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Attaining Environmental Quality: The Role of the Technical Decision-Maker*

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ABSTRACT

Technological change has been identified as the major cause of environmental deterioration. This review explores the important role played by technical decision-makers in accomplishing this change. Focus is concentrated on the attitudes of engineers and scientists toward attaining environmental quality, as well as their role in making decisions which impact the environment. An analysis of the empirical literature reveals that engineers and scientists apparently fail to perceive the importance of attaining environmental quality but this may be a result of their exclusion from influence processes affecting basic decisions concerning the environmental impact of technological change. Recommendations are made regarding the actions that can be carried out within the engineering and science professions to sensitize their members to the ecological consequences of their activities, as well as to increase their influence in decision-making.

Introduction

Environmental degradation is generally attributable to the activities of man, but exploration has only recently begun to determine which specific aspects of human behavior have contributed most to pollution. Environmental scientists, Commoner and his colleagues[1] have attempted to provide empirical answers to the question: "What actions of human society have given rise to environmental deterioration?" They investigated the impact of population growth, increased affluence, and changing technology upon pollution, and found that "the most powerful cause of environmental

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pollution in the United States appears to be the introduction of ... changes in technology, without due regard to their untoward effects on the environment."[2] Consequently, they "draw the conclusion that the predominant factor in our industrial society's increased environmental degradation is neither population nor affluence, but the increasing impact per unit of production due to technological changes."[3] As an example of this impact of technological change, their research provided evidence that the substitution of synthetic materials for natural products has considerably intensified environmental deterioration. Furthermore, this deterioration is likely to be exacerbated since synthetic materials are projected to be one of the major growth industries of the 1970's, while production of some natural products will actually diminish in output.[4]

Additional support for the above conclusions is provided by a global model based on the work of Forrester,[5] a pioneer in the field of system dynamics. This model predicts the impact of various factors upon environmental degradation. The results indicated that neither the stabilizing of population nor capital growth would be sufficient to prevent global collapse. However, the model projected that combining changes in technological policies with value changes could produce a stability adequate far into the future.

Technological change is generally accomplished through the activities of engineers and scientists who create new products and processes, emphasizing considerations of economy and convenience while overlooking, perhaps unintentionally, the environmental consequences of their work. One view is that technologists naively believe that their efforts are directed ultimately toward the public good. This is essentially the position taken by Dubos, the microbiologist and presidential appointee to the Citizen Advisory Committee on Environmental Quality who observes that:

> Throughout the maelstrom of the scientific and technologic enterprise the almost mystic belief prevails that every innovation will be of use to mankind. Every physicist believes subconsciously that new insight into the constitution of matter will result ultimately in a piece of useful hardware; every chemist and engineer expects that new products, gadgets, or services that he develops for the market will in some way improve health, make life more comfortable, and increase both Productivity and leisure time.[6]

Furthermore, Dubos censures those professionals who make unwarranted claims that new technologies will solve all of our environmental problems, and charges them with "betraying the spirit and ideals of their profession when they accept the mores of the market place."[7] It therefore appears that Dubos perceives scientists and engineers either as naively believing in the ultimate good of their technological contributions or as deliberately deemphasizing their potentially adverse consequences which they feel can

be ameliorated by new technologies. In contrast to this image, Nader, the consumer advocate, depicts these organizational professionals as being very much aware of the potentially harmful effects of their activities, but as failing to utilize their knowledge to prevent environmental damage. According to Nader:[8]

> Employed professionals are among the first to know about industrial dumping of mercury or fluoride sludge into waterways, defectively designed automobiles, undisclosed adverse effects of prescription drugs and pesticides. They are first to grasp the technical capabilities to prevent existing product or pollution hazards. But they are very often the last to speak out, much less refuse to be recruited for acts of corporate or governmental negligence or predation.

Nader attributes the lack of "independence for the organizationally employed professional to exert his conscience in practice beyond that of the employer's dictates" to the effectiveness of the multiple pressures and sanctions of employers which result in the suppression of professional integrity.[9] However, the economist Galbraith, in *The New Industrial State,* has observed "that nearly all powers–initiation, character of development, rejection or acceptance–are exercised deep in the company. It is not the managers who decide. Effective power of decision is lodged deeply in the technical, planning, and other specialized staff."[10] Nadar is not altogether in disagreement with this analysis since his own observations of decision-making in the allocation of corporate resources for control of environmental pollution lead him to conclude that: "The excuse that there is a diffusion of power in a corporation and no locus of specific responsibility has long been a preconceived strategy of insulating company leaders from having to make such decisions."[11]

If Galbraith's analysis is correct, then engineers and scientists actually play an important decision-making role as part of the corporation technostructure whereas Nader's view implies that their power is only potential and generally exercised at the discretion of management. However, since these analyses are essentially impressionistic, the question as to which role description is more accurate can be answered more objectively by examining the available empirical research concerning the role of the technical professional in the corporation, as well as the organizational loci of decision-making power.

Research on the Role of Technical Decision-Makers

Research studies have revealed that, with the possible exception of PhD's working in R & D, most non-supervisory engineers and scientists perceive that they do not have a great deal of influence in the technical decision-making process, and that this power is in the hands of management,

particularly at the higher levels.[12] One of these studies found evidence "that levels of influence tend to be alike for both supervisory and nonsupervisory engineers."[13] The conclusion that technical management is also limited in its influence is further supported by a study focusing on engineering managers which revealed the following:

> The lowest level of engineering management views itself as the most excluded group in the decision-making process and views engineering as not having a very important place in the company as well as being the least influential factor in effecting product, divisional, or departmental policies.[14]

Thus far the evidence supports an image of the technical professional as being relatively powerless in the making of decisions. However, if the locus of decision-making is within the higher echelons of corporate management, it would be crucial to examine the degree to which important technical decisions are made by executives not having the appropriate professional expertise. Gould, in *The Technical Elite,* presents data from several studies which found a clear trend toward the increasing professionalization of big business leaders since the turn of the century.[15] Gould presents a survey of the background of the two top officers of each of the 600 largest American companies which found that almost all (91%) have had some college education, and that over a third had graduate school training. Of particular relevance is the fact that this survey found that one out of every three top executives had a degree in engineering or science. This role of engineers and scientists is borne out by another survey reported by Gould of 6,000 executives in manufacturing companies which revealed that 45% held technical degrees. This survey also found that over half of those between the ages of 35 and 45 had this formal technical education. Since the study was carried out over a decade ago, a technical background may be representative of the present and future corporate executives in manufacturing.

The increasing elevation of engineers and scientists into management positions is explained by Gould as resulting from the fact that "key managerial decisions today rest increasingly on technical and scientific premises that impinge upon and frequently override financial, marketing, and other business considerations."[16] This influence is demonstrated by the fact that eight out of ten technical managers in manufacturing have purchasing responsibility, whereas only half of the non-technical managers have such purchasing power in manufacturing industries. Gould concludes that "judged by the strategic criterion of industrial purchasing power, the technical elite represents a powerful influence in industry."[17]

Gould's conclusion tends to be supported by a study of decisions within eleven business organizations involving the purchase of new products. The study revealed that the individuals most influential in the purchasing

decision were those possessing relevant expertise.[18] The importance of a manager's technical expertise is further demonstrated by the fact that it is the primary reason that organizational professionals comply with their superiors' directives, in addition to being a direct influence on their own innovativeness, performance, and job satisfaction.[19] The importance of technical expertise to environmental decision-making has been recognized by industry since practically all pollution control executives in American corporations are either engineers or scientists, with the engineers clearly more predominant.[20] The relevance of such expert power to decisions affecting technological change and pollution control is one of the crucial factors in attaining environmental quality, but as one researcher has noted "the studies of organization decision-making have given little attention to broad environmental considerations."[21] Although research of this type is clearly called for, it does appear that despite the evidence that engineers and scientists lack influence in decision-making at the supervisory and non-supervisory levels, they do attain many of the highest level positions in the organizational hierarchy. Furthermore, those engineers and scientists who rise to the higher levels of management may possess greater power on decisions affecting environmental quality than that of those executives lacking a technical background.

Attitudes of Technical Decision-Makers Toward Attaining Environmental Quality

Technical expertise of decision-makers may not be the only important variable relevant to technological change since technology as well as the other factors contributing to the environmental crisis "are ultimately determined by human decisions which are motivated by human attitudes and values."[22] It appears, however, that even among an ecology-oriented population surveyed by *Natural History Magazine* engineers are least likely, relative to other groups including businessmen, to feel that beliefs and values are a basic cause of environmental problems.[23]

Actual evidence concerning attitudes and values of organizational decision-makers as they relate to environmental quality is quite limited and sometimes contradictory. One survey of 270 chief executives of major American corporations found that the majority felt that the protection of the environment should be taken into consideration, even if it meant inhibiting the introduction of new products, limiting production, or even reducing profits.[24] However, a more recent study of 3,453 *Harvard Business Review* subscribers, three-fourths of whom were in higher or second-level management, indicated that most were not willing to allow a dissident management faction seeking a revision of corporate policy on

pollution control to press its case with top management.[25] Although over half of the chief executives of American business feel that the Federal Government should step up its regulatory activities and establish a single national standard on pollution control,[26] the most powerful organizations representing business and industry in public policy decisions on environmental quality unanimously felt that there should be only limited regulation on industrial waste discharge.[27]

Whereas, it appears that American corporations are beginning to recognize their social responsibility in such areas as pollution abatement, support among business leaders, even for the sake of enlightened self-interest, is not unanimous, particularly when it affects profit performance.[28] However, Commoner's[29] conclusion concerning environmental pollution is that "the problem stems from the development of new production technologies which ignore ecology, and which are driven by profit." In light of the role of the technical decision-maker in attaining environmental quality, it is worth noting that even among an ecology-oriented population, engineers were least likely of any group, including businessmen, to question the profit motive as it now exists.[30] This is understandable in light of the fact that engineers' goals have been found to be "directed at achieving the goals of the company and advancing within the company,"[31] and that these are "goals and aspirations appropriate to an occupation whose aim is the development of useful technologies that will compete as products in the marketplace."[32]

The problem of market competition is exacerbated by the costs associated with pollution control, but even this factor is dependent on the efficacy of the technology utilized, or what has been termed "technological uncertainty."[33] One who has attempted to utilize new technologies to solve the cost problem is DeSeversky, the aviation pioneer, but even he has encountered "opposition from managers who, while they were interested in meeting pollution requirements did not want to be bothered with handling the by-products, which would get them into new types of operations, even though they might pay the costs of the anti-pollution equipment."[34]

What appears to be necessary for attaining environmental quality are technical decision-makers for whom attaining environmental quality is a primary professional goal. However, in a study of 1,000 design engineers and engineering managers, only one out of twenty selected pollution control as one of the frontiers of technology in the 1970's.[35] Even among a sample of engineers specializing in water resources, environmental quality was perceived as a relatively unimportant problem, although public health officials in the same community felt it was the most important problem in their area.[36] This lack of concern is supported by the *Natural History Magazine* survey of its readers, which found that active participation by

engineers in the conservation-ecology movement was considerably lower than by those in other professions or even by businessmen.[37] It appears, therefore, that the technical professionals who should be most aware of the implications of technological change for pollution, have been hardly cognizant of it.

Attitudes and Participation in Decision-Making

As several researchers have noted, a critical variable in an individual's behavioral response to pollution is the perception of his role in the decision-making process related to the resolution of such problems.[38] The study of water resource engineers discussed above sheds further light on this. Despite the fact that "the engineers were convinced that their training and experience enabled them to deal with water quality problems better than others, [they nevertheless] ... saw themselves principally as technical advisors, even though government engineers as well as consulting engineers were involved in the study.... The decision-makers, suggested the engineers, are the politicians."[39] This limited role in the decision-making process may very well be the crucial factor in the engineers' failure to perceive the importance of attaining environmental quality.

While the engineers may be cognizant of the fact that they have the expertise but lack the political influence to attain environmental quality, their own lack of political participation contributes directly to this situation.[40] Spokesmen for the engineering profession have recognized this problem, as the following statement by a professional engineer demonstrates:

> For the engineer to have a stronger voice in eliminating the adverse effects of technology on the quality of life, both in his work and at the decision-making level of public life, it will require a revision, not only of his training to make him more compassionate, and better able to communicate, but also of his basic inherent psychological structure which makes him reluctant to climb the political mountain.[41]

This need for a change in basic attitudes is echoed even more strongly by another professional engineer, a White House Fellow assigned to the President's Council on Environmental Quality:

> We, as engineers, now need to make the most difficult change of all. Not just a change in our knowledge, but a change in our minds. We are so much creatures of our mental images that we find it more difficult to change our minds than to change our environment. If engineers are to stay relevant we must get involved. We must move to where the action is—in Government—and take our rightful place in the decision-making process that sets our national policy—policy that affects us all, every day of our lives.[42]

Scientists are very likely excluded at least as much as engineers from public policy decision-making. One analysis of the problem reaches similar conclusions as those presented by engineers, namely that the deterioration which is leading us toward a final castrophe can be averted by having scientists penetrate into politics.[43]

Although the importance of the engineer as well as the scientist in the attainment of environmental quality has long been recognized at the highest levels of government,[44] it appears that, with a few exceptions, these professionals have not aspired to public policy-making roles. However even when engineers and scientists do attain decision-making power, either in industry or government, their technical expertise, while necessary for solving environmental problems, often is insufficient for judgments beyond their professional competence. As one researcher pointed out,

> These professional judgments often involve assessment of public preferences that go largely unchecked. An engineer's view of public valuation of a polluted stream or a soot-ridden sky rarely is tested by investigation and commonly enters into public decision in situations in which individual citizens can express a disapproval of the plan but not of its assumptions as to their preferences.[45]

This type of behavior was found to be the case among the water resource engineers who tended to reject direct public participation with such statements as, "the public is not well informed and therefore cannot make rational judgments," and "consulting the public makes planning much more difficult, and generally it delays or even precludes any action being taken."[46] Such attitudes even exist toward the customer, since few engineers feel that the assessment of the quality of their professional performance should depend upon the consumer of their product or service.[47]

Herein lies the danger of technical experts attaining decision-making power without an associated change, not only in their attitudes toward the importance of attaining environmental quality, but toward public participation in the planning process as well. One researcher, in fact, has concluded that: "Unless our present experts broaden their views and their activities, they may well contribute more to the promotion of the environmental crisis than to its solution."[48]

Conclusions and Recommendations

This analysis of the role palyed by technical decision-makers in attaining environmental quality provided evidence to support the following conclusions:

- The immediate cause of environmental degradation is the introduction of technological change without a prior assessment of the impact of such change on the environment.

- Engineers and scientists have been directly responsible for creating technological change but they apparently have not utilized their expert knowledge to prevent environmental degradation concommitant with this change.
- The decision-making power of engineers and scientists is quite limited, even among technical management, thereby excluding them from influence processes affecting basic decisions concerning the environmental impact of technological change.
- There is a failure of engineers and scientists to perceive the importance of attaining environmental quality and this may be a direct result of their limited role in the decision-making process.
- Corporate executives possessing the decision-making power likely to have the greatest impact on the environment most often come from the ranks of technical professionals but their attitudes and behavior toward attaining environmental quality have very likely already been shaped when their organizational influence was more proscribed by their roles as non-supervisory professionals.
- Technical professionals tend to be unwilling to allow the public which may be affected by their product or service, to participate in decisions regarding the assessment of their activities.
- The limited role of technical professionals in the political influence system deprives public decision-making of the expert knowledge necessary to eliminate the adverse effects of technology.

Faced with this depiction of the technical professional as not playing as effective a role as would be required for the attainment of environmental quality, it is necessary to create some practical approaches to sensitize engineers and scientists to the ecological impact of their activities, as well as to increase their influence in decision-making. Such change is likely to be most effective if it is carried out by the technical professionals themselves, and to attain this end the following recommendations have been formulated:

1. Schools of engineering and science should be required to educate their students in the knowledge and skills necessary to deal with the impact of technology on the environment. This involves the introduction of new courses which would not only integrate relevant knowledge in such neglected areas in technical education as social and behavioral science, life sciences, and law, but also emphasize the skills necessary for carrying out technological assessment[49] and determining the social costs of innovations. There are several

approaches schools can use to integrate courses on the environment into technical curricula.[50] Perhaps, most appropriate would be required courses utilizing a systems approach to the complex problem of attaining environmental quality.[51] Examples of such courses at the undergraduate level are "Man and His Environment," required for civil engineers and architects at Stanford University[52] and "System Design and Societal Problems," a multidisciplinary sequence offered at the Polytechnic Institute of Brooklyn.[53] Requirements can be enforced by means of withholding approval of curricula lacking such courses by such accrediting groups as the Engineers Council for Professional Development. The transmitting of the appropriate environmental knowledge and skills is relatively easy to accomplish via the educational process and the degree of curricular change called for would likely be minimal.

2. Continuing education programs for experienced engineers and scientists, focusing on environmental problems should be established by schools of engineering and science, as well as by the professional associations. Some movement in this direction is already apparent as indicated by the convening of a workshop on continuing education as part of a conference on Engineering Education and Environmental Problems, sponsored by the Association of Engineering Colleges of New York State and the Office of Science and Technology of the New York State Education Department.[54] The participants in this workshop felt that for engineers and scientists to deal more effectively with the complex problems of the environment they must receive special training either to extend or update their knowledge in environmental technology as it relates to their disciplines. Furthermore, it was felt that such continuing education courses should be non-credit in order to avoid constraints which might result in a loss of flexibility. Short courses of this type are taught at Westinghouse Electric Corporation's School for Environmental Management and attracts professionals from both government and industry.[55]

3. Formal groups should be created by educational institutions and professional associations for the purpose of stimulating change in attitudes toward attaining environmental quality. The changing of attitudes vis-a-vis the environment is clearly a much more formidable task than imparting knowledge and skills. One possible approach to carrying out attitudinal change is to adapt the techniques of T-groups in order to sensitize technical professionals to their personal role in creating environmental degradation. Such sensitivity groups can be

structured as seminars and required at undergraduate and graduate levels. Professional associations as well as schools can offer such seminars as part of their non-credit continuing education programs for experienced professionals. Assistance in establishing these, as well as other types of programs may be available from the Office of Education under the National Environmental Education Act which authorizes grants and contracts to educational and other nonprofit institutions for the purpose of developing and evaluating environmental educational programs.

Since many engineers and scientists continue their graduate education in areas of management, schools of business administration should also utilize such seminars, thereby reaching the organizational decision-makers of the future. An example of this approach was a seminar offered by the Department of Management at the Polytechnic Institute of Brooklyn entitled "Ecology and Resource Management." This seminar provided engineers and scientists, who were graduate students in management, direct interaction with professionals involved in their daily activities with environmental quality in ecology organizations, government, or industry. Evaluation of attitude change toward environmental quality. as a result of participation in this seminar is currently being carried out.

4. Direct interactions between technical professionals and the public should be stimulated by educational institutions and professional associations. The purpose of these interactions would be to expose engineers and scientists to the views of the public regarding the solution of environmental problems thereby providing an important but neglected input into the decision-making process. An example of involving the public in such an interaction was a day long symposium jointly sponsored by the Center for Urban Environmental Studies and the Department of Management at the Polytechnic Institute of Brooklyn.[56] The symposium entitled "The Environment, the System, and the Citizen" brought members of the public face to face with engineers, scientists, and other professionals from business, industry, government, and ecology organizations. However, a more meaningful encounter between the technical professionals and the public is created if the focus of such meetings would be on issues directly relevant to the community such as providing for energy sources, mass transportation, or sewage treatment. An indication that this is already happening is apparent from the fact that the Department of Transportation Planning and Engineering at the Polytechnic Institute of Brooklyn has recently hosted an all day encounter between the

New York Metropolitan area public and transportation professionals as one of a series of hearings initiated by the U.S. Department of Transportation to provide information on consumer needs for decision-makers.[57] The inclusion of the public in the development, use, and regulation of technological innovations is central to a developing phenomenon which has been labeled "participatory technology."[58] The institutions of engineering and science must be directly involved in this in order to assure that citizen needs are integrated with technical expertise for making decisions about problems having an environmental impact.

5. The professional societies should play a central role in influencing public policy-making decisions for attaining environmental quality, particularly in regulating the professional behavior of environmental decision-makers. There is limited evidence that some progress has already been made in this direction. For example, the New York City chapters of the State Society of Professional Engineers carried out and published an extensive study of meeting power needs and the effects on pollution.[59] The society also sponsored legislation requiring those responsible for making major engineering decisions in utilities organizations to have professional engineering licenses. Such individuals would be subject to professional and ethical review by the State Engineering Board of Examiners. A logical extension of this would be to require major technical decisions affecting the environment to be made by individuals certified by the Environmental Engineering Inter-Society Board.[60]

   Regulating of professionals should also be applied among specialists who serve on committees that provide advice on various government levels. The National Academy of Science is now requiring that all of its consultants file statements as to any possible conflicts of interest or biases if they serve on committees advising the Federal Govenrment.[61] The professional societies must also be prepared to defend their members who blow the whistle on potentially destructive or unethical practices in their organizations. The American Association for the Advancement of Science has done this in the case of two AEC scientists who claim that they have been harassed as a result of their whistle blowing on radiation standards.[62] One recent survey has, in fact, shown that few technical professionals are willing to blow the whistle on environmental degradation either within or outside their organizations.[63] Increasing the power of the professional societies in public policy-making as well as regulating and protecting professional behavior will provide the technical expertise

and professional integrity which is so necessary for overcoming the environmental crisis.

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