

## HYDRO HALL OF FAME

# Mill Creek No. 1: Pioneering Commercial Electric Power

*Mill Creek No. 1 hydroelectric plant in Redlands, California, is the 2002 inductee into the Hydro Hall of Fame. Late in the nineteenth century, the 800-kW plant became the first hydro facility in the U.S. to generate three-phase, alternating current power. This technology enabled transmission of electricity over long distances, and paved the way for industrial growth.*

By Darrell W. Heinrich

Less than 50 years after James W. Marshall discovered gold in the tailrace of Sutter's sawmill and a mere 24 years after the transcontinental railroad linked California with the eastern U.S., California's population had grown to 250,000. What began as the Gold Rush migration continued as the railroad brought more people into the state and provided the means to send goods east to market.

California's burgeoning citrus crop also had blossomed. All that growers in the Redlands area needed was a way to get oranges—their No. 1 cash crop—from their groves to market without spoiling and at a competitive price.

For that they needed ice—big blocks of it. And the Union Ice Company stood ready to furnish it. But the amount of energy required to create the quantity of ice needed to ship the produce was high. The area had no local source of fuel oil, so the ice company looked to electricity as its preferred energy source.

Providing that electricity was the Mill

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Creek No. 1 hydroelectric plant, which began operations in Redlands, California, in 1893. The 2002 Hydro Hall of Fame inductee was the nation's first three-phase, alternating current electrical power facility and is widely regarded as the birthplace of commercial electric power in the U.S.

### Enterprising Innovation

To provide electricity to the ice company, a group of local entrepreneurs led by Henry Harbison Sinclair incorporated the Redlands Electric Light and Power Company in 1891. The entrepreneurs learned that hydroelectric power was the least expensive type of generation, and soon found a suitable water source in the mountains 7.5 miles away, where Mill Creek flowed through Mill Creek Canyon on its way to the Santa Ana River.

At the time, most utilities provided direct current electricity, which meant their customers had to be located within 3 to 5 miles of the generating plant. Single-phase alternating current had been introduced, but the technology was so new that using it to operate motors was difficult. Not to be discouraged, the power company summoned an electrical engineer named Almarian W. Decker to solve these challenges. He suggested using three-phase alternating current to

push the electricity from Mill Creek to Redlands and to provide the capability to run large motors.

At the time, poly-phase systems that created a rotating magnetic field from rotating coils were still experimental, developed by such electrical engineering pioneers as Nicola Tesla, Galileo Ferraris, Friedrich August Haselwander, and others. Decker's idea to use that type of system was so revolutionary that Westinghouse declined to build turbine-generators to Decker's specifications.

The Redlands Electric Light and Power Company then approached the newly formed General Electric Company. GE agreed to build two type "TY" AC generators to Decker's specifications. Each was rated at 250 kW of capacity and 2,400 volts of output. SCE records say "the original generators were of revolving armature type with stationary field poles as opposed to present-day practice which reverses this construction." They became

the first commercially successful generators of their kind, and remained in use until 1934.

In 1997, at the request of SCE, Edward L. Owens, consulting engineer for GE Power Systems, visited the plant to verify that the machines, bearing serial numbers 50 and 51, were

the first three-phase generators manufactured by GE. To do that, he compared the nameplates on the Mill Creek No. 1 equipment with GE's design records, which date to 1886 (GE attaches a nameplate with both a model and serial number to equipment when it is shipped). In a letter following the visit, Owen said, "At some time in the past, SCE removed one of the nameplates originally installed on the generators by GE. The nameplate was afterward placed in a vault at SCE headquarters for safekeeping. During my visit, I was allowed by SCE to inspect





Because Southern California Edison's Mill Creek No. 1 hydroelectric plant is listed on the National Register of Historic Places, the powerhouse must maintain its original appearance.

this original nameplate . . . (it) clearly showed the model number and serial number assigned to the generator by GE at the time of manufacture." Additional GE installation records support Owens' finding.

### Generating Commercial Electricity

Mill Creek No. 1 began operations September 7, 1893—about a month after the death of electrical engineer Decker. It transmitted power at 2,400 volts over the (then) 12-mile distance from the

plant to the city of Redlands. The facility was the first electrical power system to operate multiple generators in parallel on a common transmission line. A "growler," which produced a vibrating sound, helped operators synchronize the generators to the system by comparing the sound of two opposing vibrators. Later, the synchronization process used flashing lights. (The flashing light system is still used today in conjunction with a phasing meter.)

A crew of operators staffed the plant

24 hours a day. They lived in a small community at the plant, and received supplies in weekly deliveries by wagon from Redlands.

Around 1940, the plant was automated with simple equipment. When a problem was detected, an alarm was sent to a manned station at the Mill Creek No. 2 and No. 3 plants, which are housed together in the same building and also operate on Mill Creek. The control functions for this system have been upgraded to radio systems to replace the wires, but the controls still run the original system.

The electricity the plant produced cost so little, its use increased in the community. In addition to supplying power to refrigeration equipment in icehouses, the utility served other commercial and residential customers. Farmers used electric motors to pump water for irrigation. A local hotel used electric elevators. Electricity also powered conveyor belts at citrus packing houses, and other companies used electricity to print newspapers, as well as labels for orange crates. Homes used electric lighting. Even the city's trolley system, using AC to DC rotary converters, used electricity from the Mill Creek plant. Within a few years, the utility added two more generators to meet the ever-increasing demand.

In 1902, the power company merged with Edison Electric Company, which later became part of SCE. The three original generators remained in service until another single generator replaced them in January of 1935. The replacement generator had been removed from the Mill Creek No. 3 plant. Again, company records explain: "This generator was repowered for this installation with a new Pelton impulse turbine. However, the turbine was specified at the wrong operating head, and the efficiency was low. This generator was subsequently replaced with a new generator during the system frequency change after World War II. Up until the end of the war, much of the Edison system ran on 50 cycles. After the war, the entire Edison system was changed to 60 cycles to be on the same frequency as the other U.S. utilities. The turbine purchased in 1935 stayed in service, with its speed adjusted to 400 rpm from 515 rpm to match the new generator and improve unit efficiency at 60-cycle operation." (This generator is still in use.)

Despite flood damage in 1914, 1916, and 1938, the plant remained essentially intact. In the mid-1960s, another flood

## Technical Information Mill Creek No. 1

### General Information

*Location:* Mentone, California  
*Owner:* Southern California Edison  
*Prior Ownership:* Redland Electric Co.  
*Capacity:* 800 kW  
*Average Yearly Output:* 5,154 MWh  
*Head:* 510 feet (static head)  
*Average Streamflow:* 25 cfs  
*Year began operation:* 1893

### Equipment

**Turbine (1)**  
single-overhung impulse Pelton  
400 rpm  
1,450 horsepower  
Manufactured by the Pelton Water Wheel Company

**Generator (1)**  
Synchronous  
800 kW, 3-phase, 60 Hertz, 750 volts  
Manufactured by General Electric

### Construction

**Powerhouse**  
Approximately 100 feet long, 40 feet wide, 30 feet high  
Stone and mortar foundation, with a wood structure and sheet metal roof

**Penstock**  
10,715 feet long, 30-inch-diameter steel pipe

**Intake Structure**  
Stone and mortar construction

**Dam**  
Approximately 8 feet high, 20 feet wide

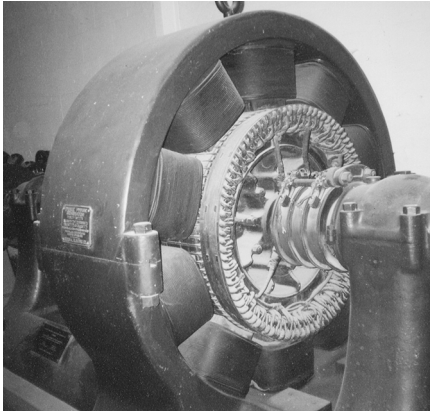
**Tailrace**  
60 feet long  
Concrete-lined soil and rock canal

**Transmission**  
60 feet of 12-kV line directly to the SCE distribution line

severely damaged the penstock. Subsequent penstock realignment increased the plant's maximum capacity to 940 kW.

Mill Creek No. 1's water comes from the common tailrace from Mill Creek No. 2 and Mill Creek No. 3. A 20-foot-wide by 8-foot-tall diversion dam sends water into the forebay of Mill Creek No. 1, if required. Before construction of the two new plants, a boiler and a Corliss steam engine were installed. Belted to the generator, the engine provided mechanical energy in times of low water.

Mill Creek No. 1 is widely regarded as the first hydroelectric generating plant in the SCE family, inasmuch as it is still in operation. Among the plant's claims to fame are recognition in 1995 as a California Historic Civil Engineering Landmark by the American Society of Civil Engineers and in 1997 as a his-



#### **Commercial Success**

The first three-phase, type "TY" AC generator manufactured by General Electric is on display at the Mill Creek No. 1 hydro plant in Redlands, California. GE built two generators for the plant; they became the first commercially successful generators of their kind and remained in use until 1934.

toric landmark of engineering by the Foothill Section of the Institute of Electrical and Electronics Engineers. In 1985, the plant was listed in the National Register of Historic Places.

Today, the area surrounding Mill Creek No.1 remains rural with mostly residential housing. The citrus industry is giving way to the expansion of the Redlands community. Although this plant now contributes less than 1 MW in Edison's system of approximately 17,000 MW (on a typical summer day), it continues to reliably support the area's power requirements. ■

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