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Environment and Technology: New Frontiers for the Social and Natural Sciences

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I speak not only as an economist with a long-standing interest in problems of environmental disruption and social costs, but also as a social scientist who is willing to view the issues raised by *Kogai* (social costs) not simply from the point of view of a single discipline, but from a broader perspective. I am aware that economics is not the only discipline which has a contribution to make to the problem of environmental disruption and environmental control. It is true the theoretical framework of conventional economic analysis is perhaps too narrow to offer the required analytical tools for the exploration of the causal process of environmental disruption and for the determination of adequate instruments of control designed to mitigate the deterioration of the environment. Some professional economists have even suggested that conventional economists would render the greatest service to posterity if they remained silent.[1] I have considerable sympathy for this view, although I have not followed this advice, at least not so far. I still hope that economics can go beyond its traditional boundaries and make

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a significant contribution to the exploration of environmental problems and policies. But then I must add that I have never been a conventional economist; I have always felt that economists, in collaboration with other social and natural scientists, will be able to make a useful contribution to our problem provided they take full account of its ecological and human dimension and develop an understanding of its substantive character.

The disruption of the environment and its protection raise problems of such complexity that no single academic discipline within its present boundaries can hope to make significant contributions to their solution without at least a basic familiarity with the knowledge of other relevant social and natural sciences. For this reason it is necessary that social and natural scientists concerned with environmental problems and policies engage in transdisciplinary research. This does not mean that they must become experts in all fields—obviously a hopeless undertaking—but they must acknowledge the nature of the interaction between the economy and the natural environment and integrate into their analytical systems the perspectives, central concepts, and theories which related disciplines have found relevant in clarifying the nature and causes of environmental disruption. For this reason alone, in addition to others which I shall indicate presently, I hope you will not consider it as empty rhetoric if I place particular emphasis on the need for interdisciplinary cooperation. In fact, in dealing with problems of environmental disruption and protective policies we are inevitably concerned with the manifold interdependencies between socioeconomic and ecological-physical systems. However, nothing seems to be less explored and more difficult than to deal systematically with the interaction of different systems either by *trans*disciplinary studies conducted by individual scholars from one discipline or by *inter*disciplinary research undertaken jointly by groups of experts from different disciplines, each bringing his own specific language, concepts, and theories to bear upon the common problem. After years of talking about interdisciplinarity, we still lack the appropriate techniques, methods, and attitudes required for such work.

Until a few years ago the causes and consequences of environmental disruption were generally neglected by social and natural scientists, with the exception perhaps of some scholars who did call attention to the fact that economic processes are causing serious damages to the environment, and hence to individuals and society as a whole. Although the evidence was all around us, few social scientists, including economists, have warned us against the dangers inherent in the fact that production and economic growth, particularly under the influence of modern technologies, tend to give rise to social costs which are not accounted for in entrepreneurial outlays. While a few economists and sociologists have analyzed the positive and negative consequences of technological changes in general and have even raised the question as to whether a collectivization of production and overall economic planning may not be desirable and necesary, they do not acknowledge the fact that new technologies and the market mechanism are conducive to a "shift" or a "socialization," so to speak, of an important part of the actual costs of production.[2] I think the same may be said of natural scientists and technologists, again with notable exceptions, who have failed to warn us in time of the social and human consequences of scientific and technological innovations.

In any event, as far as economics is concerned, our recent preoccupation with problems of economic growth and technological change in developed and underdeveloped countries went hand in hand with a neglect of environmental disruption and the practical policy implications resulting from the increasing "socialization" of an important part of the costs of production to society at large. Before dealing with some of these policy implications, let me discuss briefly what I call the substantive nature of the problem of environmental disruption and the role of the market mechanism.

The Substantive Nature of the Problem

Environmental disruption and social costs are anything but exceptions or minor side effects of economic processes.[3] Rather, they are pervasive consequences having global and regional effects which alter not only the conditions and the quality of human life, but also may affect and endanger the process of social and economic reproduction. They are *global* in the sense that certain persistent pollutants and residuals may affect potentially the entire planet by altering the chemical composition of the atmosphere, giving rise to climatic changes, with far-reaching consequences. While the global effects are not yet fully transparent, and considerable uncertainties still surround these possible and potential changes, their repercussions would have such a profound impact on human life that it is high time to begin with their systematic exploration, for example, by establishing national and international monitoring systems, and to consider possible preventive steps in order to avoid irreversible and irreparable damages.

Other effects are *regional,* that is, limited to specific areas which, however, may not coincide with national frontiers and political jurisdictions such as nations, states, counties, and so forth. These effects are somewhat more transparent and better understood. They, too, are the result of the discharge of specific degradable and nondegradable, water or airborne, as well as solid residuals with deleterious consequences on the assimilative capacity of the environment, and hence on the quality of streams, large bodies of water, the atmosphere, and the soil. They are a threat to the natural environment, to public health, and to property and materials. In addition, economic activities may be connected with high noise levels deleterious to human health. Similarly, economic and spatial concentration and high population and transportation density in urban centers affect adversely the living and working conditions as well as esthetic values for large sections of the population.

The causal processes may be further complicated by the fact that different pollutants and residuals react upon one another, giving rise to chemical concentrations changing the quality and assimilative capacity of the receiving environmental media. Finally, it needs to be emphasized that what counts is not simply the effects of a specific pollutant of air or water, but the *total* physical and social effects from multiple sources, including the degradation of living and working conditions, which determine the quality of the human environment and the extent of the damages caused. In short, both environmental damages and the quality of life must be understood as aggregates, that is, in their totality.

While it is not my intention to enter into a detailed discussion of specific causal processes of environmental degradation, it is important to emphasize that these processes are not only cumulative but also complex. Thus the combined effects of investment and allocation decisions and of the resulting discharges of residuals on the assimilative capacity of a local or regional environment may be dependent on such factors as topography, climate, temperature, wind velocity, volume and speed of stream flows, and so forth.

For these reasons the effects of any specific emission of residuals will not necessarily vary proportionately with their amount and frequency. Particularly when critical threshold levels of the assimilative capacity of the environment are reached and when different pollutants combine in chemical reactions and concentrations, the discharge of additional residual waste products may have not proportionate, but disproportionate, that is, nonlinear, effects with possibly sudden catastrophic consequences on human health and well-being. Outbreaks of the Minamata and Itai-Itai diseases in Japan are not the only examples. I am mentioning these facts for two reasons: first, as a warning against attempts to operate with constant relationships or fixed coefficients between the volume of production, the level and rate of discharge of pollutants, and the deterioration of the environment. No matter how important the input-output approach may be as an attempt to quantify our problem—and I am not denying its importance—such an approach may have its limitations as an analytical and prognostic tool and hence as a basis for the formulation of appropriate instruments of control. Second, the complex and cumulative character of the causation of environmental disruption demonstrates once more the essentially interdisciplinary character of the problem which takes us far beyond the traditional boundaries of the social sciences.

Furthermore, the causal process is not, as a rule, bilateral in character, with specific polluters causing damage to specific, identifiable individuals or affected parties. In fact, the process has nothing in common with a typical two-persons, market relationship; it is not the result of any voluntary contractual transaction. The affected persons are as a rule without protection; they have no voice in the matter; they are victims of a process over which they have little if any control. The degradation of the quality of the environment happens, so to speak, behind their backs, and the possibilities of redress are limited or ineffective under prevailing compensation laws. Neither those who contribute nor those who are affected by environmental pollution are, as individuals, able fully to evaluate the relative importance of the damages caused, quite apart from the fact that the negative effects are highly heterogeneous in character and may become apparent only after a considerable period of time; hence an evaluation in monetary terms (for example, in terms of an individual's willingness to pay or to accept monetary compensation) would be neither appropriate nor cognitively responsible in view of the nature of the damages caused and the values affected. I am not denying that it is possible to attribute a monetary value to environmental damages, to human health, human life, or for that matter to esthetic values, just as I am not denying the possibility of placing a monetary value on a piece of art. In fact, in markets such evaluations are made constantly; but I am questioning and, in fact, I am *denying* that monetary values constitute appropriate and responsible criteria for the evaluation of the damages caused by environmental disruption. This is equally relevant for the premature exhaustion of nonrenewable resources, where the interests of future generations are at stake which are not represented and therefore will not be reflected in current market prices.

However, let me suggest an even more general way of looking upon environmental disruption. Economic processes (of production, allocation, distribution, and consumption) depend upon a continuous "exchange" of energy and matter between the economy and nature. In the course of these *nonmarket* exchanges, accessible free energy-matter is transformed partly into useful commodities and partly dispersed into inaccessible energy (increasing entropy). This transformation of inputs and the disposal of residuals give rise to qualitative and quantitative changes of both the resource structure and the biosphere. Since accessible energy-matter is not inexhaustible and since the volume of pollutants cannot be increased indefinitely without reaching critical limits with often (economically and technically) irreversible effects, the interaction between the economy and nature has not only a spatial dimension but also necessarily a critical range in terms of time. To proceed in our analytical models without a time horizon, that is, without a schedule of accessible inputs and their exhaustion in time and space, and to abstract from the fact that the emission of pollutants may approach or even exceed critical limits is equivalent to ignoring the interests of future generations; such analytical procedures are not value free; on the contrary, they rest upon an implicit value judgment reflecting a lack of solidarity with future generations according to the maxim *après nous le déluge*. To summarize: The economic process "cannot go on without a continuous exchange which alters the environment in a cumulative way and without being, in its turn, influenced by these alterations."[4]

The Market Mechanism as a Causal Factor

Although rarely admitted, there seems to be increasing agreement that environmental disruption and social costs are reinforced by the principles which guide the decision-making process of producers and consumers, that is, their choice of objectives and of the kind and volume of inputs as well as the choice of technologies and location. It is inevitable that in a market economy dominated by the desire to minimize entrepreneurial costs and to maximize net entrepreneurial returns, social costs and environmental damage tend to be "externalized" as far as possible within the existing institutional and legal framework, while appropriable monetary benefits (profits) will be internalized. Even if an individual firm wanted, and would be financially able, to consider the negative environmental effects of its products and its residuals in its allocation decisions, it could do so only at the price of reducing its own relative competitive position and its earning capacity except in those cases where alternative low impact technologies, locations, and outputs would actually be less costly or more profitable. However, while not inconceivable, alternative techniques will, as a rule, not even be explored and, if available, not be introduced because common property resources such as air and water for the discharge of pollutants and other residual waste products are available free of charge. Any economic unit, whether private or public, which operates within the market nexus and is tied to national or international competition will tend to keep its own entrepreneurial costs at a minimum even though the chosen input and output patterns will give rise to discharges of pollutants with a negative impact on the quality of the environment and hence on third persons, other firms, and society at large. Hence market systems may be said to have an institutionalized "built-in" tendency to reinforce environmental disruption and social costs. In other words, we are faced with the fact that the actual total costs of production are not covered by entrepreneurial returns and that the endeavor to optimize will be a pseudo-optimization which in effect is an uneconomic use of material and human resources.

After this attempt to analyze some of the substantive and general characteristics of our problem, it is perhaps useful to refer briefly to the specific historical conditions which have contributed to placing the problem of environmental disruption in the center of scientific and political preoccupations. This can only be explained by the fact that we have experienced an almost uninterrupted period of worldwide industrial expansion during the last 25 years. In the course of this postwar expansion, investment has not only been increased and sustained but also has been accompanied by structural changes of industrial activities. It has given rise to an accelerated development and introduction of new and highly polluting technologies, for example, by petrochemical complexes, as well as to a concentration of industries in a few urban centers, to new traffic and rapid transit systems, as well as to entirely new styles of living and consumption. This economic expansion was brought about by investment decisions (that is, the choice of new lines of production, technologies, and location) which took place without prior assessment of their economic, social, and ecological consequences. While profits were internalized and provided the economic justification as well as the means for further expansion along the same lines, environmental disruption and the control of pollution by appropriate equipment were neglected, or at best postponed. Once under way, the process assumed self-reinforcing and cumulative tendencies; that is, it did not by itself generate counterbalancing tendencies to slow down the disruption of the environment. On the contrary, the process moved on at accelerated rates in the same direction. The results are reflected today in the prevailing industrial and consumption structure operating with new and dangerous technologies and products, high rates of obsolescence, heavy demands upon nonrenewable resources, and the emission of a high volume of pollutants into water, air, and soil, particularly in areas of industrial and urban agglomerations. In Japan, this pattern of location was aggravated by the fact that the new industries found it profitable to locate their plants in coastal regions close to urban agglomerations and harbor installations where imports of raw materials could reach them and from which exports could be shipped at minimum costs.[5]

Environmental Policies and Control

In view of the fact that social costs and environmental deterioration are pervasive phenomena which raise serious doubts about the functioning and rationality of the market mechanism of allocation, production, and distribution, I am rather skeptical about the adequacy and efficacy of methods of control which aim at remedying environmental damages by indirect measures in conformity with the market system. For example, the following have been suggested: penalties, such as effluent charges and taxes; rewards, such as subsidies and tax reductions for low ecological impact technologies; the establishment of private or public property rights with respect to specific environmental media; and the sale, in markets or at auctions, of such rights or permits to pollute. While such indirect inducements by penalities and rewards may not be entirely ineffective, they remain piecemeal measures which, in my estimation, will not be sufficient to safeguard human health and social and economic reproduction in modern industrial societies. Environmental protection and the reduction of social costs call for more fundamental methods of control. Their minimization depends on our ability to make the maintenance of basic standards of safety and the protection of the quality of the physical and social environment explicit objectives of public policies. In other words, what is required is the establishment and enforcement of explicit environmental quality standards or norms. Only if economic units can be induced or forced beforehand to take adequate account of the negative social effects of their investments (including the choice of technologies, of particular inputs, and the location of productive facilities) is there hope for minimizing the current trend toward a progressive deterioration of our natural and social environment.

With this end in mind I see the key to an improvement of the present environmental situation in three types of measures.

The first is a strict public control of the use of noxious inputs and the disposal of dangerous residuals, if necessary by making the emission of certain pollutants a criminal offense, or by reducing output in some areas, or even by stopping production of certain industries altogether. Government will have to make the establishment of specific production facilities dependent upon the use of low impact techniques and inputs and the introduction of permanent public controls over the emission of harmful pollutants, taking into account the local meteorological and topographical conditions and hence the capacity of the environment to assimilate pollutants without harmful effects for the population. Less developed countries must resist policies of some corporations to establish, for example, their petrochemical complexes abroad without environmental safeguards in an effort to evade the antipollution legislation in their home countries and to shift the pollution of their own environment to other shores.

The second measure is the systematic development and promotion, under public auspices, perhaps in cooperation with industry, of technologies with a low ecological impact in order to reduce the degradation of the human environment by production and consumption. The systematic exploration of available alternative technologies and proposals, the promotion of research and development in these fields, and the formulation of an explicit science and technology policy directed toward low impact technologies seems to me one of the prerequisites for the protection of the human environment in the future. The new science and technology policy will have to take account of the *total,* including the synergistic effects of all residuals and their complex interaction as well as the danger that alternative techniques may give rise to a shift of the disposal of residuals from one environmental medium to another.

A third type of measures will have to aim at increasing the natural environment's capacity to assimilate residuals, on the one hand, and developing new ways of recovering and reusing waste materials, on the other.[6] For example, the assimilative capacity of water can be increased by the construction of reservoirs to stabilize river flows, the reaerization of streams and lakes, and the treatment (prior to emission) of chemical and biological wastes by special treatment plants. The latter principle can also be applied to airborne wastes emitted into the atmosphere (for example, desulfurization). The systematic recovery of materials and their reuse would have the effect of reducing the waste (and pollution) load by channeling residuals of production and consumption back into economic processes, thereby reducing the need for (new) inputs. Of course, investments in recycling techniques would have these productive effects only if the recycling process does not give rise, on balance, to greater energy requirements and to a net increase in the creation of new waste, or to a shift of pollutants from one environmental receptor to another.

I have endeavored to show that environmental disruption, in its various forms, that is, the pollution of the environment, the exhaustion of resources, and the attainment of critical limits of the assimilative capacity of the environment, challenges existing institutional arrangements and the whole pattern of unregulated economic growth and development in the industrial societies as well as in developing countries. In other words, scarcity of resources, the disposal of residuals, and the limits of the assimilative capacity of the environment place definite constraints on economic processes and particularly on economic growth.

However, this does not mean that economic activities and economic growth must necessarily give rise to a disruption of the environment which cannot be controlled. The volume and rate of pollution as well as the exhaustion of resources depend upon institutional arrangements, upon the choice of technologies and location, and the rate as well as the quality of economic growth. In other words, as long as we regard these three factors as autonomous and beyond social control—as independent variables, so to speak—and as long as we treat the assimilative capacity of the environment as infinite and not as a scarce common asset which needs to be protected by public policies and environmental planning, we will *not* be able to cope with environmental disruption.

Environmental policies and environmental planning call, above all, for a clear conception of what is essential, desirable, and possible. What is socially essential, desirable, and possible will have to be defined in the light of resource and ecological constraints, or more concretely in the light of the consequences of the impairment of the environment on human health and well-being and the necessity of maintaining the process of economic and social reproduction. This will call for the formulation of environmental quality standards or norms. These can be elaborated only on the basis of comprehensive data and sound empirical knowledge, taking into account accessible local, regional, and global resources (including energy resources), the current rate of their extraction and exhaustion, and the present impairment and possible limits of the assimilative capacity of the environment by alternative technologies and the present and future labor force.

In the course of the elaboration of environmental quality standards, conflicts will inevitably arise between different objectives, such as present and future consumption (and production) or short- and long-term needs, as well as between rapid and less rapid economic growth, stability, and employment; between the quality of different regions (or air and water); between development with different capital- and labor-intensive technologies and environmental impacts. In addition, there will be conflicts between those who share the benefits and those who bear the costs, and last but not least between different levels and styles of consumption. Some of these conflicts are due to the lack of appropriate knowledge and criteria of assessment; others arise from the physical limitations of accessible matter-energy. Hence, choices and compromises will have to be made between these conflicting interests and goals. Regulatory agencies will not be immune to powerful influences exerted by vested interests.

An important question is whether, and how far, these societal objectives can be evaluated, compared, and balanced in terms of market or exchange value, that is, prices. This is a question to which, in my opinion, inadequate attention has been paid in the past and to which much more reflection needs to be devoted in the future. I anticipate that market or exchange values are likely to lose in importance as criteria of valuation and comparison because, as I have pointed out before, they are not sufficiently adapted and are inappropriate as indicators and criteria for the evaluation of what is socially essential, desirable, and possible. They measure only part of the actual costs; they reflect existing inequalities of income and hence inequalities in the capacity and willingness to pay for environmental amenities and the achievement and maintenance of specific quality standards. Nor do exchange values (that is, market prices) take into account the interests of future generations not represented in markets.

Conclusion

I conclude that the environmental problem will force us to rely more than hitherto on what may be called individual and societal use values reflecting basic human needs and human well-being. These basic material and psychic human needs, or at least certain minimum requirements of human well-being, will have to be defined with a maximum degree of objectivity and would have to command a high degree of political consensus in order to be acceptable and operational. Admittedly, this may not be easy to achieve, but it is at least conceivable that some consensus as to the minimum requirements of environmental quality can be agreed upon in the political process, just as civilized societies have arrived at a certain degree of consensus as to minimum requirements regarding public health, education, and personal security which must be maintained and financed collectively. Of course, calculating and reasoning in terms of heterogeneous social use values raise fundamental difficulties with regard to their evaluation; there is no common denominator in terms of which use values can be easily compared and balanced against each other. But this does not mean that choices are impossible and that decisions must be arbitrary, or more arbitrary than those arived at in terms of market prices.

In my estimation the environmental crisis may force us to reverse or even replace the utilitarian moral principle of maximizing pleasure (with maximum income for a few) by the social and *moral* imperative of minimizing human suffering. Before the individualistic moral principle of maximizing pleasures can come into play, it is first necessary to minimize human suffering by bringing our institutional arrangements, our growth and development policies, and particularly the choice of technologies and of industrial location in harmony with environmental requirements and ecological constraints.

This means that we will have to operate increasingly with explicit societal goals as to the rate and quality of economic growth instead of treating economic growth and development as an autonomous process adequately measured in terms of GNP. To this effect we will need new and more complete growth theories which pay explicit attention to the structure and limits of resources, including the assimilative capacity of the environment. Since energy resources are the strategic variable,[7] it will be necessary to develop as soon as possible a system of energy analysis, indicating as completely as possible the energy requirements of alternative lines and techniques of production, with a view to serving as a complementary tool of decision making. We need models which take into account social conflicts arising in connection with environmental policies and environmental planning, as well as the obstacles and resistances by which powerful vested interests may delay and inhibit the successful search for truthful information, the formulation of rational environmental policies, and the implementation of environmental controls by regulatory agencies. We need new social and environmental indicators measuring various forms of disruption of the physical and social environment, so that the elaboration of environmental norms can be based upon a sound empirical basis. And we will have to examine our antidepression and anti-inflation policies with respect to the impact which fiscal, monetary, and price policies have, not only upon investments, employment, and income, but also upon the rate of depletion of resources and the deterioration of the environment.

Above all, we must abandon the fatalistic belief in the autonomy of technological change. This belief has always been problematical and indeed untenable. The evolution, choice, and application of new techniques have been determined by social factors, for example, deliberate research and development policies in accordance with the priorities set either by government for military purposes or in accordance with the aim of maximizing profits. It is possible and even highly probable that under the influence of these goals the development of new technologies has actually led to a selection of those which are anything but optimal from the point of view of society, considering their ecological impact and their energy requirements. While this selective process has given rise to a choice of techniques, inputs, and location which was considered successful in terms of private cost-benefit calculations, the development and application of low ecological impact and environmentally protective technologies were actually neglected.

In my estimation, the environmental crisis, its social costs, and the moral imperative to reduce human suffering call for a fundamental reorientation of our science and technology policies and priorities. Contrary to any fatalistic attitude toward the development of science and technology, it seems to me that technologies, techniques, inputs, and the choice of location will have to be treated as *dependent* variables which can and must be changed and channeled in accordance with our societal, including our environmental, goals and objectives. In practice this will raise a series of problems, particularly with respect to the formulation of science and technology policies, the modes of public participation in the setting of priorities and purposes of research and development expenditures, and the systematic *prior* assessment of the environmental impact of alternative technologies.[8]

I am thus led to my final conclusion that the environmental crisis will further accentuate certain trends in our disciplines which have been at work for a number of decades. Environmental disruption and the need to formulate environmental quality norms will not merely force us to a continuous and systematic interdisciplinary collaboration with a view to providing the knowledge needed to diagnose present conditions in order to define future requirements and to elaborate effective policies of control. This need for interdisciplinary work is in itself a major challenge to the social and natural sciences and to the boundaries of our disciplines as presently constituted.

However, interdisciplinary collaboration, while essential, is only one part of the new tasks before us. The real challenge of the environmental problem to the social and natural sciences arises from the fact that the direction and content of research will have to be oriented by societal needs and purposes to a much greater extent than in the past. As pointed out previously, scientific research and even the development of new theories have always been determined, at least to some extent, by social conditions and the requirements of society. In the future the social and natural sciences and applied technology will have to be open to a much greater degree than in the past to environmental and ecological constraints and objectives, that is, to explicit societal needs and human requirements. In other words, theoretical work and technological research will have to be guided by societal ends and norms. This process of permitting societal purposes, and particularly environmental ends or finalities, to determine the content and evolution of scientific research may be described as a trend toward a "finalization" of the sciences.[9] This, I believe, is the *fundamental* challenge which the degradation of the human environment raises for both the social and natural sciences.

Notes

1. Alan Coddington, "The Economics of Ecology," *New Society* 15 (1970): 395
2. Ibid., p. 595
3. For a more comprehensive account of the substantive character of the environmental problems, see Allen V. Kneese, "Background for the Economic Analysis of Environmental Pollution," *Journal of Swedish Economics* 73 (1971): 1–24. Kneese makes the point that "economic theorising and research that take place without being well informed about the substantive character of problems under study is in danger of being somewhat arid because of extreme abstraction, and of expending scarce energy and talent in pursuit of relatively unimportant matter" (ibid., p. 1).
4. Nicholas Georgescu-Roegen, "Energy and Economic Myths," *Southern Economic Journal* 41 (1975): 348.
5. Kenichi Miyamoto, "Japan's Post-War Economy and Pollution Problems," unpubl. manuscript, 1975, p. 12.
6. Investments of this kind might also be considered as investments in low ecological impact technologies in a broad sense of the term. However, I prefer to consider them as separate measures in order to bring out their distinct character.
7. Energy is the strategic variable since almost all economic processes, including the activities and technologies directed toward the protection of the environment, require energy.
8. For a more detailed account of some of the problems raised by the selective promotion of technologies with a low ecological impact, see K. William Kapp (in collaboration with Hans Baumann and Peter Wachtl), *Staatliche Förderung "umweltfreundlicher" Technologien* (Göttingen: Otto Schwarz and Co., 1976).
9. See Gernot Böhme, Wolfgang van der Daele, and Wolfgang Kohn, "Die Finalisierung der Wissenschaft," *Zeitschrift für Soziologie* 2 (1973): 128–44.