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The Seabrook nuclear power plant construction project is an unqualified financial disaster. It simultaneously threatens its chief owner, the Public Service Co. of New Hampshire (PSNH) with bankruptcy and the company's electricity customers with huge rate increases. The fifteen-year history of the project is reviewed to identify "what went wrong?"

The review suggests that the basic problem has been mismanagement by both PSNH and by government regulators. A three-year regulatory imbroglio over the environmental effects of the plant's cooling system was extremely costly in the mid-1970s.

By the time this problem was belatedly resolved, the project had begun to outstrip the financial resources of its owners. These resources were seriously weakened by a political battle over how to pay for construction costs.

By the end of the 1970s, the risks of proceeding with Seabrook were beginning to exceed the benefits. PSNH management, however, chose to accept these risks, in effect betting their company that the project could be completed.

Underlying many of Seabrook's problems are certain federal nuclear regulatory policies and practices whose roots go all the way back to the Eisenhower administration. These policies are also briefly reviewed.

Ten years ago nuclear power was advertised as an important part of America's strategy to deal with OPEC and rising oil prices. Today, however, many Americans face the prospect of huge increases, not decreases, in their electricity bills as new nuclear power plants are brought into service. Other Americans have seen the value of their investments in the stocks and bonds of electric power companies that are building nuclear power plants shrink to a small fraction of their previous value. In New England, the customers of the Public Service Company of New Hampshire (PSNH) are in the former group and the company's creditors and shareholders are in the latter. The cause of these problems is the Seabrook project. Seabrook is a partially built, 2,300,000 kilowatt nuclear generating station whose principal owner is PSNH. Today, Seabrook stands as an unqualified financial catastrophe, simultaneously threatening PSNH with bankruptcy and the company's customers with staggering electric power costs.

The following article reviews the fifteen-year history of Seabrook, highlighting certain key actions and the decisions of both PSNH and federal and state regulatory authorities that led to this catastrophe.[1] This review shows that there is no simple answer to

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the question "what went wrong?" But it also suggests that a large part of the answer is captured by a simple concept: mismanagement. Both PSNH executives and regulators at times failed to do their jobs efficiently and effectively. Government agency policy shifts hindered the project's early years. Although PSNH management may, too, have made some early errors in judgement, their truly costly decisions were made in the last four years. Since at least 1980, Seabrook's owners have had clear warnings of the financial disaster that is now happening. Unlike the owners of other partially built nuclear power plants, they have not responded to these warnings by abandoning the project in order to lessen the impact of the ensuing financial damage.

Nuclear Power in New England

As a preliminary to a discussion of Seabrook, some general background information about nuclear power in New England will be helpful.

Nearly three-quarters of the nuclear power plants that are currently operating in the United States were ordered before the 1970s. The majority of these plants were ordered during the heady years of unalloyed optimism about nuclear power, between 1965 and 1968.[2] Although there were already some apparently unsettled questions about the potential dangers of large nuclear power plants, these questions came from persons or organizations that at the time seemed to hold opinions contrary to technical and economic "facts." These facts were essentially unanimously agreed upon within the contemporary business and government establishment; accordingly, America's leaders, indeed the world's leaders, fully concurred that nuclear power was both cheap and safe.

Incorporated in 1926 as a consolidation of several smaller power and light companies, PSNH, over the following years, acquired about twenty additional small electric utilities to become the largest utility in New Hampshire, serving the needs of a growing number of customers. In the late 1960s very high population growth was forecasted for New Hampshire during the 1970s and 1980s, thus increasing electric power needs. Most estimates indicated 3.5 to 4.0 percent annual growth rates accompanied by correspondingly high demands for electricity. PSNH staff members were predicting electricity demand growth of 7 percent throughout the 1970s and few, if any, informed persons would have quarreled with them.[3]

PSNH's prior experience with nuclear power, while limited, had been extremely satisfactory. Moreover, given the concurrence at the time over relative safety and expense, it was not surprising that nuclear power came under consideration as a possible solution to these potential rising demands for electricity. Hence, the initial decision by PSNH management in 1969 to "go nuclear" was neither surprising nor controversial. In the late 1950s, a consortium of New England utilities, with financial help from the United States Atomic Energy Commission (USAEC), built a pioneer nuclear power plant. The Yankee plant, a 188,000 kilowatt facility located in western Massachusetts, began operating in 1960 and subsequently proved to be remarkably reliable. PSNH owned 7 percent of Yankee. In addition, the company owned 4 percent of Connecticut Yankee, a 565,000 kilowatt nuclear power plant also built with United States government aid. Connecticut Yankee became operative in 1967 and also had a good performance record. Both Yankee plants were tremendous bargains for PSNH. For an investment of only about $10 million, the company owned approximately 100,000 kilowatts of reliable generating capacity.

In 1969 the management of PSNH decided to build a nuclear generating facility at Newington, near Portsmouth. However, the USAEC rejected the company's application for a construction permit on the grounds that the proposed site was too close to Pease Air Force Base. The USAEC ruled that the risk of a B-52 bomber, which carried nuclear bombs, accidently crashing into the generating plant was unacceptably high. The agency prohibited PSNH from building a nuclear power plant within a ten-mile radius of Pease, thereby eliminating several alternative sites that had been selected by the company. An extensive search for an acceptable site lasted two years and culminated in 1972. A site was chosen several miles from the town of Seabrook on New Hampshire's eighteen-mile Atlantic coastline. Four reasons were given for selecting Seabrook: the ocean was a convenient source of cooling water for the power plant; the site was accessible by barge, which would help minimize construction costs; the site was reasonably close to the company's major electricity demand centers; and the site offered a stable granite foundation.

PSNH awarded an $80 million contract to Westinghouse to build two 1,150,000 kilowatt nuclear steam supply systems. Company spokespersons said that the first of the two units would be completed by 1979 and the second by 1981. The Seabrook Nuclear Station would supply 70 percent of New Hampshire's electric power needs during the early 1980s at a cost estimated to be 60 percent cheaper than oil and 30 percent cheaper than coal. These plans were presented to a Seabrook town meeting and were met with an enthusiastic response as the town selectmen noted the significant revenue benefits to the community. Those at the town meeting unanimously approved the PSNH plan.

The 1972 population of Seabrook was about five thousand during the winter, when it was chiefly a fishing port, and about six thousand in the summer, due to tourism. Behind the town's rather rocky beaches were salt marshes and tidal estuaries serving as a habitat for a variety of marine life and birds.

During the months following the plan's approval, however, local opposition to the Seabrook nuclear power plant began to develop among a diverse assortment of groups. Numerous questions such as the following were raised: Would the nuclear plant hurt the town's tourist business? Would it promote further industrialization of the scenic New Hampshire coastline? Was the plant being built too close to an old earthquake fault? Was the electricity from the plant really necessary? One question, however, soon stood out as an especially troublesome one for PSNH. What would be the effects of the plant's "cooling water" discharge on the local marine ecology?

The Cooling Tunnel Imbroglio

After pressurized steam passes through the power-producing turbines of any steam-driven electrical generating plant, that steam must be condensed into liquid before it can be sent back to the plant's boiler. Some "heat sink"—in practice, relatively cool water—must be available to absorb enough heat from the steam to condense it.

PSNH had two alternatives in solving Seabrook's "heat sink" problem. After condensing the steam, the now relatively warm ocean cooling water could be sprayed into 500-foot cooling towers where its heat would, in turn, be dissipated into the air. However, since some of this water would evaporate into the heated air, a mist of rain would form as the air later cooled. Because the plant was so close to the ocean, this rain would contain salt that threatened to harm the environment. Because of this, the AEC determined that cooling towers were not acceptable at the Seabrook site. This decision

meant that PSNH would have to use the ocean as the heat sink for its nuclear power plant. The company's plan called for the construction of two 19-foot-diameter tunnels, each running 1.5 miles into the ocean. One tunnel would draw in more than one billion gallons of water per day and the other would discharge an equal volume, at a temperature about forty degrees warmer than the intake stream.

In early 1975 the Seacoast Antipollution League argued against the cooling tunnel plan in hearings before John McGlennon, the regional administrator of the United States Environmental Protection Agency (EPA). The League's witnesses contended that the discharge of hot water into the ocean would endanger shellfish and other marine life. Witnesses for PSNH disagreed. In June 1975 McGlennon approved the cooling tunnel plan. Thirteen months later, the AEC's successor, the Nuclear Regulatory Commission (NRC), issued a construction permit for the Seabrook facility and work began at the site. But the Seacoast Antipollution League and others who opposed the plant refused to give up. They appealed to McGlennon to reverse his initial decision and in November 1976 he did so, on the grounds that the cooling tunnels would cause unacceptable damage to the local marine environment. This decision about the cooling tunnels meant that the NRC was obliged to rescind Seabrook's construction permit, which it did on January 21, 1977. Four days later, however, the NRC suspended its own order, stating that the matter raised complex legal and policy questions that had ramifications for other nuclear construction projects. However, after subsequent public hearings, and about a month of deliberation, the NRC again canceled Seabrook's construction permit and ruled that PSNH would have to get the approval of the EPA director for the cooling tunnels in order to regain its permit to resume construction.

In June 1977 EPA Director Douglas Costle overturned his regional administrator's decision, determining that the tunnels were environmentally sound after all. This new decision cleared the way for construction to restart on August 1. The Seacoast Antipollution League took Costle's decision to the federal courts. In October 1977 the United States Court of Appeals in Boston denied the League's petition for a stay. Meanwhile, the NRC reversed its 1972 position on cooling towers, saying that this alternative to tunnels was now acceptable if the EPA decided that they were necessary. But the Seacoast Antipollution League had not exhausted its rights in court. The Court of Appeals decision was successfully appealed to the United States First Circuit Court. In February 1978 the Circuit Court overturned Costle, holding that he had based his decision on evidence presented outside the record, and hence unavailable to the environmentalists for cross-examination. The entire matter was sent back to the EPA directors for reconsideration. Yet again, the Seacoast Antipollution League asked the NRC to withdraw Seabrook's permits, and on July 21, 1978, the NRC obliged. Two weeks later, Costle again found the cooling tunnels to be environmentally sound, and on August 10, 1978, work resumed on Seabrook for the third time in a little over two years.

In effect, the imbroglio over the cooling tunnels had paralyzed the Seabrook project for three years—from June 1975 to August 1978. The delay was costly: Seabrook was originally supposed to cost approximately $900 million. PSNH's share of approximately $450 million, reflecting its 50 percent ownership of the project, though large relative to the company's financial resources, was well within its means. Yet during the period of delay caused by the regulatory impasse, Seabrook's estimated cost rose alarmingly, reaching some $2 billion during 1976. The project's critics began to focus on costs and found a receptive public in New Hampshire.

The New Hampshire Public Utility Commission (PUC) was allowing PSNH to include a portion of Seabrook's construction costs in its rate base, thereby significantly lightening the financial burden on the company. In May 1977 the commission granted PSNH a 20 percent rate increase, half of which was attributed to Seabrook. The result of the increase was a sharp public outcry. In response, the state legislature passed a bill prohibiting Construction Work in Progress (CWIP) for retail power sales in New Hampshire. Governor Meldrim Thomson vetoed the bill and in the 1978 gubernatorial campaign, Thomson's opponent, Hugh Gallen, made CWIP for PSNH a major issue. Bumper stickers proclaimed: Whip CWIP — Vote Gallen. Gallen was elected, and shortly thereafter he signed new anti-CWIP legislation. By the spring of 1979, PSNH management had evidently decided that without CWIP the company could no longer support its 50 percent share of Seabrook. In March a spokesman announced that the company would try to reduce its ownership by at least 20 percent. He also announced that the project was now estimated to cost $2.6 billion. Seabrook was clearly already in deep trouble.

One of Seabrook's problems was the *real* technical uncertainty about the precise effects of warm water from the tunnels on local marine life. Moreover, these effects had potential commercial significance on local industry. Of course, it is possible that John McGlennon, a lawyer who had frank political ambitions, made decisions motivated by political considerations. It is also possible that his boss, Costle, was similarly motivated. Both men may have played "fast and loose" with scientific data and opinion to serve political ends. The key point, however, is that the range of disagreement among experts on the basic technical issue of cooling towers was wide enough to sustain contradictory policy conclusions. Hence, it is equally possible that both McGlennon and Costle were honestly trying to make the most responsible decision they could in the face of technical uncertainty. Indeed, throughout the thirty-year fight over nuclear power, such behavior by public officials has been the rule, not the exception.

The February 1978 United States Court of Appeals decision illustrates another important feature of the way the administrative and legal system has dealt with technical uncertainty. The court's decision was entirely based on procedural, not substantive, issues. This situation is also typical of nuclear safety and environmental litigation.[4] The courts are extremely reluctant to second-guess the technical judgements of administrative agencies like the EPA or NRC. In 1978 the Court of Appeals did not rule on the question of whether tunnels were acceptable. It merely ruled that Costle had used inappropriate procedures for reaching his own decision.

The Three Mile Island Accident Aftermath

In March 1979 the prospects for selling 30 percent of Seabrook seemed bright. The Massachusetts Municipal Wholesale Electric Company (MMWEC), a consortium of thirty-one small municipal power companies, offered to buy 14 percent, bringing its total ownership up to 20 percent. Several other small out-of-state utility companies expressed interest in shares totaling about 8 percent. New Hampshire wholesale utility companies were also potential buyers. Then came the accident at Three Mile Island (TMI) nuclear power plant, which began on March 29. In its aftermath, outside interest in purchasing part of Seabrook rapidly died down. In October MMWEC executives notified PSNH management that their consortium would only be able to increase its ownership by a maximum of 6 percent. The PUC barred PSNH from selling shares to

New Hampshire wholesale utilities and ordered the company to retain at least a 28 percent interest in Seabrook. In November, PSNH still held 35 percent and had few realistic prospects for further sales. Part of the problem was that United Illuminating Company of Connecticut, Seabrook's second largest owner, was trying to sell half of its own 20 percent share. In March 1980 PSNH raised the cost estimate for Seabrook to $3.2 billion, attributing much of the increase to design changes needed to comply with findings of the government commissions that had investigated the TMI accident.

By 1980 the financial implications of Seabrook had become potentially catastrophic for PSNH. To understand how grave the situation had become, consider the approximate and simplified 1980 income data for PSNH shown in Table 1.

Table 1

Approximate Income Data, PSNH, 1980
(in millions)

	$	$
Revenues	351	
Fuel and Other Operating Expenses	−248	
Net Taxes	− 38	
Depreciation	− 17	
Operating Income		48
Interest	− 62	
Allowance for Funds Used During Construction (AFUD)	72	
Other Income	2	
Other Net Income		12
Total Net Income (earnings)		60

Source: PSNH Annual Report, 1980

The critical item is the $72 million *addition* labeled Allowance for Funds Used During Construction (AFUDC) to the category of operating income.

Most state public utility regulatory authorities forbid companies under their jurisdictions from earning a return on plant and equipment unless the facilities are "used and useful"—that is, operating. The basic rationale is that without such a prohibition utilities would over-invest in plant and equipment to the benefit of shareholders and the detriment of customers. The "used and useful" concept has deep roots in United States regulatory policy, going back to the first attempts to regulate railroads in the nineteenth century. The 1977-78 fight between the New Hampshire Legislature and Governor Thomson was only a recent battle in a war that has raged in American politics for more than a century. The war continues today.

Over the decades, however, the utilities have consolidated an important victory. While they are not typically permitted to include CWIP (or at least most of CWIP) in their rate bases, they are allowed to report a noncash addition to their incomes. In 1980 PSNH added to its reported earnings an amount equal to the hypothetical return that its investors would have received on the funds invested in CWIP if the assets represented

by CWIP had actually produced revenues during 1980. This noncash credit to the company's income statement is balanced by a corresponding debit to the CWIP account on its balance sheet.[5]

The key point is that PSNH's $72 million addition was not a cash inflow to the company. It is analogous to the $17 million in reported depreciation expenses. PSNH neither paid out $17 million in cash on depreciation nor took in $72 million as AFUDC. It is important to note that this $72 million was more than 90 percent of the company's total reported earnings.

PSNH's cash earnings for 1980 were $23 million ($78 million plus $17 million minus $72 million). Yet in the same year the company paid $13 million in preferred stock dividends and $35 million in common stock dividends. These payments of $48 million certainly did represent a real cash outflow. On top of this, PSNH spent $161

million in capital markets. Table 2 summarizes the results:

Table 2

Cash Flows, PSNH, 1980
(in millions)

	$	$
Net Income	60	
Cash Income	5	
Dividends	– 48	
Sub Total		(43)
Construction Costs	–233	
External Financing	200	
Sub Total		(33)
Decrease in Working Capital		(76)

Source: PSNH Annual Report, 1980

By 1980 PSNH management was liquidating their company in order to finish Seabrook. By doing so they were taking an appalling risk, for they were effectively betting their company that the project would be finished at approximately the cost and schedule then estimated. Yet *all* past evidence clearly pointed to the near inevitability of further cost increases and delays. The point of no return was rapidly approaching.

In 1980 PSNH's "writing off" of the sunk costs of Seabrook would have been financially painful but hardly fatal. At worst, common stock dividends would have been foregone for some period. But as the cost of the company's investment grew during the coming years, as management should have known it would, the threat of failure to ever finish Seabrook would become an increasingly mortal blow for PSNH as a going business concern.

The Financial Fiascoes of the 1980s

During 1981 and 1982, management's liquidation of PSNH accelerated. In 1982 PSNH had a cash deficit of more than $35 million, yet paid common and preferred dividends of $75 million. The project's costs had, predictably, continued to rise, reaching $3.6 billion by the end of 1981. On January 12, 1982, the New Hampshire PUC ordered

PSNH to sell its 4 percent share in the partially built Millstone 3 nuclear power plant in Connecticut and gave the company six months to lower its Seabrook stake to 28 percent; otherwise, PUC said, it would order cancellation of unit #2. Three days later, PSNH's bond and preferred stock ratings fell "below investment grade," an ignominy shared at the time by only two other utilities: General Public Utilities (GPU), the owner of TMI, and United Illuminating, PSNH's largest partner in Seabrook. On January 18 the PUC ordered an immediate halt to construction work on unit #2. PSNH responded by taking the commission to court in December 1982, and the state supreme court overturned the PUC order. PSNH promptly announced that work on unit #2 would continue at a reduced rate, but that total project costs were now estimated to be $5.25 billion, mainly because of added interest charges.[6]

At the end of 1982 PSNH estimated its future construction expenditures as follows:

1983: $255 million

1984: $185 million

1985: $135 million

1986: $120 million

1987: $40 million

PSNH now was probably beyond the point of no return, with unit #1 standing no more than two-thirds completed and unit #2 less than one-quarter finished. In August 1983, the Connecticut PUC ordered the state's two Seabrook owners (Connecticut Powerlight Company and United Illuminating Company) to stop all payments for work on unit #2. In September 1983, PSNH halted all construction work on unit #2 "indefinitely"; and in March 1984 United Engineers and Constructors, the architectural engineering firm in charge of building Seabrook, informed PSNH that the total cost of the two units would be $10.1 billion.

In a subsequent public statement, PSNH "rejected" the $10.1 billion figure, claiming that the total project cost would not exceed $6.9 billion. Shortly thereafter, owners accounting for 59 percent of Seabrook voted to cancel unit #2. The project's joint owners' agreement, however, gave PSNH veto power over this decision, which the company's management promptly exercised. Then, two weeks later, in April 1984, PSNH management acted on their own initiative under the terms of the joint owners' agreement and ordered all work indefinitely halted on unit #1. Meanwhile, a management consulting firm that had been retained by the Massachusetts Attorney General testified before the Massachusetts Department of Public Utilities (DPU) that a "minimum best case" additional cost to complete unit #1 alone was $2.5 billion. A more realistic figure, the firm testified, was $3 billion, completion to take at least two and one-half years from the time work resumed.

In 1972 when PSNH embarked on the Seabrook project, its debt and preferred stock were rated a solid A, and the company was a healthy public utility in a high-growth service territory. Thirteen years and more than $2 billion later, the company is stuck with a 36 percent share of a half-built $5.25 billion project that threatens to cause bankruptcy unless it is finished and the company's customers begin to pay for it. Meanwhile PSNH debt and preferred stock threaten to run the firm into bankruptcy; its debt and preferred stock were rated well below investment grade, and over 27 million common shares had been issued, constituting a dilution of several hundred percent. Dividend payments on these shares have for several years been classified as "return of capital."

What Went Wrong

The roots of the Seabrook debacle go back to the very beginning of commercial nuclear power in the United States; indeed, the seeds were planted nearly forty years ago.[7] In 1947 a new and uniquely powerful government agency was created and given full responsibility for developing the technology of atomic energy for both military and civilian purposes. For approximately the first ten years of its existence, however, the United States Atomic Energy Commission's top officials spent nearly all of their time and nearly all of the agency's money on military nuclear programs. In part, this was the unavoidable result of the magnitude of the task of building the stockpile of nuclear weapons, which was regarded as the keystone of the nation's defense program during the 1950s.

Significantly, the AEC's military tilt was also the result of a deliberate political choice. The agency's most powerful head during the Eisenhower administration, Lewis Strauss, believed that the job of developing "atoms for peace" was primarily the responsibility of private industry. The technical and managerial resources of private industry were, however, being similarly strained by the demands of military nuclear projects. For instance, the first power-producing nuclear reactors were developed by private industry for the United States Navy in order to propel submarines.

The military origins of United States nuclear reactor technology had two important consequences. First, the reactors themselves were designed for use by the Navy's highly trained and highly motivated operators but were not necessarily ideal for commercial use by electric power industry personnel. The second consequence was that the companies who developed and manufactured reactors for the United States Navy were, quite understandably, eager to capitalize on their knowledge and experience in the much more lucrative civilian market. By the early 1960s, the reactor manufacturers had modified the design of their naval reactors and began to aggressively market this new, and largely untested, product to their long-standing customers in the electric utility industry.

The nature of the commercial relationship between the reactor manufacturers and the electric power companies is an important element in the story of United States nuclear power. General manufacturers had provided technological leadership to the electric utility industry for decades. Their customers respected them and substantially lacked the ability to verify or even to question them on many technical matters. The manufacturer's new—and in reality, highly novel—products were advertised and purchased as merely a relatively modest modification to existing and well-understood electricity-generating technology. Nuclear power plants, it was clear, were not revolutionary; they were simply a cheaper alternative to heat water to make steam-driven conventional electric turbines.

Moreover, the first commercial sales of these nuclear steam supply systems were made with prices guaranteed at levels that made them "loss leaders": merchandise initially sold at or below cost in the expectation that a demonstration effect would cause additional customers to flock to the sales office and pay higher prices later on. This marketing strategy was extremely successful. By 1966, less than three years after the first loss leader sales, a bandwagon market for reactors had developed across the entire United States, with electric utility executives all but stumbling over one another in their rush to own their industry's new symbol of technological progress.

Meanwhile, the government agency that was supposed to be in control, if not in charge, of developing cheap, reliable, and safe civilian nuclear technology, was simply

a passive observer. During the crucial mid-1960s period of initial reactor commercialization, the AEC's activity in the new nuclear marketplace was essentially limited to reprinting the manufacturers' advertisements under official covers, giving the reactors the cachet of authoritative verification. But this was by no means the limit of the AEC's failure during the mid-1960s. Its leaders committed other errors both of omission and commission.

First, the AEC simply never took the job of regulating nuclear power seriously. Regulatory policy was *explicitly* based on the peculiar proposition that because nuclear technology was so obviously hazardous, the companies manufacturing and purchasing it would regulate themselves. AEC officials assumed, in effect, that manufacturers would design reactors that were "safe enough"; that construction companies would build them according to rigid standards of quality control and quality assurance, and that utility companies would operate them safely. The AEC defined its job as setting the basic design, construction, and operating standards and then "spot checking," with a strong presumption that these standards were being followed, to make sure that designers, builders, and operators were doing what they were supposed to do.

In the early years of nuclear power, the AEC's reactor program was also flawed by an important error of commission. Its scientific research program was almost totally concentrated on a single technical characteristic of nuclear power plant design: the efficiency with which reactors consumed uranium. What would turn out to be far more commercially significant areas requiring research and development—radioactive waste disposal; *safe,* as distinct from fuel-efficient, design; simplicity of operation; and a host of others—were either ignored altogether or only meagerly supported.

Signs of deep trouble quickly appeared in the United States commercial reactor marketplace. By the late 1960s, it was evident that some of the economic promises of the early years were not being kept. Nuclear power plants were costing roughly double what had been estimated to build them. The manufacturers responded with a design change that it was hoped would make reactors cheaper: they started to sell much bigger plants with the idea, borrowed from experience elsewhere, of spreading the high fixed costs of plant construction across larger units of output. By the early 1970s, utilities were buying designs for nuclear plants that were up to *six times* larger than any that had yet operated. Today, most executives in the utility industry concede that the explosively rapid scale-up of designs fifteen years ago was a costly mistake.

A second and eventually more costly problem for the infant nuclear business came from outside the closed circle of industry and government. Persons with no official connection to government regulators or industry buyers and sellers began to claim that, contrary to the assertions of all of the latter, nuclear power plants *were not safe enough.*

An essential element of opposition to nuclear power in this country is often ignored. Effective opposition has always been based on *technical arguments.* During the latter years of the 1960s, outsiders began to ask specific technical questions about reactor design and operating characteristics. And, from the first, they had the better of the argument over the questions they raised.

The watershed event was an eighteen-month public hearing held, at the insistence of outsiders, by the AEC in 1972 and 1973. At issue was the adequacy of the "Emergency Core Cooling System" (ECCS) for preventing a catastrophic accident to a pressurized water reactor. After the hearing, which lasted 125 days, AEC regulations were revised, vindicating the outsiders' claims that there were defects in the design of the reactors that utilities had rushed to buy during the preceding ten years. Prior to the ECCS hear-

ing, opposition to nuclear power was limited to local challenges to specific projects. Afterward, the issue became the inherent safety of the dozens of reactors then in operation and under construction, and hence, the basic social acceptability of contemporary nuclear power technology.

More specifically, the ECCS controversy caused the first of many expensive redesigns of commercial nuclear power plants, each with the purpose of making reactors still safer. Currently, this process continues and is the basic reason that the average cost of nuclear plants completed today is higher than the average cost of plants completed in the 1970s. United States nuclear power plants have been continually redesigned in an effort to make them comply with established safety measures and developing safety concerns. Each design change has increased the cost of the final product. Today, the fundamental point of disagreement between the nuclear industry and its outside critics is whether current designs and standards are "safe enough." There is little prospect that the argument will be resolved for at least several years, until considerably more operating experience is gained with the redesigned plants, both here and abroad, that have entered service only recently. But the weight of empirical evidence does now appear to be accumulating on the side of those who insist that today's designs are, indeed, safe enough.

Ironically, perhaps the most persuasive empirical evidence about the inherent safety of today's reactor designs comes from the April 1979 accident at Three Mile Island. For a large fraction of the American public, this accident seemed to be the definitive vindication of the claims of persons who had been fighting the nuclear industry. Something that was supposed to be *impossible,* a catastrophic accident to a large, modern nuclear power plant, had, apparently, almost happened. The nuclear industry's assurance that TMI had proved that reactors were safe, not unsafe, had a decidedly hollow ring. Yet the perspective of time and distance has added credibility to this assurance, for it is now clear that TMI confirmed some fundamental propositions about how nuclear reactors would behave under extreme conditions that before the accident had only been proven in theory. Nevertheless, it has also become increasingly clear that TMI was a true watershed for nuclear power in the United States. All of the nuclear plants completed and operating *before* the accident are now generating electricity that is relatively cheap.

The TMI accident caused a virtual two-year hiatus in the licensing of new nuclear power plants for operation. It also caused some costly design changes to plants that were partially built at the time of the accident. The combination of the delays, during a period of unprecedentedly high interest rates, and the required design changes has meant that nearly all plants still being built will produce relatively costly electricity. Many, including Seabrook, will produce electricity that by any contemporary, reasonable standards is extremely expensive: two or three times the cost of electricity produced from burning oil, unless oil-price increases exceed $75 per barrel.[8]

By the end of 1980, it should have been evident to PSNH management that during Seabrook's first few years of operation, the plant would mean more, not less, expensive electricity to its customers. It is true that 1980 was a year of deep pessimism among nearly all energy experts about the probable cost of oil during the late 1980s and 1990s. In 1980 it was not necessarily foolish to suppose that, even at a total cost of $5.25 billion, Seabrook might produce relatively economical electricity in the 1990s, assuming that the price of oil reached the levels of $100 per barrel that most experts were then predicting. Yet the key point remains—PSNH management was literally risking their company as a going business concern for arguable benefits.

Today Seabrook is an unqualified catastrophe. If unit #1 is completed and all or most of its costs are passed along to New England electricity consumers in the form of substantial annual rate increases—10 to 20 percent—for several consecutive years, there is only a small chance that those costs will be offset by future benefits to different customers. Moreover, there are several clearly more economic alternatives to Seabrook's expensive electricity. It is still in the interests of PSNH and the other owners' customers to abandon Seabrook. Unhappily, because of the investments made in the project since 1980, Seabrook's cancellation today, without substantial cost recovery from customers, could mean the end of PSNH as a going business concern and the loss of hundreds of millions of dollars for the company's bondholders and creditors. The company's failure to cancel Seabrook by 1981 was devastating: it was precisely the kind of company-wrecking mistake that top management has the ineluctable responsibility to avoid.

Notes

1. The following history of the Seabrook project was compiled by the author, entirely from public sources, over a four-year period, 1979 to 1983. It has been used as the basis for classroom discussion as part of an elective course, "Managing Energy Resources," in the curriculum of the Harvard Business School's M.B.A. program. The material in case study format is available from HBS Case Services, Harvard Business School, Boston, MA 02163, under the title *Public Service Co. of New Hampshire: The Seabrook Nuclear Project* (9-679-079). A companion Teaching Note is also available (5-685-010).
2. For more detail, see Irvin C. Bupp and Jean-Claude Derian, *The Failed Promise of Nuclear Power* (New York: Basic Books, 1981).
3. Robert Stobaugh and Daniel Yergin, eds., *Energy Future: The Report of the Energy Project at the Harvard Business School,* 3rd ed. (New York: Vintage Books, 1983). See especially Chapter 6.
4. Frederick R. Anderson, *NEPA in the Courts,* (Washington, D.C.: Resources for the Future, Inc., 1973).
5. For a definitive explanation of these concepts, see L. S. Pomerantz and J. E. Suelflow, *Allowance for Funds Used During Construction: Theory and Application* (Lansing: Michigan State University Press, 1975). For a more sophisticated account, see *Note on "AFUDC"* (0-682-032), HBS Case Services, Harvard Business School, Boston, MA 02163.
6. It has recently become apparent that throughout the history of the Seabrook project supposed cost "estimates" have never been real estimates at all. Instead they have been systematically optimistic *construction management targets.* See Michael B. Meyer, "Nuclear Power Plant Under-Estimations: Mechanisms and Corrections," *Public Utilities Fortnightly* 113, Issue 4, February 16, 1984, pp. 28-31.
7. Bupp and Derian, *Failed Promise.*
8. Cambridge Energy Research Associates, "Prometheus Bound: Nuclear Power at the Turning Point," private report, November 1983. See also Cambridge Energy Research Associates, "Prometheus Bound, Update," private report, April 1984. CERA, 56 John F. Kennedy Street, Suite 5, Cambridge, MA 02138.