13 Oct 1977

Manufacturers' Responses to Fuel Supply Problems

Evelyn R. Rosenthal

MANUFACTURERS' RESPONSES TO FUEL SUPPLY PROBLEMS

Evelyn R. Rosenthal
State University of New York
Binghamton, New York

Abstract

The progress of energy conservation in industry was investigated with the aim of identifying barriers to strong energy conservation efforts. One of these barriers proved to be fuel supply problems as exemplified by the natural gas shortage of 1976-77.

1. INTRODUCTION

Widespread awareness of our national profligate use of non-renewable fuels dates from the events of Winter 1973-74. I will not recount those events here except to note that fuel use awareness rose in step with fuel prices. (1) Management in manufacturing plants prudently instituted energy conservation programs, often with unexpected returns of fuel savings as high as 30% from small investments in labor and equipment. From the point of view of energy conservation in industry, the oil crisis accomplished in a short time much more than had the ideas and exhortations of scientists, technicians and conservationists. However, industry's accomplishments in energy conservation still lag behind what many analysts in and out of industry believe to be technologically possible and economically feasible. (2) Writing in Science on 19 April 1974, Charles A. Berg, then chief engineer at the Federal Power Commission, speculated on the reasons for this. (3) He surmised that barriers to the adoption of more energy-efficient equipment and procedures by industry were not, in 1974, technological nor economic but institutional and political. In Berg's view, increased awareness on the part of industrial managers of the economic potential of fuel conservation would lead to rapid dismantling of institutional barriers and substantial reductions in the energy needs of industry. As with most predictions in the field of organizational behavior, Berg's proved to be only partly true.

Beginning in the Spring of 1977 a team of researchers from the State University of New York at Binghamton examined a sample of industry's energy conservation activities. (The research team includes E. Rosenthal, assistant professor of sociology, S. Hsu, associate professor of geography, E. Hughs and S. Sutherlan, graduate students in geography. The research is supported under a contract from the Federal Energy Research and Development Administration to the State University of New York Research Foundation.) We sought to identify the institutional and political barriers to more efficient industry use of fuel. One of those barriers proved to be uncertainty of fuel supplies, as experienced by industrial users of natural gas during the Winter of 1976-77. I will describe briefly the course of energy conservation efforts up to 1976 as a background for demonstrating the effects of the gas shortage on conservation efforts. Some of the organizational conditions conducive to rapid adoption of energy conservation measures by 1976 will be suggested. More specifically, I will focus on the role of the natural gas crisis as a barrier to energy conservation by presenting examples of management's coping strategies when faced with gas supply curtailments. Last, I will explore the implications of those strategies for the future of energy conservation in industry.

2. DATA SOURCES AND METHODOLOGY

This past Spring and Summer we interviewed executives and managers in 31 manufacturing plants in two Northeastern metropolitan areas. We chose our 31 case studies on the basis of diversity of plant size, product, fuel needs, age, level of automation and current rate of expansion in order to test Berg's model of rational corporate decision-making in a wide variety of technological and organizational contexts.* Our interviews were mainly open-ended discussions of how management was dealing with energy problems of rising fuel prices and natural gas shortages, but also included several structured questions on plant fuel use patterns, the organization of the firm, proposed federal energy policy options, and details of management's information search behavior with respect to energy saving technology. In most plants, we were given access to records of fuel usage back to 1970. We were generously provided with data documenting management decisions on past energy conservation actions and future plans. Where security clearance was not a problem, we were permitted to tape our interviews and walk through the plant.

The data gathered from these non-randomly chosen case studies can only be suggestive of management behavior in general; validation of the findings will rest on results from a broader study not yet completed. Designed primarily as a pilot project prefacing a national inquiry into the extent, nature and pace of industrial plants' energy conservation efforts, these case studies nevertheless afford an opportunity to examine in detail management's responses to recent natural gas supply problems.

3. THE PROGRESS OF ENERGY CONSERVATION PRACTICES IN INDUSTRY TO 1976

Most managers, confident of continuing general fuel price rises, and aware of the economic potential of conservation, did attack institutional barriers and adopt or expand their use in the plant of energy-efficient technologies and procedures. Energy-efficiency gains were most impressive in plant heating, cooling and ventilation; managers showed much more reluctance to risk innovations in production processes.** In every plant we visited, management had done something about energy conservation; even the laggards in adopting energy conservation technologies had typically lowered thermostats in office areas and attended to some previously neglected maintenance chores, while the pioneers had completed energy audits, made capital investments in more energy-efficient equipment, developed plans to meet plant-wide energy use goals, and in a few cases were experimenting with new production techniques. Plants weak in energy conservation actions had not yet begun to monitor energy use in any systematic manner nor had they conducted an energy audit; nine of the 31 plants were in this category. On the other hand, nine plants had responded strongly to energy conservation. The remaining 13 plants fell between these extremes. We based these judgments on the length of time since management had begun acting on conservation awareness as well as the extent of their implementation of conservation measures by 1976.

I need to emphasize here the subjective nature of these ratings in spite of our efforts to systematize them. Each plant was assigned a conservation score theoretically ranging from zero to 12 on the basis of our analysis of interview transcripts and notes from plant walk-throughs. The scores reflect organizational changes, technological innovations and the timing of these responses. The lowest score assigned was two; the highest 12.

Plants typically adopted few technological innovations without prior organizational changes. I will not list the diverse energy-efficient technological innovations here; our research team is preparing a full analysis of these changes. Organiza-

*Rogers and Shoemaker (4) discuss the model of social change implicit in Berg's statements, and alternative models as well. Their work includes a comprehensive bibliography of empirical diffusion research from several theoretical traditions.

**The historical tendency of U.S. industrial leadership, with few exceptions, to avoid risk-taking through innovations in the production process is documented by Strassman (5) for the 19th century. My own research, nearing completion, documents for the 20th century a conservative approach to production innovations on the part of U.S. industry that reflects exaggerated and often non-rationally based perceptions of risk.

tional changes that indicate a high priority for energy conservation include: close monitoring of fuel use in production and in work environment, assignment of responsibility for energy management to a high ranking executive, formation of an energy task force, information search behavior such as attendance at industry association or fuel supplier seminars, engagement of outside consultants, and modification of financial policy to permit extended payback periods for investments in energy efficiency. Although we observed no common time sequence among these actions, plants typically began with unsystematic attempts at improving plant maintenance and reducing fuel use for space heating and cooling. Those who would prove to be most successful in conservation soon assigned responsibility for energy management to an individual or permanent committee reporting directly to the plant's chief executive. When the chief executive assumed responsibility for energy management without benefit of a committee or energy officer, however, the results were at the extremes: either nothing more was accomplished or the plant's efforts were outstanding.

As summarized in Table 1, large plant size, rapid growth of production, relatively new plant equipment, a technically-trained plant manager and plant autonomy in decision-making were important factors related to rapid adoption of many energy conservation measures. We were surprised to find that neither energy-intensiveness of plant production nor management's perceptions of the causes or future direction of energy problems were related to energy conservation efforts. As expected, we found that gas shortages were suffered equally by those who had adopted conservation-oriented policies as well as those who had not.

Interviews at plants where efforts lagged supported the converse of Berg's contention that conservation actions follow economic incentives. In other words, weak conservation programs were associated with low management awareness of the economic potential of fuel efficiency measures. Typically, the managers and executives at these plants ranked fuel last, if at all, when recounting the factors that influence their decisions. But high awareness of the economic potential of energy conservation did not guarantee strong efforts to achieve energy savings. In four cases where management had been surprised by unexpectedly large cost savings from improved plant maintenance practices, conservation efforts went no further. Here, management rejected technological and organizational changes that would lead to conservation and instead pleaded preoccupation with more urgent problems such as labor turnover, marketing difficulties or meeting production goals. Very old plant equipment or, at the other extreme, specially designed, highly automated plant equipment were mentioned by management as barriers to more effective energy conservation programs. In our sample, old or highly automated equipment was related to weak conservation programs, especially in plants with little local autonomy from centralized decision-making.

Table 1

Plant Characteristics and Energy Conservation Success (N=31)

Strength of Association With Conservation Success	Plant Characteristics
strong	plant decisions autonomous of centralized authority (n=13)
strong	recent rapid growth of production (n=10)
strong	plant manager has technical/scientific training (n=16)
strong	bulk of plant equipment at moderate level of automation (n=11)
moderate	bulk of plant equipment 10 years old or less (n=11)
moderate	300 employees or more (n=12)
no relationship	management views energy problems as worsening in the future (n=21)
no relationship	management ascribes energy problems to political causes (n=14)
no relationship	high energy cost per dollar output (n=15)
no relationship	plant experienced gas cutback of 30% or more (n=18)

4. THE EFFECTS OF NATURAL GAS SUPPLY CURTAILMENTS OF 1976-77 ON THE PROGRESS OF ENERGY CONSERVATION PRACTICES IN INDUSTRY

Our case study results show a heterogeneity of responses to natural gas supply curtailments in contrast to the similarity of management's general fuel price rise coping strategies described above.

Clearly, supply curtailments tested the ingenuity of management in a manner that the all-too-familiar problems of rising costs did not. The two challenges of management, that of rising rosts and of unavailability of natural gas at any cost, were perceived to be fundamentally different and to require responses that reflected this difference. Management saw the first challenge, rising fuel costs, as a hardship but not a crisis; most met the challenge by monitoring fuel use with an eye toward holding down costs and planning for the future on the assumption of continuing fuel price increases. To management, the second challenge of unavailability of natural gas at any cost was a major crisis if the plant depended on natural gas. Plant shutdowns were common; future plans regarding energy use showed a reordering of priorities away from holding down costs toward gaining independence from natural gas. Overall, our investigation suggests that industry's recent experience with managing gas supply curtailments worked against the goals of energy conservation. Some examples from our case studies will document this conclusion.

Of the 31 plants we studied, 18 had experienced moderate to severe natural gas supply problems, with all but two of these supply curtailments first coming during the Winter of 1976-77 (we define a curtailment of 30% or more of base year usage as moderate to severe). One plant had been cut back on gas the year before and another had had gas supply problems since 1975. Although management response to natural gas supply curtailments varied widely, concern for dollar or energy savings was unambiguously subordinated to the goal of maintaining control over production at all costs. Frequently, management's actions reflected the interaction of the timing of the gas curtailment with the economic and technological state of the plant. If a plant depended on natural gas for production or had no alternative fuel capacity for plant heating, immediate action was forced by the curtailment of gas supplies. The economic situation of the firm dictated whether the immediate action was to purchase a costly substitute fuel or curtail production to keep within fuel allotments.

Of the 18 plants cut back on gas, we saw only two cases where gas curtailment directly stimulated energy conservation. Both plants were already strongly committed to conservation goals and had acted early on that commitment. In one of these, a large chemical plant, management capitalized on the extensive publicity surrounding the natural gas shortages by enlisting the cooperation of workers in an all-out plant conservation effort. Although the company was a leader in conservation, past attempts at this particular plant to engage workers directly in those efforts had met with apathy. In this case, conservation benefits persisted after the gas crisis subsided. This counterexample to our general conclusion is included here not only for the sake of fairness, but also to demonstrate that very special circumstances need to be present in order for the gas shortage to work for energy conservation. The unique recent history of each plant was often the determining factor in management's response. The energy manager of the plant, a chemical engineer, described to us the problem and his solution:

> When the gas curtailment came we anticipated it, we had been conserving before the actual curtailment came. In February the curtailment came, effective February 8, we were trying as much as we could to hold down the gas usage. Curtailment came in the form of a phone call saying we would be cut to plant protection levels. Now these plant protection levels were figured on 1972 volumes, volumes of the plant and the efficiency of the insulation, to maintain plant temperatures at 45 degrees so the pipes don't freeze and that other areas in the plant would be protected. When the PSC came out they found that we were actually using less than what they had cut us to at plant protection levels. They cut us to 75 thousand cubic feet per day; we ended up running in the red line on the chart, nearer to 50 thousand per day. So, we ended up using less than we were supposed to be using for plant protection and keeping up our production right along with it. It's hard to push energy conservation on people working in a plant -- we're not union here, we have no union problem -- but people get too uncomfortable, they start grumbling, girls in the office like the air conditioning on cold, the heat on hot -- and this kind of thing comes along. It just gives you that extra oomph you need to push conservation on the people. This is why we had the graph, so everybody knew where we stood. People got in the swing of this conservation thing and wanted to help. After the

> initial impact it went over pretty good because they were happy to have their jobs. Other plants were being shut down.

This happy outcome was made possible by three fortuitous conditions: 1972 energy-use patterns served as the base year for calculating gas allocations, the plant's production had not grown since 1972, and energy conservation efforts since 1972 had been successful in reducing plant fuel needs by better than 30% and natural gas needs by closer to 50%. In two additional plants the gas shortage may later prove to have contributed indirectly to conservation: these two plants had done little to conserve energy in the past and managed the gas supply crisis by shutting down. However, the necessity of close monitoring of gas use to avoid penalties with minimum shutdown time led in both cases to the appointment of a full-time energy manager. As pointed out above, this organizational change often prefaced strong conservation efforts, and may well prove to stimulate energy conservation in the future in these two plants.

Since only two of the 18 plants that experienced gas supply cuts took actions conducive to energy conservation, the example cited above is most atypical in our group. More typical among our observations, and in sharp contrast to the case just cited, was the response in a second chemical plant. This plant's record in energy conservation was also excellent up to 1976 but cuts in gas supply reordered management priorities and discouraged continued conservation efforts. Again, top management led a strong energy conservation effort early on, but the plant had more than doubled its production capacity in the past four years. When natural gas curtailment came, the plant's allotment was based on use patterns generated prior to expansion but after energy conservation efforts had begun. The executive vice-president of the firm, the chief executive at this particular plant and also a chemical engineer, described his dilemma:

> Within the past four years we have literally doubled our production facilities insofar as equipment, but there's no additional gas allowable for expansion. So, we had to put in an alternate type of equipment not as an alternate source [of fuel] but as a primary source -- which now is classed as alternate. Which in turn takes away some of the natural gas that we normally would be getting. This has posed many problems for us; the cost, of course, is first. Now even with cost, during this last Winter -- propane is not as available as it has been, propane in some cases is classed as a byproduct of the natural gas industry -- we have had a great deal of problems maintaining enough propane from time to time to operate. We have since expanded our [propane] storage facilities as of this Spring. We have expanded our fuel oil storage facilities in preparation for this Winter. But we really have done, I believe, everything possible to reduce energy usage.

The plant did not shut down, and production was maintained by using propane gas where necessary at double the cost of natural gas. In addition, a new electrical heating system was installed in the Spring for office space. The total natural gas allotment has thus been freed for production use in the future, but at a cost that management considers unretrievable:

> We really can't consider payback periods when it's a shortage of fuel we can't get otherwise. I think this is secondary to payback. I like to say, yes, we have a two year or three year payback. We used to figure seven years was good. Today, most of our equipment we like to look at one [year], but on this [the new heating system] we cannot consider a total payback period. It's insurance money, to be sure we can maintain production. This is what we're doing now.

In this case, management's attention was preoccupied with the goal of protecting production in a rapidly expanding plant. The management strategies of increasing fuel storage capacity and abandoning sole reliance on natural gas where possible by installing alternate fuel standby equipment or totally replacing existing gas-using equipment are expensive measures but necessary to protect production. These strategies are either irrelevant or run counter to goals of energy conservation. They do not cut overall fuel usage, and more importantly, divert the firm's resources from further investment in conservation to investment in protection.

An alternative response to natural gas shortages, encountered in four plants, was political: management appealed the

equity of natural gas allotments. All four cases were successful in having gas supplies restored. In one case, management met with quick success since the original allocation was based on classification as a dual-fuel capacity plant when in fact the standby coal-fired boiler had not been operative in 15 years. When we visited the plant, a new coal-fired boiler was in the process of being installed. During the crisis period of about two weeks, this rapidly growing manufacturer of computerized machinery had maintained a fairly comfortable work environment by renting several large electrical space heaters; the production process does not depend on natural gas. A latecomer to conservation efforts and a large user of electricity, the company appointed early in 1976 an energy manager trained in finance who monitors energy costs and plans to conduct a plant energy audit.

This plant's strategy typifies a middle-ground case where management had lagged in energy conservation activity but began to respond to high electricity costs by 1976, before the natural gas crisis. The new energy manager's time was temporarily diverted from starting his projected energy audit in order to meet the problems caused by total natural gas curtailment. The gas curtailment was not viewed by management as a devastating event, however, since it did not interfere with production.

In this plant and two of the others where a political solution was tried and succeeded, natural gas usage was fairly light and not necessary for production. The fourth, a large primary metals plant, is a heavy natural gas user in its production process. Management responded to gas supply problems beginning in 1975 with political action but undertook other measures as well. Ironically, this case's parent company is widely cited in government documents as being heavily involved in solving the country's energy problems. Although we judged energy conservation actions at this plant to be minimal, the president of the firm described to us his multiple strategies for coping with gas supply problems in this older plant with a steady state of production. Again, protection not conservation is the dominant theme:

> We are operating on a 20 year firm gas contract, which means that in 1959 we signed a contract that gave us ten thousand mcf a day, firm, of natural gas. Which turned out starting in 1975 not to be so firm. Because of the nature of our operations, we are damaged extensively if we lose natural gas because our refractories and our furnaces are damaged. It's a very critical situation with us. So, in 1975 when the first shortage developed we were ordered to shut down our furnaces. In essence [this] would have meant that we would have lost our furnaces. And, we went to hearings in Washington, etc., the whole bit, and fortunately were able to keep our head above water. Now the next couple of years the same sort of thing developed, but the mechanisms for dealing with it had been propagated by the FPC and you now can buy gas on an emergency basis but at a very high cost. So, we have been able to get through the last two Winters basically by spending more money. We have, since the natural gas shortage developed, changed perhaps 20% of our natural gas usage to oil. For major uses, however, oil is not a substitute...
>
> Another thing that we did: we put the propane system in. We went to Louisiana and you know, it's a jungle down there, and it took us about a year and a half before we were able to buy this gas. But, that is a part of our program to try and protect ourselves. We have purchased gas and propane for emergencies. Propane is really too expensive to use, but in our situation it is an emergency thing in case the gas company calls us up and says, starting now you got no gas!

At this plant, coping with natural gas shortages proved to be very expensive. However, energy conservation at the plant had received very minor attention up to 1976 and no clear future conservation plans existed at the time of our visit.

These few examples illustrate managerial actions stimulated by a common experience under a variety of conditions. There were further variations of responses: five plants shut down to keep within natural gas allocations. Some plants managed the gas shortage easily because of existing dual-fuel capacity and no reliance on gas for production. In one plant, the gas cutback was met by moving all non-production activities from the plant site to rented commercial facilities. Where possible, management's top priorities for

actions in the energy area in the near future were for shedding reliance on natural gas in favor of fuels more dependable in supply, even at high dollar cost.

Although only two of our cases responded to natural gas cutback with energy conservation efforts, we cannot rule out the possibility that additional cases will become more active in conservation as a result of their experiences this past Winter. Based on our observations, however, we see gas supply problems as a barrier to promoting energy conservation in industry. Management priorities were diverted from conservation goals to goals oriented toward protection of plant operations. Immediate decisions as well as future plans were mostly irrelevant or inimical to the goals of reducing the overall fuel needs of industry. Reduction of uncertainty and maintenance of control in production took precedence over energy conservation and economy most noticeably in plants experiencing rapid growth of production along with gas shortages.

The implications of further gas shortages, or shortages of other fuels in the future, are not optimistic from the point of view of energy conservation. Management responded to the gas shortage as if they had been caught in a sudden rainstorm: a few had umbrellas, most ran for protection, some railed at the heavens. Only two took the opportunity to further ongoing conservation programs.

4. REFERENCES

(1) James R. Murray, et al., "Evolution of Public Response to the Energy Crisis," Science, v. 184 (19 April 1974): 257-263.

(2) J.H. Holloman and M. Grenon, Energy Research and Development (Cambridge, Mass.: Ballinger Publishing Company, 1975).

(3) C.A. Berg, "Conservation in Industry," Science, v. 184 (19 April 1974): 264-270.

(4) E. Rogers and F. Shoemaker, Communication of Innovations: A Cross-Cultural Approach (New York: The Free Press, 1971).

(5) W.P. Strassman, Risk and Technological Innovation: American Manufacturing Methods in the Nineteenth Century (Ithaca, New York: Cornell University Press, 1959).