

### *Folsom and the Birth of the Electric Grid*

EVEN NOW, 135 years later, it is not hard to imagine what Horatio Gates Livermore saw and heard as he stood on the banks of the American River where it curves past the town of Folsom.

For all the changes that have occurred in the intervening decades, including the damming of upstream river flows to create the Folsom Lake Recreation Area and the construction of a modern American River Bridge to carry a steady flow of cars between Folsom and nearby communities, the scene from this point remains much the same as it was back then. Tall bay trees shelter a quiet cove at Grinding Rock. The swish of their branches overlays the gentle sound of water lapping at the Lake Natoma shore and the honking calls of snow geese or other migratory birds.

Just up the hill from this serene park stands the historic Folsom Powerhouse.

Perhaps Livermore would be disappointed that his dream of creating an extensive industrial complex in Folsom had never reached fruition as he had envisioned it, but he could be justifiably proud of what had been accomplished. From that site emanated the nation's first high-voltage alternating-current system to transmit electricity over long distances for municipal and industrial use.

A native of Maine, Livermore was one of thousands of individuals lured to California in the early 1850s by the promise of finding gold, although his real fortune was made through lumber, mining franchises, and the political connections he'd formed as a state senator. He also carried to the West a vision of a new manufacturing community modeled after that of Lowell, Massachusetts. This modern hub would employ the latest technologies of hydropower generation to replace traditional mechanical waterwheels with steel-forged turbines and electrical wires.

Folsom seemed ideal for the venture, and not solely because of its fortuitous location along the river. The terrain featured just enough of an elevation change to easily accommodate construction of diversion canals and penstock to boost the pressure of Sierra Nevada water that would run through hydroelectric turbines.

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The town was already a center for gold mining and commerce, boasting of the first flour mill built along the American and the terminal for the Sacramento Valley Railroad, the first railroad company in the West. Folsom residents were also proud of the town's role as a key stop for the short-lived but highly regarded Pony Express mail service in 1860.<sup>1</sup>

Livermore and his two sons, Charles and Horatio P., had taken control of the Natoma Water and Mining Company and purchased several thousand acres of land along the river with plans to send lumber downriver to a mill in Folsom. By 1868, they had approached the state of California with a novel plan under which they would donate land and provide electricity for the construction of a new prison facility in Folsom. In return, they would use convict laborers to build a dam upstream, divert the water through pipes and a power station before allowing the water to flow back into the river.<sup>2</sup>

Easy to imagine, the plan took decades to accomplish, and Livermore did not live to see the completion of the red-brick powerhouse or witness the thrilling moment in 1895 when the rush of water through three turbines sparked a landmark in electrical generation.

Faced with financial boom-and-bust cycles and extended delays in construction of the granite-walled Folsom Prison, the Livermore brothers were forced to scale back their father's grand vision of a hydro-based industrial center for the town. Instead, the elder son, Horatio P. Livermore, conceived of the idea of transmitting the electricity generated at their powerhouse some 22 miles to downtown Sacramento, where it would be used to power streetcar lines and provide street lighting.

The first power flows occurred in July of 1895, but the venture received widespread acclaim on September 9 during a "Grand Electrical Carnival" held to celebrate the 45th anniversary of California statehood. Strings of thousands of electric bulbs emanated from the substation at Sixth and H streets to drape a tent pavilion on the street and outline the E.G. Atkinson Building with a brilliant electrical light. Folsom's new power station was hailed as "the greatest operative electrical plant on the American continent" by the newspapers that sponsored the festivities. The coming "Age of Electricity" was saluted by a volley of shots from militia riflemen and hailed with a parade of brightly lit floats that were pulled by the street trolleys.<sup>3</sup>

Although a similar experiment in long-distance transmission of electricity that originated at Niagara Falls, New York, was far better

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publicized—largely because of the involvement of such notable persons as Thomas Edison, George Westinghouse, and J.P. Morgan, respectively, in conceiving, building, and financing the venture—the Folsom Powerhouse was completed and operating commercially more than a year before the Niagara plant delivered its power the full 11 miles to Buffalo, N.Y.<sup>4</sup>

The Folsom plant used the very latest in equipment from the recently incorporated General Electric Company, especially a new three-phase alternating-current (AC) system that had been successfully pioneered just two years before at the high-head Mill Creek hydro facility in Southern California. The plant's four generators, which had been shipped by boat around Cape Horn, produced a little over 3,000 kilowatts, or 3 MW, of electricity that would be conducted at 11,000 volts via 60-cycle, three-phase current—the system that would eventually become the basis for standardized power-transmission networks in the United States. Technology historian Thomas Hughes summed up the relevance of this development in this way: “Industry did not need to move to the water-power site; the power had traveled over small wires to industry.”<sup>5</sup>

In June 1895, a *San Francisco Call* article discussing the soon-to-be completed power station also described a hydro mania apparent in the West: “A new kind of hustler has arisen, and within the past three or four months he has been rapidly multiplying and filling the earth. He is the promoter of new electrical enterprises, and especially the promoter of schemes for the long-distance transmission of electric power. The air of the whole Pacific Coast has all at once become filled with talk about setting up water wheels in lonely mountain places and making them give light and cheaply turn wheels in towns miles away.”<sup>6</sup>

Despite its pioneering status, the Folsom plant was not to be the centerpiece of electrical production and transmission for long.

Unfortunately for the Livermores, their main asset, access to Sierra-based water, was threatened by a severe drought just a few years after they began operations. In order to meet their contracts for supplying power to Sacramento, the Folsom facility needed to buy the output from an even newer plant built in 1899 by San Francisco entrepreneurs Eugene deSalba and John Martin. Named after financial backer Riggs Colgate, an heir to the Colgate soap and perfume dynasty, the Colgate plant on the middle fork of the Yuba River transmitted its energy more than 60 miles to Sacramento, over a 40,000-volt circuit.

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The pace of innovation was quickening, and by 1900, more than two-dozen hydroelectric stations were in operation in California, stretching from Eureka to Pomona. Advances in transmission, such as the construction of a then-record 142-mile-long power line from the Sierra projects to the San Francisco Bay Area, helped bring electricity to California's booming cities in April 1901. The wooden poles and hastily strung copper wires were soon replaced with engineered towers of steel capable of spanning the half-mile gap of the Carquinez Strait and withstanding harsh winds from the bay.

Another breakthrough, documented by the *Journal of Electricity, Power and Gas*, was the tying together of several hydropower stations at distant sites, "to be operated in unison as a single station as easily as if they were combined under a single roof."<sup>7</sup>

Martin and deSalba soon became electric empire builders, and through purchase and consolidation they created a network of electric generation and distribution companies that stretched from Chico to Stockton and beyond. Merging their holdings in the California Gas and Electric Corporation with their acquisition of the San Francisco Gas and Electric Company, deSalba and Martin in October 1905 formed the Pacific Gas and Electric Company. Capitalized with more than \$45 million in stock and debt securities, the company was able to survive the Great Earthquake of 1906, while many of its competitors collapsed. PG&E would continue its expansion by swallowing less capitalized firms and would soon become one of the largest public utilities in the nation.

Among the many early acquisitions made by Martin and deSalba was the original Folsom Powerhouse, which continued operating as part of PG&E's system until it was replaced in 1952 by a more modern 160 MW hydro plant built at the new Folsom Dam.

As breathtaking as the Northern California achievements in electrical transmission were, they were eventually eclipsed by the even longer lines built to move southern Sierra hydroelectricity to the Los Angeles area. The leading developer of the Southern California system was Henry Huntington and his Pacific Light & Power utility, formed to power Huntington's extensive streetcar lines in the booming and sprawling metropolis.

In 1913, Huntington completed the first development of the Big Creek hydroelectric complex and its 241-mile transmission line to Los Angeles. After Huntington sold his interests to competitor Southern California Edison in 1917, the Edison Company also pursued an

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acquisition program of smaller utilities until it rivaled PG&E both in the size of its territory and in operating an interconnected system of generation and transmission that covered tens of thousands of square miles.

Taken together, these investor-owned electric companies and a growing community of public-power utilities and water districts put California in the forefront of electricity generation and consumption. Writing in December 1899 about the integration of hydropower and electric lines, George Low, the founding editor of the *Electrical Journal* trade publication, offered his readers this vision of the new electric utility industry: “For not many decades will pass before the Serras will be studded with power houses from the mountain streams of the Southern California Water Company in San Diego to the McCloud River in Siskyou, whence transmissions will be run to all cities, towns and industrial centers, and these transmissions will be interlinked as intimately as are those of Southern California today.”<sup>8</sup>

Low was correct. From its beginnings as a 3 MW power plant on the side of a river with a short 22-mile-long wire connection to a population center, the California network was by the 1930s equal to, and in some ways more impressive than, any in the large industrial states of New York, Pennsylvania, or Illinois.<sup>9</sup>

### **California ISO Moves to Folsom**

Interestingly, when members of the WEPEX advisory groups were selecting the site for the new California Independent System Operator’s headquarters, the role that Folsom played in the birthing of the electric utility industry was not much of a consideration.

The policy determination that California ISO should be operated separately from the Power Exchange was given a physical dimension. A compromise was reached that the PX would be located in Alhambra, not far from Edison’s headquarters building in Rosemead, while California ISO would reside somewhere in PG&E territory or possibly in San Diego. A compromise within the compromise decided that each entity would have a backup facility located at the other’s site.

Ziad Alaywan, who in 1996 and early 1997 was PG&E’s liaison to the WEPEX technical group on logistical matters, was one of four people assigned to find a site for California ISO. “We had a site in Folsom, here, we had a site in West Sacramento, we had a site in Santa Rosa, we had sites in San Diego, L.A., and Fresno,” he recalled. “You

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know, nobody wants to live in Fresno, San Diego was too far in the south, and Santa Rosa didn't have any airport nearby."

Increasingly, Folsom moved to the top of the list because of the availability of a building in a business park at Blue Ravine Road that had formerly housed Intel Corporation offices and a Bank of America check-processing center. The building was fully wired for the kind of extensive communication network that California ISO would need. The price seemed right, Alaywan recalled, "something like 68 cents a square foot for this building."

Also important was the fact that Folsom sat on solid ground and to the best knowledge of anyone had not experienced an earthquake in tens of thousands of years. On behalf of PG&E, Alaywan and his boss Jim Macias signed the lease on the building at 151 Blue Ravine Road. "They gave me the key," he laughed in recollection. "I came here and I've got the key, but I don't know what to do with it."

The reality of the big decision hit soon after, he said. "They used to send me the bill, and I said, 'Oh my God! This is how much this thing costs!'" He knew *he* couldn't pay for it.

To put costs into perspective, the new Folsom control center would be the central monitoring station and command post for the fifth-largest integrated electricity network in the world.

### **Three into One**

By the time California embarked on its historic electric restructuring, the combined system to be put under California ISO control comprised 25,526 circuit-miles of high-voltage lines, with major interties connecting the 11 states in the Western interconnection and stretching from British Columbia to Mexico. It was anticipated that at any given moment, California ISO would be responsible for dispatching power from a thousand individual generators to meet consumers' demand for electricity, with an hourly load ranging from 20,000 MW to as much as 50,000 MW.

Besides the systems being turned over by the IOUs, California ISO also had to integrate—or at least accommodate—power flows from and between California's dozens of public power utilities and irrigation districts, and the state's water project, and maintain control over the import and export of electricity from the Pacific Northwest and the desert Southwest.

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The largest generation facilities were owned by the utilities—ranging in size from the huge nuclear complexes at Diablo Canyon and San Onofre to large “central station” power plants and smaller “peaking” units scattered throughout the system. But nearly all of the IOUs’ gas-fired power stations were being sold to other companies. In addition, California’s commitment to non-utility power supplies meant there were hundreds of smaller QFs that were hooked into the system.

The change in the state’s market structure meant that, soon, most of these facilities would no longer be centrally controlled and dispatched. Decisions about operational availability and use would rely on market forces and competitive price signals, not least-cost planning regimes subject to regulatory review. Although its federal tariffs and contractual arrangements with certain “must-run” plants gave California ISO nominal control over dispatch, the new market would be nothing like the old system.

The giant map board being installed in the control room of the Folsom building illustrated a single, interconnected grid of power plants, substations, and transmission paths. That concept was a fiction; or at best, it was a goal for the new market to achieve.

In theory, power could flow from any point in the system to any other point on the map, and an energy sale or financial transaction might well involve electricity generated in Canada being delivered to Mexico via California lines.

The reality was that because each utility had constructed its network to meet its own needs and not those of an integrated wholesale market, the Western transmission system was anything but seamless.

Armando Perez, director of transmission planning for California ISO, was at SoCal Edison for nearly 30 years. “When I was in control of the generation and the transmission, I could substitute generation for transmission at any time,” he explained. “A lot of the system was planned for the ability to control generation. Once you move into the kind of market that we have, we don’t really have any control over the generation or know which of them are going to be running at any particular point in time.”

By all accounts, there was a vast difference in the systems operated by PG&E, Edison and San Diego Gas & Electric.

In some cases, it was a matter of geography or investment decisions made at the corporate level. PG&E territory, for instance, covered vast mountainous regions prone to severe winter storms and

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served a greater number of “load centers” in the cities and towns of Northern California. Its transmission system was considered problematic and required a great deal of maintenance.

Edison, in contrast, had what some operators considered a gold-plated network, tightly configured to deliver energy to the major population centers surrounding Los Angeles. Though frequently subjected to Pacific windstorms, Edison’s system hardly ever experienced the same amount of outages as PG&E, in part because the utility traditionally installed a lot of reinforcement equipment at major substations.

The old joke among control operators, according to Alaywan, was that “when PG&E has a storm, half the system goes down. A storm comes to Southern California, everything’s fine—or at least in better shape than PG&E.”

Jim McIntosh, a veteran PG&E control operator who later became director of grid operations at California ISO, concurred that “maintenance practices have always been somewhat of a struggle” at PG&E. “If Edison needed another transmission line, or they added a generator that needed transmission, they needed three lines but put four lines in. PG&E would never do that. They’d put three lines in and if one went out of service, you’d do what we call contingencies.”

Contingencies often involved rerouting flows to restore service, he explained. “That was just kind of their design philosophy.” Too often, it meant interruptions to power flows for some customer or another. “You know, there are places down in Edison’s territory where they can have four or five lines and lose two of them and not have a problem. PG&E, if you lose two lines anywhere, you’re probably blacking somebody out by the time the second one goes out.”

The condition of SDG&E’s network fell somewhere in between. San Diego and southern Orange County were fairly discrete markets, and SDG&E had only a few major generation facilities. Instead, it relied on the 500 KV Southwest Power Link to import energy from Arizona for much of its needs while interfacing with the Mexican utility system for limited import and export opportunities.

Ed Riley, California ISO’s director of regional coordination, who put in nearly three decades at the Los Angeles Department of Water & Power, summed up the differences among the IOUs in blunt terms. “The San Diego system is a mess. The PG&E system is a bigger mess. The

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Edison system is pretty well designed, they're pretty solid," he said. "You can't really blame anybody, it's just the way it was."

It would be an important part of California ISO's job to plan upgrades and fill in holes in the systems so that system reliability would be as good or better under the new market.

### **Islands in the Gulf**

The big control areas hung together on the backbone of the Pacific AC Intertie, twin 500 KV lines that could carry thousands of megawatts between the Northwest and California. However, the energy transfer capability between the territories was severely constrained.

Historically, the most constrained areas were in PG&E territory, particularly the Path 15 bottleneck in the Central Valley and the limited transmission lines flowing into the San Francisco Peninsula. Edison's most problematic area, Path 26 east of Bakersfield, faced the additional challenge of being the conduit for scattered wind and geothermal facilities not owned by the utility.

The municipal systems were like dozens of little islands in the Gulf of IOUs, but they too had joined in constructing some major interties to access out-of-state energy supplies, with sometimes troublesome links into their local distribution systems. LADWP, along with smaller southern munis, operated a DC Intertie that brought excess Northwest energy to the Sylmar terminus in northern L.A. county.

Similarly, a group of Northern California munis joined to construct a 500 KV California/Oregon Transmission Project, called the "third AC" line, but they still relied on parts of the IOUs' network for final delivery of the power at the south end. Various joint agencies formed by munis added to the web of high-voltage lines within the region.

At its core, the mission of the new independent system operator was to take this hodgepodge of infrastructure and run it as one seamless marketplace, while providing nondiscriminatory access to the system to all market players—even if, as in the case of the munis, they were not California ISO scheduling coordinators.

This task was made even more challenging by the decades of animosity that had been built up between the public and private utilities over access to the grid. The munis had fought long and hard for their interconnection agreements to use transmission at predictable costs, and

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they were wary of any element in the California ISO tariff structure that might seem to impose higher costs or diminish their flexibility.

The introduction of new market players—power sellers, generators, and other scheduling coordinators—who also demanded fair and economic access to the transmission system was another complicating factor in the transition to the new market structure. It meant that the physical system would have to be reconfigured and operated with consideration for existing entitlements as well as for the demands of a competitive marketplace. Those battles were being fought both at governing board meetings for the new market entities and in the hearing rooms at the Federal Energy Regulatory Commission. The disputes figured directly into the ways that California ISO staff would need to design and operate the transmission system.

California ISO's official mission statement—"Reliability Through Markets"—reflected this tension. The job would require the development and installation of an entirely new computer network to track all the flows, schedules, and status of facilities. The Folsom map board offered a picture of the network, but the real work was silently conducted by the computer systems being devised by contractors and ISO staff.

"Buying the system was the easy part," Alaywan reflected. "The hard part was integrating it all together to make it work. That's what we did for about a year, trying to hook up all these pieces together to make it work."

He admitted that it could not all be done at once, and for the first year of operations, California ISO would continue to rely on the network configurations employed by the utility control areas to acquire and monitor the flow of information about the flow of power throughout the statewide system.

### **Out of the Bunkers and into the Daylight**

There was another somewhat revolutionary aspect to the siting of grid operations in Folsom. For the first time, the business of transmission would be done in a visible way. Federal rules required transmission operators to provide an Open-Access Same-time Information System (OASIS) computer network for capacity availability and pricing data. At California ISO, the public (mainly through its intermediaries in the media and government) also would be allowed access to the control

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room, albeit in a manner that acknowledged the legitimate security concerns of the network hub.

To be sure, California ISO's headquarters does not advertise itself or stand out in any obvious way from any of the other nondescript buildings in the landscaped office park on Blue Ravine Road.

Any hapless visitor who might attempt unauthorized access or even try to take photographs of the building without permission will almost immediately be confronted. "I'm going to have to ask you for that roll of film," the ever-polite but armed security guard will say as he calls for backup on his walkie-talkie.

Still, the entire atmosphere of the California ISO complex masks this devotion to silent, effective guardianship, and it's a far cry from the way that utilities traditionally maintained an almost paranoid secrecy about the location and operations of their control rooms.

"When I was in L.A., everything—*everything*—about the control center was secret," Ed Riley reminisced. "It was a secret location up in the hills, and nobody was supposed to know where it was. And the only way you got there was by going downtown and coming out with somebody" from the public information office. "When they first put up the building, they had a DWP logo on the front," Riley continued. But the head of operations had it filled in. "He wanted no recognition at all it was a department facility."

Other former utility operators told similar tales about the isolation of their energy control centers. "Ours was a bomb shelter," recalled Tracy Bibb, an ex-chief operator at Edison, who is now the director of scheduling for California ISO. "We could have thunder and lightning right overhead and somebody would say, 'Does anybody hear anything?'" He laughed. "No windows."

PG&E used to house its control room in what California ISO vice president of grid operations Jim Detmers called "the dungeon" until it was moved to a secluded, somewhat idyllic location on the 15th floor of the utility's Beale Street headquarters. "I looked out over the bay," said Detmers somewhat wistfully. "Whatever trouble you had with the PG&E system that we're still dealing with now, after you get done with the problem, you turn around and look out over the bay and go, 'Wow, I'm OK. Everything's nice. I can relax.' It was the place to be."

It's possible that some of the serenity at PG&E may have come from knowing that even if the president of the utility wanted to visit the control room, he'd have to wait for someone to let him in. "Even if

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you've got a card, they've got to buzz you in. If they don't see you, they're not going to let you in," said Alaywan. "You know, dispatchers don't like people on the floor," he explained. "Here it's different. We went from that environment to what we call the fishbowl."

From the beginning, California ISO's communications department wanted to make the engineers and operators accessible, and for public information officer Stephanie McCorkle, that meant bringing reporters and their cameras right into the control room.

"With television, unless you can give them a visual, they're not going to do the story," she said. "So to get TV to tell the story, I had to get them into the control room. To get anyone, even print, to do the story, you had to get them into the control room. And there's something magical about that control room. When you walk in, you see the importance of the place, and it just puts a visual to what's going on in there. Otherwise it's so hard to describe."

### **A System of Values**

In recounting the formation of utility networks in California and elsewhere from the vantage point of the early 1980s, historian Thomas Hughes did not specifically consider how the possibilities of industry restructuring or deregulation might alter these systems. Nonetheless, his summary comments seem especially prescient.

It is difficult to change the character of large electric power systems, he suggested. "Those who seek to control and direct them must acknowledge the fact that systems are evolving cultural artifacts rather than isolated technologies. As cultural artifacts, they reflect the past as well as the present. Attempting to reform technology without systematically taking into account the shaping context and intricacies of internal dynamics may well be futile. If only the technical components of a system are changed, they may snap back into their earlier shape like charged particles in a strong electromagnetic field. The field must also be attended to: values may need to be changed, institutions reformed, or legislation recast."<sup>10</sup>

For all the emphasis on new technology, systems, infrastructure, laws, and policies that were basic necessities for the new California Independent System Operator to accomplish its mission of ensuring "Reliability Through Markets" and open access, the hardest part of the job would be to reshape the attitudes about the transmission system that had been built like steel towers across the span of decades.