Public Service Solar

Drake Chamberlin

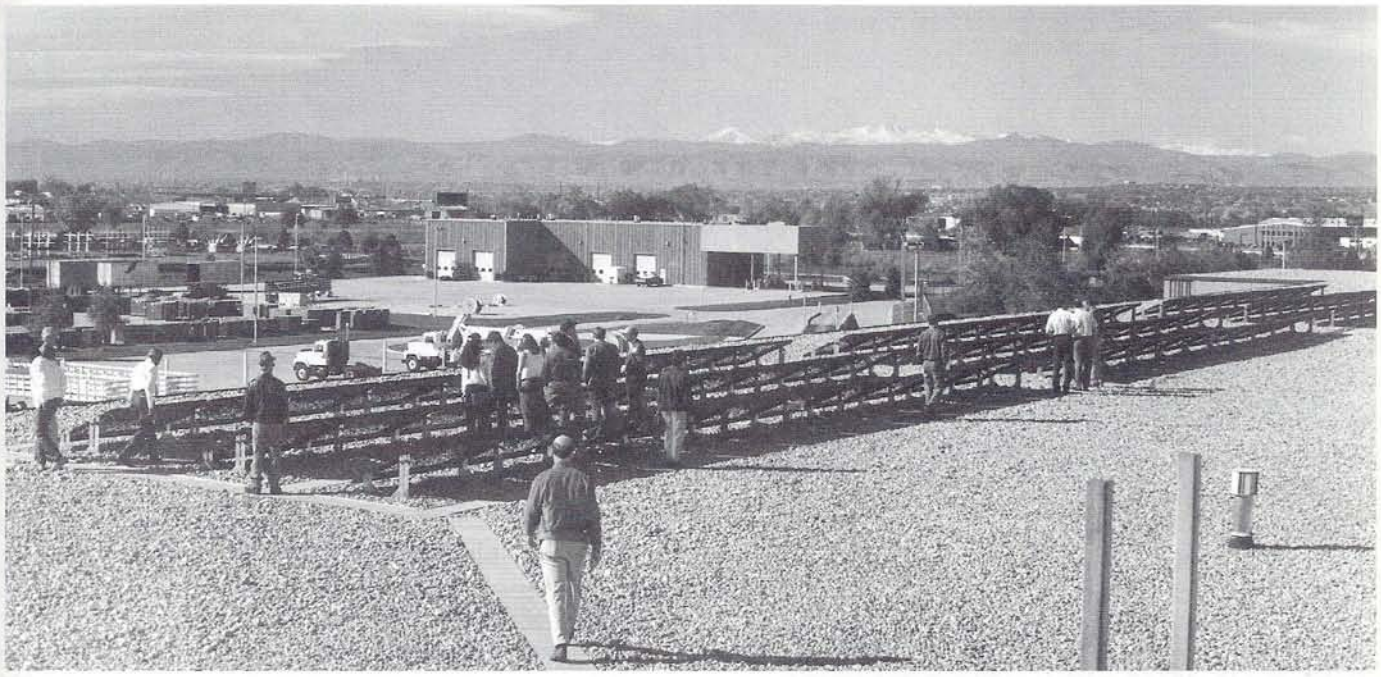
Above: Drake standing proud and thirsty in front of the PSC installation.

Below: PSC's Materials Distribution Center, home of the intertie system.

In July of 1994, I was employed by Colorado's largest utility company, Public Service Company (PSC). The project was an 18 kw solar electric system.

My job was to wire the system. This included the power conditioning equipment, conduit systems and DC wiring from array to inverters. There were multiple ac and DC disconnects. There was also solar insolation monitoring equipment and a complex system of safety relays. The output was to feed into a 120/208 volt, three-phase electrical network.

The ac power developed by the system was to be monitored by a kilowatt-hour meter, connected to phone lines. The building's electric load, tied to this PV system, was to be monitored by another phone line. This phone line was connected to the 277/480 volt meter outside the building. Phone lines were also to connect with monitoring equipment near the array on the roof.



Above: The roof mounted ninety panel, 18 kW array.

The photovoltaic array was to be installed on the roof of a giant warehouse. The site was the company's Materials Distribution Center (MDC) building in Henderson, Colorado (just north of Denver). The power conditioning and control equipment were located in the shipping and receiving area below.

The system was required to pass the state inspection for National Electric Code compliance. This is an unusual requirement for utilities.

The Crew

The project was organized by Chris Thompson of PSC. Through her continued efforts over a period of 18 months, the solar installation was made possible. The period leading up to the installation was notable for its on-again off-again nature. Without Chris' sustained efforts, the system never would have gone on line.

Mark Boettcher, an electrical engineer with PSC also played an important role. A number of Public Service employees from the MDC facility were involved as well.

Personnel from Ascension Technology, the supplier of the system came out from the East Coast. They were also instrumental in assisting with the installation.

The solar array was to be mounted by a team of volunteers. They put in a tremendous amount of hard physical labor in the scorching sun. The work required finesse, as they were handling expensive (and heavy) solar modules.

Helping me were two assistants that worked one at a time. I have known both since they were small children.

Above: Gravel holds roof jacks to roof.

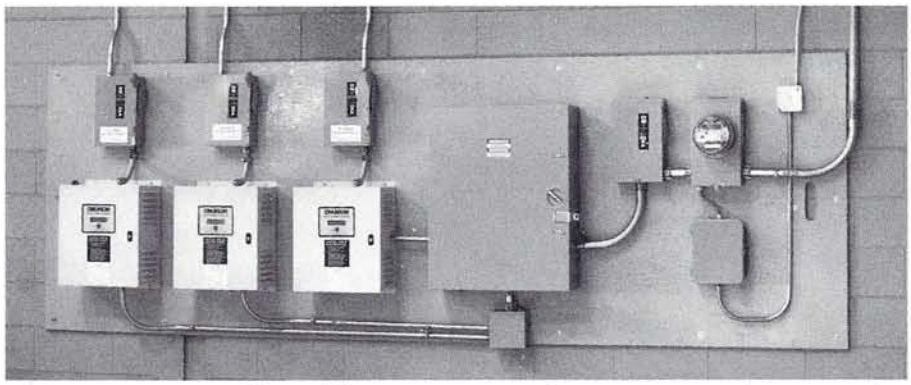
My thoroughly seasoned apprentice, Jeremy Dixon, was stranded with car trouble in a remote area. Since he was delayed, Jordan Jennings filled in until Jeremy could make it.

The System

The system was supplied by Ascension Technology, Inc. of Waltham, Massachusetts. The PV modules were produced by Mobile Solar, and the inverters by Omnion.

The solar array consists of three, 6 kW subarrays of 30 modules each. Each subarray feeds one of the three synchronous inverters.

The modules weigh about 107 pounds a piece. The measured open circuit voltage of the array is around 440 VDC (220 VDC bi-polar). The power from each module is rated at 285 Watts, with the ac contribution around 200 watts.



Above: The power conversion center.

An important element of this system is that it was required to be set up in compliance with the National Electric Code. Traditionally, these systems have had only to comply with utility regulations, which are not as stringent. This was a test to see if such a system could pass Code.

The Wiring

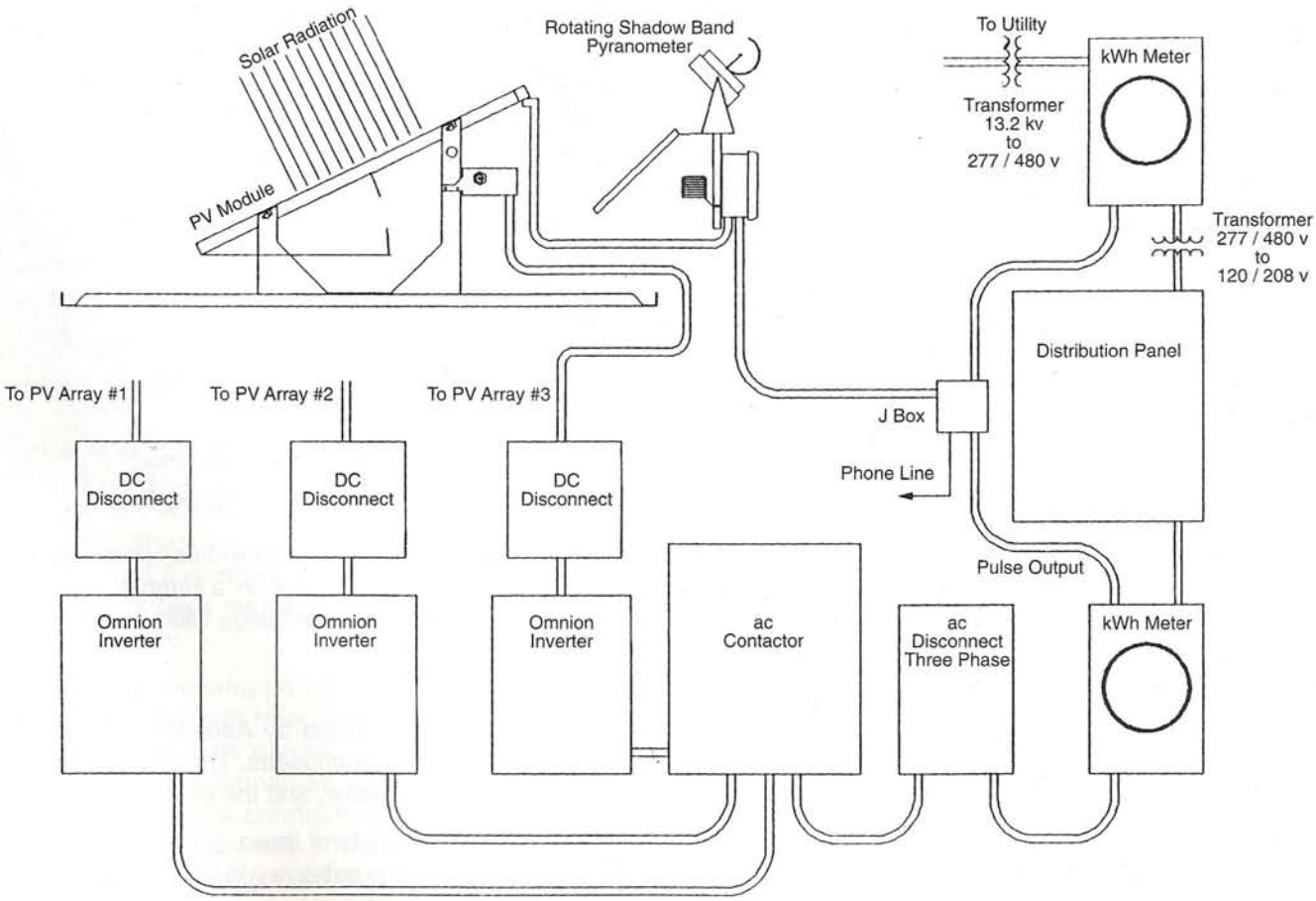
The wiring system that connects the array to the inverters and control equipment is extensive. As a demonstration system, everything had to be neat.

Three runs of conduit extend from the subarrays across the roof of the giant warehouse. The conduit penetrates the building 36 feet above the floor. They then angle down a wall to the support members of a 30 foot ceiling.

After more twists and turns, the runs finally make their way to the three inverters.

The runs consumed around a thousand of feet of 3/4 inch EMT conduit. Nearly a mile of #8 wire was used to make the DC connections. There was a separate run of 1/2 inch conduit for remote computer monitoring.

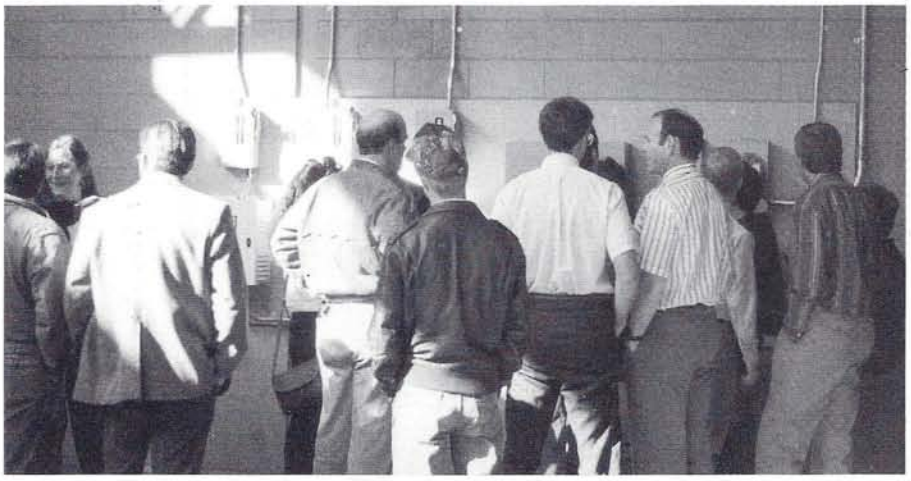
The wiring from the rooftop array supplies the three, single phase, 120 volt inverters. There is one inverter per phase of the three phase system. Each synchronous inverter automatically tunes to the impulse on the line it connects to.



No Holes in the Roof

One significant aspect of the system is the manner in which the array is mounted. The solar modules are mounted at a fixed summer angle. The low angle reduces wind loading. This is important since the system features mounting without roof penetration. The array is held in place by gravel ballast.

The team of volunteers shoveled gravel off of the designated area of the roof. A membrane was laid down on the area they cleared.



Above: PSC solar workshop.

The team then assembled the module support system. The legs, or "roof jacks," were connected to metal pans. The volunteers loaded the gravel they had earlier removed from the area on to the pans. The modules were then mounted on the roof jacks. The weight of the gravel holds the system to the roof.

Thirsty Work

Denver is a mile above sea level. A lot of Earth's protective atmosphere is left below. Much of the work was performed directly under the blazing July sun. A huge quantity of water and soft drink was consumed.

Participants had been warned that lightheadedness could be a sign of dehydration. The thin, dry air and the intense sun sufficed to desiccate workers on the roof. Chris kept morale high and strength up with pizza lunches and plenty of cold pop.

System Safety Features

The photovoltaic system "back feeds" into the grid, through the building's wiring and transformers. It is therefore essential that the system shut down if the line power should fail. This is to prevent hazards to electricians working on wiring and equipment. This safety feature is provided redundantly.

The Omnion inverters automatically shut down in the event of power failure. In addition, there is a set of relays that respond to the grid power. They disconnect the solar electric system in the event of any abnormal conditions to meet strict utility requirements which are in excess of the inverter's built-in protection.

Data

The system's performance is monitored in a number of ways. A modem on site connects through phone lines to a computer in Massachusetts. Ascension Technology's computer calls in each evening to get a report on the day's production. Ascension's computer also receives information from 46 other PV systems located throughout the country. Data is compared for various solar locations.

Solar conditions are evaluated through Ascension Technology's Rotating Shadowband Pyranometer. This instrument reads the intensity of sunlight. Once each minute, a shadow is cast over the sensor to measure diffuse light. The diffuse reading is subtracted from total illumination to evaluate the sun's intensity. This is a very simplified description of this highly sophisticated, multi-functional instrument's operation.

There is also a fixed Licor pyranometer on the array to register sunlight at the plane of the array.

Ascension's computer also compares data from the two kWh meters. One is the electric service meter by the building's transformer. The other is the one at the output of the solar electric system.

For More Information

For more information about the system, contact Mark Boettcher, whose address is given below.

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