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TIME-OF-USE PRICING FOR ELECTRIC POWER: IMPLICATIONS FOR THE NEW YORK DAIRY SECTOR
A PRELIMINARY ANALYSIS

by

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SUMMARY:

This paper examines the cost of electric power consumption on New York dairy farms. More specifically, it is a preliminary evaluation of the cost changes that dairy farmers may experience when residential time-of-use electricity rates are implemented by New York State utilities. Using a model developed for Niagara Mohawk Power Corporation, the operating cost of farm electrical equipment is estimated using both flat rate pricing and NMPC's new time-of-use rates, which are now being implemented for their farm and residential customers. Twenty-five "typical" family-operated dairy farms are evaluated with this model. Initial results indicate a cost decrease up to 10 percent as a result of the switch to time-of-use rates. Larger farms will experience a greater percent decrease in electricity costs than smaller farms. Electricity costs for all major end uses are lower with time-of-use rates than with a flat rate. These estimates assume no response in the farmer's schedule or equipment usage. Model refinement will continue.

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Introduction

Increases in electricity demand in the residential sector of society coupled with limited growth in electrical generation capacity have prompted new energy conservation mandates from the New York State Public Service Commission. In addition to overall load reduction measures, efforts have been directed toward redistributing electricity consumption away from peak demand periods, known as load shifting. To accomplish this, changes have been made to the residential rate structures employed by some New York State utilities.

This change is significant. Formerly, the charge for electricity was based on a single, flat-rate fee per kilowatt hour (Kwh), regardless of when it was consumed. Rates now being implemented more closely reflect the marginal costs of electrical generation during periods of high (peak) and low (off-peak) consumer demand. These time-of-use rates (TOU), as they are called, may have a noticeable effect on energy costs paid by large residential customers, a substantial portion of which are family-operated farms currently billed at the residential rate. This may be particularly important for those farmers who perform major electricity-consuming activities during daily peak generation periods. Much attention is focused on dairy farms because use of electric power is centered on a fixed milking schedule. And, since dairy farming is both energy intensive and the dominant agricultural enterprise of New York State, the economic ramifications of such a rate change warrant investigation.

This research, sponsored by the Niagara Mohawk Power Corporation (NMPC) examines the cost changes that may occur on typical dairy farms resulting from the implementation of time-of-use electricity rates. In the preliminary analysis reported here, flat rate vs. time-of-use rate cost comparisons are made assuming no management response by the farmer. Ongoing research will study the cost implications of utilizing energy-efficient equipment and changing the schedule of certain farm activities. Results from these and other related projects will be utilized to aid long term planning efforts and in the development of appropriate farm energy conservation programs.

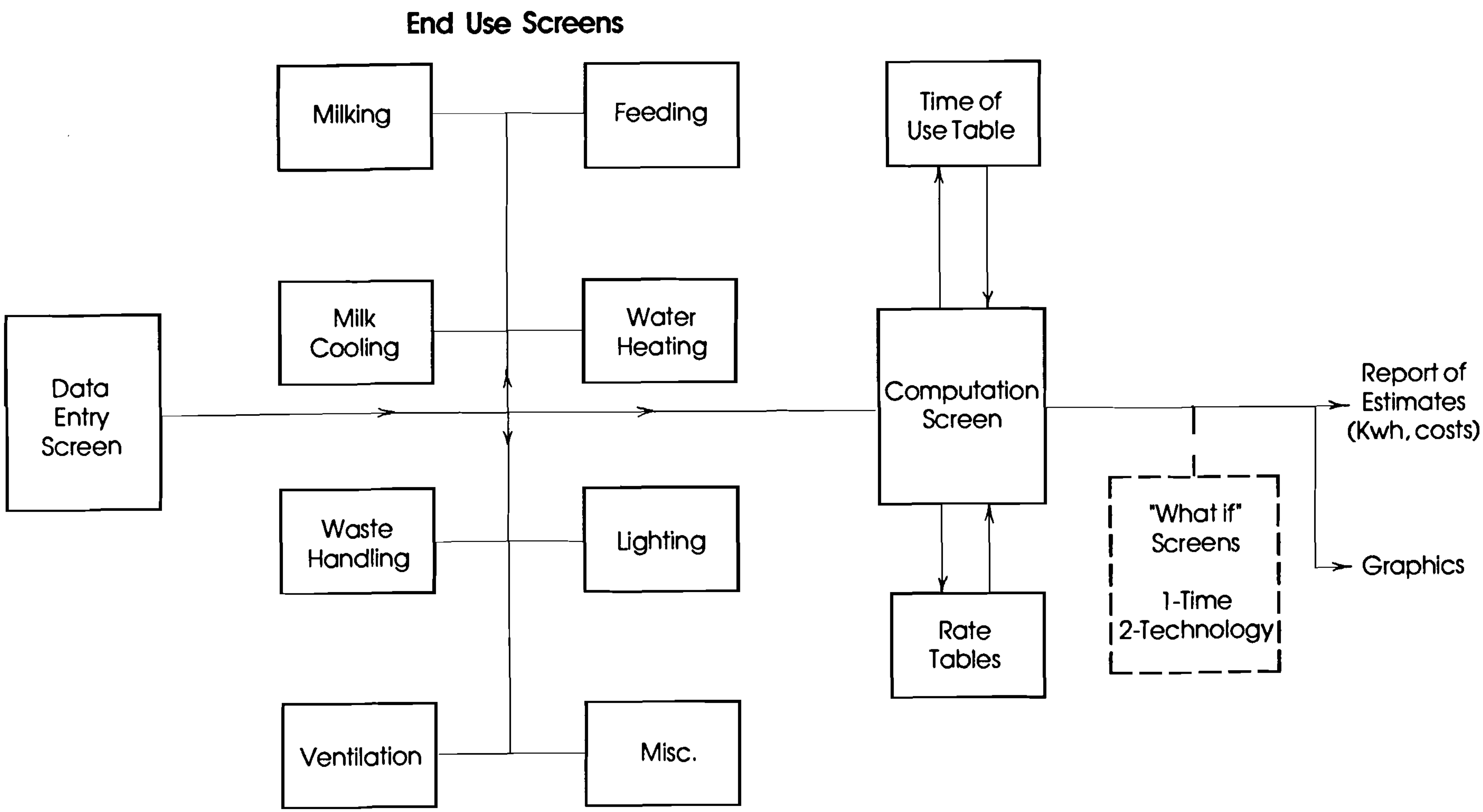
METHODOLOGY

To estimate individual farm electricity costs, a model is developed that calculates energy consumption for major electrical end uses found on most dairy farms. A schematic diagram of this model is portrayed in Figure 1. End use Kwh consumption of all farm electrical equipment is calculated using coefficients from regression models, end use indices or other algorithms that closely fit data collected from previous research projects (see Boor, Farmer, Johns). End use estimates are annualized and summed to provide a yearly energy consumption figure. Using data on the timing of equipment operation for the farm, an algorithm then apportions this total into a time-of-use category, such as peak or off-peak.

Apportioned Kwh consumption is then multiplied by its corresponding rate (in cents/Kwh) to determine the energy cost for each of the time-of-use categories. The total annual Kwh consumption is also multiplied by the current flat rate price. Using this information, the annual cost differences

FIGURE 1

FARM ENERGY ANALYSIS MODEL



between time-of-use rate and the flat rate prices can be compared and analyzed.

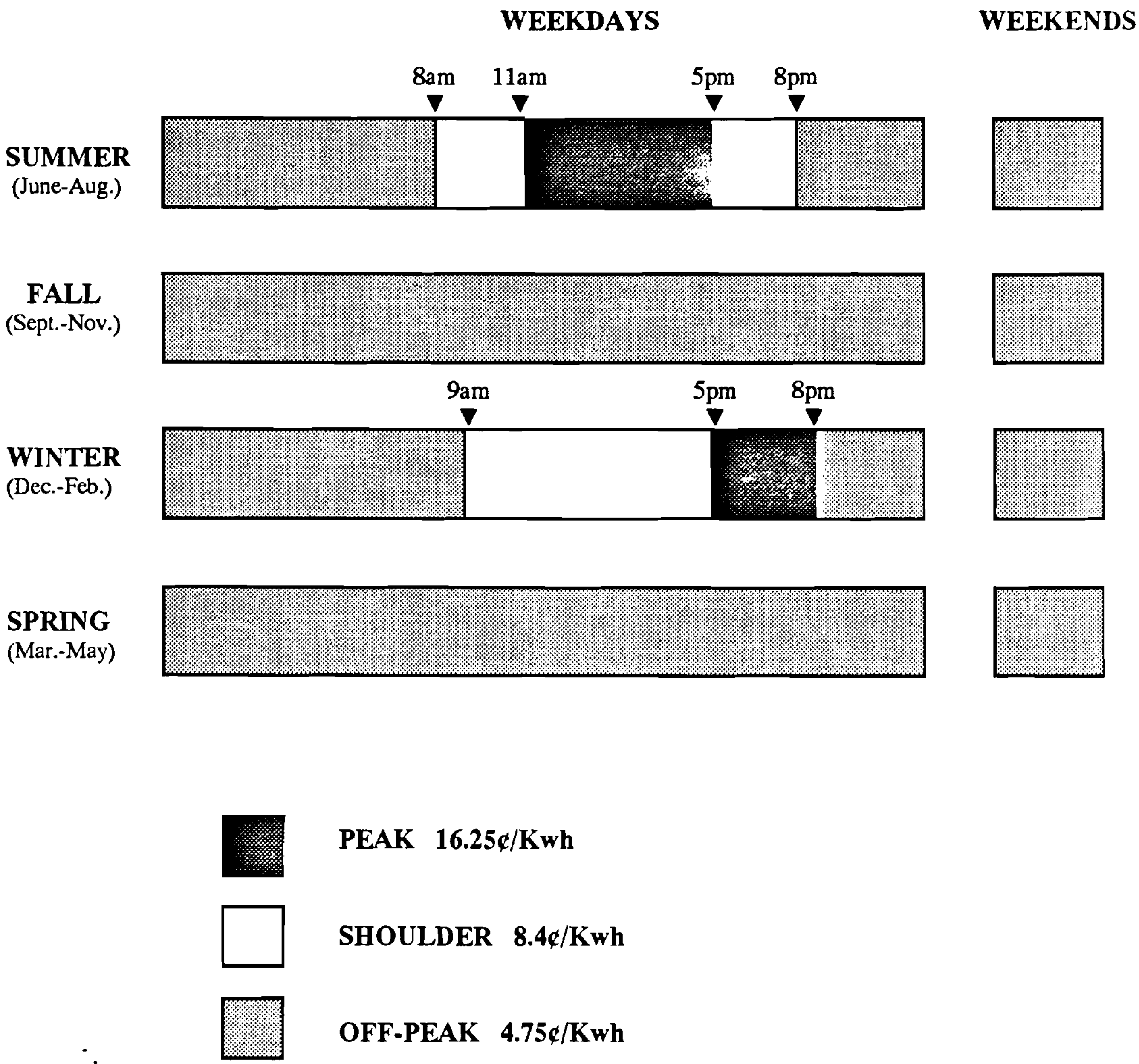
For this research, Niagara-Mohawk's residential time-of-use rate schedule (SC-1C) is employed (Figure 2). The NMPC schedule utilizes a three-tier rate structure rather than the normal two-tiered system, dividing daily usage into peak and off-peak periods, plus an intermediate-level (shoulder) period. Like other utilities, NMPC's time-of-use rate schedule varies according to season, with peak and shoulder rates reflecting the highest power generation periods that take place during the winter and summer seasons. Implementation of time-of-use rates for Niagara Mohawk's large-use residential customers began in 1990 and will be completed in 1992. TOU rates will replace a flat rate schedule (SC-1) now in use. The flat rate will remain in effect for lower-use residential customers.

MODEL REQUIREMENTS AND SPECIFICATIONS

The electrical cost estimation model is developed with a micro-computer for applications either in the office or in the field. To maintain compatibility with existing NMPC software and hardware, the calculations are performed using Lotus 1-2-3, Version 3.0. Lotus also has the capability of menu creation and high quality graphics display, both of which aid in operation and presentation. This software package requires a microcomputer with at least 1.0 megabytes of random access memory (RAM) and hard disk storage. The computer must also have at least a 80286 microprocessor in order to properly run the program.

FIGURE 2

Niagara Mohawk Time-of-Use Electric Rate



CUSTOMER CHARGE: $32.20/month

FLAT RATE **7.196¢/Kwh**
CUSTOMER CHARGE **$5.85/month**

A crucial feature of any time-of-use estimation model is the algorithm that apportions farm electrical usage into the proper rate category. In this model, algorithms have been developed for both scheduled and continuous electricity-using tasks. Scheduled tasks are those electricity consuming activities which occur at a time determined by the farmer. Milking, feeding, and gutter cleaning are examples. Continuous tasks consist of electrical demand brought about by automatic or continuously running equipment, such as ventilation and outdoor lighting. Algorithms were created to depict the daily energy consumption characteristics for tasks with uneven consumption patterns, such as the water heater and the milk cooler. When the actual consumption pattern of a continuous task was unknown, the Kwh estimate was distributed evenly across its operating time.

MODELING FARM DATA

Developing the model is an interactive process, and to achieve accuracy, it was necessary to calibrate it using farms with known energy consumption characteristics. Metered end use data and time-of-use information is extremely important. Cornell University possesses extensive data sets on New York farm electric energy use, but no large scale study of metered end use data. Fortunately, a representative data set of this type was found in a study of dairy farms conducted by a Wisconsin utility. In that research, twenty-five family-operated dairy farms from Iowa, Minnesota and Wisconsin were examined for their energy consumption patterns. The data base for each farm contained 27 months of hourly metered data comprising total energy usage and submetered data for two major end uses, the milk cooler and water heater. In addition, each farm provided information on herd size, equipment usage and milking and feeding schedules, all of which could be used to more closely model end use consumption and extrapolate important assumptions about equipment operation. Farm residence consumption was excluded from these data, an important consideration in reducing estimation bias.

The assumption was made that these farms were typical dairy operations, comparable to many family farms located in New York State. Statistics from the data set would seem to support this premise. Herd sizes from these farms ranged from 20 to 100 cows. Six of the twenty-five farms milk from a parlor setup while the remainder milk from a stanchion barn utilizing either a pipeline or bucket transfer system. Average annual milk production for the group was about 15,000 pounds per cow. Total farm energy consumption (excluding the residence) ranged from 8,800 to 81,300 Kwh per year.

Initial model testing on the 25 farms is very encouraging. We found the estimates of total farm Kwh to be 14 percent higher than the actual totals, on average. Estimates for the milk cooler averaged 5.4 percent over actual figures, while the estimator for the water heater was considerably more troublesome, averaging 63 percent over the true data. Further experimentation with water heater data led to the development of a logarithmic regression estimator, which brought the water heater estimates to within 3.5 percent of actual figures on average. With this adjustment, accuracy of total estimated Kwh consumption was improved to within 6 percent of the average true metered total.

With the model adjusted to provide reasonably accurate estimates of the known data, operational schedules for milking and feeding are entered, along with all other pertinent data. Estimated time-of-use costs are generated, by total, by end use and by each of the three time-of-use rate periods. With these estimates, comparison with the flat rate costs can now be made.

ANALYSIS

NMPC's original rate filing for time-of-use rates analyzed dairy farm customer impact for four customer groups, ranging from "small" farms (30-40,000 Kwh/year) to very large farms(>75,000 kwh/year). The 25 Midwest farms used for this research were grouped into similar size categories (plus one smaller class) for comparison purposes. The average flat rate and time-of-use rate cost estimates for each size group are displayed in Table 1.

Table 1

Flat Rate vs. Time-of-use Rate
Annual Cost Estimates
(Midwest Data)

Size Group	# of farms	Avg. Herd Size	Flat rate cost*	Time-of-use cost@	Flat-to-TOU % Change
>75,000 Kwh/year	2	88	$4,019	$3,601	-10.4%
50-75,000 Kwh/year	4	66	$3,467	$3,187	-8.1%
40-50,000 Kwh/year	8	48	$2,293	$2,183	-4.8%
30-40,000 Kwh/year	7	38	$1,870	$1,860	-0.5%
<30,000 Kwh/year	4	27	$1,271	$1,378	+8.4%
All farms	25	48	$2,337	$2,237	-4.3%

* $.07196/Kwh plus a $5.85/month customer charge ($70.20/year).

@ Peak, shoulder and off-peak per/Kwh rates plus a $32.20/month customer charge ($386.40/year).

Cost estimates do not include electricity used in the farm residence.

As shown, the model suggests that the farms using more than 30,000 Kwh/year realize a decrease in electricity costs with NMPC time-of-use rates. The comparison also shows that larger farms experience a greater percentage cost reduction than smaller farms. In fact, the smallest farms in the group would actually see an increase in their overall electric bill if time-of-use rates were imposed.[2]

How would these results compare with calculations generated with Niagara Mohawk data? Employing farm data from NMPC's time-of-use rate filing, costs are computed using current time-of-use rates and flat rates.[3] These results (Table 2) can now be compared with those found in Table 1.

Table 2

Flat Rate vs. Time-of-use Rate
Annual Cost Estimates
(NMPC Data)

Size Group	Flat rate cost*	Time-of-use cost@	Flat-to-TOU % Change
>75,000 Kwh/year	$6,151	$5,484	-10.8%
50-75,000 Kwh/year	$4,568	$4,184	-8.4%
40-50,000 Kwh/year	$3,310	$3,182	-3.9%
30-40,000 Kwh/year	$2,588	$2,500	-3.4%

* $.07196/Kwh plus a $5.85/month customer charge ($70.20/year).
@ Peak, shoulder and off-peak per/Kwh rates plus a $32.20/month customer charge ($386.40/year).

[2] Niagara-Mohawk's time-of-use rates will be mandatory for all residential customers using a minimum of 30,000 kilowatt hours per year. Other New York utilities have also set minimum thresholds for mandatory time-of-use rates, ranging from 20,000 to 42,000 Kwh per year.

[3] NMPC's original TOU impact analysis was made with proposed rates which were subsequently modified by the Public Service Commission.

Percentage change from flat rate to TOU rates for the Midwest data and the NMPC data appear to be very consistent. There are several possible explanations for this seemingly convergent outcome. The first is that the results validate the premise that Midwestern farms and New York farms are similar, particularly with regard to equipment usage and operational schedules. Secondly, the results may be an indication of the suitability of the estimation model and its underlying assumptions. Finally, the outcomes may just be coincidental. At this point in the project it would be unwise to make any authoritative conclusion until much more testing is conducted using a variety of farm data.

It is also useful to break down total electricity cost into component cost. Table 3 portrays the average electricity costs for seven major end uses of the entire 25-farm Midwest data. Also shown is the annualized monthly customer charge.

Table 3

Estimated Annual Component Cost
Flat Rate vs. Time-of-use

Rate Type	Vacuum Pump	Milk Cooler	Water Heater	Feeding Equipmt.	Waste Hndlng.	Vent.	Lights	Cust. Chg.
Flat Rate	$414	$474	$502	$315	$35	$326	$195	$ 70
Time-of-use	350	385	399	261	27	287	158	386
% change	-15.4	-18.6	-17.1	-17.2	-22.5	-12.2	-18.9	+451.1

The end use estimates demonstrate the cost differences that might be experienced from the normal usage of farm electrical equipment, without changes in time schedule. All end uses display a slight decrease in annual electrical cost. This result is expected because this electrical equipment is operated primarily during off-peak hours, when the time-of-use rate is lower ($.0475/Kwh) than the flat rate ($.07196/Kwh). Equipment operated only during peak or shoulder periods would experience costs higher than flat-rate prices.[4] Time-of-use rates for both peak and shoulder are higher ($.1625/Kwh and $.084/Kwh, respectively) than the flat rate.

Component cost estimates in Table 3 help illustrate the importance of the monthly customer charge. The monthly customer charge under flat rate pricing is $5.85, about $70 per year. However, to maintain overall revenue neutrality, NMPC's time-of-use rates include a higher customer charge, $32.20 per month. The estimates from this particular sample of farms demonstrate that even with the higher customer charge, the annual electricity cost from time-of-use rates is still lower than flat rate, except on very small farms. Component cost distribution including the customer charge for time-of-use rates is portrayed in Figure 3.

Figure 4 displays the distribution of average estimated electricity consumption by time-of-use period. Eighty-one percent of the total electricity is used during off-peak hours, while the remainder is consumed in peak (8.6%) and shoulder (10.0%) periods. When the Kwh consumption for each period is multiplied by its respective per kilowatt hour cost, the distribution changes (Figure 5). The higher per kilowatt charges of the

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[4] Estimates in this report are based on the assumption that ventilation fans operate only during milking hours and that cows are pastured during warm weather. Under confinement conditions, ventilation costs will be much higher as fans are operated throughout summer peak and shoulder rate periods.

FIGURE 3

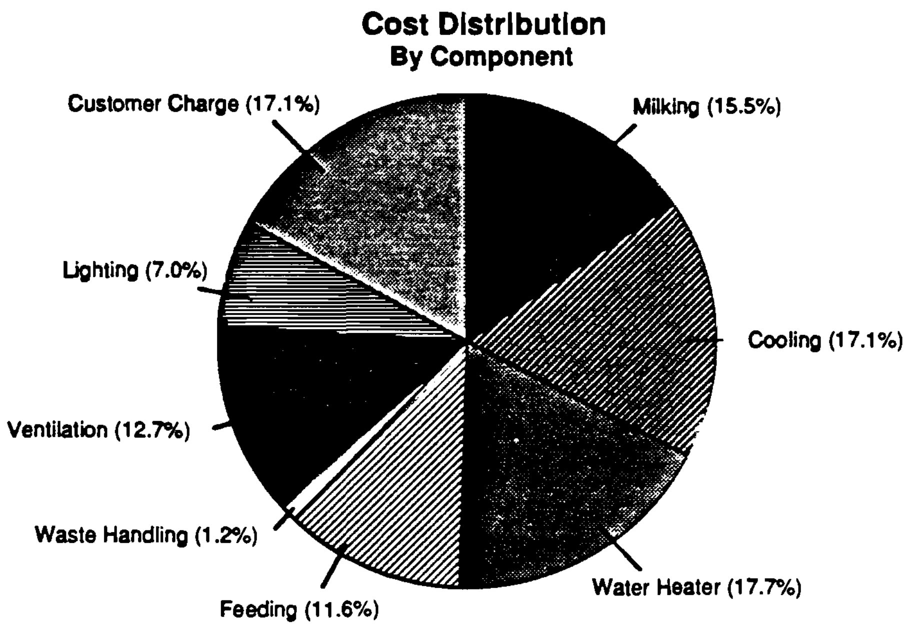

Cost Distribution
By Component
Customer Charge (17.1%)
Milking (15.5%)
Lighting (7.0%)
Cooling (17.1%)
Ventilation (12.7%)
Waste Handling (1.2%)
Water Heater (17.7%)
Feeding (11.6%)

FIGURE 4

KWH Distribution
By Rate Category

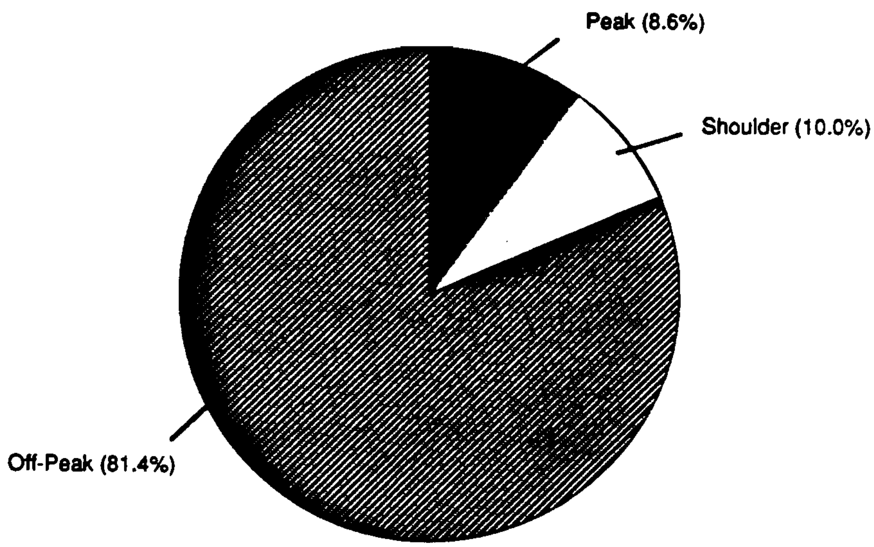
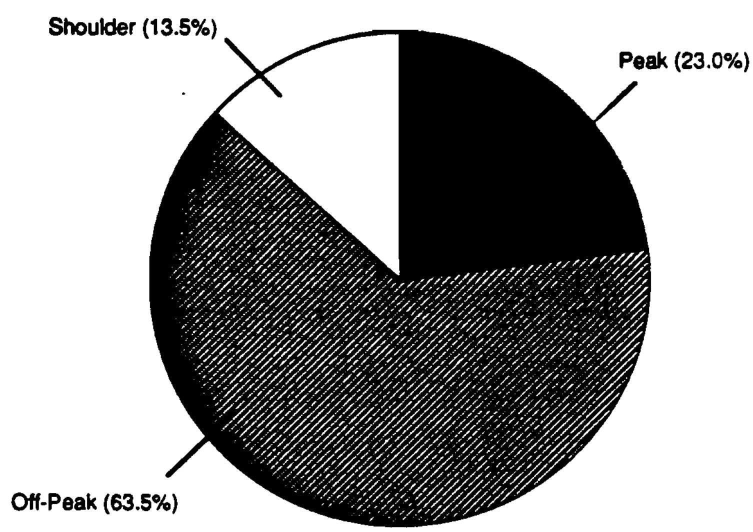


FIGURE 5

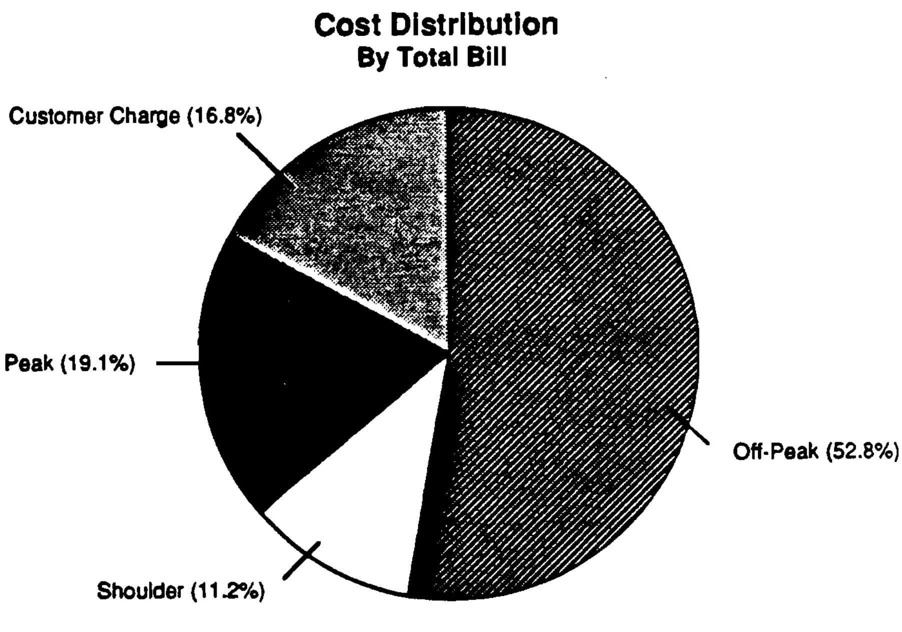
Cost Distribution
By Rate Category



shoulder and peak periods increase overall cost significantly more than off-peak rates, and now they constitute almost thirty-seven percent of total kilowatt hour charges. This graph, then, represents the time-of-use distribution for the variable costs of the farm's electric bill.

Fixed cost is now included to portray total farm electricity cost (Figure 6). The fixed cost is the monthly customer charge of $32.20 and represents about 17 percent of the total electric bill in this example.

FIGURE 6



DISCUSSION

Preliminary results from our work with a farm-level micro-computer model suggest that dairy farmers who move to time-of-use electricity rates will experience a decrease in their annual electric bills by up to ten percent. The electricity costs of individual end uses show a decrease under this new rate structure with the exception of ventilation. Small farms will experience a less significant cost decrease, vis-a-vis large farms. These conclusions, of course, are keyed to the NMPC rate structure and to what we know about end uses and the timing of equipment use for a small group of farms in the Midwest.

Further, these findings are based upon the assumption that the farmer maintains his/her operational schedule and makes no replacement of electrical equipment. Research is planned to examine cost changes that may occur, given a management or technological response by the farmer.

Finally, the estimates in this report are preliminary and subject to further adjustment. Model refinement will continue throughout this project as new algorithms are developed and tested, replacing some that have been used here. To aid in this and many other related research efforts, it would be beneficial to identify and meter a sizeable population of farms within New York State. Such an effort would give researchers a better and more complete local data base.

The results of this research provide some new information about the impact time-of-use residential rates may have on dairy farmers in New York

State. It is hoped that this research effort encourages additional inquiry into utility time-of-use rates to corroborate or modify the findings presented here.

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