Equipment. Pumping equipment in most cases is the highest power consumer in the water-supply field. It is normal practice to select pumps with the best efficiency at the head-capacity conditions normally expected for a given system. Because water-system demands can vary considerably, quite often an attempt is made to match demands with variable-speed pumping units. The result too often is inefficient operation. Although there is some advantage to having pumping units of the same size, a proper selection of pumps with different head-capacity characteristics operating individually or in selected combination to satisfy a limited number of demand conditions, would result in a more efficient operation.

The "base load" pumping principle would require additional elevated storage on some systems to handle demand fluctuations. The pump-storage combination, however, would reduce power-plant peak loads, and would simplify or, in some instances, eliminate control equipment associated with plant adjustments for rates-of-flow changes. Power cost and fire-protection insurance rate savings would partially justify additional elevated storage.

The under-sizing of transmission and distribution piping can result in false economy in terms of higher pumping head costs and excessive leakage or pipe failure because of excessive pressures. A relatively small increase in capital costs of piping will reduce pumping equipment capital costs and operating costs, but more important, it will reduce requirements for energy, which may become scarce at any cost.

Water unaccounted for through lack of, or faulty, metering results in not only a loss of revenue but encourages waste. Energy consumption associated with plant waste sludge disposal can be very high when the sludge has to be stored, rehandled, conditioned, pumped, and hauled. Governmental regulatory agencies should be expected to re-evaluate their sometimes extremely stringent restrictions on sludge disposal in areas where no significant detrimental effect on the environment would result, or where the detriment is outweighed by more critical considerations.

Conclusions

Future annual debt service costs on new capital improvements will probably increase due to inflation. In design, reliability of service and efficiency of operation to conserve energy and reduce consumable supplies per unit of production should be important goals. This could result in higher initial capital costs in some instances, a part of which will be for facilities to ensure against system failures. However, an easing of operational costs by reducing consumption of critical consumables and controlling power consumption should result.

In operation, chemicals should be conserved by not overdosing; other consumables by not wasting in other ways; fuel by no unnecessary heating, cooling or vehicular trips; electrical power by not operating equipment improperly or unnecessarily; treated water by realizing what it costs to bring it to the customer and not wasting it.

In local administration, investments in operational insurance facilities and inventories may have to increase to ensure service reliability.

Federal and state governments should realize that the water-supply field’s service to the public should not be made inordinately difficult and costly, either directly or indirectly through regulations on other utilities or by unrealistic environmental assessments and controls.

Energy for Water

John H. Lauten

A section paper selected by the JOURNAL, authored by John H. Lauten, (Active Member, AWWA), genl. mgr., Metropolitan Water Dist. of Southern California, Los Angeles, Calif. (California)

This article discusses the prospects for securing a sufficient energy supply, without which it will be impossible to provide an adequate water supply for Southern California, and the possible costs of a water supply.

Despite the experience gained from the oil embargo, about half of the American public doesn’t believe there is an energy problem, and the lack of leadership from Congress in adopting an energy policy merely reflects the indecision at home. Congressmen are elected by the people—half of whom don’t believe there is a problem. Under such circumstances how can a Congressman be expected to support an increase in gas taxes and other hard measures designed to cope with the problem? But, if the problem is not solved, the water-supply field, which must have a great deal
of energy to pump water, is going to be seriously and adversely affected.

The energy problem confronting Southern California was almost completely unforeseen just a few years ago, but in a relatively short period of time the many facts that have been available and that should have alerted the people to the problem have now become better known. The result has been that about half the people now realize that this area and the country face an energy crisis, a crisis that might have been avoided or at least moderated if action had been taken sooner.

**Water Supply as Energy Equivalents**

The Metropolitan Water Dist. relies on imported water brought long distances into the Southern California coastal plain. The water delivered through the 242-mi-long Colorado River Aqueduct and the 444-mi-long California Aqueduct requires immense quantities of energy for pumping. Water through the Colorado River Aqueduct must be pumped a total of more than 1600 ft. The northern water brought through the California Aqueduct must be lifted well over 4000 ft before flowing downhill into the coastal plain.

To depict the magnitude of energy needed, it has been translated into barrels of oil that would have to be burned to produce the amount of energy needed to pump each acre-foot of water. Putting it in this manner, it requires about 3 bbl of oil to bring 1 acre-ft of water to the coastal plain from the Colorado River. Each acre-foot of the Northern California water from the State Water Project requires the energy equivalent of about 5 bbl of oil.

Multiplying the number of barrels of oil by the quantity of water from each of these two sources produces some staggering totals. Metropolitan Water Dist. received about 1 100 000 acre-ft of Colorado River water in 1974, virtually its full entitlement. Water from the State Water Project delivered to the district last year totaled about 300 000 acre-ft out of a maximum annual entitlement to northern water of 2 011 500 acre-ft. Thus, pumping of water from these two sources last year required the energy equivalent of about 4.8 million bbl of oil.

Some other energy equivalents with respect to water are of interest. Pumping an acre-foot of water from a groundwater basin at a depth of 300 ft takes the energy equivalent of at least one-half barrel of oil. Reclaiming wastewater at a new treatment plant of the most modern design in Orange County is expected to use the energy equivalent of 3 bbl of oil for each acre-foot reclaimed. Distillation of seawater at the same plant in order to blend it with the reclaimed water will require the energy equivalent of 33 bbl of
oil for each acre-foot desalted when the plant is completed to its full size and is operating under the most efficient conditions.

Putting the use of energy for producing water in a more meaningful context, the average annual electrical consumption for a Southern California home is approximately the energy equivalent of burning 10 bbl of oil. The average annual gas consumption for a Southern California home is approximately the energy equivalent of burning 18 bbl of oil. Since each household uses about two thirds of an acre-foot of water each year, it can be seen that the energy involved in providing water, which requires the equivalent of 2 to 3 bbl of oil, is about 10 per cent of the home's total energy needs. However, when each family's use of gasoline in personal motor vehicles is taken into account, the home use of energy and the use of energy to provide water is about one half of each family's total use of energy.

The rapidly increasing cost of some of the energy needed for pumping has become a serious problem. Metropolitan has a long-term contract for power from Hoover and Parker Dams which enables it to pump the first 750,000 acre-ft of water from the Colorado River each year for only about $5/acre-ft, but the cost of the off-peak energy Metropolitan Water Dist. can purchase from Southern California Edison Co. to bring in water over and above that amount from the Colorado River has quadrupled in three years, increasing the cost of that pumping from $10/acre-ft to more than $38. In 1987, Metropolitan Water Dist.'s 50-year contract for power from Hoover Dam runs out. When the contract is renegotiated, it will unquestionably be at a far higher rate than the present one of about 2.4 mills/kWhr. With respect to the Northern California water, the state has a very favorable power contract, and thus the cost of pumping northern water to Southern California with 3-mill power is now only about $10/acre-ft. However, what will happen when that agreement expires in 1983 is not a pleasant thing to contemplate.

Additionally, it takes 2000 kWhr of electric energy to pump an acre-foot of Colorado River water, and about 3400 kWhr for an acre-foot of state project water to be delivered to the coastal plain. Using oil at $15/bbl as fuel to produce electric energy, and assuming a barrel of oil produces 600 kWhr of energy, it costs around 25 mills/kWhr to produce electric energy from oil. Assuming use of energy produced by burning oil and multiplying 25 mills/kWhr by 2000 kWhr/acre-ft, the result is a cost of $50/acre-ft to pump Colorado River water. For comparison, the present cost of $5/acre-ft is based on hydropower from Hoover and Parker Dams. For state water, the same type of multiplication for use of energy produced by burning oil gives $85/acre-ft.

The people have to be prepared to face power costs of this type within the next several years, and this does not include capital and other operating costs. Such power costs, when they occur, will have to be passed on to the water users. To illustrate what may lie ahead, present cost estimates for power from publicly financed plants to be placed in operation in the early 1980s are ranging from about 20 mills/kWhr for nuclear plants, to 30 mills for coal-fired plants, to 40 mills for oil-fired plants.

While the cost certainly is of concern, an even more fundamental question is whether all the energy needed to pump the water to Metropolitan Water Dist.'s service area of 4900 sq mi and over 10.5 million people will be available in the years ahead. The population of the district is still growing, and there is no reason to believe that growth will not continue, even if at a much slower rate than in the past. But the growth rate for the future is not certain. If the air pollution problem is alleviated (and it certainly will be when the cars now more than 2-years old are scrapped), or if the energy crisis should persuade people to move from colder states to California, there might possibly be a resurgence of the kind of tremendous population increase in the district experienced in previous years—300,000 or more persons a year.

Attempts to Develop New Energy Sources

As stated before, the American public has been slow to appreciate or believe that a real energy crisis is approaching. They must be made aware of the physical facts relating to this problem, some of which will be discussed to indicate what is happening in California in regard to trying to develop new energy sources.

Regulations to limit air pollution have made it impossible to locate new fossil-fuel generating plants on the Southern California coastal plain, unless they burn gas—and gas is now almost totally unavailable. Production from existing oil wells is declining and few wells are going to be drilled under existing federal laws controlling prices at the wellhead. Without an incentive, this condition is not likely to change. A modest growth within the Metropolitan Water Dist.'s service area is predicted for the years ahead. Demand has already exceeded supply so that the large interruptible customers—the power plants—already have been cut off and the industrial interruptible customers will be curtailed in the next few years and then cut off. What will happen when they are cut off? Some will switch to high priced, low sulphur oil, others to electric energy thereby increasing demands on the power plants, and some will just cease operations thereby adding to the unemployment problem.

A state-wide initiative approved by the voters two years ago created the Coastal Zone Conservation Com., which at least for the time being has put a stop to locating any additional nuclear or fossil-fueled power plants on the coastline. The utilities' efforts to site nuclear plants inland are encountering strong opposition. An initiative measure qualified for the 1976 state primary election under the guise of providing greater safety in nuclear reactors. It will, if passed, probably make it impossible to build any additional nuclear power plants anywhere in California at least until litigation determines the constitutionality of the measure. It will also cause the existing plants to be gradually shut down, thus compounding existing power supply problems and causing greater air pollution with greater use of oil burning plants to make up for loss of nuclear energy. As for hydroelectric plants, few feasible sites remain in our state, but any attempt to move forward with any of them would be faced with fierce opposition by environmentalists.

Today, the major portion of the electric energy produced for use in Southern California comes from burning oil in boilers. This burning of oil creates air pollution problems, and the air pollution control districts not only oppose any new large fossil fuel plants, but they would also like the existing plants phased out as soon as possible. From the point of view of international economics, it would be desirable to quit paying billions of dollars a year for foreign oil.

Oil production in the 48 contiguous states is declining despite extensive development on the outer continental shelf and Alaskan oil will not much more than offset this decline. The decline in gas production is noticeable despite assumed deregulation of gas prices. Hydro requires dams in public parks, like the Grand Canyon, and the projected nuclear growth is beyond that which will be realized by 1985. All of this means that the country will have to import oil and gas or suffer shortages, in spite of major conservation efforts.

As to the long-term picture, obviously any projection more than 10 to 20 years ahead is going to be speculative, but the demand for energy, if we continue our present lifestyle and keep developing new uses for energy, will continue to increase. In 1973 the US passed from an era of plenty to an era that is destined to be
confronted with shortages unless new energy sources are developed.

Recent statements from proponents of the nuclear initiative and one member of the new State Energy Com., indicate that the growth curves are all wrong and can stop right where they are with conservation meeting future requirements. The author hasn't found any knowledgeable person in the utility field that believes that such conservation projections are realistic.

Those who through their opposition are eliminating option after option for providing the necessary energy for our economy blindly insist that energy needs can be met by conservation and by the use of solar and geothermal power. Conservation can give us a big assist in meeting our future needs, but when conservation starts to cut into our lifestyle, it is expected that the public will be less than cooperative. We can eliminate waste, but there is only so much of that. We can build structures and machines in the future that are more energy-efficient, but that will only reduce the rate of growth in energy demands and, after an all-out conservation effort, we will still need additional sources of energy.

Solar energy is suggested as a future source. But with present technology, solar energy is going to play only a small part in meeting our needs for the next two decades.

Geothermal energy is also suggested as a source of energy. The largest US source of geothermal energy is at The Geysers in Northern California where Pacific Gas and Electric Co. operates about 500 MW of capacity utilizing dry geothermal steam. The company estimates, based on their extensive knowledge, that future energy from The Geysers area won't exceed a total of 2 million kW, which is equal to two nuclear units of about 1000 MW each, and even then the operation will be fraught with environmental problems. Geothermal resources in Imperial Valley have not proved as productive as first estimated, and the environmental problems associated with development of the resource will be substantial. In any event, it will be several decades before this resource will contribute materially to meeting the area's energy problems.

While conservation, solar energy, geothermal energy, and use of coal may go some way toward meeting future requirements, it is difficult to see how we can maintain anything approaching our present lifestyle, bring back reasonably—full employment, and have a sound economy, unless extensive use is made of nuclear power plants. The efforts of those who are blocking such plants are setting the stage for economic disaster in the near future.

One irony of the present situation is that by forcing power plants to be built in inland areas, the inexhaustible supply of cooling water from the Pacific Ocean can no longer be utilized, and an additional and truly unreasonable demand must be placed on our limited fresh-water supplies. In this regard, the district reluctantly has agreed to supply water for three proposed nuclear power projects, two in the Mojave Desert and one in the San Joaquin Valley, if use of agricultural drainage water is not required. Geothermal resources in the semiarid Southern California area, drinking water has to be used for additional power plants.

Economic Impact on Lifestyle

There are a few more points that will illustrate the problems being discussed. First, with the maximum amount of conserva-

Second, there is a relationship between the use of energy and productivity, at least with respect to those employed in the manufacturing industry. To increase productivity per worker requires use of more power.

Third, there is a relatively close relationship between the growth of energy use and growth in gross national product. The present slump in gross national product is accompanied by unemployment and reduced use of energy. Some conservation advocates contend that these relationships are bad and not in the public interest, that continued growth cannot and should not be sustained, and that somehow or other the productivity of employees must not be increased by the use of more energy. If this were to occur, the opportunities for employees to earn more and increase their standard of living would be drastically reduced. Whether employees are prepared to give up this opportunity to improve their standard of living in order to reduce the demands for energy is at least questionable at this time.

To offset the reduction in domestic oil and gas production, the federal government is trying to increase offshore oil production. But here the environmentalists and even some of the officials at the state capital are doing everything they can to block or slow up such efforts.

Another alternative is increased oil importation by the use of supertankers or the importation of liquefied natural gas. But these require larger or special port facilities, and once again the environmentalists and to some extent the Coastal Zone Conservation Com. are in opposition to such developments.

The only major natural resource in plentiful supply is coal, and efforts are being made to expand its use. Yet even here there are problems. Open-pit coal mining impairs the environment. Coal-fired plants emit waste gases that lead to environmental problems and require vast sums for effective control. Coal is located inland, and power plants thus require scarce fresh water for cooling.

Thus, we appear to be on a collision course. The water-supply field, all industry, and the entire public need vast amounts of energy to survive in our present lifestyle. Our present energy sources are in very limited and diminishing supply, yet all proposals for developing new energy supplies are beset with tremendous problems and almost overwhelming opposition.

In the face of all this, our responsibility is very clear. We must take every opportunity and use every forum to get this story to the public. The public must be impressed with the fact that it is a problem that definitely concerns them. Only if the public is convinced of the seriousness of the problem is there any chance that the nation can develop a sound energy policy, remove some of the obstacles to development of energy, and proceed to develop the needed sources of power while protecting the environment as much as reasonably possible. An equally intensive effort is needed to achieve public acceptance of the conservation measures that are necessary to eliminate or reduce all forms of waste, almost all of which involve a waste of power.

The message should be clear—only with power available, can we be assured of an adequate water supply, although at greater cost, for the present and future generations in Southern California. Only with an informed public will we get the power.