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Jay C. Andersen
Utah State University

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Department of Economics
Utah State University
Logan, UT 84322

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Much has been said and written on efficient and equitable pricing of public utility products, yet utility users are often charged prices which bear little resemblance to actual costs of providing services or to other criteria established. Among causes is the hectic schedule of the public utilities governing body which is continually bombarded by rate requests and other matters. The adversial nature of utility vs. users and the contesting users arguments in the spread of rates do not lend themselves to discovery of efficient and equitable prices. Overcapacity in electrical generating facilities which increases costs has mostly occurred because of projecting ever-increasing loads at peak capacity use hours, days, and years. Little or no attention has been given to the possibility of load management by pricing differentials or other incentives.

Functions of Utility Prices

Prices charged for utilities have various functions. The Division of Public Utilities of the Utah Department of Public Utilities has adopted appropriate rate design pricing objectives. They are given by Compton (1983) as follows:

1. Revenue adequacy. Rates to each user class should be constructed to yield the prescribed revenues, given the projected level of sales.
2. Allocative efficiency. Prices should be neither too low nor too high relative to costs since such leads to excessive or

insufficient utilization of a particular resource. Ancillary objectives (are) understandability and stability over time.

3. Distributional equity. Intraschedule cross-subsidization should be minimized. The revenue standard by which customer billings are evaluated is that which would result from the competitive supply of the good/service. For one customer within a schedule to pay that level while others pay substantially less (or more) would be inappropriate.

4. Net revenue stability. A utility's capital costs are lower when the impact of sales volatility upon profits is not exaggerated.

Until recently, the rates established for irrigation pumpers and probably for most other classes of users met none of these objectives except for overall revenue adequacy for the utility.

After much negotiating with the irrigation pumpers and several appearances before the Public Service Commission (Andersen 1978, 1980, 1981, 1982, and 1983) and with cooperation of the Division of Public Utilities, Department of Business Regulation, State of Utah, and ultimate cooperation of Utah Power and Light, a new set of rate options for the UP & L service area in Utah was adopted for the 1984 irrigation season. Four options are now available to farmers from which they must choose an option for each pump installation by October 15 prior to the year of irrigation. The following four rate alternatives are available:

Rate A: Nonparticipation in load control or time-of-day options. This is a traditional declining block schedule with high start-up or demand charges that has been in use for years.

Rate B: Participation in load control in which a pump may be shut down by automatic controls between 7:00 a.m. and 7:00 p.m. on one weekday per week which the pumper chooses. He may choose, for example, to be subject to shutdown for up to twelve hours each Tuesday during the irrigation season. The season extends from May 25 to September 15. The rate has a slightly lower demand charge, but the same declining block energy rates as Rate A.

Rate C: Participation in load control in which a pump may be shut down any weekday during the calendar week for up to twelve hours per week providing that Utah Power and Light will not shut down a pump more than three times in any given week. The rate is the same as Rate B but with a lower demand charge.

Rate D: Agreement to accept billing for different rates for power used during different periods of the day. On-peak usage is at a higher price than off-peak. Meters will record on-peak usage from 10:00 a.m. to 6:00 p.m. Monday through Friday, except holidays. Shoulder rates will apply from 9:00 a.m. to 10:00 a.m. and from 6:00 p.m. to 10:00 p.m. Monday through Friday, except holidays, and from 9:00 a.m. to 10:00 p.m. on Saturday. Off-peak will be all other usage. Off-season use is priced at less than half that charged in the other three rates.

Pumpers have options now provided they are willing and able to cope with inconveniences and trouble of load management or time-of-use pricing. They may save from a small percentage to more than half of their pumping bill. Many of the changes that pumpers could use are dependent on careful evaluation of capital and labor investments to make new rate structures work. Stability of the system will be critical so that the program can be fully adopted.

Evaluation of Past and Present Rate Structures

Utah irrigation pumpers had complained of serious adverse impacts from rates in the past and from proposed increases. Mostly, the complaints kept rates from rising as rapidly as they otherwise would have done. But, the basic contention of Utah Power and Light Company, the utility serving most Utah irrigation pumpers, was that rates needed to be raised dramatically relative to other user classes. The basis of the rate requests made it evident that little attention had been given to the basic objectives of rate design previously listed. Turn now to evaluation of the old pricing system in regard to each of the rate design objectives and some of the advantages of the new rate structure.

An interesting background factor is that in the early 1970s electrical home heating and other factors caused Utah Power and Light's peak load to be in winter. In order to equalize loads, Utah Power promoted electrical irrigation pumping and promised inexpensive power to promote summer use. Attractive rates induced large investments in land and irrigation equipment. Utah Power and Light failed to foresee the burgeoning use of air conditioning and other factors which have now caused the summer peak system loads to be approximately 5 percent greater than winter. With a succession of rate increases, power rates to irrigation pumpers have quadrupled in less than a decade as measures of peak load responsibility have been used to justify increases. Pumpers are going bankrupt at an alarming rate where they are on new developments.

Operating costs are exceeding income and real estate values are declining much more rapidly than for most farm real estate. There is an equity and an efficiency problem of having been invited to invest and then experiencing almost an immediate change in rate levels and philosophy which renders the investments unprofitable.

In regard to revenue adequacy, several hearings had been held in which it was contended that pumpers were paying far less than their share of revenue requirements. In several hearings it was suggested by the utility that the pumpers' rates be essentialy doubled. The basis for these suggestions was the company's cost of service calculations in which they based the allocation of costs on the average and excess demand method measured on twelve-month noncoincident peaks.

Efficiency criteria are being violated in the applications of the "average and excess demand" method of cost allocation, especially using the company's preferred twelve-month noncoincident peak method. Agriculture was hit hard. The formula for the average and excess demand calculation for cost of service payment responsibility is:

$$R = \frac{\overline{kw}_i}{\sum_{j=1}^{n} \overline{kw}_j}(LF) + \frac{Pkw_i - \overline{kw}_i}{\sum_{j=1}^{n} (Pkw_j - \overline{kw}_j)}(1 - LF)$$

where R = proportional responsibility for covering costs

$\overline{kw}_i$ = average kilowatts used by the ith user class (e.g., irrigation) during the period of record

$\overline{kw}_j$ = average kilowatts used by other user classes

LF = load factor or average proportion of use of the system capacity

Pkw_i = peak use of the ith user class at a 15-minute period (Utah Power and Light's preferred methodology was to measure this when class use was highest in each month even if system use was low.) The mandated methodology is, as of this year, the eight-month coincidental peak method.

Pkw_j = peak use of each of the other user classes.

This method allocates cost of service on the proportion of total system demand (the first half of the right-hand side of the equation) which is the average use by the class as compared to total use and by the penalty in the excess part in the second half of the equation if the class peak to average difference is greater than other peak to average differences. An obvious problem with this system is that if a class of service is highly variable but countercyclical, such as would be the case on a daily basis with street lighting or recreation park lighting, a rate penalty is imposed whereas a credit for smoothing the utility's load curve should be received. See the typical daily firm load curve of Utah Power and Light in Figure 1 which shows daily differences greater than the summer/fall difference. Pumpers have a tendency to avoid the summer afternoon system peak. See Figures 2 and 3 which are sample measurements for several pumpers. This pattern is related to afternoon winds and heat which cause uneven distribution of water by sprinklers and by high evaporation. Samples of daily load patterns for irrigators

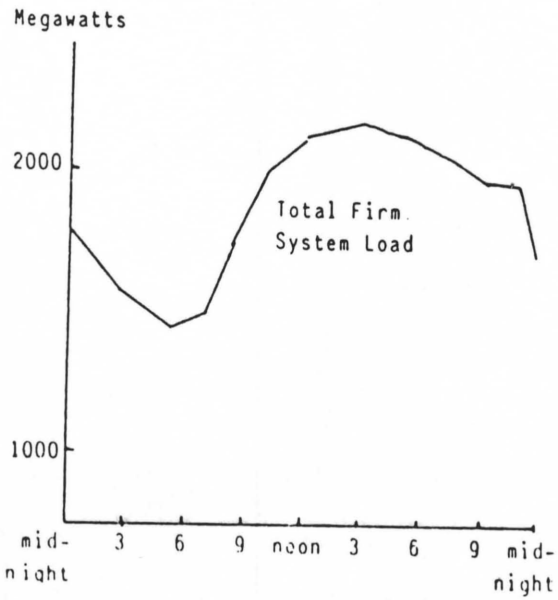

FIGURE 1. Utah Power and Light's Daily Load Curve for a Typical Day

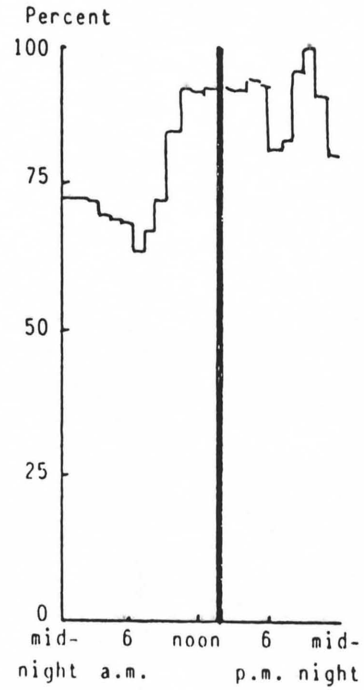

FIGURE 2. Daily Load Pattern for a Sample of Utah Pumpers on July 5, 1981 (system peak for 1981 occurred on this day at the hour ending at 2:00 pm)

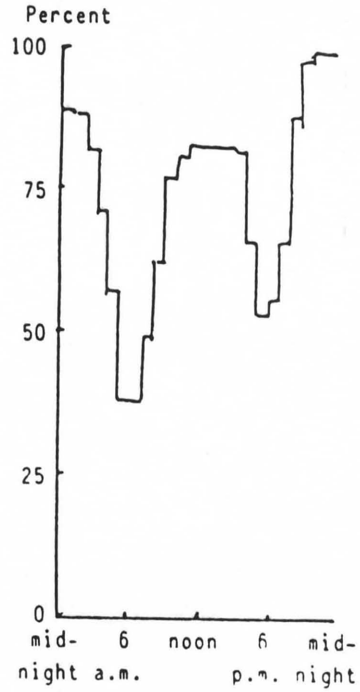

FIGURE 3. Daily Load Pattern for Average Weekdays of the Month for a Sample of Utah Pumpers, August 1978

SOURCE: A. R. Dunn. 1982. Testimony before the Public Service Commission. Case No. 81-035-13. November.

indicate a frequent midnight peak use. But they have been charged for this lack of uniformity in load rather than rewarded.

Part of the problems of revenue adequacy by class have now been corrected in which the "average and excess demand" allocation method is still used, but it is based on an eight-month coincident peak in which the penalties are only imposed on the basis of proportionate use and relative peak when the monthly system peak is occurring. Further parity is gained by discarding spring and fall months of low use so that only the relevant peaks in summer and winter are used. Pumpers have been given load management options for reducing peak daytime use for a price incentive as well as time-of-day rates in which nighttime and weekend rates are about one-third of the peak-hour rates These rates have been established on the basis of expected cost savings to the utility for supplying energy. Further reductions in pumping rates based on reduced capacity needs should result as adoption of the rates becomes widespread and is reflected in the cost-of-service calculations.

Now, relative to allocative efficiency, it is evident from the previous discussion that various sectors were not being charged rates commensurate with costs being imposed on the utility. There was no attempt to maximize economic benefits by charging a price equal to the cost of supplying an extra unit of electricity (marginal cost pricing). A declining block tariff was used with a very substantial hook-up or demand charge. Thus, the incentive was to use the last increment of power (because it was inexpensive) in each monthly billing period. The appropriate goal is for a uniform system load. Commercial air conditioning and lighting, many industrial uses, and even some residential uses are somewhat inflexible in time and season of use. In other classes more flexibility may occur. Incentives can be used where demand elasticities are higher. The irrigator can now closely calculate marginal costs of power use, investment and operating costs in accordance with the tariff. Adherence to marginal principles of resource allocation is much closer than was formerly possible, even though much could yet be done. The time-of-day rate allows least expensive power to be used first rather than most expensive. The time-of-day rate is, in effect, an increasing block rate if used appropriately. Fortunately, the time-of-day rates also provide for very inexpensive pre- and post-season rates to induce irrigators to fill the soil profile when system electrical use is down substantially. Sizing of equipment, amount of irrigation, crop combinations, and improvements in efficiency of systems will likely occur over an extended period of time in response to opportunities for efficiency improvement in pricing.

With regard to distributional equity, it is apparent that some pumpers who used electricity only in daytime and others who irrigated only at night or who pumped continuously have not been treated equitably in cost differentials. In Utah, over one-half of the farmers have small farms and are engaged in off-farm employment. As a result, they have quite frequently invested in irrigation equipment and other implements that are somewhat underutilized according to most evaluations of equipment size. The irrigation sector has a load factor of 0.62 (Faigle 1983) during the irrigation season. This indicates an average use of 62 percent of potential use for one-third of the year. This relatively low load factor during the irrigation season along with numerous indications of relatively elastic demand for irrigation water (especially precise timing of its use) suggest that much will be done to adjust use to relate to differential costs. Thus, those who can move to off-peak will do so and those who must pump on-peak will do so while paying the appropriate costs on the system. Very high demand charges have been assessed for starting up a pump no matter whether any use was on-peak or not. These can now be partially avoided and far more fairness among pumpers is provided.

On revenue stability, there are indications that carefully calculated cost-based rates have a better chance of long-term constancy than those which are based on adversial negotiations and power moves. Cycles of overexpansion and underdevelopment of generating capacity and bursting balloons of inappropriate investments on the part of utility users may be expected to diminish. In retrospect, it is easy to visualize immense savings to the utility if demand projections had been based on more accurate reflection of power costs to users. Conversely, far more conservation would have been exercised on the part of irrigators if actual cost indications had been transmitted to them at the time of investment decisions. Unquestionably, the winter peak phenomenon that existed for a while was blown out of proportion in the rate structure. Both utility and irrigators would have been better served by cost-based rates.

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