The Hobbling of Coal: Policy and Regulatory Uncertainties

The increase of controls on production and coal use is a threat to industry expansion.

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Summary. The inevitable by-product of societal concern over the side effects of coal production and use is greater than recognized difficulties to meet coal production goals. Thus, society faces the need to make trade-offs it is not adequately anticipating. The primary influences have come from air pollution regulation dealing with sulfur oxides; regulations in this realm were strengthened in 1977. Questions exist about the ability to meet these requirements and about whether tighter controls will be imposed on other pollutants. Problems also exist on the production side—labor unrest, strip-mine reclamation requirements, and delays in leasing federally owned coal.

In less than a decade, the U.S. coal industry has been transformed from a lightly regulated industry to one that is affected by many government policies. The industry that long waged a lone battle for more comprehensive government planning in energy now decries such intervention. In 1977, the General Accounting Office when appraising the state of the coal industry claimed an inability to determine whether public policy, on balance, helped or hurt coal (*1*). In this article I review these policies and suggest that the probable net long-term effect on coal production is negative. The long term will, however, be a decade or more; and, should serious barriers to coal utilization rise in the interim, energy problems of the United States could be exacerbated.

The policies restraining coal use were designed to attain legitimate social objectives, and this article cannot be expected to resolve the difficult questions as to whether the socially optimum levels of controls have been imposed. Focus is confined to the narrower question of the impact on coal and, in particular, to the suggestion that such effects may be greater than many policy-planners seem to believe.

Two basic observations may be made before I turn to review specific regulation. First, the coal situation should be considered a prime example of how energy policy-making in the United States is, in practice, an effort to avoid explicit reconciliation of our conflicting policy goals—a problem that is by no means confined to the energy realm.

We have simultaneously proclaimed as objectives the need for lessened imports, abatement of environmental damages, protection of the public from high energy prices, greater competition, and prevention of dislocation of industries and those they employ. Aside from the questions that can be raised about the wisdom of some of these goals, the clear conflicts among them must be recognized. We cannot, for example, avoid some environmental degradation if we move to increase significantly domestic energy production, particularly of coal. Policy-making has involved taking strong stands in all areas and forcing the compromises to emerge in the implementation process. As is shown below, this can be an expensive and unsatisfactory procedure. The litigative abilities of the various sides can become more important than the merits of the case.

The second key point is that the view that the fundamental constraints to coal use are on the demand side may be accepted only in a carefully qualified form. It is quite true that the initiating force in inhibiting coal industry expansion is lack of adequate signals about how much market growth will occur. The coal industry is indeed extremely touchy about any hint that it lacks the capability to produce the 1.2 billion tons of coal advocated for 1985 in President Carter's energy program (*2*). Close reading of industry statements make clear, however, that this does not imply confidence that no influences on the supply side, such as continued labor unrest and increased regulation, will impede production increases. The industry simply claims that it is not the source of any supply problems. Many critics of the industry could argue that management must be charged with at least partial responsibility for labor unrest, and those seeing an energy producer conspiracy to monopolize envision an unwillingness to expand (*3*).

The Issues

We may begin by listing the critical policies that affect coal. The most publicized, and probably the most influential, has been air pollution regulations, particularly those affecting sulfur oxides. To alleviate the impacts of these regulations, various existing and proposed laws have been designed to promote coal use. The principal supply issues are health and safety, impacts on land use, and leasing of federal coal rights. Concern, but not action, has arisen over alleged monopolization of the coal industry by oil companies. All these issues affect all methods of coal mining. However, health and safety are generally considered more of a problem with underground mining while it is the disturbances created by surface mining that are the primary land use issues.

Air Pollution Control

Sulfur dioxide emission control is not only the most important policy affecting coal, but probably the most complex. Two different types of difficulties may be distinguished.

First, many different groups have influenced the form and substance of policy. Second, the policies themselves have become increasingly convoluted.

In terms of participants, distinction should be made at least among the actual policy-makers, the lobbyists for controls, and the affected coal-using industries. The second of these three groups needs little treatment; the success of en-

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vironmentalists in securing legislative and judicial victories is by now familiar.

In contrast, the intricacies of the regulatory structure and the response of regulated users merit fuller review. The principal actors in policy-making have been the U.S. Congress, the U.S. Environmental Protection Agency (EPA), and state governments. (A fourth group—Indian tribes—also has been given some authority.) EPA has naturally pushed vigorously to ensure compliance with congressionally set air pollution control objectives. At one point in the 1970's, EPA did suggest that states retreat from efforts to comply more rapidly than necessary with federal requirements. A clear picture is not available on state practices. However, evidence does suggest a tendency for some state environmental agencies to attempt to outdo federal standards. Such ambitions have at times been thwarted by decisions elsewhere—mainly in the courts—that the plans were impractical. Congressional action has involved most of the expected political conflicts. Members of Congress from the coal states continually try to blunt the impact of air pollution regulations. Further problems seem to arise from disputes about which congressmen will exercise control over policy-making.

The regulated industries characteristically maintain a posture of perennial consternation. This attitude merits more sympathy than is normally granted. Even when the industry objections are misguided, this arises from nothing more sinister than the parochialism of which everyone is guilty. Businessmen, being normal human beings, envision themselves as providing indispensable services to society and have trouble perceiving that their interests may conflict with the public interest. (This is an attitude that should be maintained; businessmen are ill-equipped to venture outside their area of expertise to judge what is good for society.) Moreover, some aspects of policy-making may need reform. Many, apparently including those who drafted the President's energy message, feel that regulations are altered too frequently. Even if rules were constant, complaints could be levied at rule-making procedures. As I argue below, the stress on standards and timetables appears particularly dysfunctional.

When policy-makers impose goals that seem unreasonable to the affected industries and provide no credible incentives for compliance, nonattainment becomes highly probable. The industries recognize, at least subconsciously, that they are considered so essential that extensions will be granted to permit continued operation even if air pollution regulations are violated (*4*). This seems a powerful incentive for dilatory behavior. It also produces complex policies that set stringent goals but add numerous escape clauses.

To understand the problem, it is necessary to view the actual structure of policy on sulfur oxide control. Understanding federal procedures is sufficiently difficult, and thus review may be limited to that area. The first thing to recall is that two somewhat different bases—air quality and emitter performance—are used for policy-making. Air quality refers to the concentration of pollutants in the air; performance refers to the discharges allowed by a particular facility. Conflicts can easily arise between these alternative rules since they are determined by quite different methods.

Two basic concepts exist for air quality—a primary standard to prevent health hazards and a secondary standard to prevent other damages such as that to property. A maximum allowable average annual concentration is defined as well as how much deviation from the annual norm is allowed on any one day and possibly in any 3- or even 1-hour period. In addition, limits are imposed on the increases in pollution allowed in areas with air already significantly cleaner than what is required by the basic standards. This concept of controlled increases is officially termed prevention of significant degradation. This concept created so many administrative problems that in 1977 Congress enacted elaborate rules governing nondegradation (*5*).

Three levels of strictness were defined—classes I, II, and III, with class I facing the most stringent rules—and specific limits were set on the allowable increase in pollution in each class. All land previously set as class I and certain public lands, such as preexisting national parks exceeding 6000 acres in area, had to be designated class I; others, such as a new national park greater than 10,000 acres in area, must be class I or class II. Otherwise, the area is initially put into class II and the governor of the state may petition, if desired, for up- or downgrading. A further change introduced in 1977 was that areas not in compliance with air quality regulations were subject to more stringent controls. New facilities would not be allowed unless sufficient evidence was provided of vigorous efforts to attain compliance (or a vital need for the facility could be proven).

Until 1977, the emission rules for sulfur oxides required that new facilities (those facilities whose planning began after the promulgation of the rules in 1971) burning more than 250 million British thermal units (Btu) per hour limit their emissions to 1.2 pounds of sulfur oxides per million Btu burned. Compliance could be attained by the use of coal naturally low enough in sulfur content to meet the standard, cleaning the coal to acceptable levels before combustion, or by the use of devices called stack gas scrubbers that capture the sulfur oxides after burning and prevented their discharge. In practice, treatment before combustion has not yet been a relevant strategy. The choice has been between naturally low sulfur coal and scrubbers. In 1977, the option of using naturally low sulfur coal was removed by introduction of the concept of best available control technology (BACT). This technology is to involve the maximum feasible reduction in sulfur emission with an expectation that a 90 percent removal goal will be set for facilities initiated after the amendments come into force (*6*).

State of Scrubber Technology

BACT seems to exacerbate a preexisting defect in sulfur oxide control strategies. The evidence suggests that stack gas scrubbers may still not be as effective a control technology as their advocates contend (*7*). This is best seen by reviewing the latest available evidence. EPA has a contractor—PEDCo Environmental—prepare an extensive bimonthly report on the state of scrubber utilization (*8*). These reports present detailed chronologies of the operating history of those scrubbers actually in place. Scrubber advocates tend to report the summary data and ignore the case histories. The summaries show a growing number of "operational" scrubbers (31 as of September 1977). Examination of the details shows that PEDCo uses a generous definition of operational. Units are added to the operational category when test operations begin. No distinction is made about whether the units are operable (as at least two are not), meeting performance standards (which some are not); and the list even includes two small units that are basically used to test scrubber technology.

Most of the successful units are engaged in mild scrubbing (50 to 60 percent removal) of sulfur oxides from low sulfur coal. Those successes that have occurred in scrubbing high sulfur coal appear to have come at high cost. Redundant units are installed so that frequent

cleaning of the unit can occur without putting the plant out of service. The cleaning is necessary because operation tends to cause clogging and corrosion in the units. Often long shakedown periods are required to make the scrubbers operational. Even so, frequent outages seem likely. Finally, present scrubbers capture the sulfur oxides in some absorbent such as limestone, and problems arise in disposal of the resulting sludge. In short, scrubbers create cost, reliability, and waste disposal problems that could exceed those associated with nuclear power.

How then did the devotion to scrubbers arise, why the problems, and why the move to increased reliance despite such difficulties? The initial impetus is easy to explain. The policy-makers eagerly accepted the arguments of the equipment manufacturers and the coal industry that scrubbers were a cheap, available solution. Thus, scrubbers seemed an ideal solution—providing speed, low costs, and maintenance of existing regional production patterns. The question of why problems arose is simpler to explain; scrubber advocates failed to anticipate the difficulties.

Charges are often made that electric utilities did not try hard enough to make scrubbers work. Clearly, accusations of this sort are too vague to permit reasoned evaluation. It can be argued, however, that public policy was poorly designed to stimulate vigorous activity on scrubber development. Credible pressures were not being exerted on the electric utility industry. The industry had good reason to expect that the actual effect of failure to perfect scrubber technology would have been extensions of compliance deadlines. The federal government failed to correct this problem either by adopting effective incentives to compliance such as an emission tax or by financing development work on scrubbers.

The refusal to back off from stress on scrubbers can be attributed to the interaction of three quite different forces: the usual reluctance of politicians to confess their errors, the pressures of coal state legislators to protect local coal, and the desires of many environmentalists to limit the development of low sulfur western coal. These efforts failed to stop a shift to western coal, and the immediate justification for BACT is to slow this move to western coal. How successful this move will be in the long run remains more uncertain than is generally recognized, as I indicate below. (BACT also can be justified because economic growth will necessitate tightening controls on individual polluters.)

In any case, the history to date of sulfur oxide control strategy has been one of setting goals that proved unattainable and then backing away from them. Where we are heading remains unclear. One can cite several proposed new coal-burning power plants that are having difficulties securing approval because of their environmental impacts. However, the Clean Air Amendments do include numerous escape clauses that could alleviate the pressures. It seems safe to conclude that, on balance, construction of coal-fired power plants is beginning to involve increases in planning lead times comparable to those already plaguing nuclear power. The open question is whether these constraints will cause the "inadequacy" of capacity expansion so widely feared by the electric utility industry (*9*). Both determinants of the answer—what expansion rate is economically optimal and what the delays will be—cannot be satisfactorily forecast. Matters are even more confusing for other users of coal. We have very little idea about the economics of coal use under BACT for manufacturing plants (*10*).

Production Problems

With respect to these supply problems, the most serious threat has been the sharp rises (probably in the neighborhood of 10 percent per year in constant dollars) in eastern underground mining costs (*11*). The source of the rise can be epitomized as a radical change in labor market conditions. The pool of workers who felt trapped in the coal industry as job opportunities shrank as a result of falling total output and rising output per worker has vanished.

With rising output, falling output per worker, and retirements, the coal industry has turned to recruiting younger workers who demand greater compensation for or protection from work hazards. These demands have been expressed by successful appeals for a more stringent federal Coal Mine Health and Safety Act (passed in late 1969), pressures for tougher bargaining at the national level, and unilateral action through wildcat strikes at the local level.

Again enormous appraisal problems exist. The primary question is over the prospects for alleviating the cost increases. Presumably, once the industry has fully responded to new labor market conditions, no further direct cost increases should be necessary. However, if the new climate retards or eliminates productivity advance, some persistent cost rises can be expected. Real wages rise in line with productivity advance in the economy as a whole; if there is no productivity advance in coal mining even though wages rise, unit labor costs also rise. All this defies forecasting. Thus, while a slowdown in cost increases should occur, no one knows when and to what degree this deceleration will occur.

An even more difficult problem to resolve is the allocation of blame for the cost increases. The Coal Mine Health and Safety Act of 1969 is charged with causing many of the difficulties. The numerous provisions of the act mandated changes in every aspect of mining deemed to affect health or safety. Clearly, the requirements for extra equipment, for devoting more time to health and safety work, and the more frequent interruption of work by mine inspections could only increase costs. However, the magnitude of these effects remains unclear, even to many of the affected coal companies. Few such companies have tried to isolate the effects of the act from other influences on costs. Whatever the causes, the effects—rising costs—are a serious threat to the competitive position of underground coal mines.

Two further problems affect the underground mining sector. First, the growing reach of environmental regulations in general has caused lengthening of the lead times for mine construction. Numerous permits must be obtained from both agencies regulating mining and various environmental authorities such as those charged with water pollution control. Second, the industry has expressed considerable concern over the provisions of the 1977 Surface Mining Act that require control of the surface effects of underground mines.

However, the main effects of the Surface Mining Act clearly are on surface mines. The 25 strip-mine reclamation requirements of the act in section 515b include (*12*):

1) "Maximize" initial recovery so that a second disturbance to recover other seams is avoided.

2) Restore land to a condition that allows at least as good a use as that prior to mining with extra effort required if the land is considered prime agricultural land.

3) Except where impractical, restore land to the original contour.

4) Stabilize areas to avoid erosion.

5) Segregate and preserve the quality of topsoil or a subsoil of better quality than the actual topsoil.

6) Avoid disturbance of hydrologic balance with special emphasis upon allu vial valleys in the West (roughly valleys structured so that disruption of water flow would interfere with farming).

7) Revegetate the reclaimed land.

The state governments are authorized to prohibit strip mining on lands on the basis both of specific hazards such as danger of creating floods and of mere incompatibility with land use plans. The Secretary of the Interior is required to prohibit new mines in national parks and other classes of federal lands, has authorization to make prohibitions on the basis of the criteria the states may employ, and must consider private requests for bans. The law requires that when the federal coal rights were retained when the surface was sold, the surface owner must give written permission to mining. Moreover, if substantial opposition exists among surface owners to strip mining, the Secretary is encouraged to prevent the mining.

Appraisal of the law obviously differs among observers. A study for EPA by ICF, Inc., of the 1976 strip-mine bill noted that it would have modest incremental impacts over existing state regulations (*13*). ICF qualified this conclusion by warning that there were sufficient ambiguities in the law so that it could be interpreted to produce more severe effects. The coal industry has expected the worst and severely criticized the initial Interior Department implementation program for adopting far more severe interpretations than the law required (*14*).

On its face, the law does seem to involve potential for further disrupting the development of coal production. At the very least, a substantial shakedown period has been the rule with new regulations. The introduction of such provisions as alluvial valley, prime agricultural land, and surface owner protection seems particularly likely to produce implementation problems. Moreover, Secretary of the Interior Andrus has displayed a clear desire to shift the emphasis of his entire Department from its traditional role as promoter of industrial development to a posture of vigorously protecting the environment. This implies that the interpretations will be more stringent than if the Department had a different orientation.

Land Ownership

Other problems affecting western coal are associated with the complexities of land ownership patterns in the region. The federal government is the principal owner of coal rights. Thus, a substantial number of difficulties arise simply from contending with federal policies affecting the leasing and exploitation of government-owned coal. In addition, much of this federal ownership consists of reservation of mineral rights on lands for which the right to use the surface has been sold. The Surface Mining Act contains, as noted, provisions that require the consent of the surface owners before mining can proceed. The potential for obstructionism appears substantial.

Moreover, the ownership of coal is fragmented by such practices as the "checkerboard" pattern of grants of land to railroads (so-called because the split between railroads and the federal government looks like a checkerboard when mapped). Indian tribes and others also own coal rights. Thus, the problems of working with the federal government are compounded by the difficulties of also dealing with owners of surface rights and others who own coal (*15*).

The most pressing problem seems to be the difficulty in securing permission to exploit existing leases. Approval of exploitation plans has been deemed a major federal action requiring an environmental impact statement. Unfortunately, the Bureau of Land Management, which has primary responsibility in this realm, has proved inadequately staffed to complete the reports rapidly.

A long-term problem arises from the combination of a moratorium on new leases that has prevailed since 1971 and 1976 amendments to the leasing laws. The moratorium does allow leasing of limited tracts adjacent to previously leased land when the extra land is needed to permit optimal development of the property. However, it is not clear whether these leases are being granted as frequently as would be socially optimal. An environmental lawsuit has further restrained leasing.

The overall moratorium began because of concern that too few leases were being exploited. The delays in removal were the result of various forces, including a long gestation period for the environmental impact statement and a rethinking of goals initiated by Secretary Andrus. The leasing amendments mandated greater planning by the Interior Department, increased reporting requirements on firms, and a requirement that leases be developed within a decade (*16*). A U.S. government task force has charted the net effect of all these regulations, and as far as I can tell after winding my way through the four gigantic charts (each of which more than covers a large desk), once leasing resumes, it would take a decade to move from initiating a lease sale to production (*17*). In short, production controls have imposed two severe costs on the coal industry—higher direct costs and the cost of delay.

Several problems are associated with all these restraints. One could follow the General Accounting Office and conclude that the mass of restrictions will prevent the opening of enough new coal mining capacity to meet even the billion-ton level widely forecast for 1985 (*18*), let alone exceed this level as President Carter has proposed. Certainly, considerable doubt may be raised about the short- or long-run efficacy of BACT in reversing the shift to western coal. The numerous available surveys of coal industry expansion plans suggest a heavy concentration of new capacity in the western United States (*19*).

Given the prevailing long lead times, it may be difficult to reorient radically immediate expansion plans. When sufficient time exists to shift emphasis back to eastern coal, it is not clear that this shift will be economically attractive. Continued sharp rises in eastern mining costs may erode the incentives provided by imposition of BACT. Western coal may be sufficiently cheaper that it can overcome the cost disadvantage of BACT. Besides it may prove significantly cheaper to apply BACT to low sulfur coals, and much of the western coal is destined for use in the southwestern states. Moreover, it appears that the lead times for a large new coal-based project may soon no longer differ significantly from those of a nuclear plant. If this is true, managers of electric utilities, on the basis of their belief that, if time permits, it is cheaper to build a nuclear plant, will return to the nuclear option.

Coal Use Incentives

In part, to offset the effects of all these policy measures, President Carter has proposed extensive legislation. Therefore, it is worth discussing his efforts to develop a program to provide incentives to coal use.

The coal use incentives in the 1977 energy program proposed by President Carter are a complex set of basic prohibitions, taxes, and subsidies. In addition, long lists are included giving reasons why temporary or permanent relief can be granted from the requirements to use coal or to be subject to taxes. The basic prohibitions are that new electric power plants and new large industrial boilers

must use coal and that, after 1 January 1990, gas use in electric power plants should cease. A shift to oil from gas could be allowed only under special circumstances, and earlier conversions could be required if considered feasible (*20*).

The tax-subsidy elements of the program consist first of taxing oil and gas use and then providing tax rebates equal to the amount of investment expenditures made to use either coal or synthetic fuels from coal. The proposed tax system involves several features. First, the oil system is different from that for gas. Second, electric utilities are treated differently from other industries. Third, the rates are adjusted for inflation. Abstracting from inflation adjustments, the electric utility tax system involves a flat tax of 25 cents per million Btu on oil use after 1982. Other taxable oil users pay a tax that starts at 15 cents per million Btu in 1979 and rises in steps to 50 cents in 1985. All these tax rates are to be raised at the same rate as the implicit deflator for the gross national product. The basic gas tax is ultimately set at the difference (on a per-million-Btu basis) between prices for number 2 fuel oil in the region and the actual cost of gas to the consumer. Again a phased introduction is proposed for the taxes. Electric utilities would not be covered until 1983, and from 1983 to 1985 the tax would be 50 cents per million Btu below the level required in the basic formula. The reduction falls to 25 cents in 1987 and 1988 and disappears in 1989. Other users start being taxed in 1979 with a reduction that is set at $1.05 in 1979, falls to 40 cents in 1980, then more gradually goes to 15 cents by 1984 and in 1985 the full tax is applied. The amount of oil and gas taxed would vary with consumption. Those using less than 500 billion Btu would be exempt from tax. The exempt amounts are reduced for larger users and those using 1.5 trillion Btu or more pay the tax on all oil and gas use.

The energy bill that passed in the House included prohibitions close to those proposed by the President. The tax provisions, however, were substantially altered. Essentially the same tax on oil was set for electric utilities. Large industrial boiler fuel users of oil and gas also were subjected to taxes roughly equal to those proposed by the President. However, the House exempted more users and subjected others to lower taxes. A flat cents-per-million-Btu tax starting, without inflation adjustment, as a maximum of 65 cents in 1983 and rising to 75 cents in 1985 was set for electric utility gas use (*21*). This last tax cannot raise costs of gas above the cost per million Btu of fuel oil.

At least three problems threaten to undermine the President's program. First, the proposals were weakened in the House and have done even worse in the Senate. Second, the Administration may have significantly underestimated how much incentive would be needed to encourage coal use in the face of all the difficulties facing the coal industry. Third, there is good reason to suspect that more restrictions on coal production and use will arise. Existing programs could be made more stringent, and action might be taken in other areas—notably, control of air pollution due to nitrogen oxide, carbon dioxide, and trace elements.

Conclusions

In this article, I argue that the prospects for coal use have been hindered by growing restraints on coal production and use. The constraints increase the costs and lead times of coal-related developments. President Carter has proposed measures to offset this process. The potential for enactment, wisdom, and efficacy of the Carter proposals remains very much in doubt. For present purposes, wisdom and efficacy are the principal issues.

One can dispute the wisdom on two levels. First, the whole idea of promoting coal use could be challenged. Better ways may exist to deal with U.S. energy problems. Second, the concept of first adopting ambitious goals for controlling the side effects of coal production and use and then adding another complex program to cushion the shock seems unnecessarily cumbersome. Given the evidence that the Administration does not understand the full impact of the controls being imposed on coal, the efficacy of its incentive program also remains very much in doubt.

The risks of failure are quite serious at least through the 1980's. The failure of the coal option to develop as expected may be very expensive to remedy. Emergency replacements may be very costly. With sufficient time, a more efficient adjustment process can emerge.

Our current knowledge is inadequate to indicate whether or not the controls on coal produce benefits commensurate with their costs. The main conclusion reached here is that the costs of restricting coal production and use have been underestimated. A particular concern is that the expenses associated with learning how to comply with new regulations are inadequately considered. In sum, we and our policy-makers are insufficiently aware of how great a conflict exists between proposals for expanding coal use and policies that hobble coal. As a result, we are not making adequate preparations to resolve the problems that may arise.

References and Notes

1. U.S. Congress, General Accounting Office, *U.S. Coal Development—Promises, Uncertainties* (General Accounting Office, Washington, D.C., 1977), especially p. 1.7.
2. The overall energy goals were reported [U.S. Executive Office of the President, Energy Policy and Planning, *The National Energy Plan* (Government Printing Office, Washington, D.C., 1977), pp. 95–96] in barrels per day of oil equivalent. However, several sources have reported the tonnage assumptions [U.S. Executive Office of the President, Energy Policy and Planning, *Replacing Oil with Coal and Other Fuels in the Industrial and Utility Sector* (Executive Office of the President, Washington, D.C., 1977), p. III-2; U.S. Congress, Congressional Budget Office, *President Carter's Energy Proposal: A Perspective* (Government Printing Office, Washington, D.C., 1977), p. 47; U.S. Congress, Office of Technology Assessment, *Analysis of the Proposed National Energy Plan* (U.S. Government Printing Office, Washington, D.C., 1977), p. 46]. For coal industry reaction, see G. R. Schleede, "The outlook for coal demand and supply" (National Coal Association, Washington, D.C., 1977).
3. For typical attacks, see J. M. Blair, *The Control of Oil* (Pantheon, New York, 1976); R. Engler, *The Brotherhood of Oil* (Univ. of Chicago Press, Chicago, 1977). For a more restrained view, see T. D. Duchesneau, *Competition in the U.S. Energy Industry* (Ballinger, Cambridge, Mass., 1975).
4. For a similar argument applied to automobile pollution, see H. Margolis, "The politics of auto emissions," *Public Interest* **49** (fall 1977), pp. 3–21.
5. Here, as in much of the rest of the article, I have relied on reading the laws when I could obtain copies [U.S. House of Representatives, *Clean Air Amendments Conference Report* (Report 95-564), 95th Congress, 1st session, 1977].
6. *New York Times* of 27 October 1977 reported that new sources were being defined by EPA as those started after March 1978 when the implementation plan is expected to be complete; members of Congress were quoted as feeling that the date the act passed should be the cutoff point. In any case, we now have two vintages of new sources—those covered by the 1971 rules and a later vintage covered by the implementation of the 1977 Clean Air Amendments.
7. See, for example, Sulfur Oxide Control Assessment Panel, *Final Report on Projected Utilization of Stack Gas Cleaning Systems by Steam-Electric Plants* (U.S. Department of Commerce, Washington, D.C., 1973); U.S. Environmental Protection Agency, *Report of the Hearing Panel, National Public Hearings on Power Plant Compliance with Sulfur Oxide Air Pollution Regulations* (Government Printing Office, Washington, D.C., 1974).
8. PEDCo-Environmental, Inc., *Summary Report—Flue Gas Desulfurization Systems—August-September 1977* (PEDCo, Cincinnati, 1977).
9. Adequacy is, like an energy gap, the layman's imperfect description of an excess demand created by price controls. For a typical example of the concern, see *7th Annual Review of Overall Reliability and Adequacy of the North American Bulk Power Systems* (National Electric Reliability Council, Princeton, N.J., 1977).
10. For a review of the problems in appraising these issues, see R. L. Gordon, *Historical Trends in Coal Utilization and Supply* (National Technical Information Service, Springfield, Va., 1976). U.S. Executive Office of the President, Energy and Policy Planning, *Replacing Oil with Coal and Other Fuels in the Industrial and Utility Sector* (Executive Office of the President, Washington, D.C., 1977), was accompanied by a report by Energy and Environmental Analysis, Inc., *Methodology: Replacing Oil and Gas with Coal in the Industrial Sector*, 1977. Unfortunately the only verifiable data in the report are the costs of a representative boiler, and these estimates are suspect. Considerably higher figures are given by M. H. Farmer, E. M. Magee, and F. M. Spooner [*Application of Fluidized-Bed Technology to Industrial Boilers* (National

Technical Information Service, Springfield, Va., 1977). Farmer *et al.* of Exxon Research and Engineering Company prepared the study for EPA, FEA, and ERDA].
11. The starting point for the calculation is an estimate made by C. J. Johnson and me that 1969 prices were in the range of 18 to 20 cents per million Btu's [C. J. Johnson, "Coal demand in the electric utility industry," thesis, Pennsylvania State University, University Park (1972); R. L. Gordon, *U.S. Coal and the Electric Power Industry* (Johns Hopkins Univ. Press, for Resources for the Future, Inc., Baltimore, Md., 1975)]. Comparisons were made on *Coal Week* listings of 1977 quotations for coal selling on long-term contracts, deflating by the implicit deflator for the gross national product.
12. U.S. House of Representatives, *Surface Mining Control and Reclamation Act of 1977 Conference Report*, 95th Congress, 1st session, 1977.
13. ICF, Inc., *Final Report Energy and Economic Impacts of H.R. 13950 (Surface Mining Control and Reclamation Act of 1976)* (ICF, Inc., Washington, D.C., 1977). For an alternative view on total costs, see Energy and Environmental Analysis, *Benefit/Cost Analyses of Laws and Regulations Affecting Coal* (Government Printing Office, Washington, D.C., 1977).
14. The numerous papers making the case were made available to me by the National Coal Association.
15. See W. E. Tyner, R. J. Kalter, J. P. Wold [*Western Coal: Promise or Problem?* (Department of Agricultural Economics, Cornell University, Ithaca, N.Y., 1977)] for a review of these problems, which suggests that ownership patterns and leasing policies hinder both ensuring maximum returns to the federal government and efficient industry development.
16. U.S. Congress, Public Law 94-377, *An Act to Amend the Mineral Leasing Act of 1920, and for Other Purposes*, 94th Congress, 2nd session, 1976.
17. U.S. Mountain Plains Federal Regional Council, "Preliminary draft of permitting procedure for surface mining of coal on federal lands or coal deposits" (Denver, Colo., 1977).
18. See for example U.S. Federal Energy Administration, *National Energy Outlook, 1976* (Government Printing Office, Washington, D.C., 1976).
19. G. F. Nielsen, "Coal mine development and expansion survey . . . 617.3 million tons of new capacity 1977 through 1985," *Coal Age* (February 1977), pp. 83–100.
20. U.S. Executive Office of the President, *National Energy Act, 1977*.
21. U.S. Congress, House of Representatives, *HR 8444*, Report No. 95-543 (1977), especially pp. 429–467.
22. I thank various government agencies that made reports available to me, ICF, Inc., and Robert Kalter who directly supplied their reports, coal industry sources who provided their material, and E. Welch who checked the manuscript for me.

Brazil: Energy Options and Current Outlook

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Summary. Brazil's energy options and current outlook are examined, and a summary of known reserves of fossil and renewable energy resources is given. Brazil has abundant renewable energy resources but very modest reserves of fossil fuels. Consequently, the emphasis in the future will have to be on the utilization of solar energy, hydroelectric power, and biomass in a program designed to preserve local traditions and culture.

Brazil has an area of 8,511,965 square kilometers and a population of approximately 110 million people (*1*, *2*). The country was kept dormant as a Portuguese colony for more than 300 years and, after gaining political independence in the last century, remained as a producer and exporter of agricultural products, mainly coffee and sugar, until World War II.

After World War II, Brazil entered a phase of accelerated industrialization which resulted in the growth of very large cities in the southern (and more temperate) part of the country and, consequently, in an exodus of rural populations to urban centers. The fraction of the population living in cities increased from 36 percent in 1950 to 45 percent in 1960 and 56 percent in 1970.

The energy consumption "per capita" of the average Brazilian therefore increased enormously in a brief span of time; in addition, the profile of consumption changed very significantly. Figure 1 indicates that by 1976 Brazil had reached a level of consumption comparable to some of the less developed European countries (approximately 10 megawatt-hours per year per capita) (*3*).

Energy consumption as a function of per capita income has increased in recent years in a manner similar to that in developed countries. Thus the country has entered a phase of modernization in which the energy-intensive consumption patterns of the great industrial countries have been adopted, without any critical assessment, through the transplantation of modern, foreign industries. As shown in Fig. 2, the relation between per capita energy consumption (E) and per capita income (I) is practically linear, a characteristic of highly developed countries (*4*, *5*).

The ratio of total energy used to per capita income has also remained almost constant in the last 10 years at the level of 60×10^3 British thermal units (Btu) per dollar. This is approximately two-thirds of the value in the United States (*6*) and indicates that the efficiency of energy use has been slowly improving (Fig. 3); however, less energy is needed in Brazil to produce one dollar of income than in the United States, indicating a smaller use of energy-dissipating devices such as air conditioners and freezers.

The profile of consumption (*3*) changed in a somewhat predictable fashion in the era of cheap and abundant petroleum (Fig. 4). The relative importance of biomass in the balance of the energy consumed decreased dramatically from 1940 to 1975, with a corresponding growth of petroleum consumption.

Coal has had an insignificant role in energy consumption in Brazil, but hydroelectric power has increased its share to 20 percent of the total energy consumption in recent years. The balance is taken by petroleum; its contribution has grown from 9.2 percent in 1941 to 28.0 percent in 1952 and to 44.8 percent in 1972 (Fig. 5). Natural gas consumption has been negligible.

The energy profiles of Brazil and the United States are compared in Table 1. Petroleum represents approximately 44.8 percent of the total energy consumed in Brazil and only 20 percent of it is produced internally. The remaining 80 percent (700,000 barrels per day) is imported at a cost of more than $3 billion per year. To compensate for this deficit in the balance of trade, the country has to export large quantities of raw minerals, agricultural products, and semi-industrialized goods.

The future prospects for energy consumption are presented in Fig. 6, which shows the official projections for con-

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