra note 24, at 2, 46, so these increments are at least partly reflected in the cost differentials contained therein.}

On balance, considering the limited extent to which the above factors were included in estimating mining costs, and remembering that surface mining costs were inflated slightly by the partial inclusion of reclamation expenditures which are to be separately considered below, those cost differentials appear to be somewhat conservative. It is impossible to state with confidence by how much, but an average of $0.50 to $0.75 per ton does not seem an unreasonable guess.

\textit{61. INFORMATION CIRCULAR 8535, supra note 57, at 3, reports, for example, 1969 strip mining costs of between $1.64 and $3.83 per ton in the West, as compared with $4.01 to $5.40 in Appalachia and $3.46 to $6.95 in the Central region.}

In most of the Western coal states, little underground mining is currently performed, \textit{COAL, supra note 7, at 11, and information on costs is scarce.} Reported cost data for Utah, the major Western underground producer, indicate a differential between underground and surface mining similar to that in the East, \textit{COAL AGE,} April 1973, at 159-77; but present deep mining technology is not suitable for the thick coal deposits of the Northern Great Plains region. Schanz, \textit{supra note 59.} Pending possible development
However, since the main potential demand for Western coal is at a great distance (i.e., the Midwest), transportation costs must also be taken into account in order validly to compare the alternatives. In addition, the energy content of Western coal is typically lower than that of Eastern. It appears that the total cost of using Western surface mined coal currently exceeds that of local deep mined coal in most markets, although Western coal is probably competitive as far east as Chicago. Continued improvements in transportation systems, as well as alternative technologies like mine-mouth electrical generation with ultra-high voltage, long distance transmission, may reduce the future cost of Western coal relative to Eastern.

On the basis of the above-estimated cost differentials and recent levels of coal output, one may approximate the total savings in coal mining costs attributable to strip mining at between $875 million and $1460 million annually.

62. Most of the Western coal is of sub-bituminous or lower rank, with the former ranging between 8500 and 10,600 British thermal units (Btu) per pound, while in the East the coal is mostly bituminous and averages 12,000 to 13,000 Btu per pound. INFORMATION CIRCULAR 8535, supra note 57, at 3; TASK FORCE, supra note 24, at 6, 106-12; CONGRESSIONAL RESEARCH SERVICE, supra note 11, at 11.

63. i.e., the long-run cost of mining (as distinguished from the currently high market price, see INDEPENDENCE, supra note 8, at 106), added to transport cost, per unit of energy content.

64. Long-distance rail transportation costs for coal in the last several years, using efficient "unit trains," have been reported at between 5 and 8 mills per ton-mile. MIT, supra note 60, at 39; CONGRESSIONAL RESEARCH SERVICE, supra note 11, at 19. It may be possible to achieve a cost of slightly over 4 mills (somewhat higher in current dollars). BUREAU OF MINES, U.S. DEP'T OF THE INTERIOR, INFORMATION CIRCULAR 8614: COMPARATIVE TRANSPORTATION COSTS OF SUPPLYING LOW-SULFUR FUELS TO MIDWESTERN AND EASTERN DOMESTIC ENERGY MARKETS 13 (1973). At 5.5 mills and 7.5 mills, respectively, the cost of moving Western coal to Chicago averages $0.37 and $0.50 per million Btu. MIT, supra note 60, at 40. This may be compared with an average mining cost differential between Eastern deep mined coal and Western strip mined coal of about $0.35 per million Btu. TASK FORCE, supra note 24, at 33. Typical transportation costs for using Eastern coal are $0.05 to $0.10 per million Btu. R. GORDON, U.S. COAL AND THE ELECTRIC POWER INDUSTRY 82 (1975). Taking account of both mining and transportation costs, the Federal Energy Administration has reported $0.83 per million Btu as the estimated average minimum delivered cost in Chicago of Northern Great Plains surface mined coal, as compared with $0.79 for Appalachian underground mined coal. TASK FORCE, supra note 24, at 58 (1973 prices).


66. This range is obtained simply by applying the $3 to $5 per ton estimate of cost savings to the 1973 surface mined production of 292 million tons. COAL, supra note 7, at 11. The approximately 50 million tons of Western coal output is treated identically to Eastern output for purposes of this calculation, on the assumption that opposing factors which differentiate the two segments of the industry tend to offset one another. On the one hand, roughly half of the coal strip mined in the West is shipped East, see BUREAU OF MINES, U.S. DEP'T OF THE INTERIOR, BITUMINOUS COAL AND LIGNITE DISTRIBUTION,
As for future cost savings from strip mining, countervailing factors may be discerned. On one hand, the lower ratio of recoverable reserves to current output in strip mining than in underground mining may indicate, in the East if not in the West, that cheap coal is scarcer in strip mining and thus that mining costs will rise faster there than in underground mining.\(^7\) In addition, rising land costs will tend to affect surface mining more than deep mining. On the other hand, labor costs historically tend to increase faster than capital and material costs, and since underground mining is comparatively labor-intensive, this trend will operate to the advantage of surface mining.\(^6\) Finally, as the total demand for coal increases, the total savings will rise for any given per-ton differential between strip mining and deep mining costs. United States coal production has been variously estimated to grow from recent levels of around 600 million tons annually to between 740 and 895 million tons by 1980; and to between 980 and 1100 million tons by 1985.\(^69\) If the above mentioned cost factors should balance out, it is

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\(^1\) See note 64 supra. On the other hand, the portion of Western coal which is used locally would probably cost more than an additional $3 to $5 per ton to replace by local underground mining, see note 61 supra.

The estimate given in the text assumes a constant coal output, and in theory it should be adjusted downward somewhat to account for the fact that as the price of coal increases (which would occur in the absence of strip mining), the quantity demanded decreases. However, because the energy-equivalent price of coal's chief competitor, oil, is now far above the cost of deep mined coal, it is unlikely that the quantity of coal to be demanded in the future would be significantly lower than 1973 output even with a price increment equal to the differential between deep mining and strip mining costs. (In terms of energy content, coal would have to cost about $40 per ton to equal the recent price of oil, Federal Energy Administration, Summary: Impact of Surface Mining Bill on Overall Energy Policy (1975), while the cost of mining coal at new deep mines has been estimated at $12.50 to $16.66 per ton, Task Force, supra note 24, at 31. Recent market prices of coal have been substantially higher than the long-run cost—e.g., $22 to $28 per ton on the spot market, Federal Energy Administration, supra—largely because of the increase in demand resulting from adverse developments in the world oil situation. Independence, supra note 8, at 104, 106.) Cf. 1 Charles River, supra note 57, at 160-61, where even on the assumption of an oil price rise from the pre-embargo level much smaller than what has in fact occurred, the 1980 demand for Appalachian coal was projected to exceed 1970 production in the face of a coal price increase of up to $3.22 per ton ($4.60 in 1975 dollars).

\(^6\) See Coal, supra note 7, at 5, 11; Task Force, supra note 24, at 105; Risser, Coal Strip Mining: Is It Reaching a Peak?, 244 Transactions of the Society of Mining Engineers, AIME 245 (1969).

\(^68\) 1 Charles River, supra note 57, at 379. One cannot rule out the possibility, however, that deep mining techniques might change in response to rising labor costs so as to become less labor-intensive than strip mining.

\(^69\) The first estimate for each year is from W. Dupree & J. West, United States Energy Through the Year 2000, at 33 (1972). The second is from Independence, supra note 8, at 108.

Under a hypothetical regime of greatly increased dependence on coal as an energy resource, production levels might be as high as 1376 million tons in 1980 and 2063 million tons in 1985. Independence, supra note 8, at 108.
reasonable to expect, then, that the overall savings from strip mining will grow by at least two thirds in the next decade.

A. Distributional Aspects of Strip Mining Savings

Four major classes may be identified among the potential beneficiaries of the cost savings associated with strip mining: consumers (through lower prices), owners of mining firms (through profits), mine workers (through higher earnings), and owners of the mining rights (through rents or royalties).

Coal mining historically has been a competitive industry. Although the recent trend is in the direction of fewer and larger firms, the degree of concentration is still relatively low; moreover, there do not appear to be substantial barriers to entry by new firms. Hence it is unlikely that over the long run coal mining firms could appropriate a significant proportion of the cost savings from strip mining in the form of excess profits.

The proportion which accrues to owners of coal itself (or rights thereto) depends on the scarcity of reserves amenable to surface extraction. Although, as observed above, strippable coal reserves are comparatively scarcer than deep reserves, such coal nonetheless appears to be sufficiently plentiful to support even greatly increased production at little increase in cost. This means that the owners of coal mined

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71. "Whereas in 1955 the 15 largest coal producing companies accounted for about one-third of U.S. production, they now account for more than half." Task Force, supra note 24, at 8.

72. 1 Charles River, supra note 57, at 216, 228; Gordon, supra note 64, at 67-68.

73. The cost of entry is moderate, economies of scale are not important beyond output levels which are small relative to market demand, and reserves are generally available to new entrants. 1 Charles River, supra note 57, at 228-30. A study of coal reserves held by large coal producers in Appalachia showed that under 15% of total reserves elsewhere reported were owned by companies producing more than 100,000 tons per year in 1967. Bureau of Mines, U.S. Dep't of the Interior, Analysis of the Availability of Bituminous Coal in the Appalachian Region 20 (July 1971). (This study indicated, however, that the existing data on total reserves might be somewhat overstated.)

74. By "excess profits" is meant returns to mining firms in excess of the cost of capital, i.e., the level of returns which is barely sufficient to induce firms to remain in the industry. See, e.g., J. Henderson & R. Quandt, Microeconomic Theory: A Mathematical Approach 115-16 (2d ed. 1971).

75. 1 Charles River, supra note 57, at 254, 268, 381-87; Task Force, supra note 24, at 28, 31. See Strippable Reserves, supra note 15.

Although the proposition stated in the text is unquestionably true for the West, some have disputed whether it is true for the East. Gordon and the MIT study refer to reports that large blocks of strippable land, necessary for new large surface mines, are becoming scarce in the Central region. Gordon, supra note 64, at 104; MIT, supra note
surface methods should be unable to command significant royalties or economic rents, a conclusion which is borne out by data on the actual magnitude of royalty payments in strip mining. Typical royalty rates in the recent past amount to under 15% of the average cost differential between surface and underground mining. As for the distribution of these payments, ownership patterns in the eastern coal regions indicate that a large portion goes to benefit already affluent property holders. In the West, the federal government is the principal owner of coal-bearing lands.

It is conceivable that through union bargaining power, mine workers might have appropriated to themselves part of the potential cost

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60, at 37. As Gordon notes, perhaps the only conclusion one can draw with confidence is that the data on the economic recoverability of coal reserves are simply inadequate to support firm assertions one way or the other.

76. An economic rent is income received by an owner of a scarce resource "above the minimum amount necessary" to induce him to keep the resource employed in its current use. HENDERSON & QUANDT, supra note 74, at 121.

Only if coal deposits recoverable at a cost below that of underground mining were quite limited in relation to the rate of coal consumption—i.e., if the supply of strip mined coal were highly inelastic—would one expect rents to be bid up to the point where a large proportion of the benefits of strip mining accrued to mineral owners. See generally Davidson, Falk, & Lee, The Relations of Economics, Rents and Price Incentives to Oil and Gas Supplies, in STUDIES IN ENERGY TAX POLICY 115 (G. Brannon ed. 1975).

Even with plentiful reserves, sufficient concentration in their ownership might lead to monopoly, as distinguished from scarcity, rents; but, although large-scale holdings of coal account for a substantial portion of reserves in some areas (see, e.g., J.D. MCATEER, COAL MINE HEALTH AND SAFETY: THE CASE OF WEST VIRGINIA 142 (1973), the actual degree of concentration does not appear high enough to give rise to such rents. See note 73 supra.

77. INFORMATION CIRCULAR 8535, supra note 57, at 5, estimated royalty payments in 1969 to range from $0.15 to $0.28 per ton. An average of $0.25 has been reported for Boone County, West Virginia, in 1974, Melton, Coal Reserves Should be the Subject of Equitable Ad Valorem Taxation, 76 W. Va. L. Rev. 325, 330 (1974). See also CEQ, supra note 18, at 101-102 ($0.25 for typical Appalachian surface mine in 1972); 1 MATHEMATICA, supra note 17, at I-17 ($0.40 in eastern Kentucky in 1971).

Since what are called royalty payments often include both an economic rent component and a resource cost component (i.e., compensation for the use of the mined land itself during mining), the above figures probably overstate somewhat the magnitude of the true economic rents in question.

During the last two years, as coal prices have increased markedly, it has become common to base royalties on a percentage of the selling price, and payments have risen substantially, in some cases to over a dollar per ton. Interview with Harold Davis, editor, COAL AGE, New York City, November 1975; telephone interviews with David Maneval, Appalachian Regional Commission, Washington, D.C., February 1976; U.S. Bureau of Mines personnel, February 1976. However, since royalties in underground mining have apparently increased commensurately, id., this change probably does not reflect a new-found scarcity of strippable reserves.

78. According to one report, small (under 100 acres) and medium (100 to 600 acres) "native land owners probably own less than 10% of Appalachia's coal fields . . . ." Diehl, Stripping Away the Myths, PEOPLE'S APPALACHIA, Sept.-Oct. 1971, at 5, 7. See also MCATEER, supra note 76; STANFORD RESEARCH INSTITUTE, A STUDY OF SURFACE COAL MINING IN WEST VIRGINIA 41 (1972).

79. TASK FORCE, supra note 24, at 7.
savings from strip mining. Union wage scales, however, are generally equivalent in deep and surface mining, and the smaller labor and other input requirements of surface mining are indeed reflected in the $3 to $5 per ton cost differential reported above.

Most of the savings, then, apparently take the form of lower prices for coal. The initial recipients of this benefit are mainly electric utilities, and to a lesser extent other industrial users of coal, such as steel producers. Ultimately, household consumers of electric power in coal-using regions and of goods and services produced through the use of electricity may be expected to enjoy the utilities' savings, assuming that utility regulation is effective. Obviously, these benefits, though subject to some regional variation, are widespread throughout the economy and among income classes. It is, in fact, low-income consumers who are affected the most, given present rate structures, when the price of electricity increases or decreases.

IV
ENVIRONMENTAL COSTS

The environmental consequences of strip mining have been extensively documented elsewhere, and only a brief summary will be given.


However, until 1974, an important fringe benefit, contribution to the union welfare fund, was paid on a per-ton-of-coal basis, thus increasing labor's rate of compensation in surface mining relative to that in deep mining. (These contributions have already been accounted for in the estimates of mining cost differentials reported above.)

81. Another possibility is that mine workers may have taken advantage of the development of surface mining to push wages in both types of mining above the level they would otherwise have attained. However, even if this were the case, the historical resistance of money wages to decline from levels previously reached makes it highly doubtful that any future restrictions on surface mining would bring wages down again. See, e.g., M. Baratz, The Union and the Coal Industry 98-99 (1955). Hence, this possibility is irrelevant to the issue of how present policy choices will affect the distribution of cost savings from strip mining.


here. At current rates of mining, somewhere between 50,000 and 100,000 additional acres of land are directly disturbed by strip mining each year.\textsuperscript{84} While in area mining the direct physical impact of the operation is mainly confined to the surface actually mined, in contour mining additional amounts of land, in some cases several times as much as the coal-yielding surface area, can be affected by spoil piles, landslides, and other incidents of the operation.\textsuperscript{85} Beyond this, highwalls—of which there were an estimated 20,000 miles as of 1972\textsuperscript{86}—may isolate larger regions from human and wildlife access.\textsuperscript{87} The visual impact of strip mining, of course, “often extends well beyond the boundaries of the directly affected mining areas. . . . [W]here contour mining is employed, the landscape of a large area is rendered discordant and ugly even though only a small fraction of the land is directly disfigured.”\textsuperscript{88}

Damage of a more palpable sort also extends far beyond the mined sites themselves. In the Eastern United States, acid as well as other toxic substances from strip mining severely contaminate surface as well as ground water, in some cases rendering streams poisonous to aquatic life. As of 1967, about 5800 miles of streams were polluted by acid and other substances from coal mining, of which surface mining contributed perhaps 25%. Sedimentation caused by erosion, especially in the case of mining on slopes, and alterations in the flow characteristics of ground and surface waters are additional problems associated with strip mining. Increased flooding can be one result. It has been estimated, for example, that by 1967 sediment from surface mining had reduced the flood-carrying capacity of about 7000 miles of stream channels.\textsuperscript{89}

\textsuperscript{84} This approximate range is derived from data on surface mining coal yields and land disturbance found in CEQ,\textsuperscript{18} supra note 18, at 28; 2\textsuperscript{nd} CHARLES RIVER,\textsuperscript{57} supra note 57, at 124-27; 2 MATHEMATICA,\textsuperscript{17} supra note 17, at VI-1; NAS,\textsuperscript{83} supra note 83, at 30-32.

\textsuperscript{85} See also AUSTIN & BORRELLI,\textsuperscript{83} supra note 83, at 13; S. REP. No. 93-402, 93d Cong., 1st Sess. 33 (1973).

\textsuperscript{86} CEQ,\textsuperscript{18} supra note 18, at 1.

\textsuperscript{87} In addition to the 192,000 acres in West Virginia which had been directly disturbed by surface mining as of the mid-1960's, an additional 411,000 acres of land had been cut off by the barrier of highwalls. BOCCARDY & SPAULDING,\textsuperscript{83} supra note 83, at 2-3.

\textsuperscript{88} House\textsuperscript{'}s Hearings,\textsuperscript{15} supra note 5, at 852.

\textsuperscript{89} CEQ,\textsuperscript{18} supra note 18, at 13, 25-26; SPAULDING & OGDEN,\textsuperscript{83} supra note 83, at 8, 9, 15; SURFACE MINING,\textsuperscript{1} supra note 1, at 54, 63, 64. For additional discussions of the hydrologic impact of surface mining see R. BOHM et al., A PROGRESS REPORT ON NSF/
Acid is generally much less of a problem in the West, but other substances inimical to plant growth may be brought to the surface and released into waters during surface mining.\(^9\) In terms of acreage directly disturbed by surface mining, the environmental impact per ton of coal extracted should often be much lower than in the East, because of the very thick coal seams. However, off-site effects are potentially serious. Disruption or depletion of scarce ground water by strip mining is a significant problem in arid Western areas.\(^9\) The fragile ecology is also highly susceptible to the erosion which can result from mining activities.\(^9\) Finally, surface mining in the West might disturb the habitats of certain endangered species.\(^9\)

In human terms, the effects of strip mining can mean desolate physical surroundings, risk of property damage and injury from landslides and flooding, destruction of agricultural resources, contamination or diminution of water supply, loss of recreational opportunities, and “a stark . . . and intolerable degradation in the quality of life in local communities.”\(^9\) Some attempts have been made to impute dollar values to certain of strip mining’s effects,\(^9\) but satisfactory results are

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RANN Funded Research Related to Environmental and Economic Aspects of Coal Production 45-61 (University of Tennessee 1974) [hereinafter cited as Progress Report]; H.R. Rep. No. 94-45, supra note 1, at 100-03. In some instances, surface mining may have a beneficial effect by causing water to be stored in the ground and gradually released, thus improving stream flow during dry periods. See Bohm, Lord, & Patterson, supra note 38, at 55; Surface Mining, supra note 1, at 64.


91. NAS, supra note 83, at 13, 43. Aside from the direct impact of mining itself, energy facilities which may be associated with Western coal mining, such as mine-mouth power generating stations and coal gasification plants, would create major demands on the region’s scarce water resources. See Independence supra note 8, at 303-311; NAS, supra note 83, at 100-03; Task Force, supra note 24, at 54-57.

92. Alluvial valleys have been identified as areas where, because of their vulnerability as well as their hydrologic importance, surface mining could be particularly damaging. NAS, supra note 83, at 12, 44, 45.

93. Id. at 12.

94. S. Rep. No. 93-402, supra note 84, at 33. See also Progress Report, supra note 89, at 91, 92.

95. The U.S. Department of the Interior, for instance, estimated the increased annual hunting and fishing benefits which would flow from “basic reclamation” of surface mined areas at about $50 million in the early 1960’s. Spaulding & Ogden, supra note 83, at 41. Adjustment (downward) for the proportion attributable to coal mining and (upward) for economic growth and inflation since that time produces approximately the same figure of $50 million for the annual recreational benefits in the form of fishing and hunting which are potentially foreclosed by the environmental damage from the coal strip mining which had occurred by about 1964. Assuming that the damage, unrepaired, persists for many years (see note 106 infra), one may approximate the total loss involved at one billion dollars, using a 5% future discount rate; or at $500 million, using a 10% rate. This does not take into account the probable future increase in demand for such recreation.

In a more recent study of a particular scenic area in Appalachia, the present value of the recreational benefits from preserving the area from strip mining was estimated to
very difficult to obtain. There are obvious practical difficulties in trying to get at the theoretically appropriate measure by the direct route of simply asking people how much monetary compensation they would require in order to accept strip mining's environmental damage. For one thing, to produce valid results this approach requires that those polled understand the relatively complex nature of the damage in question. Less direct techniques for estimating environmental costs often proceed according to a variety of questionable methodologies and assumptions, rely on a considerable degree of guesswork, and leave out significant values altogether.

be $71 million at an 8% discount rate, and $33 million at a 10% rate (1973 dollars). Since the foregone coal output would be 28.6 million tons, this roughly implies an environmental cost of strip mining at this location of between $1.15 and $2.48 per ton of coal, counting only recreational values. Hearings on H.R. 3, supra note 83, at 1291.

Attempts have also been made to measure the property damage due to increased flooding and related effects of surface mining. An analysis of these variables in several Appalachian watersheds indicated that strip mining was responsible for damage to households at rates of between $0.39 and $0.74 per ton of coal (apparently in 1973 or earlier dollars). Progress Report, supra note 89, at 83-87.

There are less obvious theoretical difficulties as well, e.g., the public-good nature of most environmental benefits may create incentives for people to misrepresent their true preferences. For discussions of the various problems with this approach, see Fischer, Willingness to Pay as a Behavioural Criterion for Environmental Decision-Making, 3 J. Environmental Management 29 (1975); Lave, Air Pollution Damage: Some Difficulties in Estimating the Value of Abatement, in Environmental Quality Analysis: Theory and Method in the Social Sciences 213, 231-32 (A. Kneese & B. Bower ed. 1972).

The more usual way to put the question is, how much would people be willing to pay in order to avoid strip mining's environmental damage? One formulation assumes that strip mining constitutes the status quo; the other, that undisturbed land does so. This may be less of a problem where the type of damage in question is directly comprehensible in, e.g., aesthetic terms. At least one study has attempted to measure the visual aesthetic value at stake in a strip mining-power generation development by use of direct survey techniques. Randall, Ives, & Eastman, Bidding Games for Valuation of Aesthetic Environmental Improvements, 1 J. Environmental Econ. & Management 132 (1974). It was not possible, however, to separate the power plant/air pollution component from the mining component of the benefit variable.

One common practice is to use market prices of proxies for the value in question (e.g., the cost of transportation to a recreational area) without estimating consumer surplus, which is the relevant measure of the benefits. See B. Ackerman, S. Rose-Ackerman, J. Sawyer, & D. Henderson, The Uncertain Search for Environmental Quality 104-109 (1974); Cost-Benefit Introduction, supra note 39, at 31-40.

In one study, "the loss of aesthetic values at the mining site by the general public [was] assigned a value of $1.00 per acre disturbed." Howard, A Measurement of the External Diseconomies Associated with Bituminous Coal Surface Mining, Eastern Kentucky, 1962-1967, 11 Natural Resources J. 76 (1971), reprinted in Issues, supra note 2, at 148, 161.

How, for example, should one account for the worth of natural areas to people who have not yet visited them but value the opportunity to do so, or simply care about them anyway? For the worth of preventing possible long-term deleterious effects on ecological balance? See Spore, The Economic Problem of Coal Surface Mining, 2 Environmental Affairs 685, 688-89 (1973).
In the case of the multifarious, often intangible, and inadequately understood values at stake here, one must treat figures thus arrived at with much care, viewing them only as imperfect reference points in the process of forming a judgment as to the values' importance. Probably the best course of action in this case is directly to compare the actual environmental harms with the estimated costs of alleviating them, a comparison which may be rendered more meaningful by being framed in per capita or per household terms. In order completely to offset the cost savings from strip mining, for instance, the "average American" would need to value the environmental harms caused by a year of strip mining at between $4.12 and $6.86. Ultimately, we as a society—i.e., Congress on our behalf—must in effect impute a dollar amount to the environmental values at stake by the act of deciding how much it is worth to protect them.

Certain important characteristics of these values should be taken into account in making such a decision. First, much of the damage from strip mining is potentially of long duration; in some instances it may be viewed as essentially permanent. Future, as well as present, wants and preferences must therefore be given serious attention, and there is good reason to believe that the weight people place on environmental benefits will grow in the years to come. Increasing income tends to lead to more leisure, and "[r]ising education levels . . . seem to be
associated with increasing preferences for taking this leisure in a natural environment. . . .”107 Moreover, since the nature of the long-run damage from surface mining and the importance to be attributed to it in the future are matters of some present uncertainty, it may be prudent to give the benefit of the doubt to the environment when weighing it against better circumscribed values.108

A. Distributional Aspects

The environmental harms from strip mining are to an important extent concentrated geographically in the locations where the activity takes place. Certainly there is opportunity here for large direct costs to fall on local residents; this is emotionally attested to at Congressional hearings by inhabitants of strip mining areas.109 Since much surface mining occurs in economically depressed areas, many of the people thus affected by concentrations of environmental harms are poor to begin with.110 It may be feasible, as well as fair, to devise compensation schemes with respect to those localized effects of surface mining which are not avoidable through reclamation or other controls, i.e., such temporary incidents of mining operations as noise and vibration and aesthetic disturbance. It has been suggested, for instance, that surface mining be taxed for the specific purpose of compensating the affected communities.111

Beyond impinging on those who reside near strip mining activities, some environmental costs are more widely distributed through our


108. This notion has been developed in more rigorous form in Arrow & Fisher, Preservation, Uncertainty, and Irreversibility, 88 Q. J. ECON. 312 (1974); and in Fisher & Krutilla, Valuing Long Run Ecological Consequences and Irreversibilities, 1 J. ENVIRONMENTAL ECON. & MANAGEMENT 96 (1974). One “main conclusion is that a conservative policy with respect to irreversible modification of the environment is indicated.” Fisher & Krutilla, supra at 97.

109. See, e.g., House Hearings, supra note 5, at 675-713.

110. For instance, the central Appalachian areas which produce 40% of the region’s surface mined output “have the highest percentage of families below the poverty level in Appalachia—over double the national average—and the unemployment rate is higher than the rest of Appalachia and the nation.” CEQ, supra note 18, at 77.

One potential source of regionally concentrated harms is the depressing effect of environmental degradation on economic development. See note 249 infra.


It would not be desirable, however, to allow local communities to be “bribed” into permitting the operation of surface mines completely free from environmental constraints (even supposing that the worth imputed to local environmental harms would be low enough in relation to the cost of controls for this to be a realistic outcome). Others, including geographically distant persons as well as future generations, also have legitimate interests in the environmental values at stake.
society. Obviously, those who visit the affected regions and others who are particularly concerned with environmental preservation or outdoor recreation would derive the most benefit from reductions in those costs. There is some evidence that such persons tend to have higher than average income.\textsuperscript{112} To the extent, though, that surface mining affects such things as future ecological stability, soil fertility, and water supply, it is reasonable to treat the environmental damage as of broad society-wide interest.

V

RECLAMATION

Traditionally the term reclamation has referred to a discrete post-mining operation undertaken to repair the land disturbance created by surface mining. Here the term will be used in a broader sense, to comprehend the entire range of environmental protection techniques which may be used not only after coal extraction has been completed but also as an integral part of the ongoing mining process.\textsuperscript{113} In the context of this Comment's evaluative framework, reclamation should be viewed as providing a set of alternative mining technologies which reduce both the negative environmental consequences and, generally, the production cost savings which flow from strip mining.

The basic problems in strip mine reclamation are (1) to insulate the toxic (usually, acid-forming) materials from the surrounding environment; (2) to return the site to an acceptable topography (contour); (3) to stabilize the area to prevent erosion and sliding; and (4) to revegetate the surface permanently.\textsuperscript{114} In addition, where mining adversely alters ground or surface water patterns, reclamation may involve repairing or countering those effects. The feasibility and cost of performing these tasks may depend on a number of factors which vary

\begin{itemize}
\item \textsuperscript{112} Freeman, supra note 49, at 272.
\item \textsuperscript{113} Many experts have noted that reclamation tasks can be more effectively and less expensively performed when they are designed into mining procedures from the start. CEQ, supra note 18, at 28; GRIM & HILL, supra note 16, at 17; MATHEMATICA, supra note 17; NAS, supra note 83, at 87. In any event, specific environmental controls are frequently required during mining operations to avoid problems of water pollution and erosion. See note 114 infra.
\item \textsuperscript{114} See generally, on reclamation, CEQ, supra note 18; F. Doyle, H. Bhatt & J. Rapp, Analysis of Pollution Control Costs (EPA-670/2-74-009, 1974); Processes, supra note 16; GRIM & HILL, supra note 16; Maneval, supra note 16, at 10; Mathematica, supra note 17; NAS, supra note 83; Stanford Research Institute, supra note 78; SURFACE MINING, supra note 1.
\end{itemize}
greatly among regions and among specific sites within each region: slope, climate, chemistry of the various affected strata, hydrology, physical properties of the spoil, depth and thickness of the coal deposit, etc. It is generally conceded that even under the most favorable circumstances, land that has been changed from its wild state by surface mining cannot ordinarily be restored to near its original condition, at least within a time-frame congenial to human thinking. Apart from areas whose pristine character is itself of high value, however, elimination of significant environmental injury appears to be feasible for at least some strip mining. Often, for example, surface mined land can be successfully returned to agricultural uses.

Lesser degrees of reclamation are of course possible and are commonly performed. Regrading of the mined area, for instance, may stop short of covering the highwall. For the most part, however, the

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116. The phrase “elimination of significant environmental injury” is intended here to mean, in essence, that for practical purposes the result is as if surface mining had never taken place. More specifically, it means: (a) restoration of the affected area to its previous long term land use potential (excepting, of course, the ability to yield coal, but including, inter alia, aesthetic dimensions of land use); (b) avoidance of long term adverse off-site impacts of magnitudes greater than those associated with non-mining land uses compatible with and generally acceptable in the surrounding area; and (c) avoidance, during the mining and reclamation process, of non-minor adverse off-site impacts beyond the temporary visual and aural features of those operations (the ugliness of the mining site, the noise from blasting, and the like).

Cf. H.R. 25, supra note 3, at § 515(b)(2). Cf. also definitions of “restoration,” “reclamation,” and “rehabilitation” at NAS, supra note 83, at 11.

The experience with coal surface mine reclamation in Great Britain and Germany, see CEQ and House Hearings, supra indicates that massive land disturbance per se need not preclude successful restoration. While the problem of acid-forming material is often more severe in this country, it appears that with proper separation and handling of overburden strata, acid contamination can be effectively controlled in many cases. See, e.g., 2 Mathematica, supra note 17, at III-8-28. Other aspects of some American surface mining are more problematical, namely, erosion and sliding on steep slopes, and fragile soil in Western regions. See text accompanying notes 124-28 infra.

120. In some instances, it may be possible to avoid all significant environmental
above-mentioned elements of reclamation appear to be highly interdependent, and environmental costs tend to rise steeply with reductions in reclamation efforts below those required to avoid any significant long-term damage. A case in point is restoration of the original topography in contour mining, by placing spoil on the mined bench rather than the downslope. Although this can be the single most difficult and expensive measure in the environmental control of contour mining, in its absence not only does a central source of aesthetic disturbance remain, but sliding of spoil and erosion from the highwall are also likely to occur, and complete revegetation and prevention of acid contamination are more difficult to achieve. More generally, successful revegetation requires a stabilized surface and the segregation and burial of toxic strata, which also are necessary to avoid water pollution. Erosion control itself depends in part on the presence of suitable vegetation.

Even with the best reclamation efforts, there are two major classes of strip mining in which the feasibility of success is especially uncertain: operations on steep slopes and in arid regions of the

injury except certain aesthetic or land-use problems associated with the topography of the mined site. In the West, coal seams are sometimes so thick and shallow that the overburden volume is insufficient to restore the original elevation of the mined land. See House Comm. on Interior & Insular Affairs, Surface Mining Control & Reclamation Act of 1974, H.R. Rep. No. 93-1072, 93d Cong., 2d Sess. 89-92 (1974). The resulting geographical depression may or may not have an adverse impact on the surrounding area, depending on considerations of local land use and hydrology.

The mountaintop removal method of strip mining practiced in some Appalachian areas also changes the local topography by turning hilltops into flat land and filling other areas permanently with excess spoil. 2 Mathematica, supra note 17, at V-3-37. See also CEQ, supra note 18, at 23-24; Processes, supra note 16, at 38-40. It appears, however, that landowners in these circumstances desire a flat configuration to result. 2 Mathematica, supra note 17, at V-10. Rounded contours may nonetheless be technically feasible, perhaps requiring less spoil to be stored elsewhere as well. See H.R. Rep. No. 93-1072, supra at 86-88; 2 Mathematica, supra note 17, at V-10-11.

121. See, e.g., CEQ, supra note 18, at 25-29, where a rough quantification of environmental harms associated with various mining-reclamation alternatives indicates that the overall level of damage drops off rapidly in response to relatively small increments in expenditures. Similarly, the Mathematica study found that modified surface mining methods which more closely restore the original topography can substantially reduce environmental injury from mining at little or no increase in cost over conventional methods. 1 Mathematica, supra note 17, at I-43, 71-75; 2 Mathematica, supra note 17, at V, VI-viii-ix, 56-58. See also CEQ, supra note 18, at 22, 26-33; Hearings on CEQ Report, supra note 117, at 7-8; Hearings on S. 2777 & S. 3000 Before the Subcomm. on Minerals, Materials and Fuels of the Senate Comm. on Interior & Insular Affairs, 92d Cong., 1st Sess., pt. 3, at 971 (1972) [hereinafter cited as S. 2777 & S. 3000 Hearing].


123. See, e.g., CEQ, supra note 18, at 94; Grim & Hill, supra note 16, at 149-51.

124. The definition of "steep" for this purpose varies from site to site according to
West. In the former case, the principal difficulty is stabilizing the spoil after mining. While returning the material to its original position on the solid foundation of the bench increases the stability of the land over that resulting from conventional mining practices, it still may have a greater tendency to slide or erode than in its previous undisturbed state. There appears to be substantial doubt as to whether slopes over about 25 degrees can be permanently restored. About one third of Appalachian strip mined output came from slopes steeper than 25 degrees in 1971, while about 80% of the strippable reserves in that region appear to be on slopes of under 25 degrees.

In the case of Western strip mining, one major unsolved problem is that of revegetating the mined areas in conditions of low rainfall and poor soil quality. Topsoils in many Western coal regions are quite fragile, and even careful attempts at segregation and replacement after mining may fail to provide a medium adequate to support plant growth. The effectiveness of irrigation and various soil treatments is uncertain.

As indicated in the preceding note, the stability of restored slopes depends not only on steepness but also on other factors. A number of techniques can be used to counteract instability, such as compaction of spoil and construction of drainage channels to guide water away from the mined area. Interview with David Maneval, Appalachian Regional Commission, Washington, D.C., May, 1974; 2 MATHEMATICA, supra note 17, at III-19-23; Hearings on CEQ Report, supra note 117, at 73. But as a general rule, a 50% grade, about 26 degrees, is regarded as the upper limit for stable fill slopes. (Sometimes the limit can be extended to about 33 degrees with compacted material.) DEPT OF WATER RESOURCES, MARYLAND, B. BECKER & T. MILLS, GUIDELINES FOR EROSION AND SEDIMENT CONTROL PLANNING AND IMPLEMENTATION 35 (EPA-R2-72-015, 1972); HIGHWAY RESEARCH BOARD, NATIONAL RESEARCH COUNCIL, CONSTRUCTION OF EMBANKMENTS 15 (1971). "[M]aximum vegetative stability cannot be attained on slopes steeper than 33 percent [18 degrees]." DEPT OF WATER RESOURCES, MARYLAND, ET AL, supra at 21 (emphasis added); NAS, supra note 83, at 53.

See also PROGRESS REPORT, supra note 89, at 151; Hearings on CEQ Report, supra note 117, at 60, 69-70.

The NAS report observed that the potential for success is "critically site specific"; the numerous variables must be examined in advance of mining at each site. The study did conclude, however, that some of the Western coal lands—generally those with greater precipitation—have a high probability of being successfully reclaimed; but the exact techniques for doing so are not yet known. In desert regions, the probability of success is "extremely low"; while in many other areas the reclamation potential is simply a matter of great uncertainty. NAS, supra note 83, at 2-4, 73-87.

NAS, supra note 83, at 43-45.
A. Reclamation Costs

Available estimates of reclamation costs are extremely varied. One factor making it particularly difficult to predict future costs in this area is the probable development of integrated mining-cum-reclamation techniques in which environmental protection is less expensively achieved than in conventional approaches.\textsuperscript{129} For any given per-acre expenditure, moreover, the thickness of the coal seam crucially affects the resulting reclamation cost: the thicker the seam, the smaller the cost increment per ton of coal mined.

On the basis of the existing evidence, it is not implausible that the reclamation costs necessary to avoid significant environmental injury from strip mining (where this objective is attainable) could average below $1000 per acre; nor is it implausible that they could average as much as $10,000 per acre.\textsuperscript{130} It appears more likely, however, that typical costs will be in the neighborhood of $3000 to $5000 per acre.\textsuperscript{131}

\textsuperscript{129} Indeed, the very imposition of effective environmental constraints on surface mining can be expected to induce such cost-saving innovations. See \textsc{Doyle, Bhatt, \\ & Rapp, supra note 114, at 37; NAS, supra note 83, at 13-14, 52; Schmidt-Bleek \\ & Moore, supra note 39, at 20; S. 2777 \\ & S. 3000 Hearings, supra note 121, at 971.}

\textsuperscript{130} See note 131 infra.

\textsuperscript{131} The major cost element in reclamation is earth moving, i.e., separating, replacing, and regrading the material removed in the process of uncovering coal. In area mining, estimates for the cost of restoring the original topography of the land generally range between $600 and $2400 per acre. \textsc{Processes, supra note 16, at 120-121; NAS, supra note 83, at 88. (All costs herein are expressed in second quarter 1975 dollars). Improved techniques might reduce even the lower end of this range. Unfortunately, it is not always possible to determine from available estimates whether the regrading process in question includes adequate segregation of various strata and isolation of pollution-forming material. There are, however, separate data on the cost of replacing topsoil, averaging $300 to $600 per acre. NAS, supra note 83, at 54; \textit{but cf.} 2 \textsc{Charles River, supra note 57, at 124, citing a figure as low as $65 per acre.}

Reggrading in the case of contour mining is typically more difficult than in mining on flat land, especially if spoil must be recovered from the downslope. Where regrading efforts are integrated with mining so as to allow the direct placement of spoil into previously mined sections, the cost of restoring the topography can be reduced considerably. CEQ, supra note 18; \textsc{Mathematica, supra note 17; Saperstein \\ & Secor, Improved Reclamation Potential with the Block Method of Contour Stripping, in Selected Papers, supra note 87, at 25. Cost estimates for contour restoration, often based more on theory than practice in the case of newer techniques, vary from $250 or $400 per acre to perhaps $6000. The most plausible range appears to be $1000 to $3500. See, e.g., CEQ, supra note 18, at 28, 29, 97-102; Doyle, Bhatt, \\ & Rapp, supra note 114, at 13-37; \textsc{Processes, supra note 16, at 112-113; Hearings on H.R. 3, supra note 83, pt. 2, at 1277-80; Maneval, supra note 16, at 30; 2 \textsc{Mathematica, supra note 17, at VI. (In some instances, estimates must be translated from cost per ton to cost per acre for purposes of comparison here.) Again, it is not clear to what extent these amounts cover adequate isolation of toxic strata, but at least the higher figures include topsoil segregation. One study has reported the costs of spoil separation and burial at $520 per acre. 2 \textsc{Mathematica, supra note 17, at VI-19.}

Reggrading costs for the mountaintop removal method of mining have been less fully explored, but one analysis concludes that modified techniques could achieve environment-
Within that range, flatter sites generally require lower expenditures than those on slopes, and arid sites generally require higher expenditures than those with moderate precipitation. Using the example of $5000 per acre for contour mining, $4000 for (non-arid) area mining, and $4500 for Western area mining, the reclamation cost per ton of coal mined is shown in Table 1 for a range of seam thicknesses typical of the region where each type of mining predominates. It will be observed that in the East, these costs range for the most part between one eighth and one third of the estimated average cost differential between strip mining and totally acceptable reclamation at no increase in cost over conventional mining methods. 2 MATHEMATICA, supra note 17, at V-3-37, VI-57.

Another source of reclamation expense is revegetation. This process typically costs between $250 and $500 per acre. DOYLE, BHATT, & RAPP, supra note 114, at 48; PROCESSES, supra note 16, at 177; Hearings on H.R. 3, supra note 83, at 1277-1279; STANFORD RESEARCH INSTITUTE, supra note 78, at 63. Cf. 2 MATHEMATICA, supra note 17, at VI-26, 27. In arid regions, special measures may be necessary at an additional cost which is not well known. Total revegetation expenses in such cases might be in the neighborhood of $1000 per acre. NAS, supra note 83, at 75-77, 87-90.

Especially where mining is performed on slopes, various water diversion or treatment facilities may be required, at least temporarily. The costs thereby incurred are probably highly variable, but the magnitude of $200 to $350 per mined acre appears to be typical. 2 CHARLES RIVER, supra note 57, at 171; 2 MATHEMATICA, supra note 17, at VI-23; STANFORD RESEARCH INSTITUTE, supra note 78, at 63, 151; SURFACE MINING, supra note 1, at 82.

In sum, a reasonable range for reclamation costs implied by the above data would be between $1000 and $4000 per acre for area mining (about $500 more in the West) and between $1800 and $5000 per acre for contour mining. Since it is likely that some of the estimates relied upon do not account completely for the expense of effectively segregating spoil components or such other possible requirements as spoil compaction or repair of hydrological disturbance, the lower end of this range should be viewed as conservative. Reclamation experience in other countries tends to support this judgment, although because of differing mining conditions, especially in Germany, the data are not directly comparable. In the German brown coal industry, an integrated surface mining technology which restores mined land to “full agricultural productivity” has total reclamation costs of $3800 to $5800 per acre. Hearings on H.R. 3, supra note 83, at 1296-1303. In British surface mining, the cost of reclamation, which includes separate removal and replacement of both topsoil and subsoil, as well as intensive revegetation treatment, averages $5300 per acre. Id. at 952-956; CEQ, supra note 18, at 88-90. The estimates presented in the text thus emphasize the higher cost figures.

132. The per-ton costs are calculated on the commonly used basis of an 80% coal recovery rate, which means that 1440 tons of coal are extracted per acre-foot of mined seam. CEQ, supra note 18, at 28; Hearings on H.R. 3, supra note 83, pt. 2, at 963; STRIPPABLE RESERVES, supra note 15, at 11, 13.

133. Treatment of the relationship between acres mined and acres disturbed is unfortunately far from uniform among the various studies of reclamation costs. Assumptions about this ratio, often only implicit, appear to vary substantially, and moreover it is often not possible to determine whether the data are based on reclamation cost per mined acre or per disturbed acre. Where modern, concurrent reclamation approaches are used, however, little additional land beyond the mined area is disturbed. See, e.g., 2 MATHEMATICA, supra note 17, at II-28-35, V-4, 39, 58. Hence, it is probably safe to treat the $4000 to $5000 used here as referring to mined acreage, and the estimates given in Table 1 are so derived.
underground mining ($3 to $5 per ton). In the West, estimated reclamation costs often represent a very minor increment to the cost of coal.\textsuperscript{134}

Table 1

<table>
<thead>
<tr>
<th>Seam Thickness</th>
<th>Contour Mining Reclamation Cost</th>
<th>Area Mining Reclamation Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>2 foot seam</td>
<td>$1.74 per ton</td>
<td>$1.39 per ton</td>
</tr>
<tr>
<td>3</td>
<td>$1.16</td>
<td>$0.92</td>
</tr>
<tr>
<td>4</td>
<td>$0.87</td>
<td>$0.69</td>
</tr>
<tr>
<td>5</td>
<td>$0.69</td>
<td>$0.56</td>
</tr>
<tr>
<td>6</td>
<td>$0.58</td>
<td>$0.46</td>
</tr>
<tr>
<td>7</td>
<td>$0.50</td>
<td>$0.40</td>
</tr>
</tbody>
</table>

West

<table>
<thead>
<tr>
<th>Seam Thickness</th>
<th>Reclamation Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>5 foot seam</td>
<td>$0.62 per ton</td>
</tr>
<tr>
<td>20</td>
<td>$0.16</td>
</tr>
<tr>
<td>50</td>
<td>$0.06</td>
</tr>
<tr>
<td>100</td>
<td>$0.03</td>
</tr>
</tbody>
</table>

VI

MINING HEALTH AND SAFETY HAZARDS

Underground coal mining is a dangerous occupation and in the past has resulted in proportionally more work-related injuries than surface mining. The average injury rates for 1960-1970, generally before the impact of the Federal Coal Mine Health and Safety Act of 1969,\textsuperscript{135} were as follows:\textsuperscript{136}

\textsuperscript{134} A word should also be said about auger mining reclamation (see note 16 supra). Where, as is usually the case, auger mining is performed in conjunction with contour mining, the only additional reclamation cost should be that of sealing the auger holes, a fairly minor expense. Where augering is carried out independently on hillsides from a narrow bench, the cost of reclamation still appears to be low: about 8¢ per ton. CEQ, supra note 18, at 29. One potentially severe environmental problem in auger mining occurs when the machinery penetrates deep-mined areas inside the hill. Acid mine water can then be released through the holes. It may be possible to seal them with impervious materials, but the preferable solution is to avoid augering near underground mines. See Processes, supra note 16, at 49.

\textsuperscript{135} For an analysis of the Act, see Note, \textit{A Case Study of Legislative Implementation: The Federal Coal Mine Health and Safety Act of 1969}, 10 Harv. J. Legis. 99 (1972) [hereinafter cited as \textit{Case Study}].

\textsuperscript{136} CEQ, supra note 18, at 135-36.
In terms of injuries per ton of coal mined, the differences are even greater. The average rates for 1968-1970 were as follows.\textsuperscript{137}

### Table 2

<table>
<thead>
<tr>
<th>Mining Method</th>
<th>Fatalities per million man-hours</th>
<th>Non-fatal injuries per million man-hours</th>
</tr>
</thead>
<tbody>
<tr>
<td>Underground</td>
<td>1.35</td>
<td>47.56</td>
</tr>
<tr>
<td>Strip</td>
<td>0.49</td>
<td>23.01</td>
</tr>
</tbody>
</table>

Applying these rates to recent output levels of surface mined coal, one may estimate that about 150 additional deaths and 6000 additional injuries per year would result from substituting underground mining for the same output.

In addition to accidents, underground mining historically has posed a substantial occupational risk in the form of coal workers' pneumoconiosis, the "black lung" disease.\textsuperscript{138} This illness may cause, among other things, severe breathing difficulty with accompanying disability, and premature death.\textsuperscript{139} "[I]t appears that the rate of pneumoconiosis among working underground miners is probably somewhere between 10 and 15 percent";\textsuperscript{140} around one or two percent suffer from the disease in its most severe, and generally fatal, form.\textsuperscript{141}

The Coal Mine Health and Safety Act mandated significant improvements in mining practices in order to reduce the incidence of injury and disease. The frequency of fatal accidents in underground mines has declined substantially in the several years since the implementation of the Act.\textsuperscript{142}

\textsuperscript{137} Id.


\textsuperscript{141} Shoub, \textit{supra note} 140, at 9, 10, 11, 14, 15, 17.

\textsuperscript{142} \textit{Mining Enforcement & Safety Administration, U.S. Dep't of the}
Table 4

<table>
<thead>
<tr>
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</tr>
</thead>
<tbody>
<tr>
<td>Fatalities per million man-hours</td>
<td>1.21</td>
<td>0.87</td>
<td>0.60</td>
<td>0.49</td>
<td>0.43</td>
<td>0.41</td>
</tr>
</tbody>
</table>

The non-fatal injury rate has not shown consistent improvement, although in 1974 it dropped from the previous average of about 50 per million man-hours to 35.81. As for black lung disease, it is difficult to measure the actual health impact of the 1969 Act because the recent prevalence of the disease reflects years of past exposure in the mines. Based in part on the British experience with coal mine dust control, it may be anticipated, though, that the Act's ultimate result will be a great reduction in the amount of black lung disease, conceivably even its virtual elimination.

To measure the importance of the hazards which remain in coal mining after the impact of the 1969 Act is taken into account requires placing a money value on injury, disease, and death. It is highly problematical to assign a meaningful dollar figure to a particular person's death, but it is possible to do the same for a relatively small risk of death or of non-fatal accidents and illness. There are innumerable occasions in life where people choose to bear these risks in return for other, quite finite, gains, such as the use of automobiles and airplanes. The most appropriate theoretical measure of the cost to miners of coal mining accidents and disease is the amount of compen-
tion necessary to induce them voluntarily to assume the risks involved.147

One attempt to estimate the relationship between occupational risk and wage compensation in a variety of jobs found that workers receive around $300 annually148 for each additional chance per thousand of dying during a one-year period. This single figure measures the rate of compensation for bearing the risk of both fatal and non-fatal occupational injuries,149 since the two rates evidently are highly correlated from industry to industry.150 Because the amount one can afford to spend (or demand) for safety depends on one's income, it is appropriate to adjust the $300 figure upward to reflect the fact that the population analyzed had below-average earnings. Assuming a relationship of strict proportionality, the revised figure based on average income is about $400.151 On the basis of several alternative assumptions about future

149. The wage compensation measured in this study actually accounts for only a portion of the total value of death and injuries, because a significant part of the costs of at least non-fatal accidents is already paid for in other ways, notably workmen's compensation. See Thaler & Rosen, supra note 148, at 29.
150. Id. Unfortunately for purposes of comparison here, the reported high correlation between fatal and non-fatal accident rates does not appear to be true of recent injury experience in underground and surface mining: the fatality rates have been converging, while the non-fatal injury rates remain far apart. However, the downward bias thus introduced into the estimates below of the accident-cost differential between the two types of mining is probably minor because of the considerably greater value attributable to fatal than to non-fatal injuries. For instance, of 9,348 disabling injuries among underground miners in 1970, 9,156 resulted in no permanent disability, i.e., they caused only a temporary absence from work. BUREAU OF MINES, U.S. DEP'T OF THE INTERIOR, INFORMATION CIRCULAR 8613: INJURY EXPERIENCE IN COAL MINING, 1970, at 25 (1973) [hereinafter cited as INFORMATION CIRCULAR 8613]. On the basis solely of foregone earnings due to deep mine accidents, the cost of non-fatal injuries during the 1960's averaged about one third of the losses due to fatal injuries. J. MOORE, HUMAN CAPITAL COSTS IN DEEP AND SURFACE MINING OF COAL: A PRELIMINARY STATEMENT 15, Table 5A (Appalachian Resources Project, University of Tennessee); results summarized at Hearings on H.R. 3 and Related Bills Before the Subcomm. on the Environment & the Subcomm. on Mines & Mining of the House Comm. on Interior & Insular Affairs, 93d Cong., 1st Sess., pt. 2, at 1276 (1973). When the non-financial aspects of death as against injury are taken into account, surely the disparity between fatal and non-fatal risks must be even greater. Moreover, it is likely that a greater proportion of the costs of non-fatal injuries than of death are compensated for separately from the extra wage payments at issue here. See note 149 supra.
151. The $400 to $300 ratio is approximately the ratio of the average income of workers in manufacturing to the mean earnings of the sample used in Thaler and Rosen, supra note 148. Letter from Martin Bailey, Univ. of Maryland Dept. of Economics, to author, Jan. 6, 1976. A slightly lower figure would result from using national income per worker as the standard for average income. See M. Bailey, Benefits of Safety 14 (unpublished manuscript 1975).
accident rates and labor productivities in coal mining, that value results in the following estimates of the accident costs associated with deep and surface mining:

Table 5

<table>
<thead>
<tr>
<th></th>
<th>Underground</th>
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<th>Surface</th>
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<tbody>
<tr>
<td></td>
<td>@ .35</td>
<td>@ .40</td>
<td>@ .25</td>
</tr>
<tr>
<td>fatalities per million man-hours\textsuperscript{152}</td>
<td>10$</td>
<td>11$</td>
<td>2.7$</td>
</tr>
<tr>
<td></td>
<td>11.2 tons per man-day\textsuperscript{153}</td>
<td></td>
<td>36 tons per man-day\textsuperscript{154}</td>
</tr>
<tr>
<td></td>
<td>13.4 tons per man-day\textsuperscript{155}</td>
<td></td>
<td>36 tons per man-day\textsuperscript{156}</td>
</tr>
<tr>
<td></td>
<td>8$</td>
<td>9$</td>
<td>2.7$</td>
</tr>
</tbody>
</table>

This yields an excess accident cost in underground mining of between 5\$ and 8.3\$ per ton of coal.

The validity of these results depends, of course, on whether the subjective value to workers of the hazards they face on the job are accurately reflected in the financial compensation they receive, which in turn depends critically on whether workers are well-informed about the nature and magnitudes of such hazards. This is open to serious question, and therefore it is desirable to test the data against other approaches to valuing risks.

A widely used method to estimate the cost of accidents and disease is to calculate the value of the earnings lost as a result. Although this measure has been persuasively criticized as an irrelevant concept for purposes of valuing risk of death,\textsuperscript{157} it is reasonable to think that loss of income is at least one important element in the calculus of individuals confronting occupational or other hazards.\textsuperscript{158} Presumably the total

\textsuperscript{152} These rates are slightly below the lowest annual averages already achieved, 0.43 (1974) and 0.30 (1973) for deep and strip mining, respectively. The assumed level of underground mining fatalities has in fact been surpassed by some firms operating underground mines. Wall St. Journal, Jan. 18, 1973, at 1, col. 6.

\textsuperscript{153} These rates are approximately equal to the lowest annual averages already achieved. See note 152 supra.

\textsuperscript{154} This level of output per man-day is the most recent, and lowest, reported for underground mining since the 1969 Act went into effect. NCA, supra note 8, at 84.

\textsuperscript{155} This level is based on the assumption that after full adaptation to the changes brought about by the 1969 Act labor productivity in deep mining will recover half of the loss experienced up to 1973. See NCA, supra note 8, at 84.

\textsuperscript{156} This is the approximate output per man-day achieved in strip mining in 1970; since then, productivity has declined less than 4%. NCA, supra note 8, at 84.

\textsuperscript{157} See Life and Limb, supra note 147.

\textsuperscript{158} This is obvious in the case of non-fatal injuries. In the case of death, while loss of the ability to earn income is irrelevant to the victim, he may be very interested (while alive) in the effect of that loss on his dependents. See, e.g., Schelling, supra note 146.
value placed on such risks should be several times the size of that component. The results of one attempt to estimate the foregone-earnings cost of coal mining accidents\textsuperscript{159} yield a range of 2.8¢ to 5.6¢ per ton when adjusted for a projected fatality rate of 0.35 per million man-hours and labor productivity of 11.2 tons per man-day. This is broadly consistent with the comparable figure of 10¢ per ton under the labor market approach above.\textsuperscript{160}

In the case of black lung disease, it is more difficult to associate a cost with a unit of coal output. For one thing, the relationship between exposure and development of the disease is poorly understood. From the available rough estimates, however, one may infer that between 3 and 8 cases of black lung occur per million tons of deep mined coal.\textsuperscript{161}

A very approximate way to obtain a hypothetical value for this extent of the disease would be to assume that people view the illness as about as bad on the whole as a serious injury\textsuperscript{2} (with a distribution of severity in each case from minor long-term disability to death). Then by applying the labor market figure of $400,000 per "unit" of occupational risk,\textsuperscript{163}

Of course, loss of earnings is recognized as an important component of the damages which are intended to "make the victim whole" in personal injury actions. See 2 HARPER & JAMES, THE LAW OF TORTS 1299, 1316 (1956).

159. Moore, supra note 150.

160. See also Statt, Social Benefit Versus Technological Risk, 165 SCIENCE 1232 (1969), which presents a risk-benefit trade-off curve based on a variety of activities such as dangerous sports, air travel, and cigarette smoking. By visual inspection of Starr's "voluntary" risk graph, id. at 1234, one may estimate, for example, that an exposure level of 0.35 fatalities per million man-hours corresponds to a compensation rate of $215 per year (expressed in 1975 dollars). This agrees very closely with the comparable value derived from Thaler and Rosen, supra note 148, which is about $250. (At about 1800 working hours per man-year, see INFORMATION CIRCULAR 8613, supra note 150, at 33, 0.35 fatalities per million man-hours equals .00063 per man-year. If workers require $400 per year as compensation for bearing one chance in a thousand of dying during the year, this rate implies a compensation level of 0.63 times $400, or about $250.)

161. One investigation has indicated that at the 1972 employment level in deep mining, between 883 and 2391 new cases of pulmonary disease appear annually among underground miners. R. BOHM et al., A PROGRESS REPORT ON NSF/RAHH FUNDED RESEARCH RELATED TO ENVIRONMENTAL AND ECONOMIC ASPECTS OF COAL PRODUCTION 111, 124 (University of Tennessee 1974) [hereinafter cited as PROGRESS REPORT]. Since the 1972 deep mine output was 304 million tons, NCA, supra note 8, at 82, this means 3 to 8 cases per million tons of coal. It has also been estimated that about 30% of underground miners contract black lung disease by retirement age. APPALACHIAN REGIONAL COMMISSION, MANPOWER REPORT FOR THE APPALACHIAN COAL INDUSTRY 32 (1973). If coal mining is viewed as a lifetime occupation, during which is produced perhaps 100,000 tons of coal per worker (based on 35 years of work), that implies 3 cases per million tons. See also Lave & Freeburg, Health Effects of Electricity Generation from Coal, Oil, and Nuclear Fuel, 14 NUCLEAR SAFETY 409, 412 (1973).

162. I.e., an injury resulting in death or permanent disability.

163. Thaler & Rosen, supra note 148, suggest a compensation rate of $400 (after adjustment for inflation and a low-income sample) for bearing the level of risk represented by one chance in a thousand of dying during a year, where the risk also includes non-fatal injuries. See text accompanying note 149 supra. Otherwise
where each unit consists of one death and about six serious non-fatal occurrences, one arrives at a value of $57,000 for the average case of black lung disease. For the above incidence rates, this is equivalent to between 176 and 466 per ton of coal. Another way to approach the problem is to compare the cost of foregone earnings or lost productivity from black lung with that of mining accidents, on the assumption that the ratio of total value (including "pain and suffering," etc.) to income loss is about the same in each case. Productivity losses from black lung disease have been estimated at between 0.62 and 1.65 times the comparable losses from deep mining accidents in 1970. Since the labor market compensation value of the accidents is 27.66 per ton in current dollars, the equivalent value of black lung disease is 176 to 45.56 per ton, surprisingly almost identical to the previous estimates.

If the 1969 Act results in an 80% reduction in black lung disease, the cost will decline to between 3.46 and 9.16. In sum, then, the future cost of disease and injury in underground mining is likely to be in the range of 86 to 176 per ton above that of surface mining. Without any decline in the incidence of black lung, the differential might be as much as 506. It must be remembered, however, that these estimates derive from tentative and highly approximate measures.

A. Distributional Aspects

The premise underlying the labor market study relied on in this section is that workers actually receive compensation equal to the value of the occupational risks they bear. If this is true of coal mining, then the cost of work hazards there is borne by mining firms and is already reflected in the production costs discussed above.

As previously suggested, ignorance of the true scope of the hazards would tend to invalidate the crucial premise. Inadequate appreciation of the dangers of mining, especially in terms of disease, may well have

expressed, that rate is equal $400,000 for the amount of injury represented by one death.

164. Bailey, supra note 151, at 9 reports that in 1970 occupational accidents resulted in 14,200 deaths and 90,000 permanent impairments, or a ratio of about one to six. It is assumed for purposes of estimation here that less serious injuries account for a negligible portion of the $400,000 figure.

165. While in calculating this cost for mining accidents, the investigators examined the actual time lost from work by victims, Moore, supra note 150, in the case of black lung disease the investigators estimated the effect of the disease on reducing the productivity of working miners, Progress Report, supra note 161. The results are therefore not exactly comparable, and the black lung estimates are probably conservative, yet the two approaches are basically similar.

166. See note 165 supra.

167. This seems to be a reasonable expectation, on a comparison of the recent American incidence with that achieved in Britain. See, e.g., Progress Report, supra note 161; notes 144, 145 supra.
been a significant factor in the past, but it is likely less so now. Another consideration is the nature of the employment opportunities facing prospective coal miners: where alternative jobs are scarce or low-paying, one would expect workers to be able to command a relatively low price for risk bearing. Such characteristics have historically been true of one major coal producing region, Appalachia; however, they are counteracted by factors of geographic mobility and unionization in coal mining. In fact, wages in coal mining are relatively high, even on a national basis, and substantially exceed average earnings in manufacturing even after subtracting the cost of pre-1969 Act mine accidents and disease as calculated on the assumption of average American income. Hence, it is not unlikely that, in terms of distributional norms, coal miners receive a fair level of compensation for the occupational hazards they face.

The cost of this compensation should ultimately be shared in the same manner as other mining costs, i.e., mainly by consumers and partly by those who might receive rents or profits from coal mining. To the extent that one regards the hazards as incompletely offset by compensation, their costs clearly are concentrated on the miners who turn out to be victims, and their families.

VII

ENERGY SELF-SUFFICIENCY

Because coal is this nation's most plentiful fossil fuel, it figures significantly in recent proposals to reduce U.S. reliance on imported oil. Although the actual extent to which energy self-sufficiency ought to be pursued, and the appropriate role of coal in that pursuit, are questions which are far from settled, coal reserves appear ample

168. See, e.g., CEQ, supra note 18, at 69-73.
169. That is to say, workers can and do look elsewhere for employment. The population of Appalachia declined by over 10% during the 1960's. Id. at 71.
170. See, e.g., Baratz, supra note 81.
171. I.e., using the $400 compensation figure discussed at text accompanying notes 148-51 supra. For inter-industry comparisons of wage rates, see NCA, supra note 8, at 87.
172. See, e.g., INDEPENDENCE, supra note 8; U.S. ENERGY RESEARCH AND DEVELOPMENT ADMINISTRATION, A NATIONAL PLAN FOR ENERGY RESEARCH, DEVELOPMENT & DEMONSTRATION: CREATING ENERGY CHOICES FOR THE FUTURE (1975). As this Comment goes to press, the Federal Energy Administration has released the 1976 NATIONAL ENERGY OUTLOOK, which updates the analysis contained in the INDEPENDENCE report.
173. Stockpiling imported oil, for instance, might be a less costly way to reduce vulnerability than attaining total energy independence. See MIT, supra note 60, at 25. Coal itself might be inferior to other domestic energy sources as the basis for substantially increased self-sufficiency. See GORDON, supra note 64. See also ENERGY POLICY PROJECT OF THE FORD FOUNDATION, A TIME TO CHOOSE: AMERICA'S ENERGY FUTURE
to satisfy any plausible increases in the use of this resource, with or without strip mining. As previously discussed, there is a difference in the costs of the two mining methods. In the long run, the significance of increased energy self-sufficiency to the strip mining issue lies mainly in the greater magnitude of potential cost savings, as well as the other benefits and harms of strip mining, which would result from producing a larger output of coal.

The short-run dimensions of this relationship are more complex. Restrictions on surface mine production would obviously make it more difficult to sustain or increase total coal output at the same time. In general, the shorter the time-frame allowed for adjustment, the more costly it would be to replace the lost production. It is commonly reported that three to five years are required to open new underground mines. For moderate increases in underground production, this period marks the time beyond which long-run costs are applicable, although equipment or other bottlenecks might prevent an expansion within that time-frame large enough to offset a total ban on surface mining. Within the three-to-five year period, increases in deep mine output depend largely on more intensive use of existing capacity, through, e.g. adding work shifts or reopening existing mines not...


174. For instance, the demonstrated underground mining coal reserve base is more than 100 times greater than the total coal output projected for 1990 under Project Independence's hypothetical accelerated development scenario; the latter output itself is over four times the size of current coal production and exceeds Project Independence's most optimistic estimates of 1990 demand. INDEPENDENCE, supra note 8, at 103, 106; TASK FORCE, supra note 24, at 4, 16.

175. The term "long run" refers here to the period of time required for the coal industry to adjust to new government policies or other changes in supply or demand conditions. It is essentially defined by the length of time needed to develop new mines. See text accompanying note 177 infra.

176. But some scenarios for achieving energy self-sufficiency actually involve lower coal output than otherwise, for example where nuclear development is emphasized. See INDEPENDENCE, supra note 8, at 46-51.


Because of production shortages of surface mining machinery, the development time for additional large surface mines may currently be at least as long as that for deep mines. Veto Hearings, supra at 127. Small surface mines, often relying on highly mobile equipment also employable in highway construction or other activities, commonly enter and leave production with much shorter lead times. See, e.g., 1 MATHEMATICA, supra note 17, at I-16.

178. See, e.g., MIT, supra note 60, at 39-40; TASK FORCE, supra note 24, at 47-49.

179. "Tradition and current mining methods . . . have prevented a more rational utilization of the rapidly rising investment in mining equipment which is idle, on the average, almost one third of the time." NATIONAL PETROLEUM COUNCIL, supra note 12, at 135.
currently operating. 180 There is dispute as to how much, if any, excess or “surge” capacity remains in the mining industry; 181 undoubtedly it is lower now than in the past. 182

In any event, short-run expansion in underground output involves extra costs, in the hiring and training of new workers, in overtime pay, in lower productivity because of difficulties in integrating maintenance tasks with expanded work schedules, etc. 183 Based on 1972 industry conditions, one very rough estimate of the short-run elasticity of supply is about one; 184 which means that to replace, e.g., a third of surface mined output, 100 million tons, with an equivalent increment in deep mined coal 185 would require a temporary rise in price of 33% over the long-run cost, or perhaps an additional $5 per ton. However, recent prices have already been considerably above long-run costs, precisely because of short-run demand-supply imbalance, 186 and the Federal Energy Administration apparently believes that a drop in surface mined output of that magnitude would cause the price of coal to rise to the oil equivalent level of $40, or by $12 to $18 per ton. 187 Such temporary price increases would affect only a portion of the coal market,

180. At least until the recent past, the coal mining industry has typically had substantial “surge” capacity: perhaps 50 to 100 million annual tons in the form of mines that rapidly open or close in response to changing demand conditions. (Some of these, however, are surface mines). TASK FORCE, supra note 24, at 44.

181. Compare, e.g., Veto Hearings, supra note 177, at 159 with id. at 72, 128. One examination of the supply of low-sulfur coal in Appalachia concluded that, as of mid-1974, many deep mines were operating below capacity and that there was “the potential for immediate production expansion by operating additional days and shifts.” EPA, AN INVENTORY OF COMPANIES PRODUCING LOW SULFUR COAL IN ALABAMA, KENTUCKY, PENNSYLVANIA, TENNESSEE, VIRGINIA AND WEST VIRGINIA, at v (1974). On the other hand, it seems reasonable to assume that, with the very high price of coal prevailing during the last two years, much of the available capacity for short-run expansion in output has already been drawn into production.

182. Among the factors responsible are recent increases in demand and a low rate of investment in new facilities caused by uncertainties about various unsettled policies affecting coal. INDEPENDENCE, supra note 8, at 104. See also RISER, supra note 7, at 11-12; TASK FORCE, supra note 24, at 44; and note 181 supra.


This elasticity estimate is particularly “rough” as used here, because it apparently applies to the supply of low-sulfur coal from both deep and strip mining. The deviations from these assumptions in the present analysis, however, tend to balance out: restrictions on surface mining reduce available mining capacity while neglect of sulfur content increases it.

185. As in strip mining, recent output levels in deep mining have been about 300 million tons per year. See COAL, supra note 7, at 11.

186. See note 66 supra.

187. FEDERAL ENERGY ADMINISTRATION, supra note 66.
though, since about 80% of coal output is sold pursuant to long-term contracts.\textsuperscript{188}

To the extent that restrictions on surface mining could not, even at higher cost, rapidly be offset by increased output from the remainder of the mining industry, oil imports would tend to rise temporarily. The Federal Energy Administration and U.S. Bureau of Mines have estimated that the various controls contained in H.R. 25 would in its first year of full implementation result in a reduction of between 40 million and 162 million tons below the coal output which would otherwise take place.\textsuperscript{189} This estimate has been the subject of much dispute,\textsuperscript{190} and other studies have suggested that the worst plausible impact of the bill would be a production loss of 86 to 90 million tons.\textsuperscript{191} All of these figures, however, are apparently based on the assumption that none of the lost output would be offset by increased mining at existing facilities, by relocation of equipment and other mining resources displaced by the controls, or by development of some new mining capacity in the interim between enactment and implementation.\textsuperscript{192} Since some contribution could be expected from one or more of these sources, the actual short-run impact of oil imports should be lower than the above estimates imply. If coal output fell by 50 million tons, 207 million barrels\textsuperscript{183} of oil would be needed to replace it, about 9% of total 1973 oil imports.\textsuperscript{194} The difference in cost between this oil and the coal it would replace is about one billion dollars at the recent world price.\textsuperscript{185}

In terms of energy self-sufficiency goals, the importance of such a temporary rise in the use of oil is difficult to evaluate. For the duration of the loss in coal production, the adjustment to another oil embargo, if one should occur, might be somewhat more difficult.\textsuperscript{186} But it must be noted that the transformations in the patterns of national energy use necessary to achieve meaningful reductions in vulnerability are long-term processes at best.\textsuperscript{197} In particular, the near-term ability of the

\textsuperscript{188} Id.
\textsuperscript{189} Id.; Veto Hearings, supra note 177, at 133-42.
\textsuperscript{190} See, e.g., Louisville Courier-Journal, June 30, 1975, § A, at 1, col. 1; N.Y. Times, June 8, 1975, § 1, at 24, col. 3; Veto Hearings, supra note 177, at 158-67.
\textsuperscript{191} EPA, Office of Planning & Evaluation Memorandum on Summary Analyses of the Strip Mining Legislation, June 6, 1975.
\textsuperscript{192} See id.; Veto Hearings, supra note 177, at 159, 188.
\textsuperscript{193} Federal Energy Administration, supra note 66.
\textsuperscript{194} Independence, supra note 8, at 353.
\textsuperscript{195} This is based on an average coal price of $20 per ton and a world oil price of $11.60 per barrel. Federal Energy Administration, supra note 66.
\textsuperscript{196} But it has been argued that this effect would be minimal because residual oil, the fuel which would replace the lost coal in power generation, is imported from relatively secure, i.e., non-Arab, sources. Veto Hearings, supra note 177, at 163.
\textsuperscript{197} "Oil imports will remain level or rise in the next few years, no matter what long term actions we take." Independence, supra note 8, at 7.
economy to use additional amounts of coal is quite limited, irrespective of the coal supply potential. Technologies to convert coal into synthetic liquid and gaseous fuels, for example, will not be available on a significant commercial scale until well into the 1980's. Even "[a]llowing for the greatest possible extent of conversion of electric power plants from oil and gas to coal," 1980 coal demand will probably be only 75 million tons, or 11%, greater than historical (pre-embargo) trends would predict.

In sum, it appears that, short of a total ban or its equivalent, the disruptive impact of surface mining restrictions on energy concerns is likely to be limited even in the short-run context. Substantial temporary increases in fuel costs could result from rapid imposition of such restrictions, but this is largely a problem of timing, which could be mitigated by allowing several years for implementation of the mining controls.

A. Distributional Aspects

Since the central effect of greater energy self-sufficiency on coal mining is a probable increase in the demand for coal, the long-run distributional considerations are basically identical with those previously discussed.

To the extent that strip mining policy delayed or reduced the movement away from imported oil, any cost in increased vulnerability would presumably fall in the first instance on the former users of the displaced coal; but in the event of an actual oil emergency, government intervention would probably redistribute the burdens more widely across the economy. To the extent that strip mining policy caused temporary coal cost and price increases, the distribution of the additional mining costs would be somewhat different than the long-run pattern previously analyzed. The price rise required to call forth high-cost temporary additions to supply would necessarily be greater than the rise in the average cost of producing coal, so that part of the consumers' loss would be gain to the mining companies, in the form of short-run profits. Because of the role of long-term contracts, this effect would not

198. Id. at 6, 48; MIT, supra note 60, at 37, 41.
200. Congressional Research Service, supra note 11, at 10, 35; Independence, supra note 8, at 137-38; Risser, supra note 7, at 49.
201. MIT, supra note 60, at 41.
203. See recent profit data at Veto Hearings, supra note 177, at 164.
occur across the board but would be concentrated on those who buy in the spot market. The increased cost of substitute coal, or oil, would also presumably affect electricity consumers of utilities whose current coal supply might be displaced by strip mining restrictions.

VIII

SULFUR AND COAL

Among the various physical and chemical characteristics of coal, one of special current significance is the sulfur content. When burned as a fuel, coal emits into the atmosphere varying amounts of sulfur dioxide and related compounds, air pollutants which are generally recognized as constituting a widespread public health problem. In order to attain the air pollution control standards prescribed under the federal Clean Air Act, major changes must be made in established patterns of coal use. Of the approximately 500 million tons of steam coal expected to be burned during 1975, government agencies variously estimated that between 150 million and 240 million tons would fail to comply with Clean Air Act sulfur requirements as originally promulgated. Numerous strategies have been proposed to reconcile...
energy demands with air quality goals, and the optimal solution to this very complex problem is beyond the scope of this Comment. The concern here is more limited, to examine the general impact of sulfur pollution control requirements on the strip mining problem as otherwise analyzed herein.

About two thirds\(^2\) of the nation's coal reserves are considered to be of low sulfur content, i.e., one percent sulfur or less.\(^2\) However, the distribution of coal by sulfur content is not uniform across coal regions. The Central region has practically no low-sulfur reserves; perhaps one third of Appalachia's reserves are low in sulfur, mostly located in West Virginia and eastern Kentucky; while the vast preponderance of Western coal contains less than one percent sulfur.\(^2\) Indeed, the West contains about 70% of the total national low-sulfur reserves by tonnage (somewhat less on a Btu basis).\(^2\) For the most part, the patterns in coal sulfur content are similar for deep and stripable reserves.\(^2\)

One inference from these facts is that sulfur air pollution con-

94-59, 94th Cong., 1st Sess. 17-45 (1975); INDEPENDENCE, supra note 8, at app. 305-19; SOBOTKA & COMPANY, supra note 208, at 5; TASK FORCE, supra note 24, at 67. Among the alternatives are increasing the production of low sulfur coal; installing flue-gas desulfurization systems at power plants to remove pollutants from the emissions, see note 219 infra; reducing the sulfur content of some coal through physical removal processes, see GORDON, supra note 64, at 130; RISSER, supra note 7, at 45; building taller power plant stacks to disperse emissions and rationing low-sulfur fuel supplies according to meteorological conditions, see INDEPENDENCE, supra note 8, at app. 305-19; substituting low-sulfur oil for coal in power generation; and delaying attainment of, or modifying, certain air quality standards, see, e.g., Bagge, Coal and Clean Air Law: A Case for Reconciliation, 4 ECOLOGY L.Q. 479 (1975).

211. CONGRESSIONAL RESEARCH SERVICE, supra note 11, at 18; BUREAU OF MINES, U.S. DEP'T OF THE INTERIOR, INFORMATION CIRCULAR 8312: SULFUR CONTENT OF UNITED STATES COALS 8 (1966) [hereinafter cited as INFORMATION CIRCULAR 8312]; TASK FORCE, supra note 24, at 5.

212. Conventionally, coal with a sulfur content of not more than one percent has been considered "low-sulfur" coal. However, most coal with one percent sulfur cannot, without additional treatment, meet the new source performance standard for power plant emissions, see note 207 supra. The crucial variable is the amount of sulfur per Btu: typical Eastern (bituminous) coal, at 12,000 Btu per pound, must contain under 0.72 percent sulfur to meet the standard, while typical Western (sub-bituminous and lignite) coal, at 8,000 Btu per pound, must contain under 0.50 percent. Hence, the sulfur advantage of Western reserves is lower than it superficially appears to be. Much of the "low-sulfur" Western coal cannot meet the new source performance standard. RISSER, supra note 7, at 40-41; TASK FORCE, supra note 24, at 40; Rieber, Low Sulfur Coal: A Revision of Reserve and Supply Estimates, 2 J. ENVIRONMENTAL ECON. & MANAGEMENT 40 (1975).

213. INFORMATION CIRCULAR 8312, supra note 211.

214. ASSESSMENT, supra note 209, at 13.

constraints will tend to shift some future coal mining to the Appalachian and Western regions and away from the Central region. This shift suggests a potential for greater environmental damage from surface mining,216 or for somewhat higher reclamation costs, especially since the Appalachian low-sulfur reserves may be located disproportionately on steeper slopes.217 Each of these tendencies is counteracted to some extent in the West by the high coal output per acre of disturbed or reclaimed land.218

Another effect of sulfur air pollution standards is an increase in the cost savings associated with the Western strip mining which substitutes for Eastern (mainly Central) coal production. By importing low-sulfur coal from the West, Central users would often avoid the necessity of sulfur removal treatment such as flue-gas desulfurization.219 This represents a saving of perhaps $5 to $7 per ton,220 which, however, is partly offset by the need for additional particulate pollution control in the combustion of low-sulfur coal.221 If, apart from the sulfur standards, Western coal is about as expensive to use in the Central region as local deep mined coal,222 its new cost advantage would therefore be somewhat greater than the $3 to $5 per ton typical of strip mining in the East.223 The impact of the standards on Eastern mining costs is less clear. Low-sulfur coal is generally more expensive to produce than higher-sulfur coal, by either underground or surface methods,224 but it is not obvious whether the cost differential between the two mining methods is larger.

216. See text accompanying notes 124-25 supra.
217. See CEQ, supra note 18, at 52, 54.
218. See text accompanying note 24 supra.
219. For analyses of the feasibility and cost of this process, which removes sulfur compounds from power plant stack gases, see COMMISSION ON NATURAL RESOURCES, supra note 206, at 385-457; PEDCO-ENVIRONMENTAL SPECIALISTS, INC., FLUE GAS DESULFURIZATION PROCESS COST ASSESSMENT (Prepared for EPA, 1975); SULFUR OXIDE CONTROL TECHNOLOGY ASSESSMENT PANEL, FINAL REPORT: PROJECTED UTILIZATION OF STACK GAS CLEANING SYSTEMS BY STEAM-ELECTRIC PLANTS (Submitted to the Federal Interagency Committee on Evaluation of State Air Implementation Plans, 1973).
220. This range is based on a flue-gas desulfurization cost of about 3 to 4 mills per kilowatt-hour for new power plants, see PEDCO-ENVIRONMENTAL SPECIALISTS, INC., supra note 219, at 3-21, and a ratio of 9500 Btu per kilowatt-hour generated, see EPA, A PRELIMINARY ANALYSIS OF THE ECONOMIC IMPACT ON THE ELECTRIC UTILITY INDUSTRY OF ALTERNATIVE APPROACHES TO SIGNIFICANT DETERIORATION B-1 (1976) (hereinafter cited as PRELIMINARY ANALYSIS). It is assumed that, because of the difference in energy content, each ton of Western coal replaces ¾ ton of Central coal.
221. See, e.g., ADMINISTRATOR OF EPA, supra note 210, at 21-22.
222. See text accompanying note 64 supra.
223. The alternative of low-sulfur underground mining in the West of course places a ceiling on the cost advantage which may properly be attributed to Western surface mining, but unlike Eastern low-sulfur mining, see note 225 infra, this ceiling is probably higher than $3 to $5 per ton, see note 61 infra.
224. See 2 CHARLES RIVER, supra note 57, at 44-45; ADMINISTRATOR OF EPA, supra note 210, at 22.
or smaller for low-sulfur coal. On balance, the evidence therefore does not allow of a firm conclusion as to whether coal sulfur limitations will increase or decrease the total savings obtainable from strip mining. Given the role of Western coal, an increase is certainly not improbable. Moreover, because low-sulfur strippable reserves are concentrated in locations where the feasibility of reclamation is uncertain, the potential benefits, in terms of mining costs, from surface mining in environmentally high-risk circumstances appear especially likely to rise.

The magnitudes of the above-mentioned effects are quite difficult to gauge, because they depend, among other things, on how coal users balance a number of competing cost factors which are not yet settled. What is clear is that the shifts in coal production suggested solely by the distribution of reserves by sulfur content will be moderated by the availability of alternative means to meet air quality goals using medium and high-sulfur coal. One study concluded that flue-gas desulfurization or other removal processes combined with higher-sulfur coal will be cheaper than low-sulfur coal for most users required to reduce sulfur emissions, and it forecasted that only 15% of 1980 steam coal consumption will derive from low-sulfur reserves. Although the cost and reliability of flue-gas desulfurization are subject to controversy, even under less optimistic assumptions about this process there is little doubt that a substantial portion of coal use will continue to rely on higher-sulfur sources under the established air pollution constraints. Recent

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225. One consideration which suggests that the differential might be less for low-sulfur coal than for the average of all Eastern coal is the comparatively limited scale of low-sulfur strippable reserves in the East. At about two billion tons by one estimate, ASSESSMENT, supra note 209, at 13, the latter are only about ten times the size of the total (all sulfur levels) annual output of Eastern surface mining. Underground low-sulfur reserves in the East are at least ten times as large as strippable reserves. Id. (It must be remembered that available reserve estimates are subject to considerable variability and uncertainty).

226. These include long-term mining costs for low-sulfur steam coal, transportation rates, costs of boiler and particulate control modifications which may be necessary at generating plants which switch to low-sulfur coal, and, notably, costs of desulfurization processes. See, e.g., 2 CHARLES RIVER, supra note 57, at 30-99; GORDON, supra note 64, at 130-31; SOBOTKA & COMPANY, supra note 209; TASK FORCE, supra note 24, at 40.

227. Indeed, “in 1980 about one-fourth of utility coal requirements can be relatively high in sulfur content—at or above 2 percent sulfur—and still comply with existing regulations without flue-gas desulfurization.” ADMINISTRATOR OF EPA, supra note 210, at 21.

228. SOBOTKA & COMPANY, supra note 209, at 5-7.

229. The definition of “low-sulfur” used in this study, namely conformity with the federal new source performance standards, see note 207 supra, is stricter than the conventional one percent criterion, so this estimate is somewhat conservative in terms of the latter definition.

230. See, e.g., GORDON, supra note 64, at 172-77; COMMISSION ON NATURAL RESOURCES, supra note 206, at 385-457.
EPA estimates of future coal production under present Clean Air Act standards indicate that the proportion of national output mined in Appalachia will change from 64% in 1973 to 50% in 1980; in the Central region, from 25% to 19%; and in the West, from 9% to 26%. Despite the significant shift to Western strip mining implied by this forecast, Eastern production is still predicted to increase in absolute size, even in the Central region, with most of the coal in the medium and high-sulfur categories. In terms of the overall costs and benefits at stake, then, consideration of the sulfur problem does not, in a long-run setting, seem to cast the strip mining issue in a dramatically altered light.

The short-run aspects are somewhat different. As of 1972, about 30% of the low-sulfur coal used in power plants, 28.5 million tons, came from Appalachian surface mining, mostly on slopes of over 20 degrees. Western low-sulfur surface mining was of a similar magnitude and has grown substantially since. Whether viewed directly in terms of clean air benefits or as a means to comply with pollution control constraints imposed by existing public policy, the surface mining in question is thus potentially of greater social value than it would otherwise appear to be.

If, for instance, the above Appalachian output were to be temporarily replaced with high-sulfur coal or medium-sulfur oil, sulfur dioxide emissions would increase by 88 or 28 pounds, respectively, per ton of low-sulfur coal replaced. On the basis of one highly approximate valuation of the adverse effects of sulfur dioxide pollution, this could be equivalent to an additional social cost of $9.70 or $3.10, respectively, per ton of coal.

Turning the argument around, sulfur constraints on coal use tend to make it more costly than it would otherwise be to offset rapid reductions in surface mined coal output. As pointed out, in Section VII, within a three to five year period, mining costs incurred to replace lost coal output would rise as existing capacity had to be used more

232. CEQ, supra note 18, at 54.
233. Id.; Assessment, supra note 209, at 2, 4, 5.
234. CEQ, supra note 18, at 66-67.
235. A cost of about 11¢ per pound of sulfur dioxide (8¢ in 1970) is derived from estimates of the total national damage caused by sulfur pollutants to human health, materials, and esthetics. T. Waddell, The Economic Damages of Air Pollution 130 (EPA, 1974) (best estimates), and total national sulfur oxide emissions, id. at 127 (correcting for the printing error therein). See also Commission on Natural Resources, supra note 206, at 626, 631, where pollution from a remotely located power plant and an urban power plant in the Northeastern U.S. is estimated to cost, respectively, 10.5¢ and 27.5¢ per pound of sulfur dioxide emitted (21¢ and 55¢ per pound of sulfur).
intensively. The impact of sulfur constraints on this problem is in
effect to reduce the available capacity, because much of it is for higher-
sulfur coal, and demand will be concentrated on the low-sulfur por-
tion. \(^{236}\) Hence, if air quality goals are not relaxed, the potential for
temporary increases in coal prices and oil imports caused by strip
mining restrictions would be somewhat greater than previously indicated.

A. Distributional Aspects

As suggested above, one likely effect of sulfur constraints is some
alteration in the regional distribution of surface mining, increasing
potential environmental costs in Appalachia and the West while decreas-
ing them in the Central region.

If surface mining policies result in temporarily increased pollutant
emissions, the inhabitants of areas whose power generation relies on the
displaced low-sulfur coal will bear the main burden, \(^{237}\) with the most
susceptible being the very young, the very old, and those afflicted with
chronic lung or heart disease. \(^{238}\) Alternatively, the populations of
these areas would probably pay much of the temporarily higher cost of
the low-sulfur coal or other fuel which might be substituted to avoid
such additional air pollution during the period of adjustment to a rapid
imposition of strip mining restrictions. \(^{239}\)

IX

REGIONAL UNEMPLOYMENT

The cyclical unemployment currently afflicting the national econo-
my is largely a problem in macroeconomic management, and strip
mining policy can contribute very little one way or the other in this
area. \(^{240}\) Nevertheless, because Appalachia in particular is a region both
where economic stagnation has been a persistent long-term phenome-
on \(^ {241} \) and where coal mining has historically been an important ele-

\(^ {236} \) As previously indicated, the movement from higher-sulfur to low-sulfur coal
may not be drastic, because in many cases pollution control requirements will be met
through means other than the use of low-sulfur coal.

\(^ {237} \) It is conceivable, however, that high-sulfur supplies would be redistributed
from areas with worse air pollution to areas with cleaner air.

\(^ {238} \) See National Air Pollution Control Administration, supra note 206, at
156.

\(^ {239} \) See text accompanying note 204 supra.

\(^ {240} \) Surface mining is in any case a relatively small industry in terms of employ-
ment, about 38,000 in 1973. Task Force, supra note 24, at 46. It has been estimated
that the total amount of unemployment resulting from the production losses which the
Federal Energy Administration predicted would occur under H.R. 25, see text accompa-
nying note 189 supra, would be between 0.01% and 0.04% of the civilian labor force.
Veto Hearings, supra note 177, at 162.

\(^ {241} \) See the Appalachian Regional Development Act of 1965, 40 U.S.C. App. § 2
(Findings and Statement of Purpose).
ment in local economies, changes in mining employment might conceivably have significant distributional consequences in terms of aggravating or ameliorating regional concentrations of poverty and related ills.

For Appalachia as a whole, coal mining is not so great an economic factor as it was in the past. In 1970, the industry provided about 115,000 jobs in the region, or under 2% of total regional employment; surface mining accounted for 0.3% of regional employment. On a local scale, though, coal mining in some instances plays a major role: in a few counties the industry provides 40% or more of total earnings.

For a given coal output, underground mining employs more workers than surface mining; hence, if losses in surface output caused by strip mining policy were replaced by increased underground mining, the overall employment impact would probably be positive. From a regional perspective, of course, it is important where the replacement mining occurs. In fact, the areas currently supporting high levels of strip mining in Appalachia also generally appear to have substantial amounts of deep mining and deep reserves, so that relatively local substitution would be possible for the most part. This result is not guaranteed, however, since market forces could establish the new mining elsewhere. For instance, if reclamation difficulties on steep slopes or outright limitations on such mining should cause output in contour mining to decline, some of the loss would probably be made up by strip mining in flatter areas. Sulfur constraints, on the other hand,

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242. See Bohm, Lord, & Patterson, supra note 38, at 78. Unemployment is generally costly from an “efficiency” standpoint, because it represents productive resources that are going unused. However, unemployment is perhaps even more a matter of distributional concern, since the foregone production essentially corresponds to the income loss suffered by those who are unemployed. (Under competitive market conditions, wages equal the value of the production attributable to the “marginal”—or last-to-be-hired—worker. See, e.g., Henderson & Quandt, supra note 74, at 68, 81-84, 129).

243. CEQ, supra note 18, at 73. Much of the information used in this section is taken from Chapter Four of the CEQ report, at 69-82.

244. Id. at 72.

245. Conceivably, the lost surface output would not be replaced at all; but, as suggested at note 66 supra, if the price of oil remains high, the substitution of deep mining would probably be economically viable. One study of the Appalachian coal industry concluded that a ban on contour and auger mining (where, however, the assumed cost differential below deep mining was less than that estimated here) would result in increased regional employment even in the face of an oil price much lower than what currently prevails. 2 Charles River, supra note 57, at 478.

246. CEQ, supra note 18, at 55, 74.

247. Based on recent average labor productivities in deep and strip mining, only about one third of the lost surface output would need to be replaced by local underground mining in order to offset the loss in strip mining jobs. See CEQ, supra note 18, at 74.
would probably counteract this shift to some extent, since low-sulfur reserves in the East are scarce outside of central Appalachia, where mining on steep slopes is currently concentrated.  

In sum, although increased Appalachian employment would not be an unlikely result of restrictions on strip mining, net employment losses are also a possibility, especially in the short run.  The Council on Environmental Quality has developed various scenarios of the regional employment impact of surface mining slope limitations based on alternative assumptions about the degree and nature of replacement mining, and these provide some indication of the possible magnitudes of the effects in question. In the case of a prohibition of contour mining on slopes over 20 degrees, the estimates range from a gain of 1650 jobs to a loss of 12,481 jobs. Since job losses or gains have a “multiplier” effect, as the drop or rise in spending caused by the initial change creates additional losses or gains, unless offset by compensation payments (in the case of unemployment), the total employment effect under each scenario could be greater, perhaps by a factor of two on the average.

On a region-wide basis, employment impacts of these magnitudes are relatively minor, but to a significant extent job losses could be concentrated in certain local areas, which are often in poor economic conditions.

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248. See CEQ, supra note 18, at 51, 54, 65; INFORMATION CIRCULAR 8312, supra note 211. But see PROGRESS REPORT, supra note 161, at 150-58, reporting the results of an analysis which indicates that sulfur constraints on coal would not improve the effects of a twenty degree slope limitation on Appalachian mining output.

249. As a long-run matter, it has been suggested that control or elimination of surface mining could produce large regional economic benefits, quite apart from any direct effect on employment in the coal mining industry, by preserving the “outdoor recreational amenities” of Appalachia as an attraction to business activities. W. Mierinka, ENVIRONMENTAL MANAGEMENT AND REGIONAL ECONOMIC DEVELOPMENT 9 (1971).

250. CEQ, supra note 18, at 63-67, 74-82, 137-43.

251. This is based on a 10% increase in deep mining in the central portions of Appalachia and a large but incomplete shift of surface production to slopes under 20 degrees. Id. at 137-143. (The summary of this analysis given by id. at 78 appears to be in error).

252. This is based on no increase in deep mining and no shift of surface production to lower slopes. Id. at 137-147. This report also presents scenarios based on a fifteen degree slope limitation, and the relevant employment effects range from 2,636 to 15,785 mining jobs lost. Id. at 76.

253. Additional employment gains would result only if the economy were not at full employment (which is, however, always a matter of degree in practice).


255. Ten thousand jobs, for instance, represent 0.15% of regional employment. CEQ, supra note 18, at 73.
health to begin with.\textsuperscript{256} Of course, even if the ultimate effect of strip mining controls were increased local employment, some temporary job losses could occur while adjustment took place. These problems, however, appear to be of the sort which is manageable by special compensatory programs.\textsuperscript{257} The total scale is relatively small\textsuperscript{258} and the persons suffering major losses are identifiable. Hence, it would be feasible as well as fair for the wider public benefiting from controls on strip mining to support unemployment payments, as well as job training, mobility programs, and similar economic aid, to offset possible negative employment effects of the controls.

X

Administrative Costs

The cost of administering and enforcing strip mining policy depends, of course, on the nature of the policy. A policy of no intervention would cost nothing to administer; essentially the same would be true of a flat prohibition on strip mining.\textsuperscript{259} Regulatory alternatives between these extremes would require governmental resources to inspect and monitor mining and reclamation activities, process information, apply sanctions, and carry out related administrative functions. In addition, regulation\textsuperscript{260} would impose costs on mining firms. Most of the burdens of compliance are those involved in reclamation efforts themselves, which have already been considered, but there are also some costs which are appropriately attributed to the process of administering reclamation requirements. These would include “paperwork” and time spent at regulatory proceedings, and possibly such devices as performance bonds.

\textsuperscript{256} See id. at 77-82, 140-143.

\textsuperscript{257} See, e.g., Freeman, Haveman & Kneese, supra note 38, at 147-48.

\textsuperscript{258} If, for example, 6,000 surface miners lost their jobs and stayed unemployed for an average of one year, full compensation for lost earnings would cost about $90 million. See U.S. Bureau of Labor Statistics, Dept of Labor, Employment & Earnings 74 (Sept. 1975). While this is by no means a trivial sum, it is, by assumption, of a “one-shot” nature, as distinguished from other costs and benefits of strip mining which flow year after year. Put on a comparable annualized basis, assuming a 10% future discount rate, this compensation would be the equivalent of $9 million a year.

\textsuperscript{259} But the cost of enforcing health and safety standards at underground mines, a more difficult task than at surface mines, would rise as underground mining expanded to replace the lost coal output. See Coal Mine Health and Safety Act, 30 U.S.C. §§ 801 et seq. (1970).

\textsuperscript{260} This term is used here in a broad sense, and is meant to encompass not only the traditional “standards” approach but also other forms of government intervention such as taxation designed to internalize external costs. In cases where external costs are easy to measure and monitor, the latter approach is likely to be less expensive to administer, see, e.g., Freeman, Haveman & Kneese, supra note 38, at 97-107, but strip mining is probably not such a case. See Bohm, Lord, & Patterson, supra note 38.
One estimate of the governmental cost of administering effective strip mining regulation may be derived from past experience in state programs. Pennsylvania's regulatory efforts have been widely recognized as among the nation's most successful, and in fiscal year 1972 the state spent about one million dollars in this area, or, in current dollars, approximately five cents per ton of surface mined coal. If one ignores any regional differences which might lead to higher or lower enforcement costs, this implies a national cost of roughly $15 million annually. Another comparison, probably an upper limit, is provided by the administrative cost of enforcing federal coal mine health and safety regulations, which is currently about $45 million per year.

One likely source of privately borne administrative cost is a performance bond requirement in surface mining regulation. If mine operators had to post bonds in the amount necessary to cover the cost of successful reclamation, premiums would probably average about one cent per ton, or $3 million per year altogether. Since a large portion of the premium payments merely represents the actuarial value of reclamation expenditures made on behalf of defaulting mine operators, only part of this sum should be considered a true administrative cost. The magnitude of the remaining privately borne costs is very difficult to gauge, but they can largely be accounted for in terms of time spent by mining firm personnel. For example, at an assumed average expend-

261. See, e.g., AUSTIN & BORRELLI, supra note 83; Hearings on H.R. 3, supra note 83, pt. 2, at 894; ISSUES, supra note 2, at 223, 226.
262. CEQ, supra note 18, at 47.
264. This is based on recent output levels of around 300 million tons annually. See COAL, supra note 7, at 11.
265. EXECUTIVE OFFICE OF THE PRESIDENT, THE BUDGET OF THE U.S. GOVT: FISCAL YEAR 1976, App. at 557. (The figure of $45 million is based on the estimated fiscal 1976 cost of coal mine inspections plus most of the cost of program administration for the Mining Enforcement & Safety Administration; some of that agency's activities concern non-coal mining). This program is probably more expensive than strip mining regulation would be because, first, it covers both surface and underground mines and, second, the inspection and enforcement activities appear to be more intensive than those required for regulating the environmental aspects of surface mining. See, e.g., 30 U.S.C. § 813(i) (1970).
266. See, e.g., CEQ, supra note 18, at 103-123; H.R. 25, supra note 3, at § 509.
267. This estimate is based on a bond premium of slightly over one percent, see ISSUES, supra note 2, at 166; 2 MATHEMATICA, supra note 17, at VI-14, and an average reclamation cost of slightly under one dollar per ton, see text accompanying note 134 supra.
268. In addition, strip mining regulation might also require firms to obtain technical
iture of one man-month each year on the part of the management at each of the 3000 surface mines in the United States,²⁶⁹ such administrative burdens might amount to approximately $7.5 million.²⁷⁰

Total administrative costs of strip mining regulation, then, would probably be in the range of $25 million to $60 million a year.

A. Distributional Aspects

If administrative costs were borne by federal or state government, citizens would share the burden according to the operative system of taxation, which is ordinarily more regressive on the state level than the federal.²⁷¹ It would be appropriate, however, for the governmental expense of enforcing strip mining policy to be shifted to mining firms, e.g., in the form of permit fees.²⁷² If government intervention is warranted in the first place as the alternative which maximizes the overall net value obtainable from surface mining,²⁷³ then the expense of administering the intervention may be viewed as a cost of strip mining itself, which should be taken into account by firms in making their mining decisions.²⁷⁴ In that case, and also in the case of any administrative burdens borne by firms in the first instance, the costs of enforcing strip mining policy would be shared in a manner similar to other mining and reclamation costs.

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²⁷⁰. This example assumes an average annual salary of $30,000 for the relevant personnel.
²⁷¹. See, e.g., H.R. 25, supra note 3, at § 507(a).
²⁷². This calculation must, of course, take into account the likely administrative costs of intervention.
²⁷³. Consider, for example, a marginal mine which could just break even extracting coal while meeting the applicable environmental constraints. If society must spend additional resources to enforce those constraints, then the operation would constitute a net social loss and is preferably not undertaken.
XI

POLICY IMPLICATIONS

The theoretical set of policy choices underlying the preceding analysis consists of alternative types and degrees of restrictions or conditions on surface mining, ranging from total non-intervention to a flat prohibition on the activity. Ideally, by assigning definite numerical magnitudes to all of the relevant values and by specifying the relationships among them in precise quantitative form, one could select the best alternative through the use of a mathematical optimization algorithm. Clearly, however, the uncertainties and gaps in understanding concerning the strip mining problem, as well as the difficulties in estimating certain values and the complexity introduced by consideration of distributional norms, preclude the use of that method here. By less sophisticated inspection, it is nonetheless possible to discern from the results of the above investigations one broad policy approach which appears preferable to the major alternatives: namely, to impose on strip mining activities the constraint of avoiding any significant environmental injury; or, in more compact terms, to require "virtual restoration" of the affected areas.

The analyses of mining costs and reclamation indicate, first of all, that virtual restoration could probably be achieved, and the nation could thus obtain a great reduction in environmental harms, at the cost of only a fraction of the total savings produced by strip mining. The necessary reclamation would cost, in the East, an average of perhaps $0.50 to $1.00 per ton and in the West, $0.10 to $0.20 or less. Total cost savings in strip mining would thus be reduced by between $125 million and $250 million, from the $875 million to $1460 million attributable to uncontrolled strip mining. The environmental constraint policy might, however, foreclose strip mining in some circumstances where the activity currently takes place, notably on steep slopes and in arid Western locations. The maximum amount of production subject to preclusion would appear to be in the neighborhood of 100 million tons.

The optimization problem could be conceived, for instance, as that of minimizing the total social cost of producing a given output of coal; see text accompanying notes 43-44 supra. The set of policy choices is what is called the "decision variable" in optimization theory; the expression defining how social cost depends on this variable, the "objective function." See generally, W. Baumol, Economic Theory and Operations Analysis 3-10 (2d ed. 1965).

275. The optimization problem could be conceived, for instance, as that of minimizing the total social cost of producing a given output of coal; see text accompanying notes 43-44 supra. The set of policy choices is what is called the "decision variable" in optimization theory; the expression defining how social cost depends on this variable, the "objective function." See generally, W. Baumol, Economic Theory and Operations Analysis 3-10 (2d ed. 1965).


277. This figure is based on 1973 coal production, to allow comparability with the estimates of total cost savings and other values presented herein.

If all surface mining on slopes steeper than 25 degrees were foreclosed, about 47 million tons of coal output would be lost. (Derived by applying 1971 slope distribution,
Additional surface mining elsewhere would probably replace much of this production, but it must be assumed that the replacement mining would be somewhat more expensive.\textsuperscript{278} If on the average the cost savings from such mining were only half those in unrestricted surface mining, total savings before subtracting reclamation costs would be reduced to between $725 million and $1210 million.\textsuperscript{279} Table 6

\textsuperscript{278} If the coal industry is reasonably effective at minimizing costs, the existing pattern of mining activities is probably less expensive than what would take its place if a portion of present mining opportunities were foreclosed. Some markets, for instance, would have to depend on more distant sources, involving higher transportation costs.

\textsuperscript{279} The former figure is based on a $3 per ton average cost differential between surface and deep mining; the latter figure, on a $5 differential.

As indicated in text accompanying notes 225-26 supra, air pollution control requirements could raise the cost of foreclosing strip mining on steep slopes and in the
presents the reasonable upper and lower limits of the cost of requiring virtual restoration in strip mining, based on the above-mentioned ranges for the cost of reclamation, the cost differential between underground and surface mining, and the extent of preclusion of current strip mining operations.

Table 6\textsuperscript{280}

The dollar figures represent the total annual cost in millions of virtual restoration. The figures in parentheses represent the percentages by which the total savings otherwise obtainable through strip mining will be reduced by requiring virtual restoration.

<table>
<thead>
<tr>
<th></th>
<th>No preclusion, lower reclamation costs</th>
<th>No preclusion, higher reclamation costs</th>
<th>Maximum preclusion, lower reclamation costs</th>
<th>Maximum preclusion, higher reclamation costs</th>
</tr>
</thead>
<tbody>
<tr>
<td>$3 per ton differential</td>
<td>$125 (14%)</td>
<td>$250 (28%)</td>
<td>$285 (32%)</td>
<td>$420 (48%)</td>
</tr>
<tr>
<td>$5 per ton differential</td>
<td>$125 (8%)</td>
<td>$250 (17%)</td>
<td>$385 (26%)</td>
<td>$520 (36%)</td>
</tr>
</tbody>
</table>

To this must be added the cost of administering the intervention, $25 million to $60 million. That cost would be avoided, in part\textsuperscript{281} under a flat ban on surface mining, but the administrative costs are minor compared to the savings in mining costs under the virtual restoration policy. A ban would give up these large benefits in return for a relatively small reduction in environmental harms, since by hypothesis no significant permanent injury would occur in either case.

Both administrative and, more importantly, reclamation costs would, of course, be avoided under a policy of non-intervention. These costs, under the restoration approach, would be about one to two dollars per capita annually, and a reasonable regard for the environmental values at stake suggests that they are likely to be worth at least that much. Apart from this judgment, however, two additional considerations argue in favor of the latter policy. First, while the cost savings of strip mining are widely dispersed through the economy, many of the environmental harms fall in concentrated form on individuals and communities in the areas where mining happens to take place, which are frequently in poor economic health as well. Fairness would seem to require that the latter groups be protected against such losses, and that the broad class of beneficiaries pay the cost of doing so, which would generally be small on an individual basis. Second, some of the environ-

\textsuperscript{280} See note 259 supra.
mental harms of surface mining are long-lasting and difficult to reverse, and their importance to future populations is a matter of present uncertainty but is likely to increase. Hence, the values at risk are preferably treated with caution and should be preserved unless clearly not worth the cost.

Other policy alternatives include the imposition of lesser degrees of environmental protection than that suggested above. The discussion on reclamation indicated, however, that without fairly complete restoration of the affected areas, substantial environmental problems generally will occur, and that the reduction in cost obtained from lower levels of environmental protection tends to be small relative to the increase in environmental damage. Moreover, the fairness and permanency considerations just set forth also apply to policies which provide for only partially effective reclamation.

In relation to the problem of occupational hazards, the policy of requiring virtual restoration appears to be substantially superior to a ban and only slightly inferior to alternatives involving lesser environmental restrictions. With the accident and disease rates that appear likely to prevail in future coal mining, each million tons of surface mined coal represents a savings of 0.14 fatality, 17 non-fatal injuries, and between 0.6 and 1.6 cases of black lung disease, or in monetary terms $90,000 to $140,000. It is not clear that the proposed virtual restoration approach would lead to any significant increase in underground mining; but supposing that all strip mining on slopes over 25 degrees and in the West were precluded and that half of the lost output were replaced by underground mining, the additional accident and disease cost would amount to between $4.5 million and $7 million a year. While no number of deaths may be considered negligible, it is doubtful, especially in view of the likelihood that miners are largely compensated for their risk bearing, that this increment would be sufficient to tip the balance against a virtual restoration policy.

It is uncertain whether restrictions on surface mining would have positive or negative net effects on Appalachian unemployment. In the short run, it seems likely that the impact of a total ban would be worse than that of a lesser restriction. In the long run, the relative effects might be reversed. In any event, the overall magnitude of surface mining policy's possible contributions to regional unemployment is small.

282. The rates assumed here relative to accidents are 0.35 and 0.25 fatalities per million man-hours, 35 and 15 non-fatal injuries per million man-hours, and 13.4 and 36 tons of coal per man-day, in underground and surface mining, respectively. See notes 152-56 supra and text accompanying note 143 supra; preliminary compilations, supra note 142. The black lung incidence represents an 80% reduction in the rates estimated. See text accompanying notes 161 and 167 supra.
in relation to crucial other values, and negative effects could and should be treated with compensatory programs.

Energy and sulfur pollution concerns are mainly relevant to the strip mining policy decision in terms of short-run adjustment problems. Obviously, the more restrictive of strip mining the intervention is, the greater potential there is for temporary cost increases or shortages of low-sulfur and domestic fuel. This consideration need not significantly affect one's choice of permanent policy alternatives, however, because the short-run effects in any case would be greatly influenced by the manner in which the policy was initially introduced. For example, by giving the coal industry several years' "advance warning" of an impending strict environmental constraint, the temporary problems of adjustment would probably be reduced to near the level of whatever lesser restriction might otherwise have been imposed (and which could also be imposed as an interim measure under the former alternative).

The issue, then, is largely one of timing the introduction of the new policy to attain the desired balance between temporary fuel cost increases or shortages, on the one hand, and continued environmental damage from strip mining, on the other. Unfortunately for purposes of that assessment, it is highly uncertain to what extent the imposition of the environmental constraint of virtual restoration would in fact reduce surface mine output in the short term or to what extent the remainder of the industry could rapidly replace the lost production. It is at least plausible, though, that a net loss of some 50 million tons per year, including a sizeable amount of low-sulfur coal, would result from implementation of a virtual restoration requirement sooner than three years from enactment. Because of the high cost of replacement fuel and especially because of the potential for increased air pollution health hazards, it would probably be desirable to delay full implementation of the constraint for that period.

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283. In anticipation of the constraint, mining firms could order new equipment, develop new mines to replace expected lost production, etc. But see note 284 infra.

284. Because of uncertainty as to how much coal production would turn out to be foreclosed by the strip mining policy, mining firms in fact might be reluctant to invest in additional capacity in the interim period; hence, the temporary losses in output (if any) that do occur when implementation begins may not be fully offset immediately by new mining. Cf. INDEPENDENCE, supra note 8, at 104 (uncertainty as to, inter alia, the nature of the still-undetermined national strip mining policy may be deterring development of new coal mines). However, uncertainty is a constant fact of life in business, and if anyone is in a good position accurately to evaluate the impact of regulation on coal mining, it would appear to be coal producers. At the least, therefore, one should be able to expect that serious losses in output due to surface mining policy would be foreseen and planned for by the industry.

285. This figure reflects an assumed initial loss of 100 million tons from existing mining, half of which is offset by expanded production elsewhere. See text accompanying notes 189-193, 211a supra.

286. A three to five year phase-in is recommended in PROGRESS REPORT, supra.
A. The Significance of Uncertainty

The above conclusions are based in part on an assessment of probabilities: what appears likely to be the cost differential between underground and surface mining, the cost of effective reclamation, and so on. It has been observed that there are substantial uncertainties as to some of these matters, particularly reclamation costs, which might turn out to be significantly greater or less than the estimates relied on in the preceding discussion. An important aspect of the policy problem, then, is to take such uncertainty into account in choosing the appropriate form of intervention. Policy alternatives need to be evaluated not only on the assumption that one's best estimates will turn out to be true, but also in relation to the possibility of different outcomes.

Viewed in this light, the proposed virtual restoration approach appears to have significant advantages over the opposing alternatives of prohibiting surface mining or of imposing only minimal controls on the activity. If reclamation costs turn out to be lower than expected, either of these other policies would be even less attractive relative to the first approach, since a ban would mean foregoing greater savings in coal mining in return for a given (small) amount of environmental benefits, while minimal controls would mean foregoing a given (large) amount of environmental benefits in return for lesser savings in coal mining. On the other hand, if the costs of reclamation turn out to be very high, or its feasibility severely limited, either a complete ban or minimal controls might be preferable to strip mining with intensive reclamation efforts, depending on the relative weight attached to the environmental harms and the potential cost savings at stake. In this case, however, the environmental constraint policy would automatically tend to approximate the results of a ban, since coal producers always have the option of turning to underground mining if its cost is exceeded by that of surface mining-cum-reclamation. Hence, the only outcome in which the proposed policy might be significantly inferior to an alternative is that involving higher than expected reclamation costs together with a relatively low valuation of the relevant environmental harms. It seems highly doubtful that the possibility of this result should outweigh the

Oil imported to replace the 50 million ton loss could cost the equivalent of an additional $20 per ton of coal, see text accompanying note 195 supra; the 50 million tons of replacement coal would probably cost at least an additional $5.50 to $7.50 per ton (reflecting both the long-run cost differential between strip mining and deep mining and a short-run coal price increase) and possibly more, see text accompanying notes 185-88 supra; and the loss of low-sulfur coal might cost up to $10 per ton in increased air pollution, whose health effects would be concentrated on certain vulnerable groups, see text accompanying notes 235, 238 supra. The environmental harms of the affected strip mining would thus need to be valued much higher in order to offset the short-run impacts of a restrictive policy than to offset the long-run impacts.
likelihood of major gains from a virtual restoration requirement under other outcomes.\footnote{287}

In sum, choosing either of the broad alternatives to the proposed environmental constraint would foreclose—where the constraint policy would not—the opportunity to benefit from outcomes which are more favorable than expected, without providing commensurate advantage with respect to outcomes which are less favorable than expected.

\section*{B. Uniformity or Flexibility}

Accepting that a requirement of no significant environmental injury in strip mining is preferable to either lesser standards of environmental protection\footnote{288} or a flat ban on strip mining, one might nonetheless argue that such a uniform constraint\footnote{289} is inferior to more flexible regulatory approaches. The environmental value of each mining site is not necessarily the same, nor is the cost of reclamation. Hence, the argument runs, it should be possible to maximize net benefits by requiring different degrees of reclamation at different sites.\footnote{290}

As a general principle, it is no doubt true that there is some potential efficiency loss in treating all strip mining alike. However, several aspects of the strip mining problem indicate that the loss is probably not large and that the administrative costs of treating each operation individually would be too great to make the approach worthwhile. First, the nature of strip mining is such that the potential environmental harms from mining seem to correlate fairly well with the costs of reclamation: where reclamation is expensive, the benefits (or the environmental costs of not reclaiming) also tend to be high.\footnote{291} If the reclamation costs necessary to meet a uniform strict environmental constraint deter mining under certain circumstances, then, it is probably efficient for mining not to occur there. A related point is that, as

\footnote{287. Given the initial judgment that the environmental values at stake are worth at least a significant part of the savings from strip mining, and taking account of the distributional and permanency aspects of those values discussed above, it is unlikely that the (probably small) risk of losing all the savings in the course of preventing most of the environmental harms could reasonably justify sacrificing the environmental values simply in order to be sure of retaining all the savings.}

\footnote{288. This category is intended to include not only a minimal level of reclamation but intermediate levels as well. See text preceding note 282 supra.}

\footnote{289. Observe, though, that a certain degree of variability is inherent in the definition of "significant environmental injury" underlying the proposed constraint. In terms of "aesthetic" land use dimensions, strip mining subject to intensive reclamation would meet the environmental standard in many agricultural settings but not in Yosemite Valley.}

\footnote{290. See, e.g., Brooks, supra note 38, and Issues, supra note 2, at 133-143.}

\footnote{291. For instance, stabilizing a restored steep slope may be difficult and costly, but failing to do so would also be environmentally costly because of the serious damage from erosion, sliding, water pollution, etc. See text accompanying note 122 supra.}
previously indicated, environmental harms at each mining site generally rise sharply as the degree of reclamation drops below that required for virtual restoration.\textsuperscript{292} Thus the potential for achieving efficiency gains by “trading” less intensive control at one location for more intensive control at another appears to be much more limited in the case of strip mining than in the paradigm of fungible water pollutants pouring into a single river.\textsuperscript{293}

Finally, and probably most important, a scheme which attempted to determine the optimal extent of reclamation separately for each mining site would involve enormous administrative burdens.\textsuperscript{294} Such an approach would require a great deal of information which is very difficult to obtain. While a residuals charge system\textsuperscript{295} of taxing each mining operation its marginal environmental costs might be able to dispense with half the information—that dealing with the costs of reclamation (which it would be up to the mining firms to find out)—the various environmental harms which might flow from each mining operation would still have to be measured and valued in money terms. As is clear from the earlier discussion of the subject, the environmental impact of strip mining is multi-dimensional and includes far-reaching consequences whose quantification is highly problematical, certainly in the routinized fashion which would be necessary for the administration of such an approach. A general regulatory policy of individualized environmental restrictions on strip mining, then, does not appear to be a desirable alternative to a uniform standard.\textsuperscript{296}

\textbf{C. Implementation Issues}

The policy proposed in the preceding discussion has thus far been referred to in quite general terms; the choice of specific means by which to implement this basic approach clearly can make a great deal of difference in how successfully its goals are achieved. This subsection briefly considers some of the major issues pertaining to the implementation of strip mining policy.

\begin{itemize}
  \item \textsuperscript{292} Cf. Griffin, \textit{supra} note 111, at 294.
  \item \textsuperscript{294} On this point, see Bohm, Lord, \& Patterson, \textit{supra} note 38.
  \item \textsuperscript{295} See, e.g., Freeman, Haveman, \& Kneese, \textit{supra} note 38, at 97-107; Kneese \& Bower, \textit{supra} note 293, at 97-142; A. Kneese \& C. Schultze, \textit{Pollution, Prices, and Public Policy} 87-96 (1975).
  \item \textsuperscript{296} This is not necessarily to say that no conceivable variations in the basic constraint ought to be allowed; see, e.g., note 120 \textit{supra}. The point is simply that as a general approach a widely applicable standard of reclamation seems justified.
\end{itemize}
1. Means and Ends

There are, broadly, two different ways to characterize the environmental standard of virtual restoration in strip mining. One is simply to characterize it as an objective, which would require that policymakers specify any of a number of rules in order to attain this objective: restricting mining to certain locations, prescribing mining techniques, or requiring particular sorts of reclamation procedures. The other way to characterize the standard is as both an end and a means; that is, as a rule, directly imposed on coal producers, on the environmental results required in strip mining, without specifying how mining firms must go about reaching those results. The second alternative has important advantages.

By leaving each mining firm free to choose how it will achieve the environmental standard, this approach gives the market mechanism the opportunity to minimize the cost of meeting the policy objective. Firms would have a strong incentive to develop and use low-cost techniques, and also to operate in locations where the cost of reclamation is low. Especially because the expense and effectiveness of various mining and reclamation methods are imperfectly known and subject to change, it would probably reduce both the amount of error and the informational burden of administration to place the choice of method on the individual firms, whose business it literally is to discover and act upon the relevant information.

2. Standards Specification

In any result-oriented approach, the obvious question is how to define the desired result and in what detail. For purposes of monitoring and enforcement by the regulatory agency, the concept of virtual restoration necessarily must be rendered in more concrete operational form as to the various dimensions of acid pollution, erosion, topography, hydrology, and so on. It is less apparent how much specificity Congress should write into its legislation and how much should be left to the responsible agency to develop. There is good reason to expect, however, that in the absence of highly definite standards in the law as enacted, the general policy contained therein would be eroded in the administrative process in the direction of more lax environmental protection. Hence, an unambiguous specification by Congress of the

297. For example, the revegetation requirement in several states consists of performing several seeding operations. CEQ, supra note 18, at 46.

298. See, e.g., id. at 32; Larsen, Federal Regulation of Strip Mining, 2 ENVIRONMENTAL AFFAIRS 533 (1972).

results to be achieved by strip mining operations would be desirable.

3. Enforcement

The conceptually simplest and most direct method of enforcing the new environmental standards would be merely to impose sanctions on mining firms for failing to achieve the standards. For several reasons, this device, if relied on exclusively, would likely prove to be inadequate. Given the nature of the activity being regulated, it would be quite difficult to design a system in which the threat of future penalties operated on firms' decisions in the desired way. In general, a long and complex set of mining activities would take place prior to the assessment of (possible) penalties for failure to attain the required results, making the link between the sanction and the behavior sought to be controlled a fairly tenuous and uncertain one. The problems with such an enforcement approach are compounded by the fact that the feasibility of successfully attaining the environmental standards is sometimes uncertain at the outset of mining activities.

It would be preferable, then, to adopt some preventive or forward-looking enforcement tool, through which society's collective preferences concerning the risks of reclamation failure can be brought to bear and mining firms can be more effectively constrained to meet the standards. One appealing method is to require that firms *insure* the attainment of the prescribed environmental results: in practice, by posting a performance bond in an amount sufficient to pay for the necessary reclamation if the firm itself fails to comply. Not only would this help protect environmental values in the event of actual failure, but, more importantly, the system would provide appropriate incentives to avoid failure in the first place. Each coal producer would be confronted with the actuarial cost of nonperformance before beginning to mine, and in addition the system would generally introduce a third party—the surety company—with a strong interest itself in policing and enforcing performance.

It is now a truism that administration is very much a part of the political process, and that the parties likely to exert the greatest influence in it are those who perceive themselves as having the greatest stake in its outcome, normally the regulatees. See, e.g., M. Bernstein, *Regulating Business by Independent Commission* (1955); M. Edelman, *The Symbolic Uses of Politics* (1964); M. Olson, *The Logic of Collective Action* (1965); D. Truman, *The Governmental Process* (1951).

Performance bonds are already used in many states, CEQ, *supra* note 18, at 103-123, but they are often used ineffectively. Brooks, *supra* note 38, at 143-44; CEQ, *supra* note 18, at 38.
4. Environmental Uncertainty

The above-mentioned uncertainty regarding reclamation feasibility has additional implications for the design of strip mining regulation. The concept of insuring successful attainment of environmental standards is in reality not quite the same thing as making sure of successful attainment: in some cases, the uncertainty cannot be fully resolved until after mining is performed, at which point it will be too late to avoid or correct environmental damage if effective reclamation turns out not to be feasible. While an accurate appreciation of the risks by coal producers and sureties would tend to deter mining in highly uncertain situations, the remaining threat to the environmental values at stake may still be significant enough to justify certain departures from the regulatory strategy heretofore proposed in order to reduce the risk of failure.

One supplementary policy that deserves consideration is government-supported research and development concerning reclamation in the environmentally most sensitive, or risky, areas, the arid West and the steep slopes.\(^3\) This measure would not, of course, produce immediate results, and in the interim one might impose a temporary moratorium on the types of mining in question. With respect to established patterns of ongoing mining, the disruption involved in such a tentative ban may outweigh the possible benefit, but it does appear sensible to postpone the development of risky mining activities that are still merely a potentiality. This suggests that at least the large-scale expansion of Western surface mining should be delayed until the uncertainties about controlling its environmental impact are better resolved. Another approach would be to specify, for environmentally risky circumstances, the use of certain mining and reclamation procedures which involve the least risk of environmental damage—this at the cost of the flexibility referred to earlier in this discussion. Finally, the risk of failure could be reduced by subjecting strip mining plans to screening by an administrative agency, with a view to establishing the feasibility of reclamation before mining is permitted.

XII
THE CONGRESSIONAL LEGISLATION

The surface mining legislation passed by both Houses of Congress in 1975, H.R. 25, would have established environmental standards which generally appear to be consistent with the policy suggested by this Comment's analysis.\(^3\) A stated purpose of H.R. 25 was to "assure

\(^3\) See, e.g., 1 MATHMATICA, supra note 7, at 11-16.

\(^3\) This discussion is by no means intended as a comprehensive evaluation of H.R. 25; the purpose is rather to compare certain central features of the bill with the results of
that surface mining operations are not conducted where reclamation as required by [the bill] is not feasible." These reclamation requirements in addition to the broad prescription to return the affected land to its original land use potential, included, *inter alia*, restoring the approximate original contour of the mining site, stabilizing surface areas, preserving the topsoil, avoiding acid drainage and sedimentation, restoring the ground water recharge capacity of the area, preventing significant "irreparable offsite damage to hydrologic balance," and permanently revegetating the affected land.

In some instances, however, the standards failed to express the goal of no significant environmental injury with sufficient clarity and precision, and improvements would be desirable in future Congressional action. It was not always clear, for instance, that the environmental results attained by mining operations must be permanent in nature. Although the vegetation standard was adequately described in this respect, the regrading requirement was not: §§ 515(b)(3) and (4) require compaction "where advisable to insure stability" and stabilization of "surface areas . . . to effectively control erosion," but it was not distinctly stated that the contour of the land must remain in its restored condition and not slide after a few years. Also, such phrases as "effectively control erosion" and "minimize the disturbances to . . . the quality and quantity of water in surface and ground water systems" are susceptible of a diversity of interpretations. In particular, requiring mining operations to minimize an environmental disturbance would not necessarily prevent mining in circumstances where significant environmental damage cannot be prevented. "Minimize" presumably means to reduce as much as possible, and it is always possible to reduce damage as much as possible, even where the results are unacceptable in terms of the underlying policy objective.

this Comment's analysis of the strip mining problem. For a detailed examination of an earlier Congressional strip mining bill, see Larsen, *supra* note 298.

305. These are for the most part found in *id.* § 515.
306. Some exceptions to this requirement were provided for, as where the coal deposit is so thick relative to the overburden that spoil volume is insufficient, *id.* § 515(b)(3), and where a specific post-mining land use would benefit from the creation of level land in mountaintop removal mining, *id.* § 515(c).
307. *Id.* § 510(b)(3).
308. Section 515(b)(19) required the establishment of "a diverse, effective and permanent vegetative cover native to the area of land to be affected and capable of self-regeneration and plant succession at least equal in extent of cover to the natural vegetation of the area . . . ."
309. This requirement was, however, more clearly expressed in the provision relating to mining on steep slopes: contour backfilling of spoil material is required, "which material will maintain stability following mining and reclamation." *Id.* § 515(d)(2).
310. *Id.* § 515(b)(4).
311. *Id.* § 515(b)(10).

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Another aspect of the performance standards in H.R. 25 is that some dealt more in terms of methods than results. This approach is probably justified in the case of the special provisions for mining on steep slopes, wherein mining operations are generally prohibited from placing spoil on downslopes, as a means of reducing the chances of failure in high-risk circumstances. The stream siltation standard is more questionable: mining operations are required “to prevent, to the extent possible using the best technology currently available,” siltation of a greater magnitude than existed prior to mining. This phraseology evidently reflects an uneasy compromise between Congress’s desire for an unambiguous standard in this area and the fact that, at least during mining and reclamation operations, it may be neither possible nor— in order to avoid significant environmental injury—necessary to reduce additional siltation all the way to zero. Requiring the use of the best available technology, however, would not guarantee the avoidance of significant environmental damage in all circumstances and at the same time might impose unnecessarily high costs on mining operations in situations where less than the best technique would suffice to achieve acceptable results.

A. Enforcement

As enforcement methods, H.R. 25 would have established two complementary devices which should be retained in future strip mining legislation. One was a performance bond requirement, with the size of the bond set in an amount “sufficient to assure the completion of the reclamation plan if the work had to be performed by a third party in the event of forfeiture.” Clearly, a critical step in the administration of this provision was the regulatory agency’s decision on releasing the bond after mining operations are completed. The criteria provided by H.R. 25 were unfortunately somewhat ambiguous as to whether the

312. Id. § 515(d). “Steep slope” was defined as “any slope above twenty degrees or such lesser slope as may be defined by the regulatory authority after consideration of soil, climate, and other characteristics of a region or State.” Id. § 515(d)(4).

313. Id. § 515(b)(10)(B).

314. It appears that after mining and reclamation activities were completed, the operators would be required to prevent additional siltation without qualification as to “the extent possible.” Id. § 519(c)(2). See H.R. Rep. No. 94-189, 94th Cong., 1st Sess. 84 (1975): “[I]t is the intent of the conferees that, after mining and reclamation there be no offsite degradation of water quality.”


316. H.R. 25 provided that mining firms would be required to submit to the regulatory agency a plan describing how the environmental standards of the bill would be achieved, in order to obtain a permit to mine. H.R. 25, supra note 3, at § 508. See text accompanying note 320 infra.

317. H.R. 25, supra note 3, at § 509(a).
agency was to evaluate activities or results. For instance, the bill provided that 60% of the bond could be released “[w]hen the operator completes the backfilling, regrading, and drainage control of a bonded area in accordance with his approved reclamation plan . . . .” but again it would be preferable to make clear that the results of that work must be such as to preclude all future significant environmental injury.

The other major enforcement tool in H.R. 25 was a permit system, wherein strip mining would be allowed only after a showing that the bill’s environmental standards could feasibly be achieved. By requiring applicants for surface mining permits to demonstrate to the regulatory agency, on the basis of detailed supporting evidence, how those standards would be met, this provision would not only help reduce the risk of environmental failure but would also tend to control administrative decisionmaking by establishing a focus for public awareness and participation and a basis for effective judicial review.

B. Other Provisions

H.R. 25 did not attempt to impose a moratorium on expanded strip mining in arid Western regions; nor did it provide for special compensatory aid to persons losing their jobs because of the legislation. As suggested earlier, each of these measures would be desirable to include in future legislation.

The bill did, however, contain a significant provision not proposed in this Comment’s analysis, namely a differential reclamation fee imposed on surface and underground coal mining to fund reclamation of

318. But the bill did clearly specify results with respect to at least one dimension of environmental damage, siltation; see note 314 supra. “No part of the bond . . . shall be released . . . so long as the lands to which the release would be applicable are contributing suspended solids to streamflow or runoff outside the permit area above natural levels under seasonal flow conditions as measured prior to any mining and as set forth in the permit.” H.R. 25, supra note 3, at § 519(c)(2).

319. Id. § 519(c)(1).

320. Id. § 510(b).

321. See id. §§ 507 and 508.

322. Section 513 provided for public hearings to be held regarding permit applications, upon the request of any person “with a valid legal interest.” In its report on H.R. 25, the House Interior Committee stated that “in imposing several provisions which contemplate active citizen involvement, the Committee is carrying out its conviction that the participation of private citizens is a vital factor in the regulatory program as established by the [bill].” H.R. Rep. No. 94-45, supra note 1, at 83.

323. See H.R. 25, supra note 3, at § 520.

324. Section 522 of the bill did, however, provide for states to designate areas as unsuitable for surface mining on the ground, inter alia, that “reclamation pursuant to the requirements of this [bill] is not feasible.” Id. § 522(a)(2).

325. Earlier versions of Congressional surface mining legislation did contain such provisions, but they were dropped in H.R. 25 at the recommendation of the Administration. See H.R. Rep. No. 94-189, supra note 314, at 88.
abandoned previously-mined land: $35 per ton of strip mined coal and $15 per ton of deep mined coal.\textsuperscript{326} The differential was evidently intended to help offset the high cost of health and safety controls in underground mining.\textsuperscript{327} Unless this provision operated merely to avoid temporary dislocations during adjustment to the 1969 Act,\textsuperscript{328} however, it clearly would lead to economic inefficiency by promoting higher-cost coal production rather than lower.\textsuperscript{329}

\textbf{C. Timing}

H.R. 25 provided a timetable for implementing its provisions which in general would have required compliance with the mandated environmental performance standards within 30 to 36 months after enactment.\textsuperscript{330} In addition, new mining operations would have been required to meet specified interim standards from the date of enactment, and 135 days thereafter existing operations would be subject to the interim standards with respect to land not yet mined.\textsuperscript{331} The interim requirements included several of the most important permanent environmental performance standards, namely, restoring prior land use potential, restoring approximate original contour,\textsuperscript{332} segregating topsoil, protecting hydrology and water quality, establishing permanent revegetation, and, on steep slopes, contour backfilling with minimal placement of spoil downslope.

Although the implementation schedule established for the permanent provisions of H.R. 25 would have approximated the minimum period necessary for adjustment by the coal industry, the interim requirements themselves were stringent enough to raise the possibility of significant short-term production losses, especially in strip mining on steep slopes. It would be preferable to phase in the more difficult environmental standards, e.g., contour restoration, over a longer period than that provided in H.R. 25. An additional alternative might be to

\textsuperscript{326} H.R. 25, \textit{supra} note 3, at § 401(d).
\textsuperscript{327} \textit{See} H.R. REP. No. 94-45, \textit{supra} note 1, at 129.
\textsuperscript{328} But § 401 provided that the fee would continue for ten years, subject to Congressional renewal. H.R. 25, \textit{supra} note 3, at § 401(d).
\textsuperscript{329} Conceivably the fee differential could be justified as a means of internalizing the external cost of surface mining which remains even after meeting the prescribed environmental standards, but there is no evidence that the fee was calculated to bear an accurate relation to that cost.
\textsuperscript{330} \textit{See} H.R. 25, \textit{supra} note 3, at §§ 503(a), (b), (c), 504(a), 506(a).
\textsuperscript{331} \textit{Id.} § 502. These interim requirements would have applied only in states having their own surface mining regulation, which included, as of March, 1975, all states in which strip mining occurs except Alaska, Arizona, Texas, and Utah. S. REP. No. 28, \textit{supra} note 1, at 202.
\textsuperscript{332} Variances from this requirement would have been allowed under certain conditions where a different surface configuration would serve a specified land use, H.R. 25, \textit{supra} note 3, at §§ 502(d), 515(c). \textit{See} note 306 \textit{supra}. 
allow for temporary variances in cases where, as with the production of low-sulfur coal, mining is of particular social value.

CONCLUSION

This Comment has sought to determine what can be meaningfully concluded about the desirability of alternative "solutions" to the strip mining problem. Although one's choice of policy ultimately depends on certain subjective judgments about the importance of different values as they affect different people, it has been possible to identify one policy approach as superior on the basis of the probable magnitudes and nature of the relevant costs and benefits together with broad considerations of distributional fairness. That approach, in essence, is to impose a constraint on strip mining which would permit the activity only on the condition that the site were virtually restored, so that no significant environmental injury resulted. Such a strategy appears likely to achieve the best balance among the competing values at stake, especially in the context of imperfect knowledge and uncertainty concerning the strip mining problem.

The recent Congressional attempts to regulate surface mining have been largely consistent with that approach. As modified in the ways suggested in this Comment, a measure along the lines of H.R. 25 should be enacted into law.