Ozone Depletion Revisited

EPA Regulation of Chlorofluorocarbons

Robert L. Rabin

LAST OCTOBER, prime news coverage focused once again on chlorofluorocarbons (CFCs), a chemical substance suspected to cause an especially pernicious, imperceptible form of environmental degradation. Only two years earlier, a governmental ban on using CFCs as a propellant in aerosol spray cans appeared to have met public safety concerns. But then, on October 7, 1980, in an advance notice of proposed rulemaking, the Environmental Protection Agency (EPA) indicated that the hazards associated with CFCs loomed larger than ever—raising the prospect of further regulatory action. EPA also announced that if additional controls are to be imposed, it leans toward a marketable permits system, an economic incentives approach that has been much discussed in the literature but is still untested in the rough-and-tumble world of regulatory reform.

What are the hazards posed by CFCs? How does the growth in the chemical's use both here and abroad affect the regulatory problem? If further controls are needed, is the innovative marketable permits approach the best way of proceeding? As EPA considers further action, these issues deserve careful examination.

The Theory and Its Consequences

Chlorofluorocarbons are a family of chemical substances that have a wide variety of industrial, commercial, and consumer uses. Beginning in 1974, scientists warned that one of the great virtues of CFCs—their chemical stability—might also be a critical vice. Unlike most other chemical compounds containing chlorine, which break up in the lower atmosphere, CFCs appear to remain intact as they rise slowly to the stratosphere (the region of the atmosphere ten to fifty kilometers above the earth's surface). In the stratosphere, ultraviolet radiation causes them to decompose, freeing the chlorine atoms which, in turn, destroy ozone through further catalytic reactions.

The destruction of any substantial portion of the so-called ozone shield in the stratosphere would be cause for substantial concern. That shield limits the amount of damaging ultraviolet radiation that reaches the earth's surface—radiation within the spectrum harmful to human and other organic cellular matter. While the level of stratospheric ozone varies under natural conditions, it is subject to imperfectly understood dynamic forces of creation and destruction which maintain a relative level of equilibrium. If the ozone depletion theory is accurate, this equilibrium is jeopardized by the continuing chemical invasion.

Note, then, that the scientific side of the CFC scenario has two distinct aspects. The ozone depletion theory indicates the stratospheric effects likely to result from continued release of CFCs into the atmosphere. But the theory generates real concern only when it is

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linked to a growing body of scientific research indicating that damaging ultraviolet radiation has potentially harmful impacts on human and other organic cellular life.

The government has relied heavily on the National Academy of Sciences (NAS), both to validate the theory and assess its impact on living organisms. The initial NAS findings were reported in 1976–77. Shortly thereafter, the Clean Air Act Amendments of 1977 directed EPA to sponsor further research, report to Congress, and regulate unreasonably dangerous impacts on stratospheric ozone (see sections 150-59 of the act). A year later, in 1978, came the aerosol ban.

Students of the regulatory process might well have predicted a period of inattention, or at least benign neglect, after this flurry of activity. Not so, however, in the case of CFCs. With the continuing congressional mandate to sponsor research and to report, EPA turned once again to NAS for further scientific evaluation, and also funded research by the Rand Corporation on the economic consequences of broad-based CFC regulation. By mid-1980, having new data in hand, the agency seriously contemplated the prospect of more far-reaching action.

What caused its concern were the two latest NAS reports (*Stratospheric Ozone Depletion: Chemistry and Transport* and *Protection against Depletion of Stratospheric Ozone by Chlorofluorocarbons*, December 1979), which suggested that the depletion problem was even more serious than had been previously thought. NAS estimated that at 1977 levels of CFC release, the ozone layer would eventually be depleted by 16.5 percent, reaching one-half of the estimated steady-state depletion within thirty-five years (error range of ± 11.5 at a 95 percent confidence level).* Moreover, should the release of CFCs continue to grow at its current rate of 7 percent annually (more on this later), NAS projected a 75 percent likelihood that ozone depletion would eventually exceed 30 percent of current levels.

Turning to biological harm, the scientists discussed an array of findings. Skin cancer is the principal type of direct harm to humans associated with damaging ultraviolet radiation. Based on an evaluation of epidemiological data, nonmelanoma skin cancer—the nonfatal but disfiguring variety—would be expected to increase by about 4 percent for every 1 percent increase in ozone depletion. If stratospheric ozone were in fact to be depleted by 16.5 percent, this incidence ratio of four-to-one would translate into several hundred thousand more cases of nonmelanoma skin cancer in the United States alone. The relationship between malignant melanoma skin cancer—which is frequently fatal—and damaging ultraviolet radiation is less clear, but sufficiently well established for the NAS to predict several thousand additional cases a year (based on an incidence ratio of about two-to-one).

The harm anticipated to other biological systems is similarly a function of cellular damage, observed in controlled and open-field experimentation. While the data are far from conclusive as yet, it appears that a wide variety of plants, including such staple crops as sugar beets, tomatoes, and corn, would be seriously affected. Similarly, a number of marine organisms that are critical links in the biological food chain—anchovies, crab, and shrimp larvae, for example—appear to have a very low tolerance for increased doses of damaging ultraviolet radiation. Finally, NAS described the potential "greenhouse" effect, or contribution to the warming of the earth's atmosphere, that might result from a continuing increase in the level of heat-absorptive CFCs in transit to the stratosphere.

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In the final analysis, EPA will be forced to a scientific judgment under conditions of uncertainty. The ozone depletion theory rests on atmospheric modeling which the NAS report finds strongly persuasive. The chemical industry argues, to the contrary, that no action should be taken until actual measurements of significant CFC depletion are available. Arguably, however, such measurements will be

* The latest available reaction rate data indicate that the NAS estimate may need to be revised downward to about 10 percent steady-state depletion at 1977 levels. (See Commission of the European Communities, Scientific Workshop, Evaluation of Effects of Chlorofluorocarbons on Atmospheric Ozone, Brussels, January 13-15, 1981.)

available only after the aggregate emissions have exceeded the threshold of tolerable risk. The scientific debate is too technical to pursue in detail here and certainly beyond my competence to resolve. I put it aside, so that we might consider the economic and political dimensions of the problem.

A Growing and Diversified Market

CFCs are nontoxic, nonflammable, chemically inert, and score very high on thermal energy absorption. It is perhaps no surprise, then, that the Rand report on CFCs (*Economic Implications of Regulating Chlorofluorocarbon Emissions from Nonaerosol Applications*, June 1980) indicated that the demand for CFCs is growing steadily—and will continue to do so for the next decade at least. Overall, Rand estimated a 7 percent annual growth rate in U.S. production. (Data obtained by EPA from the Chemical Manufacturers Association indicate a probable 9 percent growth rate in foreign production.)

Most striking, though, are the variety of uses to which CFCs are put, even with aerosols out of the picture. CFCs serve as a blowing agent in both flexible methane foams (used in bedding, furniture, automobile seats, and carpeting) and in rigid polyurethane foams (utilized as an extremely efficient means of insulation for buildings and mobile refrigeration units). They are also a widely used blowing agent in nonmethane foams (polystyrene sheet products, which are fabricated into foam trays, cups, egg cartons, and fast-food wrappers). Beyond that, because of their exceptional thermodynamic qualities, CFCs are employed as the refrigerant in automobile air conditioners, industrial and commercial air conditioners, and home refrigerators and freezers. They are also an important solvent. In particular, they are highly valued by the electronics and aerospace industries as a precision cleaning agent for printed circuit-boards, scientific instruments, and in a variety of contamination-controlled environments.

Obviously, not all of these product areas are growing at the same rate. And as might be expected, the feasibility of product substitution for CFCs varies from one use to another. Other characteristics of the CFC market that are critical to risk/growth projections deserve mention too, even if they cannot be spelled out here: (1) different members of the CFC family—with corresponding differences in ozone depletion potential—are used in various end products; (2) some uses of CFCs involve immediate emission, while others contribute to the "bank" of CFCs trapped until the end product is destroyed; and (3) some CFCs contain hydrogen atoms which appear to diminish significantly their ozone-depleting potential (both NAS and Rand excluded these nonhalogenated CFCs from their primary analysis).

What is crystal clear, however, is that CFCs possess admirable properties that give them a competitive edge in many fields—an edge they are not about to lose. Rand projected aggregate U.S. emissions by 1990 at more than double the current level, with flexible foams, solvents, and rigid foams growing at an especially dramatic pace—well in excess of the estimated overall increase of 7 percent annually.

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Thus, the economic data underscore the import of the scientific findings. If the main NAS conclusion—16.5 percent depletion at steady-state 1977 emission levels—is reasonably accurate, the biological impact of continuing uncontrolled growth in CFC use could be devastating. EPA's responsibility under the Clean Air Act to take further regulatory action would be clear. The critical question would then be what form the action should take.

Regulatory Options

Even if sufficient risk of biological harm exists to warrant regulatory action, two troublesome questions must be addressed before an appropriate level of emissions control can be established. The first is a familiar one: how do we weigh the costs of projected ozone depletion against the forgone benefits of CFC use to arrive at a target level of control? A moment's reflection on the earlier discussion of risks and benefits should be sufficient to demonstrate the boldness it would take to assert that, say, a 2 percent ozone depletion level, as distinguished from a 5 percent or an 8 percent level, is *the* appropriate target. As we shall see, however, it is realistic to think in terms of short-term strategies moving *in the direction* of an "appropriate" depletion level—strategies that require far less precision about eventual goals for the time being.

But cost-benefit analysis, so conceived, turns out to be less intractable than the other major difficulty—the fact that CFC emissions recognize no national boundaries. Scientists believe that a pound released on the other side of the globe is potentially as damaging to the ozone layer above the United States as a pound released here. And the data on worldwide use suggest the magnitude of the problem; as indicated earlier, extraterritorial emissions are estimated to be growing at 9 percent annually.

This growth rate must be read in conjunction with another salient fact. Currently, the United States accounts for only about a third of total world emissions. Working with these and related figures, EPA calculated that the difference in eventual steady-state ozone depletion if the United States immediately reduced its emissions by 70 percent, compared with a failure to take any action—assuming in both cases that 1990 emission levels, once reached, were maintained indefinitely—would amount to only a reduction from 32 percent to 26 percent in stratospheric ozone depletion, as long as the rest of the world did not enact controls. In short, if the magnitude of the problem is correctly perceived, international action is essential.

In view of these major obstacles, EPA discusses three threshold options in its advance notice of proposed rulemaking — wait-and-see, no growth, and substantial reductions. The agency rejects the first. While unilateral U.S. action can achieve only a limited impact, a total failure to act could easily contribute to a response in kind abroad. However it might be phrased, a wait-and-see approach would signal a lack of genuine concern—to domestic CFC industries and foreign producer nations alike. Moreover, European producers, accounting for roughly another third of total emissions, have taken at least some action in response to the earlier U.S. ban—a partial ban on aerosols, a freeze on overall production capacity, and a commitment to discuss further reductions in formal meetings.

Still, we are a long way from a genuine international cooperative effort and, as a consequence, the substantial reductions option was also rejected as a present strategy. Indeed, it might well backfire, lulling foreign producers into thinking that the problem had been diminished by unilateral U.S. action to the point where it could be ignored for a while.

Recognizing these considerations, EPA proposed a short-term freeze at current production levels, linked to substantial reductions in the future when corresponding steps were taken by foreign producer countries (assuming, obviously, that the ozone depletion theory maintains its credibility). Interestingly, in devising a politically pragmatic approach for dealing with the tangled world of international politics, the agency side-stepped the need to

"True, the fluorocarbon industry's threat to the ozone layer may very well be serious, but the ozone layer's threat to the fluorocarbon industry is equally serious."

commit itself at present to a flat figure of "acceptable" ozone depletion.

Nonetheless, the enactment of a production cap would necessitate regulatory controls powerful enough to eliminate continued growth, and a tentative commitment to even more stringent controls in the future would suggest the wisdom of a strategy having built-in flexibility. EPA's inclination to adopt a nontraditional economic incentives approach, a marketable permits system, has to be evaluated with these considerations in mind.

It would be feasible, of course, to choose a traditional regulatory option. Following its earlier course, the agency could simply impose another product ban. But that would be to rely on a very crude tool. Surely, it would be arbitrary to ban emissions of the product whose share of the CFC market most closely approximates the projected 7 percent growth increment—solely on the grounds that such overall market growth is the agency's regulatory target. If instead the agency were to ban just those products that were, on some basis, deemed to be "inessential," the usual economic efficiency arguments would apply: why impose a collective judgment that a designated product is inessential rather than adopt a quota and allow the market to determine the shifts in demand? Politically as well as economically, there seems to be no persuasive reason for pursuing this option.

Another traditional option would be command-and-control regulation. There are many precedents. The Clean Air Act, for example, has been implemented principally through federal and state regulations setting performance and design standards for various classes of polluters. With respect to CFCs, the Rand study suggests that recovery and recycle standards could be set for some flexible and rigid foam manufacturing, equipment standards could be established for solvent applications, and product substitutes could be mandated for certain refrigeration uses.

Nonetheless, a strong case can be made against traditional regulatory standards. First of all, Rand concluded that some of the most important uses of CFCs—including auto air conditioners and building insulation—would not be touched by technology-based standards under the current state of the art. Second, adoption of all currently feasible standards would have a limited overall impact on emission reductions because, according to Rand, the rate of growth in CFC use would be diminished but growth would continue nevertheless. Finally, Rand's cost projections are consistent with what economists would expect: mandatory controls within the range of feasibility turn out to involve about double the compliance costs of a comparable level of control implemented through a marketable permits system. The reason for this is that mandatory controls do not ordinarily reflect the most cost-effective means of achieving a target level of controls. The agency has neither the data on production costs nor the ability to set selective standards that would be required to establish economically efficient limits.

The third major option available to EPA is an economic incentives approach. In recent years the agency has experimented with such measures, principally under the Clean Air Act, and much has been written about bubbles, offsets, and the banking of emissions reductions—strategies designed to achieve greater economic efficiency in controlling air pollution. Despite a great deal of discussion, however, a marketable permits system has yet to be implemented. For a variety of reasons, CFC regulation appears to be an excellent candidate for the maiden venture.

In contrast to the other regulatory control options, a marketable permits system would allow the agency to exercise precise control over the aggregate output of CFCs. A quota would be set imposing a target level of emissions—under the EPA proposal, at current production levels—and a corresponding number of permits would be issued for the use of CFCs. The permits would be written in terms of a standard permit-pound, which would be based on chlorine content—the ozone-depleting constituent of CFCs. Trading in permits, once issued, would be openly allowed among users of the various types of CFCs. Since chlorine content varies among types of use, those products dependent on CFCs that have a greater ozone-depleting potential presumably would incur a correspondingly greater cost of materials.

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In my view, there is a great deal to be said for such an approach. First, it would create incentives for cost-justified technological controls on CFC emissions and for consumer shifts in demand to close substitutes for CFC-using products. Neither of these incentives is necessarily a by-product of command-and-control regulation.

In addition, a marketable permits system should be considerably easier to enforce than a command-and-control system. Under the latter, an enforcement scheme is likely to rely upon investigation and inspection techniques to ensure compliance with design and process standards. Because of the large number of industrial users, even a carefully designed system of audits and random spot-checks would probably involve substantial agency resources. In comparison, a marketable permits system could be enforced principally by requiring that the five domestic producers of CFCs maintain adequate records of their sales.

Still another advantage is that the system should give the agency greater flexibility in reacting to developments. Consider the possibility that, at some future time, either scientific data or international political developments make it advisable to adjust the domestic level of emissions. At that point, *any* agency response would probably be hotly contested. But adjustments in the flow of a permits pipeline would be less likely to be disruptive—both economically and politically—than having to reconsider design standards or selective bans.

From the EPA's standpoint, a marketable permits approach has a much better chance of getting a decent trial on CFCs than in most other areas. For one thing, there would be the significant benefit of operating in an area uncluttered by the dense tangle of statutory provisions and implementing regulations that so frequently ensnares efforts at regulatory innovation. Every venture under the Clean Air Act has to accommodate itself to this jungle. By contrast, apart from the aerosol ban, there is no regulatory framework for CFCs and, consequently, no built-in obstacle to a permits scheme.

In addition, the massive cloud that overhangs effective regulation of CFCs—the worldwide scope of the problem—has its silver lining on the domestic side: a nationwide trading market, as contrasted to the limited regional and local markets that often undermine the effectiveness of air-quality control trading schemes. Finally, the very nature of CFCs is a distinctive attribute from an economic incentives standpoint. Unlike air pollutants that are an unwanted secondary consequence, a by-product of industrial processes, CFCs are an end product of a manufacturing process. As a result, the measurement problems that frequently plague pollution-related economic incentives proposals—by making it unclear whether genuine emission reductions have been effected—are virtually nonexistent in dealing with CFCs.

It is the exceedingly rare reform measure that is without problems, and the marketable permits system is no exception. One of these is the basic question whether the system would be implemented through an auction or an allocation scheme—a decision that EPA left open in its proposal. Under an auction scheme, EPA would sell off permits in a market that might be unrestricted or that could be limited to producers, industrial users, or in a variety of other ways. Circumscribing the participants could cause problems at the political level; for example, the question could arise (largely hypothetical, in my estimation) whether environmental groups should be able to buy up permits in order to achieve greater-than-mandated limitations on emissions. Collusion is another possibility. Conceivably, large-scale participants might attempt to reap monopolistic profits from the permits market. But such practices seem highly unlikely, in view of the number of prospective participants and the profusion of uses to which the permits would be put.

If an auction system were chosen, other

problems arise as well. Because EPA would generate revenues from the auction of permits, a legal question of statutory authorization exists. My own view is that the case law allows the agency to collect funds as a secondary consequence of a regulatory scheme implemented principally as a control measure under the broad language of section 157 of the Clear Air Act, but the issue is not free from doubt. (Compare *Federal Energy Administration* v. *Algonquin SNG*, 1976, with *National Cable Television* v. *U.S.*, 1974.)

Most critical of all, however, if the Rand study is right, the auction revenues might be so large as to cause serious political and economic repercussions. While Rand estimated compliance costs at about half those imposed by "feasible" mandatory controls, it concluded that the transfer payments generated by purchase of the needed permits would be massive —more than $1.5 billion over a ten-year period, even if emissions limits were at the relatively modest level equivalent to achievable cutbacks under feasible command-and-control regulations. Note that these transfer payments, unlike compliance expenditures, are not a real resource cost; they are simply a transfer of revenues from one set of pockets to another, from the CFC permit purchasers to the government. For this very reason, the politics of implementation could be complex and controversial.

Similarly knotty problems would be encountered if EPA were to select an allocation scheme. At the outset, the problem of transfer payments reappears, posing a dilemma over distribution of the permits. If allocation were to producers, they would pocket the wealth created by property rights in a scarce resource that they would be supplying to CFC users. A serious equity issue obviously arises. On the other hand, if allocation were directly to CFC users, the transfer payments would probably be drastically reduced. As long as the allocation reflected historical patterns of usage, trading among these end-product assemblers—which would be the exclusive source of explicit transfer payments—would probably be relatively limited in the initial round. But allocation to users—whose numbers are in the thousands and whose claims to special equitable consideration would be staggering—might well create an administrative nightmare.

Without a doubt, these distributional issues raise serious problems. And the details of implementation are not insignificant: would the permits, for instance, be for an unlimited term, a single year, or some intermediate life? This question alone is inextricably related to the distributional issues just raised. Nonetheless, while the agency needs to give careful consideration to these questions, there is no reason to think they are insoluble.

Similar caution has to be exercised in defining the parameters of the system. On the domestic side, there is a "second-best" concern, to use economic jargon. If the permit system were to raise the price of CFCs as compared with riskier unregulated product substitutes, it may be that no regulation would be better than a partial scheme. And some of the chief substitutes for certain CFC uses do pose problems of toxicity and flammability. So the issue is not merely of academic interest.

On the international side, there are questions of how imports and exports are to be handled. Exports pose one dilemma: if they were restricted by a permits scheme, would foreign producers simply step into the breach —nullifying the impact of regulatory control at the cost of domestic producers? Imports pose another: would they be incorporated into the permits system, subjected to a separate allocation, or treated otherwise? Fortunately, because of transportation cost constraints, both imports and exports account for a relatively small percentage of domestic production and use. Again, however, the issues require serious consideration.

Indeed, there are no easy answers to the problems posed by CFC emissions. The ozone depletion theory is not unassailable; a measure of scientific uncertainty will continue to exist in the near future at least. The reactions of foreign nations to various options the United States might exercise cannot be predicted with great confidence. And each of the regulatory control strategies that EPA might employ is open to debate. Yet, unless the credibility of the NAS reports is seriously undermined, the CFC problem appears sufficiently grave to warrant the rather modest first-stage production freeze that EPA has proposed. And the agency's marketable permits system holds great promise as an equitable and effective implementation strategy. ■