Energy for irrigation

Jerry D. Knutson, Jr.
Robert G. Curley
Edwin B. Roberts
Robert M. Hagan
Vashek Cervinka

The need to use water wisely has been realized in California for decades. Until recent years, however, little attention was paid to another natural resource, energy, and its relationship to water. Since most of California does not receive significant amounts of rain during the growing season, the state depends on the storage of winter rain and the runoff from snow in lakes, reservoirs, and underground aquifers. Very little of California's vast water storage system could be used if it were not for pumps and the energy they require to move water—and energy costs continue to increase. The study summarized here was undertaken as a first step in understanding the energy requirements for irrigation.

Over 95 percent of the energy used to irrigate in California is electricity. In 1972, the year on which this study was based, approximately 7 billion kilowatt-hours (KWH) of energy were used to pump irrigation water—more energy than the combined gasoline and diesel energy that is used for crop establishment and cultural practices (fig. 1).

The primary energy required to generate and distribute the KWH used at the pump would be approximately three times as great. (Primary energy can be approximated by dividing pumping energy by .31.)

Pumping energy for irrigation is divided into four categories: (1) Application energy—the energy for moving water in gated pipe or for pressurizing sprinklers. Most of the energy in this category is consumed by sprinklers, even though only 20 percent of the irrigated acreage is sprinkler irrigated. (2) On-farm well energy—the energy consumed by on-farm pumps for pumping ground water to the surface. (3) Federal or state water-project energy—the energy that state and federal agencies use to pump irriga-

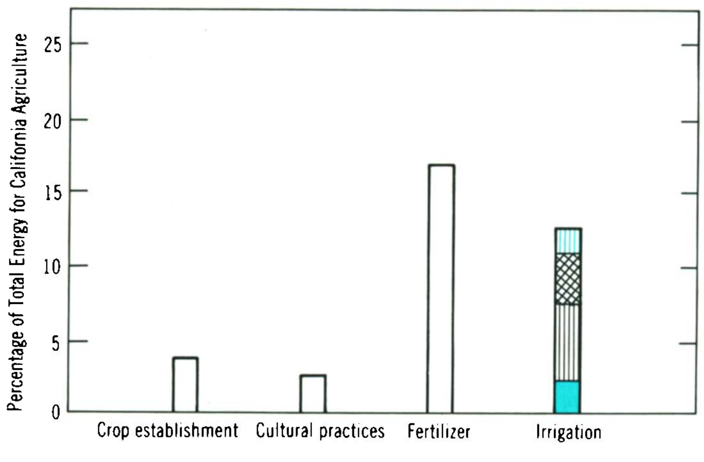

Fig. 1. Comparison of irrigation energy with other key energy requirements for California agriculture. Energy requirements for crop establishment, cultural practices, and fertilizer are taken from the 1974 report "Energy Requirements for Agriculture in California" by the California Department of Food and Agriculture and the Department of Agricultural Engineering, UC Davis.

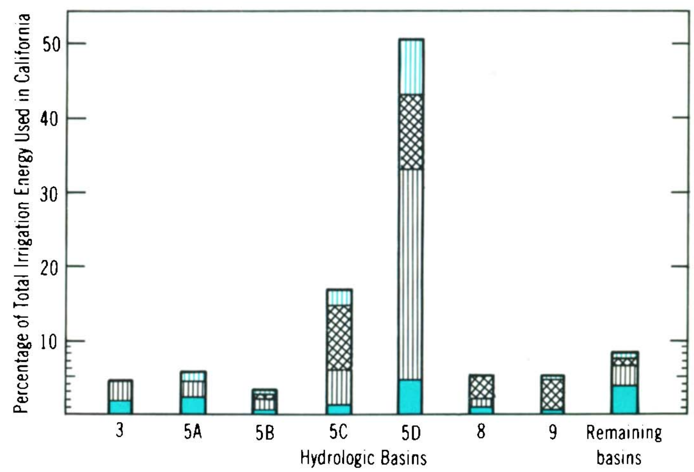

Fig. 2. Categories of pumping energy used for irrigation in California in selected basins.

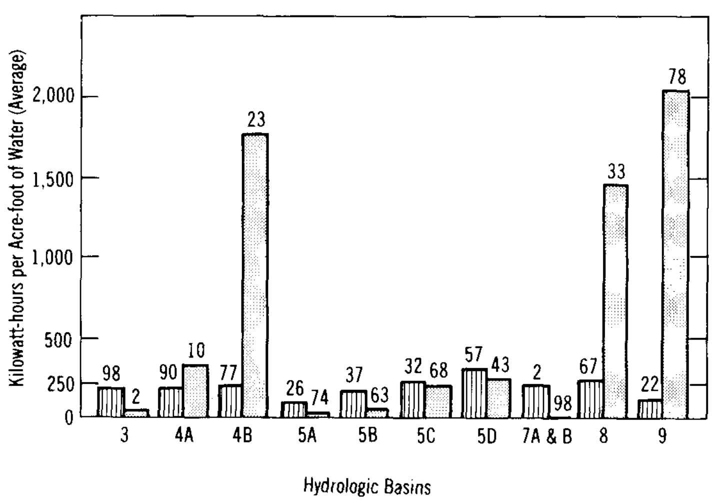

Fig. 3. Energy required to pump water from on-farm wells versus surface water in the major hydrologic basins of California. Surface water is pumped by irrigation districts and by federal or state water projects. The numbers above the bars indicate the percentage of water used in each basin from ground or surface sources.

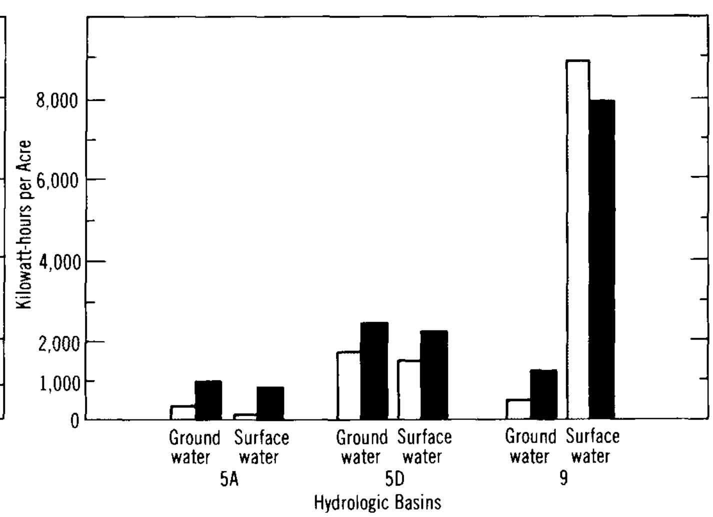

Fig. 4. Energy required to irrigate alfalfa in three hydrologic basins in California: ground water versus surface water and sprinklers versus surface methods. It was assumed in these calculations that sprinklers would use 20 percent less water than would gravity methods.

tion water in the large water projects. (4) Irrigation district energy—the energy local agencies use to pump the irrigation water they supply to farms.

The amount of energy represented by the four categories varies considerably by location (fig. 2). For example, pumping from on-farm wells uses over half of the total irrigation energy for Basin 5D (southern San Joaquin Valley), where pumping depths are the greatest in the state—but less than 2 percent in Basin 9 (San Diego River), where 78 percent of the water is surface water. Approximately 50 percent of the state's total irrigation energy is used in Basin 5D, with its large acreage and great pumping depths; very little energy is used in the large irrigated acreage of the low deserts (Basins 7A and 7B), because 98 percent of that water is gravity fed from the Colorado River.

Figure 3 compares the average kilowatt-hours per acre-foot (KWH/AF) required to deliver surface water and water from on-farm wells to the field in ten widely different basins. In general, more energy per acre-foot is required to deliver ground water than surface water. The exceptions to this are in Basins 4A, 4B, 8, and 9, where federal or state water projects lift surface water considerable distances to reach the crop-growing areas.

Energy required for irrigating an acre of crop depends on (1) the energy needed to bring the water to the field, and (2) the method of application—the amount of water applied and the energy required to apply it. Although sprinklers, in general, reduce the amount of water needed, they require additional energy per unit of applied water to pressurize the system. The energy to pressurize a typical sprinkler system at 55 psi is 216 KWH/AF if the overall pumping plant efficiency (energy efficiency of the pump and motor) is 59 percent. If a large amount of energy is required to lift ground water or deliver surface water to the field, sprinkler systems may reduce the total energy needed for an irrigation system.

Figure 4 compares energy required for irrigating alfalfa by gravity methods (border, basin, or furrow) versus sprinklers, and using ground water versus using surface water in three basins. More energy was required for sprinklers than for gravity methods except for surface water in Basin 9 (San Diego River), where part of the surface water is pumped from the Colorado River, resulting in an average energy input of 2,035 KWH/AF for delivery. The additional 216 KWH/AF required to pressurize sprinklers is more than offset by the 20 percent saving in water. Sprinklers can also reduce total irrigation energy where extremely deep on-farm wells are being used.

There are three key factors in the efficient use of energy for irrigation. The first is to minimize water use consistent with good yields. This requires application methods that use water efficiently, as well as good water management. The second key factor is to employ application methods that use energy efficiently under the specific conditions. The third is to keep the pumping plant (pump, motor, and well) in good operating condition.

These factors are somewhat interrelated, making the overall problem of energy use rather complex. Economics plays an important role in decisions on pumping plant maintenance and type of irrigation system to use. The need for additional information on irrigation energy use grows more important with each increase in the cost of energy.

Jerry D. Knutson, Jr. is Development Engineer, Robert G. Curley is Extension Agricultural Engineer, Edwin B. Roberts is Staff Research Associate IV, and Robert M. Hagan is Professor of Water Science, University of California, Davis. Vashek Cervinka is Senior Analyst, California Department of Food and Agriculture.