Article and photographs by Matt Herron

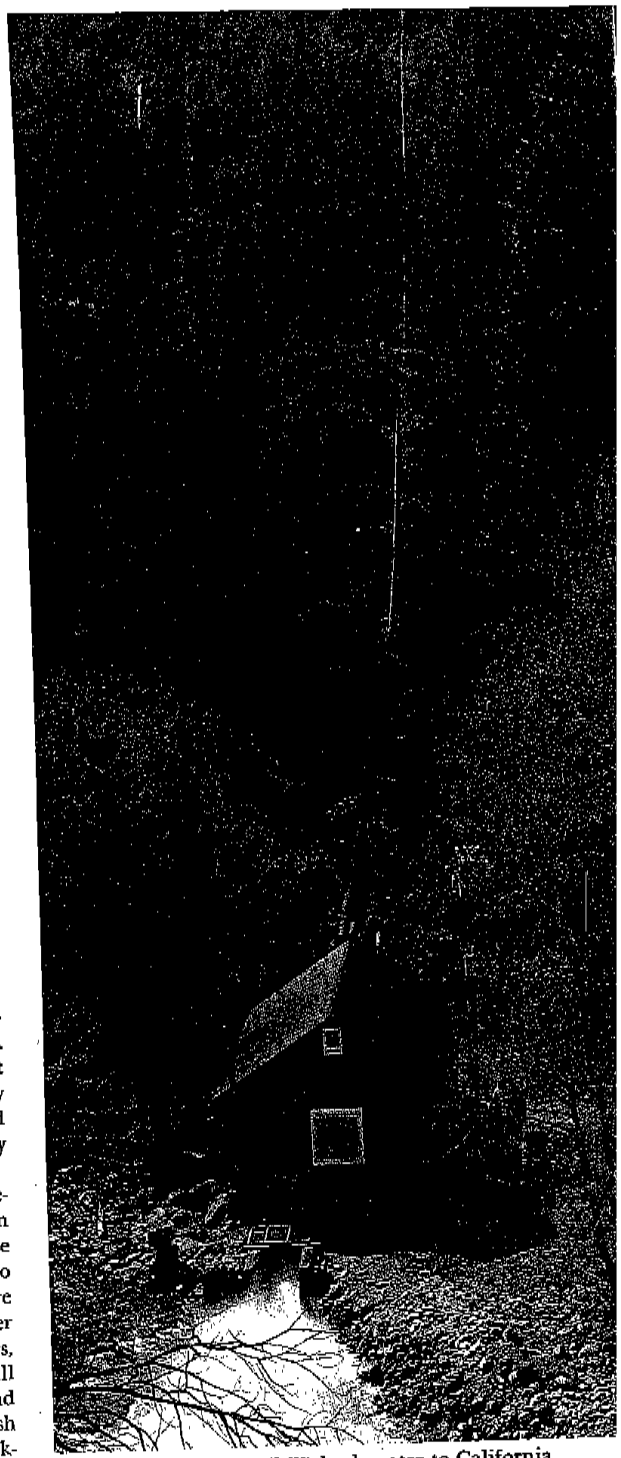
The rush is on to find new gold in falling water

Small hydroelectric power stations could take the place of 45 nuclear generating plants by 2000—if governments decide to go that route

One morning in late January of 1848 in newly settled country, James Marshall, a carpenter, stood in the tailrace of a sawmill he was building for Captain John Sutter on the South Fork of the American River not far from what is now Placerville, California. Marshall was trying to puzzle out the hydraulics of a crude waterwheel he and his men had recently erected in the framework of the mill. The giant undershot wheel was developing scant power, and Marshall had fixed his attention on the flow of water along the tailrace, which had been experimentally deepened the day before and scoured by the river through the night. A scattering of bright colors caught his eye—colors that proved to be gold. Marshall's discovery, engendered by his attempts to harness the power of the river, touched off a stampede for riches unparalleled in the history of this country.

One hundred thirty-five years later, in a curious reworking of that history, a second gold rush has been unleashed by a farsighted Act of Congress. Like the California panners, today's prospectors are seeking to wring wealth from falling water. Some of them are scouring the same rivers that attracted the first placer miners to California. They are a diverse lot—ranchers, farmers, lumber companies, irrigation districts, small towns and municipalities, private entrepreneurs and consortia of small investors—all locked in a feverish competition for small hydroelectric sites. To the seekers, energy has become the Mother Lode of the '80s.

The catalyst that touched off this alchemical reac-



Penstock (long pipe on hill) leads water to California powerhouse; "rooster tail" plume occurs only during test.

Barbara and George Mallett gather family in front of their generating station; a turbine is visible inside.

tion was the passage in 1978 of the National Energy Act, a key provision of which mandated that utilities buy power from anyone who could produce it, and at rates determined by the principle of "avoided costs," that is, at what it would cost a utility to generate that power itself or purchase it from another utility (SMITHSONIAN, November 1982).

It seemed a very *American* thing to do. Individual entrepreneurs in their quest for profit, it was thought, would accomplish the nation's interests more swiftly and efficiently than could a federal bureaucracy. The Public Utilities Regulatory Policies Act (PURPA), that tributary of the Energy Act that carried the gold, required utilities—which had been in the habit of paying small power producers as little as a half cent per kilowatt hour—to pay a handsome sum, often as much as *eight* cents.

What was good for the enterprising developer could be good for the country, too. Small hydro, one of many technologies encouraged by PURPA, is often a benign energy source. It displaces oil tankers, smoke plumes and possibly acid rain. It is exceedingly durable; a well-built plant will go on producing 50 years or longer. It does not alter the shape of watersheds or back up rivers 20 miles. Mostly it churns power at existing dams or borrows a portion of a mountain stream, returning it unchanged two to four thousand feet below. It is uniquely suited to the scale of small enterprise. It thrives on the cunning of scarcity, the ingenuity of limited means; its economics perish under the attention of top-heavy bureaucracies. In its separate pieces, it is not a major resource. But taken as a whole, in combination with other renewable energy sources, small hydro can go far toward relieving this country of dependence on foreign oil. A recent study by the U.S. Army Corps of Engineers suggests that small hydro at 2,000 new sites could add 45,000 megawatts of generating capacity (the equivalent of 45 nuclear power plants) by the turn of the century.

The scramble for small-hydro sites that followed passage of PURPA took different forms in different places. In the East, hydro had been a developed resource from the middle of the 19th century until the 1930s and '40s, when economies of scale made small-generation plants unprofitable, or merely inconvenient. By the hundreds, these durable civil works were shut down. Still viable, they rusted away. Weeds grew through powerhouse walls, dams spalled, weirs crumbled, penstocks collapsed, rats nested among the windings of perfectly good generators. Now, many of these old plants are being coaxed to life. Industry had come later to the West, much of it after the large hydroelectric projects, and consequently there were few small plants standing ready for a quick refit.

Western riparian landscape presents itself in two

Based in Sausalito, California, Matt Herron has written, photographed stories for SMITHSONIAN *on oceangoing classrooms and the shapes of whales.*

general varieties, each with its own problems and its own hydro technology, a reflection of the trade-off in the physics of falling water between pressure and volume. Precipitous mountain watersheds laced with energetic, fast-falling streams lend themselves to high-head projects, to turbines that utilize the weight of water piled hundreds of feet in a penstock and released through high-pressure jets against a wheel of buckets: the impulse turbine or Pelton wheel—abundant energy from relatively little water.

The low-head landscapes, the broad valley floors crossed by massive canals carrying slow-moving volumes of irrigation water, demand a different approach. Water in volume, conveyed through a fall of 60 feet or less from a dam or reservoir, yields power with little pressure: this setup requires the Francis turbine, a chambered nautilus of gently curving vanes spinning in the base of the powerhouse.

For a small developer trying in the early days to scratch together a project, endurance was a big asset. As Barbara Mallett explained: "Building a hydro project is like eating an elephant. You have to go at it one bite at a time." She and her husband, George, proprietors of the Mom & Pop Power Company of Weaverville, California (between Redding and Eureka), recently guided the first stage of their hydro plant through a minefield of federal, state and local regulations, and brought it successfully on line.

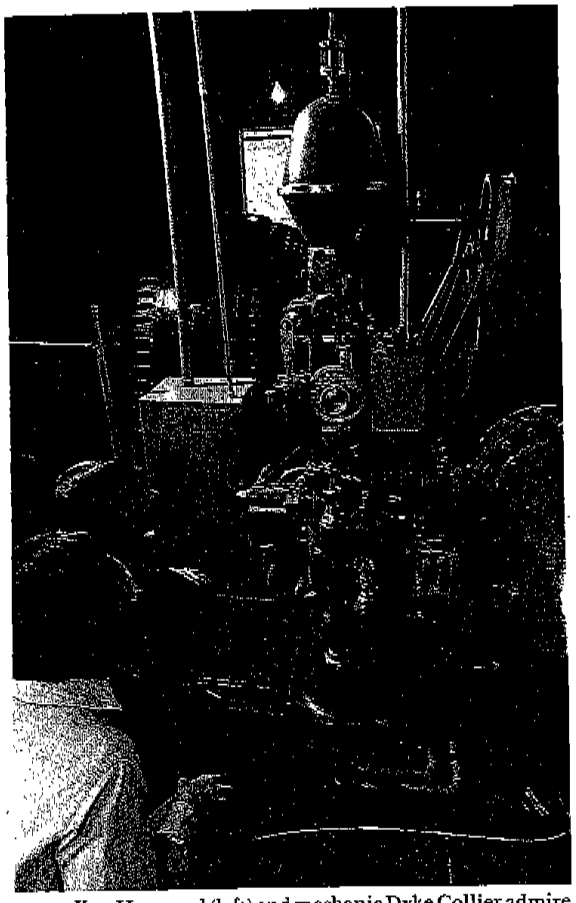
More kilowatts for the buck

The entire civil, electrical and literary works of Mom & Pop Power—the Pelton turbines, the generators, the switching and interconnection gear, the penstock, trash racks and tailrace, the engineering studies, environmental reports, regulatory permits, power contracts and associated paper by the megaream will add up to no more than $190,000 by the time the second turbine and generator go into operation this winter, bringing the plant's capacity to 600 kilowatts. Translated into dollars per kilowatt of generating capacity, a convenient yardstick often used by the industry to assess profitability, the Malletts appear somehow to have left the world of ordinary finance and learned to fly with the angels. Fifteen hundred dollars in hydro circles is considered bargain basement for a kilowatt of installed capacity; $2,000 or even $2,500, a prudent investment. Mom & Pop kilowatts, on the other hand, came home at less than $400. The figure is a little misleading, however. It does not reflect the rustic powerhouse and associated works that were already in place and churning out a steady 60 kilowatts for the resort business the Malletts bought 11 years ago in California's coastal mountains.

The Malletts decided to apply for a hydro license exemption. Consulting firms have offered that service for as much as $30,000. They managed it for $300. There were no beaten paths; everything was new, untried, experimental. They were, as Barbara put it, "always composing at the piano." So were the various bureaucracies whose approval they needed: the California Department of Fish and Game, the U.S. Fish and Wildlife Service, the Water Quality Control Board, the Office of Historic Preservation, the California Public Utilities Commission, the Pacific Gas & Electric Company (PG&E), 13 federal agencies ranged alongside the Federal Energy Regulatory Commission —and, for ultimate approval, the FERC itself. To some degree, all were unsure how to apply the new laws, how the regulations would sift out in practice, and most were elbowing for administrative turf.

PG&E claims with some justification to be—in its encouragement of conservation and the development of

Dottie Mallett, 14, broken arm and all, guides into place a section of pipe for powerhouse tailrace.



Ken Henwood (left) and mechanic Dyke Collier admire 1920 governor (apparatus in center) in powerhouse.

renewable power sources—the most enlightened utility in the country. Nevertheless, the utility had never before negotiated a contract with a private hydro producer under the PURPA laws, probably never had dealt with any project as small as the Malletts'. There were problems from the start: problems of communication (megawatts talking to miniwatts), and problems of execution (every agreement represented to PG&E a new and potentially dangerous precedent).

A major issue was the capacity contract: an agreement beyond the basic power contract to pay the Malletts extra money for that portion of their power which they could absolutely guarantee to deliver, even in a maximum drought year. PG&E charges its commercial customers more for guaranteed power, so it pays more. But maybe not to Mom & Pop.

The Malletts drove the 280 miles to San Francisco on three separate occasions for formal meetings with a PG&E negotiating team—in all, 12 days at the table. Eventually, the couple came to believe that PG&E would not sign a capacity contract under any conditions, and Barbara took the problem to the California Public Utilities Commission. "Of course, CPUC doesn't like to play Crusader Rabbit, but they looked at our contract and the figures seemed to be in order so they talked to PG&E. We got our contract in three days," she said.

Bill Zemke, the PG&E engineer who led the negotiating team, remembers the difficulty the utility had in adjusting its expectations, accepting a less sophisticated level of data. "It was sometimes agonizing, but we hope it ended fairly well."

Compared to eating the elephant, building the project was easy. The Malletts put up $18,000 of their own money, and found creative financing for the rest. They installed the new turbine, the generator and the switching gear, and had everything working in about a month.

Eighteen hundred applications a year

With the plant turning an annual $80,000, more or less, the payoff anticipated in under three years, the Malletts have moved on to other challenges. They do workshops and consulting. They travel and lecture. Barbara has organized a support group, the Small Power Producers Association of California, to help newcomers struggling in their footsteps, for the gold rush has created its own problems. Consider the numbers. In 1978, the year PURPA was enacted into law, 18 applications to build small hydro projects were filed in the entire country; in 1981, the figure was 18 *hundred* applications. Fully a quarter of them were filed in California where developers seemingly staked claims on nearly every rill, river and tricklet in the