Mining and the Environment

Case Studies from the Americas

edited by Alyson Warhurst

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CHAPTER 2[1]

US ENVIRONMENTAL REGULATIONS AND THE MINING INDUSTRY: LESSONS FOR CHILE

Juanita Gana

In the design and implementation of environmental regulations, the United States is far ahead of many other countries. With more than 20 years of systematic efforts to protect the environment and improve the quality of life for its citizens, the United States can offer several lessons to Chile and other countries with less experience.

For any country planning to pursue environmental stewardship, aspects of the utmost relevance are

- The development of environmental consciousness, the mechanisms of social pressure, and the policy-making response;
- The approach selected to deal with the problems, the tools used, and the ability of these to solve the problems with minimum adverse economic impact;
- The impact of environmental regulations on productivity, market structure, and economic growth;
- Regional impacts and their effect on employment; and
- The reaction of industry and the labour unions.

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It would not be prudent for other countries to simply duplicate either the style or the specific mechanisms of a specific US policy-making experience. For countries with different political, social, economic, and, especially, ecological conditions, it might even be dangerous. The lessons from the US experience, whatever they may be, must be adapted to the context in which they are to be used.

Also, we cannot say that the United States has found the ultimate formula for dealing with environmental problems. After two decades, the principal moral is that no such formula exists and that environmental policies should, above all, be flexible. The time may be too short, and we are still in the experimentation stage. The very nature of the problem forces us to recognize a deep void in our scientific knowledge about ecosystems and the impacts of human activities — a void that might never be filled to the extent that we feel secure about the consequences of our decisions. That has been the ultimate challenge of environmental problems: the increasing awareness of our poor understanding and our lack of control over nature.

The focus of this research on mining reflects the importance of this sector to the Chilean economy. This makes it of special relevance to identify the problems this sector poses for the environment, as well as become aware of the possible consequences that environmental regulations would have for this sector. These concerns are covered, and the present regulatory scheme and its impacts on the mining sector, particularly the copper industry, are also examined. The paper also discusses the efficiency, cost-effectiveness, dynamic efficiency, and equity of existing policies and mechanisms.

As mentioned, environmental policy in the United States is still in its trial-and-error phase. This paper examines new trends in environmental policy-making and the ways they might affect the mining industry. I take a closer look at the case of mining-waste disposal, which is receiving a lot of attention from the industry, environmental groups, and the government. The discussion of mining-disposal regulations involves not only the next step in the control of the industry but also an interesting experiment. New procedures and new concepts are being tested; their success may bring about important changes in ways of writing environmental policy. Finally, I summarize the main conclusions from the US experience and make some recommendations for policy formulation and implementation in Chile.

This study is by no means exhaustive: it is the product of a 3-month project and focuses on just some of the several themes relevant to environmental policies in the United States. Even then, the treatment of themes cannot help being somewhat superficial. Nevertheless, the study develops a sense of the main policy issues and establishes some guidelines for future policy-making.

US environmental regulations and the mining industry

The first US pollution-abatement regulations date from mid-century. The *Water Pollution Control Act* of 1948 and the *Air Pollution Control Act* of 1955 were enacted by Congress to address the increasing health hazards posed by industrial activities and the lifestyle of US society. The purpose of enacting these laws was mainly to grant the federal government the authority to allocate resources to investigate the causes and effects of pollution and to train human resources from state and local agencies. These laws also transferred some responsibilities from the state to the federal level. However, the state governments still had the authority to implement and enforce regulatory programs.

The need for a national framework and a stronger federal presence became more and more evident as environmental problems grew and public opinion became more sensitive. State legislation was dispersed and became a potential source of competitive disadvantage. As a consequence, states were often reluctant to take the initiative. Reacting to a strong environmental movement, Congress passed the *National Environmental Protection Act* (NEPA) in 1969, which was to become one of the most influential environmental regulations in the United States and abroad (Anderson et al. 1984).

NEPA was the first attempt to give a systematic and coherent framework to the problem, and it established a conceptual basis upon which other legislation was created or amended. Although NEPA gave little guidance on how its general objectives were to be met, it established a powerful mechanism for introducing environmental considerations into the decision-making process. This mechanism was the environmental-impact assessment (EIA), which NEPA required before any major federal action that would significantly affect the quality of the human environment could be undertaken. The EIA process forced federal agencies to take environmental concerns into consideration during the planning process. NEPA also made it possible to challenge federal actions affecting environmental quality, resulting in a number of high-profile court cases that served to raise public awareness and concern about environmental problems (Anderson et al. 1984).

The institution to implement NEPA was created in 1970. Several government agencies were already in charge of implementing and enforcing the several dispersed laws that in some way or another protected the environment, but Congress decided to create a new, separate agency, the Environmental Protection Agency (EPA). The rationale for the EPA was to fulfil the need for an independent institution with the expertise to formulate environmental regulations and to oversee their implementation and enforcement. Having a separate agency raised the issues not only of coordination and regulatory consistency and coherence but also of autonomy. Other government agencies were in charge of fulfilling several other objectives, with the environment being only one of them and probably not the most relevant (see, for example, the case of the US Atomic Energy Commission in Anderson et al. 1984). After this basis for environmental policy-making was set, frantic activity began in Congress.

As a consequence of its rather low national profile, mining pollution occupied a secondary place on the US environmental agenda during the last decade. The pollution produced by the chemical and petroleum industries seemed far more worrisome. But the environmental impacts of mining range from land disturbance produced by exploration, development, and mining activities, especially in the case of open-pit mining; to the pollution of surface water and groundwater by metals, toxic chemicals, and acid mine drainage; to the pollution of air by SO_2 emissions and the like. Fugitive dust may also be an environmental hazard, although its impact is mostly impaired visibility. Mining pollution tends to be very localized, and because the population is generally sparse around mines, fewer people are exposed to health risks and aesthetic effects than is the case with industrial pollution in suburban areas. Nevertheless, mining pollution may have important ecological and aesthetic effects (Gomez et al. 1979; Vogely 1985; MacDonnell 1989).

Regulations affecting mining were introduced because of broader concerns, with the result that the role of the mining industry in the policy-making process has been minor. The mining industry's loss of importance in the US economy and its diminished strategic significance have further reduced the industry's negotiating power. The fact that mining has not played an important role in environmental policy-making contrasts sharply with the impact that environmental regulations have had on the industry.

The relevant regulations and legislation include NEPA, the *Clean Air Act* (CAA), *the Resource Conservation and Recovery Act* (RCRA), *the Comprehensive Environmental Response, Compensation, and Liability Act* (CERCLA), *the Surface Mining Control and Reclamation Act* (SMCRA), and the *Mining Law.*

The impact of environmental regulations on copper mining

Much controversy surrounds the environmental regulatory framework and the burden it has imposed on the copper mining industry. Complaints about exaggerated costs and the loss of competitiveness have been recurrent. Negative impacts on employment and on regional economic activity have also been a part of the discussion.

According to the US Department of Commerce and its Bureau of Analysis (USDC 1988), expenditures for pollution abatement and control have been constantly rising since the early 1970s, except during the 1980–82 recession (see Table 1).

Table 1. Total expenditures for pollution abatement and control, 1972–87.

	Total expenditures (billions of 1982 USD)															
	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987
Abatement costs	40	46	47	50	53	55	58	60	58	57	55	56	61	65	68	68
Air	15	18	18	21	22	23	24	24	25	26	25	26	28	30	31	28
Water	20	21	21	23	24	25	27	26	25	22	21	21	23	25	26	28
Solid	7	8	9	8	8	9	9	10	11	11	10	19	11	11	12	13
Total abatement and control costs [a]	43	49	50	54	56	59	62	63	62	60	58	60	64	68	72	71

Source: USDC (1988).
Note: USD, United States dollars
[a] *Includes regulation and monitoring costs, as well as research and development expenditures.*

Overall, these expenditures grew at an average annual rate of 3.4% during 1972–87. Currently, the annual level of expenses is close to 70 billion United States dollars (USD), about 2% of the US gross national product.

Among laws and regulations, the CAA has been considered by far the most expensive. More than half of the expense of air-pollution abatement is for controlling pollution from mobile sources, reflecting the importance of vehicle emissions as a source of air pollutants.

Another source, the McGraw-Hill (1982) annual survey, indicated that pollution-control expenditures on average accounted for more than 5% of total capital expenditures during 1975–79; 3%, during 1980–84. In the case of mining, McGraw-Hill estimated a total of 21.8 billion USD in capital expenditures for 1970–81. An EPA study cited in MacDonnell (1989) gave a significantly lower figure: about 8.9 billion USD. The EPA study also gave an estimate for 1981–90 of 5.3 billion USD. EPA used engineering estimates of costs for compliance with federal air and water regulations, whereas the US Department of Commerce and McGraw-Hill relied on industry surveys and may have included other regulatory costs.

In terms of total costs, including control and maintenance, the EPA study indicated a cumulative annualized cost of 15.5 billion USD for 1970–81. The annualized cost for 1981 totalled 2.6 billion USD, and the cumulative annualized costs projected for 1981–90 totalled 32.7 billion USD. Following the general pattern, the CAA has been the most expensive regulation for the mining industry (SMCRA in the case of coal production). According to the same EPA study, cited in MacDonnell (1989), about 80% of the mining industry's expenditures for pollution abatement in 1970–81 were for control of air pollution; the other 20% were for control of water pollution.

In absolute terms, the iron and steel industry has been the most affected by air- and water-pollution-control costs, followed by the copper industry. Of the total 8.9 billion USD of investment reported by the EPA, 4.6 billion USD was spent by the iron and steel industry, and around 2.1 billion USD was spent by the primary copper industry (the last figure includes only costs for air-pollution control). Nevertheless, in terms of pollution-abatement costs as a proportion of total capital expenditures, the copper industry shows an outstanding 41%, whereas the iron and steel industry shows only 18% (Sousa 1981).

Because copper is the most important mineral in Chile, the following pages concentrate on the impact of the CAA on the copper-smelting industry. In the United States, this industry has been one of the sectors most affected by environmental regulations, particularly the CAA (Sousa 1981).

The CAA and the copper-smelting industry

The CAA regulates SO_2 emissions and sets primary and secondary standards for this pollutant. Sulfur dioxide is a primary focus of the CAA. The pollutant has a number of negative impacts, including aggravation of symptoms of heart and lung disease and increased incidence of acute respiratory disease. It can also be toxic to plants, erode statues, corrode metals, harm textiles, impair visibility, and contribute to acid deposition (GAO 1986).

The principal sources of copper are sulfide deposits. The production of each tonne of copper releases an equal or greater volume of sulfur. The recovery of copper from sulfide ores is done by pyrometallurgical processes that separate the copper from other elements like sulfur. After the copper ores are ground and concentrated, the concentrate is smelted, passing through a circuit of furnaces, converters, and roasters, any one of which may release sulfur into the atmosphere as SO_2. Finally, the blister obtained from the smelters is refined. For a description of these processes, see Rothfeld and Towle (1989).

Oxide ores used in the production of copper do not present this SO_2 problem because they are treated by hydrometallurgical processes. Unfortunately, oxide ores play a minor role in the copper industry because of their relative scarcity — only about 16% of US copper production involves oxide ores (Rothfeld and Towle 1989). However, they present higher risks of water pollution (USDC 1979).

At the national level, the major source of SO_2 emissions is the power-utility industry (Table 2). Copper smelters make a significant contribution, especially at the regional level. Both industries together generate more than 70% of total SO_2 emissions in the United States (Rothfeld and Towle 1989). According to EPA figures cited by the US Bureau of Mines (USBM), utility boilers generated 14.7×10^6 t of SO_2 in 1985, whereas copper smelters produced only 0.6×10^6 t. But in the states with the greatest smelting capacity — Arizona, New Mexico, and Utah — utility boilers generated 0.2×10^6 t of SO_2, whereas copper smelters generated 0.6×10^6 t of SO_2 (USBM 1989) (Table 3).

Table 2. Sources of SO_2 emissions in the United States, 1980.

	SO_2 emissions	
Source	($\times 10^6$ t)	(%(
Utilities	15.8	62.7
Nonferrous-metals smelters	1.4	5.5
Copper smelters	1.1	4.4
Others	6.9	27.4

Source: GAO (1986).

Table 3. Regional distribution of SO_2 emissions from power utilities and copper smelters, 1985.

State	Copper smelters ($\times 10^3$ t)	Utility boilers ($\times 10^3$ t)
Arizona	454.5	106.9
New Mexico	96.6	70.7
Utah	8.3	22.1
Total for 3 states	559.4	199.7
Total for 48 states	578.0	15 249.9

Source: Rothfeld and Towle (1989).

Yet these SO_2 emissions levels represent an important CAA accomplishment, because copper smelters played a much more important role in SO_2 emissions a decade ago. In 1980–88, SO_2 emissions from copper smelters were reduced by 73%, from 1.1×10^6 t to 0.3×10^6 t. In 1987, the aggregate capture of SO_2 emissions was 83% (Rothfeld and Towle 1989). Control is currently estimated at far more than 90%, thanks to the retrofit of San Manuel (Magma Copper Company) and additional improvements derived from previously retrofitted plants. With currently available technology, it is possible to capture 99% of SO_2 from the gases released from smelters (Rothfeld and Towle 1989).

Before air-quality standards and emission limitations were enforced at the federal level, some degree of control was provided at the state level. Some smelters had already decided to recover SO_2 to produce sulfuric acid, even without regulations, as in the case of Garfield Refining Company. In such cases, around 60% of SO_2 emission was captured from roaster and converter gases. The remaining 40% came basically from reverberatory-furnace stacks and from fugitive gases from what were mostly old plants. The problem with recovering SO_2 emissions from reverberatory furnaces — a technology widely used some decades ago with copper smelters — was the weak gas stream, which contained less than 1% of the SO_2. It was technologically and economically impracticable to recover SO_2 under those conditions, even though there was a possibility that some technical obstacles could be overcome (Rieber 1986; Rothfeld and Towle 1989).

After implementation of the 1970 CAA, some smelters installed acid plants and used tall smokestacks and intermittent controls to comply with the ambient-air-quality standards. But the 1977 amendments to the CAA prohibited the use of these techniques for stationary sources and required permanent controls. The only alternative for copper smelters was to replace the reverberatory furnace with other technologies, like flash or electric furnaces or bath smelting. (The use of scrubbers, a technology that power plants use to remove the sulfur from coal, is not economically feasible for copper smelting because of the greater amounts of sulfur involved. There are also additional storage costs and so on [Rieber 1986].) These other furnaces and the use of enriched oxygen did provide a gas stream strong enough to allow the recovery of SO_2 (Sousa 1981; Rothfeld and Towle 1989).

The huge investments needed to retrofit the plants, most of them built in the early 20th century, led the industry to ask for some relief. In addition to the financial burden, the industry cited a lack of proven technologies for controlling high levels of SO_2 emissions. Eventually, the industry did get some relief — the Non-ferrous Smelter Orders (NSOs) provision. The NSOs allowed smelters to delay new investments and to use temporary measures, like curtailed production or taller stacks, to comply with ambient-air-quality standards. The NSOs extended compliance deadlines by 5 years, with the possibility of a second extension.

Although the provision was intended to apply to all nonferrous-metals smelters, only copper smelters — San Manuel (Magma Copper) and Douglas (Phelps Dodge), in Arizona; Chino (Phelps Dodge [by that time owned by Kennecott Corporation]), in New Mexico; and McGill (Kennecott), the only Nevada smelter— requested NSOs. After these NSOs expired, San Manuel, Douglas, and Chino requested a second round (McGill had shut down in 1983). Although San Manuel obtained a second NSO, Douglas shut down in 1987. Chino was retrofitted before the final decision. The government also gave the industry some financial support by allowing rapid amortization of pollution-control equipment and by providing tax credits for such investments (Larsen 1981).

The first smelter to change its process technology was Inspiration, which converted to electric furnace in 1974. The last smelter to invest in SO_2 control will be El Paso, owned by Asarco Incorporated. In the last three decades, there has been only one new greenfield project, Hidalgo, owned by Phelps Dodge. Hidalgo began operating in 1976. From the beginning, it introduced air-pollution-control technology, and it was, at the time of its construction, considered to be the most modern and efficient copper smelter in the country (Rothfeld and Towle) 1989.

Technology

EPA standards demand a permanent end-of-pipe type of control. Dispersion techniques have been explicitly prohibited, as well as temporary reductions in production levels. Consequently, legislation has implicitly imposed the SO_2-fixation method for reducing SO_2 emissions. This has meant replacing old reverberatory furnaces with other equipment to recover SO_2 and produce sulfuric acid.

The US smelting industry uses flash and electric furnaces, but bath smelting has also been used in other countries. Other techniques are either unproven for use at an industrial scale, like the ammonia scrubbing system, or too expensive to use with copper concentrates, like the limestone scrubbing system used in coal-fired electric-power plants.

For the most part, smelters choose the technology that suits their own site-specific conditions, such as metallurgical parameters or input supplies. The tendency has been to use Outokumpu smelting technology, which accounts for more than 75% of the flash furnaces currently operating in the world and two-thirds of the new capacity. Although the Outokumpu technology has important advantages, such as being the lowest-risk option, the Inco and Noranda processes also have advantages, such as simplicity and the capacity for handling dirtier concentrates. Each of these technologies achieves full compliance with strict environmental standards, but the Mitsubishi continuous smelting process yields the highest level of SO_2 fixation (more than 99%).

Although the replacement of reverberatory furnaces has brought additional capacity, increased productivity, and energy savings, these investments might not have been made had there been no regulatory requirements (Sousa 1981; Rieber 1986; Cook 1989; Roethfeld 1989). The new technologies reduce operational costs, but in terms of capital costs, the scale shifts in favour of the old technology (Cook 1989). For greenfield projects, however, the new technologies have smaller capital and operational costs than a reverberatory furnace does, according to Burckle and Worrell (1981).

A company's decision to produce sulfuric acid is also considered a consequence of the regulatory environment, because the sulfuric acid market by itself fails to justify its production (Rieber 1986; Rothfeld and Towle 1989). Nevertheless, some smelters have long been producing sulfuric acid, like the Garfield smelter, which built an acid plant in 1916 (Navin 1978). In any case, ore leaching and electrowinning are creating an interesting alternative market for sulfuric acid.

The introduction of these technologies was not trouble free. Although they were being used in other countries, they had not been tried at full scale or under the metallurgical conditions of the US smelting industry. Temporary closures, delayed start-ups, and productivity losses were part of the costs of complying with the regulations. Moreover, after the new technologies were introduced, some smelters still had problems complying with emission standards — Inspiration and Hayden (Asarco) are examples (GAO 1986).

The cost to the industry

Analyzing the costs that environmental regulations imposed on the copper industry, the USBM (1989) determined that the principal impact was on smelting, because compliance with the CAA entailed major process changes, substantial capacity reduction, and increasing export of ores and concentrate. Other researchers drew the same conclusion. According to a study done for EPA in 1978 by A.D. Little, Inc. (Sousa 1981), 24% of the copper industry's total investment in the 1972–75 period went to pollution control. For copper smelters, the figure was 74%. Only 4% of this investment was for water-pollution control; the other 96% went to air-pollution control.

The strong impact of the CAA and its SO_2 standards on the copper industry stimulated several studies. Some of these studies were prepared for the EPA, some were prepared for the industry, and at least a couple were prepared for Congress to use in considering protection for the domestic copper industry. USBM's Minerals Availability Program prepared the most complete report. This study, by Rothfeld and Towle (1989), examined the remaining seven southwestern smelters (which accounted for 96% of the US smelting capacity in 1987) and identified the regulatory impacts, including monitoring and direct administrative costs. The study concluded that, on average, environmental, health, and safety regulations added 0.032 USD/lb (1 lb = 0.454 kg) to operating costs. Sulfuric acid credits reduced this figure to 0.019 USD/lb. (For comparison, the total operating cost for an average smelter was 0.123 USD/lb — see Table 4.) These regulations also added 0.031–0.104 USD/lb to capital costs, depending on the smelter. (These calculations assumed operation at full capacity and excluded administrative overhead and indirect costs. The calculation of capital costs assumed a 15% rate of discount.) Metallurgical conditions, size of the plant, degree of obsolescence, and technological choices were the main factors affecting compliance costs. If both operational and capital costs are taken into account, compliance with environmental regulations represented 45% of total smelting costs and 14% of the total costs of producing a pound of refined copper (assuming no capital costs other than regulatory capital costs). Rothfeld and Towle also indicated that the capital costs of retrofitting a smelter averaged 150 million USD.

Table 4. Operational costs for an average smelter.

Source of costs	USD/lb	%
Labour	0.0465	37.8
Energy	0.0374	30.4
Supplies	0.0391	31.8
Total cost	0.1230	100.0

Source: Rothfeld and Towle (1989).
Note: USD, United States dollar; 1 lb = 0.454 kg.

The calculations given by Rothfeld and Towle (1989) take into account productivity gains resulting from new and improved technology, lower energy costs, and greater production capacity. These calculations also include health and safety expenses, but according to a study cited in Sousa (1981), 95% of the total regulatory expenses are attributable to compliance with EPA standards. On the other hand, those figures may be considered conservative because they include only direct costs and do not take into account the opportunity costs involved in the slow process of obtaining permits — legal fees, red tape, and delays add to the costs.

Several other studies tried to measure the actual costs of environmental regulations or to assess possible impacts of full compliance and stricter standards. For example, the Congressional Research Service (CRS 1984a), analyzing different sources of data, gave a cost for full compliance — not necessarily effective compliance — ranging from 0.05 to 0.15 USD/lb. An industry source gave the highest estimate, but the State of Arizona gave the most probable estimate, an average of 0.09 USD/lb. Earlier studies, like Sousa (1981), gave effective costs ranging from 0.03 to 0.05 USD/lb and projected an additional cost of 0.10 USD/lb for full compliance with the 90% emission-control standard.

Studies tended to overestimate future environmental costs because they normally included the cost of compliance for smelters that would shut down. These smelters usually had the highest retrofitting costs. Exploratory studies also failed to take into account substitution effects or technological improvements. Although actual costs were less than previously estimated, the relative impact of environmental regulations on operational costs was greater, because operational costs were reduced through modernization.

It is also interesting to notice that the estimates prepared by governmental agencies at the beginning of the environmental era often underestimated the real costs of compliance by the copper industry. For example, in 1971 the President's Council on Environmental Quality (CEQ) estimated that air- and water-pollution control would require capital expenditures of 311–682 million USD (MacDonnell 1989). If operation and maintenance are included, the cost goes up to 346–758 million USD (Charles River Associates Inc. 1971). Even if we take the highest point of the CEQ estimate and adjust for inflation, actual costs were more than double the estimated costs.

This underestimation of real costs was rather common. A lack of experience and a poor understanding of some industries and their technological challenges most often led to optimistic assessments of the economic impact of regulations. Certainly, in the case of the copper industry, the dramatic changes that took place in the US economy and international markets did not help.

If projecting environmental costs proved to be a difficult task, identifying the actual cost of compliance for the smelting industry was not much easier, as we have already seen. The current accounting system makes no clear distinctions among regulatory costs, leading sometimes to important discrepancies, depending on the methodology used for estimating. Figures given by companies usually refer to total investments, without adjustments for increased productivity or higher energy efficiency; some may be exaggerated just to improve the external image of the company (Gulley and Macy 1985).

The CAA amendments of 1990

The CAA amendments of 1990 introduced additional controls for SO_2 emissions and focused on the power-utility industry. Nevertheless, the regulations pertaining to toxic substances released into the air are a possible new source of compliance costs for copper smelters and for the copper industry in general. The Bush administration estimated the annual cost at 3 billion USD to the whole economy. Industry estimates ranged from 14 billion to 62 billion USD (Portney 1990). Uncertainty about the cost to the mining industry is even greater.

Production and employment levels

Probably the most dramatic impact of environmental regulations has been the shutdown of several smelters (which may be evidence of an overwhelming financial burden) and, as a consequence, the reduction of the national smelting capacity. An equally visible consequence has been the reduced levels of employment in the industry.

In 1970, the United States had 17 smelters, and the total primary smelting production was about 1.6×10^6 t of copper. Two decades later, in 1989, the number of smelters had been reduced to eight, and production had been reduced to 1.5×10^6 t of copper; there was one new greenfield project. Smelting production reached its lowest level in 1983, with 1×10^6 t of blister and anodes. The smelting and refining industry suffered a steeper decrease in employment, from an estimated 11 600 workers in 1967 (Charles River Associates Inc. 1971) to about 5 400 workers in 1988 (USBM 1989).

The reduction of capacity and production has certainly been an important factor in accomplishing environmental goals; such reductions may even be an inevitable short-term consequence of implementing environmental controls. According to GAO (1986), 56% of the reduction in SO_2 emissions from nonferrous smelters was achieved because of reduced production; only 44%, because of retrofitting and new technologies.

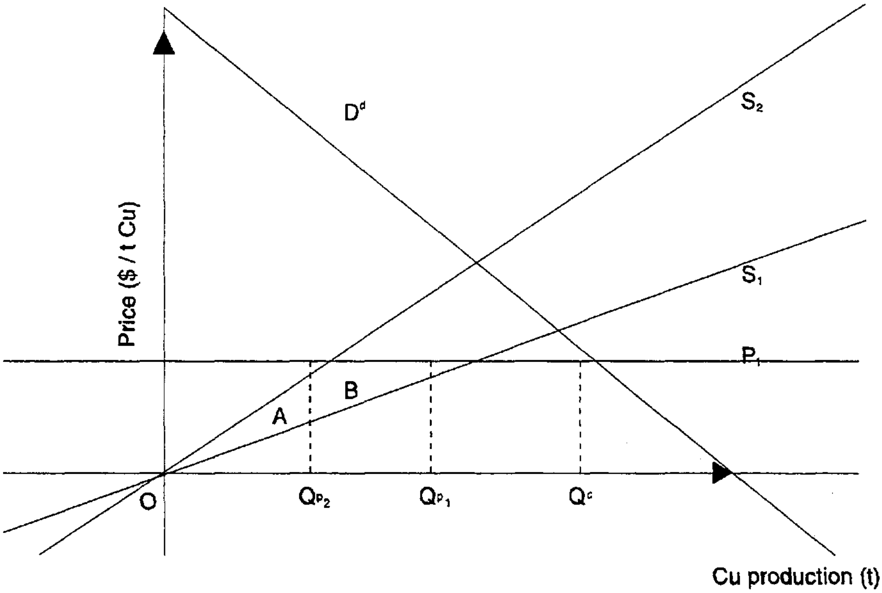

Figure 1. Cost of copper production.

The shrinkage of the smelting industry — and of the copper industry in general — is certainly an additional cost to society. This can be seen in Figure 1, where area A represents the higher operational costs, already discussed, and triangle B represents the cost of reduced production and employment (the smaller the mobility of capital and human resources, the larger the triangle).

This cost has not been included in most evaluations of the impact of pollution controls on the industry — estimates have concentrated on operational costs. Nevertheless, attempts have been made to estimate the impact on total capacity and employment; at first, the estimates were far too low. CEQ, in its "most extreme scenario," projected the stabilization of smelting capacity at around 1.6×10^6 t. It also fell short in employment estimates, predicting that employment would not fall below the 1970 level. In 1970, total employment in the copper industry was estimated to be 54 000; by the end of the next decade, it was around 18 000 (MacDonnell 1989).

If we use the triangles in Figure 1 and apply the capacity lost during these last decades and Rothfeld and Towle's (1989) operational costs of compliance, we obtain a figure close to 63 million USD. This may be an underestimation, as the calculation of regulatory costs took into account only direct costs, and we are not allowing for any expansion and are assuming perfect mobility of resources. But it may also be an overestimation, as the enforcement of environmental regulations was not the only reason for the reduction of US copper-smelting capacity. As we review the circumstances, we find that some shutdowns would have taken place regardless of environmental regulations (Mikesell 1988). In fact, even some plants that were already in compliance and thus not threatened by new capital expenditures closed. In fact, 5 of the 10 closed smelters already had control equipment in place to meet SO_2 emission limits (GAO 1986).

Several factors compounded the difficulties for the copper industry during the late 1970s and early 1980s. The most important was the crisis in the international copper market (Mikesell 1987). Copper prices reached their lowest levels since the early 1930s. Excess capacity (created during the early 1970s in an over-optimistic reaction to good market conditions) and declining rate of growth in copper consumption caused the glut in the market. Lower-quality ores, higher labour costs, and older plants made it difficult for US copper producers to confront a more competitive market. In addition, some companies were going through hard financial times.

International competitiveness

Environmental regulations have corroded the competitiveness of US copper producers and reduced their world-market shares. In the US market, increased imports of refined copper have compensated for decreased domestic production. This effect does not necessarily increase the social cost of environmental regulations unless we consider, first, that there is a premium for reduced vulnerability and, second, that the United States is not a marginal actor in the international market.

If we look at the first consideration, we find that although some decades ago copper was a strategic material, times have changed. Nowadays, copper is a traditional metal with many possible substitutes, and external supplies come from allied countries that are fairly stable politically and economically. In 1986, the worst year of the crisis in the copper market, refined-copper imports reached a maximum of 23.5% of the total apparent consumption (Mikesell 1987).

Regarding the second consideration, we can say that although the United States is one of the most important copper consumers and producers in the world, its role in the international market is not decisive. In 1986, it imported slightly more than 500 000 t of refined copper. Moreover, most of this trade was with Canada, to some extent a captive market.

The industry argued that environmental regulations were one of the main reasons it needed protection against copper imports. The additional costs imposed by compliance with air-pollution and other controls were identified as a significant factor in the domestic industry's loss of competitiveness. Other producing countries without similar standards and requirements were said to be subsidized.

Several studies were done to assess the real damage and the need for relief. As mentioned earlier, this concern stimulated most of the research on the costs of environmental regulations to the copper industry. Congress discussed the possibility of protection for the domestic copper industry in 1978 and 1984. In both cases, although the International Trade Commission recommended import relief under the escape clause of the *Trade Act* of 1974, Congress ultimately denied the copper industry's petition for import protection.

The crisis affecting the US copper industry was not unique. Other base-metals industries were experiencing similar disruptions, as was the iron and steel industry. The issues were similar: depressed markets, loss of competitiveness, temporary and permanent closures, and unemployment. Environmental regulations, particularly air-pollution standards, were also an issue, although not as much as in the copper industry (Crandall 1981).

The structural causes of the crises were also similar. Although environmental controls were imposing a significant burden on US industry, other factors played a role. The most important of these was the change in the traditional behaviour of the international metals markets. The growth rate of world demand for all basic metals was decreasing; to an important extent, this was a result of the energy crisis and the increasing concern about materials-use efficiency. The economic recessions of the mid-1970s and early 1980s somewhat obscured the reduction in the materials-use intensity indices (Tilton 1990).

On the supply side, equally important changes were taking place in the late 1960s with the emergence of new low-cost producers, who increased competition in international markets. In the copper industry, an important change was the nationalization process in the late 1960s and early 1970s, which not only altered the organization of the industry and augmented the role of state enterprises (Sousa 1981; Cook 1989) but also affected companies with incomes heavily dependent on their *filials* (subsidiaries). Direct investment losses were equally significant for some of them, such as Anaconda (Navin 1978).

US industry was badly prepared for the new scenario. Obsolescence was a problem for most of the plants, especially compared to the state-of-the-art plants being built in countries like Japan and Korea (see, for example, Adams [1986] for the case of the iron and steel industry; Sousa [1981], the copper industry). An equally relevant factor was higher labour costs.

Productivity growth in the copper industry decreased during the 1970s and early 1980s, but wages continued to rise at the normal rates. For copper smelters and refineries, Sousa (1981) found a negative rate of productivity growth (averaging –0.3%) for the 1960s and 1970s.

High interest rates in the United States also eroded the position of these US industries, which needed to undertake big modernization projects to comply with environmental regulations and deal with the competitiveness crisis. Some companies were already highly indebted and burdened financially (Navin 1978; USDC 1979), and the appreciation of the dollar exacerbated these problems (Sousa 1981; CRS 1984). For the copper industry, a more fundamental factor was its reliance on ores of relatively low quality (Sousa 1981; CRS 1984).

One of the reports prepared for Congress concluded that environmental costs were one among several factors affecting the industry (CRS 1984b). After balancing the different factors generating the differential between the costs borne by US producers and those borne by their lowest-cost competitors, the report suggested that import protection would give only temporary and marginal relief and would not address the root problems of the industry.

Although Congress was concerned about the economic and social impacts of additional shutdowns in the copper industry, other considerations also influenced its final decision to deny the petition for protection. One consideration was that such protection might adversely affect the copper-user industry, possibly shifting the competitiveness problems to that sector. Other considerations were the possibility of complaints under the General Agreement on Tariffs and Trade and other treaty obligations and the possibility of negative impacts on the economic stability of allied copper consumers (CRS 1984b).

Although the iron and steel industry got secured trigger prices during the 1970s and import quotas in the 1980s, the copper industry was less successful and had to overcome the crisis without special protection. Nevertheless, in the end, both had to accept drastic restructuring. High-cost plants and producers went out of business, and those who remained had to reorganize production, renegotiate labour contracts, and undertake major modernization projects. In the copper industry, the results were impressive — the average production cost went down 42.5% between 1981 and 1989, in real terms. Productivity increased both at the industry and at the smelter and refinery levels (USBM 1989).

Investment trends

Frequently, the industry has argued that the regulatory framework and its financial burden will lead to the migration of US investment to countries where regulations are less strict or nonexistent. Some analysts, like MacDonnell (1989), have supported this hypothesis, but the complexity of the subject makes it difficult to assess the real impact of environmental regulations on investment decisions.

The hypothesis and some caveats

The logic of the arguments for the investment-migration view, at first glance, seems to be crystal clear: in loosely legislated countries, mining production is less costly and more profitable. Available data on capital expenditures for pollution abatement confirm that US multinationals spend considerably less overseas than at home (UNCTC 1985).

But some considerations weigh against this view. One is that technology tends to be homogeneous, especially the processes and equipment used to produce internationally traded commodities. Companies investing overseas will use the technologies developed in countries already subject to strict environmental regulations.

Another important consideration is the reputation of the enterprise. Big multinationals with headquarters in developed countries would not like to be perceived as taking advantage of other countries and damaging their environment. The old stereotype of the multinational company stripping the assets of developing countries as fast as it can no longer pertains. In the late 1960s and early 1970s, the relationship between multinationals and developing countries changed dramatically. The multinationals have been more concerned to understand and fulfil the expectations of developing countries, creating a new type of partnership. Furthermore, stakeholders and environmental groups in home countries have begun to exert pressure on multinationals to protect the environment; sometimes this pressure is even greater than that exerted by host governments.

Although governments of some developing countries may have a more lenient attitude, the trend is toward increasing environmental control. Developing countries are introducing environmental concerns into their development projects, either voluntarily or because they are obligated to do so by the policies of international funding organizations, such as the World Bank and the Inter-American Development Bank. This trend toward increasing environmental control has in some cases created a disincentive for overseas investment. Lumpy and politicized processes add to the uneven capacity of these countries to formulate and enforce environmental regulations (Leonard 1988).

Nevertheless, to the extent that developing countries tend to use the experience of developed countries, there may be a trend toward a homogeneous treatment of environmental policies around the world. Unless their investments are short-sighted, multinationals will likely anticipate future changes and introduce environmentally friendly technologies from the start.

Yet, homogeneous treatment of environmental policies does not imply that the costs of compliance would be the same everywhere (Leonard 1988). The costs of compliance depend on regional environmental conditions and availability of inputs. Cost differentials may also result from building more-efficient institutional structures and less-cumbersome administrative procedures, and this is also possible in developing countries that have the will to learn from the experience of other countries.

It is not easy to discern from the available data the impacts of environmental regulations on investment in the mining industry. Certainly, increased costs have eliminated marginal projects in the United States, and even expansions have been affected to the extent that EPA's New Source Performance Standards (NSPS) also apply to new equipment. But as we have seen, many other factors affected firms' decisions in the 1970s and 1980s. International-market conditions were no incentive to invest anywhere, unless in highly profitable projects like small polymetallic deposits with high ore grades or expansions with low operating costs.

Political and general economic conditions added to the problems. During the 1970s, the relationship between multinationals and host countries suffered drastic changes, provoking the flight of mining multinationals and a general distrust of the stability of foreign-investment regulations in least-developed countries (LDCs). During the early 1980s, LDCs became less antagonistic as their external debt increased and international capital markets became more elusive. Some overseas investors benefited from the LDCs' critical need for capital and foreign resources. The trend toward the privatization of state companies made these countries attractive in the 1980s. Leonard (1988) had this to say about multinationals' overseas-investment decisions:

> When US companies, even those facing extreme pressure because of pollution problems at home, decide to build a plant abroad instead of in the United States, they do not necessarily do so because of differentials in pollution controls or because governmental and public concern for the environment may have delayed construction. Conversely, an industrializing country may have no intention of becoming a pollution haven, but other forces may induce it to attract certain high-pollution industries just the same. Thus, a major methodological problem is that it is difficult to single out the effects of any one factor in assessing either international comparative advantages or individual industrial-location decisions.

Leonard examined US Department of Commerce data on direct investment of US companies overseas in the late 1970s and early 1980s. He found that the mineral-processing industry's share of total US foreign direct investment did rise by a few points and that the portion of investment directed to developing countries also grew slightly, particularly during the early 1980s. An important portion of that investment went to Brazil and Mexico. The pattern is somewhat similar but more pronounced for the percentages of total capital expenditures going to LDCs. Leonard (1988) concluded that "stricter American environmental regulations have contributed to the international dispersion of some basic mineral-processing industries, such as copper, zinc and lead processing." Nevertheless, he added, "this trend is enhanced by other factors, such as the changing availability of raw materials, other nations' requirements that minerals be processed in the country where they are mined, and various economic factors including low prices, high interest rates, and recessions."

In the copper-smelting industry, only one greenfield project and some expansions were initiated during the 1970s and 1980s, but the situation now looks brighter. Plans for the 1990s include the expansion of the Cyprus smelter by 50% and the construction of a new smelter in Texas by Mitsubishi. Although environmental costs have affected the US industry, the location of the Mitsubishi smelter indicates that other factors have a more important influence on an investment decision. Mitsubishi is also involved in the biggest copper-mining project of the 1990s, La Escondida in Chile, but that project does not include smelting capacity.

Generally, as copper prices recovered, US production levels increased substantially. New projects are developing, which confirms that, overall, market conditions are still the main driving force. The improved market conditions will allow a better assessment of the impact of environmental regulations. Environmental regulations are the cause of cost differentials, but general wisdom and interviews with mining companies indicate that market considerations, the quality of the ore deposits, and long-term stability mostly guide their investment decisions.

Trends in policy-making and waste mining

The design, implementation, and results of a certain policy depend on more than economic factors: political and institutional considerations also come into play.

The setting for environmental policy in mining involves the role of mining in the US economy and, equally important, in the regional economy. A little bit of history and a look at recent structural changes help to explain the attitude of the industry, its involvement in the policy-making process, and its power of negotiation. Other elements are the structure of the industry and features of the international markets.

The reaction of the industry

Complaints were registered by the industry about the competitiveness of the eight plants closed in 1985; four had introduced technologies to control air pollution. White Pine was among those that reopened. So was Garfield, after a big modernization program that placed the plant among the lowest copper producers. Ray (Kennecott) and Ajo (Phelps Dodge) were closed for other reasons. McGill (Kennecott), despite having no pollution-control equipment, was not violating the EPA's National Ambient Air Quality Standards (NAAQS), according to the General Accounting Office (GAO 1986). According to Sousa (1981), it was. Although Kennecott rebuilt the reverberatory furnace, more stringent standards were introduced and it had to operate with NSOs. It was uneconomical to build a sulfuric acid recovery plant, and in 1981 it was evident that the plant was going to close (GAO 1986).

Of the plants that closed later, Tennessee Chemical apparently was in compliance; Douglas was not, and although it requested a second NSO, it looked like it was only a matter of time before it had to close (Rieber 1986):

> The closure of the Douglas smelter by 2 January 1988 is virtually assured, with or without a binational agreement. Given the plant layout, the age and type of furnaces, the projected state of the US copper market and the problem and costs of acid sale or disposal, Phelps Dodge will not build an acid plant. Given the first three factors alone, it is very doubtful that, even if an acid plant were emplaced, SO_2 capture would meet NSPS. Although its present smelter operating profits are favorable vis-à-vis other US smelters, this antiquated facility could not bear the financial burden of new equipment and APC [air-pollution control] in the existing plant.

As Sousa (1981) reminds us, it was uneconomical to built a sulfuric acid plant.

Morenci, the principal violator of NAAQS in Arizona, had already paid 682 500 USD in fines before it closed. Ajo and Hayden were also contributing and paid 25 000 and 52 500 USD, respectively. Phelps Dodge was planning to invest 195 million USD in its Morenci and Ajo operations and was negotiating with EPA in 1981. Ray was supposed to be redesigned to achieve 90% control in 1983. According to Sousa (1981), however, White Pine – Copper Range Company processed copper concentrates with a low sulfur content and was in compliance with the standards.

At first, the reaction of the industry was to resist the new regulations and to delay compliance. Citing considerations like a heavy financial burden, higher operational costs, and a lack of proven technology, they sought relief. To support their arguments with numbers, they hired various consulting firms to study the situation. They did achieve section 119 of the 1977 amendments.

The copper industry was not the only one having problems with compliance. A common feature of environmental policy-making has been the underestimation of the costs of compliance and, generally speaking, an overestimation of the technological capabilities of the industry. The 1977 amendments recognized how unrealistic the original deadlines were. "Despite the high cost and technical uncertainties implied in replacing all reverberatory furnaces by other smelting processes, according to the Arthur D. Little report economic considerations were absent in the establishment of NAAQS" (Sousa 1981).

But the copper industry got more than just a new deadline — it also got the NSO, a mechanism that was not available to all industries. In part, Congress seems to have considered the risk of closures and shutdowns resulting from a depressed copper market (GAO 1986). Even with the NSO, however, the industry was still having trouble complying with the NAAQS, and those companies not in compliance in 1977 did little to improve this situation. All of the nonferrous smelters requesting NSOs were copper smelters. Three of the four that obtained NSOs applied for a second period; the fourth simply went out of business.

The Division of Stationary Source Enforcement (DSSE) reported in 1978 that almost 50% of the 27 nonferrous smelters were operating in violation of the regulations governing SO_2 emissions. In contrast, by the end of 1979, "only 6.2% of the major air pollution facilities identified by the EPA were not in compliance with regulations." In 1980, DSSE reported litigation over the State Implementation Plans (SIPs) of Arizona, Utah, and Nevada. In the meantime, one smelter closed, and "the closing of this smelter has resulted in the only change in the compliance situation."

It is interesting to notice that more than half of the reduction in violations in 1977–86 was achieved by the closure of some smelters in 1984 and 1985. This is not surprising if we consider that only Douglas was releasing around 300 000 t of SO_2 a year. The report of the State of Arizona indicated that in 1984, the copper smelting industry incurred only one-third of the total cost of compliance.

The strategy of the states in developing their SIPs and enforcing compliance with the NAAQS depended to some extent on the industry's importance to the regional economy. Their approach was generally to negotiate first and to use court orders as a last resort; this was in part because of the huge legal expenses and time involved.

A comment on recycling

Arizona has had the highest levels of SO_2 emissions from copper smelters and the highest number of NAAQS violations (GAO 1986), partly because this state has more than 50% of the US smelting capacity and partly because its copper smelters have had more problems with compliance. Of the seven smelters operating in the 1970s, four have since shut down. This may have been one of the reasons Arizona's SIP approval took so long (Rieber 1986). Some sources indicated that other factors contributed to the plant closures. Sousa (1981) recorded that

> while US copper firms have relied largely on mining technology to maintain their competitive position in the world copper market, smelting technology in this country has not progressed at the same rate. Continued reliance on scale economies to reduce costs will likely yield diminishing returns.

To some extent, productivity growth did decrease because of the diminishing returns on the use of economies of scale (CRS 1984), not only in the smelter and refinery but also at the extractive level.

Innovation in the mining industry is likewise a difficult subject: recent studies found that only 10% of both federal and private investment in nonfuel-materials research and development (R&D) deals with minerals supply; the remaining 90% is directed to materials utilization. The studies also found that industry invests about four to five times as much as the federal government on R&D related to nonfuel-materials supply. However, the R&D intensity of nonferrous metals industries is well below average.

Transboundary issues

The control of SO_2 emissions has had another kind of international dimension: SO_2 particles can travel many miles and generate acid rain — either wet or dry — far from the original source of the emissions. Consequently, flows of SO_2 emissions into and out of the United States have created conflicts with Canada and Mexico. But the flow to Canada is estimated to be more than double that from Canada. US SO_2 emissions appear to cause pollution problems in southeastern Canada. Most of these emissions come from power utilities and industries in the northeastern states. The main sources of Canadian SO_2 emissions are the nonferrous smelters in southeastern Canada.

Canada has been complaining for a long time about the problem, but in the 1980s, US policy and resources were focused mostly on studying it. Several meetings and special commissions were set up to study the issues, without specific outcomes. With the 1990 CAA amendments, however, the United States began to specifically address the problem.

There were several reasons for the delay. Most important were the economic impact and the equity issue for US power utilities and coal producers. Copper smelters played a secondary role because they were not the main offenders and the controls already in place made them a minor source of the problem at a national level. The US interest in a free-trade agreement with Canada may have been a major factor in the Bush administration's strong support for the initiative.

Similar problems have plagued the relationship between the United States and Mexico, although apparently these are not as salient as the US–Canada border issues. For a description of the transboundary issues in US–Mexico relations and the agreement to limit SO_2 emissions from the "Gray triangle," see Rieber (1986).

New trends in policy-making and mining-waste disposal

Environmental problems are complex and evolve with time and the social and economic contexts. Moreover, adjustments and sometimes major modifications in the system have to be made because of the relative lack of previous experience.

New knowledge about the health and environmental impacts of economic activities has stimulated policymakers to modify existing standards or create new ones. In the 1990s, the focus has been shifting to regional and global environmental problems, such as acid rain, ozone depletion, and global warming. Small and nonpoint pollution sources will become the targets of future efforts as the major polluting industries and firms are brought under control.

The approach to old and new problems will tend to be more integral, involving multimedia. Major efforts will be made to better prioritize environmental problems and to concentrate available resources on those issues with higher risks to human health and the environment.

Policymakers will be under greater pressures to change the policy mechanisms for dealing with environmental problems. Different sides are seriously criticizing command-and-control regulations because it is doubtful that such regulations will help achieve environmental goals in the long term. The increasing marginal costs of pollution abatement, the US industry's competitiveness problems, and the need to reactivate economic growth have made it urgent to improve the cost-effectiveness of the system. The trend is toward market incentives, with emission or effluent charges or pollution permits in some but not all areas.

All these changes will require institutional adjustments. Bureaucratic inertia may be one of the major obstacles in the way of greater efficacy and efficiency. Multimedia approaches will challenge the compartmentalized structure of the EPA. But the tension between decentralization and consistency and coherence — not to mention the loss of power — is another issue.

There is also a need to modify the public's perception. More and better information, improved communication channels, and new ways to involve the community are crucial to efforts to implement new policy concepts. A better understanding of the real risks and the trade-offs of environmental protection is fundamental to creating the necessary Congressional support. Participation will certainly be needed as the abatement efforts shift to small and nonpoint sources.

This section discusses some of the major changes affecting environmental policy-making, particularly in the case of mining-waste-disposal regulations. Recent proposals have introduced some of the new policy concepts, and it may be worthwhile for the reader to appreciate possible obstacles in the way of modernization.

Multimedia approach

At the beginning of the environmental era, the tendency was to react to the most pressing problems and the issues on the front pages of newspapers. Consequently, the approach was partial and had a media focus.

The main concerns in the early 1970s were air and water pollution — the most visible problems — so the first laws to be amended were the CAA, in 1970, and the *Clean Water Act* (CWA), in 1972. As the problems of air and water pollution were to some extent being resolved, new problems appeared, either because they had been overshadowed by previous emergencies, because new technological developments had created new problems, or simply because the media approach just shifted problems from one medium to another.

This partial vision had a strong influence on EPA's organizational structure, undermining its capacity to take a more integral perspective on environmental problems. The principal divisions of EPA were created following Congressional activity and reinforced the legislative pattern and fragmentary nature of US environmental policy (for example, see SAB 1990; Portney 1991). EPA's compartmentalized structure also created coordination problems, as well as inconsistency. Lastly, individual firms faced cumbersome and lengthy permitting processes.

These problems were already apparent in the early 1980s. The EPA (1984) noted that coordination problems often led to the duplication of research, inconsistent risk assessments for the same substance, the transfer of pollutants from one medium to another, and the uncoordinated regulation of the same industry by different programs. More recently, William Reilly, the new administrator of the EPA, stressed the shortcomings of the then current approach, particularly its negative impact on pollution prevention (Reilly 1989). EPA supported the Conservation Foundation's New Environmental Policy Project. The model developed by the Conservation Foundation requires the consideration of the environment as a whole in all decisions, a single-permit system, and the standardization of regulatory procedures (Irwin 1989).

Nevertheless, the change to a multimedia approach faced several obstacles, ranging from bureaucratic resistance to Congressional reluctance to award more authority and discretion to EPA. Industry was also concerned, fearing that changes in the status quo would bring new problems and necessitate new controls, with new costs.

Another consequence of a partial view was that it made it difficult to prioritize environmental problems and allocate resources to problems with higher health and environmental risks.

Risk assessment and prioritization

The objective of the Comparative Risk Project, developed in 1986, aimed to establish the risks currently posed by major environmental problems, given existing levels of control (EPA 1987). The study distinguished cancer and noncancer health risks and ecological and welfare effects and broke new ground.

The study's conclusions, based on the "informed judgement" of experts, were somewhat disturbing (EPA 1987). The ranking rather mismatched EPA's priorities, although the latter coincided with public opinion, reflecting the source of Congressional action. The best example of a discrepancy was the CERCLA program. According to the study, the risks associated with hazardous-waste disposal were rated very poorly. But Congress had reacted quickly and appropriated billions of dollars for the program's implementation.

The scientific basis for this first comprehensive attempt to assess the real risks was not as solid as one might have wanted. However, there was no doubt that the project was important, as the Science Advisory Board pointed out (SAB 1990). The report, in identifying the most significant risks, was an important step toward better allocation of limited resources.

EPA had used risk assessments on previous occasions when designing regulations. It had also used site-specific risk assessments when developing the National Priority List of CERCLA (Russell and Gruber 1987). But this was the first time that the concept had been used in a comprehensive way.

Risk assessment could be used to tailor standards and controls to local conditions and actual risks, improving the efficiency of the system (Tietenberg 1988). In addition, risk assessment provides a scientific foundation for identifying the social benefits of pollution abatement. One of EPA's goals is to impose requirements only where the benefits of regulation would outweigh the costs. However, it has proven difficult to design regulations that both meet this standard and are enforceable (EPA 1990). The second-best alternative is the use of cost-effective mechanisms, and this means an increasing reliance on market incentives.

Market incentives

The use of market incentives to internalize environmental costs of private decisions and reduce excessive pollution-abatement expenditures is getting increasing political support. The idea is not new. Economists have long been suggesting the use of taxes and marketable permits.

The Emissions Trading Program was the first attempt to introduce more flexibility into the ways environmental goals could be met. Concerned with the impact of future growth in nonattainment, Congress introduced this limited version of a marketable-permits system in the 1977 CAA amendments. The system awards emission-reduction credits to firms that reduce their level of emissions beyond those stipulated in the regulations. The firm can bank the credits and use them in the future for the same plant, or it can trade them to another company (Tietenberg 1988; Hahn 1989; Liroff 1989).

Nevertheless, not until the late 1980s did the concepts of market incentives and pollution permits find their way to Congress and the White House. The inclusion of a pollution-permit system in the 1990 CAA amendments was a landmark. Other market incentives have been proposed, including some to control CO_2 emissions to mitigate the greenhouse effect. Market incentives include the removal of barriers that prevent markets from working effectively and the elimination of government subsidies that stimulate the excessive use of natural resources.

Several economic and political factors explain why Congress and the White House endorsed the use of market incentives for environmental protection (Hahn and Stavins 1991). The economic recession of the early 1980s and the general slowdown of the economy had increased the marginal costs of pollution abatement. Easy targets had already been controlled; the next step would be to control the small and nonpoint pollution sources, which tend to present more complex problems. The technology for additional reductions of emissions and discharges implied higher abatement costs. Further economic growth also posed a challenge. Concerns about the international competitiveness of the US industry and the economy's capacity to absorb additional environmental costs motivated the search for more cost-effective mechanisms.

An important political factor influencing the use of market-based instruments during the Bush administration is that this kind of scheme fit well with the goals of the Republican administration. With the introduction of market incentives, the Bush administration was able to fulfil its commitment to environmental protection without intervening further in the economy and without imposing overwhelming costs on the industry or on the fiscal budget.

The introduction of market incentives was facilitated by the environmental movement's willingness to use economic tools in the search for better environmental quality. The Environmental Defense Fund, the Wilderness Society, and other well-known environmental groups have successfully used cost–benefit analyses to support their cause (see, for example, Stavins 1983, 1987; Goerold

1987). Their philosophy regarding the use of market incentives is pragmatic: if it works to protect the environment, let's do that. Nevertheless, the environmentalists are cautious, especially when economics is applied to more basic principles.

But the industry has not shown the interest one might have expected. It tends to be more conservative and to fear new rules for a game it already knows how to play. Administrative uncertainty and unexpected additional costs are at the root of that fear.

Although some analysts say it is premature to anticipate a massive use of market incentives, there is certainly a trend (Stavins 1991). In any case, there is consensus that the use of market incentives has to complement, not be a substitute for, the old system.

Institutional challenge

Institutional change is required if these concepts are to be incorporated into regulatory programs. The structure of EPA, its composition of human resources, and its budget need to reflect a higher degree of integration and a stronger role for economics. More administrative discretion may also be needed. This brings up a complementary subject: decentralization.

If a lack of flexibility stands in the way of more cost-effective ways of attaining environmental goals, a higher degree of decentralization will be needed. This will only work if state authorities have the commitment and resources to formulate their own programs and to monitor compliance. Theoretically, state authorities are in a better position to understand the specific problems and risks in their regions (at least, they are in a better position than Washington) and can tailor regulatory programs to the preferences of local communities and their willingness to pay for a cleaner environment. State authorities are also in a better position to monitor compliance and enforce regulations.

However, public-interest groups fear that giving greater discretionary powers to state authorities may mean a dirtier environment. The possible political alliances between local politicians and industry and the need to foster regional economic development may lead local authorities to soften regulations and standards, as well as enforcement.

Although the industry may benefit from this trend, it may also fear an excessively disparate regulatory system. This may be especially true of companies with plants in more than one state. Uniform regulatory programs are more expensive in terms of compliance but reduce administrative costs and uncertainty.

Finally, for certain problems, federal authorities cannot be replaced. These include interstate acid rain and water pollution and global problems. In some areas, important economies of scale and the need for a critical mass call for a stronger federal role, as in R&D activities or in the development of information systems.

RCRA amendments and mining-waste disposal

With the Bevill Amendment of 1980, mining wastes and certain mineral-processing wastes were temporarily exempted from RCRA regulations. The exemption was granted by Congress until EPA finished a study to determine whether these wastes should be classified as hazardous or nonhazardous. In 1985, EPA submitted the results of this study to Congress and, in 1986, published a regulatory determination on extraction and beneficiation wastes from mining. The principal conclusion of the study was that mining wastes should not be regulated as hazardous under Subtitle C of RCRA as originally proposed. Instead, EPA suggested a "tailored" approach for mining and beneficiation wastes under Subtitle D (nonhazardous wastes).

Since then EPA has worked intensely to produce draft regulations addressing concerns about the generation and regulation of mining wastes. The products, Strawman I and Strawman II, have been discussed by a variety of stakeholders: industry, environmental groups, the states, and federal agencies. The Policy Dialogue Committee (PDC), created in 1991, was the last chapter of this EPA effort. EPA intended to bring all interest groups to a public forum and eventually generate some agreements.

The reauthorization of the RCRA by Congress — which was to make a final decision on the legislative framework for handling these wastes and municipal and household wastes as well — was expected to take place in 1991/92. Although it was too early to predict the outcome of the EPA effort at the time of writing, some interesting aspects deserve attention: the unusual rule-making process itself; and the concepts in the regulatory proposals.

The most interesting feature of this process is the involvement of diverse interest groups in preparing and discussing the EPA draft regulations *before* Congress made its decision. Usually, public involvement takes place at three different stages in the legislative and regulatory process. First, the public has a chance to lobby and to bring expert witnesses once a statute has been introduced for Congressional discussion. Second, after Congress adopts a statute, EPA prepares and proposes the corresponding regulations to implement the statute; here the public may intervene by commenting on the proposed regulations. Third, after the regulations come into force, the public always has a chance to challenge in court the ways the law is implemented and enforced.

In the case of the RCRA amendments, though, instead of waiting for Congress, EPA took the initiative and started an informal rule-making process that had no precedent. This gave EPA the time and flexibility to involve the interest groups in the process. Moreover, the PDC gave these groups a chance to dialogue and interact. The groups may still consider each other as adversaries, but the communication flow — usually from each group to EPA — became multidirectional. This EPA initiative may have set an important precedent by making environmental policy-making in the United States less confrontational. This in turn might facilitate the implementation of regulations, reducing the legal and administrative costs and speeding up the whole process.

The concepts in the regulatory proposals included the use of a decentralized regulatory system, relying to an important extent on state-formulated programs; the development of programs on the basis of the real risks posed by mining wastes, instead of their potential risks; the use of site-specific controls; and the adoption of a multimedia approach, also a departure from the usual way of doing environmental policy in the United States.

Most of these concepts were present in the original formulation of RCRA regulations and are consistent with the new trends in environmental policy. Although the amendments contain no categorical statements, one may wonder whether they would have found their way into the regulatory language in the 1970s as easily as in the 1980s. The application of these concepts to mining-waste disposal has brought new light to them, particularly concerning the tensions and possible trade-offs of more cost-effective programs. Therefore, the experience may prove interesting.

In the 1990s, waste disposal will most probably be the main domestic issue on the US environmental agenda. For the mining industry, the reauthorization of RCRA and the approval of mining-waste regulations will be the next big regulatory step.

The problem

Around 4 or 5 $\times$ 10^9 t of waste is generated in the United States annually. An estimated 40% of this is from mining operations, including development, tailings, and leaching (Stone 1989). The other big waste generator is agriculture, contributing about 50% of the total.

Of the roughly 1 $\times$ 10^9 t of wastes produced by metals mining operations, 44% comes from the development stage; 33%, from tailings; and 23%, from leaching. Of the total, more than 50% comes from copper production (MacDonnell 1988). This is not surprising if we consider that more than 99% of the ore extracted is waste. Consequently, the copper-mining industry will probably be the most affected by the new regulations for mining-waste disposal.

Although these figures are impressive, the real risk posed by mining wastes is less thrilling. According to RCRA criteria, less than 25% of the ~250 × 10^6 t of hazardous wastes annually produced in the United States comes from mining and beneficiation. In the copper industry, most of the hazardous wastes (82%) come from copper-dump leaching operations.

Mining ranks second in the list of big generators of hazardous wastes. According to figures from the Congressional Budget Office (cited in Dower 1991), 48% of US hazardous wastes are generated by the production of chemical and allied products, and 18% are produced in the primary metals industry. Petroleum and coal products generate another 12%.

Although mining wastes pose some degree of environmental risk, particularly to groundwater, they differ from other industrial hazardous wastes, as well as from municipal and household nonhazardous mining wastes. Mining wastes

- Come in higher volumes, especially compared with the volume of the associated products;
- Cover large area;
- Are disposed of at the site where they are generated, thus involving no transportation of hazardous substances;
- Are usually disposed of in dry and sparsely populated areas;
- Consist, to an important extent, of unprocessed waste; and
- Pose lower risks.

History of RCRA and mining-waste-disposal regulations

RCRA was formed in 1976 in response to public alarm over hazardous-waste sites. RCRA combined two previously existing regulations, the *Solid Waste Disposal Act* and the *Resource Recovery Act*, and was intended to provide the EPA with the authority to regulate, control, and monitor hazardous substances. Two years later, in 1978, EPA proposed rules for hazardous-waste management under Subtitle C, creating a special-waste category to include mineral-industry wastes. EPA's intention was to give some flexibility to the industry in the treatment of these wastes, given their special nature (Kimball and Moellenberg 1990).

Nevertheless, in the regulatory document that EPA submitted to Congress in 1980, mining wastes were practically subject to the same requirements as those affecting industrial hazardous wastes, with the exceptions only of overburden used for reclamation purposes and *in situ* mining wastes. EPA also proposed to list several mining-processing wastes to be regulated as hazardous wastes under the same Subtitle C.

Congress, aware of the particular characteristics of mining wastes and concerned about imposing unnecessary costs on the industry, prohibited EPA from applying hazardous-waste regulations to solid wastes from extraction, beneficiation, and processing of ores and minerals until the completion of the detailed studies of these wastes. This was the so-called Bevill Amendment, introduced in the *Solid Waste Disposal Act* amendments of 1980. The deadline for the studies was 1983. As a consequence, except for those hazardous wastes not deemed unique to the mining industry (that is, chemical substances), mining and processing wastes were temporarily exempted from RCRA regulations. At most they were subject to state regulations.

In 1984 several environmental groups sued EPA for failing to meet the deadline (*Concerned Citizens of Adamstown* v. *EPA*). They also challenged the inclusion of mineral-processing wastes in the Bevill Amendment. In response, EPA scheduled the completion of the studies and limited the number of mineral-processing wastes to be exempted.

In December 1985, EPA submitted the study to Congress. The report concluded that regulation of mining and beneficiation wastes under Subtitle C of RCRA was unwarranted. However, acknowledging some potential risks, EPA decided to develop a program under Subtitle D (nonhazardous wastes).

Given the original objective of Subtitle D — to regulate municipal- and household-wastes disposal under state supervision — EPA suggested a special program tailored to mining wastes. EPA was concerned about the need to take into account the fact that the risk varied from site to site, depending on the characteristics of the particular mining wastes and on local environmental factors, such as climate, geology, hydrology, and soil chemistry. Consequently, EPA proposed a flexible, site-specific, risk-based program (Housman and Walline 1990).

Another EPA concern was that the responsibility for administering Subtitle D of RCRA had been left to the states. EPA suggested a stronger role for federal authorities to ensure human health and environmental protection.

The 1986 report failed to address the issue of mineral-processing wastes from either abandoned or inactive mine sites. A decision was made in May 1991 regarding the 20 mineral-processing wastes subject to the exclusion, following a 1988 court order that restricted the interpretation. Eighteen were kept under Subtitle D. The other two were made subject to Subtitle C, CERCLA, and the *Toxic*

Substances Control Act. The mineral-processing wastes removed from the exemption and those never listed are subject to Subtitle C if they have hazardous-waste characteristics. If not, they may be regulated under the new program under Subtitle D.

Since 1986 EPA has been working to develop a regulatory program through its Office of Solid Waste (OSW) and Region VIII (its regional counterpart). The same year as EPA released its report, it established a Mining Waste Regulatory Development Workgroup, with members representing EPA offices and federal agencies. This workgroup acted as an advisory group for the OSW.

In 1987, EPA established an External Communications Committee, consisting again of representatives from EPA and other federal agencies. Its role was to foster communication among all interested parties, including state agencies, industry, and public-interest groups.

In 1988, EPA released Strawman I, a set of draft regulations developed jointly by the OSW and Region VIII. Understood to be a working paper, Strawman I was to serve as a starting point for discussion. After receiving written and oral comments from the interest groups, the OSW and Region VIII prepared a second version, Strawman II, published in 1990.

In 1991, EPA officially created the PDC to bring all interested parties together to exchange points of view. Each group — whether state, federal, industrial, or environmental — has seven representatives on the PDC. The Keystone Center has acted as an independent facilitator for the meetings. The PDC meets every 6 weeks, and the meetings and their minutes are open to the public.

Group involvement and the PDC

Environmental policy-making in the United States has been extremely confrontational. In part, this is a consequence of US political culture and the common use of the judiciary system to solve disputes. Thus, EPA's efforts to involve interested parties from the very beginning and to reach some degree of consensus are especially interesting.

Usually, EPA prepares draft regulations after Congress enacts a piece of legislation. In this case, the OSW suspected that the reauthorization of RCRA — which would have triggered the normal process — would take some years. So, the OSW took the initiative to obtain inputs from all the interested parties right from the beginning. The OSW's objective was to create a regulatory program that all parties could live with.

The OSW had another purpose in mind. Under conventional circumstances, EPA cannot influence Congressional decisions, as other players might, by lobbying. Congressional and White House approval of a bill is a very political process.

The creation of the PDC gave EPA an alternative for influencing decision-making at the approval stage. The spotlight on the issues and the interaction with the other interest groups gave EPA better access to the political scene.

To avoid bureaucratic deadlock, EPA opted for an informal process that would not require the endorsement of high management levels. The first step was Strawman I, a first draft prepared by the OSW and Region VIII in 6 weeks. The purpose of the document was not to deliver EPA's final word on mining wastes but to stimulate discussion.

As part of the effort to encourage the public to participate, EPA gave financial support to a number of groups in 1988 to analyze the problem and respond to Strawman I. With this funding, the Western Governors Association (WGA) formed a mining-waste task force; 21 states participated (Housman and Walline 1990). Also participating was Colorado Trout Unlimited, formed in 1990 by several prominent environmental groups, such as the Environmental Defense Fund and the Mineral Policy Center. Finally, EPA also supported an association of small-scale miners, the Northwestern Mining Association. The American Mining Congress represented medium- and large-scale mining companies in the discussion.

This support — as well as the focus of Strawman I on practical issues, rather than on regulatory principles — stimulated and facilitated the participation of the groups. Thanks to this approach, EPA received input from the industry, environmental groups, federal agencies (such as the USBM), and the states (under the umbrella of WGA). Public hearings were held, as well as informal meetings, and USBM, WGA, and the American Mining Congress prepared written comments. Informal channels between EPA and other parties were also used.

After 2 years of discussion and work, EPA published Strawman II, a review of Strawman I that incorporated oral and written comments received. It was closer to a final draft, but EPA still invited discussion. As usual, environmental groups charged EPA with being too lenient, and the industry complained about the rigidity of Strawman II — according to the industry, it was closer than Strawman I to Subtitle C. In this second round of discussions, the OSW realized that an important part of the problem was the lack of understanding each group had of the other parties' concerns and that each one's strategy was basically to recover lost ground.

To overcome this impasse, the OSW proposed to the EPA Deputy Administrator that the PDC be set up under the terms of the *Federal Advisory Committee Act* (FACA). The purpose of FACA is to sanction external advice given to governmental agencies and to prevent unnoticed outside influence. FACA had been used before, most often to form regulatory-negotiation committees. These committees had to be established by statute, and the participants had to agree to waive their right to sue each other over the agreements achieved. In this case, there was no statute and the OSW preferred to avoid pressuring the groups to make final agreements. The alternative was to form the PDC, which would have none of these requirements. The Deputy Administrator of EPA approved the OSW proposal and the PDC constitution in April 1991 (EPA 1991).

The PDC gives a great degree of freedom to both the OSW and the groups. The agreements of the PDC do not require the support of EPA's Administrator, and the groups are not forced to reach agreements that compromise their future actions. With the PDC, direct compromise and some consensus are possible. An agreement is a powerful signal to Congress, although such an agreement has no resolutory status.

It is too early to comment on the success of the PDC, but all the groups agreed that participating on the PDC improved their understanding of each other's concerns. Certainly, this was one of EPA's main objectives in setting up the group. The PDC has also focused the debate on specific issues and provided an equal standing to the different parties in the discussion.

The groups seemed less optimistic when asked about possible agreements. At the time of writing it looked like the positions of state and federal agencies and the industry were getting closer, whereas the environmental groups were lagging behind. Several factors may explain, in part, the difficulties in reaching some consensus. For one thing, unlike members of a regulatory-negotiation committee, these players had no real authority to make decisions. If the PDC members are able to reach some agreements, Congress may take these into consideration but only as advice. This feature theoretically increases the freedom of the players, but it diminishes their confidence in the PDC's ability to influence policy decisions. I say "theoretically increases the freedom of the players," because the use of a public forum puts different groups in the spotlight — especially environmental and industry groups — and forces them to emphasize principles over concrete issues. Extreme positions tend to be favoured over pragmatic compromises because of the fear of diluting the message in an attempt to find intermediate positions.

Some participants expressed their apprehension about the Keystone Center's role as facilitator. They did not consider the Keystone Center a truly impartial facilitator, as it has a contract with EPA and has to follow its guidelines.

The size of the group does not facilitate interaction among the different parties. This obstacle may be overcome to some extent through the recent creation of subcommittees to discuss specific issues.

Informal pre-meetings of some of the PDC members have reinforced the natural distrust between the groups — the groups that did not attend fear the development of covert agreements.

The problem is too broad, involving too many fundamental issues. Too much is at stake for each group. Although the advisory character of the PDC diminishes the pressure to some extent, the groups still feel that agreements will entail important public compromises and set possible precedents.

The PDC has probably brought the two extremes of environmental controversy to the table. The gap between the industry and the environmental groups appears very wide, which is partly a consequence of powerful images built up in the past. The mining industry looks at environmental groups as if they were concerned only with birds and bunnies, and environmental groups consider mining the most backward industry in terms of environmental responsibility. Each group recognizes that there is a broad spectrum on each side, and it is not clear what the position of the representatives in that spectrum is.

The reauthorization of RCRA by Congress has stimulated parallel lobbying. The different groups are aware of this phenomenon, reinforcing their lack of confidence in the PDC's ability to produce concrete outcomes.

Finally, the PDC was established after 3 years of discussion of the issues, and some participants feel frustrated because the PDC is bringing the discussion to the starting point again.

Some of the obstacles mentioned by the interviewees may be overcome in the future with a different design for the PDC and its meetings or with better timing. Other obstacles may require more substantial efforts, as distrust appears to be an important component. However, this kind of initiative may be extremely useful, regardless of whether it achieves more tangible outcomes.

The issues under discussion

Several issues were under discussion in the Strawman I and Strawman II periods, as well as during PDC meetings. In the following pages, I examine the most controversial issues, particularly those related to the new trends in environmental policy-making. They are discussed separately, although all are strongly related.

STATE VERSUS FEDERAL AUTHORITY — The distribution of power between federal and state agencies is probably one of the main issues. To an important extent, this is the institutional counterpart of uniform versus site-specific regulations. The state authorities are better prepared to evaluate the specific environmental impact of a mining site. They have first-hand knowledge of the conditions in which the companies work — both the operational characteristics and the environmental setting.

Many states already have programs to ensure adequate management of mining and minerals-processing solid wastes. These programs cover aspects like groundwater, land reclamation, dam safety, and financial assurance (Housman and Walline 1990). These programs vary from state to state, according to variations in climate, geology, and environmental sensitivity of the impacted areas (Stone 1989). It seems inefficient to disrupt existing programs.

Various EPA documents have recognized the important role that the states play in formulating and enforcing specific regulations. EPA is interested in maintaining its flexibility. It wants its programs to be compatible with state programs, and it wants to give the states a leading role in developing, overseeing, and enforcing their own mining-waste-management plans (Housman 1990).

EPA is still responsible for protecting human health and the environment. If a state has not developed a special program or does not meet minimum federal criteria, EPA needs the authority to go beyond the general guidance and assistance guaranteed under Subtitle D.

The industry, USBM, and WGA support a stronger role for the states in the design and implementation of programs. The industry and USBM believe that state agencies are better acquainted with mining specificities. Mining activities are highly concentrated in a few states, and those states have ample experience dealing with the mining industry. The industry also wants to see a better delineation of authority to avoid "having to serve two masters." States want to maintain their current programs and their authority.

Environmental groups fear that too much discretion on the part of the states will result in insufficient environmental protection. They want to see a stronger role for EPA. Their arguments are diverse. They fear that state authorities may be influenced by industry to set softer standards and loosen monitoring and enforcement programs, especially in states where mining is an important source of income. Although a state may be genuinely committed to an environmental program, it may not have the necessary resources and capacity to establish and enforce this kind of program.

EPA has proposed that plans be approved by EPA. Once the plans are approved, EPA's regional offices would have oversight and enforcement authority in the states, and EPA would issue and enforce permits in nonapproved states. EPA also suggested that it would intervene whenever human health or the environment is at especially high risk.

The conflict between EPA and the supporters of greater state discretionary power is really about some ambiguities in EPA proposals, especially in those paragraphs giving EPA authority over state programs in special circumstances. "EPA could usurp regulatory authority from the states at any time" (Kimball and Moellenberg 1990; USDI and USDA 1990).

FLEXIBILITY AND UNIFORMITY — Tailoring a program to site specifics is an important departure from traditional regulatory programs. EPA recognizes that the benefits of environmental protection (or the damages of no protection) depend on the specific environmental conditions. Instead of trying to apply an across-the-board regulatory program, EPA is attempting to design a program on the basis of the real risk posed by mining wastes, getting closer to the ideal scheme. EPA is also putting more emphasis on balancing those benefits with the costs imposed on the industry.

These concepts were in EPA's draft regulations and helped EPA gain Congressional approval for the Bevill Amendment. Although EPA's language insists on the idea of flexibility, EPA bases its proposed standards on ongoing regulatory programs and considers design and operating criteria that run counter to the original spirit of flexibility.

EPA's groundwater standards are designed to match the maximum contaminant levels of state programs established under the *Safe Drinking Water Act.* If these data are unavailable, a health-based risk-assessment standard is used. If neither of these standards is available, background levels become the criteria.

The industry considers the performance standards of Strawman II to be inflexible and even more stringent than those of Strawman I and closer to those of Subtitle C. USBM and the industry want to restrict EPA's role to that of providing technical guidelines — they do not want EPA to impose specific technologies.

On the opposite side, environmental groups consider flexibility risky; they want national minimum-performance standards. They argue that flexibility and state discretion imperil environmental protection because it may become a source of competitive advantage for the states. A flexible program is also more difficult to monitor and enforce because it requires higher administrative capacities and more resources. The environmentalists want to see a prescriptive and detailed program.

This partly explains why environmentalists want a statute provision allowing citizens to sue companies with unsound environmental practices. Without this provision, severe environmental damage has to occur before citizens can sue a company.

MULTIMEDIA APPROACH — The multimedia approach is another shift from the traditional approach. Although mining is already subject to several environmental regulations, including those of state programs that deal with mining-waste disposal, EPA is concerned about some remaining gaps (Housman 1990).

EPA wants RCRA amendments to cover the whole spectrum of mining-related environmental problems. A multimedia approach would also have administrative advantages: for example it would avoid duplication and conflicts between different regulations, reduce the administrative burden, identify possible disincentives, and give regulators a better picture of what is going on. EPA proposed the idea of a one-permit system incorporating all current regulations plus new ones. The states are expected to design a multimedia approach that addresses air, water, and soil contamination and incorporates existing permit requirements such as those required by the CAA (Housman 1990).

EPA wants to extend the scope of the regulatory program to include exploration wastes and materials that are not necessarily waste, such as those related to heap-leaching operations and abandoned mines. If active leaching piles — considered operating units, not waste — are left unregulated, companies might extend the life of these piles simply to avoid the cost of regulatory closure. The exclusion of abandoned mines from this program might provide a disincentive for recycling and, in general, the disincentive for a more effective cleanup of hazardous sites (Peterson n.d.). EPA intended to include incentives to mine mining wastes wherever there may be a net gain for both the environment and the company. EPA is aware that because of the present structure of CERCLA, the development of incentives will require streamlining of the regulatory process and revision of current operating and performance standards (Housman 1990). Environmental groups welcome the multimedia approach because it reduces the possibilities of gaps and of shifting the problem from one area to other.

However, the industry definitely opposes a multimedia approach. Although it makes sense for the industry to resist new standards and controls, the industry also opposes a one-permit system, a system that would reduce administrative costs. The industry argues that changing the system will introduce uncertainty and that the net costs of the change are unclear. The industry prefers keeping a system that, if not perfect, is better known and will bring no additional surprises.

USBM and the states are in a mixed position. USBM wants a single regulatory program for all wastes, including processing wastes, to reduce the administrative burden and increase consistency. USBM also emphasizes that re-mining of old mining-waste sites and impoundments and recycling of materials to reduce hazardous waste should be encouraged. But USBM opposes the one-permit system and the inclusion of exploration wastes and heap-leaching materials. USBM maintains that if there are gaps, it is because current laws are ineffectively enforced, and it fears the duplication of authority and programs (USDI 1990; USDI and USDA 1990). The states agree with the inclusion of heap leaching in the program but are more cautious about the multimedia concept. They do not want to disrupt current programs and think that having a comprehensive permit will affect current institutional structure.

In Strawman II, EPA gave up on the idea of a one-permit system and left the issue of abandoned mines for future amendment of CERCLA. Heap leaching is still under discussion.

CRITERIA FOR STANDARDS — Many issues related to criteria for standards have generated discussion. The most important of these issues are compatibility with existing standards, like those of CAA or CWA; the distinction between old and new facilities; and the use of technology versus performance standards.

As expected, the industry opposes stricter standards and, whenever possible, prefers to keep the primacy of current standards — especially the more lenient ones, such as those for groundwater quality — and the use of background levels. Inertia also explains some of the resistance to new standards. Although the industry struggles to avoid additional or more stringent standards, the position of environmental groups is that there should be no degradation. The industry is also concerned that compliance with new standards may not be feasible or economical in the case of old facilities. The states have proposed a deadline for old facilities to comply. Finally, the industry and USBM prefer having performance standards, instead of technology standards, because of their effects on innovation. USBM emphasizes that the industry should be allowed to find less expensive solutions.

Final comments

It remains to be seen whether the EPA initiative provided useful inputs to Congress and helped to shape more meaningful and realistic statutes. But it is at least useful to reveal some of the tensions and obstacles in the way of more flexible and cost-effective programs and consensus.

We may see that to an important degree, the trade-off between more flexible programs and effective environmental protection rests on the real independence of local authorities and their capacity to implement and enforce the regulations. Enforcement failures and consequent environmental degradation may outweigh potential benefits. The political structure of the United States enhances the struggle for control between the regions and Washington. This tension is heightened by the extreme positions adopted by the industry and the environmental groups. Both have taken RCRA amendments as their trench to defend their dearest positions, increasing the usual distance. The industry strategy is to bring all new regulations under the RCRA umbrella to avoid new regulatory initiatives in other battlefields. The approval of RCRA amendments is the industry's opportunity to protect itself from new laws. Environmental groups see RCRA as their best opportunity to get a comprehensive regulatory scheme for the mining industry. Other initiatives, like modification of the *Mining Law*, will probably take longer to be approved because the issues are more fundamental and controversial.

Another big obstacle is industry and bureaucratic inertia. The discussions have made industry inertia especially patent, confirming the generally conservative attitude of the mining industry and its aversion to taking risks and trying new approaches. The industry is particularly sensitive to uncertainty. Bureaucratic inertia will probably become apparent after the implementation of a program.

Finally, ambiguity is an important barrier to agreement. The different sides tend to interpret procedural or substantive ambiguities to support their prejudices or fears. This tendency hardens positions and make things more difficult than they really need to be. The Strawman and PDC exercise helped to expose this problem.

Policy recommendations

Certainly, environmental regulations have had an effect on the US mining industry's profitability. Companies have been forced to retrofit or renovate installations or leave the market. Increasing operational costs have affected their international competitiveness, and to some extent, this may be changing the world allocation of mining investment. Employment levels have fallen substantially, and local economies have borne part of this cost.

Environmental regulations have also brought with them important benefits: better air and water quality and reduced health and environmental risks. It is unclear whether the benefits compensate for the costs, much less whether the net social benefit is maximized. The aggregate numbers may show positive net results, but at a regional or local level the situation may be very different. Sometimes it is clear that the same results could have been achieved by spending less.

This does not necessarily imply a negative assessment of efforts so far or a denial of some important achievements. I wish to emphasize the trade-offs in environmental policy-making and the difficulties in measuring these trade-offs — gains against costs — and in making rationally optimal decisions about the appropriate levels of pollution control and environmental protection.

By learning lessons from the US experience, we can make our own process in Chile less painful, more efficient, and more effective as we strive to improve both the quality of our environment and our chances of keeping on a sustainable-development path.

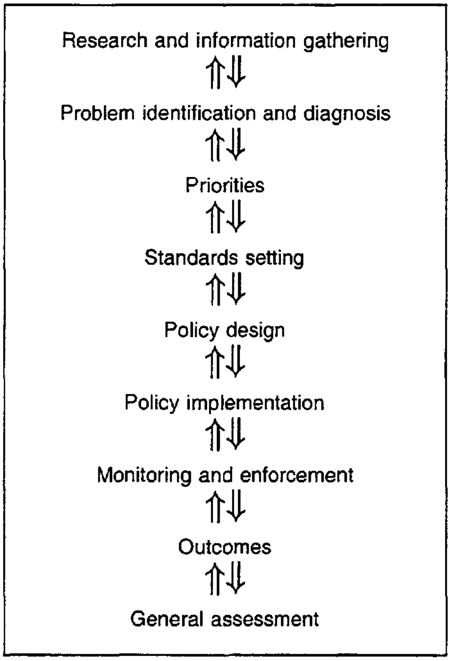

Figure 2. The policy-making process.

If one were to draw a flow chart to illustrate the policy-making process, it might look like Figure 2. The arrows emphasize the dynamic and interactive nature of a process that is never really complete. All the steps shown, particularly research and information gathering, are essential to achieving environmental goals, but here I concentrate on policy design and implementation (although, actually, policy design encompasses design at all stages). I first discuss the main criteria for assessing the desirability of a policy and some concepts that should be at the basis of policy design. I will then discuss tactical issues like instrument choice and institutional aspects, keeping my analysis to a general level, although I will discuss the specifics of mining regulations when relevant.

Main criteria for policy assessment

Three main criteria can be used to assess the desirability of a policy:

- *Effectiveness* — Are we going to be able to reach the goals we have set? This is an obvious criterion, but experience shows that it is not always easy to meet. The reality is complex and evolves over time. Are we introducing dynamic considerations, such as economic growth and its impact on pollution levels? Are our goals too ambitious, leading to the inevitable extension of deadlines and the eventual abandonment of original programs, undermining our credibility? Are we overlooking relevant second-order factors, like indirect disincentives to recycle?

- *Efficiency and cost-effectiveness* — How close will policy outcomes be to the socially optimal levels of pollution control? Are we to the greatest possible extent taking into account the benefits and costs of environmental controls? Given a specific standard, is this the least expensive way to achieve it? Are we taking into account compliance costs, control and monitoring costs, enforcement costs, and general administrative expenses?

- *Political feasibility* — Will a policy have enough political support? How long might it take to get approval from the legislative and the executive? How much resistance will there be in the implementation stage? How fair will the various interest groups perceive the policy as being? What are the chances of long-term stability?

From an examination of US experience, five central concepts emerge in the design and implementation of an effective, efficient, and politically feasible environmental policy.

An integral, multimedia, ecosystemic perspective

An ecosystem is a set of interdependent organisms in an ongoing process of adaptation to their environment. An ecosystem is described in terms of its biological elements, their mutual relationships, and their relationships with the physical and chemical media that support life.

When we are concerned about environmental quality, we are concerned about the disruption of these relationships and the endangerment of the capacity of the system to adapt, evolve, and survive. So it seems logical to use a systems approach to confront the problem. This is the only way to take into account multiple relationships, impacts of several orders, and synergistic effects. It is the only way to be really effective.

We have already seen that taking a partial view of environmental problems creates new and sometimes worse problems. Other negative practical consequences are difficulties in prioritizing problems, resulting in inefficient allocation of available resources; duplication of effort; missed opportunities for economies of scale and positive indirect impacts; and a complex and cumbersome bureaucratic structure.

We may call this multimedia or systems perspective an integral perspective, as opposed to a partial one. It is fundamental to have this integral perspective from the beginning, instead of thinking of superposing different programs at a later date. The perspective taken at the start will not only affect the perception of opportunities to attack the problem but also avoid the creation of inertial forces and interests among the different actors in the system, as happened in the United States.

Flexibility

Policymakers, industry, and the public have to be aware that conditions will be changing and that the regulatory system has to be flexible enough to adapt to new circumstances. Additional knowledge and information, new technologies, and new socioeconomic conditions will necessitate modifications to priorities and strategies. Moreover, the environment is constantly evolving, and the problems will change. The ongoing assessment of policy outcomes should provide a feedback process to ensure that the regulatory system adapts properly to changing circumstances and remains effective and efficient (see Figure 2).

The regulatory system should be flexible in yet another sense. Once the system is established, the main concern is in meeting ambient-quality standards (these standards should be emphasized more than emissions standards). Whenever possible, firms and individuals should be given discretion to choose how best to meet these standards. This is the best way to ensure minimum compliance costs and also to promote technology development.

However, the need for flexibility has to be balanced against the need of economic agents to reduce uncertainty. This is a particularly strong concern in the mining industry. Clear rules and appropriate phasing of programs will be central to balancing these needs.

Specificity

Environmental problems differ from region to region. The types of pollutants emitted or discharged and the capacity of the environment to cleanse itself vary. Population density and the degree of exposure also vary geographically. Negative externalities depend on the kind of economic activity pursued. Environmental impacts are specific to an ecosystem and its demographic and economic conditions. This is especially true of the environmental impacts of mining activities.

On the other hand, people's preferences for environmental quality and other goods depend on socioeconomic and cultural factors that are equally diverse.

The more we are able to tailor environmental programs to the actual problems, the more effective we will be in reaching our goals and the less we will have to spend in doing so.

This is consistent with a multimedia approach. As the complexity of the system increases and we try to go from thinking of the parts to thinking of the whole, we may want a different way of simplifying the real world: reducing the geographical areas to which certain parameters apply. The limits of a properly defined ecosystem may be the alternative we are seeking.

Participation

The public has the last word on the importance and adequacy of environmental policies. Communities should play a substantive role in the policy-making process to ensure equity, effectiveness, and efficiency of the regulatory system. The community's preferences for a cleaner environment and ecological preservation are the ultimate criteria that shape the benefits of environmental protection.

On the other hand, to increase the feasibility, effectiveness, and efficiency of a policy, diverging interests should be reconciled by avoiding confrontational dynamics and using negotiation. Confrontational dynamics are time and resource consuming. Involving all the interested parties ensures fairness; legislative expedience; reduced resistance and litigation in the implementation phase; and increased likelihood of long-term stability.

A public that has been manipulated by the misuse of information is not well prepared to assess environmental problems or to judge policy matters. Lack of awareness about health hazards and ecological risks on the one hand and biased and inflamed discourses in favour of environmental protection on the other distort public opinion and diminish people's capacity to make a proper assessment of alternatives. This is why objective information and public awareness are so important.

The public should also be aware of the costs of environmental protection and of the consequences of their everyday actions. Few people realize that environmental problems and solutions are tied to daily decisions and that costs are going to be borne by the whole of society. A community must be well informed so that it can make responsible decisions about how much economic growth it may have to sacrifice in order to enjoy better environmental quality.

Pragmatism

The feasibility and effectiveness of a policy depend on how realistically it is framed. Strict programs that go beyond the real capacity of the industry to comply result in extensions that undermine the credibility of the new deadlines and the technical capacity of the agency and implicitly justify leniency in enforcement of legislation.

Ambient-quality standards should be defined on the basis of human health first and welfare and ecological considerations later on. However, specific programs for reaching those standards, phases, and deadlines should be based on considerations of economic and technical feasibility, with market considerations included. Timing is key to avoiding unnecessary costs and to reducing industry resistance.

Instrument choice

We are looking for a flexible, integral, participatory policy to insure effectiveness, efficiency, and feasibility. What are the instruments that best serve our purposes?

Before there were environmental policies, the courts were the only recourse for those affected by environmental problems. This proved to be ineffective and inefficient because of the uncertainty surrounding court decisions. The law left too much scope for interpretation. It was also expensive, and transaction costs were prohibitive for some of those affected. The public-good nature of this solution generated the problem of free riders. Finally, information was scarce, and secret settlements precluded the diffusion of information relevant to other actors. Of course, the use of courts to address environmental problems depends on a well-developed and accessible judiciary system.

As we have seen, although command-and-control regulations significantly advance the cause of environmental protection, they have been open to many criticisms. Some regulations have been attacked more than others (for instance, design versus performance standards), and the system has been accused of being rigid, bureaucratic, and expensive.

The same voices of criticism have advocated both the use of economic incentives (taxes and marketable pollution permits) and, in a more general sense, the use of the market to correct failures and eliminate distortions. To be sure, with market incentives one still needs regulations, but the mechanisms used to ensure that standards are met are different.

There is another alternative — the Coasian solution. This means leaving the interested private parties to negotiate over the problem, with property rights well defined. This theoretically optimal solution has been mostly kept within the pages of textbooks because its appeal depends on rather unrealistic assumptions. Normally, the negotiated outcome differs from the optimal solution because of transaction costs, strategic behaviour, manipulation of information, and income effects. Also, although theoretically efficient, this approach fails to address equity issues, like intergenerational concerns and the distribution of property rights. Uncertainty is another shortcoming of this approach.

Emphasis should be given to the role of ambient-quality standards in controlling the environmental impact of economic activities. It is preferable to set general targets for pollution abatement and to allow the allocation of the targets among the pollution sources to be driven by economic instruments such as taxes or permit prices. If this is impossible, then setting performance standards is still preferable to setting design standards. Also, where relevant, intermittent controls, depending on, for instance, meteorological conditions, are preferable to permanent controls. The mechanisms that we choose to ensure that our environmental-quality targets are met should at the same time allow for economic growth and be able to adjust to new conditions smoothly. Economic instruments (like taxes or permit auctions) may be preferable because they raise funds to support the whole system. These preferences have to be balanced against considerations of technical feasibility, such as the capacity to monitor compliance and enforce regulations and the ability to meet environmental-quality targets without creating hot spots or long-range problems like acid rain.

Looking at the situation in the United States, one might be tempted to jump into marketable pollution permits to achieve environmental standards:

- They ensure that environmental goals are met;
- They give firms the flexibility to choose their own strategy to comply while minimizing their costs;
- They adjust to economic growth and inflation; and
- They provide important dynamic incentives for developing new environmental technologies.

Marketable pollution permits seem just perfect; nevertheless, we have already recognized some caveats. The most obvious has to do with the case of substances that are toxic and pose big health and environmental risks at even low concentrations. In such cases, we cannot allow firms to decide the appropriate level of pollution abatement on the basis of their particular costs.

With this exception, three main considerations determine whether it is worthwhile to use marketable pollution permits. First, although the use of pollution permits instead of command-and-control regulations may increase net social benefits, the gain greatly depends on the competitiveness of markets. The gain is not as great in highly concentrated markets (either the permits market or the product market) as in atomized markets. Still, if pollution permits are used in markets in which they become a serious entry barrier, they may result in losses of efficiency that counteract the advantages of the system.

Second, the costs of environmental protection include not only the compliance costs of the firms but also the control, monitoring, and enforcement costs and the general administrative costs of setting up the system in the first place. The use of pollution permits (particularly ambient-quality permits, as opposed to emissions permits) is theoretically the most efficient approach but requires advanced modeling techniques and an especially good system of monitoring and compliance. These requirements limit the economic and technical feasibility of implementing a system of pollution permits.

Finally, marketable pollution permits will not work as well as command-and-control regulations if the pollution problem is so acute that it requires maximum control.

When choosing specific instruments, it is crucial that we look at the characteristics of the environmental problem; the specifics of the sources of the problem; and the social, economic, and political conditions we face. In this sense, the instruments we choose have to be appropriate for specific situations, and most likely, a mix of different instruments will be needed to reach global goals.

Having said this, I wish to call attention to the use of case-by-case negotiations for controlling the impacts of medium- and large-scale mines — the big point sources — and propose a modified version of the Coasian solution. The negotiations will take place after a general framework has been established. The framework will comprise delimitations of ecoregions; ambient-quality standards, related global abatement targets, and maximum emissions ceilings; clear definitions of property rights; decentralized authority and resources; empowerment of local communities; and clear rules for negotiation. Environmental-protection specifics (such as how the standards will be met) and specific programs (with specific degrees and types of control and timing) will be left to negotiations between the industry, local community, and local authorities. Ideally, the negotiations will cover all the relevant issues at once, giving rise to a single permitting process. The outcomes will reflect community preferences, specific environmental conditions, and the particular conditions of the firms and will address equity, effectiveness, and efficiency concerns. Of course, this scheme will be valid for either local or regional environmental impacts.

Central authorities will have the main responsibility for defining the framework and will generally oversee the process, including monitoring of compliance and enforcement of ambient-quality standards and negotiated agreements. Equally important, the environmental agency will have a central role supporting the development, analysis, and diffusion of information deemed relevant to the negotiations. Finally, I emphasize the importance of having the appropriate financial and human resources to undertake the task. These will include properly trained government officials and community and industry representatives.

Environmental problems generated by small mines, mainly groundwater and surface-water pollution, will require different schemes. Also, global problems will require a national strategy.

Institutional aspects

An integral, flexible, and participatory approach requires a great deal of multidisciplinary work, as well as interaction and coordination of various government agencies and private institutions.

Each and every ministry and government agency must become sensitized to the environmental impacts of economic activities and must consider the environmental impacts of every policy and program. The use of EIAs has become a normal practice in the United States and has had an important impact. However, it is necessary to go beyond bureaucratic mechanisms that may become just part of a red-tape ritual.

An approach like the one I have just proposed also requires a great degree of decentralization. Although central administration is required to secure at least a minimum degree of environmental quality and uniformity, most of the decisions can be made at the regional or local level, depending on the scope of the environmental problem. This will require the empowerment of regional and local authorities and the promotion of community organizations. The delegation of authority has to be matched with the appropriate human and financial resources to ensure the capacity of the local agencies to deal with the problems.

The Ministry of Mines

The institution ultimately responsible for designing, implementing, and enforcing environmental policies should be a special environmental agency with the independence and expertise necessary to undertake the effort. The Ministry of Mines has nevertheless a very important role in representing the interests of the mining sector according to long-term mining-development policies. The Ministry of Mines will be the main contact between the environmental agency and the mining sector and will be the principal source of information. The ministry will also be the main source of support for the industry, to minimize compliance costs.

The Ministry of Mines should develop appropriate channels of communication with the environmental agency to ensure that policy decisions are well informed and take into account factors affecting the development of the mining sector. Collaboration and policy coordination play a very important role in the effective use of available resources.

Another important area of work is the development of information and policy analysis. The assessment of the actual environmental impacts of mining, as well as of the impacts of environmental regulations on the mining industry, is a basic step and fundamental input for policy-making. Such assessments will require the establishment of channels of communication with the industry, the installation of monitoring equipment, and the development of modeling techniques. To evaluate the capacity of various segments of the industry to comply, international-market conditions and technology availability should be considered. Imagining innovative ways to fulfil environmental goals and formulating strategies to compensate for potential losses of competitiveness and employment are some of the challenges facing the ministry.

The development of new environmental technologies should be a central element in the promotion of R&D. The future competitiveness of the industry may depend to an important extent on its capacity to develop less expensive pollution-abatement technologies. For instance, SO_2-fixation techniques, alternative uses for H_2SO_4, and hydrometallurgical techniques should have an important place on the agenda. The Ministry of Mines can also promote technology transfer, especially in the case of small-scale mining. Extremely important is the development of training programs to create the required expertise in the different areas and at the different levels. Finally, the Ministry of Mines can improve the linkage between the domestic mining sector and international expertise, promoting exchange programs with and technical assistance from those countries with more experience.

Final comments

It would be inconsistent with the principles expressed here to go much further in making specific policy recommendations. These depend on the diagnosis and the particular conditions where the problems are experienced. For the copper industry, all I can say is that the most expensive environmental regulations will be those governing SO_2 emissions and mining wastes. Consequently, special attention should be given to assessing the possible economic impacts of these regulations and to fostering the development of cost-effective alternatives for dealing with these problems.

A scheme like the one I proposed will be feasible in a country like Chile: the administrative division of the country may be useful in establishing an eco-regional approach, and the small number of big mining firms will make it easy to use a case-by-case approach and to enforce negotiated agreements. It seems evident that Chuquicamata should not be subject to the same degree of emissions control as Ventanas or Chagres.

Chile and other countries that are beginning to develop an environmental-policy framework and the institutional structure to implement it have enormous challenges ahead. But they also have important advantages over countries that began the effort some time ago. Chile can learn from the experiences of other countries and avoid making the same mistakes. Also, Chile has none of the inertia that has impeded change and improvement in those other countries. So it is important to introduce, from the beginning, the right concepts to avoid confronting strong inertial forces from bureaucracy, the industry, and the public.