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The Myth of Best Practices: The Context Dependence of Two High-performing Waste Reduction Programs

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Consider three streams of pollution prevention literature. The first (e.g., Lovins and Lovins 1991) argues that there is so much "low-hanging fruit" out there (particularly in the form of wasted energy) that simply harvesting the fruit will enable us to resolve many of our policy problems. The second is exemplified by the story of an economist walking down the street with his daughter. When she suggests picking up a twenty-dollar bill lying on the sidewalk, he says not to bother: if it were real, someone would have picked it up already. That is, the hidden costs of achieving waste reduction and energy conservation must exceed the benefits, or the market would already have discovered them. Between these extremes is a group of authors (e.g., Hirschhorn and Oldenburg 1991; Royston 1979) who acknowledge that there are some managerial obstacles to pollution prevention, but who suggest that adhering to a number of simple principles and practices ("best practices") will enable those obstacles to be overcome with ease. For example, Michael Royston and Donald Huisingh suggested at the Greening of Industry Conference (November 17–19, 1991, in Noordwijk aan Zee, the Netherlands) that the key ingredients were top management commitment and problem solving on the shop floor. At other times we hear of the need for direct incentives and extensive data collection.

Hirschhorn and Oldenburg (1991) go well beyond a few simple prescriptions. In their sophisticated analysis of managerial strategies they argue that industrial waste reduction is a four-stage process and that each stage presents unique obstacles to performance that are often compounded with obstacles from prior stages. In the first stage, people should "exploit readily visible, easily implemented, low cost, and low risk opportunities" (p. 76). In the second stage, firms should aim to discover waste reduction opportunities that are not readily apparent. The third stage involves implementation of technology where there "is economic uncertainty because of substantial changes in technology and equipment" (p. 95). The final stage involves creation of dramatically new clean technologies. For each obstacle these authors describe a preferred managerial solution. Many of these preferred solutions correspond to the prescriptions of other authors.

This chapter compares two waste reduction programs in one company, the Florida and East Coast Synthetic Olefins Corporation (FLECSOCO) (a pseudonym), one of the twenty largest firms in the chemical industry. The company emits remarkably little waste, given its production volume. These low emissions levels result from the selection of relatively clean products, the construction of relatively clean plants, and the progressive improvement of existing processes to reduce waste emissions. The chapter compares programs in the third category, the progressive improvement of processes, at two plant sites, one located in Marbletown and the other in Schisttown. The success of these programs suggests that there is probably more fruit out there than even the optimists imagine and that it can be plucked cost-effectively. However, when the programs were examined closely, it was seen that many of the absolutist prescriptions and "best practices" that have been written about were violated. For example, at neither site did data collection drive problem solving. Instead, intensive data collection was reserved only for identified problems and solutions. Likewise, at neither site were direct financial incentives offered to participants. These were seen as liabilities for a program. Similarly, at both sites, all four of Hirschhorn and Oldenburg's temporal stages were pursued simultaneously, not serially. By the same token, at the site with a program that achieved superior waste reduction, problem solving was not pushed to the shop floor, while at the site with the less successful program it was.

It is not the intention here to develop an alternative set of best practices. Such an approach can work only if Hirschhorn and Oldenburg were correct when they asserted that the four stages represent a temporal ordering rather than different aspects of the task, if there were one best way of attacking each aspect, and if that best way were independent of the firm, the industry, and the location.

Instead, this chapter will show that the managers observed had to manage a tension between two competing demands. On the one hand, particular aspects of the waste reduction problem are best solved by particular individuals with particular skill sets and access to particular information sources. Housekeeping problems are best solved by the operators; process design changes by the production engineers assisted by operators; and research and development conundrums by specialists. Therefore, the first demand is to construct programs that use the groups most relevant to the specific problems at that site.

On the other hand, waste reduction managers rarely have free or guaranteed access to these target people. Most of the time they compete with a number of other functional managers who also have "top management commitment" (e.g., managers for safety, energy conservation, affirmative action, and training). Furthermore, the target people have very limited time, since most of it is devoted to producing chemicals. Therefore, the second demand is to design programs that make it possible to obtain the people and resources needed for effective waste reduction.

When waste reduction took precedence (e.g., for compliance problems), the first demand did also. That is, waste reduction managers could easily obtain the specific resources they needed. Most of the time, however, the second demand dominated. To get the resources they needed, the waste reduction managers had to do two things. First, they had to avoid conflicts with other actors' interests. Second, they had to offer more than waste reduction, or even waste reduction with a high return on investment. They made their programs more attractive to line management and participants by offering joint gains between their own objectives and those of other people on the site (see Bachararah and Lawler, 1990).[1] The political and structural obstacles that defined the constraints and created the possibilities for joint gains varied across time and between the sites. At Marbletown, the program designer, an energy conservation manager, could develop a program that targeted the most effective group on the site, the junior engineers. At the Schisttown program, this was not the case. Although the Schisttown program, which targeted the operators, was inferior in terms of its narrow waste reduction goals, this is not necessarily the case once benefits to other goals, accrued through joint gains, are considered.

THE TWO SITES

The Marbletown site, located in the southeastern United States, is the only plant site in FLECSOCO's Marble Division and one of the largest chemical facilities in the state. It comprises twenty-four processes producing mainly commodity chemicals, but also some specialty chemicals, a power supply, an incinerator, and a biological oxidation plant. It employs about 3200 people, including about 1000 maintenance contractors. It is nonunion and has been since opening in 1958. Within each process in the Marble Division, as in the Schist Division, there are three or four hierarchical levels of line engineers under one of the twenty superintendents. Each superintendent reports to one of four production managers, who, along with people such as the human resources manager, are known as major managers.[2] The major managers report to the facility general manager.

The Schisttown site, located in the western United States, is one of the company's three production facilities in the Schist Division and one of the largest chemical facilities in the state. It was purchased in 1938 and employs between 900 and 1200 production workers in thirteen plants under seven superintendents. It produces a mixture of commodity and specialty chemicals as well as power for the site. Most of the specialty chemicals are intermediaries for biocide production. Since the processes are on a smaller scale, production at the site is much more labor-intensive than at the Marbletown site. The union was decertified in 1971 after a prolonged campaign that began when neither of two competing unions could obtain a clear mandate from the employees. Unlike the Marbletown plant, the Schisttown plant has neither a hazardous waste incinerator for solid waste nor a biological oxidation facility for aqueous waste.

DATA COLLECTION

Most of the data were collected through interviews of fifty to ninety minutes' duration. Five interviews were longer, lasting two to three hours. Key interviewees were interviewed several times. Company employees were interviewed at corporate headquarters in September 1989 (eight interviews); at various plants, specifically Marbletown in May 1990 (eleven), Schisttown in June 1990 (sixteen), Hornfelstown, in the Hornfels Division, in October 1990 during a visit to discuss safety management (one); and at various seminars, conferences, and other opportunities (four). Four interviews were carried out by telephone, and many were also followed up by telephone.[3] The interviews at corporate headquarters included senior managers responsible for various aspects of health, safety, and environmental management as well as government and public affairs. In the plants, the principal interviewees were the program designers. However, other interviewees included design and production engineers, production managers, senior site management, and managers in a number of functional specialties such as research, technical services, and community relations. Key interviews and sections of interviews were transcribed. In addition, trade literature and company publications were reviewed and the records of an "ethical investment" firm were examined. Finally, the author discussed the work and exchanged literature with a journalist who writes about the company. An earlier draft of the manuscript was read by key people in the two divisions and corporate headquarters. This proved to be a valuable source of new data, insights, and clarification. Differences were discussed and changes were made at the discretion of the author.

Attempts to gather quantitative data to illustrate the argument were generally unsuccessful. While FLECSOCO keeps good emissions records, waste production records tend to be unsystematic—that is, they are good for the waste streams that are measured, but many streams are not. Data are stored in individual production units. Data on specific waste reduction projects are embedded in company-confidential data bases. Further, it is often very difficult to disaggregate the waste reduction portion of a project from the capital expansion part. Interestingly, even if personnel at the two sites had been prepared to provide the data they possessed, which they said would have required days of work, those data would not have been comparable. One site did not even bother to record one class of projects—very low cost initiatives—until 1990, they were considered relatively unimportant. The other site concentrated most of its ongoing programmatic waste reduction efforts in that area.

Because the two sites have such different technology, and because the Schisttown site has virtually no aqueous or solid waste treatment facilities (cf. Thompson 1967), it could not be shown empirically that waste reduction efforts at Schisttown are less effective than those at Marbletown. Therefore opinions were sought from three people with direct experience in environmental management at the two sites. All three said without hesitation that the Marbletown program is more effective. One, the youngest, believed that the difference was due to technology alone. The other two believed emphatically that the differences were managerial. On the basis of this, as well as the refrigeration system example presented later in the chapter and the fairly sketchy quantitative data that it was possible to gather (particularly on project size), it is the author's conclusion that the Marbletown site's program is more effective and that the differences are principally due to differences in program design.

A MAP OF THE CHAPTER

In the next section, the company's definition of waste reduction is bisected to correspond to two distinct sets of activities observed at each plant site. This yields four cases, two at each site, which are then described in detail. Two analytic sections follow. The first shows that an information-processing lens can explain why differences in program design lead to differences in performance. This leads to the first demand above, that the program design should engender the information flows that maximize performance. But why would managers choose designs that appear to be inferior? The second analysis argues for the second demand, political acceptability, and asks whether side benefits to other actors compensate for lower levels of performance when measured in terms of narrow corporate goals. The argument is bolstered with data from other programs in the Hornfels and Schist divisions.

TWO TYPES OF WASTE REDUCTION

Pollution management is generally divided into two categories: pollution control and pollution reduction. Pollution control refers to the treatment of a waste stream to curtail emissions to the environment. Pollution reduction involves the redesign or modification of processes or operations procedures so that less waste is produced in the first place. At FLEC-SOCO, all pollution-reducing technical changes are given one name: "waste reduction." However, it was observed that waste reduction projects fall into two distinct categories that have different objectives and therefore are assessed using different criteria. The author labeled one type "compliance-oriented waste reduction" and the other "savings-oriented waste reduction." For compliance-oriented waste reduction the project focus is on the amount of waste reduced. For a given waste reduction goal, people design systems as cost-effectively as possible. For savings-oriented waste reduction, the amount of waste reduced is generally subordinated as a goal to the rate of return on investment (ROI).[4] Although the Marble Division has accomplished most of its pollution reduction through savings-oriented waste reduction projects, the Schist Division has reduced most of its pollution through compliance-oriented waste reductions.

Compliance-oriented waste reduction projects are often initiated in response to either a regulation or a management policy decision to change the base assumptions for running the plant. These changes tend to alter

dramatically the economics of disposal. For example, once Schist Division management decided to close the Schisttown site's surface impoundments, the cost avoided by eliminating the liquid waste stream of 64,000 tons per year was absolutely enormous. However, without that decision, the emissions reduction project would have seemed inordinately expensive. Therefore, it is rarely meaningful, except in a relative sense, to talk about ROI for compliance-oriented waste reduction projects.

Compliance-Oriented Waste Reduction

Marbletown

Examples of compliance-oriented waste reduction projects at Marbletown include a recovery system that captures fugitive emissions from a hydrocarbon loading dock and returns them to the process; a special filter that captures fugitive emissions through vents in such a way that they can be trapped and released back into the process (instead of the whole filter being burned); improved procedures for purging vinyl chloride from vessels before maintenance or after leaks are discovered in loaded tank cars; and increased retention of polymers so the entrained monomer can be released to the air in a sealed storage area and returned to the process.

Compliance-oriented waste reduction projects are initiated by the plants themselves during normal operations, during biennial compliance reviews, or with plant expansions. The biennial compliance review is a formal meeting between the plant superintendent, his or her key staff, and key members of the environmental staff. At that meeting they review the plant's permits and discuss noncompliance events, permit exceedences, and recurring problems. If these are thought to be excessive, particular waste streams will be targeted and systems designed to deal with problems. Emissions are reduced during plant expansions for two reasons. First, and principally, capital expansions require repermitting of the plant. Because the region does not attain the national ambient air quality standard for volatile organic compounds, a new permit that allows the plant to increase its emissions would require the firm to find an offsetting reduction in another process on the site or buy a reduction from another plant in the region. Therefore, management refuses to submit applications that require emissions increases. Hence, the increased emissions from increased capacity must be compensated for through design changes elsewhere. Second, a capital expansion itself is a change moment in the plant's life. It opens up the whole technical system for negotiation much more than do routine operations. At that time, a lot of the barriers to change are not present; the plant will be down for a protracted period, people are thinking and talking about redesign, and a request for large capital, onto which an environmental request can easily be appended, is going to the board. The environmental staff like to help the process engineers, production engineers, and research engineers exploit that moment to ensure that emissions improvements are brought about.

Schisttown

Schisttown's compliance-oriented waste reduction efforts technically are extremely impressive. After a decision in 1984 to close the thirteen acres of surface evaporation ponds that had been used to receive the site's liquid waste, a team of 156 engineers and operators was put together. The team came up with twenty projects that reduced the quantity and toxicity of waste from the various streams and then cleaned up the waste sufficiently to feed back as an input to the facility's brine cells, where it could be made back into chlorine gas and sodium hydroxide (caustic soda). One stream, which had a high fluoride content, had to be sent off-site to a hazardous waste management facility to prevent poisoning the cell electrodes. In 1989, for an additional $1,300,000, that stream was virtually eliminated. Unfortunately, because the law changed shortly after the decision to close the ponds, the waste reduction process had to be accelerated. Because there wasn't time to work out how to remove impurities from the waste already stored in the evaporation ponds, the salt had to be encased in concrete, rather than processed through the brine cells. This left a "tomb" in the middle of the site.[5]

People at the site have also eliminated 63 percent of the waste sent off-site. One-half of this was the fluoride waste, and significant amounts were reduced with two other projects, one that eliminated white water from a synthetic rubber plant and one that eliminated waste from a research plant. It may well be that these should be classified as savings-oriented waste reduction rather than compliance-oriented waste reduction, but data are not available with which to make this determination. Chemical emissions that must be reported under Section 313 of SARA Title III (Emergency Planning and Community Right-to-Know Act) were reduced by 30 percent between 1987 and 1989.

Savings-Oriented Waste Reduction

Marbletown

The Marbletown savings-oriented waste reduction program is FLECSOCO's flagship initiative. It has been extremely successful and phenomenally profitable. FLECSOCO has had limited success transferring the program to other locations, however.

The program began in 1980 as an attempt to control energy costs. The division's long-term fuel gas supply contract had expired, so the long-run marginal cost of gas had risen significantly. Division management asked a senior engineer to investigate ways of reducing energy usage. The program he developed, a variation of a program developed in the company's Gneiss Division, was disarmingly simple: junior engineers were invited to submit designs for cost-effective energy conservation projects with a capital value of $10,000 to $200,000 to a competition committee comprising senior engineers, some superintendents, engineering managers, and a representative from the capital planning economic evaluation area. The projects had to offer an ROI exceeding 100 percent.[6] The submissions did not have to be formal, but they had to provide data and sketches that would substantiate the energy savings the engineers claimed. The competition committee reviewed the submissions, declared some of them "winners," and provided a ranked list of projects to division management. The review consisted of an oral presentation by the person submitting the project, a more detailed financial analysis, and a check of the engineering details to ensure that the works would operate as claimed. In return for their efforts, each of the submitters of winning projects received a plaque at an awards ceremony and the opportunity to oversee the detailed design and construction of the project. They did not (and still do not) receive any financial rewards.

The winning projects were placed into a pool with other projects submitted to the division for small capital allocations. Division management then allocated the capital money to the process areas and always included money for the winning projects. The money was then invested, at the discretion of the major manager overseeing the process, either in the projects or for some other need.

The success of the program has amazed everyone in the corporation, in terms of both its longevity and its effectiveness. Everyone thought the division would run out of energy conservation projects after the usual program life of two or three years. On the contrary, the plant engineers and operators have been able to come up with more and more projects each year. For the 1991 contest there were 144 entries, of which 128 were winners. Aspects of the history of the competition are highlighted in Table 6.1. Interviewees now believe that there are "almost an infinite number of projects out there."

The competition has changed a little since its inception. First, the hurdle ROI dropped to 30 percent with the price of energy.[7] Second, the categories of projects have increased to include all small-capital projects (i.e., up

Table 6.1
Results of the Marbletown Competition[1]

Type of Project	1982	1983	1984	1985	1986	1987	1988	1989	1990	1991	1992
Non-WRFP projects above ROI cutoff[2]	27	32	38	59	60	90	71	42	78	73	74
WRFP projects above ROI cutoff							23	22	37	35	35
Cross-subsidized WRFP projects							1	3	16	18	19
Total projects	27	32	38	59	60	90	95	67	131	126	128
Investment ($MM)[3]	1.7	2.2	4.0	7.1	7.1	10.6	9.3	7.5	13.1	8.6	6.4
Annual Savings ($MM)[4]	3.0	7.6	8.3	10.2	8.3	11.5	18.0	37.0	17.6	27.6	20.3

SOURCE: Company materials.

NOTES:
[1] Table presents only those projects with a capital cost of less than $2 MM ($2,000,000). In addition, there were a few projects each year with a larger capital cost. Capital for these is allocated differently.
[2] Energy conservation, yield, maintainability, etc.
[3] Investment and savings are for projects with ROIs above the ROI cutoff.
[4] Total annual savings accruing from that year's projects.

to $2,000,000 instead of $200,000), large-capital projects (more than $2,000,000), and expensed projects. Expensed projects and large-capital projects are not funded from the small-capital pool, however. Also, the $10,000 minimum cost criterion was changed to a $10,000 minimum savings criterion. Finally, the categories of projects have been increased to include yield improvements, maintenance cost reduction projects, waste reduction projects (in 1986), and a few small-capital expansions. Waste reduction projects have a different investment criterion, however. There is no formal ROI requirement. The criterion was changed in 1989 to state that the ROI for the group of projects from a given plant must exceed 100 percent.[8] This enabled the rate of waste reduction to be accelerated by packaging projects that save a lot of waste with projects that save a lot of money. Projects include such things as redesigned refrigeration systems, preheating fluids, reconfigured distillation columns, and removal of bottlenecks in processes.

Schisttown

More than fifty savings-oriented and compliance-oriented waste reduction projects were carried out at Schisttown between 1984 and 1989. However, it is often difficult to tell which projects fall into which category. Once constraints are imposed on emissions—in this case the decision to close the surface impoundments—the economics change enormously, so that virtually any project becomes attractive. In 1989 a total of thirteen projects in both the savings-oriented and compliance-oriented waste reduction categories were proposed at Schisttown. All of these involved investments of less than $200,000. By comparison, in the same year, Marbletown implemented fifty-five savings-oriented waste reduction projects, many of which had a relatively high capital value. In addition, there were a large number of expensed projects at both sites.

The clearest way to differentiate the compliance-oriented from the savings-oriented waste reduction projects is in the process that those on the site claim to use to approach the problem. For compliance-oriented waste reductions, the approach is quite formulaic. Engineers develop a quantitative scheme for ranking the waste streams. For example, they might give volume a weight of five and toxicity a weight of seven. They collect data and rank the streams against the weights to determine which stream is most important. They then use a number of techniques to work out how to reduce the waste. For savings-oriented waste reduction, however, the approach is quite different. Instead of collecting data first and then working out how to act, the employees develop an idea for attacking the problem and then collect data to substantiate their approach. That is, while compliance-oriented waste reduction is essentially a deductive process, savings-oriented waste reduction is a much more creative and inductive process.

Two projects were clearly cost-effective waste reduction projects and involved significant engineering. The first involved the recycling of catalyst from a specialty chemical plant. The addition of new catalyst was causing a huge amount of tar to form. Hence, the more catalyst added, the more material had to be drained from the process to get rid of the tar. This created a vicious cycle. Over the prior three years, the company had carried out a series of research projects to determine whether or not recycling the catalyst would cause explosions or lead to the buildup of materials toxic to the process or the product. However, according to one interviewee, "there was no incentive for catalyst recycle until one day the source of disposal went away and we just had to sit there and eat it." Most of the waste had been sent to a local thermal oxidizer, and the excess was sent to either Marbletown or Hornfelstown for incineration. One day the thermal oxidizer went down and the plant was stuck with a "huge stream" of waste. The engineers decided to simply recycle it by running a pipe from the tail end of one process to the front of a prior one. It was a "no-cost no-brainer" that saved three dollars per pound of waste.[9] As a result, the disposal problem went from one of disposing of tar full of fresh catalyst to one of disposing of spent catalyst. This halved the waste volume. In a subsequent stage, production engineers hoped to reduce the waste by a further 80 percent by changing the process to reduce the amount of catalyst added.[10]

The second project illustrates one of the core differences between the Schist Division and the Marble Division. In 1985, as part of a plant modification, an engineer at Schisttown was asked to design a refrigeration system for a chemical stream. The engineer worked out that he could use a countercurrent heat exchanger to cool a hot effluent stream with an influent stream. This would be cheaper and more reliable than a chlorofluorocarbon-based system and would leak much less. However, the design was unusual and a bit complicated. Although the heat exchanger was installed eventually, the engineer had a lot of trouble justifying it to plant management. If this had occurred in Marbletown, it would have been installed readily; it would have been funded as part of the energy/waste competition.

Most of the other savings-oriented waste reduction at Schisttown occurs on a much smaller scale, through programs in the individual plants. The programs vary from plant to plant, and the two examined by the author, representing seven production facilities, are presumably the best. The programs are overseen by a committee comprising employees from

the shop floor and an engineer. These committees attempt to solicit waste reduction ideas from others on the shop floor. It was observed that suggestions came principally from one of two sources.

One plant had a suggestion box. The plant superintendent brought the idea of using suggestion cards with him when he transferred from the Hornfels Division.[11] Suggestions were collected and acknowledged daily. In 1989, 165 were received. At its monthly meeting, the committee authorized funding for projects and awarded a small prize to the two best suggestions for the month. Not surprisingly, the scale of these projects is much smaller than those in the Marble Division. The ten biggest projects in 1989 yielded savings of $125,000.[12]

Implicit at this plant, and explicit at the second Schisttown plant examined, is the use of techniques of statistical quality control for the generation of savings-oriented waste reduction projects. At the second plant, savings-oriented waste reduction was integrated into operator training. In particular, in an attempt to push decision making down the organization under the rubric of continuous improvement, management had provided operators with training in a number of process management techniques. As part of that training, the operators were required to go back into the plants and apply the techniques to the management of a waste stream. This had led to a number of projects that reduced waste.

INFORMATION AS A KEY TO PROGRAM EFFECTIVENESS

Because waste reduction is a difficult information-processing problem, by analyzing the informational aspects of each of the four waste reduction programs one can understand differentials in program success. The core problem is that people can process only limited amounts of information (Simon 1976), and they must search for the information they need to make decisions (March and Simon 1958). Therefore, factors such as the context within which decision making occurs shape the availability of different types of information. This prejudices the information search and leads to local rationality that may be quite different from the global rationality expected (Cyert and March 1963).

In previous work, the author elaborated on these ideas for energy conservation decision making, a form of waste reduction, in universities (Cebon 1990, 1992). It was observed that three distinct classes of solution-specific information had to be brought together for a given solution to be adopted. The first class, technical information, generally defines the characteristics of the technology to be implemented and includes such things as its specification, performance, and price. This information generally comes from sources outside the organization. The second class, contextual information, describes the location in which the technology will be situated and hence the precise interfaces the technology must satisfy to fit into that location[13] (i.e., the requirements for the technical system, with all its idiosyncrasies, and likewise for the people directly affected).[14] This information is generally embedded in the workplace. The third class, connected information, deals with aspects of the technology and its implementation relevant to other functions. A particular technological change may affect worker safety, satisfaction, or skills, for example. This information comes from groups within the organization that are functionally or geographically removed from the site of the technology (Lawrence and Lorsch 1967). The author found that in the relatively mechanistic (Burns and Stalker 1961) universities he studied, changes in structure that increased access to one class of information generally reduced access to the others. Therefore, energy management decisions appeared highly structure-dependent, and solutions requiring high technical and contextual information were selected only in extraordinary circumstances, such as when the senior university administration was devoting a lot of attention to energy conservation.

If one considers three different types of waste reducing technological changes, different mixes of these types of information are seen. Housekeeping changes require very little technical information but lots of contextual information. As a general rule, the amount and complexity of the technical information required increases markedly as changes become more capital-intensive. The person or group identifying and appraising the problem needs a conceptual understanding of the relationships between larger and larger parts of the plant. For example, to eliminate waste oil that is dripping into a sump, the oil can be stopped at the source or intercepted before it enters the sump. To eliminate an entire refrigeration step, the whole production process must be understood, as well as a number of alternatives to refrigeration. Also, possible technical solutions and ideas may come from increasingly diverse parts of the environment. Ideas about valves can come from any chemical plant. Ideas about homeomorphic sets of steps may have to come from particular plants halfway around the world. Valves come from valve suppliers, but special equipment may need to be designed or purchased from obscure sources. For R&D projects, contextual information is probably of limited use once the problem has been defined. The requirements for connected information are probably independent of project type.

One can understand the differences in the effectiveness of the two

savings-oriented waste reduction programs at the Marbletown and Schisttown sites by considering the differences in their location in the company's information-processing system. The Marbletown program involved engineers being assisted by operators, while the Schisttown program involved operators being assisted by engineers. When the engineers are the focus of the program, they will use both the contextual information that the operators give them and that which they gather themselves to enhance their understanding of the technical system as a whole. Given a much more abstract set of skills, an understanding of the larger spatial extent of the plant, and much better access to FLECSOCO's technical information-processing network, the engineers can solve problems better. For example, a number of engineers interviewed discussed the ease with which they could call or e-mail people they hardly knew halfway across the world to discuss particular technical issues (cf. Granovetter 1973).[15] Therefore, because the junior engineers have access to the right mix of information and because the projects are just the right size to excite them, a political climate that enables them to do the work and motivates them to want to do it will lead to the generation of many projects.

When the program involves operators being assisted by engineers, however, as at Schisttown, we can expect to find fewer large projects for two reasons. First, the operators have limited conceptual understanding of the process, a limited spatial domain in which they can act, and virtually no access to FLECSOCO's technical network. Very good contextual information without good technical information will result in housekeeping modifications. Although the engineers are supposed to help the operators with the savings-oriented waste reduction work, helping is very different from having the responsibility and incentive themselves. Second, the techniques used by the operators, such as statistical charting, assume that the basic technology is fixed, and they look for incremental improvements, particularly in operation, of the basic technology. As illustrated by the catalyst recycling and refrigeration projects described earlier, however, the big savings come through changes in core technology. Those changes will not flow from the techniques the operators are taught.

POWER AND JOINT GAINS AS KEYS TO PROGRAM ACCEPTABILITY AND SURVIVAL

The above analysis of the information structuring of the problem leaves two questions. A fairly simple analysis of the problem structure suggests that an approach to savings-oriented waste reduction that focuses on the junior engineers, as does the Marbletown program, will be much more successful. Since the Marbletown program had been in existence for six years before the Schisttown program was set up, why did the manager at Schisttown choose to focus on the operators? Second, why isn't the difference between the two savings-oriented waste reduction programs replicated in the case of compliance-oriented waste reduction?

These two questions can be answered by considering the politics of organizational decision making. Waste reduction decision making requires bringing together resources from throughout the organization and hence winning the support of the parties that control each resource. Two aspects of this are noteworthy. First, and most obviously, environmental managers tend to be much less powerful than production managers and need significant resources that are controlled by production management. The production manager must allow the production process to be changed. This may well be disruptive. In addition, because waste reduction solutions are highly contextual, the changes are best designed by the production employees themselves, though not necessarily by the operators, removing them from the production process. Simultaneously, managers from many other equally important, yet low-powered functional specialties—such as quality, safety, automation, and training—are vying for the same production resources.

Second, and more subtly, large organizations tend to have trouble allocating small amounts of capital efficiently (see Ross [1986], for example). Although some waste reduction investments are large, most tend to be small, so difficulties can be expected. Compounding this, many corporations try to ensure that capital is used efficiently by deliberately allocating applicants less capital than is requested. Waste reduction projects, being optional and proposed by low-powered environmental managers, are likely to be eliminated after such rationing.

Obstacle-Free Compliance-Oriented Waste Reductions

Early in the chapter it was argued that to survive, a program such as a waste reduction program must attract all parties whose participation is needed for success. Many of the power, informational, and ethical obstacles to compliance-oriented waste reduction are avoided by timing the projects with the company's capital cycle and giving them a compliance orientation. When demands press, managers have no trouble getting resources—people or money—so that pragmatic, rather than elegant, solutions are developed. Therefore, no context-driven differences appear.

The power obstacles revolve around securing resources from superintendents and the board. Superintendents can be won over, particularly in the allocation of design engineers' time, if there is any threat to regulatory approval of capital projects. "It really gets the skids moving," noted one interviewee. The board is generally supportive of these sorts of projects, despite their cost, once the need for compliance is established. Second, the "moment" created by either the capital project or the biennial compliance inspection frees up communications and information sharing. Finally, in the mid-1980s the Corporation's board created a special capital pool for environmental projects. This has almost certainly removed any stigma associated with doing capital projects for compliance. In fact, the stigma tends to be attached to not doing them soon enough to enable them to be done properly.

Managing Savings-Oriented Waste Reduction

When managers must compete with one another for access to people in the core of the organization, however, they are constrained to creating programs that do not conflict with other programs and that provide something extra—often joint gains—to the people in the core and, to a lesser extent, to other functional managers.

It is important to realize that the people managing waste reduction programs all have extensive experience as plant superintendents. Therefore, any discussion of power or interests does not imply the existence of conflict. The program designers are fully aware of the superintendents' incentive structure and the constraints under which they operate. They are fully capable of completely avoiding any sign of conflict arising from program design. One program manager said, ["The positions to organize programs like this are generally taken by people with lots of experience . . . . You need experience to know how to maneuver to get the right support at the right level to make these things work. You need to know who these people are and how to get them on your side."]*

Another noted: ["These programs tend to be run by very experienced people. You have to be very experienced. If the guy running the program is not experienced he is going to get wrapped up in doing stuff for its own sake. An experienced guy, however, will look at the resources he has available and how far to go in this to use about the right amount of resources . . . so as not to overemphasize your program vis-à-vis other areas."]

Later, the same interviewee added: ["The key is the leader of the pro-

* Quotes delineated with brackets ([ ]) are reconstructed from notes. They are not verbatim quotes.

gram. He has to understand what he is trying to do. If he doesn't understand that, he has no chance of succeeding. . . . The guy must design the program to match the situation he is working in and make it a successful thing."]

What might be conflicts in some organizations are simply seen as realistic constraints here.

Creating Success at Marbletown Through Joint Gains

Before one can see why the waste reduction manager at Schisttown would have been unlikely to succeed if he had tried to implement the Marbletown savings-oriented waste reduction program, it is necessary to understand why the Marbletown program works. It will be shown that the superintendents and engineers had strong incentives to support the initiation and continuation of the program, virtually irrespective of its energy and waste reduction performance. Furthermore, the program did not risk opposition from parties who could obstruct it—top management and other functional managers.

Initial Support from Plant Superintendents

In the early 1980s, the Marbletown plant superintendents were feeling two cost pressures. First, between 1981 and 1982 the company, having suffered badly in the market as a result of oil price shocks, decided to diversify into specialty chemicals. This meant limited capital funds for the commodity processes that predominate at the site. Second, because energy prices were high and commodity processes are energy-intensive, the inefficiency of some processes at Marbletown was a concern. An important way the superintendents of these processes could get money would be through the divisional small-capital funds, which are allocated to the site rather than the business. The best way they could compete for these funds was on the basis of ROI. Therefore, a group of superintendents were strong early supporters of the energy conservation project competition. They used the competition to fund projects that allowed them to do things they wanted to do, but incidentally gave them energy conservation gains. For example, one superintendent used the competition to increase the capacity of his process by 30 percent while justifying the projects on the basis of energy savings.[16] As additional benefits at his process, the competition projects improved operating efficiency at low capacity, made the process easier to run, and increased enormously the production range in which the plant was profitable. The company saw this when the market for the product picked up in the late 1980s.

In 1980, the company saw its chief resource for this type of problem solving as its junior engineers rather than its operators.[17] After a couple of years, the competition organizer realized that in addition to providing challenging and interesting work, the competition projects provided excellent training opportunities for the junior engineers. As the competition organizer stated, ["There's a lot of training involved in the projects. The engineers take a project to completion. They use decision-making tools. They learn the process of getting ideas, collecting data, evaluating projects, making presentations, doing detail design, and supervising construction."]

He went on to add: ["Get people making decisions early in their careers. The important thing is that decision making is not guessing. There is a technique. People need to get a feeling for the number of facts they need to gather before making a decision. . . . As you move on, the mistakes become more expensive."]

Over time, engineers found that by involving the operators they supervised in the process, they could generate more projects. Therefore, the competition also enhanced their management skills.

Support from Junior Engineers

While training may be a virtue, it doesn't explain why the junior engineers would participate in the competition enthusiastically. To understand this, the structure of FLECSOCO's internal labor market must be considered.

The plant superintendents have managed to enact a shared belief, which may or may not be true, that excellence in the energy/waste competition is vital for junior engineers wanting promotions. The argument is quite simple. First, the competition enables participating engineers to stand out from the other engineers and be seen by the superintendents of other processes. There is a public awards ceremony and winners get a paragraph in the division newsletter. Only one or two other activities in the division offer this sort of prominence. As one interviewee described it:

> And, what [the competition organizer] successfully did is he convinced plant superintendents and engineers that if you did not participate in that program; if you did not turn [in] a WRFP [Waste Reduction for Performance] or energy project, and if you were not at the big meeting every year to receive an award [when] all the major managers were sitting there and you got to walk up the aisle, and the general manager handed you your award and shook your hand; if you weren't one of those guys, you weren't going to get very far in FLECSOCO.

Second, if an engineer can do well in the competition, he or she has a set of skills that the company values. That engineer can work with data, work with and inspire the people he or she supervises, make decisions, write capital requests, oversee detail design, and supervise construction. Therefore, the claim has very high face validity to all involved. It is this high face validity that enables the shared enactment. Without it, the whole system fails.

Consider the counterexample of the safety and environment superintendent, one of the routes to a plant superintendent's job. This position was created to try and alleviate some of the pressure on the plant superintendents as they attempted to meet safety, environmental, quality, and productivity objectives simultaneously. It was also seen as a training exercise. The hope was that these people, when they became plant superintendents, would have a strong safety or environmental focus.[18] Each safety or environmental superintendent oversees four or five plants. One interviewee described what happened after the position was created: "We titled the job 'superintendent' to try to impress upon the people in the division that it was a serious job. We even came out with letters to say that we had put our best people in those jobs."

Unfortunately, the best people weren't put in the jobs. This interviewee continued:

> This meant that the superstars go straight to running the plant [as production supervisors]. This is an important point, because if we had successfully sold the job as being an intermediate step to plant superintendent, we would have had more of our superstars ask for the job. . . . [We couldn't sell this idea because] in FLECSOCO [we] will never promise a guy his next job. We could pick a safety superintendent, and we could insinuate that he will be the next plant superintendent, but we will never promise that. . . . And, unless it actually works out that way, the superstars perceive very quickly that it is all false.

Over time, the safety and environment superintendent's job has become more routinized, and so it has become less of a position for superstars. However, in its more routine form, it could still be seen as an important job for ascending junior professionals.[19]

Continued Support from Superintendents

Finally, one must ask why the plant superintendents continue to support the project competition. Three reasons seem apparent. First, while it is possible to fund any worthwhile project at FLECSOCO, that money is not necessarily easy to obtain. Superintendents always seem to have an incentive to get more money. Therefore, once the competition was in

existence and using up 25 percent of the site's small capital, the superintendents had a big incentive to participate. Second, the superintendents are in "friendly" competition with one another. Their plants are constantly being compared to other plants on the site and to others making the same product.[20] Plants are evaluated regularly on the basis of a scorecard, a set of measures of plant performance. Since the initial placement of plants on various dimensions on the scorecard is a function of the basic technology, the relative rankings of the plants at a particular point in time are not terribly important. However, changes in those rankings over time are. Therefore, superintendents are constantly trying to improve the performance of their plants. Third, one area in which superintendents derive their status is in their ability to promote junior members of the company. If superintendents believe the project competition provides the route to success and want their engineers to be successful, they will support the competition.

Avoiding Conflict with Other Programs and Interests

While the Marbletown program provides joint gains to superintendents, engineers, training personnel, and, from the point of view of energy conservation, waste reduction and maintenance personnel, it is important to realize that it also avoids a number of important conflicts.

Capital

The first conflict avoided is over capital. As noted earlier, the program is unusual in that the money is allocated after the projects are selected, rather than from within a fixed budget as might be expected. Asked why, the competition organizer responded, "The competition started in Gneiss [Division]. . . . [The program designer] made a mistake of trying to commit capital. It meant that every year he had to fight to get capital. Therefore, I avoided any control over capital. I didn't want to do it and I didn't want to compete with the major managers. I'd lose. . . . The managers are under a lot of pressure to fund the projects anyway."

Asked what that pressure was, the organizer explained that the competition process creates expectations from a large number of parties, particularly the engineers who have come up with the designs, to spend the money on the winning projects even though the superintendents don't have to. The problem with the Gneiss Division approach is that in a company where both the program managers and the division managers change jobs about every three years, it would not be long before either a program manager or a general manager would arrive who was not interested in either making a pitch for funds or providing them.

Time and Rewards for Engineers and Other Line Employees

For the same reason, no financial awards are given in the competition to the engineers who come up with the designs. As the organizer explained, "There are no financial rewards, since it competes with the line. A program cannot compete with the organization. That is, WRFP has no bureaucracy and no budget." Instead, the plant simply gives out a plaque that could be interpreted as a symbolic promise of financial rewards later on.

Another potential conflict might be that the competition takes up too much of engineers' time. An engineer who was interviewed explained that it didn't. He came up with projects by thinking about savings-oriented waste reduction and energy conservation opportunities as he walked around the plant. The competition took only a little time to keep notes, collect relevant data, and do brief write-ups of proposals.

Other Functional Groups

A further conflict might be that the group that is formally responsible for capital project appraisal would be offended that another group on the site had started to usurp its role. After all, the competition involves a committee formally evaluating engineers' proposals. Serendipitously, the program designer avoided this conflict by inviting a member of the capital planning/economic evaluation staff to join the competition committee. Initially, he felt he needed assistance with the economic evaluation aspects of the program. Subsequently, he realized that the program really "treads on their toes" significantly. However, since the capital planning people were brought in from the start, and learned more about technical evaluation—an area where they needed help—there were no problems.

A final conflict was pointed out in discussions of the program with the organizer of a similar energy conservation program at another site. He pointed out that programs like this could cause antagonism because they encouraged managers to underallocate their annual monies to some areas in the hope of picking up money for those areas through the competition. The Marbletown contest managed to avoid this conflict by opening itself up to a large number of functions (maintenance, savings-oriented waste reduction, yield improvements) in addition to energy conservation.

In summary then, the program organizer at Marbletown had a successful program because he managed to pitch it to the right people in the organization, the junior engineers. At the same time, he offered them and their supervisors reasons to support the program that were completely independent of their belief in energy conservation (and subsequently waste reduction). These included capital and engineer training for the superintendents and recognition for the engineers. Finally, by design and by accident, he managed to avoid conflicts with the superintendents and major managers, other functions, and the capital allocation staff.

Explaining Success at Schisttown

The beginning of the widespread use of quality circles in the United States in 1981 is a good marker for the start of concern about operator empowerment and skills. The Marbletown savings-oriented waste reduction program, which began in 1980, predated this.[21] By 1987, when the Schisttown program was created, the need for operator empowerment and skills development was well embedded in company ideology, and "continuous improvement" was seen as fundamental to corporate success.[22] Continuous improvement, which is part of total quality management, uses specific techniques to analyze problems. The Schisttown program was designed to provide continuous improvement training for operators.

A program designer explained that at most sites the rate of turnover of top site management is very high and that new initiatives are risky. Program designers are never sure how much effort programs are going to entail or how well they are going to work. Therefore, unless the program managers have sufficient power to have a program stand on its own, they have to piggyback it onto something else. That something should be relatively enduring in corporate strategy. This will enable them to sell it to the next general manager; it will give them support from other functional managers; it will be more attractive to superintendents; it will give them a reasonably good idea of how well it is going to work; and it is likely to stay institutionalized as long as the company is pursuing that particular strategy. This would explain why the program designer at Schisttown chose to align his program so closely with the continuous improvement effort.

Another interviewee picked up on the use of operators and hinted at another important advantage:

> I think it gives the operator a focus on really understanding cost-effective changes. And the other thing I believe is [that] when I talk to our employees, from the president to the newest hire . . . I really think our people really do have a significant environmental sensitivity, so if you can figure the right formula to capture that personal enthusiasm for the environment into job enrichment, and [identify] projects which will do something good for the environment as well as FLECSOCO, to which our employees are really dedicated, then I think you have a combination which is really win-win, in

> that you have something our people can get excited about. As long as you do that cost-effectively with these high returns on investment, you hit a home run.

Attaching the program to the operators offered the company two other important advantages. FLECSOCO had to manage a major crisis in the mid-1980s when problems with one of the effluent streams at the Gneiss Division set off a public scare. This came on top of fifteen years of adversarial relations with the government and bad relationships with the public. A key part of the crisis was the realization that employee morale had dropped precipitously. In addition, the company reconceptualized its relationship with its institutional environment (cf. Bartunek 1984). It started to see the community, rather than the government, as the initial source of regulations.

The Schisttown site is in a part of the country with a very high environmental sensitivity. Thus, one advantage of using operators is that those who actively participate in environmental management are less likely to feel they are working for a polluting company and more likely to sell the company's environmental record in the local community. A second advantage is that this particular program design takes up very little of the organizer's time, as opposed to the Marbletown program, which requires that every project be examined before and audited after. At Schisttown, because of the region and because the company wanted to build an incinerator there, community relations are much more important than marginal waste improvements. It was more important that the waste reduction manager spend time educating the community on the enormous amount of waste the plant had already reduced (principally through the off-the-ponds project) than ensuring that future waste reduction projects are the best possible.

Note, however, that several important waste reduction projects did not come out of the operator-level program, but rather, came from the engineers. These include the refrigeration system project and the project to eliminate the fluoride waste stream.

Thus, at Schisttown, the program designer could not construct a program like the one at Marbletown without creating conflicts. Because the program was situated at a different time in a different place, he had to pitch it to the operators. Therefore, we see, once again, a program that offers joint gains for the participants and the superintendents that have nothing to do with waste reduction and the implementation of a design that avoids conflicts with the interests of others at the site.

A Difference Between Program Outcomes: The Schisttown Refrigeration System

Given the above explanations, it is now clear why the Schisttown engineer had trouble funding the heat exchanger for the design of the refrigeration system. At Marbletown, the energy/waste competition projects are assessed on the basis of relative waste and energy merits independent of the concerns that dominate the plant superintendent's thinking, such as minimizing the amount of time taken in making decisions, focusing attention on decisions that affect the core operations of the plant, and emphasizing the dimensions on which he is evaluated. At Marbletown, the heat exchanger would almost certainly have been funded. At Schisttown, the project would come out of a superintendent's budget or capital submission directly. Superintendents within FLECSOCO are assessed on the basis of a scorecard with a number of unit ratios for operation of the plant (dollars per pound of product, accidents per hundred worker-years, energy per pound, and so forth). Until the recent ozone hole controversy, because refrigeration was not part of the core process of the plant, chlorofluorocarbon (CFC) usage was of no importance to plant management. Therefore, it wasn't measured and it wasn't on the scorecard. The particular refrigeration system to be designed would use a trivial amount of energy compared to the rest of the plant. Therefore, plant management would have been perfectly happy with a standard CFC-based refrigeration system. In other words, although the heat exchanger was better in terms of corporate profitability and waste reduction objectives, it didn't fit into the local definitions of either (Cyert and March 1963).

More Differences: The Schisttown and Hornfels Competitions

To round out the discussion, two other programs must be considered: one in the Schist Division and one in the company's Hornfels Division. The Hornfels program aimed at energy conservation and, like the Marbletown energy conservation competition, was modeled after the Gneiss Division program. The program at Schisttown was an attempt to implement the Marbletown competition, without the waste reduction component, as a part of Schisttown's continuous improvement effort. Although, on the surface, these two programs were virtually identical to the Marbletown program—both involved engineers submitting competitive designs for consideration by a committee—slight differences undermined support from key actors.

The Schisttown competition, which started in 1987, ran for two years. In both years projects totaling about $8 million were designated as winners, for an average ROI in excess of 100 percent. The organizing committee decided to scrap the program in the third year. The differences at Schisttown revolve around the way capital is allocated. Each division is given money to allocate as small capital for projects of less than $2 million. Two equity-based principles are commonly used to allocate capital to the individual plants: the replacement value of the capital and the amount allocated in the previous year. Plants might be allocated 4 percent of their replacement capital, for example. At the Marbletown, Gneiss, and Hornfels divisions, the energy/waste competition added a third principle. Instead of allocating all the small capital on equity-based criteria, a portion of it was put into the competition and therefore allocated on the basis of efficiency. At Schisttown, the program oversight committee couldn't persuade the general manager to do this. Instead, the general manager insisted that, irrespective of the competition outcomes, all the small capital would be allocated according to the equity-based criteria. In so doing, he immediately eliminated most of the incentive the superintendents might have had for participating in the competition. Instead of the engineers' submissions being seen as a source of extra capital, they were seen as a time sink. Once sufficient projects had been identified to use the annual budget wisely, there was no point in wasting time on fancy proposals. As the organizer explained, ["At the superintendent level, they didn't want to see guys writing these up and submitting them. They would rather see their guys working on the projects themselves."]

The Hornfels program started in 1983 and lasted about five years. It was scrapped in 1988 when the number and quality of projects submitted started to decline. In the third and fourth years there were about forty worthwhile projects; the fifth year yielded only thirty. While the organizer suggested in an interview that there was less energy conservation potential there, that appears implausible, as the Hornfels Division is several times the size of the Marble Division. It cannot be said that the program was a failure, given that the organizer may not have wanted the program to take off to the same extent as that at Marbletown. That is, it cannot be assumed a priori that the organizer was trying to create a successful program when it would have been easier to create a satisfactory one. But since the program died as soon as energy prices dropped, it can be said that it was not well institutionalized.

In the author's assessment, three aspects of the Hornfels program design prejudiced its success. First, as with the competition at Gneiss, funds were allocated before the winners were picked. As noted, the organizer at Marbletown saw this as a liability at Gneiss. Presumably, it was a liability at Hornfels also, and the program would have been much harder to fund once energy prices started to fall. Second, the Hornfels Division is huge—consisting of more than 150 plants—and there isn't the same dominance by commodity plants as in the Marble Division. For this reason the competition organizer had concentrated on the energy-intensive plants and had advised the specialty plants not to bother participating in the competition. The superintendent of one specialty plant, who was asked about engineers in that plant participating in a subsequent version of the competition set up for savings-oriented waste reduction, he said that this was discouraged because the big savings are in the commodity plants and so there is no point in competing with them.[23] Third, with such a huge site and such an enormous staff, it may be hard to create the perception that the program enhances a person's chances for promotion. That is, the facility is so large that everyone is anonymous and differences in technology that normally are compensated for rise up as obstacles. The shared belief is not enacted.

A corporate reader of a draft of this chapter suggested a fourth reason. Another difference between the Hornfels and Marbletown programs was that Hornfels accepted proposals for the competition four times yearly instead of once. In such a situation, the frequency of competition deadlines makes it relatively easy for people to indefinitely defer putting effort into writing submissions.[24]

CONCLUSION: BEST PRACTICES REVISITED

By examining two high-performing waste reduction programs in detail, it has been shown that by looking at particular aspects of the waste reduction problem, it is possible to identify key actors to solve the problem. The most efficient programs will engage those actors. However, before a program can be excellent, it has to survive. To do that, it must engage the target people, motivate them, and provide them with sufficient information and resources to do a good job. In addition, the program must have full and continuing support from the managers who supervise the participants. Programs that do not do so will not survive more than a couple of years and will be difficult to sustain in the meantime.

The data presented here suggest that there are a number of very important principles that managers must keep in mind when designing programs—principles in which, not surprisingly, the best practices of which one reads are subsumed. For example, participants need something to motivate them to participate. However, we cannot say, a priori, whether that should be a financial reward, a pat on the back, a veiled promise of promotion, an appeal to the health and welfare of the community, exhortations from top management, or an opportunity for a diversion from routine work. While we can expect some of these incentives to be more effective in general, which one is best in a particular instance depends on many things occurring in other functions and at other locations in the plant, elsewhere in the corporation, elsewhere in the industry and supplier networks, and within the local community.

Another important principle is that a program cannot violate the territory of the people who supervise the participants. Furthermore, a good program offers something that will make these people want to actively support it. It will also offer something to people from other functional groups. Finally, as far as possible, a good program will situate itself in the corporate information-processing system in a manner appropriate to the technical problem at hand. There may be a number of other key principles that were not demonstrated in this comparison of two cases.

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NOTES

1. In addition, they emphasized the importance of waste reduction and made it seem easier by arguing that corporate decision makers should employ the same processes for waste reduction that they do for safety.

2. The number of major managers at a site varies over time, depending on demand. As managers become more experienced, their responsibilities increase and so the number of managers needed declines.

3. Telephone interviewees were given an opportunity to review the interview notes, since the telephone interviews weren't taped, as the personal interviews were.

4. More formally, compliance-oriented waste reduction programs aim to maximize (pounds reduced) / (dollars invested). Savings-oriented waste reduction programs aim to maximize (dollars saved) / (dollars invested). For a given waste stream and a rational organization, these criteria are identical. A compliance-oriented waste reduction exercise should subsume all the savings-oriented waste reduction projects. However, we will see that the projects tended to be quite different.

5. People outside the division thought these projects were well engineered but that the division had acted too late. Because the division lacks a biological treatment facility or aqueous discharge permits, it was very vulnerable to a change in regulations. People in the organization had seen federal and state regulations coming, but the division did not act until the regulations were upon it. The author inferred from interviewees' comments that they felt this made the works more expensive and was part of the reason for having to encase the prior waste. This prediction is exactly opposite to the prediction that would follow from Jackall's (1988) argument at the "Alchemy" firm he studied. He would have expected management to wait until the last possible moment so they would not have to be held accountable for the expenditure.

6. Only operating (noncapital) savings were to be considered.

7. The original high ROI criterion was used because savings were in short-run energy acquisitions. The price of fuel was high in 1980, but there was no guarantee that it would stay high. As the price of fuel dropped, the hurdle ROI dropped to 30 percent. A project yielding 100 percent ROI in 1981 would have yielded about 30 percent ROI in 1988.

8. More specifically, the company has no formal requirement that a WRFP (Waste Reduction for Performance) project should have an ROI exceeding a particular value. However, competition organizers wanted to encourage personnel to ferret out both the very high return projects and those that reduced much waste but weren't very profitable. Therefore, they partitioned the projects into three categories—those with an ROI less than 30 percent, those with an ROI between 30 percent and 100 percent, and those with an ROI greater than 100 percent. The organizer added the criterion that the mean ROI for projects in the first and third categories must exceed 100 percent for a given plant.

9. Half the savings were in avoided disposal costs and the other half were in saved materials.

10. By developing techniques to keep up the activity of the catalyst, the engineers hoped to reduce the tar production.

11. It appears that parts of FLECSOCO have used a suggestion card system very similar to this one for many years. Such a system was used in the main research laboratory in the 1930s.

12. Expenditure figures were not available, but none of the projects appear to have required significant capital.

13. Contextual information differs from tacit information (that based in skill) in that contextual information can be communicated if the person wanting the information knows what question to ask.

14. One interpretation of the findings of a recent study on the impact of

maintenance contracting on safety in the chemical industry is that one of the reasons contractors have more accidents than permanent employees is that they are not sufficiently informed of the contextual idiosyncrasies of the processes on which they are working (Wells et al. 1991, 150).

15. A number of corporate artifacts show the company's emphasis on communication. The corridors in corporate headquarters are wide enough for people to walk eight abreast. This undoubtedly facilitates conversation. Similarly, when the company designed its new main research laboratory in the 1930s, the floor plan was organized to force everyone past everyone else's desk regularly. Finally, one of the plant sites was building a process similar to one located in Germany. The operators of the German facility participated actively at several stages in the design review for the new process.

16. All ROI calculations assumed that the superintendent was running the plant at the capacity demanded by the market at that time.

17. For a capital-intensive company, a key source of competitive advantage lies in its ability to design efficient processes and construct them quickly and well. Therefore, engineers who are good at design and construction are a vital resource.

18. It is the author's understanding that these positions have been very successful in terms of assuring safety and environmental performance. However, the point is that they have failed to achieve one of their goals: to provide environmental or safety sensitivity training for all upcoming managers. Notwithstanding, about 50 percent of plant superintendents have some sort of safety or environmental experience.

19. One can only speculate as to why it was easier to create the shared enactment in one case than the other. The author uses two plausible explanations. First, it is very easy to see if safety superintendents are being promoted, but it is much harder to work out whether competition winners are. Many more people win in the competition, and it is always assumed to be a relatively marginal thing. Second, there may be a professional/cultural reason. Knowing how to manage safety is something the company asserts is important, but knowing how to design, build, and manage things is something any junior engineer knows is important.

20. For example, FLECSOCO has seventeen plants globally making one common plastic.

21. The Marbletown site formed several quality circles in 1987. They have been successful and have endured.

22. The firm has pushed waste reduction to various extents since the 1960s.

23. This interviewee was selected by the safety staff as an excellent safety manager. It may well be that the managers at Marbletown who are overly concerned about safety also discourage their engineers from worrying about waste. The author did not investigate this, however, since Marbletown interviewees were selected by the environmental staff.

24. At both the Hornfels and Schisttown sites, the program organizer stayed in the division after the competition was terminated. Therefore, we can eliminate the hypothesis that these programs died because the organizers weren't around long enough for the programs to be institutionalized.

REFERENCES

Bacharach, Samuel B. and Lawler, Edward J. 1980. *Power and Politics in Organizations: The Social Psychology of Conflict, Coalitions, and Bargaining*. San Francisco: Jossey Bass.

Bartunek, Jean M. 1984. "Changing Interpretive Schemes and Organizational Restructuring: The Example of a Religious Order." *Administrative Science Quarterly* 29(3): 355–72.

Burns, Tom, and Stalker, G. M. 1961. *The Management of Innovation*. London: Tavistock Publications.

Cebon, Peter B. 1992. "Twixt Cup and Lip: Organizational Behavior, Technical Prediction, and Conservation Practice." *Energy Policy* 20(9): 802–14.

Cebon, Peter B. 1990. "The Missing Link: Organizational Behavior as a Key Element in Energy/Environment Regulation and University Energy Management." Master's thesis, Department of Civil Engineering, Massachusetts Institute of Technology, Cambridge, Mass.

Cyert, Richard M., and March, James G. 1963. *A Behavioral Theory of the Firm*. Englewood Cliffs, N.J.: Prentice-Hall.

Granovetter, Mark S. 1973. "The Strength of Weak Ties." *American Journal of Sociology* 78(6): 1360–80.

Hirschhorn, Joel S., and Oldenburg, Kirsten U. 1991. *Prosperity Without Pollution: The Prevention Strategy for Industry and Consumers*. New York: Van Nostrand Reinhold.

Jackall, Robert. 1988. *Moral Mazes*. New York: Oxford University Press.

Lawrence, Paul R., and Lorsch, Jay W. 1967. *Organization and Environment: Managing Differentiation and Integration*. Boston: Graduate School of Business Administration, Harvard University.

Lovins, Amory, and Lovins, L. Hunter. 1991. "Least-Cost Climate Stabilization." *Annual Review of Energy* 16: 433–531.

March, James G., and Simon, Herbert A. 1958. *Organizations*. New York: John Wiley.

Ross, Marc. 1986. "Capital Budgeting Practices of Twelve Large Manufacturers." *Financial Management*, Winter, 15–22.

Royston, Michael G. 1979. *Pollution Prevention Pays*. New York: Pergamon.

Simon, Herbert A. 1976. *Administrative Behavior: A Study of the Decision-making Process in Administrative Organization*. New York: Free Press.

Thompson, James D. 1967. *Organizations in Action*. New York: McGraw-Hill.

Wells, John C.; Kochan, Thomas A.; and Smith, Michal. July 1991. "Managing Workplace Safety and Health: The Case of Contract Labor in the U.S. Petrochemical Industry." A Report to the Secretary of Labor for the Occupational Health and Safety Administration.