



Book Reviews

Daniel Martin, *Three Mile Island: Prologue or Epilogue?* (Cambridge, Mass.: Ballinger, 1980).

Modern technology has provided us not only with goods and services, but also with an inner peace deriving from a sense of invulnerability. In return, technology has demanded from us a new kind of societal faith. We must believe that any device that has the potential to be threatening has a companion mechanism to control it. We must also believe that there are people who understand the control mechanisms and who are making sure they are in place. The accident at Three Mile Island reminded us that both the control mechanisms and the people who operate them can fail. Daniel Martin's stated purpose is to reconstruct that event, then address a fundamental issue: Our society has learned to live with auto accidents, plane crashes, and oil spills, accepting them somewhat fatalistically because we gain more than we lose through occasional failures. *But are we really equipped, physically and emotionally, to tolerate a catastrophic failure of a nuclear reactor?*

Martin feels that we have avoided this question in the past. We assumed that every conceivable breakdown could be analyzed in advance and a machine built to counteract it,

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and that other machines would counteract failures in the monitoring machines. We further assumed we could train people so well that they would override the unbreakable machines only when necessary. *Three Mile Island: Prologue or Epilogue?* shatters these illusions dramatically, leaving the reader convinced that there is no way to avoid that ultimate question: Are we prepared to accept a meltdown, or shall we build only those technologies whose failures we can tolerate? It is not investigative journalism; it does not assign blame; it does not seek out conflicting statements. It is written with the perfect hindsight afforded by thousands of pages of hearings and reports available from the President's Commission and elsewhere. Its minute-by-minute account of the actual events is captivating: the reader feels like an all-knowing but helpless fly on the wall, who knows exactly what is going awry technically and organizationally, knows what the operators are doing wrong, and knows of the training deficiencies that led to their mistakes. The reader looks on anxiously as the utility, the NRC, and the state and federal governments try to figure out how serious the problem is and how to hide their ignorance from a panicky public.

Martin explains lucidly technical phenomena, like the behavior of saturated steam, which allows a pressure relief valve to control the temperature of the reactor core. Each chapter describes the events from the perspective of the participants, including utility officials, reactor operators, the governor, the NRC, and the White House staff. The text is punctuated with vignettes that would appear out of context to be gallows humor, or merely anecdotal illustrations of Murphy's laws. However, they leave the reader with a realistic appreciation for the differences between theory and practice.

Warning lights flash but operators fail to notice them. Another light indicates that a valve is closed when in fact it is jammed partially open. A hydrogen recombiner is available for emergency use, according to NRC regulations, but it is not connected to a power supply, and no one can enter the area it is in to hook it up. The NRC discovers that it has been using the wrong formula to analyze the possibility that the reactor might explode. The respirators worn in the reactor control room make talking very difficult, especially on the phone, so crucial communications are garbled, as when "site emergency" (a term indicating serious danger) is recorded as "slight emergency." The chairman of the NRC calls the governor of Pennsylvania but is unable to get through. By leaving schools in session, the governor ties up the buses that would be necessary for any thorough evacuation of the endangered area.

Another author might have elected to highlight other events to emphasize how many systems worked well. Martin's intention, however, was to convince the reader that a catastrophic reactor failure is eventually inevitable.

The book is not as analytical as its subtitle implies. Only one chapter in fourteen addresses the "Prologue or Epilogue?" issue. That chapter could stand alone, but the first thirteen chapters take the reader through such an exciting account of the TMI incident that the impact of the final chapter is magnified tenfold.

The analysis is from the perspective of a political scientist, focusing mainly on the stakes held by the institutions involved, and the societal decision to be faced. It does not directly address the economic viewpoint: that the problem can be formulated as a simple risk/benefit analysis, and can be examined at the limits where the probability of failure is made arbitrarily small and the magnitude of that failure catastrophic. Martin implicitly rejects this formulation of the problem, treating catastrophic failures as a discontinuity, not as a predictable projection of past events.

The problem, as Kenneth Boulding once observed, is how to learn about cliffs without falling off them. We learned about earlier, more forgiving, technologies in the way that an

infant learns about hot stoves and stairs. But in the twentieth century we have developed a few technologies whose uncertain risks we cannot evaluate because we cannot afford to do the experiment. Nuclear meltdowns, the greenhouse effect, and nuclear war are a few examples. The impacts of such modern technologies "reach" so far through space and time that markets cannot ensure an economically efficient balance between benefits and risks, and ethical implications cannot be ignored. Risk/benefit analysts, especially those who have already calculated how many cylinders must be unloaded before they will play Russian roulette, are likely to find Martin's reconstruction of the TMI incident only anecdotal, and perhaps irrelevant. However, analysts concerned with the social and political aspects of technologies that fail catastrophically will find Martin's case study fascinating and important.

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Carroll L. Wilson (Project Director), *Coal: Bridge to the Future*, Report of the World Coal Study (Cambridge, Mass.: Ballinger, 1980).

This world coal (WOCOL) study reports the findings of an interdisciplinary energy policy study group directed by Carroll L. Wilson, chairman emeritus of the Massachusetts Institute of Technology's civil engineering department. The group is appropriately polyglot and represents mineral engineering and coal project analysts from both industry and government institutions around the world.

WOCOL is independent, deriving its primary support from university, private institutional, and foundation funding—not exclusively from governments, although it relies on support and previous work from the U.S. Department of Energy. For its international perspectives it depends on World Bank and similar studies abroad, especially by the Organization for Economic Cooperation and Development (OECD).

The goal is "to examine the future needs for coal . . . and to assess the prospects for expanding world coal production, utilization, and trade . . .," with special attention promised to environmental issues. The report concludes on a note of cautious optimism: that world coal resources are adequate through the year 2000, provided that the supply side receives immediate assistance and the demand side is not overconstrained. Supporting conclusions are that there are no insurmountable obstacles to the control of environmental health and safety hazards, technical improvements, the functioning of the marketplace, or the financing of expansion. This leaves as the only concern the adequacy of lead times should a high-coal environmentally worst case occur. The report favors a policy of incentives now to the supply side to guard against such an event.

Energy specialists who have been looking for a demonstration that coal will dominate fuel alternatives will be disappointed in the way that the report reaches its conclusions. WOCOL

abandoned at an early stage any attempt to define or model supply and demand in precise ways. Thus, it represents at best a Delphic market survey that attempts to reach a consensus on future energy imbalances between potential production "capabilities" and "requirements." Economists will be particularly critical of this. Lacking substantive analysis, the principal exercise of the study becomes its estimation of aggregate coal supply and demand balances for each country under (1) moderate and (2) maximum consumption scenarios. Serious problems attend this exercise, reflecting on each WOCOL conclusion.

The analysis of coal resources, reserves, and production is naive. No attempt is made to categorize individual regional endowments by the petrographic and geological conditions important to the costs of mine output and delivered prices. No range of prices portraying potential supply in the short or intermediate run is provided. Indeed, no estimates are given of the extent of uncharted resources. Helpful estimates of the investments and costs of typical supply chains are provided, but they are quite inadequate for the prediction of efficient potential supply patterns over the period. Similar details, necessary for a proper spatial assessment of reserves, are also lacking on transportation and on the linkages through ports and other facilities. Indeed, over half the developed reserves from which current world production comes are omitted from the review. Clearly, some notion of the elasticities of supply for these and rival resources at very high energy prices is critical to the WOCOL predictions.

Given the general adequacy of total world resources, the study focuses on the lead times required to construct specific linkages as the central regional trade problem. However, the examinations of trade routes and spatial distributions of demand are superficial, so the study provides little proof of the comparative advantages implied by the WOCOL trade patterns. Over 75 percent of the total cost of delivered energy in the typical chain stems from the stages following coal extraction and cleaning. The lead times required for the construction of user facilities are longer than those required for mine development. The latter lead times, therefore, cannot be the critical constraints. WOCOL provides no analysis of rival fuel options, elasticities of demand, or ease of substitution. As Gordon points out (1976, 1977, 1978), these factors are critical to the analysis of a coal supply system. WOCOL simply assumes the extent to which natural gas, oil, nuclear, and exotic fuels sources will not be sufficient to meet the world's growing energy demands. Because WOCOL procedures beg the question of economic efficiency, there is no way to validate its fuel source hypotheses. Estimates are confused further by the fact that the individual country trades are not computed on a consistent basis.

The report seems singularly deficient in cost engineering details about the major alternatives for mining and delivering coal safely and cleanly. Had the report represented the considerable and growing technical literature on the comparative costs of mining, reclamation, mineral preparation, conversion, and environmental control, it would have helped to define substitutes and alternative coal sources. But this report leaves estimates of production costs and use unrelated through regional supply and demand elasticities. The lack of explicit reference to engineering economy and epidemiological studies makes it difficult to appraise sensitive elements in study comparisons. If the technical, geological, and environmental conclusions are not demonstrated but asserted, what is the chief value of the study? The survey's merit must rest on the economic implications about the extent of coal use and the probability of chronic excess demand occurring. Its concerns are supported currently by the upswing in the exports of U.S. steam coals following the doubling of oil tariffs by OPEC. Most interest has been excited by the WOCOL estimates of export balances, described at a

time when energy policy modeling failed to predict significant new demands in international markets. The study is the first to publicize the implications of nuclear delays occurring abroad. It is the first to suggest also that the two major coal-rich developed countries, the United States and Australia, must provide the world's coal surge export capacity.

The authors predict greatly increased coal consumption, which could triple to 7500 million tons of coal equivalent (mtce). However, the report's gross import estimates are not high compared to its estimates of export potential by country. World coal trade increases only to 560 mtce in the moderate-growth case or 980 mtce in the high-growth case. These expectations are well within the 930-mtce export capacity of the industry.

Only in the "worst case" do import demands of 1500 mtce exceed the export potential. The deficit is 570 mtce. Is this hypothetical shortfall cause for alarm? The study attempts to argue that it is, but is unconvincing for two reasons: one, as already noted, is the lack of economic analysis and specific information by regions for coal types serving the various markets. The second reason is simply that the world's traded sector supply is a very small part of the general coal supply system under discussion. WOCOL obviously judges the general system's elasticities of supply to be high, since it assumes that the industry is capable of tripling output without difficulty—adding 5000 mtce. The export sector of the system is a relatively small part of this increment. For boiler uses, these coals exhibit a high degree of substitutability. Because the traded increment in question is only one-tenth of the total increase in supply, therefore, it is likely to be as easily generated as the domestic component of supply. Thus, the high supply elasticity presumed in general would seem to preclude WOCOL concerns over excess demands developing in the export sector. For these reasons, the study's alarm about potential shortfall will be questioned by most experts.

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W. T. Ziemba, S. L. Schwartz, and E. Koenigsberg, eds., *Energy Policy Modeling: United States and Canadian Experiences: Volume I, Specialized Energy Policy Models; Volume II, Integrative Energy Policy Models* (Boston: Martinus Nijhoff, 1980).

You can't judge a book by its cover, as the saying goes. From the title of this two-volume set, one might expect to find inside some fascinating comparisons of U.S. and Canadian energy problems; a description of the policymaking processes in the two countries, and a discussion of how models have been used and misused in these processes. What one actually finds is a series of papers largely devoted to technical descriptions of various energy models. Although the United States is named first in the book's title, the papers are drawn from those presented at the Canadian Energy Policy Modeling Conference of 1978. About 60 percent of the contributors to the two volumes are from Canada.

It is also difficult to tell from the titles what each volume is about. The first volume, *Specialized Energy Policy Models*, contains sections discussing energy demand modeling; energy supply modeling; coal and transportation modeling; and the problems and interac-

tions of energy, environment, and conservation. Some of the models described are actually very broad in scope, for example, "The Energy Demand Forecasting System of the National Energy Board" by Preece, Harsanyi, and Webster, and "Modeling U.S. Coal Supply and Demand" by Edward Griffith. The second volume, *Integrative Energy Models*, comprises sections on the process of energy policy modeling; national and regional energy modeling; the Alaska gas pipeline; and the problems of financing energy development projects.

Although the back covers proclaim that a major aim of the conference was to "determine the extent to which energy modeling had and could make a contribution to energy policy decisionmaking," there is little discussion of this issue in most of the papers. Two panel discussions, one on "Important Canadian Energy Decisions for the 1980s and Beyond," and the other on "The Future of National Energy Modeling," make a hasty effort in this direction, as do short papers by W. Marcuse and Harvey Greenberg.

One would expect, at a conference of this type, to hear some discussion of energy relations between the United States and Canada; the opportunities for modeling in this area would appear to be abundant. The regulation of energy trade by each country is characterized by rather complicated problems of bilateral monopoly, second-best pricing, game theory, and the theory of exhaustible resources. If any work is being done in this area, it was not represented at this conference.

My overall impression is that this conference tried to bite off more than it could chew: the entire discipline of energy modeling in two countries. The result is something of a potpourri of papers. The strong points of the books are the editors' introductions to each section, which are excellent literature reviews. The book is useful to own as a reference.

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