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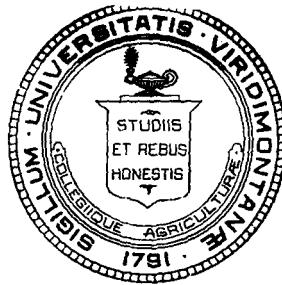
ELECTRICAL POWER USAGE IN
VERMONT COOPERATIVE CREAMERIES

By O. M. CAMBURN

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By O. M. CAMBURN

Studies of electrical usage by dairy machinery were made in five cooperative creameries. Costs amounted to 3.5 percent of the total cost of operation and rates ranged from 4.08 to 1.83 cents per kilowatt hour.

The kilowatt hour usage at the several plants by 14 different types of mechanism as well as the cost of lighting were determined and are indicated in the text.

INTRODUCTION

Electricity is available to and is the principal power used in most Vermont dairy plants, a few plants being without this flexible power. In a recent study made of the cost of operating five cooperative creameries it was found that the cost of electricity was 3.5 percent of the total cost of operation. A special study was made to determine the amount used by each machine in each creamery. The cost of electrical power was then distributed to the several operations.¹

PROCEDURE

Prior to the operation of each piece of electrically driven dairy manufacturing equipment, the power line was tapped at the switch box and a watt-meter installed, in order to measure the power used by each machine when operating. Meter readings were taken from time to time, the time consumed in each step of the operation recorded and the weight of product handled noted. From these data, electrical usage was determined per unit of product.

RATES

Annual electricity usage per creamery varied from 16,480 to 154,042 kilowatt hours, and the rates from 4.08 to 1.83 cents per kwh. (table 1). The creamery which used the least electricity and at the highest average rate did not use mechanical refrigeration. The other four rates averaged 2.31 cents per kwh. The three creameries, each of which annually

¹ Acknowledgment is made of and appreciation expressed for the helpful cooperation of Mr. L. F. Parker, formerly instructor in electrical engineering, who made the electrical readings.

received 15,000,000 or more pounds of milk, averaged to use 128,423 kwh. of electricity annually at an average rate of 1.98 cents per kwh.

The electricity consumed by the compressors in the four creameries where artificial refrigeration obtained was 78.4 percent of the total.

ELECTRICAL USAGE

Refrigeration.—The rated capacity of refrigeration compressors is stated as tons of refrigeration produced in 24 hours. The tons of refrigeration developed were calculated from the rated capacity and time operated. The actual hours of operation were reduced to a percentage of 24 hours. This percentage was then applied to the rated capacity to secure the tonnage of refrigeration developed.

Five refrigeration compressors at four creameries averaged to use 27.50 kwh. per ton of calculated refrigeration developed, ranging from 25.91 to 29.45 kwh. (table 2). Farrall reports 26 kwh. per ton of refrigeration.¹ The electrical usages per ton of calculated refrigeration developed were 27.44, 29.45, 27.63 kwh. at creameries S, V and W and 27.05 and 25.91 kwh. for each of the compressors at creamery U.

Churning.—The average electrical usage during five churnings at four creameries was 1.77 kwh. per 1,000 pounds of cream, ranging from 1.49 to 1.89 kwh. (table 3). Farrall reports 1.97 kwh. per 1,000 pounds of cream.¹ The range per 100 pounds of butter made was from 0.34 to 0.47, averaging 0.43 kwh.

Horizontal Coil Vats.—The horizontal coil vats, in which the shipping milk was mixed and pre-cooled, averaged to use 0.014 kwh. of electricity per 100 pounds of milk (table 4). The range was narrow, 0.011 to 0.018 kwh. Creameries S, T, U and W used 0.018, 0.012, 0.011 and 0.014 kwh. respectively. When cream was pasteurized, the electrical usage to operate the coils was 0.017, 0.015 and 0.016 kwh. per 100 pounds of cream at creameries S, T and U respectively, or but little more than was used when milk was handled.

Cream Separators.—The average electrical usage for the combined operation of shafting, separators, preheaters and milk pumps at five creameries was 0.74 kwh. per 1,000 pounds of milk separated, the range being from 0.49 to 0.93 kwh. (table 5). Ten-horse-power motors were used where the per unit minimum and maximum usage prevailed. Five-horse-power motors were used at the other three creameries. The per unit electrical usage at creameries S, T, U, V and W was 0.93, 0.86,

¹Farrall, A. W. Power Requirements of Electrically Driven Dairy Manufacturing Equipment. Calif. Sta., Bul. 433 (1927).

0.81, 0.60, and 0.49 kwh. respectively. However, in order to analyze the differences, these usages are broken down into specific operations.

The electrical readings for the operation of shafting were 1.5, 1.7, 1.4, 1.1 and 1.3 kw. per hour. Usage was greatest at creameries S and T, where long shafts were supported by many hangers and several idling pulleys were in use. The electrical usage, per 1,000 pounds of milk separated, to operate shafting was 0.43, 0.25, 0.32, 0.20 and 0.14 kwh. The large usage (0.43 kwh.) at creamery S was due to the use of a 10-horse-power 100-volt motor to operate a long shaft from which power was taken to run different machines. Even when other machines were idle, this long shaft had to be driven to separate milk. The electrical usage per 1,000 pounds of milk separated, to bring the separators up to full speed and operate until milk was turned into them, was 0.07, 0.10, 0.08, 0.04 and 0.03 kwh. respectively. The largest usage per unit (0.10 kwh.) was at creamery T where the two separators ran empty for an hour and a half awaiting the last truck load of milk. The electrical usage needed to operate the separators only, shafting usage being eliminated, per 1,000 pounds of milk separated was 0.33, 0.37, 0.36, 0.30 and 0.28 kwh. respectively at creameries S, T, U, V and W. The average per unit usage was 0.33 kwh., indicating that under full load the five separators made rather uniform usage of electricity. Farrall reported 0.305 kwh. per 1,000 pounds of milk separated. The per unit electrical usage for the complete operation of shafting, starting the separators and operating under full loads, averaged 0.66 kwh., and was 0.83, 0.72, 0.76, 0.54 and 0.45 kwh. respectively at creameries S, T, U, V and W. In order to propel 1,000 pounds of milk through preheaters at creameries S and T required 0.05 and 0.04 kwh. respectively. At creameries S, U, V and W, the centrifugal milk pumps, alone without shafting, used 0.05, 0.05, 0.06 and 0.04 kwh. respectively, while the reciprocal cream pump at T used 0.10 kwh.

Milk Pumps.—The average electrical usage for the operation of belt-driven centrifugal milk pumps, including the shafting, was 0.20 kwh. per 1,000 pounds of milk moved, the per unit usage 0.23, 0.22, 0.22 and 0.15 kwh. respectively at creameries S, T, U and V (table 6).

Ice Cream Freezer.—The horizontal dasher, brine type ice cream freezer at creamery V was operated by a three-horse-power 220-volt electric motor which used 0.475 kwh. of electricity per 10-gallon batch of ice cream or 2.04 kw. per hour of actual operating time. Operated in conjunction with the freezer, a three-fourth horse-power motor driving a brine pump used 0.07 kwh. per 10-gallon batch, or 0.6 kw. per hour. The total electrical usage for freezing was 0.545 kwh. per

10-gallon batch of vanilla ice cream. The electricity used for freezing increased constantly and gradually during the freezing process up to the time when the brine was turned off, after which the power usage gradually declined during the whipping operation.

Ice Crusher.—An ice crusher, driven with a five-horse-power 220-volt motor used 1.2 kilowatts per hour or 0.577 kwh. per ton of ice.

Condensing Evaporator.—The condensing evaporator at creamery V used 11.91 kwh. of electricity per 1,000 pounds of plain condensed skimmilk manufactured, 9.59 kwh. for the 10-horse-power motor driving a 20-inch exhaust fan and 2.32 kwh. for the three-horse-power operating motor. The fan used 5.75 kw. and the operating motor 1.13 kw. of electricity per hour of operation. The plain condensed skimmilk was cooled in a 300-gallon horizontal coil vat which used 1.6 kwh. of electricity per 1,000 pounds of condensed milk. At creamery W, the plain condensed skimmilk was cooled in a 300-gallon vertical coil cooler, which used 1.4 kwh. of electricity per 1,000 pounds of condensed skimmilk cooled.

Milk Agitators.—Two mechanical agitators were used in the cheese vats at creamery V to stir the milk. One used a quarter-horse-power 110-volt motor, consuming 0.209 kilowatts per hour, the other a one-third horse-power 110-volt motor using 0.241 kilowatts per hour. A cheese curd mill equipped with a one-horse-power 220-volt motor used 0.179 kwh. per 1,000 pounds of curd or 0.748 kilowatts per hour.

Casein Machinery.—Green casein curd was flaked in beater type grinders. The 10-horse-power 220-volt motor at creamery T operated a 48-inch hot-air blower, also a short shaft to operate the grinder, the electrical usage being 0.188 kwh. per 100 pounds of curd flaked. The grinder operated continuously for 13 minutes to flake 799 pounds of curd. The 10-horse-power 220-volt motor at creamery W propelled a long shaft with 11 hangers and four idling pulleys, to operate all the equipment on that floor, including the casein curd grinder. The curd grinding was intermittent by two-minute periods with about 10-minute intervals during which time the grinder ran without load. Under these conditions the total consumption was one kilowatt hour to flake 272 pounds of casein curd, or 0.361 kwh. per 100 pounds. The actual grinding of each 100 pounds of green curd consumed 0.191 kwh., which figure is comparable with 0.188 kwh. usage at creamery T. The balance was consumed by the longer period of operation without load. Thus the larger usage of the smaller grinder was due to the method of intermittent operation. This excessive electrical usage could have been avoided by continuous grinding. Hot air was forced through the casein-

drying tunnel at creamery T by a 48-inch fan driven by a 10-horse-power 220-volt motor. The electrical usage was 3.75 kw. per hour for nine hours or 33.75 kwh. daily, which at an average rate of two cents made a daily cost of 67.5 cents. At creamery W only one-fourth as much drying tunnel space was used. The 20-inch fan driven by a two-horse-power 220-volt motor used 0.7 kilowatt per hour for 12 hours daily, which at a two-cent rate made a cost of 17 cents.

Can Washers.—A half-horse-power 110-volt motor was used at creamery S to operate a single can, expanding brush type can washer. The electrical usage was 0.80 kwh. per 100 10-gallon milk cans. The rotary lift type can washer at creamery U was operated by three two-horse-power 220-volt motors. The electrical usage was 0.94 kwh. per 100 milk cans. A rotary can washer at creamery W was operated with a five-horse-power 220-volt motor, the electrical usage being 1.03 kwh. per 100 milk cans washed. This creamery also used a continuous type can washer operated by a seven and one-half horse-power and a half-horse-power motor. The electrical usage was 1.34 kwh. per 100 10-gallon cans. No inspection was made of the cans as they left the washers, as to their cleanliness, dryness or bacterial count.

Elevators.—The elevators at creamery U operated by a five-horse-power 220-volt motor used 0.014 kwh. to lift a 700 pound load 16 feet and return. That at creamery V used a five-horse-power 220-volt motor which required 0.024 kwh. to lift 900 pounds 20 feet and return. The electrical usage was 0.011 and 0.013 kwh. per 10,000 foot-pounds at creameries U and V respectively.

Clarifier and Viscolizer.—A 10-horse-power 220-volt motor through a short shaft and belt propelled a clarifier which used 0.677 kwh. of electricity per 100 pounds of cream processed at creamery U. The viscolizer at creamery V set at 1,200 pounds pressure and driven by a 20-horse-power 220-volt motor used 0.613 kwh. per 100 pounds of buttermilk.

Electricity for lighting averaged \$220.87 annually for five creameries, ranging from \$132.42 to \$356.61. Little night work was done at three creameries, each of which spent less than \$200 annually for lights, and the arrangement of each was such that little or no extra lighting was necessary during daylight hours. On the other hand, the arrangement was such at the other two creameries that extra lighting was needed in various locations throughout all working hours and, furthermore, some night work was done. Thus creamery location and original plant lay-out have a permanent effect on the electricity requirement for lighting purposes.

TABLE 1.—ANNUAL USAGE OF ELECTRICITY

| Creamery | Total annual receipts milk and cream | Electricity | | |
|----------|--------------------------------------|--------------------|----------|------------|
| | | Annual power usage | Per kwh. | Total cost |
| | lbs. | kwh. | cts. | |
| S | 5,858,751 | 40,094 | 3.31 | \$1,327.86 |
| T | 12,232,817 | 16,480 | 4.08 | 671.80 |
| U | 14,864,020 | 154,042 | 1.83 | 2,813.23 |
| V | 17,127,745 | 144,088 | 1.98 | 2,846.84 |
| W | 20,302,114 | 87,140 | 2.12 | 1,849.65 |

TABLE 2.—REFRIGERATION COMPRESSORS

| Creamery | Motor size | Compressor rated capacity | Operating time | Calculated refrigeration developed | Electricity | |
|---------------|------------|---------------------------|----------------|------------------------------------|-------------|----------------------------------|
| | | | | | Total used | Per ton calculated refrigeration |
| | h. p. | tons | hrs. | tons | kwh. | kwh. |
| S | 40 | 16 | 8.75 | 5.83 | 160. | 27.44 |
| V | 80 | 40 | 10. | 16.66 | 490.64 | 29.45 |
| W | 20 | 12 | 12. | 6. | 165.75 | 27.63 |
| U | 25 | 12 | 10.50 | 5.25 | 142. | 27.05 |
| U | 50 | 25 | 10.50 | 10.94 | 283.50 | 25.91 |
| Average | | | | | | 27.50 |

TABLE 3.—CHURNING

| Creamery | Cream used | Butter made | Total used | Electricity | |
|---------------|------------|-------------|------------|------------------------|-----------------------|
| | | | | Per 1,000 pounds cream | Per 100 pounds butter |
| | lbs. | lbs. | kwh. | kwh. | kwh. |
| T | 1,558 | 684 | 2.32 | 1.49 | 0.34 |
| U | 960 | 390 | 1.81 | 1.89 | 0.46 |
| U | 940 | 381 | 1.73 | 1.84 | 0.45 |
| V | 1,679 | 675 | 3.15 | 1.88 | 0.47 |
| W | 1,640 | 650 | 2.86 | 1.74 | 0.44 |
| Average | | | | 1.77 | 0.43 |

TABLE 4.—HORIZONTAL COIL VATS

| Creamery | Motor size | Kind of vat | Product | | Electricity | |
|---------------|------------|-------------|---------|--------|-------------|------------------------|
| | | | Handled | Weight | Total | Per 100 pounds product |
| | h. p. | | | lbs. | kwh. | kwh. |
| S | 10 | Coil | Milk | 28,115 | 5.07 | 0.018 |
| T | 5 | Coil | Milk | 32,751 | 4. | 0.012 |
| U | 2 | Coil | Milk | 36,408 | 4. | 0.011 |
| W | 10 | Coil | Milk | 54,113 | 7.50 | 0.014 |
| Average | | | | | | 0.014 |
| S | 10 | Coil | Cream | 1,189 | 0.20 | 0.017 |
| T | 5 | Coil | Cream | 4,069 | 0.64 | 0.015 |
| U | ½ | Spray | Cream | 1,900 | 0.30 | 0.016 |
| Average | | | | | | 0.016 |

TABLE 5.—SEPARATING CREAM

| Creamery | Motor size | Machine | | Electricity | | | Milk separated |
|----------|------------|---------------------|----------|--------------|------------|-----------------------|----------------|
| | | Kind | Operated | Hourly usage | Total used | Per 1,000 pounds milk | |
| | h. p. | | hrs. | kw. | kwh. | kwh. | lbs. |
| S | 10 | Shafting | 0.9 | 1.5 | 1.35 | 0.43 | 3,145 |
| | | Separator, empty | 0.2 | 1.1 | 0.22 | 0.07 | |
| | | Separator, full | 0.8 | 1.3 | 1.04 | 0.33 | |
| | | Preheater | 0.8 | 0.2 | 0.16 | 0.05 | |
| | | 2 Pumps | 0.8 | 0.2 | 0.16 | 0.05 | |
| | | | | 2.93 | 0.93 | | |
| T | 5 | Shafting | 6.1 | 1.7 | 10.37 | 0.25 | 40,839 |
| | | 2 Separators, empty | 1.5 | 2.7 | 4.05 | 0.10 | |
| | | 2 Separators, full | 3.9 | 3.9 | 15.21 | 0.37 | |
| | | Preheater | 4. | 0.4 | 1.60 | 0.04 | |
| | | Cream pump | 4. | 1. | 4. | 0.10 | |
| | | | | 35.23 | 0.86 | | |
| U | 5 | Shafting | 0.6 | 1.4 | 0.84 | 0.32 | 2,654 |
| | | Separator, empty | 0.2 | 1.1 | 0.22 | 0.08 | |
| | | Separator, full | 0.6 | 1.6 | 0.96 | 0.36 | |
| | | Pump | 0.6 | 0.2 | 0.12 | 0.05 | |
| | | | | 2.14 | 0.81 | | |
| V | 5 | Shafting | 3.8 | 1.1 | 4.18 | 0.20 | 21,028 |
| | | 2 Separators, empty | 0.8 | 1.1 | 0.88 | 0.04 | |
| | | 2 Separators, full | 3. | 2.1 | 6.30 | 0.30 | |
| | | 2 Pumps | 3. | 0.4 | 1.20 | 0.06 | |
| | | | | 12.56 | 0.60 | | |
| W | 10 | Shafting | 5.4 | 1.3 | 7.02 | 0.14 | 48,433 |
| | | 2 Separators, empty | 1. | 1.3 | 1.30 | 0.03 | |
| | | 2 Separators, full | 4.4 | 3.1 | 13.64 | 0.28 | |
| | | 2 Pumps | 4.4 | 0.5 | 2.20 | 0.04 | |
| | | | | 24.16 | 0.49 | | |
| Average | | | | | | 0.74 | |

TABLE 6.—MILK PUMPS

| Creamery | Time operated | Electricity | | | Milk pumped |
|--------------|---------------|--------------|------------|------------------|-------------|
| | | Hourly usage | Total used | Per 1,000 pounds | |
| | hrs. | kw. | kwh. | kwh. | lbs. |
| S | 1.3 | 2.2 | 2.86 | 0.23 | 12,495 |
| T | 4.8 | 1.8 | 8.64 | 0.22 | 40,011 |
| U | 4. | 2. | 8. | 0.22 | 36,408 |
| W | 5. | 1.6 | 8. | 0.15 | 54,113 |
| Average..... | | | | 0.20 | |