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# TIME-OF-USE PRICING FOR ELECTRIC POWER: IMPLICATIONS FOR NEW YORK DAIRY FARMERS


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## ABSTRACT

This report examines new residential time-of-use electricity rates and the effects they may have on New York dairy farms. The operational and regulatory framework for electric utilities is discussed and the rationale for moving from flat rate pricing to time-of-use pricing is explained. Major farm activities requiring the use of electricity, as well as the daily operation times of major equipment clusters, are reviewed. Survey data are utilized to group farms by size and equipment to portray "typical" electrical usage patterns for a cross section of farm types.

This study also estimates current electricity costs to farmers. These estimates help set the stage for evaluating the impact time-of-use rates may have on many dairy farms within the state. Finally, some options are reviewed that farmers may wish to adopt in response to perceived cost changes from time-of-use rates.

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# TIME-OF-USE PRICING FOR ELECTRIC POWER: IMPLICATIONS FOR NEW YORK DAIRY FARMERS

## INTRODUCTION

Electricity plays a vitally important role in New York agriculture. Throughout the last half-century, the continuing development of new electrical technology has greatly reduced the need for manual labor required to operate a successful farm enterprise, and it is responsible for large increases in agricultural productivity.

Today, electric power is essential to the viability of New York agriculture, and to the state's overall economic well-being. With more and more economic growth, however, comes a potential problem. Increases in electricity demand in all sectors of society, coupled with limited growth in electrical generation capacity have, at times, strained the ability of New York utilities to meet the demand for power. This has prompted new energy conservation mandates from the New York State Public Service Commission. In addition to overall load reduction measures, efforts have also been directed toward redistributing electricity consumption away from peak demand periods.

To accomplish this redistribution, some significant changes have been made to the rate structure mechanism used by New York State utilities for some classes of customers. For example, to date, the charge for electricity used by residential customers is based on a single, flat-rate fee per kilowatt hour (Kwh), regardless of when it is consumed. Rates now being implemented differ by time of day and season to 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, are being implemented by utilities across New York for their largest customers under order of the New York Public Service Commission (Order 88-23) and may have a noticeable effect on energy costs paid by large residential customers, a substantial portion of whom are family-operated farms.[1]

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[1] Farm operations that have a home on the premises are generally classified under a residential rate category, unless the home and the outbuildings are metered separately. Most family farms would be in a residential rate category.

Time-of-use rates may be of particular interest to those farmers who use electricity during daily peak generation periods. Of this group, much attention is focused on dairy farms because their use of electric power is centered around a fixed milking schedule. And, since dairy farming is both energy intensive and the dominant agricultural enterprise of New York State, the economic impacts of time-of-use rates on the dairy farm warrant further investigation.[2]

This publication contains an examination of electricity consumption patterns and costs on New York dairy farms within the context of both flat rate pricing and new time-of-use rates. It is organized into four major sections. The first describes the provision of electricity and the general nature of time-of-use rates. Section two describes electrical consumption activities and electric-powered equipment found on typical dairy farms across the state. The third section contains a cost comparison for farms switching from flat rate to time-of-use pricing, using a microcomputer-based forecast model. The final section examines some possible management strategies and technology that can be adopted to achieve electricity cost savings in the short and long run.

## THE PROVISION OF ELECTRIC POWER

Everyone uses electricity. Yet few people understand how it is produced, distributed and sold within the consumer marketplace. To comprehend the nature of electricity generation and consumption, it is necessary to understand the framework within which an electric utility operates. For this reason, some background information is presented here.

Electricity is produced by spinning turbines connected to the armatures of large electric motors. Several types of fuel can be used to spin these turbines, such as steam from coal-fired boilers, water-powered (hydro) impellers, or nuclear reactions. From the motors, electricity is sent through a complex infrastructure of transmission lines and distribution stations until it reaches the customer, who accesses it through connecting wires and by pushing a switch. Large scale storage of electricity is difficult, so in the United States power is generated continuously and is made available to customers on a 24-hour basis.

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[2]Legislation to exempt New York dairy farmers from time-of-use electricity rates was introduced in Albany in 1990 (see Senate Bill S-7513, March 1990) but was not approved.

Electrical usage is measured in kilowatt hours (Kwh), which is defined as a unit of energy equal to that of expending one kilowatt (1000 watts) in one hour. As an example, a 100-watt light bulb illuminated for one hour would consume one-tenth of a kilowatt hour. Farm electric motors designed for heavy loads, such as those used to handle livestock waste or move feed would expend considerably more kilowatt hours over the same time period. As each electrical device is operated, a meter installed at the customer's service entry records the number of kilowatt hours consumed. This meter is read periodically by the utility, usually at 30 or 60 day intervals. The total number of Kwh's consumed during that period is then used to determine the customer's electric bill.

The electric bill contains three parts: the customer charge, the electricity charge, and taxes and assessments imposed by units of government. The customer charge represents a fixed fee for providing power to that customer, including hook-up, meter reading, and periodic maintenance costs. The electricity charge is the variable cost of producing the actual power used, computed by multiplying total Kwh use by the electric utility's customer rate, priced per kilowatt hour. The sum of the service charge and the electricity charge can be subject to several assessments including a state and local sales tax, an optional municipal tax, a gross receipts tax, and in some urban areas of the state, a tax for public transportation. A fuel adjustment charge may also be a part of the utility bill to account for cost variations in the purchase of fuels used for power generation.

## ELECTRICITY MARKETS

The market for electric power is organized as a natural monopoly, one producer selling electricity to a large number of consumers in a specified geographic area. In the past, a monopoly structure was necessary due to the high costs incurred in power generation and distribution. Economies of size dictated the need for large generating facilities with enormous capital investments, which usually detered potential competitors from entering the business. This is less true today because technological advances have led to the expansion of the number of independent power producers. Despite some increased competition on the supply side, many distribution networks are routed to fixed customer locations and buyers do not have free access to alternative electrical markets. They must obtain power from the utility to which they are connected.

Economic theory predicts that a monopolist will sell a commodity or service at a higher price and in lower quantities than a good sold in a purely competitive market situation. However, the provision of electricity has been recognized as a vital public interest and government has intervened to regulate the electric utility industry on behalf of society. The purpose of such regulation is to remove some of the elements of monopoly power, resulting in an increased supply of the good or service at a lower customer price.

The regulation of electricity markets in New York is in the hands of both the Federal Energy Regulatory Commission (FERC) and the New York Public Service Commission (PSC). FERC is a five-member independent commission within the Department of Energy, which, among other things, sets rates and charges for the sale and interstate transportation or transmission of natural gas and electricity, and licenses hydroelectric projects. The PSC is a statutory agency of the state consisting of a seven-member board appointed by the governor and approved by the state senate. It also has a professional staff to analyze specific regulatory issues. The PSC regulatory mandate deals primarily with state issues. It has a broad mandate to ensure that safe and reliable utility service is made available at reasonable rates and with the least adverse effect on the environment.

With regard to electricity, the PSC enacts regulations designed to simulate competitive market conditions. To do this, the PSC has been empowered to enforce a number of regulatory measures. It sets performance standards for utilities, orders safety and equipment improvements, reviews fiscal and operational records and resolves customer complaints. Determining the proper utility rate is the PSC's most publicized regulatory function. By setting the rate, the PSC not only determines what customers will pay for electricity, but it also limits the amount of profits that can accrue to the utility. Hence, rate setting is the crux of public utility regulation.

The process of setting a utility's electrical rate, called a rate case, is usually a lengthy and detailed procedure. It involves an initial rate proposal made by the utility, followed by a PSC investigation into the economic effects of the proposal. Additional input may be provided by the utility, the PSC, or by the general public. A rate hearing is held by the PSC, after which the proposed rate is approved or rejected. From initial filing until a PSC decision is implemented, rate cases may take a year or more to complete. It may take even longer if a party appeals the decision in the courts.[3]

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[3] During periods of rapid inflation, rate cases may be filed more frequently in an attempt to keep pace with the rising costs of inputs needed to generate power, particularly labor and energy based inputs. Between rate cases, fuel adjustment charges are also used to recover added fuel costs for power generation.

Electric customers want reliable service at the lowest possible price. They insist that PSC regulators maintain rigid control over electric rates. However, utilities must purchase many of the inputs needed to generate power at the current market price (e.g., coal, labor, etc.). For this reason, utilities' prices cannot be completely controlled by the PSC. Instead, the PSC tries to set a rate that strikes a reasonable balance between the revenue needs of the utility and the desires of cost-conscious customers. In addition to covering all variable costs, the utility must be permitted to make a competitive return on its investment. This is necessary to pay current stockholders and attract the new capital needed to replace worn out equipment, improve efficiency and operate successfully in the long run.

## ELECTRICITY CONSUMPTION AND PRICING STRUCTURES

Electric utilities generate and transmit power to a wide variety of customers for commercial, industrial, residential, agricultural and governmental use. This diverse clientele has differing energy needs and usage characteristics. For example, the daily and weekly electricity demand of an office building would differ greatly from that of a factory, a hospital, a theater or a farm. Energy use also varies by season, with peak consumption corresponding with business, recreational or comfort needs. In New York State, peak demand normally occurs in the summer and winter months, when extreme weather conditions often induce higher electricity consumption for space cooling and heating.

During times of exceedingly high electrical use, demand can briefly surpass the normal output capacity of a particular utility. In this situation, a utility may be forced to generate or purchase reserve power at greater expense, or else execute immediate load-reduction measures.[4] Either action can be very costly to both the utility and the customer. Thus, avoiding supply and demand imbalances in the electricity market becomes an important utility goal. This goal can be achieved through two possible routes: increase electricity supply, or reduce customer demand.

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[4]Balancing supply and demand during these peak periods across service territories in the state is facilitated by the New York Power Pool Agreement among the major New York Electric utilities. Under the Power Pool Agreement, the member utilities have worked toward improving savings through energy and capacity exchange, consistent with power system reliability requirements. Since April 1977, through a computer-directed economic dispatch, the bulk power supply system within New York has operated as a single system, while maintaining the identity of each member company.

Along with building new power plants to expand generating capacity, increased emphasis is being placed on energy conservation to reduce overall demand and on shifting the remaining demand from peak to non-peak periods. This type of electrical systems planning, one of a number of demand side management (DSM) programs, can be a cost-effective method for encouraging more efficient utilization of available electricity resources. To better understand how TOU rates and other DSM programs work, it is necessary to examine the pricing structure of electricity.

In a competitive marketplace, the selling price of a good or service closely reflects its marginal cost of production. However, unlike most goods or services, the unit cost of generating electric power varies substantially over a wide range of output levels. Because demand conditions can change drastically throughout any 24-hour period, unit costs of meeting that demand will also change, and a single flat rate charge for electricity cannot reflect the true variable cost of electricity generation.

From an economic perspective, this is an inefficient condition which leads to a misallocation of resources. A single flat rate price provides no incentive for customers to reduce their electricity consumption at times when demand and generation costs are high, nor does it encourage more consumption during off-peak periods. The solution is to establish a set of prices which more closely follows changing electricity generation costs through daily and seasonal cycles. In this fashion, electricity customers are given a correct price "signal" which reveals to them the true cost of consuming that good at a particular point in time.

In practice it would be difficult, if not impossible, to administer a system of prices which reflected even the hourly variation in production costs. Moreover, such a system would be the cause of much confusion among customers. Instead, many utilities have adopted a pricing system which establishes two or three time blocks of electricity prices, based upon times of high (peak) and low (off-peak) generating costs. The price of each block is set equal to the average of the marginal costs in that time period. Thus, these "time-of-use" rates reasonably parallel production costs, giving the customer an incentive to move his/her consumption activities away from high-cost peak periods to less costly off-peak periods.

Properly developed and administered, time-of-use rates encourage a more efficient pattern of electricity consumption. By this action, utilities can postpone the construction of new generating facilities, thereby reducing their costs and enabling them to keep prices down.

## IMPLEMENTING TIME-OF-USE PRICING IN NEW YORK STATE

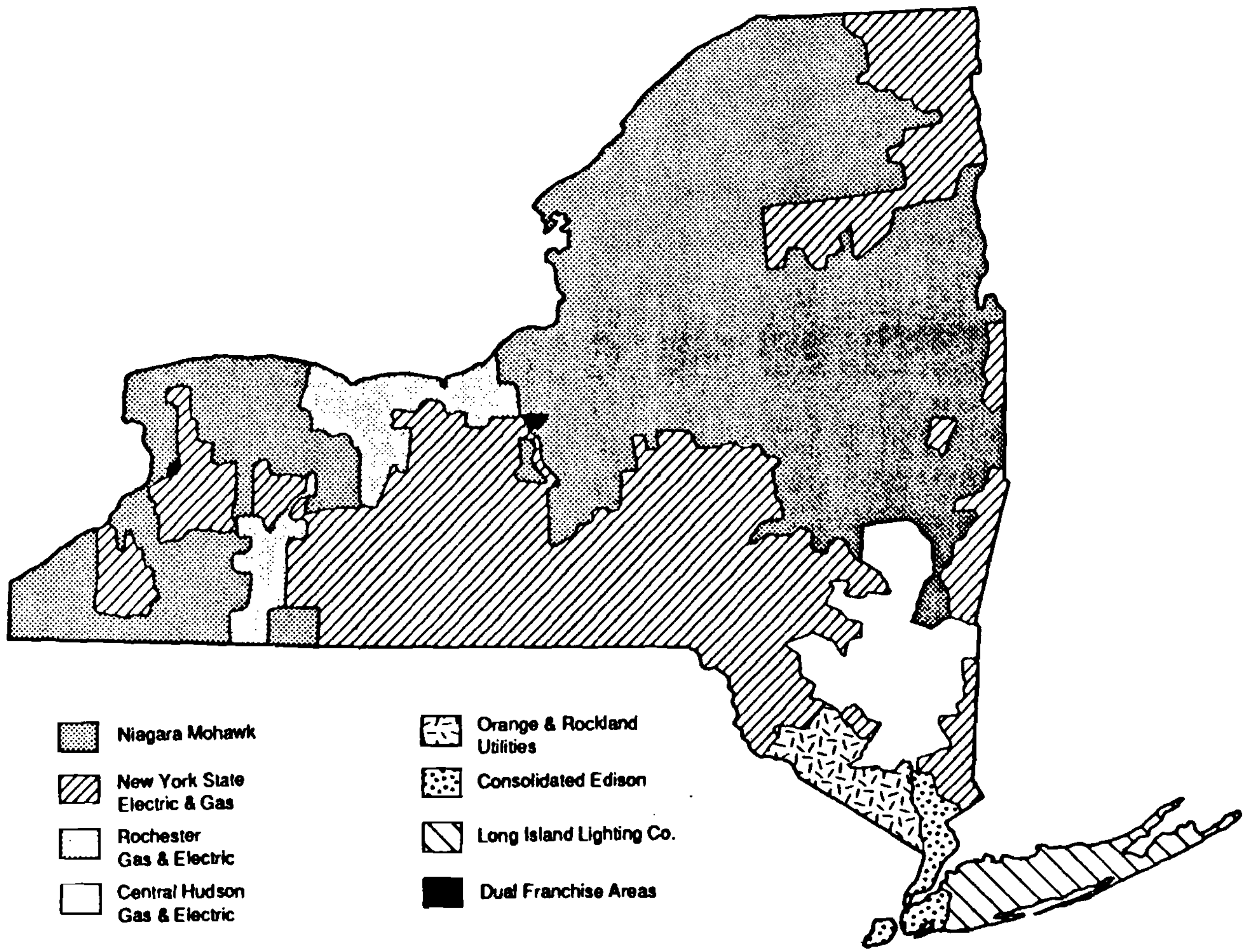
Electrical service to New York State customers is provided by seven major electrical utilities plus a number of small community power generators and rural electric cooperatives. As this report examines time-of-use pricing within the context of agriculture, attention is focused on the four major upstate utilities which together serve nearly all of the state's dairy farms. Those utilities are Central Hudson (CH), Niagara-Mohawk (NMPC), New York State Electric and Gas (NYSEG) and Rochester Gas & Electric (RG & E) power companies. A map portraying the approximate service areas in the state for these utilities is found in Figure 1.

Time-of-use rates are developed around the utility's overall daily electricity output schedule, which in turn is based upon customer demand. Sample schedules of generated power, known as system load curves, are portrayed in Figures 2a and 2b. A utility usually has daily occurrences of high and low electricity demand, which correspond to high and low generating costs. In constructing a time-of-use rate schedule, rate periods and prices are set to correspond with the production costs at these output levels. The system load curve for a weekday normally differs from that experienced on a Saturday or a Sunday. The load curve also changes from season to season, so in addition to having daily rate periods, time-of-use rates in New York also reflect changes in marginal generation costs between seasons.

Figures 3 through 5 portray the time-of-use rate schedules used by three of New York's major utilities. Each time-of-use rate schedule is different, exhibiting the unique generating characteristics and differing customer demands of their utility. Time-of-use rates are divided into peak and off-peak price categories. In addition, NMPC and RG & E use a third rate period, called a shoulder, which is set at an intermediate price level. Seasonal variations are built into their TOU rates, in both time schedule (NMPC) and in price (RG & E).

Time-of-use rates also contain a fixed monthly customer charge, covering the cost of administration, meter reading, maintenance and other service obligations. From Figures 3-5, it can be seen that TOU customer charges are considerably higher than the customer charge associated with flat rate pricing. Under a ruling from the New York

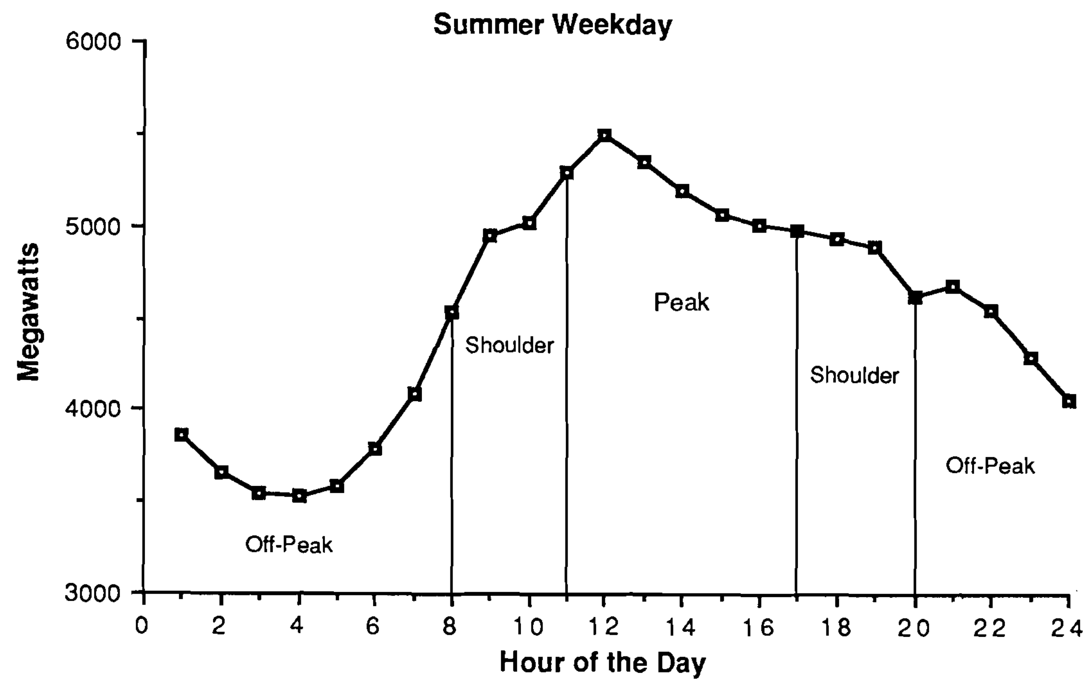
## Figure 1.
## SERVICE TERRITORY MAP OF MAJOR NEW YORK UTILITIES



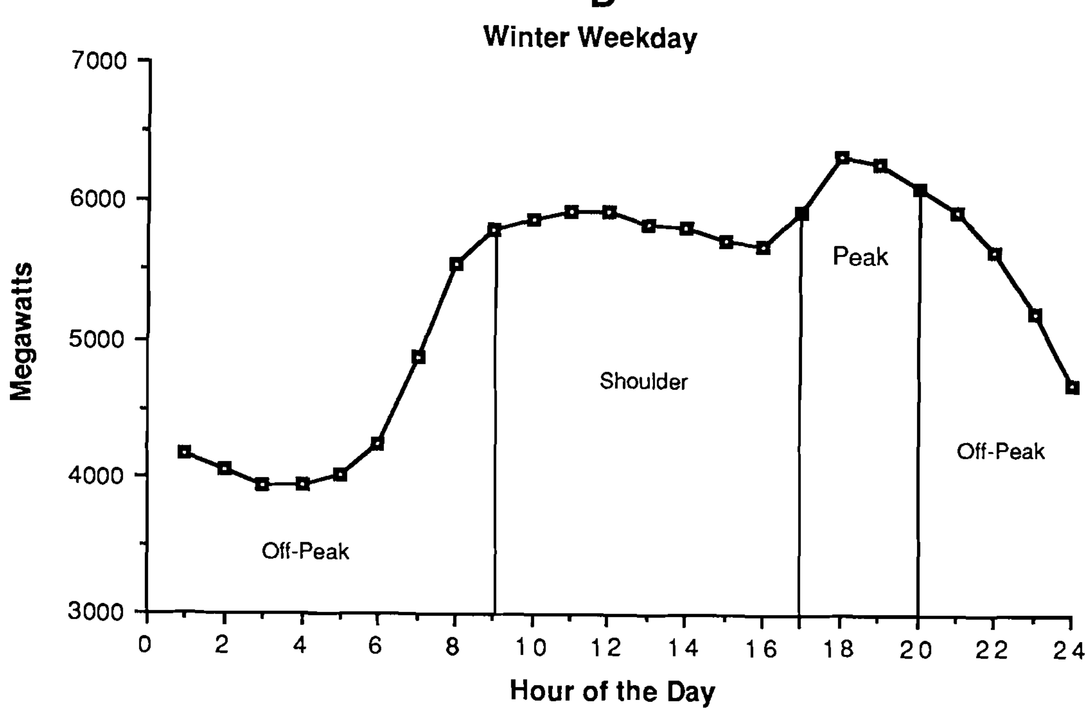

Source: Adapted from New York Power Pool Map, 1985.

## Figure 2.
## TYPICAL SYSTEM LOAD CURVE AND TOU PRICING SCHEDULE

### A

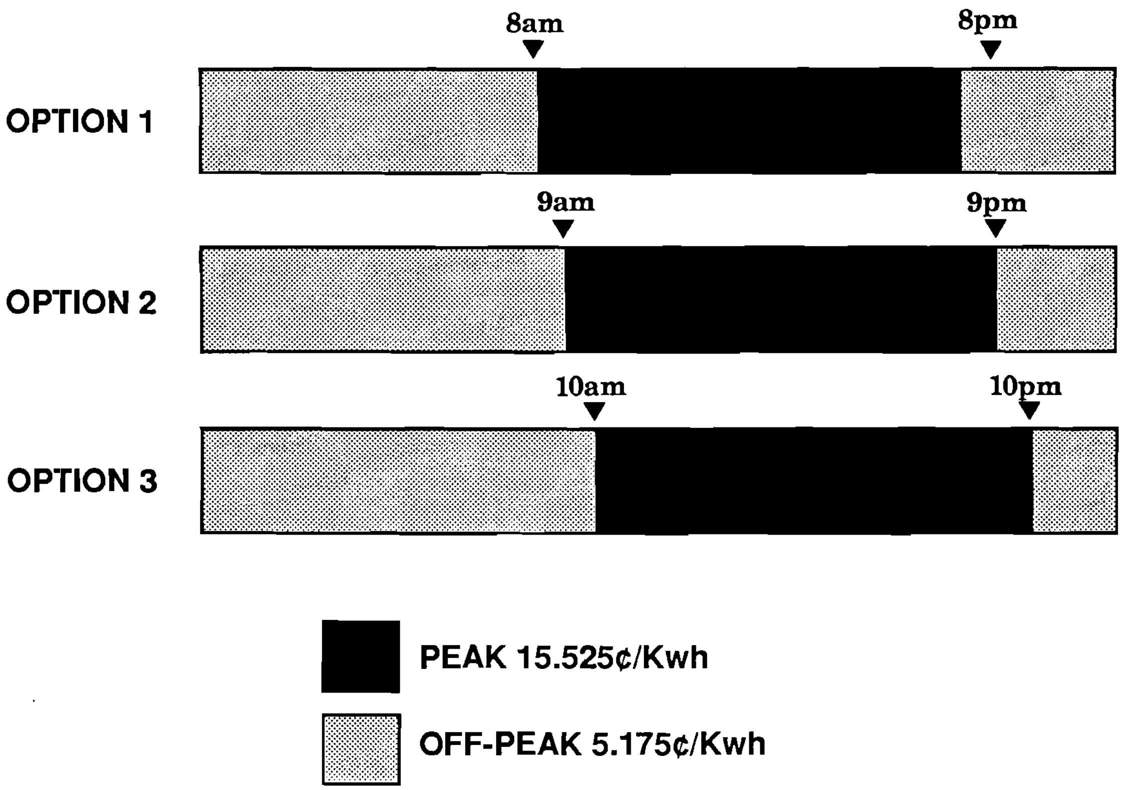



### B




Source: Niagara Mohawk Power Corporation

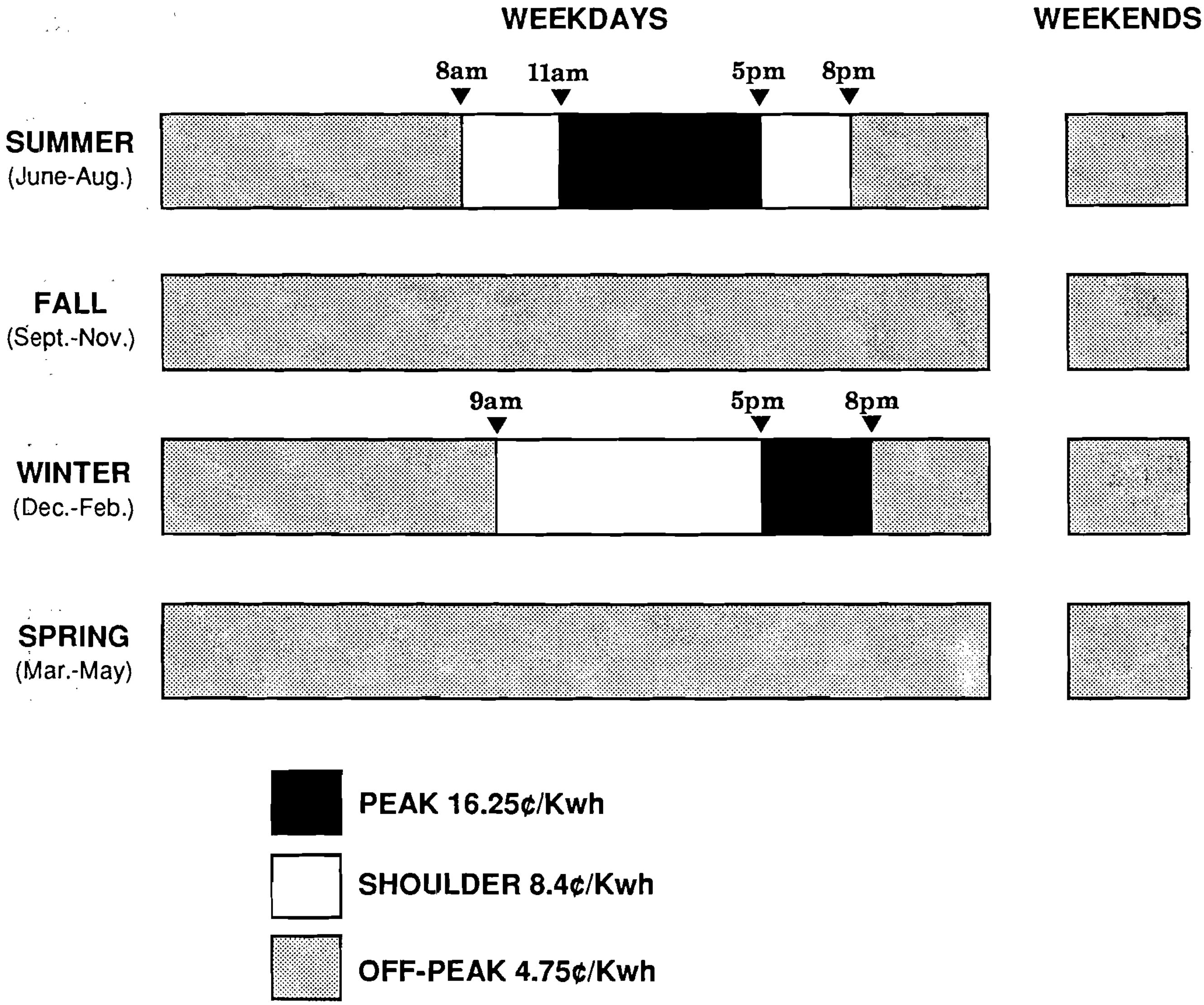
## Figure 3.
## CENTRAL HUDSON TIME-OF-USE ELECTRIC RATE




**CUSTOMER CHARGE: $10.00/month**

| | |
|---|---|
| **FLAT RATE** | **9.004¢/Kwh** |
| **CUSTOMER CHARGE** | **$6.20/month** |

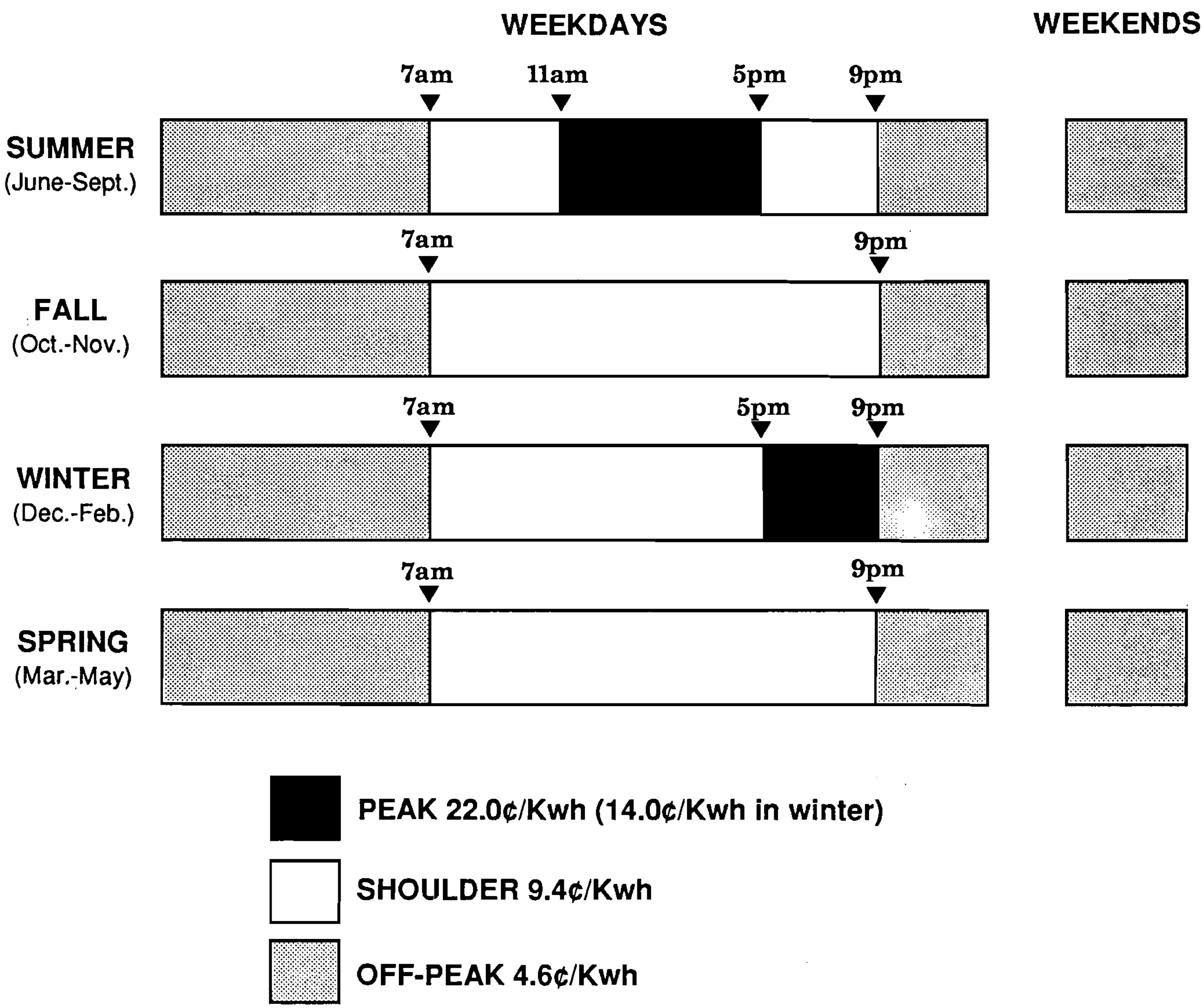
## Figure 4.
## NIAGARA MOHAWK TIME-OF-USE ELECTRIC RATE




**CUSTOMER CHARGE: $32.20/month**

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

## Figure 5.
## ROCHESTER GAS & ELECTRIC TIME-OF-USE ELECTRIC RATE




**CUSTOMER CHARGE: $24.80/month**

| | |
|---|---|
| **FLAT RATE** | **8.439¢/Kwh** |
| **CUSTOMER CHARGE** | **$6.00/month** |

Public Service Commission, utilities implementing time-of-use rates have been allowed to adjust TOU customer charges to maintain overall revenue neutrality, i.e., total revenues from residential customers will remain the same. Hence, a higher customer charge "picks up the slack" for time-of-use rates, implying that the TOU electricity charge, by itself, will be lower than the charge incurred under the existing flat rate.

Time-of-use rates are presently being mandated for only "large" users of electricity within a residential customer classification. For example, NYSEG's proposed TOU rate will apply to residential customers using over 42,000 Kwh per year. Other thresholds range from 15,000 to 30,000 kwh per year (Table 1). To facilitate TOU billing adjustments and new meter installations, some utilities have chosen to phase in TOU rates over a two- or three-year period, beginning with the largest users of electricity. Niagara Mohawk customers, for example, will also receive "dual billing" for a year prior to being switched over. During this period, they continue to receive the flat rate electric bill but also receive a mock time-of-use bill for comparison-only purposes. The TOU bill provides information on how much electricity is consumed at times when peak and non-peak rates are in effect and can be used to help understand the potential cost differences from shifting consumption to off-peak periods.

Table 1

RESIDENTIAL CUSTOMERS ELIGIBLE
FOR TIME OF USE RATES

| Utility | Minimum Annual KWH Usage for Mandatory TOU Rates |
|---|---|
| Central Hudson | 15-20,000 Kwh* |
| Niagara Mohawk Power Corporation | 30,000 Kwh |
| New York State Electric & Gas | 42,000 Kwh |
| Rochester Gas & Electric | 24,750 Kwh |

*Actual Kwh threshold is based upon a summer monthly usage of at least 1,700 Kwh per month. This range provides an approximation.

A customer can roughly determine eligibility for TOU rates by multiplying his/her Kwh consumption as reported on a typical monthly bill by twelve and comparing it against the utility's minimum threshold (Table 1). According to data from a 1987 farm management and energy survey, researchers at Cornell University indicate generally that from 55 to 75 percent of New York dairy farms would qualify for mandatory time-of-use rates, based on the power use thresholds established by upstate utilities (Table 1).

Assuming that the majority of dairy operations will be moved to time-of-use rates, what then will be the cost impact to the individual farm business? Unlike flat rate pricing, many factors will influence the farmer's electric bill. In the next section, equipment usage is examined for its contribution to the farm electric bill.

## ELECTRICITY USE ON DAIRY FARMS

As time-of-use electrical rates go into effect, detailed information about electricity consumption on the dairy farm becomes an important factor in estimating farm energy costs. This section examines the operations and equipment that use electric power in day-to-day farming activities.

### DAIRY FARM CHARACTERISTICS

What are the characteristics and activities that typify a New York dairy farm? Statistical data from Cornell University farm surveys are extracted throughout this section to portray a "typical" electricity-using New York dairy farm.[5] As shown in Table 2, these data sets suggest that the average dairy farm is over 400 acres in size, including rented and owned property. Both surveys show an average herd size of about 70 cows. The annual herd average is about 14,000 pounds of milk per cow.

Both surveys suggest that over 80 percent of the farms milk cows in a stanchion barn, using either bucket milking machines or a pipeline. The remainder of the farms have a milking parlor. Farms with milking parlors generally have larger herd sizes than

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[5] Much of the data for this report are taken from the 1987 Farm Management and Energy Survey, which sampled farms from upstate New York, and the 1988 Rural Household and Farm Energy Survey, which was limited to farms and rural households in the NMPC service territory. Both surveys were designed by the Department of Agricultural Economics at Cornell University and financed by NMPC.

do farms with stanchion barns, along with higher milk production averages. Only six percent of farms surveyed milk three times a day.

According to actual utility billing data attached to the 1988 survey, annual electricity consumption averaged 53,569 kilowatt hours, at a cost of $3,688. This figure includes electrical usage in the farm residence and for all farm-related equipment, including those

Table 2

STATISTICAL SUMMARY OF DAIRY FARM SURVEYS

| Parameter | 1987 Farm Management and Energy Survey (758 farm responses) | 1988 Rural Household and Farm Energy Survey (712 farm responses) |
|---|---|---|
| Average farm size | 403 Acres | 414 Acres |
| Average herd size | 70 cows | 72 cows |
| Farms with < 50 cows | 22% | 26% |
| Farms with 50-150 cows | 59% | 70% |
| Farms with >150 cows | 19% | 4% |
| Milk production/cow | 13,721 lbs. | 14,199 lbs. |
| Milking twice daily | 94% | NA |
| Milking 3 times/day | 6% | |
| Milking system | | |
| Stanchion barn | 80% | 83% |
| (with buckets) | (33%) | (25%) |
| (with pipeline) | (48%) | (58%) |
| Ave. herd size | 58 cows | 64 cows |
| Ave. prod./cow | 13,450 lbs. | 14,774 lbs. |
| Milking parlor | 20% | 17% |
| Ave. herd size | 127 cows | 114 cows |
| Ave. prod./cow | 14,778 lbs. | 14,774 lbs. |
| Annual Kwh use | NA | 53,569 Kwh |
| Annual electricity cost | $4,319 | $3,688 |

NA= Information not available.

used on a seasonal or irregular basis. Normally, the farmhouse consumes 15-35 percent of that total (Wisconsin Public Service Corporation, 1990; undated).[6] For this section, average farm electricity excluding the residence is assumed to be 43,000 Kwh/yr.

As one might expect, there is considerable variation in electricity usage from farm to farm, and these averages are presented only to illustrate common energy consumption features and costs. Today, new technologies and efficient farm management practices help to reduce overall electricity use on many farms. Nevertheless, as a general rule of thumb, the larger the herd size, the greater the amount of electricity used. We now examine the major electrical end uses that operate on most New York dairy farms.

## DAIRY FARM END USES AND ENERGY CONSUMPTION

On a dairy farm, there are many different activities, called end uses, that contribute to total electrical usage. These end uses can be categorized into several major groups, including milking, milk cooling, water heating, and livestock feeding. Other prominent electrical end uses are associated with manure handling, lighting and barn ventilation.

Previous research examining electricity consumption by dairy farm end use has established some general patterns. For example, milk cooling, water heating and the vacuum pump are usually the largest consumers of electricity in day-to-day farming activities, accounting for up to three-quarters of the farm's entire electric load. Livestock feeding equipment (e.g. silo unloader, bunk feeder, etc.) and in some cases, ventilation can also consume a sizeable amount of electricity. Table 3 displays the relative importance of electrical consumption for dairy farm by end use, as reported in various sources (Boor et al. 1986, 1988; Farmer et al. 1989, undated; McFate; Johns; Peterson). The percentages shown vary as a result of factors such as climate, equipment age and condition, and farm management practices.

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[6]On smaller farms (< 30,000 Kwh/yr) the house can account for more than half of total electricity use (Farmer et al., 1989 undated). Because farmhouse electricity consumption is not a direct result of farming activities, it will not be examined within the scope of this report. Farmers interested in household energy savings should contact their utility company for ways to reduce home electricity consumption.

## TIMES OF USE AND THE FARM ELECTRICAL LOAD SHAPES

Before time-of-use pricing, farm electricity charges were always determined by multiplying aggregate end use electricity consumption by a single, fixed price per kilowatt hour. With the new rate schedule, electricity charges now become a function of time. To estimate electricity cost, it is necessary to know when each end use is operated. Information from the 1987 survey and other sources provide some insight into the daily schedules for the activities listed in Table 3. With accurate data of daily operational characteristics, statistical models can be used to approximate Kwh usage of each end use by time of day. From this information, the electricity cost can be calculated. Each farm end use is now examined for its operational attributes and its overall contribution to electricity costs on the farming operation.

Table 3

ELECTRICITY CONSUMPTION BY END USE

| End Use | Percent of Total Farm Electricity Use* |
|---|---|
| Vacuum Pump | 19-22 |
| Milk Cooler | 13-40 |
| Water Heater | 15-40 |
| Feeding Equipment | 7-10 |
| Waste Handling | 2-5 |
| Lighting | 7-15 |
| Ventilation | 3-12 |
| Miscellaneous | 5-10 |

Sources: Boor et al., 1986, 1988; Farmer et al., 1989, undated; McFate; Johns; and Peterson.

*Farm house electricity consumption is not included in these estimates.

Milking

Many older farmers can recall a time when milking cows was done entirely by hand, but today, all farms utilize a vacuum operated milking system powered by an electrical motor. The vacuum pump is generally used more hours per year than any other piece of electrical equipment found on the farm. A typical vacuum pump constitutes 19 to 22 percent of a dairy farm's overall electricity use, depending on its size, condition and daily usage. For the average New York farm (43,000 Kwh per year excluding the residence), this pump would use about 8,800 kilowatt hours per year, or 24 Kwh per day. Using a generalized flat rate charge of 8 cents per Kwh, the vacuum pump's electricity cost would amount to $705 per year.[7] Farm operations milking three times per day generate one and a half times more electricity at the vacuum pump than farms milking twice daily. This increases the vacuum pump's contribution to the farm's total electric bill.

Now consider daily milking times. Most farmers milk cows twice a day at approximately 12-hour intervals, usually in the morning and evening. If milking times occur during the inexpensive off-peak rate period, electricity costs associated with the vacuum pump (and related milking equipment) will be lower, compared to the flat rate. Conversely, milking that takes place during a more costly on-peak time will be higher than the flat rate. In some cases, morning and evening milking times will span different rate categories, making the cost changes more difficult to estimate.

For most farmers, milking time depends on several factors, including herd size, type of milking equipment, milking duration, and customary habits and practices. Milking time may also be affected by outside influences such as field work, school time tables, milk pickup schedules, or seasonal time changes.

Milking times from the 1987 survey were examined according to various herd sizes and equipment configurations. Average milking times for these groups are displayed in Tables 4 and 5. For those farmers milking twice daily, morning milking commences between 4:30 and 6:00 a.m. and is completed between 7:30 and 8:30 a.m. Afternoon milking times are more variable, beginning anywhere from 3:30 to 5:30 p.m. All the groups examined complete their afternoon milking around 7 p.m. For these farms, total time used for daily milking (excluding related chores) was between 3 and 7 hours.

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[7] Eight cents per kilowatt hour is an assumed rate used to make cost calculations in this section. This is approximately the average flat rate of the four major upstate utilities.

Table 4

MILKING TIMES FOR NEW YORK DAIRY FARMS
(710 farms milking twice daily)

| Barn Type | Morning Start | Duration (mins.) | Afternoon Start | Duration (mins.) | Total min/day |
|---|---|---|---|---|---|
| Stanchion | | | | | |
| < 50 cows | 5:58 a.m. | 92 | 5:29 p.m. | 92 | 184 |
| 50-149 cows | 5:48 a.m. | 119 | 5:03 p.m. | 117 | 236 |
| > 149 cows | 5:16 a.m. | 168 | 4:11 p.m. | 164 | 332 |
| Milking Parlor | | | | | |
| 50-149 cows | 5:13 a.m. | 158 | 4:18 p.m. | 153 | 311 |
| > 149 cows | 4:36 a.m. | 225 | 3:33 p.m. | 213 | 438 |

Source: 1987 Farm Management and Energy Survey

Table 5

MILKING TIMES FOR NEW YORK DAIRY FARMS
(42 farms milking three times daily)

| Herd Size | First Start | Duration (mins.) | Second Start | Duration (mins.) | Third Start | Duration (mins.) |
|---|---|---|---|---|---|---|
| 254 Cow Average | 4:33 a.m. | 237 | 12:23 p.m. | 238 | 8:17 p.m. | 231 |

Source: 1987 Farm Management and Energy Survey

Farms milking three times daily milked at eight hour intervals, beginning roughly at 4:30 a.m., 12:30 p.m., and 8:30 p.m. Larger herd sizes extended total daily milking time to almost 12 hours. This time allotted to milking is the primary reason for the vacuum pump's significant electrical consumption.[8]

Milking is probably the most important activity on a dairy farm. Thus, from the farm operator's viewpoint, other farm activities and their corresponding electrical end uses are coordinated around the daily milking schedule. With this in mind, the remaining end use categories are now discussed not only in terms of their electricity consumption and time-of-use, but also in relation to the farm's daily milking chores.

Milk Cooling

Milk leaves the cow at 98° and must be cooled quickly to about 38°, the optimal storage temperature (Sanford, Ludington and Guest). A refrigerated, stainless steel tank, called a bulk cooler or bulk tank, is used for this purpose.

Major electrical components on a bulk cooler include the compressor pump and fan and an agitator motor to stir the milk. The bulk tank operates much the same as a household refrigerator. It runs constantly as it cools the milk to the proper temperature; then runs periodically to maintain that temperature setting. The bulk tank is shut off only after the milk has been collected by the milk hauler. Pickup is made on a daily or every-other-day basis.[9]

There are many factors that cause wide ranges in the energy consumption of a cooler. Size, age, temperature setting, pick-up schedule, ambient air temperature, and internal design features can all have significant effects. In any case, the cooler can be one of the largest electricity users on the farm. Previous research has found the bulk tank to constitute anywhere from 13 to 40 percent of a farm's total electricity use. For the average farm portrayed in Table 2, consumption would range from 5,600 to 17,200 kilowatt hours per year, or roughly 15-47 Kwh per day. At 8 cents per Kwh, the cost would be from $450 to $1,375 annually.

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[8] For pipeline systems, the vacuum pump also operates during the wash and rinse cycles.

[9] Eighty-six percent of the farms in the 1987 Survey had their milk pick-up every other day.

Estimating the time-of-use energy cost for a bulk cooler is difficult, due to an uneven pattern of electricity consumption. Figure 6 portrays the average hourly electrical demand by bulk coolers from 26 dairy farms in Wisconsin, Minnesota and Iowa.[10] The peaks shown in the graph indicate periods of high electrical usage by the cooler as it refrigerates milk received from the morning and evening milking. Once reached, the cooler runs intermittently to maintain that temperature, consuming from 0.1 to 0.2 kilowatts per hour. The graph also reveals that six to seven hours are needed following milking to cool the milk down to the proper storage temperature.

The two Kwh "spikes" in the graph occur about two hours after the start of each milking, which are 6 a.m. and 5:30 p.m. (the average starting time of the 26 farms). Given this pattern of electrical use, it becomes clear that in addition to the aforementioned factors affecting the electrical costs of the cooler, the time-of-use electrical cost from the milk cooler is dependent upon the milking schedule. And if milking takes place during or just prior to the onset of a shoulder or on-peak rate period, the highest cooler electricity demand will occur during a higher priced rate period, and subsequent TOU electricity cost will be higher than with the flat rate.

Water Heating

Hot water is an essential element of dairy farming, used to wash, clean and sanitize equipment and facilities. A ready supply of hot water is necessary to obtain sanitation and health certifications required for the sale of milk within the state of New York. As a result, dairy farms have a water heater in their milk house. Most farms utilize electric water heaters, although a small percentage may use petroleum fuels. The 1988 Rural Household and Farm Energy Survey found electric water heaters on 72% of the farms, followed by natural gas water heaters on 10% of the farms, bottled LP gas heaters (6%) and oil (6%).

Water heaters, like bulk milk coolers, must quickly change the temperature of an incoming liquid and hold it there for later use. On most farms, well water of 45° to 55° is used. This water enters the heater tank through an inlet valve and is heated to temperatures as high as 160°. The water heater operates continuously to maintain a ready supply of hot water for farm use around the clock, and to bring replacement water

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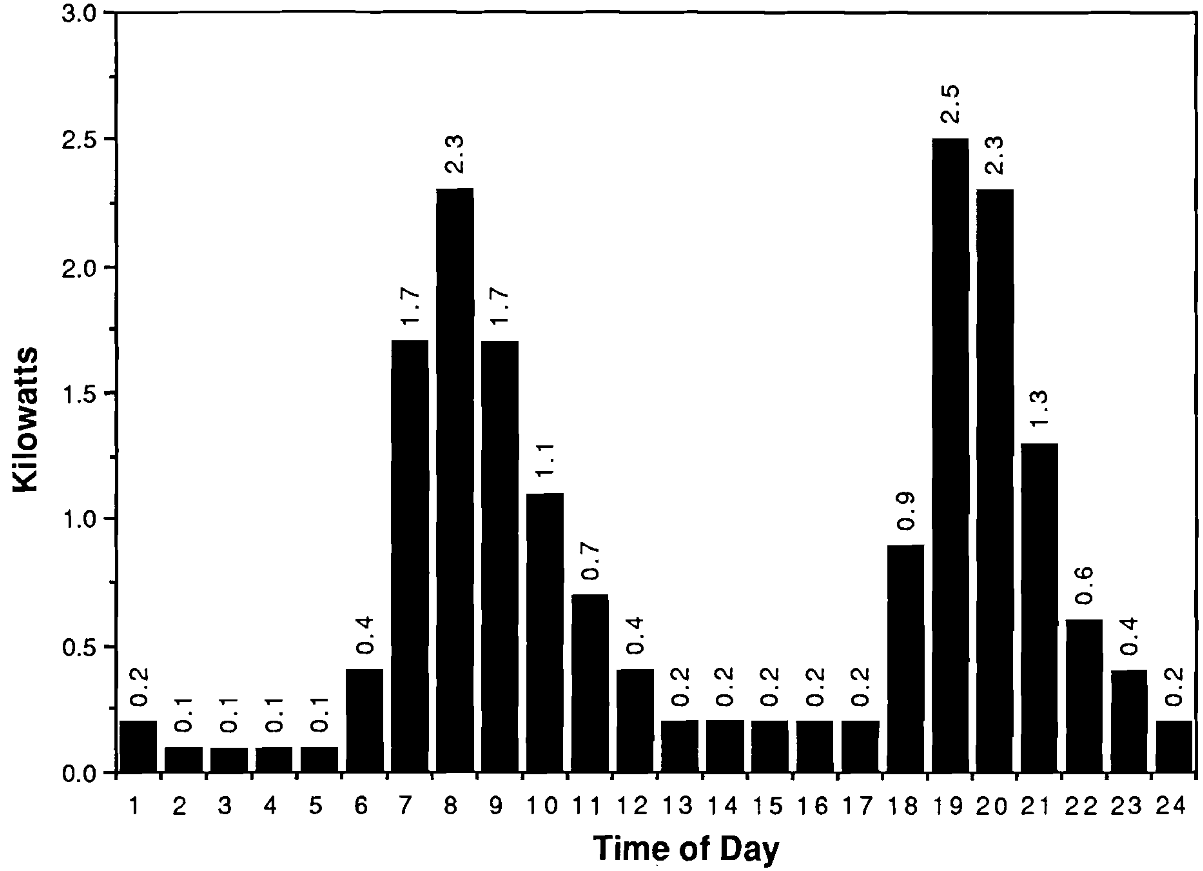
[10] See "Dairy Study Phase II" (1987) by Dairyland Power Cooperative, La Crosse, Wisconsin for details.

## Figure 6.
## DAILY MILK COOLER ELECTRICITY DEMAND




Source: Dairyland Power Cooperative

Note: Data portrays the milk cooling sequence for a farm milking twice daily at 6a.m. and 5:30p.m.. A third milking would add another sequence to the graph.

up to the set temperature as quickly as possible. Because of its operational characteristics, and the inlet versus holding temperature differential, the water heater can consume a sizable amount of electric energy. On some farms,[11] this can amount to as much as 40 percent of the total electricity used on the farm. At this level, the electricity charge for heating water on the average New York dairy farm would be around $1,400 per year.

During a typical 24-hour period, the water heater exhibits an hourly usage pattern similar to that of the bulk cooler. Figure 7 displays the composite hourly electricity demand for water heaters in the Wisconsin study mentioned above. Once again, there is clear evidence of peak power usage coinciding with the twice-daily milking activities. In this case, it is likely that this increase results from the washing activities that conclude each milking. There also exists a 6-8 hour time lag between the start of milking chores and a leveling off of water heater Kwh demand.

From Figures 6 and 7, it is apparent that hourly electricity demand of both the milk cooler and water heater are strongly influenced by a farm's daily milking chores. The significance of these hourly usage variations becomes evident when time-of-use rates are added into the picture. Clearly, if the majority of milk cooling and water heating activities take place during peak rate periods, the costs of those functions will increase compared to flat rate pricing. If, however, some of the cooling and heating occurs during the lower priced off-peak hours, some cost savings may be experienced. In a later section of this report, the possibilities of off-peak usage for energy intensive electrical appliances are investigated.

Feeding

Next to milking chores, feeding livestock is probably the most time-consuming activity on a dairy farm, especially if one considers planting and harvesting into that calculation. Good feeding practices are not only essential to high milk production but also to good herd health. Feeding is especially important for confined herds, and during winter months when no pasture supplement is available.

Most dairy farms use considerable electrical equipment in feeding their livestock. Silo unloaders and bunk feeders are the most commonly used implements, but moving

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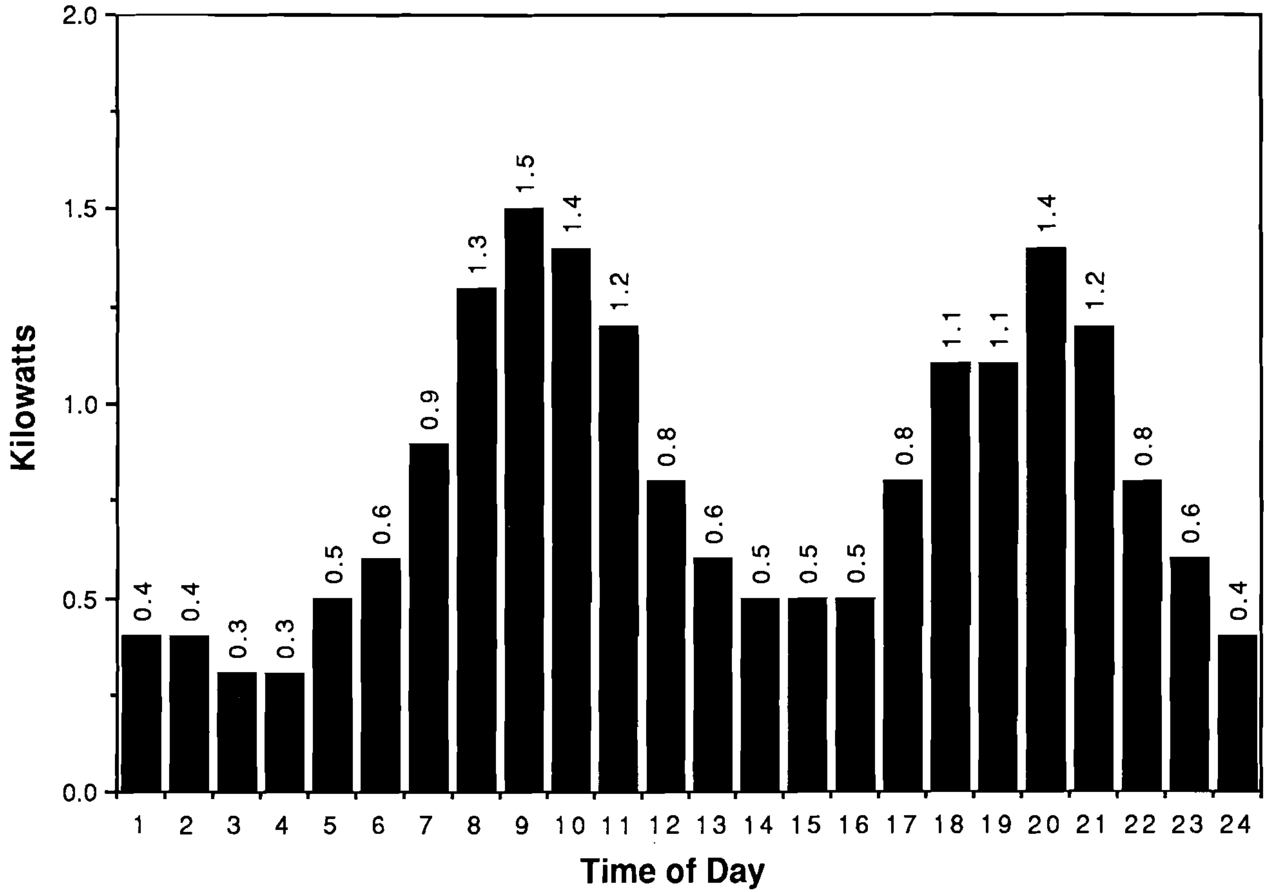
[11]Because of their 3-cycle (sanitize, rinse and wash) cleaning procedures, pipeline washing systems may require more hot water than a comparable sized bucket system with hand washing.

## Figure 7.
## DAILY WATER HEATER ELECTRICITY DEMAND




Source: Dairyland Power Cooperative

Note: Data are for farms milking twice daily feed from storage to cow may also require numerous types of conveyance machinery such as augers, conveyor belts, electric feed carts, etc.

Table 6 profiles the usual number of daily feedings with electrical equipment.[12] As shown, the majority of farmers surveyed feed their cattle twice a day. Another one-third of the respondents feeding them either once or three times daily, with a smaller percentage feeding four times or more per day. Average feeding times (Table 7) generally occur immediately before or after the daily milking, along with a mid-morning or early afternoon feeding.

The feeding times for livestock and equipment utilized for that purpose vary by season on many dairy farms. During warmer months, the availability of pasture and harvest cutover may reduce the number and/or length of daily feedings with electrical equipment. In winter, cattle are usually fed more heavily from the silo and/or bunk feeder. In addition to working longer hours, these electric motors must also work harder during cold weather due to the added difficulties in extracting frozen feed from a silo.

The feeding schedule for livestock tends to be more flexible than the daily milking schedule. As a result, it may be easier to reduce feeding electrical costs simply by avoiding, whenever possible, operating feeding equipment during peak rate periods.

Manure Handling

The handling of animal wastes is a necessary activity wherever livestock congregate. Such places include feeding and watering areas, the milking area, the free-stall barn and the corridors between these locations.

Animal waste is handled via one of two methods, according to its composition. Solid manure, composed of animal wastes and absorbent materials such as straw is usually spread over crop or pasture land as fertilizer. Animal waste can also be slurried with water creating liquid manure, which is stored in earthen lagoons or large enclosed tanks. From there it is periodically applied into the ground as a soil nutrient.

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[12] Feeding with electrical equipment is assumed to mean the operation of a silo unloader, bunk feeder, conveyor or other electrical device, as opposed to, say, manually distributing hay bales or grain.

Table 6

DAILY FEEDINGS ON NEW YORK DAIRY FARMS

| Number of Daily Feedings | Percent of Dairy Farms |
|---|---|
| 1 | 19 |
| 2 | 53 |
| 3 | 14 |
| 4 | 11 |
| 5 or more | 3 |

Source: 1987 Farm Management and Energy Survey

Table 7

AVERAGE DAILY FEEDING TIMES ON NEW YORK DAIRY FARMS

| Number of Daily Feedings | First | Second | Third | Fourth | Fifth |
|---|---|---|---|---|---|
| 1 | 9:44 a.m. | | | | |
| 2 | 7:09 a.m. | 4:14 p.m. | | | |
| 3 | 6:43 a.m. | 10:50 a.m. | 4:23 p.m. | | |
| 4 | 6:19 a.m. | 8:59 a.m. | 4:31 p.m. | 5:45 p.m. | |
| 5 | 5:30 a.m. | 7:28 a.m. | 10:22 a.m. | 1:14 p.m. | 4:40 p.m. |

Source: 1987 Farm Management and Energy Survey

The equipment and machinery used to handle manure differs according to its composition. Solid manure is removed from a stanchion barn with a gutter cleaner, operated by a large heavy-duty electric motor. In larger barns, two motors may sometimes be used. Free stall alleys and feed areas are cleaned either with a tractor and scraping blade or with an electric alley scraper. Manure from a milking parlor is generally liquified with water. Liquid manure is transferred via electric pump through a system of pipes to a holding tank or lagoon.

From the 1987 survey, electric gutter cleaners were found in 94% of dairy farms with stanchion barns. Gutter cleaners were also used on almost 30% of farms using a milking parlor.[13] The most common motor sizes for gutter cleaners found in this survey were three and five horsepower.

Alley scrapers were much less common. Less than two percent of all the dairy farms surveyed had one or more alley scrapers in use. Presence of other manure handling equipment was also quite rare. Stackers, mixing equipment and related implements appeared on less than one percent of the farms surveyed. For these reasons, this report concentrates on gutter cleaning, the more common method of manure handling.

Gutter cleaning is normally a morning activity. Most farms in the survey performed this activity between 8:30 and 9:00 a.m., after the morning milking. Forty percent of those farms also cleaned the gutters a second time, in the afternoon. This normally takes place in late afternoon, before the evening milking begins.

Electricity used for waste handling comprises only 2 to 5 percent of the total farm power usage. For the average farm, this would be from 850 to 2,200 Kwh per year at a cost of $70 to $175.

## Lighting

Lighting is needed for any outbuilding or structure used in a dairy operation, and it is especially important during the short days of winter. In many states, the minimum

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[13] This may seem incongruous as many parlors use a liquid manure system. However, it might refer to the existence of a gutter cleaner in the free stall area, or that a stanchion barn with gutters was converted to free stall use once the parlor system was built.

Grade A standard for lighting in the milk house and milking parlor is 20 foot candles, while the standard for stanchion barns is 10 foot candles. The feeding area, the free stall area and calf holding areas are also commonly lighted.

Lighting needs generally coincide with milking chores and with other activities that occur during non-daylight hours. Most older stanchion barns have been retrofitted for electric lighting using conventional screw-in incandescent bulbs. Newer structures, particularly milking parlors and milk houses, are often wired with more efficient fluorescent lighting.

Most farms also use outdoor lighting. In addition to their safety and security functions, these "nightlights" can also be placed near bunk feeders, etc. to stimulate night time livestock feeding and improve feed conversion. A common type of outdoor lighting is the mercury vapor lamp, which operates automatically "dusk 'til dawn" with a light-sensing on/off switch. Some farms still employ manually-operated incandescent flood lights for outdoor lighting. While they are cheaper to install than fluorescent lighting, incandescent lamps are considerably less efficient because much of the electric energy they use is converted to heat rather than light.

Electricity needed for lighting purposes varies according to bulb type and quantity, building size, season, and daily usage. Normally lighting consumes about 7 to 15 percent of total electricity costs. At that rate the annual lighting usage for the typical New York farm is from 3,000 to 6,500 Kwh per year, at a cost of $240 to $520.

<u>Ventilation</u>

Livestock respond adversely to extreme climatic conditions, particularly heat and humidity. Summertime heat stress on cows can reduce milk production by as much as one-half of their normal levels (Wisconsin Public Service Corporation, 1990; undated). Some form of ventilation is therefore necessary whenever cows are congregated for milking or feeding. Air movement is also needed during the winter when cattle are confined indoors to vent off excess moisture and odor.

The configuration of the milking system determines the need for ventilation. Milking parlors are usually small and enclosed, and need ventilation for the cows (and the operators) during milking hours throughout the year. A stanchion barn can sometimes take advantage of natural ventilation through open windows and doors, and may only

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Ventilation fans used for agricultural purposes are the familiar propeller type, and vary only in diameter and efficiency. The standard motor size is ½ horsepower for fans 36" in diameter, and 1 horsepower for 48" fans. Smaller fans of 12 and 18-inch diameter sizes also are used in some farm applications.

Estimating the Kwh used for ventilation of farm buildings is difficult as each farm has different ventilation requirements. Research shows most fan use takes place during the two hottest summer months of July and August. For this report, ventilation is assumed to be in use during summer milking times. In addition, farms with a parlor are assumed to have a fan running concurrently with milking times throughout the year.

Ventilation normally accounts for 3 to 12 percent of total farm electric consumption, which is from 1,300 to 5,200 Kwh per year on the average New York farm. With time-of-use rates, electricity costs for ventilation could rise due to considerable fan usage taking place during summer peak load (and pricing) periods. Again, because ventilation needs are fixed to particular daily and seasonal periods, most ventilation cost savings would probably be achieved through the use of high efficiency fans.

### Miscellaneous Electricity Consumption

Every farm has electrical devices that are used periodically in day-to-day or seasonal farm activities. Examples of these types would be the well pump, grain drying fans, arc welders and power tools. These are classified as miscellaneous electricity uses.

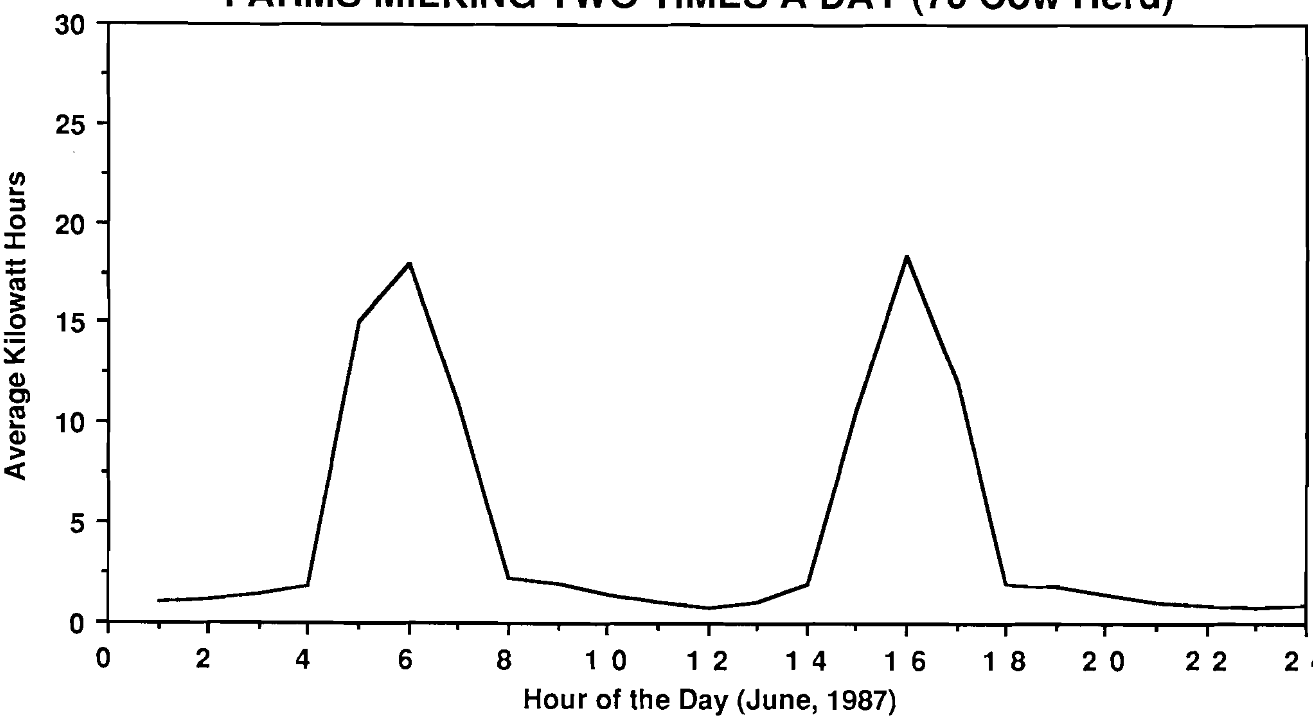
## THE FARM LOAD SHAPE

Each component of farm electrical consumption and its time-of-use pattern is now aggregated to portray an overall daily load shape profile. As described, major uses that occur in conjunction with daily milking activities greatly affect the shape of this profile. During milking, the vacuum pump is in operation, as is the bulk tank agitator and milk transfer pumps. Immediately following milking, the cooler continues to refrigerate milk and equipment washing begins, triggering both the water pump and water heater. On many farms, other tasks closely follow milking chores, such as gutter cleaning or feeding livestock. The resultant daily load shape indicates usage peaks corresponding to each milking event and its ancillary activities. This holds true for farms that milk three times per day. Figures 8 and 9 portray load shapes for two typical dairy operations.

Thus far, we have discussed the generalities of electric power supply and demand as they relate to the New York dairy farmer. The implementation of demand-side management techniques by state utilities, particularly time-of-use electricity pricing, will undoubtedly have some economic impact on the dairy farmer. We have also examined the major electrical end uses on a typical farm, their normal hours of operation, and their contribution to overall electricity consumption.

Attention is now turned to estimating the effects on farm costs resulting in the move from flat rate pricing to time-of-use pricing. To do this, a model is developed that incorporates the rate structures described in the first section together with the end use characteristics enumerated in this section. This model is used to compare the two pricing strategies for representative farm types.

**Figure 8.**
**DAIRY FARM ELECTRICITY USE PROFILE**
**FARMS MILKING TWO TIMES A DAY (70 Cow Herd)**




Source: Cornell University Dept. of Agricultural Engineering

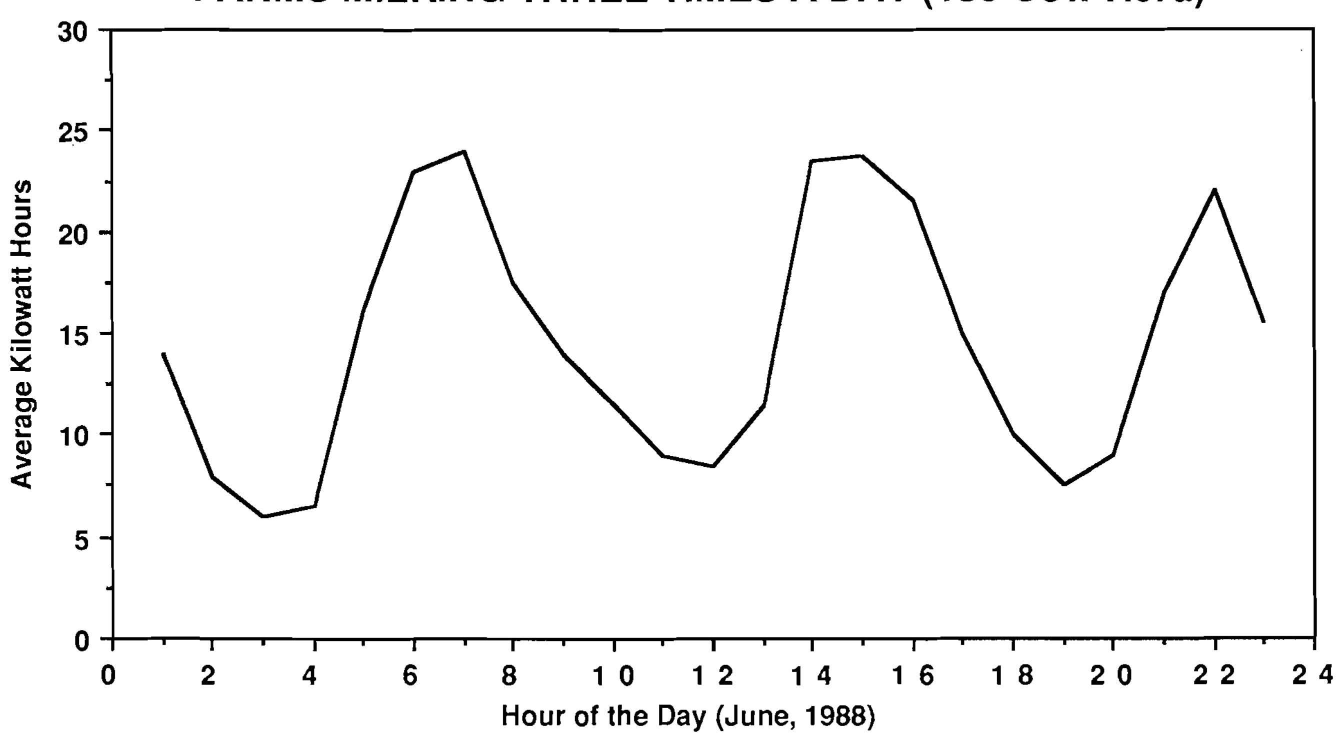
## MODELING ELECTRICAL COSTS

In this section the electricity charges for time-of-use rates are estimated and compared against a flat rate price. Information from a sample of typical dairy farms is entered into a computer model and cost estimates are calculated. From these estimates a determination can be made regarding the likely consequences of time-of-use pricing on dairy operations, given the specific conditions of the individual farm.

### METHODOLOGY

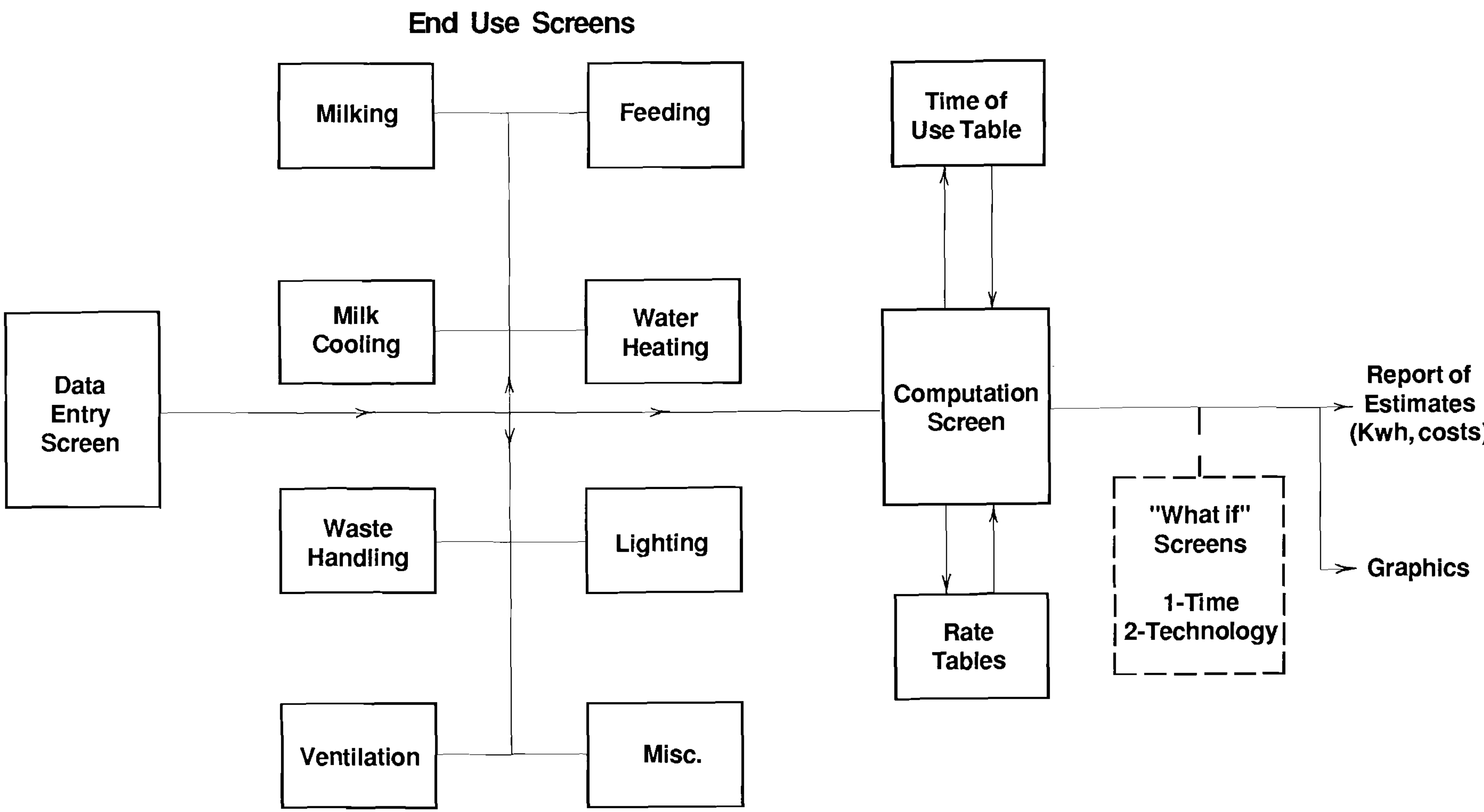
To estimate individual farm electricity costs, a model is developed that calculates energy consumption for major electrical end uses found on most dairy farms. A schematic diagram of this model is portrayed in Figure 10. End use Kwh consumption of all farm electrical equipment is calculated using coefficients from regression models, end use indices or other algorithms that closely fit data collected from previous research (see Boor et al., 1986, 1988; Farmer et al., 1989; undated; Johns). Estimates of end use

**Figure 9.**
**DAIRY FARM ELECTRICITY USE PROFILE**
**FARMS MILKING THREE TIMES A DAY (130 Cow Herd)**




Source: Cornell University Dept. of Agricultural Engineering

Figure 10.
FARM ENERGY ANALYSIS MODEL



electricity consumption are annualized and summed to provide a yearly energy consumption figure. Using data on the timing of equipment operation for the farm, this total is apportioned by time-of-use category, such as peak or off-peak.

Kilowatt hour consumption in each category 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. Assuming that there is no load shifting caused by the new rate, the true, annual cost differences between time-of-use rate and flat rate prices can be compared.

We illustrate this procedure by using Niagara-Mohawk Power Corporation's residential time-of-use rate schedule SC-1C (Figure 4). The NMPC schedule utilizes a three-tier rate structure, dividing daily usage into peak and off-peak periods, plus an intermediate-level (shoulder) period. NMPC's time-of-use rate schedule also varies according to season, with peak and shoulder rates reflecting the highest marginal cost or peak demand periods during the winter and summer seasons.

## 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 are extremely important. Cornell University has two 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. Electricity use in the farm residences was excluded from these data.

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 have milking parlors, 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.

With the model calibrated 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. As more data become available, further refinements will be made to the computer model.

ANALYSIS

For illustrative purposes, the 25 Midwest farms were grouped into four size classifications, ranging from very large (>75,000 kwh/year), to very small (less than 30,000 Kwh/year). Cost estimates for each farm are computed, then averaged by size group. The average flat rate and time-of-use rate cost estimates for each size group are displayed in Table 8.

As shown, the model suggests that the farms using more than 30,000 Kwh/year would realize a decrease in electricity costs by moving to time-of-use rates. 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.[14]

It is also useful to break down total electricity cost by component cost. Table 9 portrays the average time-of-use electricity costs for seven major end uses of the entire 25-farm sample.

These end use estimates further demonstrate cost differences that might be experienced from the normal usage of farm electrical equipment, without change in time schedule. As can be seen, all end uses display a slight decrease in annual electrical cost.

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[14] Niagara-Mohawk's time-of-use rates will be mandatory for all residential customers using a minimum of 30,000 kilowatt hours per year. (See Table 1).

Table 8

ANNUAL DAIRY FARM ELECTRICITY COST ESTIMATES
(based on Midwest Data)

| Size Group Kwh per Year | Number of Farms | Average Herd Size | Cost* Flat Rate | Cost* Time-of-Use Rate | Percent Change |
|---|---|---|---|---|---|
| > 75,000 | 2 | 88 | $4,019 | $3,601 | -10.4 |
| 50-75,000 | 4 | 66 | 3,467 | 3,187 | -8.1 |
| 40-50,000 | 8 | 48 | 2,293 | 2,183 | -4.8 |
| 30-40,000 | 7 | 38 | 1,870 | 1,860 | -0.5 |
| < 30,000 | 4 | 27 | 1,271 | 1,378 | +8.4 |
| All farms | 25 | 48 | $2,337 | 2,237 | -4.3 |

Source: Dairyland Power Cooperative, 1987.

*The flat rate used is $0.07196/Kwh plus a $5.85/month customer charge ($70.20/year). The TOU rate contains rates for a peak, shoulder and off-peak periods plus a $32.20/month customer charge ($386.40/year). See Figure 2 for the complete rate schedule. Cost estimates do not include electricity used in the farm residence.

Table 9

ESTIMATED ANNUAL COST BY END USE
(Flat Rate vs. Time-of-Use Rate)

| Type of Rate | Vacuum Pump | Milk Cooler | Water Heater | Feeding Equipment |
|---|---|---|---|---|
| Flat Rate | $414 | $474 | $502 | $315 |
| Time-of-Use | 350 | 385 | 399 | 261 |
| Percent Change | -15.4 | -18.6 | -17.1 | -17.2 |

| Type of Rate | Waste Handling | Ventilation | Lights |
|---|---|---|---|
| Flat Rate | $35 | $326 | $195 |
| Time-of-Use | 27 | 287 | 158 |
| Percent Change | -22.5 | -12.2 | -18.9 |

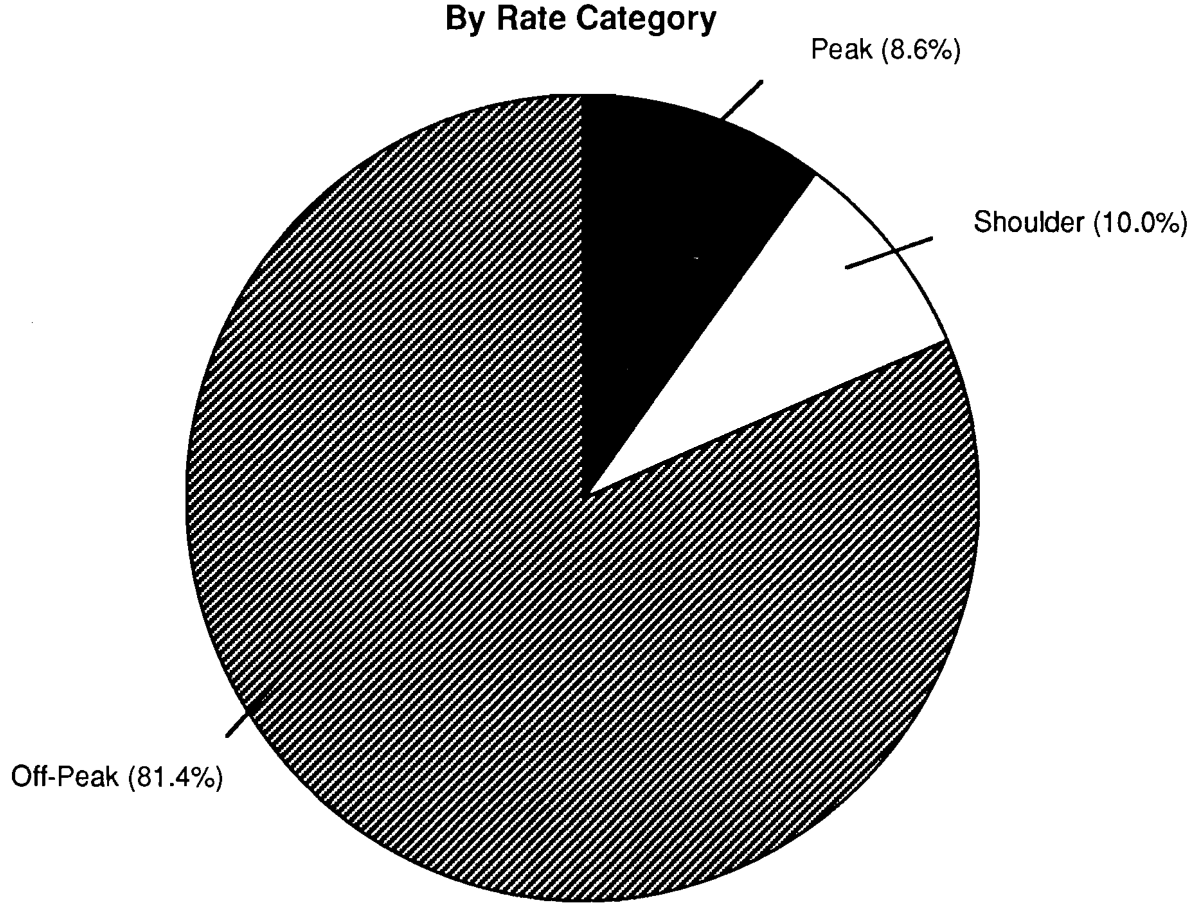
Figures 11 and 12 provide an explanation of why total time-of-use costs for these farms are lower than with flat rate prices. Using the average of the 25-farm sample, the estimated annual electricity consumption is distributed by time-of-use period (Figure 11). As shown, 81 percent of the total electricity is used during off-peak hours, when the time-of-use rate is lower ($0.0475/Kwh) than the flat rate ($0.07196/Kwh). Assuming no change in behavior or technology in response to the rate, the remainder is consumed in peak (8.6%) and shoulder (10.0%) periods, both of which are priced higher than the flat rate price.

When the Kwh consumption for each period is multiplied by its respective per kilowatt hour cost, the actual cost distribution across TOU rate periods is revealed (Figure 12). This graph represents the distribution for the variable costs of the farm's electric bill.

**Figure 11.**

**KWH DISTRIBUTION**

**By Rate Category**

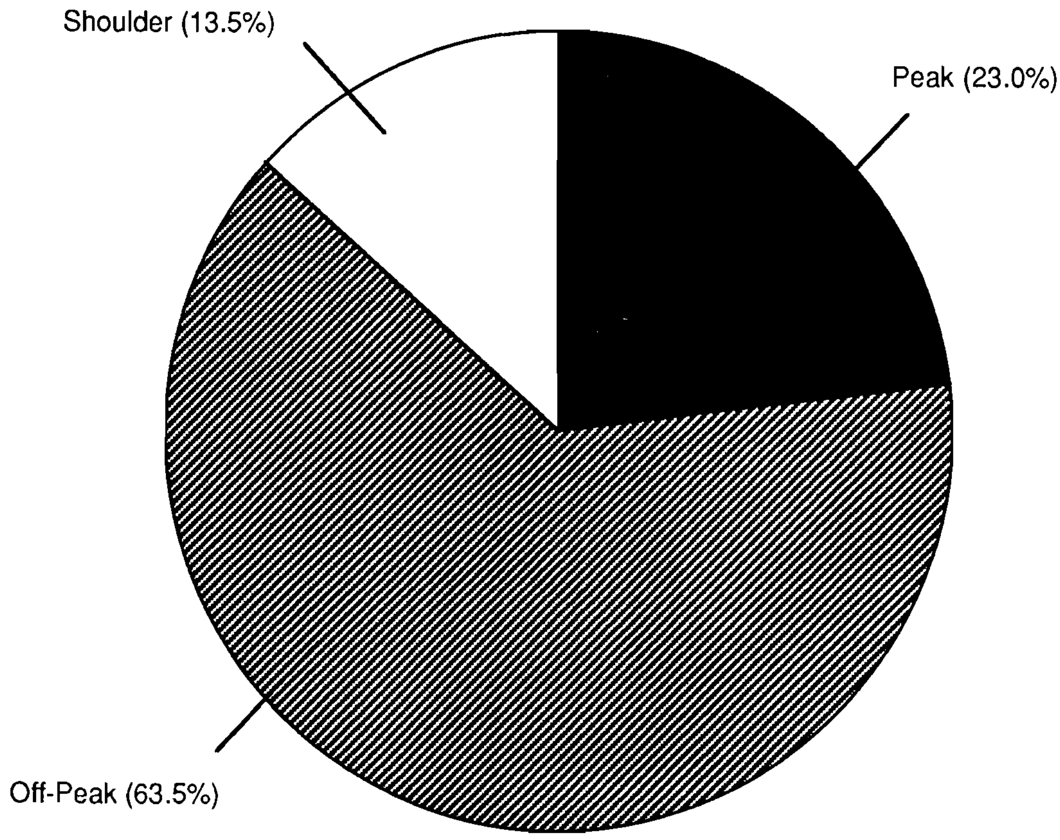



**Source: Estimated from Energy Forecast Model**

Hence, it is the predominant use of off-peak electricity that lowers the overall energy cost significantly. NMPC's time-of-use rates contain a higher customer charge, $32.20 per month, which will offset this reduction and help maintain approximate revenue neutrality to the utility. 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 would be lower than under the flat rate, except on very small farms, many for which the rate may not be mandatory.[15]

To see the total cost distribution (variable plus fixed costs), the customer charge (representing fixed utility costs) is included to portray the distribution of total farm

**Figure 12.**
**COST DISTRIBUTION**
**By Rate Category**




**Source: Estimated from Energy Forecast Model**

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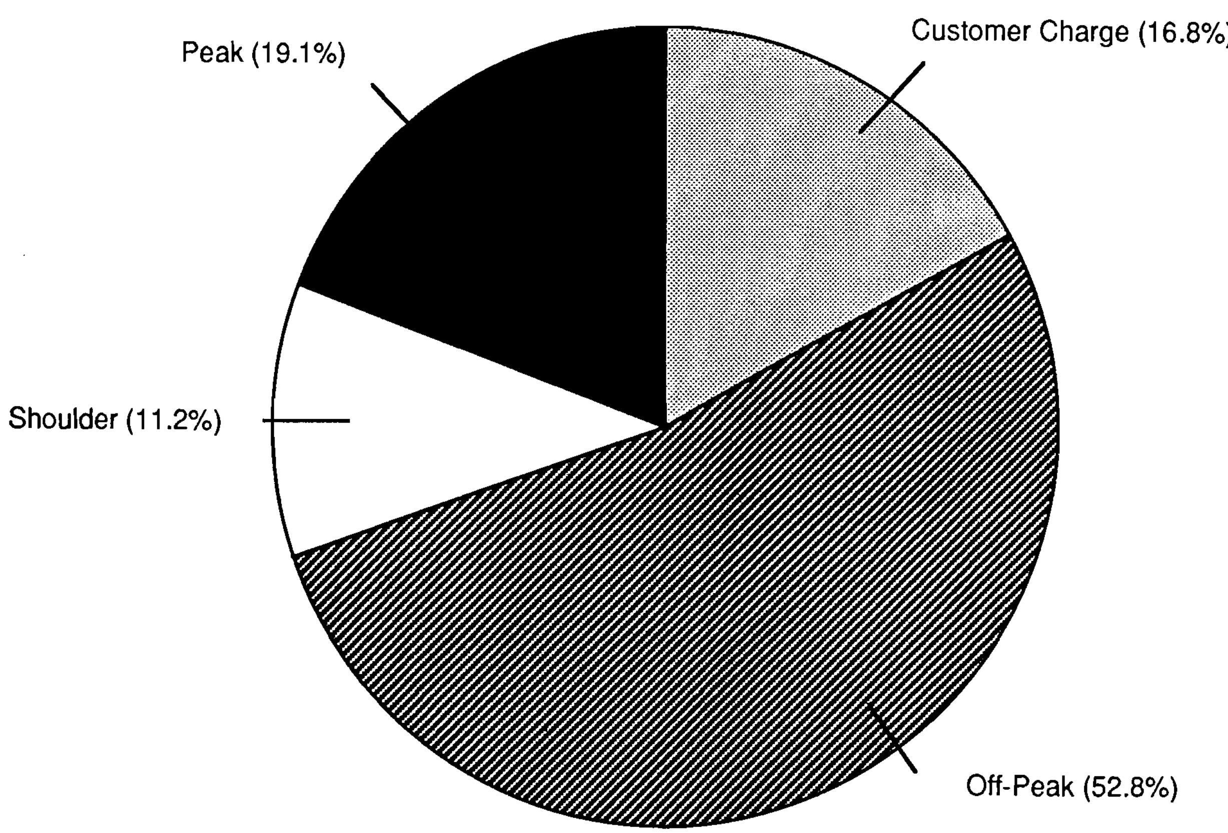
[15] Local taxes and other assessments are excluded from these figures.

electricity cost (Figure 13). The customer charge represents about 17 percent of the total electric bill in this example.

Preliminary results 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, without changing electric-using equipment or altering the timing of its use. The electricity costs of individual end uses decrease under this new rate structure. Small farms will experience a less significant cost decrease, compared with large farms. These conclusions are, of course, keyed to the Niagara Mohawk's time-of-use rate structure and to what we know about end uses and the timing of equipment use for this particular group of farms. Given a different group of farms with different equipment or operating schedules, and with different rate structures, minimum usage thresholds and customer charges employed by

**Figure 13.**
**COST DISTRIBUTION**
**By Total Bill**




**Source: Estimated from Energy Forecast Model**

other New York utilities, it would be impossible to extend the above conclusions over the entire dairy farm population of New York without further research.

Finally, these findings are based upon the assumption that the farmer maintains his/her operational schedule and makes no replacement of electrical equipment. What happens in the event a farmer finds that his/her electric bill increases from the move to time-of-use rates, or that he/she simply wishes to reduce his electricity costs even more? In the next section, some ideas are discussed that could help reduce electricity consumption and lower time-of-use electricity costs.

## COST AND ENERGY SAVING SUGGESTIONS

From the previous section, it appears that cost savings will accrue to some dairy farmers in the switch from flat rates to time-of-use rates. There may also be farmers who will find that their electric bill increases from this change. To most farmers (even those experiencing initial cost savings), there may be some options available to reduce electricity costs. These adjustments might involve changing operational schedules, or replacing inefficient appliances or equipment. Both approaches will be briefly examined in this section.

### SCHEDULE ADJUSTMENTS

The time-of-use rate schedules shown in Figures 2-4 are designed to mirror marginal production costs for power generation. With peak and shoulder periods occupying only a small portion of a daily usage time, there are opportunities for rescheduling farm chores to achieve some cost savings. For example, by moving daily livestock feeding to off-peak hours only, a 60-cow farm previously feeding with a fixed, year-round schedule could save $100 or more a year in electricity costs. Milking schedules, although less flexible than feeding, could also be adjusted somewhat for similar cost savings. With that adjustment, additional savings might automatically accrue at the milk cooler and water heater.

Another way to change the schedule of certain electricity consuming activities is with a timing device. Placing a timer on a water heater to heat water only during off-peak hours limits on-peak heater usage to temperature maintenance without affecting sanitation requirements. Farmer et al. (1989; undated) reported annual savings of $95 to $371 with a timing device. Timing devices may also be useful for certain lighting and ventilation applications.

## TECHNOLOGY ADJUSTMENTS

Another way to reduce electricity costs is by replacing old equipment with new, energy efficient models, or by adding devices which lower usage. Some examples are now discussed. They are general in nature and should only be considered following on-site evaluation by someone knowledgeable in that particular technology. The ideas presented here are not exhaustive, and other farm-specific energy saving technologies, including utility rebates or other incentives for purchasing fans, water heaters, efficient lighting and heat recovery and precooler systems, may also be available. Utility field representatives, an equipment dealer, an agricultural engineer, or Cornell University Extension can provide assistance with specific energy savings questions.

### Electric Motors

Prior to the mid-1970's, electric motors were principally designed and manufactured at low cost, rather than for efficiency. This took place at a time when many American farmers began modernizing their operations with new electric powered equipment. As a consequence, a large number of farms were equipped with these electric motors. Unfortunately, these same types of motors continue to be used on many farms, and as technology has improved they are, by current standards, inefficient.

Efficiency of a motor can be measured as a percentage, taking the mathematical form (National Food and Energy Council):

$$\text{Efficiency} = \frac{\text{Mechanical Energy Out}}{\text{Electrical Energy In}} (100)$$

An inefficient motor would have high internal power losses, resulting in wasted electric power each time it is operated. Thus, the higher the efficiency rating, the less wasteful the motor. A high efficiency motor will have an efficiency rating five to 10 percent higher than a regular motor, and over a span of several years, its cost savings can be considerable.

According to the National Food and Energy Council, high efficiency motors can be justified for farm applications where they will be run more than 2,500 hours per year. This would make them ideal candidates for vacuum pumps, ventilation fans, and some feeding equipment. Efficient motors used in these applications would normally save $25 to $100 in electricity costs per year under typical situations. While the initial cost of a high efficiency motor is 30 to 50% higher, electricity cost savings could permit a payback within 2 to 3 years of purchase for small motors, 3 to 5 years for larger units.

Vacuum Pump

In addition to employing energy efficient motors, electricity used by the vacuum pump can also be reduced by utilizing a more efficient milking system. An experimental vacuum pump milking system of this type is currently being designed and tested by the Department of Agricultural and Biological Engineering at Cornell University.

The system is an adjustable speed drive vacuum pump, which generates needed vacuum to a milking system, while reducing the need for the pump to operate continuously at full speed. In addition to reducing electricity demand, the pump also provides better vacuum stability than conventional systems.

Initial results have been promising. Using an adjustable speed drive system has reduced vacuum pump electrical demand by 50-60 percent in tests conducted at the Cornell Teaching and Research Center, with annual cost savings calculated at $648 per year. With a cost of $2,700, the expected payback for this particular system was calculated to be 4 years (Pellerin). It is anticipated that this system will undergo several more years of testing before being marketed.

Milk Cooling

To reduce milk cooling time and conserve bulk tank energy, several innovations have been developed that begin the cooling process before the milk reaches the tank. These "pre-coolers" surround the milk-carrying pipe with cold water to drop milk temperature, thereby reducing the work of the bulk tank's compressor (refrigeration) unit. The electricity saved through the use of a precooler varies considerably, but has been shown to cut cooling costs by over 50% under ideal conditions (Sanford et al.). A precooler for a farm producing 1.5 million lbs. per year will cost from $1,000 to $1,500 (Farmer et al., 1989; undated).

A related type of precooler, using ice rather than water, can cool milk down all the way to storage temperatures, saving even more compressor electricity. However, energy utilized to make ice for this process can sometimes more than offset electricity saved through the bulk cooler. In this situation, these precoolers may be well suited for time-of-use rates as ice making could be scheduled during lower priced off-peak hours, and thus be more cost effective.

Precoolers are not widely used on New York farms. Data from the 1987 and 1988 surveys found that only 11 to 14 percent of the farms used some type of precooler in their dairy operation.

Water Heating

Some methods to conserve power consumption have also been developed for the water heater. The most common type is an insulation blanket wrapped around the heater to reduce standby heat loss. However, there may be circumstances where insulation wraps are not suitable. In a damp milk house environment, the blanket can trap moisture against the heater wall, leading to corrosion and a shortening of the appliance's usable life (Wisconsin Public Service Corporation, 1990, undated).

Additional energy savings can be achieved through the use of a heat exchanging unit. With a heat exchanger, inlet water is first warmed with waste heat generated from the bulk tank compressor. Warmer inlet water would require less energy to bring to storage temperature. Boor et al. (1986, 1988) suggests substantial (>50%) savings in water heater energy consumption with use of a heat exchanger. Kammel and Patoch reported an average energy savings of 48% with a heat exchanger. He also noted an eight percent reduction in energy use at the bulk tank with the same heat exchanger, as a result of heat dissipation at the compressor. Less than one-third of the New York dairy farms surveyed in the 1987 and 1988 surveys utilized heat exchangers.

Livestock Feeding and Waste Handling

Energy efficient motors would help to reduce electricity consumption of heavily used feeding equipment. On some farms, improved design of the feeding setup may also improve the efficiency of feed moving equipment.

Some larger dairy operations are installing highly sophisticated computerized feeding systems as a means to reduce labor requirements and improve feed conversion on the farm. These types of systems are often quite costly, but can be more energy efficient than conventional feeding methods.

The amount of time and energy devoted to waste handling would appear to be too small to justify major expenditures for energy saving purposes only. A farmer wishing to improve the efficiency of the waste handling system should consult with an equipment dealer or agricultural engineer to determine what, if any adjustments, could be made to a current setup.

Lighting

Indoor lighting needs occur in response to night time conditions and to conform with minimum milking standards. Rescheduling daily activities to reduce lighting costs is limited and may have only a small effect on electricity cost. Better savings can be achieved with the use of high efficiency bulbs.

A simple energy conservation method being employed on many farms is the replacement of incandescent bulbs to a more efficient fluorescent system. While more expensive to buy and install, fluorescent lights have greater lighting capabilities and last 10 to 24 times longer than incandescent bulbs.[16] Using the example of a 50-cow stanchion barn, a Wisconsin utility examined the cost of installing, operating and maintaining three different lighting systems for a 20-year period. A properly installed and maintained fluorescent tube lighting system was found to cost about $4,200 over that time span, compared to $9,200 for a comparable incandescent bulb system. This would result in a savings of about $250 per year.

For general outdoor lighting, mercury vapor lighting is the most commonly used. Farmer et. al. (1989; undated), note cost savings of about 55 percent when replacing less efficient incandescent flood lights with mercury vapor lighting. In recent years, high

[16] According to estimates from the Wisconsin Public Service Corporation, lights used in a dairy barn have the following average life span:

| | |
|---|---|
| Incandescent Bulbs: | 750 hours |
| Screw-in Fluorescent Bulbs: | 7,500 hours |
| Tube Fluorescent Bulbs: | 18,000 hours |

pressure sodium bulbs have become more popular for outdoor lighting. They are more expensive to purchase than mercury vapor lights, but over a five-year period have been found to be the least costly type of outdoor lighting overall in terms of combined purchase, installation and energy cost (Agriculture Energy Information Program).

Ventilation

Fans should be equipped with high efficiency motors. Fans themselves are rated according to the amount of air they move, measured in cubic feet per minute (CFM). A normal rating for a 36" fan would be 9-10,000 CFM while the bigger 48" fan would move 18-20,000 CFM. A better gauge of fan efficiency is measured by cubic feet per minute per watt (CFM/watt), which brings into account the fan's electricity consumption. This can also be called the Ventilation Efficiency Ratio (VER). Normal VER ratings for agricultural fans would range from 10 to 20, with 12 to 13 being the most common (Agriculture Energy Information Program). In a University of Illinois study of high efficiency ventilation, fans tested there were found to range from 13.4 to 23.4 CFM/watt (Wisconsin Public Service Corporation, 1990; undated).

As with lighting, efficient fans (a high VER rating) are more expensive to purchase, but will save money over time. In tests conducted by Cornell University, fans with a VER rating of 21 were found to reduce annual operating costs by 37% compared to fans with a VER rating of 12.6.

Many utility companies now offer rebate or purchase assistance programs for farm ventilation fans, which can cover a considerable portion of a fan's purchase price. Only high-efficiency fans are generally eligible for these types of programs. Prior to making any fan purchase, contact your utility to determine if they offer any kind of fan rebate program.

Maintenance of ventilation equipment is also very important to reducing electricity cost. Belt adjustments, periodic fan cleaning and proper louver positioning are all essential upkeep activities. The use of thermostats and humidistats can also help lower ventilation costs.

Another often overlooked attribute of farm lighting and ventilation use is the wiring system. Many older dairy barns were later retrofitted for electricity, often by a farmer or someone other than an electrician. This wiring may be poorly installed or no longer adequate for today's lighting loads. In extreme cases it may even be the cause of stray voltage or become a potential fire hazard. Farmers should periodically have their wiring inspected by an electrician to replace faulty or outdated wiring, not only to eliminate electrical leakage, but also to protect against fire.[17]

[17] Doing so may also have the added benefit of reducing fire insurance premiums.

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