Investigators Agree N.Y. Blackout of 1977 Could Have Been Avoided

On a muggy July evening about a year ago New York suffered its second major blackout in a dozen years. Some 8 million persons in New York City and Westchester County lost their electrical service, subways and elevators went dead, rioting and looting broke out, and losses reached at least $310 million. Recriminations began to fly even before the lights were restored. A spokesman for Consolidated Edison, the utility serving the area, initially blamed the outage on an "act of God"—two lightning strokes that unexpectedly knocked out key transmission lines bringing power to the city from the north. But Mayor Abraham Beame, issuing his verdict before any real facts were available, indicted Con Ed for "gross negligence." Shortly thereafter a series of investigations were launched—by the utility, the city, the state, and the federal government—to determine what went wrong. Now, with the release of the Federal Energy Regulatory Commission's final report, the results of several investigations are all in and a verdict is possible.

The investigators agree on many essentials but differ on which events were most crucial and who is to blame. Con Ed's own multivolume review*—"the most comprehensive self-analysis of a power failure ever published by a utility"—describes a long catalog of mishaps without specifying a prime cause of the blackout and without making strong accusations. The three government reports,† in varying degrees of explicitness and harshness, primarily blame Con Ed's top management, much as a captain is blamed if his ship and crew perform ineptly. Some investigators also blame other utilities and the New York Power Pool, which coordinates transfers of power among utilities, for bumbling during the crisis, and fault federal and state regulators for failing to ensure that Con Ed would provide reliable service.

Electrical systems are so complex that it is difficult to single out any one event or circumstance as *the* cause of the blackout. Even after suffering a staggering series of natural shocks, mechanical failures, and human errors, Con Ed came within a hair of avoiding complete collapse. That leaves investigators plenty of room to lament that, if only this or that had been different, there would have been no blackout.

More Vulnerable than Most

To begin with, the Con Ed system regularly operates under constraints that render it more vulnerable to blackouts than most utilities. Largely because of its island geography, Con Ed has relatively weak connections to utilities to the east and west, thus limiting its ability to import power in an emergency. At the same time, it imports substantial amounts of power over major lines running north, and these are vulnerable to interruption. Some of this power comes from Con Ed's own plants, which have been located far north of the city in recent years because of legitimate concerns for preserving urban air quality. The rest comes from other utilities that can generate power much more cheaply than Con Ed, whose skyrocketing electrical rates are the highest in the nation. The power lines funnel through Westchester County in narrow corridors where physical proximity makes them vulnerable to simultaneous loss by lightning, severe weather, or other causes. And when they near the densely populated, water-bound metropolitan area, they dive into the most extensive underground network of high-voltage cables in the world—a system that confronts Con Ed with unique operating problems that also contributed to the blackout.

Even Con Ed's harshest critics generally agree that it faces unique problems. But that is no excuse, they contend, for failing to plan, design, maintain, and operate a reliable electrical system. Yet on the night of the blackout, virtually everything that could go wrong did go wrong.

The trouble began at 8:37 p.m. on 13 July when lightning struck a tower in northern Westchester County and short-circuited two 345-kilovolt lines. Transmission towers are designed to ground most lightning strokes, but grounding along that route was later found less effective than it was supposed to be. Whether proper grounding would have snuffed out the crisis before it began is not known.

Once the short circuit occurred, protective relays, the next line of defense, triggered circuit breakers to open at both ends of the affected lines, thus isolating the problem from the rest of the system. That is exactly what the circuit breakers are supposed to do. However, they are also supposed to reclose automatically once the fault dissipates, and this they failed to do. One transmission line failed to reclose because of a loose locking nut in a circuit; the other because a reclosing circuit had been disconnected and not yet replaced with a new device designed to lessen the possibility that reclosing might damage generators. There is "no apparent reason," according to the state report, for Con Ed's failure to install the new device sooner.

Two other facilities also tripped out of service after the first lightning stroke. A nuclear reactor shut down automatically when the circuit breakers that opened to contain the lightning fault also deprived the reactor of any outlet for its power—a design feature that has since been criticized by most investigators. And another 345-kilovolt line—a major tie across the Hudson—tripped out because a protective timing device was designed improperly by Con Ed. It indicated, incorrectly, that other circuit breakers had not opened to contain the lightning flash, and so it triggered a backup relay that opened the tie across the Hudson in a misguided effort to save the day.

Thus, in one stroke of misfortune, Con Ed lost three major transmission lines and its most heavily loaded generator.

Even so, Con Ed regained its equilibrium by importing more power on the remaining tie lines and by increasing its own generation somewhat. But neither Con Ed nor the power pool tried to restore a reasonable safety margin so that the system would be prepared to cope with another crisis. Then lightning struck again. At 8:55 p.m. a second stroke hit another tower and short-circuited two more 345-kilovolt lines. Again there was a malfunction. One line reclosed automatically as it was supposed to; the other remained open because a relay had been set primarily to protect a nuclear reactor (which, ironically, was out of service) rather than to facilitate reclosing of the line. Con Ed now considers that judgment to disconnect a mistake—throwing away protection of the system because

*Con Edison Board of Review, "System Blackout and System Restoration," First Phase Report, 26 July 1977, Second Phase Report, 24 August 1977, Third Phase Report, 28 December 1977. †"Report of the Special Commission of Inquiry into Energy Failures," 1 December 1977 (the city's report.); "State of New York Investigation of the New York City Blackout," a report by Norman M. Clapp, special consultant, January 1978; Federal Energy Regulatory Commission, "The Con Edison Power Failure of July 13 and 14, 1977," final staff report, June 1978.

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of uncertain worries by the manufacturer over what the shock of reclosing might do to the generator shafts. The loss of the line triggered still another malfunction; it caused a temporary power surge that tripped out another 345-kilovolt line. This should not have happened but did, because of a bent contact on a relay.

The double lightning hits were a rare event. But the mechanical and design failures turned it into an unprecedented crisis. With so many lines out of service, huge overloads now threatened to knock out the few remaining ties to other utilities. The situation could still have been saved by alert, well-trained operating personnel. They could, for example, have shed some load or increased generation to restore equilibrium. But Con Ed's control room succumbed to confusion and panic and did neither effectively.

Con Ed's system operator based his initial strategy on a belief that a particular transmission line was still in service—when in fact it had been knocked out of commission and he should have known that. He failed to read a teletype machine which indicated that the line was down. Moreover, because of Con Ed's antiquated control room layout, he was unable to see a more dramatic indicator in another room—a flashing screen with a high-pitched alarm. The personnel there knew the line was out but failed to tell him. Had the system operator realized the line was out, according to the state report, the circuit could have been reclosed manually and the blackout averted. More important, the operator might have been spurred to take any number of corrective actions to save the system.

As it was, he ignored repeated suggestions from the power pool that he shed load. Then, as the situation deteriorated, he essentially abdicated and dumped the decision-making responsibility on his boss, the chief system operator, who sat at home in the dark reading diagrams by a kerosine lantern and issuing orders over the phone. All of this took precious time and put the onus on a man whose knowledge of the crisis was necessarily limited. The chief ordered voltage reductions—but they were too little and too late. Eventually he also ordered that a block of customers be disconnected. Whereupon the confused system operator pushed the disconnect buttons and nothing happened. Under stress, he apparently turned a master switch the wrong way.

The performance of Con Ed's reserve generators was equally erratic. Con Ed's system operator delayed 8 minutes after the first lightning strike before requesting a fast load pickup from generators that were supposedly able to respond in 10 minutes. He got only half the power he expected—and only 30 percent of what Con Ed had incorrectly told the power pool it could provide. Some equipment malfunctioned; other units were undergoing routine inspection but had not been removed from the fast-start availability list; some were not even manned. Similarly, when Con Ed sounded the maxiumum generation alarm some 10 minutes after the second lightning strike, it again failed to get the anticipated response from its 30-minute reserve generators.

As the system cascaded toward collapse, heavy overloads caused the failure or deliberate disconnection of all remaining ties to neighboring utilities. Con Ed was now an island, isolated from outside help. Its last hope was an automatic load shedding system that had been installed after the 1965 blackout. The system worked beautifully to disconnect customers. It detected the rapid decline in frequency caused by the crisis and disconnected enough customers to push the frequency back toward normal. But it also unexpectedly caused a rapid rise in system voltage that caused a major generator to shut down. That sealed the system's doom. The frequency declined again and more load was automatically shed, but it was not enough. The remaining generators could not restore equilibrium. Eventually, protective relays shut them down to prevent damage. By 9:36 p.m. the city was blacked out.

How could the last line of defense—the automatic load shedding system—produce such unexpected, and disastrous, results? Largely because Con Ed engineers never dreamed their system would be reduced to such a small island. So they never bothered to analyze what would happen to system voltages after automatic load shedding on an isolated system—one dominated, to complicate matters, by underground cables that pose unique voltage complications of their own.

Efforts to restore service were hampered by additional mishaps—giving the looters plenty of time to do their mischief. Some sections remained without electricity for 25 hours. Con Ed made an abortive attempt to raise the whole system at once—a risky venture that only succeeded in damaging some equipment. Then it began the laborious task of activating the system piece by piece. Even if all went well the job would probably have taken 12 hours. But there were repeated delays caused by an unanticipated loss of insulating oil pressure on underground cables, an inability to start generators that were supposedly designed to start without external power during emergencies, voltage difficulties, and damaged equipment. It was a fitting epitaph for a night of frustration.

Who, or what, was to blame? Virtually no one is still trying to pin the rap on the Deity. Con Ed now places the underlying cause closer to Earth—but still outside the utility. While acknowledging its own

errors, Con Ed, in a press release, put the blame on "legislative, regulatory and environmental opposition" that thwarted its efforts to build generating plants in New York City, a pumped storage plant along the Hudson River, and new transmission lines that would have provided alternative routes for power after the lightning struck. None of the other investigations, except for a preliminary federal report that was later reversed, accepts that excuse. On the matter of building plants in the city, for example, investigators point out that Con Ed had enough unused generators in the city to meet the

Briefing

Water Projects: President Facing a Defiant Congress

President Carter has run into still more trouble on Capitol Hill over water projects policy reform, and the question arises whether this time he will back up his policies with one or more stiff veto messages to a seemingly defiant Congress. Last year, after first coming on strong with his "hit list" of projects he proposed to stop, the President compromised with congressional leaders and signed a public works money bill that continued a number of the projects which the Administration had found economically and environmentally unsound.

Now it turns out that House and Senate conferees have approved a public works bill that breathes new life into six of the water projects that were struck from last year's bill as part of the President's bargain with the powers-that-be on the appropriations committees. Moreover, these committees, together with those that handle the public works authorization bills, have taken other actions which fly in the face of Carter's proposals for reforming the policies under which water projects are planned and justified.

For instance, short shrift was given the President's proposal that the interagency Water Resources Council chaired by the Secretary of the Interior be assigned a strong role in reviewing project plans of the Corps of Engineers and other construction agencies to make sure they are consistent with established policies and have undergone rigorous and impartial benefit-cost analysis. Under the appropriations bill, funding for the council would be cut off while at the same time money for some 2300 additional employees for the two major construction agencies, the Corps and the Bureau of Reclamation, would be provided.

Also, whereas the President had proposed that the states be made to bear a larger share of project cost as a way of drawing them deeply into the politics of project planning and justification, the authorization bill reported out of the House public works committee would actually waive the nonfederal share of the costs for a long list of channel dredging projects and for some water supply facilities. In addition, this measure would have Congress simply declare that certain plans (such as open sea disposal of spoil from the Gulfport Harbor project in Mississippi) are cost-effective, however they might show up under formal benefit-cost analysis.

Taking note of all this, Representative Robert W. Edgar, a 35-year-old Democrat from Pennsylvania and a junior member of the public works committee, has referred to the bill as a "symbolic nose-thumbing at the President's proposed water policy." Another young dissident on the committee, Representative David E. Bonoir, a freshman Democratic congressman from Michigan, has pointed out that nearly half of the projects in the bill, representing more than a half billion dollars of proposed construction, have not even received the approval of the Chief of Army Engineers, which traditionally has been a prerequisite for congressional approval.

The White House has made it clear that the President will veto the public works money bill this year, and has indicated that he may very well do the same in the case of the authorization bill. But there is a question as to just how tough he will be in setting forth what he will and what he won't accept. In the opinion of some, such as Brent Blackwelder, lobbyist for water policy reform on the staff of the Environmental Policy Center, the public works committees will have played Carter for a fool if he lets them get by with a few token concessions, such as eliminating the six projects which supposedly were killed last year.

Blackwelder puts forward the somewhat paradoxical idea that the deterioration in relations between the President and Congress really began in earnest last year with Carter's decision not to veto the public works money bill. "The message the members got," he observes, "was twofold. First, 'Carter won't stand behind you if you go out front to support his position [as several members did]. He'll cut you off at the knees without even consulting you.' The other message members got was, 'You apply the screws to Carter, and he backs off. He is weak and not a leader.' So it was doubly damaging." In Blackwelder's view, as in that of many other observers on Capitol Hill, Carter had now best act quickly, in matters of water policy reform as well as in other policy areas, to erase the messages of the past and send out some forceful new ones.

Alaska Lands: Senate Panel Tilts More Toward Development

The Alaska lands bill expected to be reported out of the Senate Committee on Energy and Natural Resources after Congress returns from its Labor Day recess will reflect far less emphasis on wilderness preservation than the measure that has been passed by the House of Representatives. Indeed, the measures will be so far apart that whether an Alaska lands bill can be enacted before Congress adjourns in October is in doubt.

The House bill, which is generally consistent with what the Carter Administration and the environmentalists' Alaska Coalition have proposed, makes some concessions to development interests but would nevertheless preserve several large regional ecosystems intact as undisturbed wilderness. For example, neither mining nor oil and gas development would be allowed in either the proposed Gates of the Arctic Wilderness National Park (to cover an area half again the size of Massachusetts) or the enlarged National Arctic Wildlife Refuge (to cover an area larger than West Virginia). Under the Senate committee bill, on the other hand, substantial parts of these areas would be classified for "multiple use" management, with mining, oil and gas development, and construction of roads a possibility.

Senator Ted Stevens of Alaska has exercised a major influence on the committee during "mark-up" sessions on the bill. Reflecting what seems to be the prodevelopment attitude of most nonnative Alaskans, Stevens has insisted that the park and refuge boundaries and land use classifications not constrain mining and oil and gas development. To take the

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crisis—they simply did not work in time.

The three government reports primarily blame Con Ed, although they emphasize different sins of omission and comission, and some find other culprits as well.

However, all three agree that the blackout could and should have been avoided.

The Federal Energy Regulatory Commission argues that the "single most important" immediate cause of the blackout was the failure of the system operator to take corrective action by promptly shedding load or increasing generation within the city. It considers the blackout

specific example of the Gates of the Arctic Wilderness Park of 8.1 million acres which the House bill would create, Stevens prevailed upon the committee to provide for a park of 4.5 million acres in two separate units, split by a 2.7-million-acre "preserve" to accommodate sports hunting and bordered on the south by "national recreation areas" in which mining and haul roads could be allowed.

Mining companies such as Anaconda and Kennecott have numerous claims scattered over the heavily mineralized belt on the south slope of the Brooks Range, and they do not want their exploration and development activities hemmed in or impeded. Stevens and the committee have been of a mind to give them what they want.

In light of the different philosophies that have been at work in the Senate and House, the outlook is for a lot of hard, difficult bargaining once the legislation goes to conference, if indeed it gets that far this year. Senator Mike Gravel of Alaska, who thinks Senate conferees would yield too much to the House, has vowed to try to block Senate action by filibustering. For its part, the Alaska Coalition would prefer no bill this year to the one which the Senate committee is about to report.

Environmental Lobbyists Quarrel over Endangered Species Act

A fierce but little-noted dispute is now going on within the environmental community in Washington over what posture environmental lobbyists should assume in the face of the clamor in Congress to amend the Endangered Species Act of 1973, which expires this fall. Things have reached such a pass that some environmental leaders are accusing others of having stabbed them in the back.

The Endangered Species Act (ESA), together with the hotly debated issues to which it is giving rise, is in fact such as to make this community a den of quarrelsome lions. As the ESA is now written, and as interpreted by the Supreme Court in its recent ruling in the snail darter case, the act imposes an absolute bar to any federal project that would extinguish any species of plant or animal listed by the U.S. Fish and Wildlife Service (FWS) as endangered.

Congress, which loves the middle ground, almost certainly would not have enacted the ESA in so absolutist a form had a majority of the members understood what they were doing. And it is now virtually a foregone conclusion that the act will not be extended without change but rather will be amended to allow for at least some exemptions or exceptions.

Indeed, as it stands, the ESA is such strong medicine the FWS has shied away from listing many species that are endangered. Moreover, environmental groups have on at least one occasion chosen not to invoke the ESA in court for fear of intensifying the pressures in Congress to weaken the act. Last winter a group of environmental leaders decided out of political caution not to bring suit to stop the TVA's Columbia Dam project on the Duck River in Tennessee even though this project could extinguish some five species of mussels already listed as endangered.

Environmental lobbyists had been girding themselves to fend off an attack on the ESA when, last spring, Senator John Culver (D–Iowa) and Senator Howard Baker (R–Tenn.) of the Committee on Environment and Public Works put forward a proposal to amend the act. While their proposed amendment would allow some projects to be exempted, its intent was to keep federal construction agencies on their mettle not to threaten rare species if it can possibly be avoided. It would (*Science*, 4 August) set up a Cabinet-level council that could grant requests for exemptions—but only by a "super majority" of at least five of the seven votes on the council and after determining that the construction agency has consulted in good faith with the FWS in an effort to resolve the problem.

Although the environmental groups continued to view the proposed Culver-Baker amendment warily, many of their lobbyists kept in close touch with the senators' staff people and some concluded that this proposal represented the best hope of saving the ESA and maybe even improving on it.

Ann Graham, a lobbyist for the National Audubon Society, decided that the Culver-Baker amendment deserved a forthright expression of public support. On 17 July, as the Senate was taking up the Culver-Baker amendment, Elvis J. Starr, president of Audubon, wrote Senator Culver praising the amendment and observing that in its present form the ESA is "so rigid" as to make for a "growing timidity" in its use on the part of environmentalists. The amendment was passed 2 days later by 94 to 3 (opinions differ as to whether other changes made on the floor were of much consequence, but Audubon believes they were not). The National Wildlife Federation and the Nature Conservancy has since joined Audubon in endorsing the Culver-Baker approach, but some groups identified with an umbrella environmental organization known as Monitor have assailed Audubon bitterly.

In a letter to Starr, Tom Garrett of the Defenders of Wildlife said that he was "fairly inured" to "divisiveness and backstabbing within the conservation movement." But, he added, it was absolutely shocking that Starr would have placed in Senator Culver's hands such a letter and thereby undercut proposals to extend the ESA without amendment or, at a minimum, to exclude even the possibility of exemptions for most projects had already well under way. Garrett said that if Audubon persists in "undercutting the rest of the [conservation] movement by promoting the Senate bill in the House, another disaster could be in the offing."

"If this happens, Elvis," warned Garrett, "it is predictable that the movement will become embroiled in still another internicine war, probably the biggest and worst so far."

The oddest thing about this family quarrel is that many environmental lobbyists know that they do not now have, and probably have never had, any politically realistic alternative to the Culver-Baker amendment (either as it stands or perhaps in some modestly improved version). Indeed, despite all the bitter talk, the ESA legislation now emerging in committee in the House is likely to resemble the Senate-passed bill and to have at least the tacit support of most environmental groups when it comes to a floor vote, including at least some if not most of those that belong to Monitor.

Luther J. Carter

a failure of control and operations rather than of planning and design.

Neither the state nor the city investigation found a "single most important" cause; they cite a number of factors including operator error, mechanical failure, poor planning and design, and shoddy maintenance and testing. In some cases the reports contradict each other, with one exonerating Con Ed for practices another condemns.

The state report, prepared by Norman M. Clapp, former chairman of the Wisconsin Public Service Commission, finds that cost-cutting compromises weakened the design of the system—as when Con Ed in 1972 chose the cheapest of six alternatives for increasing its ties to other utilities; any of the other five, Clapp says, would have averted the blackout. Clapp also chides Con Ed for "unwarranted complacency" in leaving equipment out of service for long periods. A tie between New York and New Jersey, for example, was down for months while Con Ed dawdled about getting a major replacement part; Clapp believes it would have prevented the blackout if it were available. That assertion is challenged by the federal report.

The city's report, issued by a special commission appointed by former Mayor Beame, was the most prosecutory in tone; it still turns Con Ed managers apoplectic. Although the report contains several assertions that do not jibe with other findings, the city's inquiry played a key role in spotlighting the confusion in Con Ed's control room.

All three reports put the ultimate responsibility on management for failing to train employees for emergencies, ensure that equipment was in good operating condition, and otherwise guarantee the reliability of the system. The state report suggests that "serious financial constraints" led Con Ed to cut too many corners. The city report argues that the rate structure for utilities provides no incentive for reliable service.

Con Ed has steadfastly asserted that its system met all applicable design criteria, but that claim is based, according to the state and federal reports, on a strained interpretation of the criteria. Con Ed was required to design its system to cope with the simultaneous loss of two "adjacent" circuits as a "single contingency." But the 345-kilovolt lines that succumbed to the first lightning stroke were not, strictly speaking, adjacent. They were carried on the outside of the same towers but were separated by smaller lines between. So Con Ed did not, in fact, design for their simultaneous loss.

Con Ed also asserts that, however disappointing its efforts to call up reserve generation were, it at least met its minimum 10-minute operating reserve as required by the New York Power Pool. But that assertion, according to the state report, is "beside the point." The pool's reserve requirements are aimed at coping with potential generating losses, not with the loss of transmission lines. Indeed, the criterion assumes that there will be enough lines available to transfer reserve power to the utility that needs it. There was ample reserve capacity in the pool the night of the blackout—it simply could not be delivered to Con Ed. Neither Con Ed nor the pool had thought through the problems that transmission losses could cause.

What should be done to prevent a recurrence? Con Ed has already initiated a new storm watch procedure. When a thunderstorm is forecast, it beefs up generating units and personnel to handle the possible loss of major transmission lines to lightning. The utility has also added another senior person to its control room to ease the strain of coping with emergencies. And it has returned downed equipment to service, accelerated construction of a new underground cable to New Jersey, intensified its training programs, provided all its gas turbines with remote-start capabilities for emergencies, started to reinforce its most vulnerable overhead lines, and taken dozens of other corrective measures. These should, according to the federal report, "substantially reduce" the likelihood of another blackout. But the state and city reports call for more radical reforms, including economic sanctions against Con Ed's stockholders for unreliable performance, the addition of public members to Con Ed's board, and a new corporation to operate transmission lines in the state. The State Public Service Commission has deferred making a decision on some of the most costly recommendations.

On 26 September, just 75 days after the blackout, the Con Ed system was subjected to another emergency even more serious than that of 13 July. Six lightning bolts hit transmission circuits and knocked four of them out of service for substantial periods. Again, automatic reclosing devices failed to perform, so various protective devices shut down 40 percent of Con Ed's generation. But personnel responded more alertly this time and shed enough load to cope with the crisis. This episode can be read as a vindication of Con Ed's improvements—or as evidence that defects continue to threaten the system. It seems clear that the utility's managers have armed themselves to cope with the events that caused the last blackout. But will they be able to head off the next?

—PHILIP M. BOFFEY

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Carter Reorganization Panel Says Federal Data Processing Is Lagging

The U.S. government gave the early impetus through its military and space agencies which built the American lead in computers and then became the biggest customer for data processing equipment in the world. It is rather ironical, therefore, that the federal government for more than a decade has been a butt of criticism for the way that it buys, manages, and uses computers and associated technology.

Over the years, this criticism has shown up in congressional complaints, blue-ribbon panel studies for the Executive Branch, and a long series of hectoring General Accounting Office reports. The most recent and perhaps definitive word on the subject comes from the Carter Administration's government reorganization effort, specifically from a group commissioned to look not at a particular agency, but rather at the government's ubiquitous data processing subculture.

The Federal Data Processing Reorganization Project, as it is called, was primarily concerned with management

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