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COLD TURKEYS AND TASK FORCES:
PURSUING HIGH RELIABILITY IN CALIFORNIA'S CENTRAL VALLEY*

by

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I. INTRODUCTION

From 1979 to the summer of 1985, 17,000 residential and commercial customers of southwest Bakersfield, California, were plagued with many and often severe power outages. Residents accustomed to receiving all the electricity they desired "at the flick of a switch" recurrently found themselves without use of lights, air conditioners, refrigerators, and other products that have become virtual necessities in modern society. The Pacific Gas and Electric Company (PG&E), charged with supplying electrical services to this arid, oil rich region of California's lower Central Valley became increasingly the target of intense community wrath. Company complaint lines were jammed with calls, angry letters were written to the local paper. City officials were repeatedly contacted with demands that they "do something" about the persistent blackouts. In short, electrical reliability, which almost never emerges as a topic for community debate because of American utilities' proud record of delivering as much power as customers desire, became a major local issue and deeply felt concern in Bakersfield.

If community reaction to the problems was particularly intense, the eventual responses of city government and PG&E itself were also extraordinary. After patiently accepting company assurances that the problem would be solved, while experiencing continued blackouts, the city council took the highly unusual step of filing a formal complaint against PG&E
with the California Public Utilities Commission (CPUC). This action in turn prompted the company to initiate a thorough reconstruction effort "of a magnitude that had never been attempted before, and probably never will be attempted again," according to several senior executives. PG&E set up a special task force whose exclusive mission was to "fix the problem." Four months and nearly $15 million later, over 150 miles of new underground electric cable had been replaced in the affected area - nearly 25-30 percent of the local service area - and a number of other tasks were completed that substantially improved the local system's capacity. These efforts required the temporary redeployment of well over a hundred workers from all over the company, and posed many additional organizational challenges. Happily, this work has paid dividends. Outages have fallen to well below acceptable levels, and there is renewed, if somewhat reserved, confidence in the utility from city leaders and citizens.

Why is this case interesting and what can be learned from it? It is a clear example of the challenges involved in attempting the extraordinary organization goal of "failure-free," operational reliability. Like all utilities, PG&E's greatest asset is its reputation as a company that can be counted on in all types of circumstances to provide adequate supplies of electric power. It is a reputation well deserved. The reliability of electric power in California is so high as to be taken almost for granted.[1] "Of course, electricity is always
at the wall socket whenever we want it." It is a little remarked wonder of advanced industrial society. And PG&E is one of the biggest, most diversified and best of the investor owner utilities.[2] The company serves a total of 4 million electric customers, who reside in a land area about the size of the New England states. In 1984, PG&E's electrical services were available 99.965 percent of the time they were requested. That is, the average customer lost power for only 3.5 hours out of every 10,000 (or about 3 hours per year) in which he or she sought to operate equipment using electricity. In 1985, the service availability rating had risen to 99.968 percent.

The utility is a prime example of a class of "high reliability" organizations that take on an extraordinary goal - to operate complex, often hazardous technical systems in a nearly failure-free manner. "High reliability" organizations are those in which operational reliability rivals short term efficiency as a dominant day-to-day goal. The higher the perceived hazard or costliness of operational failures, the more insistant the demands for high levels of reliability. A number of organizations in our society are being pressed to take on the goal of attempting to achieve nearly failure-free operational performance.[3] A characteristic feature of these organizations is the relatively clear specification of operational failures and the consistent efforts to reduce their number to very low levels. For example, the Air Traffic Control (ATC) service of the Federal Aviation Administration attempts to completely eliminate
situations in which there is unsafe separation between aircraft under ATC control. The challenge is remarkable, yet some have come close to succeeding. However, because systematic study of successful high reliability organizations is rare, we know very little about why they are able to meet their goals, or what the costs of nearly error-free performance are.[4]

PG&E has come quite close to achieving the extraordinary technical and managerial goal of highly reliable, nearly failure-free operations: a goal the public and its leaders wish very much to be achieved continuously. Yet surprisingly, in southwest Bakersfield, the company faltered, was increasingly puzzled about why and embarrassed about its failure to repair the situation, then dismayed by the community’s reactions, and, in the end, showed itself able to mount an extraordinary effort to overcome the problem. The reasons this problem became acute and the dynamics of the company’s response in resolving it indicate some of both the surprises involved in the steady pursuit of high reliability operations and of the organizational requisites for achieving it.

Analyses of the rare events in an organization’s life that challenge its self-image can shed light on its essential character and, in this case, can provide valuable insight into the organizational prerequisites for nearly failure-free performance. Indeed, two characteristics of high reliability organizations are clearly highlighted by the Bakersfield events: the need for processes to detect the early on-set of problems
that could mature and overwhelm the system; and the capacity to contain, then mitigate the consequences of failures in the unusual circumstances when they occur.[5]

Before going into detail, it is important to set the Bakersfield locale into the broader PG&E and California context. Situated in the far southern reaches of PG&E’s service area, the division operates a significant section of the company’s vast residential and commercial power distribution system, dispensing power flowing to it through high voltage bulk transmission lines and alternative energy electricity generating plants scattered throughout northern California and the Sierra Nevada mountains, and frequently with energy imported through long distance networks from as far north as power abundant Washington state.

Reliability is a key operating objective for the company, with particular emphasis on assuring adequate power supply in all kinds of conditions, and maintaining the 14,000 miles of transmission lines feeding the sweeping filigree of some 96,000 miles of distribution lines. The margins for error are small. The goal is a constant level of voltage with margins of plus or minus (+/-) 5 percent of nominal voltage. Wider fluctuations could result in very costly failures and consumer and regulatory difficulties. Intense planning efforts are made to forecast future needs and work through the long multi-year approval and construction processes associated with maintaining the reserve capacity necessary to assure availability of power generating facilities when they will be needed. Similarly, intense planning
and day-to-day monitoring efforts are devoted to tracking the behavior of power flows through the transmission system to avoid the small power fluctuations that signal problems in generation or the security of the lines: problems which must be isolated or risk severe damage to generating and transmission equipment and loss of power over wide swatches of the service area. Doubly and triply redundant networks and finely tuned control system monitoring are the rule. The emphasis on failure-free performance is paramount - and sets the premises for the overall operating organization culture.[6]

The thousands of local circuits in the distribution system operate with less insistent demands for completely failure-free, "zero defect" operations than the transmission system. There are many more miles of less robust lines strung in narrow rights-of-way snaking through a variety of ecological areas. These lines are much more vulnerable to damage from falling trees, birds and wind.[7] Costs would be astronomical to provide the redundancies, robustness and control systems needed to match the day-to-day reliability of the transmission system. Rather distribution systems can be designed to limit the scope of outages due to a break in the lines; the consequences of separation in these radial delivery lines can be bounded, limited to a relatively few customers. And the restoration of power and repair of such problems can usually be accomplished in short order.

Thus, the cultures of reliability vary somewhat between the
transmission and distribution systems, with "distribution" pressing for levels of reliability in terms of almost all of the people almost all of the time, (in this sense somewhat less insistent on "failure-free" operations.) Transmission attempts to prevent any interruption of flow. The case of the southwest Bakersfield can be seen as one in which the regular, accepted level of error for the distribution system was challenged and demands were made to reduce it substantially.

II. WHAT HAPPENED IN SOUTHWEST BAKERSFIELD?

The events involving PG&E in southwest Bakersfield, summarized in Table 1, can be divided into three periods of increasing company concern about the severity of the underlying problems. During the first phase - from 1979 to the summer of 1984 - there was an unusual amount of customer time lost to outages in the south-west area, and the power failures emerged as a salient political issue. In the second phase, the community was increasingly upset about the situation, the city moved toward taking formal action with regard to the problems, and the company began to commit extra resources and energy to alleviate the power failures. When the outage difficulties persisted into the summer of 1985, city officials filed their formal complaint, prompting the company to undertake its extraordinary reconstruction efforts. This marked the beginning of the final phase. Details of these periods are discussed below after setting Bakersfield and its southwest area into context.
Table 1
Key Events in Bakersfield Case

Phase 1

1. 1979 - Local company officials first realize that there's an unusual problem with electrical outages in the southwest area; company headquarters is unaware of the difficulties.
2. 1981 - The PG&E division encompassing Bakersfield first submits a budget request for underground interruption equipment; the request is denied.

Phase 2

3. Summer, 1983 - The company begins elbow replacements in the southwest area, after receiving word from company headquarters about a system-wide elbow problem.
4. 1984 - A series of severe blackouts prompts many complaints from customers, increased media attention to the outage problem, and informal discussions between city officials and PG&E representatives; the division director authorizes a special study of the problems in the area, and assures city officials that action will be taken to alleviate the difficulties.
5. November, 1984 - The "Thanksgiving Day disaster" leaves 7,000 southwest residents without power for up to six and a half hours; in response to city criticism, PG&E initiates its first task force.
6. March, 1985 - Exec. Vice-President announces to local press the PG&E will "fix the problem."
7. May/June, 1985 - Despite the completion of the first task force's work, a series of major blackouts again plague the southwest area.
8. Early July, 1985 - The city manager drafts a complaint to the CPUC, threatening PG&E with termination of its ability to provide service in the area; the complaint is approved by the city council, shortly thereafter the company commits itself to a major new effort.

Phase 3

9. July 18, 1985 - PG&E announces the formation of a new task force to tackle the outage problems, to be headed by the assistant to vice president for electric operations.
10. Christmas, 1985 - By this date, the task force completes most of the reconstruction work in the southwest area.
11. January 23, 1986 - The Bakersfield City Council meets to review the progress to date, and congratulates PG&E on its efforts.
12. April, 1986 - The city drops its complaint to the CPUC against PG&E.
Bakersfield and the Southwest Area

Bakersfield, a city of about 130,000 people in 1984, is located toward the south end of the San Joaquin Valley, about 115 miles north of Los Angeles. Bakersfield is the county seat and largest city in Kern County. The city's summer weather is one of its most prominent natural characteristics; it is very hot, and dry, with an average high temperature of about 90 degrees from June through August. Newspaper articles about conditions in the summer months used words like "sweltering." The weather is very significant for our story, because it results in high demand for air conditioning and refrigeration, which require electricity.

The economy of the community is based on oil and agriculture. Kern County is the largest producer of oil among the nation's counties. It produces 60 percent of the state's oil, some 255 million barrels in 1985, worth more than $5 billion. When oil prices were high, Bakersfield was booming. Indeed, Bakersfield was the fastest growing city in California between 1980 and 1984, based on increases in population, retail sales and construction. With the advent of the oil price slump, however, much of the luster went out of the local economy, as thousands of people lost their jobs. In mid-1986, county unemployment stood at 12.7 percent, well above the national average of 7.0 percent.[8]

Bakersfield is governed by a seven member city council and a mayor with relatively limited political power. Two features of city government were particularly significant in this study. The
council is not highly professionalized. Its members are paid a minimal amount, and are not provided with personal aides. (Though they can and do draw upon county administrative staff for assistance, these people have functions other than directly serving the council). As a result, the council had relatively little capacity to be proactive in investigating problems such as those that emerged in the southwest area of Bakersfield. This may help, in part, to explain why the council’s was slow in taking decisive action, until the summer of 1985. Council members are also elected on a district basis. Once the blackouts emerged as a salient political issue, they could not be ignored by the council members representing the heavily affected districts.

Located south of downtown and west of State Route 99, the main artery cutting north-south through the city, the southwest area of Bakersfield contains middle to upper middle class residences, with some businesses and oil company facilities. There is also a sizable retirement community, "Kern City," near the center of the region. Virtually the entire area lies within Bakersfield city limits. There could be no debate over which local political officials were responsible for addressing the problems in the area. (Local governmental officials, such as county supervisors, sometimes become involved in seeking solutions for the recurring outages. In this case they did not because they lacked jurisdiction.)

The southwest area has been the site of particularly
vigorous population growth in recent years. Throughout the period of serious outage problems, community residents expressed beliefs that the difficulties might be due to failure of the city or utility to adequately plan for the growth that occurred. City and company officials denied this claim.

The area affected by the outage problems is served by an underground electrical system initially installed in the mid-1960s, to satisfy environmentalists' desires to eliminate the visual impact of overhead lines. This was one of PG&E's first uses of underground wiring and equipment for a largely residential area. When the project team was established, company officials believed that power failures would be minimal. The system would be shielded from the vagaries of man and nature that plague overhead cables and equipment. Falling trees, high winds, perching birds, and errant drivers which cause harm to overground lines were removed as problems - virtually everything necessary to distribute electrical power was buried below ground. And underground materials were expected to have low failure rates in the absence of external stress.

Phase 1

In retrospect, first evidence of the problem could be seen as far back as 1979. Local PG&E staff in Bakersfield realized there were reliability problems in the southwest area unexplainable by chance alone. These difficulties, however, were thought to be relatively limited in scope. The local staff were not concerned about the number of outages, which was not
considered extraordinary, but rather that there were too many customers affected by each instance of power failure. In utility terms, the underground system lacked the "interruption equipment" to prevent a problem affecting only one small segment of the underground network from triggering a power shut down for many customers.[9] This meant that an outage typically affected 3,500 customers, rather than the some 50 affected by the typical outage associated with overground lines.

By 1983, after nearly four years of sporadic outages at an annual rate several times the average for the whole system, local PG&E personnel came to believe that they might also have a problem with the "elbows" connecting underground cables to transformers.[10] This conclusion was prompted by information from PG&E's General Office indicating widespread failures in other areas of the type of elbows used in southwest Bakersfield. To this point, local staff did not believe there was a serious problem with the underground cables themselves.

Company activities during this period followed practices appropriate for normal operating conditions. Outages were handled on a case-by-case basis, reacting to individual problems, repairing the break and waiting for the next outage. By summer of 1983, the company began replacing some elbows. However, the local division was unable to secure priority funding for interruption equipment, despite making a third successive request in its annual budget proposal. (PG&E's headquarters may have had limited options with regard to isolating the problem by supplying
interruption equipment. The products necessary to meet problems of underground systems were only just becoming available during the period in which the outages in Bakersfield were emerging as a salient local issue).

No special studies of the Bakersfield outage problem were conducted. No outsiders were brought in to help with the situation. Indeed, throughout Phase 1, General Office personnel did not view the problems in Bakersfield as extraordinary, or deserving of extra attention or resources. Performance data from other areas served by underground electrical systems indicated blackout problems similar to those facing Bakersfield. San Jose, Stockton, and Antioch, among others, were also having problems, although the scope of the customers affected in southwest Bakersfield was far greater. The company’s approach in all these areas was to proceed with an incremental strategy, "responding to failures," as far as possible.

Community concern over the problem increased during Phase 1, although actual complaints were sporadic. The number and severity of outages varied greatly, and consumer complaints followed the same pattern, waxing when problems increased and waning during times of uninterrupted electrical service. The Bakersfield Californian, the major local newspaper, reported on the outages that occurred, but only began to discuss the recurrent pattern of outages in about the summer of 1983. A review of newspaper stories shows that even then the blackout problem was well down the priority list of local stories.
receiving coverage.[11] And there was little attention to the outage difficulties on the part of local city officials. In response to constituent complaints (and in some cases first hand experience with blackouts), individual city councilmen expressed concerns to local PG&E management, but the matter did not become a formal issue for the council, and no official action was taken. In a nutshell, concern was latent in the community, rather than organized.

No other public agencies or officials were involved in the outage problems facing the southwest area during this period. The CPUC had not yet become aware of the unusual blackout problems plaguing the region. This was also true of others who might have had some interest, such as state legislative representatives.

Phase 2

Company attention to the problems in the southwest area began to increase significantly in the summer of 1984. Much of this was the result of a particularly bad series of outages, and the community’s strongly negative reaction to them. The blackouts could hardly have come at a worse time. Temperatures were soaring, and demand for electricity was at its highest. For instance, the Bakersfield Californian reported that with temperatures hovering around 100 degrees, 15,500 PG&E customers were without power at some point during the weekend of July 14-15. Another 6,000 people were without electricity on the following Monday. (Typically, an average PG&E customer
experiences about 180 minutes of outage per year. In southwest Bakersfield, this had risen to from 500 to 1000 minutes.) The patience of Bakersfield citizens was being sorely tried. Angry calls poured into PG&E from its residential and business customers.

Notably, community pressure came from individuals, rather than groups. According to both city and company officials, Bakersfield was different from some other cities in which PG&E operates in that company problems did not prompt creation of locally based community organizations. PG&E officials commented later that community pressure might have reached critical levels earlier had there been existing community groups, as in San Francisco, ready to do battle with the company over PCB spills, and/or had such groups been formed during the outage difficulties.

The local media became more important players at this time. The Californian ran several stories about the extent of the problems, PG&E’s uncertainty about how they should be addressed, and long-suffering residents’ frustration with the situation. These stories were complete with such headlines as "PG&E Denies Fiddling Around While Residents Do Slow Burn." Local television stations also ran stories on the situation. Company officials considered this media attention very embarrassing and troublesome.

In response to the severe summer outages and the pressures from the community, the problems in the southwest area moved to
center stage for division management. The division head authorized a special study of the situation. The result was a number of recommendations for system improvement, including a significantly greater elbow replacement effort, and a renewed call for interruption equipment. These recommendations would have required significantly increased resource commitment from the company. Division staff delivered a presentation to the General Office regarding the problems in the area, and the recommended improvements. General Office turned down the funding request, based on the belief that the problems in Southwest Bakersfield still did not warrant an extraordinary commitment of resources. Company officials still believed that reconstruction needs in other areas were as great as were needs in Bakersfield.

This was a key turning point in the evolution toward major problems. By this time, there were a host of warnings, signals that could alert the General Office that they could be on the brink of a significant failure. Yet these signals were not heeded. Why was the General Office unwilling to commit new resources at this time, or recognize the magnitude of the situation facing the Kern division?

This was due, in part, to the fact that the headquarters staff overseeing distribution activities did not share the same sense of urgency about the situation felt by Bakersfield staff. As a consequence, top management of Electric Operations was not informed in much detail of what was going on. While managers receive regular reports from the field including information
about the outages, the reports are not detailed enough to alert PG&E executives to problems within subsections of the company's geographical regions. In the absence of direct knowledge, top management depends on staff to let them know about problems such as those occurring in southwest Bakersfield. (In fact, a key person in top management initially learned about the Bakersfield problem came from newspaper accounts, and not from staff at all). Additionally, due to the beginning of a major re-orientation within the General Office about the role of the regions, there was growing sentiment in San Francisco that region management, e.g., the Bakersfield-Fresno region, should be "solving their problems themselves." As a result of these and other factors, the consensus among top management about the need for correction in Bakersfield was not forthcoming.

The next catastrophe, however, prompted the company - and the community - to make a stronger response. On Thanksgiving Day in 1984, 7,000 southwest area customers lost electricity for several hours. The lights went out at about 8:00 a.m. Power was restored to some residents within an hour, many others waited until nearly 2:30 p.m. Dinners were foiled, cold turkeys waited hours for hot ovens. Television carrying major college football games from the east were dark. Angry calls flooded city and local PG&E officials. The outage earned particular ire from city leaders because many of them were personally affected. The mayor, who lived in southwest Bakersfield, found his own dinner plans interrupted while he was in the midst of responding to
constituents who were more than a little upset about the state of electrical service in the area. One irate citizen demanded that the mayor come "cook my turkey."

Soon after, the city council called PG&E representatives before it, demanding to know how PG&E was going to solve the problems that had plagued the area. When word of this disaster and confrontation reached San Francisco, a limited task force aimed at fulfilling the recommendations contained in the previous summer's staff report was authorized.

From a public relations standpoint, the words used by PG&E executives were almost as significant as their deeds. In March, 1985, the newly appointed executive vice president held a press conference in Bakersfield in which he said the outage problems would be dramatically reduced. This action greatly "upped the stakes" for PG&E, placing still more pressure on company officials to take quick and decisive action to curb the outage difficulties.

By May of 1985, the first task force's efforts were largely complete - at a cost of about $1,000,000. Initially, it appeared these activities had paid dividends, because outage rates went down. However, a more serious, quite troubling turn was in the offing. Based on reports of widespread failures elsewhere of the type of cable used in the southwest area, some in company management by now had become convinced that the difficulties "would never really be solved" until the underground lines themselves were replaced. Such a development had been difficult
to imagine 15 years earlier, when the underground system was first installed in the southwest area. At that time, PG&E used newly developed high molecular weight polyethylene (HMWPE) cable. The industry had expected these cables to last for thirty years.[12]

City staff, who had started to take a more active role in reviewing PG&E activities, were also becoming concerned about company information they had received which seemed to suggest that only a portion of the problems were attributable to elbow failures - the difficulties which were the primary focus of the first task force. One staff member began to seek insistently from local PG&E people more detailed technical information about the underground lines. Still, it took one more series of problems for concerns to be translated into action.

By May, the outages returned and, in June there were even more failures. The record for June of 1985 was actually worse than it had been in June of the prior year. (Average customer hours lost to outages in southwest Bakersfield from January - June, 1985, were 2.4 times the systemwide rate.) According to both company insiders and outsiders, "the patience of the community had run out."

The utility's reliability problems had finally become a manifest local political issue. This is something PG&E officials try hard to avoid throughout the system, usually with considerable success. They attempt to maintain a low profile, to be an invisible service company with an image of strong community
ties. Now, as one Company official said, "Our (local) people have become outsiders in their own community."

City officials scored the company for its prolonged failure to correct the difficulties, and the city manager drafted a complaint to the California Public Utilities Commission (CPUC.) (The CPUC staff had become aware of the unusual amount of outage time in the southwest area earlier in the year, and had met with company representatives about their plans for addressing the situation. They apparently did not discuss the possibility of a formal complaint from the city, and did not advocate such an approach.) The complaint accused PG&E of providing inferior service, and demanded there be improvement within six months or the city would find another company to provide electrical services. With a few modifications, notably the removal of the explicit threat to remove the franchise from PG&E, the proposal was approved by the city council and filed with the CPUC.[13]

The continuing reliability problems in the spring, and the threat of a CPUC complaint triggered a dramatic response: the establishment of a large, extraordinary task force devoted specifically to solving the problem - now understood to require the unprecedented, wholesale replacement of many miles of underground lines. The complaint was a catalyst that brought several concerns together, focussed the attention of top management, and resulted in an abrupt decision to "do whatever was needed to get the job done."

This concern was due less to fear that harsh regulatory
actions would result than to a more general sense about corporate reputation, coupled with a concern that this situation could color other PG&E matters before the CPUC. There was worry about adverse publicity associated with a CPUC hearings on the Bakersfield situation, and some concern that the Commission might impose fiscal sanctions on the company. (Most people within and outside the company did not really think the city would actually seek to carry through on its earlier threat to remove the franchise from PG&E. While the service area of PG&E's chief competitor, Southern California Edison, extends north to just over the mountains south of Bakersfield, the difficulties in securing an alternative electrical service provider are quite formidable.) The intensity within the company was heightened by that public announcement in Bakersfield, by the newly appointed executive vice president.

PG&E abruptly committed itself to vastly increased activity. On July 18, the company announced an all-out effort to correct the problem. The stage was set for the third phase of the Bakersfield events.

Phase 3

The company approached the challenge through a number of major, highly visible steps. The assistant to the vice president for electric operations was temporarily reassigned from his regular duties in the General Office. He was given full responsibility for heading the effort and, backed by strong assurances from the General Office, operated with nearly complete
autonomy. A new task force was created, one much larger than the special group that preceded it. Personnel were drawn from local employees and from volunteers throughout the PG&E service area for a project that was anticipated to take from four to six months. At its peak, the task force consisted of almost 200 people - linemen, electrical engineers, cable splicers, and customer service representatives - performing a wide variety of functions. Situated in a large area adjacent to the local operations headquarters, it was administered separately from the region office.

The task force administration placed an unusual emphasis on community relations. This decision was based on project director’s view that the credibility of the company had to be restored along with the reliability of the underground electrical system. The task force made a thorough effort to inform local media and city officials of company plans and activities. This contrasted significantly with the company’s general practice - procedures that had been in effect in Bakersfield prior to the advent of the second task force - of refraining from giving outsiders detailed information about local PG&E operations.

More specifically, a media coordinator was brought on board and entrusted with the responsibility of smoothing relations between the company and the press. City staff were provided materials they requested, and invited to attend task force planning meetings. Presentations were made to the city council. And significant thought was put into how the company would come
across to the public over the coming months. For instance, the project director developed a strategy of conservatively estimating goals and promises of progress in his presentations of task force work activities to city officials. Then he made a concerted effort to "beat" these goals. He believed that such signs of company success and efficiency were necessary to combat the image of the company that had been formed over the previous few years.

In deciding what was to be done, the task force drew largely from the ideas and plans that had been developed within the Bakersfield office over the previous year. Task force personnel felt no need to bring dramatically different notions of what changes might be made in the southwest area. What they brought was a change in organizational commitment, management style, and resources. This was evident in the planning stage where the PG&E engineer most thoroughly acquainted with the technology of underground cable -- a real pro and recognized industry expert -- was temporarily detailed from the Engineering Department to provide on-the-spot assistance.

The project director, to insure credibility in the plan, employed as consultants two faculty from a notable regional engineering college to develop a computer model with predictions of reliabilities of the proposed components. This done, he arranged for the local newspapers to interview these researchers and discuss the project, in the hope of increasing public confidence in the PG&E plan.
When it went into action, the "Southwest Project" mounted a vigorous, intense program carrying on, by all accounts, a massive effort in the affected area. The heart of the effort was the replacement of existing underground cable with new lines that were believed much less vulnerable to failure. Initially, the task force began with the goal of replacing 570,000 feet of cable, but eventually the target was raised to over 800,000 feet, or over 150 miles. The team also installed isolation equipment which had been desired for a long time, constructed a new high voltage line, the "Rosedale tie," connecting the affected area with a PG&E substation, and made other adjustments to the system.

The project was organized for maximum flexibility, speed and the capacity to concentrate resources. Activities were undertaken quickly, with key decisions made in the field, rather than through the usual elaborate process of obtaining approval from successive layers of administrative authority. The usual approval for specific activities from higher levels within the organization was largely suspended, leaving an unusual amount of authority with mid-level supervisors actively involved in the project.

The work was exceptionally demanding for the first three months. Project personnel worked a "12 days on, 2 days off" cycle. Typically, work started early in the morning and ended well in to the evening - though according to several participants, psychologically they never seemed to leave their jobs during this period. Work was allocated among four teams
each divided into a construction crew and a service crew of some 35 men each, made up of half local crews and half volunteers. Each team would swoop down on a new area laying down cable, with a fifth crew acted as facilitators and additional support in pressed areas.

Crews were aware of how much work the other crews were able to complete, and what their performance in feet of line laid, mistakes made and quality assurance records. Weekly meeting were held with all supervisors to discuss progress and acknowledge high performance. This encouraged friendly, often intense competition among the crews, as they attempted to outshine each other, resulted in a ratcheting of daily and weekly goals until about 6 miles per day was reached. At its peak, there were days with 170 men in the field.

There was also an unusual degree of teamwork. The use of personnel from many different regions, and the requirement that many different types of activities be performed simultaneously, meant that people quite unaccustomed to working together were forced to do so. By all accounts, the project participants pulled together very well, and avoided turf battles that could have torpedoed the company’s efforts.

In the meantime, customer relations staff would inform a new set of people that their power would be temporarily disconnected for a specific period - usually about 12 hours. They were also prepared to deal with the complaints that arose from such actions.
The project was not simply an intense application of familiar technology and procedures on a massive scale. New techniques had to be learned, indeed developed, in dealing with problems of such large scale replacement and improvement of underground electrical distribution systems. For instance, the teams adapted new, more sensitive infrared inspection techniques to test the quality of splices in the cables just after they had been completed. Using some 20 quality assurance people, flaws were identified "on the spot" (not well after the fact by subsequent inspection teams as was usual) and the workman who had done the flawed work was responsible for fixing it immediately. The new technique and immediate inspection and "worker identification with error" practice substantially reduced the number of "first time" flaws and the probability that later repairs would be needed.

And established techniques were substantially modified "on the spot." The replacement was a massive job, and presented unusual problems. As one project leader put it:

Most of the work could be done using the usual methods but some procedures used for smaller jobs were just too costly for such a big job, e.g., when you have a long stretch of cable (underground) you have a hard time pulling out the old cable and pulling a replacement in. When we had this problem on small jobs, we'd have dug the line up, but we couldn't do that all over SW Bakersfield. On bigger jobs with longer stretches we usually put in a 3' x 5' splice box in the middle and pull both ends through from the middle. But splice boxes cost about $1000 each and on the SW project we'd have to put in a lot of'em. It was just too much money. We had to find a ways to improve productivity.... By trial and error, after several things were fabricated that didn't work, we discovered that digging down to cable level at one enclosure (end of a section) we could pull and replace cable pretty well. It was a big improvement.
By Christmas of 1985, the bulk of the work had been successfully completed. The project crew finished laying new cable on December 13, and PG&E personnel who had been brought in from outside areas nearly all returned home. The remaining work consisted largely of installing remaining interruption equipment, ensuring that connections were proper, and general monitoring and quality control activities. Such tasks continued into the late spring of 1986, although the work was conducted at a much less feverish pace than in the previous summer and fall.

What were the major benefits of the project? Most significantly, it brought reliability of service in the southwest area in line with that which characterizes the rest of the PG&E system. Indeed, for the months following peak project activity, reliability in the southwest area exceeded the systemwide average. And, from the standpoint of the company, the project restored much of the good will that had been lost. City council members who had been critical of PG&E praised the work on the project during a January 23, 1986, council meeting about the progress made to date. And city and company representatives reported a dramatic decline in complaints about services. As a further sign that PG&E had met expectations, the city dropped its complaint with the CPUC in April of 1986.
Individual project team members found that the project had given them a strong feeling of accomplishment, as well as an exceptional feeling of comraderie with their fellow workers. Former participants speak of their activities during the project almost fondly, with phrases like "the most important work I’ve done." They also stress gaining an appreciation of the work of other units within the organization. For the majority of employees, these aspects of the project, as well as the unusually high financial compensation that was provided, seem to have more than offset the personal costs involved.[14]

In human and financial terms, the costs of the project activities were high. Almost $15 million was spent on the project; about $870 per customer in the affected area and considerably more than would have been spent following normal procedure.[15] This included additional payments to PG&E personnel in straight pay, overtime, per diem lodging, and other costs, such as paying costs for participants that were not compensated by the company’s relatively generous pay policy.[16] In particular, there were some stress related problems resulting from the intensity of the work, such as uncommon weight loss.

There were indirect costs for the company as well. Temporary transfer of personnel to the Bakersfield area, some of whom were among the most skilled company employees, meant that some projects planned for other areas were put on
hold. Additionally, there were concerns about establishing a bad precedent for headquarters-field office relations. Some company managers worried that implementation of the task force made it appear that the General Office would "reward" a district that was really unable to solve its own problems, while ignoring a district that was able to address its problems without help from headquarters.

Obviously, costs were incurred by others as well. Southwest area residents endured the occasional planned electricity shut downs necessitated by the reconstruction efforts. (The deceptively challenging task of keeping customers informed of company plans was itself a major undertaking for the company). Not every resident was greatly affected. However, some customers experienced multiple power outages, and these outages often came at very inconvenient times. And some customers' lawns and gardens were heavily damaged in the course of project crew activities, although PG&E made an unusually vigorous effort to restore property to its original condition if that was possible, or reimburse consumers for losses if it was not. For the most part, residents endured the above problems very well, apparently glad "PG&E was finally doing something" about the outages.

III. LEARNING FROM EXTRAORDINARY RELIABILITY PROBLEMS

How did utility leadership respond to the situation
they had created and then worked vigorously to change? Were there lessons to be learned about their operations and management decision processes? Do the dynamics of this case apply to others; what generalizations can be derived from the particulars? Are there insights here that enlighten the dynamics, operation and design of "high reliability organizations?"

From the time the task force was initiated, there was a consistent effort to gain experience and learning from the embarrassment. PG&E senior management was taken aback by what seemed to burst upon them as a major local political matter. The company had failed significantly to produce the one quality - very high operating reliability - that is a main reason why regulatory bodies protect it from competition. Senior executives had a significant technological surprise when the underground cables were discovered to have a much shorter life than originally supposed, and they experienced the political problem abruptly with little warning. And the company was wary of the response the CPUC might have in other rate setting matters due to Bakerfield’s tribulation. Company leaders did not want to experience such a situation again.

Three types of learning were evident: the peculiarities and processes involved in operating with and replacing underground electric power lines on a wide scale; the difficulties of sensing the early on-set of potential
failures and then communicating negative information in a manner as timely as the unusual circumstances warranted; and the requisites for rapidly deploying and operating a moderately sized task force with an urgent mission. The latter two aspects directly increased our understanding of "high reliability organizations."

Operational Learning. The task of replacing underground cable was relatively new, certainly in the magnitude and at the speed necessary in the Southwest Project. It called on widely ranging skills applied vigorously to a new problem; one that was likely to arise in other parts of the PG&E system. Assembling a task force made up both of local employees and volunteers from each of the other regions limited the demand on each region. It also had the intended effect of training over 100 people in the techniques, problems and operations of this kind of project who, as one of its leaders noted, "were dispersed back through the system." These people form the nucleus of teams that are now engaged in replacement project of smaller scale under less time pressure.

The massive cable replacement and quality control efforts also allowed managers to see what needed to be done in similar circumstances in the future. As a result, company bulletins were written, and drawings and procedures were standardized. The company made video tapes illustrating how to operate technologies used for the first
time in the southwest area. Project technical learning has already begun to diffuse through the company. One does not, however, get a sense that the conditions (and costs) which produced the extraordinary commitment and energy exhibited by the project's crews have been systematically noted, or encouraged in other situations. [17]

There are other opportunities for more general learning. How could the General Office have been taken by surprise both technically and politically? Why was the community so patient with the utility? Are there insights about the requisites for high reliability operations?

Communication Lags. The utility has a well staffed home office. One of its engineering staff was a leading expert on underground cable. And the company prides itself in being sensitive to the political sensibility of the hundreds of cities, towns and villages in its service area. What were the conditions that resulted in the long delay before the General Office noticed and reacted to the situation in Bakersfield - a delay so attenuated that the problem took on extraordinary political, as well as organizational and technical, dimensions? What have been the responses to these conditions?

Recall the two compounding technical problems: the connectors (elbows) and interruptor equipment between the cables and transformer boxes, and the integrity of the cables themselves. The first was detected and addressed.
It was within the range of normally expected and encountered technical problems. The second problem was systemic, specifically not expected; the type of problem that was outside the mental set of almost everyone in the company. It was, for all intents and purposes, unthinkable.

Initially, cable problems were camouflaged by the elbow situation originally thought to be the whole problem. The early expectations for long cable life (twice the useful time that actually resulted) plus the masking effect of the smaller, more routine elbow failures prompted a situation where the underlying problem was quite outside the perceptions of those on site and almost everyone in the General Office.

It is also likely that the sheer scale of the affected area introduced a "formidability factor." If area wide problems were evident, they would be quite demanding and costly in local region budget terms. If speedy remedies were called for, as well, costs would be even higher and operational changes indigestible. The suspected costs and effort necessary if the problem was systematic could lead to a denial of the problem until it was absolutely unavoidable.

The utility also had a tradition of local discretion. In the relatively rare instance in which higher level consultation or direction was needed, such matters were often taken directly through informal personal contacts to the General Office, thus, by-passing the Region Office.
effect, the locals were expected and wished to be free to solve problems their own way. If problems of scale did occur, it could be interpreted as a failure of local management to anticipate them. This could lead to sanctions, and perhaps reduced discretion. Thus, while there were a few people in the field who suspected early in this case that cable integrity was the deep problem, they neither had the expertise nor the motivation to make an issue out of it. The tactic was to press for marginally increased funds to resolve the elbow/interruptor matter, and later to study the overall situation (tacitly hoping the cable was not really the problem.)

The several engineering experts on the General Office staff who realized that a significant technical problem with underground cable existed were part of the Engineering Department, not the Electric Operations Department which was directly responsible for reliable distribution policy. It was the view of those in Engineering that they would not intervene even if they knew about a problem in Operations unless asked. No one in Operations knew to ask them and they did not initiate an alert. ("It's not our job, and when we tried to help in the past, we got dinged for poking our noses into matters uninvited.") There was, on the technical side, an "organizational timidity" to press stridently enough to be heard by those few in the General Office who had the authority and responsible to act
decisively, in a timely fashion.

There was another baffle to action as well - a reluctance to inform the senior executive overseeing electrical operations. Mid-way in the second phase, when the technical problem of the cable became recognized, the person in the Electric Operations Department who headed the division directly responsible for electric power distribution, (as contrasted to its transmission) did not take the matter to his immediate superior, the man who would eventually give the order to "do whatever needs to be done to fix it." This senior official discovered the problems almost on his own, well into the Phase Two period. He then sought out the expert in Engineering for a briefing and began to realize the full dimensions of the problem.

It is not clear why the senior executive who could order resources and concentrate authority to deal with the problem was informed so late in the evolution of this problem. Perhaps the perspective of his direct subordinate was that he should be in charge and things were under control; perhaps he did not recognize the full ramifications of the situation in Bakersfield; or perhaps he was reluctant to share his technical views with a superior who, as was the case, had a "power generation" rather than a "power distribution" background. In any event, the person who could make the difference was not fully aware of the difficulties until they burst upon him abruptly in mid 1985,
several years after the on-set of quite high levels of outages in Bakersfield.

What factors inhibited communication within the General Office and between it and the field offices and muted an insistence on attended to problems that must have been seen by operating and management people as potentially severe ones? This situation speak directly to more general concerns with the dynamics and operations of high reliability organizations. One of the central requirements in high reliability operations is continuous attention to detecting the early onset of potential failures, then communicating such information insistantly to management.[18] Without the processes and the incentives to do so, significant surprise is likely to be costly.

Two requisites follow: formal information gathering, distribution and analytic processes designed to detect early deviation from known performance standards that are sensitive enough to reveal the unexpected; and a climate or culture within the organization that encourages (or at least does not inhibit) reporting such information even if it suggests the person or unit reporting it may be responsible for the problem. The first requisite is mainly a matter of structural and information collection design. These can be changed rapidly. The second is both more important and more difficult to effect; it is a matter as much of attitude and executive behavior as of formal procedures.
The culture of the Electric Operations Department, the largest and most complex in the utility, is shaped by a strong sense of professionalism grounded in long experience in particular technical functions, e.g., power generation, transmission and distribution, engineering, etc. This blends a professional insistence on technical discretion with a reticence to subordinate oneself to those of different technical/operational backgrounds. This re-enforces the tendency to communicate informally with those in the hierarchy of a similar background or community, an "old boy" network based on experience with the details and tribulations of working with a particular set of complex, demanding technologies.

Other conditions also foster a sense of local identity and sensitivity. The utility's 28 divisions differ greatly in the types of problems they must face due, in part, to widely varying climate and geographical conditions. They are manned by often long-time residents, who are proud of their local company accomplishments and community relations. And the local and regional offices are sensitive to what sometimes seem to be slights or condescending attitudes of the General Office, located in San Francisco, toward those regions (like Bakersfield) in rural California.

With this cluster of conditions, similar to many large scale, dispersed organizations operating complex systems, it is not surprising that problems appearing to be within the
scope of local authority and capability are not emphasized in communications to the General Office. Nor is it surprising that vigorous calls for help on more significant ones might be deferred until there was absolutely no question that local capabilities were being overwhelmed by the nature of the problem.[19]

Timely information about the state of the operating system is obviously a prime concern for operators of tightly coupled systems like large scale electric power networks. Did formal information systems reduce the likelihood of inhibited communications to top managers? PG&E has extensive daily and weekly reports designed to inform key officials about the integrity and troubles of its huge system. One of these, the "Morning Report," provides information on system production and special technical and operating problems or unusual circumstances to senior managers each day. This assists in directing immediate attention and alerting managers to special problems. It does not include warnings based on longer term statistical analyses of system or sub-system performance trends (information which might have alerted top managers to the Bakersfield problem.) These are done by technical staff both in the General Office and in the regions, who are trusted to identify significant problems and bring these to managerial attention. This relationship assumed that technical staff both had the analytical tools to discover
potential surprises and knew the types of problems their line managers wished or needed to notice.

Two things resulted from this division of labor. Managers were able quickly to spot and address time sensitive problems, e.g., damaged equipment, unusual local circumstances, or indications of significant human failure. However, both general office and regional managers were sometimes unaware of problems or patterns revealed by technical analysis concerning more slowly developing, system-wide matters. Staff engineers seemed reluctant to press the implications of analysis that was not very convincing, i.e., break news that might turn out to be bad news. This seemed to be partly a matter of headquarters staff deferring to regional diagnosis - not "getting bloodied by getting into the field," as one senior executive put it - compounded by a sense that unless there was quite conclusive evidence, it would not result in much action and the analyst might be seen as a "nervous Nellie," a sort of a "technical wimp,"

One consequence of the Bakersfield turmoil has been a slight decline in the confidence of senior management in the capability of technical staff to alert them fully and quickly on system related problems. As a result, information on daily outages, formerly routinely routed to regional and General Office engineering staff, is now highlighted when operations show unusual patterns.
Community Patience. Unusually high rates of power outages persisted in southwest Bakersfield for years before the situation "went public" and became an explicit political issue. Had a similar situation developed in one of the coastal cities of California, especially the Bay area, there would have been an almost immediate hue and cry. What might account for the extraordinary patience of Bakersfield's citizenry?

The character of local political culture is the most plausible explanation. California's Central Valley is rooted in a highly individualistic, rural past. Self-sufficiency is a strong value and the role of government is minimized. In Bakersfield, this is expressed in individualized politics, with a limited number of community organizations, and very few grass roots political or consumer groups. The city council is part time with limited staff. People look to themselves individually to satisfy needs. The main organizations of influence are large oil companies with world wide perspectives, and large agricultural land owners, employing few permanent employees, with managers having county or valley-wide perspectives. And the utility is seen as a friendly contributor to the area: its employees loyal both to company and community. Finally, the southwest area was relatively new, the home of many newcomers drawn by the local oil boom. Many residents apparently saw themselves as temporary, with potentially
little at stake in the community itself.

These factors resulted in a situation in which those most affected by the outages had very limited alternatives, even if they were exercised enough to become active. They confronted a utility that had done well by the community, and whose managers were local, long-time residents; as one city official put it, "good people, trying hard to fix the problem." There was no prima facie case to support the opinion that PG&E was trying to evade the problem. In fact, the utility was sending a million dollars replacing "elbows" in a effort to fix it. And there were no consumer or grass roots political groups to petition. It was either hope for the best, devote energies to organizing in a community whose values were highly individualistic, and/or await action from a city council that was part-time whose members took a limited view of government. Some citizens became active, but most waited with slowly increasing irritation for things to improve. It took the series of massive outages to overcome local reticence. Then the response was muted angry and the reluctant admission that those "good friends at PG&E couldn't solve the problem after all."

(It should be noted, however, that one structural factor probably increased the pressures on PG&E once public anger reached the boiling point. This was the fact that council members were elected on a district basis, rather than at-large. Thus, a few council members, whose districts
included the affected area, were especially unable to avoid the issue, and felt even more compelled to "do something." The outage problems actually became a campaign issue in these districts.)

The public response finally became intense and dramatic after the massive Thanksgiving day outage. This political uproar culminated with the city filing the formal complaint before the CPUC. This was what the new city manager described as one of the three "elephant bullets" (and twelve rabbit bullets) he felt was in the kit of a new city manager. He noted "you don't want to use high powered bullets on small game.... I figured I had an elephant on this one!" Blam!

Project Learning - A Model for Task Force Response?. When the city finally got PG&E's attention, dramatic action followed. The project was a nearly unqualified success. If this case were used as a basis for a generalized model for how an organization devoted to high operational reliability should respond to an extraordinary challenge, what requisites are evident?

The essential features of a "Southwest Project Task Force Model" are:

1. Virtually no limits on the amount of material and human resources available to the project team from company headquarters.

2. A very "flat" organizational structure, with key
decision made by people "on the firing line," without the need for extensive review by higher authorities.

3. Personnel required to work exceptionally long, intense, well compensated hours.

4. Functionally different personnel working in much closer coordination with one another than they do normally.

5. Work designed to foster competition between crews or teams.

6. On-the-spot quality control feedback and immediate adjustment judged on the basis of clearly specified performance criteria.

Together these features enable quick, intense action, for there would be few delays from missing equipment, lengthy task approval processes, misunderstandings between units, and normal limitations on the amount of effort people can be expected to contribute in a day. The direct and indirect costs are also likely to be high.

An additional requisite arises if the situation has deteriorated to the point where community and/or customer confidence has been lost.

7. Project activities must be authoritatively and physically "visible."

Once a high reliability organization's capacity to
sustain "failure free performance" is seriously questioned, a concentrated and candid effort to reassure the public is needed before reliability as an issue is likely to recede in the public’s consciousness. Ultimately such efforts must be grounded in solid evidence of improved performance, but more than that may be needed. Announcing the assignment of an assistant to the vice president, crews at work at all hours of the day and into the night, local officials and the public provided with extraordinary amounts of "inside" information, and unusual efforts to compensate consumers for project related losses together lift the project out of the ordinary and signal the depth of an organization’s commitment.

What conditions which would prompt an organization to commit the extraordinary effort necessary to realize such requisites? The key factor combined the public’s response to the situation and a characteristic of the structural defect.

8. Strong and direct pressure to improve reliability, exerted be another entity perceived as capable of imposing meaningful costs on the organization.

In our case, the city council (and secondarily the CPUC) played this role. It posed the threat of bad publicity, franchise removal, and enlisting the power of the CPUC. As a result of this and the deep embarrassment felt by utility executives, the utility abruptly decided to tackle the problem immediately, entirely and quickly applying the
solution - replacement of 150 miles of underground cable - they now realized was necessary. It seems unlikely that PG&E would have opted for immediate, wholesale replacement in the absence of such pressure. A company may commit project-by-project, steadily over some time, very substantial resources to effect reliability, e.g., developing new training programs to improve operator performance, developing new mechanisms for detecting systemwide errors, increasing the amount of redundancy in operations. But it is unlikely to modify the way it normally conducts business in the absence of the need to cope with external demands. In addition to the need for thoroughness and speed, the technical characteristics of the problem prompted the choice of the task force mode of operations.

9. A "lumpy" operational problem rooted in wide spread structural defects requiring nearly simultaneous remedy across a significant part of the system.

The work needed in the southwest area to restore reliability meant the replacement of the heart or perhaps nerves of the delivering system itself - in the shortest possible time. This was a staggering prospect. The southwest area is a relatively large one, and underground cables were wearing out all through it. Even a piece-meal approach, the usual and most economically efficient mode,
would have meant a major effort. This probably could have been dealt with in more or less the usual way, had not the pressure for speedy resolution become so urgent.

When speed became necessary, the needed level of effort far exceeded the capabilities of permanent personnel at the Bakersfield facility. Many additional people having a wide range of skills would have to be assembled very quickly and organized to working intensely together for a relatively short time. Contracting out would be time consuming to start-up and learning derived from the project would be lost to most company personnel. A task force drawing completely from company personnel was the most apt organizational form. It was also quite unusual, flew in the face of familiar patterns of work and authority, and was likely to be much more costly than the usual practices. Without the political pressure to replace so much cable very quickly, PG&E would not have moved to the technically less efficient task force mode.

The Southwest Project has become a strong object lesson for company officials. Their experience - and reflection - has gained significant attention throughout the industry.[20] Almost immediately after the project was completed several of its key leaders wrote technical papers and made a series of presentations to technical gatherings. And the company assembled a study group to review the organizational problems highlighted by events in Bakersfield
Labelled the "Diagonal Slice" Working Group, it drew articulate and experienced participants from various levels of the company into a series of meetings in which candor and comment across hierarchical levels were encouraged. The Working Group agreed on some 25 recommendations relevant to the whole system. Some of these are now being implemented.

The group's work was done when major organizational changes within the utility were being considered, and much of its discussion re-enforced these considerations. As a consequence of these and a number of other factors, the utility is now undergoing a major internal change. The overall direction is to increase the line authority and accountability of the now 6 major regions (made up from some 13 smaller former divisions.) This entails the integration of all functions of the gas and electric operations department into a regional office. Some of the Working Group's recommendations were similar to those emerging from other discussion, some were unique. Those being put in place include:

* A reduction of General Office staff with some increase in the Region offices (this came at a time when for other reasons the Company was planning to reduce its work force by some 2000 persons from the General Office through transfers, lay-offs, and early retirements;
* Substantially increased expenditures for reliability ($60 million for cable and interrupters has recently been authorized over the next ten years;)

* More technical reports directly to region managers (done;)

* Greater role for region manager in management of local staff;

* Greater role for regional management in developing utility policy and budget process.

In general, the changes are designed to give local managers more responsibility for solving problems, while at the same time giving them more capacity to address difficulties that may arise.

Finally, it has been two summers since the end of the Southwest Bakersfield Project. Is it too soon to detect its results? Notably, reliability in the southwest area has remained quite high. Two other bits of evidence are available. Soon after the project was completed, a TV poll taken was in Bakersfield. While biased in unknown ways, it does give an indication, over 60 percent calling in indicated satisfaction with the utility response. And company officials who had become cautious about promising better service in Bakersfield now speak more confidently. One of the project’s local leaders recently noted:

[The project] was pretty successful... We really solved the problem! At first, many people weren’t sure. They said
they'd wait for the summer when it was hot. The press thought there might still be problems. They called up and wanted to discuss the project... We got some good press on that. Now we are into the second summer and service is very good. We've been acknowledged for solving the problem. And the city council and manager are happy. We were a big problem for them."

[And there have been other affects.] The crews that worked on the project from here; the quality of their work has improved. They learned that some of the stuff here was not installed properly, in some cases not designed well. We learned a lot and work quality was stressed on the project. ... Our work is much better now.

A Concluding Note

We conclude with two observations concerning the relationship of political and regulatory bodies and the attainment of the very reliable operations of hazardous technical systems. Public officials and many other concerned citizens want so called "high reliability organizations" (HRO's) to respond to surprise and difficulties in an extraordinary manner. They wish such organizations to rise to the occasion all the while providing continuously the uninterrupted flows of service and benefits. One implication of this demand is that HROs must be allowed, through rate hearings and/or a deeper more generous understanding of organizational economics, enough elasticity that they can reform themselves in times of crisis. This means the capability to hold in reserve sufficient uncommitted resources ("organizational slack" in one dialect,) for example, to maintain enough personnel so they can be redeployed to meet exceptional challenges,
without harm to critical projects. Nor should the organization be penalized for deviating from conventional material supply practices during the crisis, else swift reactions to addressing the reliability problems is damped by too detailed a regard for costs.

This is also a strong implication for public regulatory agencies. They should develop a much better appreciation than they now have for the actual functions and the costs of maintaining the "reliability reserve." The Bakersfield experience underlines the importance of developing clearer standards for what is unacceptable performance in the area of reliability. There are no utility or region wide standards of "acceptable reliability." Some utility functions are evaluated in absolute terms - never fail to provide enough generating capacity, never allow bulk transmission lines to fail. Both seem almost attainable. For other functions, however, absolutely failure-free performance standards do not make sense; the costs are recognizably too high for the service gained. A clearer sense of what specific level of errors are "unacceptable," would give signal the conditions when a company should make an extraordinary effort to improve reliability.
Footnotes

1. For a summary of the overall record of the utility industry, see U.S. Congressional Research Service (U.S.C.R.S.,) "Are the Electric Utilities Gold Plated? A Perspective on Electric Utility Reliability." A study for the Subcommittee on Energy and Power of the Committee on Interstate and Foreign Commerce, U.S. House of Representatives, April, 1979. The report argues that, due to the importance of electricity to everyday life, the industry had developed "an almost perfect electrical system."


3. Examples abound: the extraordinary problems of operating nuclear power plants; public wariness of the industrialization of genetic engineering; demands that air traffic control be failure-free; insistence on accuracy in identifying dangerous drugs; alarm regarding the safety of bridges and dams and the use of pesticides in agriculture; and, less dramatically, concerns that the distribution of electricity, on one hand, and computer based financial and administrative data, on the other, be quickly and very accurately effected over very large geographical regions.


5. The examination of the unusual situation in southwest Bakersfield is part of a larger effort intended to address, in part, the limited understanding of the organizational requirements for avoiding operational failures. The "High Reliability Organizations Project" is intended to deepen our understanding of such entities, and of the managerial and public policy implications of nearly error-free performance. It is led by: Todd R. La Porte, Department of Political Science; Karlene Roberts, School of Business Administration; and Gene I. Rochlin, Institute of Governmental Studies and the Energy and Resources Program, University of California, Berkeley. The project has initiated studies in three organizations that continue to meet and often surpass
society's criteria for reliable performance. In addition to PG&E, they are:
--The Air Traffic Control System, Federal Aviation Administration;
--The U.S. Navy, Carrier Group 3, and its two nuclear aircraft carriers, U.S.S. Enterprise (CVN 65) and U.S.S. Carl Vinson (CVN 70.)
This work includes intensive on-site field work in each organization.

6. Note that the orientations of power generation and transmission stem from different conditions. Generation is concerned with the reliability of supply, availability of power based on adequate reserves of generating facilities. Individual facilities may be out, i.e., components may fail, but due to reserve capacities assurance of supply is maintained. Transmission, on the other hand, is concerned with the continuity of flow. Great emphasis is placed on limiting the failure of components, e.g., high voltage power lines, and stressing redundancies of channels.

7. Over $44 million was spent annually for tree trimming!


9. Interruption equipment would include such devices as underground fuses, which effectively localize the effects of faults on a particular line. More specifically, any time there was a problem of one of the underground circuits, all the customers on that circuit would lose power.

10. Elbows are black, L-shaped rubber insulated devices that connect underground cables to power transformers. There are between three and nine elbows to a transformer and one transformer for about every 20 customers.

11. In July, 1983, for instance, PG&E was mentioned in only two front page stories in the local newspaper. In neither case was the utility the main focus of attention, nor were the outage problem discussed. (The articles pertained to a major heat wave that was gripping the city.) The local story that received the most attention that month dealt with a proposed new shopping center, and its impact on downtown development.
12. It was only later found that such cable was susceptible to damage and insulation leaks. While PG&E had come to realize these problems, and were using different cable for newer developments within the region, much of the southwest area was still served by HMWPE cables.

13. Shortly thereafter, one of the council persons who was soon to stand for re-election made the utility's problems a campaign issue.

14. Benefits also accrued specifically to some of the key players, as well. The city manager, who came to Bakersfield in 1984, mid-phase two of our story, and who initiated consideration of the formal complaint to the CPUC, noted that his role in the Southwest Project episode is one of the few things the citizen associated with him during his early tenure. And the Assistant to the Vice-President, who took charge of the Project, was promoted to Vice President shortly after its completion due, in part, to his vigorous and effective preformance.

15. Although this project was not a massive construction effort, the utility spends some $500 million each year on capital expenditures for the electrical distribution system.

16. One of the first acts of the task force director was to cancel all vacations "for the duration" including his own. The company re-imbursed those who therefore suffered price or deposit penalties in travel or accomodations.

17. These aspects are quite similar to the patterns of attitudes and norms we find in other groups striving, successfully, for high reliability operations. See K. Roberts, et al, "Report on an Organizational Culture Survey from U.S.S. Carl Vinson," Univ. of Calif., Berkeley, CA., July 1987.

19. Noteably, these conditions also encourage norms that prompt members to coalesce in remarkable demonstrations of cooperation and commitment when serious problems or failures do occur.

20. One of the project leaders recently noted that he was receiving several calls each week from other utilities who see themselves as likely to face similar problems in the near future.