Business & Technology Strategies

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C&I CASE STUDIES IN BENEFICIAL ELECTRIFICATION

Agribusiness: Dairy Water Heating

BY TOM TATE, APRIL 2018

SUBJECT MATTER EXPERT FOR QUESTIONS ON THIS TOPIC

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INTRODUCTION

The wise use of electricity, *Beneficial Electrification*, has sparked widespread re-thinking of policies that encourage or mandate less electricity use and promote infrastructure planning. Advancements in electric technologies continue to create new opportunities to use electricity as a substitute for on-site fossil fuels like natural gas, propane, gasoline and fuel oil, with increased efficiency and control. It also offers local economic development and enhances the quality of the product used by the customer.

Electrifying industrial and commercial processes is a proven method to help local businesses stay competitive. Beneficial electrification strengthens the cooperative presence in the community and offers benefits to the electric system. Working with agribusiness customers is a good place to start. To provide examples of various approaches to working with C&I customers on beneficial electrification initiatives, NRECA is developing a **series of case studies**.

NRECA
America's Electric Cooperatives

MEMBER PROFILE

This report should be of interest to any cooperative where dairy operations comprise a significant portion of the load. For cooperatives with other agricultural load, many aspects of water heating for dairy can be applied, especially in swine and poultry operations. Finally, Appendix C offers links to several additional resources, including a description of a dairy energy audit.

DESCRIPTION OF PROBLEM/OPPORTUNITY

Background

Building load in an environment of mandated load reduction and an emphasis on increasing the percentage of renewal sources in the fuel mix may seem like a daunting, if not impossible, task. However, building load through beneficial electrification provides cooperatives with a mechanism to satisfy various stakeholders, while delivering significant benefits to members. Implementation of beneficial electrification programs can have substantial beneficial impacts in:

- Reduction of GhG emissions
- Providing operational savings for members
- Improving the health and safety of members' employees
- Helping members achieve corporate green energy/efficiency goals

Beneficial electrification is the process of replacing a fossil-fueled technology with a more efficient, electric alternative. The case can be made that the entire cooperative movement is built upon beneficial electrification of a different type, replacing manual, labor-intensive processes with electric powered alternatives. So, the concept is part of the co-op DNA.

For load growth, co-ops need to take over market share currently served by fossil fuel technologies, especially those using propane, diesel, and gasoline. With the current abundance of natural gas driving those prices down, tackling situations in which that is the fuel is far more difficult to justify financially to a member. Heating water in a dairy may consume over 20 percent of the electricity used, according to data collected by the University of Minnesota (U of MN) at their research dairy operation in Morris, MN, making it a prime candidate for beneficial electrification.

THE DAIRY WATER HEATING MARKET

The dairy industry represents a significant portion of American agribusiness, with every state in the country having some level of dairy production (see **Table 1**).[1] Of course, some states like Wisconsin are known for their dairy output. The top 10 states in terms of numbers of milking head is shown in **Figure 1**.[2]

Critical challenges being faced by the dairy industry include (not in order of importance):

- Low prices due to over production
- Increasing international competition
- Impact of governmental regulations
- Prevention of disease
- Herd and production management in erratic weather patterns
- Need to contain costs

1 https://www.progressivepublish.com/downloads/2017/general/2016-pd-stats-highres.pdf

2 https://www.statista.com/statistics/194962/top-10-us-states-by-number-of-milk-cows

TABLE 1: Dairy Statistics By State

State	Number of Licensed Dairy Herds (2016)	Total Milk Production in Millions of Lbs (2016)	State	Number of Licensed Dairy Herds (2016)	Total Milk Production in Millions of Lbs (2016)
California	1,420	40,469	Missouri	1,100	1,373
Wisconsin	9,520	30,123	Kentucky	630	1,048
New York	4,650	14,765	North Carolina	210	965
Idaho	520	14,665	Maryland	420	956
Michigan	1,810	10,876	Tennessee	300	696
Pennsylvania	6,650	10,820	Oklahoma	160	692
Texas	400	10,773	Nevada	20	660
Minnesota	3,350	9,666	Maine	250	630
New Mexico	150	7,711	Connecticut	120	408
Washington	480	6,650	North Dakota	85	345
Ohio	2,560	5,532	Montana	65	295
Iowa	1,265	5,034	New Hampshire	120	284
Arizona	110	4,788	South Carolina	60	250
Indiana	1,145	4,151	Massachusetts	140	215
Colorado	120	3,923	Louisiana	100	169
Kansas	290	3,329	Mississippi	75	144
Vermont	820	2,724	Wyoming	10	140
Oregon	230	2,593	West Virginia	75	134
South Dakota	235	2,546	New Jersey	60	122
Florida	120	2,503	Delaware	35	96
Utah	180	2,095	Alabama	35	92
Illinois	640	1,903	Arkansas	60	79
Georgia	210	1,830	Hawaii	2	35
Virgina	615	1,723	Rhode Island	10	14
Nebraska	175	1,399	Alaska	2	4

Source: https://www.progressivepublish.com/downloads/2017/general/2016-pd-stats-highres.pdf

PREVIOUS VIEW

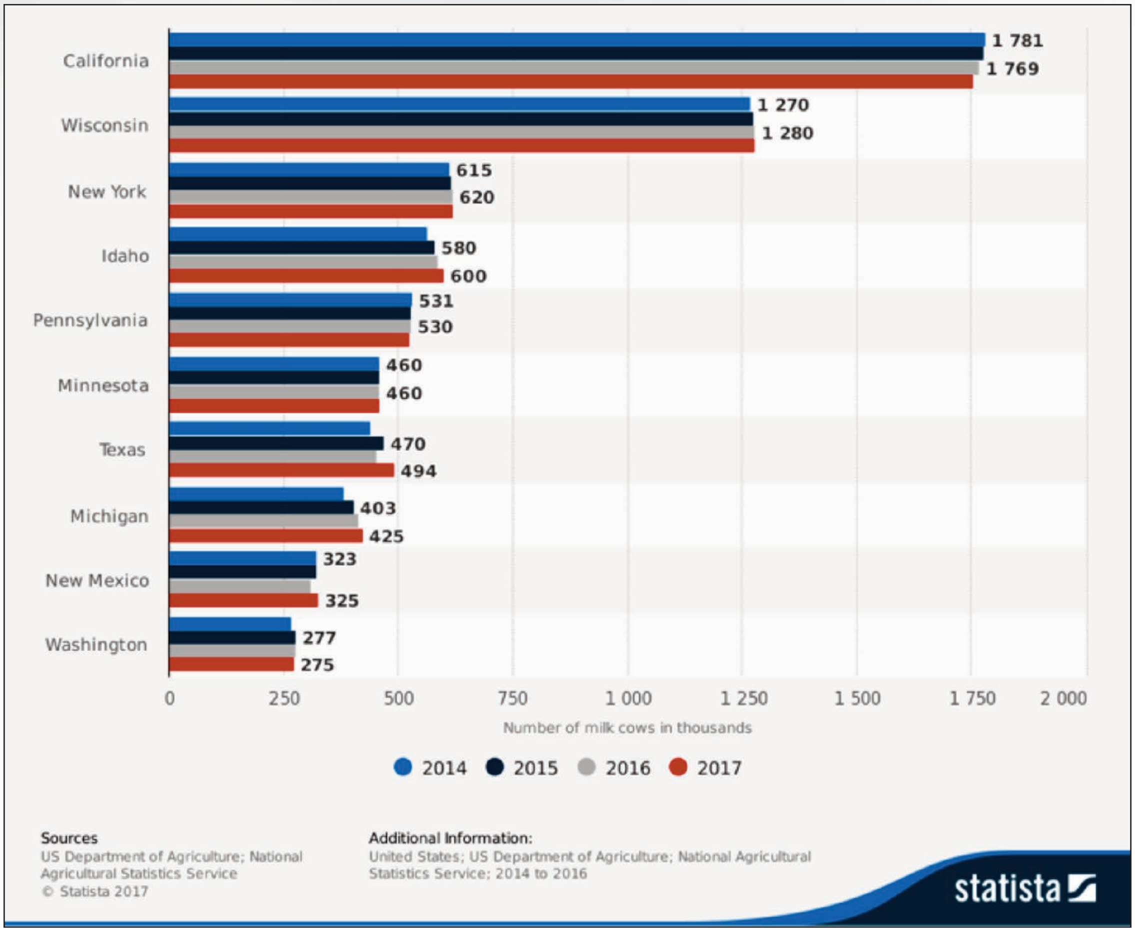

FIGURE 1: Top 10 States By Number Of Milk Cows from 2014 to 2017 (in 1,000s)

Based on discussions with the U of MN and Virginia Tech (VT) research dairy operations, energy use breaks down into these key areas, again not in order of magnitude:

- Heating water
- Moving water
- Moving milk
- Chilling milk
- Watering the herd
- Sanitation — milk lines and holding tanks
- Cleaning — alleys, other areas
- Illumination
- Ventilation

DESCRIPTION OF THE TECHNOLOGY APPLICATION

As noted previously, a dairy faces numerous challenges to productive and profitable operations. Table 2 represents areas where application of efficient electric solutions can be of benefit in a dairy operation.

This report is focused on methods for improving the efficiency of water heating in dairy operations. The primary application for hot water is for sanitation and cleaning of milk holding tanks. There are actually three (3) liquids that should be involved in the water heating process: milk, hot refrigerant, and water. Two have heat

TABLE 2: Efficient Electric Solutions

Challenge	Technology/Solution
Maintaining animal welfare in erratic weather patterns, especially heat and drought	Fans, misters, water reuse
Increasing productivity in winter months	LED lighting
Improving efficiency of operations	LEDs, VFDs on pumps and motors, heat exchangers, sanitation & cleaning methods
Meeting regulatory, environmental, and other requirements	All the foregoing, renewable energy, nutrient management programs,
Declining prices from overproduction, new competition internationally	All the foregoing

to get rid of and one has heat to absorb, as described below:

- Chill milk from 95°F to 38°F for preservation
- Heat well water from 60°F[3] to 179F° for sanitation
- Reduce refrigerant temperatures from approximately 180F° to their optimal design levels

The challenge and opportunity is in bringing the milk, water, and refrigerant together, **indirectly**, using the least amount of energy possible. Fortunately, technologies exist to make this happen.

In the case of the VT Kentland facility (see **Appendix B**), its flat plate heat exchanger can transfer about 15° of the milk's temperature, leaving 42° for the refrigeration unit to reduce. This warmer water is pumped to a holding tank for use in flushing the alleys.

The hot refrigerant from the holding tank chiller/refrigeration unit is then pumped to the preheater where up to 60 percent of the heat is recovered and transferred into the 60° well water. This preheated water is sent to the heaters to be raised to the required temperature.

There are a number of opportunities to improve this heat transfer and thereby the efficiency of the operation using readily available technologies. The key players in this effort are flat plate heat exchangers, tank style heat exchangers, variable frequency drives (VFDs) that provide variable speed capabilities to pumps (vacuum and liquid), and heat pumps to bring water to the finished temperatures required. Opportunities include:

1. Increase the amount of time/surface area for the milk to be "in contact" with the well water for precooling. According to research[4], this can reduce the milk temperature by up to 40°, saving up to 60 percent of the cooling costs.
2. Replace standard pumps with variable speed alternatives, which can save up to 60 percent[5] of their operating cost and extend the pump life by reducing RPMs.
3. Extend the time that refrigerant and well water are "in contact" to recover more heat and reduce primary heating costs.
4. Replace old compressors with more efficient models to increase refrigeration efficiency by up to 62 percent, as documented by experience at the U of MN dairy operation.
5. Insulate milking parlor cleaning lines to reduce heat loss allowing for lower entry temperatures.
6. Insulate water heating tanks to reduce heat loss.
7. Improve maintenance practices in all areas to manufacturers' recommendations to maintain efficiency and extend operating life.

The milk production portion of dairy operations is the most energy intensive because milk has to be collected, transported, chilled, and held at the proper temperature; and all milking lines sanitized between milking sessions and holding

[3] The water temperature of the Kentland facility's water at the well head.

[4] http://www.milkproduction.com/Library/Scientific-articles/Management/Dairy-farm-energy-efficiency

[5] http://www.milkproduction.com/Library/Scientific-articles/Management/Dairy-farm-energy-efficiency

tanks washed following collection by the processor. The common element in all these activities is water. Water reuse can contribute to the overall efficiency of the milk production. See **Appendix B** for more detail.

THE MILK COLLECTION PROCESS

Before getting into the details of heating water for sanitation purposes, it is important to give a high level view of the milk production process. Cows are taken to the milking parlor where their milk is collected either by machine or robot. The milk collected is piped to a refrigerated holding tank.

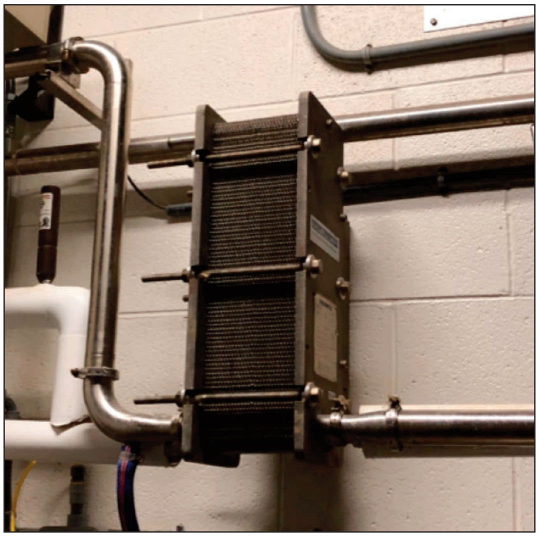

FIGURE 2: Kentland Flate Plate Milk Pre-cooler

FIGURE 3: VT Preheater and Primary Heater Installation

The milk is collected at temperatures between 95 and 99° F and needs to be rapidly chilled to and kept at 38° F. On the way to the storage tank, the milk is typically precooled by passage through a heat exchanger (see Figure 2). The collection medium in the heat exchanger is water, and the water will typically absorb between 10 and 15° F. This warmer water may then be pumped to a holding tank for other use or may be discharged.

The precooled milk enters the holding tank where refrigeration units reduce its temperature to the target level. Hot refrigerant can then be piped to another heat exchanger to preheat the water that will be used for milk line cleaning and sanitization and tank washing.

TYPICAL WATER HEATING PROCESS

Research for this report included a visit to the Virginia Tech (VT) Kentland research dairy facility in Whitethorne, VA. The Kentland operation heats water for the sanitation of the milk lines and tank washing using a pair of Mueller Model D Fre-Heaters as preheaters (50 gallons each) and a pair of Bradford White Eco Magnum ef Series tanks in the primary heating role (100 gallons each).

The refrigerant lines from the milk chiller are routed into the Mueller tanks where the heat is captured and transferred into the water (see Figure 3). According to the manufacturer, up to 60 percent[6] of the waste heat is recovered. The preheated water is then piped into the main heating tanks where propane is used to bring the water to the required temperature, approximately 179°F.

[6] https://dfe.paulmueller.com/Product/FreHeaters/ModelDFreHeater

When the cleaning operation begins, the water is piped to the milking parlor and the lines are flushed. A second wash cycle follows where food grade cleaning and sanitation elements are mixed with the hot water. For sanitation, the water needs to be 160°F at the start of the lines and 130°F at the end. Spent water is sent to a holding tank for subsequent use in flushing the feeding barn alleys.

BENEFICIAL ELECTRIFICATION OPPORTUNITIES IN WATER HEATING

The process of heating water for milk line sanitation and milk storage tank washing should be looked at as having two major components:

- Moving the water, and
- Heating it to required temperature levels.

A complete solution should incorporate energy efficiency improvements in both areas.

Moving the water from its source, usually a well or wells, can be made more efficient by replacing vacuum and liquid pump motors with variable frequency drive (VFD) alternatives, which give the pumps variable speed capability. Using VFD pumps at the well head and in any other fluid transfer situation (except for the inline pumps in the milking parlor[7]) will also contribute to energy efficiency. The VFD pump brings two key benefits to the water heating and fluid transfer processes:

- They can reduce energy by as much as 75 percent,[8] and
- They extend the life of the pump motor.

Reusing the water from the milk precooling operation can also increase efficiency. The warmer water can be pumped to the preheaters for use in capturing heat from the refrigerant.[9] This warmer water can reduce the amount of energy needed to raise it to final temperature in the primary heater(s), reducing the amount of energy used.

HEAT PUMPS

The final step is to replace the fossil fuel-based primary water heaters with more efficient electric alternatives, such as heat pumps and chillers. Considerable research has gone into the efficacy of heat pumps for dairy water heating, especially internationally where dairies face an even higher cost of energy in many situations.

Research has investigated ground source, water source, and air source heat pumps. According to an article out of the UK[10], they found the following Coefficients of Performance (COP) in dairy applications (shown in Table 3).

TABLE 3: COP in Dairy Applications

Type	Typical Seasonal COP
GSHP	4 to 5
ASHP	3 to 6
WSHP	3.5 to 4.5

Another manufacturer[11] reported that their heat pumps were achieving COPs as high as 8.0 in specific situations.

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7 Did not find sources of VFD options for these smaller pumps.

8 See the U of MN example in Appendix A.

9 http://www.omafra.gov.on.ca/english/livestock/dairy/facts/88-032.htm

10 http://www.ddc-ales.co.uk/creo_files/upload/documents/heat_pumps_for_dairy_farms_a5_cropped_changes.pdf

11 http://www.mayekawausa.com/industrial-refrigeration/products/heat-pumps/water-heat-source-eco-cute

Readily available technology in the form of VFDs, heat exchangers, heat pumps, and chillers can be utilized to provide significant efficiency improvement for the dairy operations in your service territory.

In large commercial dairy operations where milk is pasteurized and processed for drinking, cream, yogurt, and cheese uses, heat pumps represent an even larger opportunity for saving by converting excess heat from various operations into a variety of water temperatures for process use[12] including steam. According to a white paper by Emerson Climate,[13] large scale dairy heat pumps can have paybacks as short as 2.7 years.

CHILLERS

The use of chillers in dairy operations is another alternative. In this application, the excess heat from the chiller operation is captured to supply up to 100 percent of the hot water needs for the dairy. These chillers are generally based on the more efficient scroll or screw technologies versus the more common reciprocating style.

Upgrading a dairy operation with chillers may require more space and facility retrofitting to accommodate the equipment than installation of a heat pump. However, one U.S. manufacturer, WHRL Solutions, Inc.,[14] offers solutions for both situations: WHRLcool and WHRLflo for Retrofits. The company's descriptions follow:

- ***WHRLcool®*** Integrated Chiller Range. A full range of industrial chillers with integrated heat recovery. Available in 20 to 160 ton systems in both air-cooled and water-cooled options.
- ***WHRLflo®*** Retrofit System Range. Available as a full range of retrofit kits featuring easy to install modular skids suitable for fitting on to most existing cooling systems.

One installation of the WHRLflo system generated the following hot water production financial and performance (data from the WHRL Solutions website):

- 4,000 cow dairy farm
- 5,000+ gallons of FREE hot water available for cleaning
- Eliminated propane use for producing hot water
- Return on Investment (ROI)
  - Cost of fully installed *WHRLcool®* system including hot water storage: $85,890
  - Total Savings = $30,000
    - $25,000 Propane
    - $5,000 electrical
- **PAYBACK: 2.86 YEARS**

THE BOTTOM LINE

The important take away from this section is that readily available technology in the form of VFDs, heat exchangers, heat pumps, and chillers can be utilized to provide significant efficiency improvement for the dairy operations in your service territory.

HOW DOES THE MEMBER BENEFIT?

Improving the water heating efficiency of your dairy members will reduce their costs of operation, potentially improve the quality of their milk (if they are experiencing sanitation issues), and reduce their GhG emissions by eliminating or reducing the use of fossil fuels.

Table 4, compiled from data presented in an excellent document by Milk Production[15], provides a summary of efficiency improvements realized by employing the technologies referenced in this report.

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12 https://www.iea.org/tcp/end-use-buildings/hpt

13 http://www.emersonclimate.com/Documents/Vilter/Product_Brochures/White_Paper_2011ECT-27_C.pdf

14 http://whrlsolutions.com/the-solutions

15 http://www.milkproduction.com/Library/Scientific-articles/Management/Dairy-farm-energy-efficiency

TABLE 4: Efficiency Improvements

Equipment	% Energy Use	Alternative Tech	Benefits
Vacuum pump	20-25	VFD	Reduce energy operating costs up to 60%, extend pump life with lower RPM
Precool milk Direct, in-tank cooling	>50	Indirect heat exchange, precooling	Reduce milk temps up to 40°, save up to 60% of cooling costs, milk temp from cows 95-99, target = 38
Water heaters /storage	25	Insulation, heat exchangers	Reduce heat loss by up to 3% and thereby operating costs
Refrigerant and cleaning line heat loss		Insulation	Reduce heat loss by up to 3% and thereby operating costs

HOW DOES THE COOPERATIVE BENEFIT?

Cooperatives benefit every time they engage with their members and work to help them improve the efficiency of their operations. By helping members make the most efficient use of the electricity they buy from the cooperative with application of beneficial electrification, they:

- Demonstrate their commitment to the member and its success
- Reduce operating expenses for the member helping increase its profit, ROI, and competitiveness, which helps ensure its viability and continuing operation on co-op lines
- Increase revenue to the cooperative from new technologies that displace fossil fuels
- Increase member satisfaction with the cooperative

WHAT ARE THE EXPECTED REDUCTIONS IN FOSSIL FUEL USE AND COST AND SUBSEQUENT GHG REDUCTIONS?

Outside major cities and towns, natural gas is frequently unavailable. In these areas, propane is going to be the primary fossil fuel displaced in commercial and industrial applications. Because of the widely varying types of commercial equipment, it is difficult to calculate a broad estimate of GhG reduction.

Fortunately, there are methods to calculate the reductions in specific situations. Working with equipment vendors to calculate the reduction is an excellent approach, especially with proven technologies like heat pumps.

A second approach is to use the EPA's baseline calculation of the amount of GhG in an 18-pound propane cylinder. If the amount of propane consumed by the water heater is known or can be determined, the reduction in GhG can be calculated. Here is the formula from the EPA website[16]:

18 pounds propane/1 cylinder
× 0.817 pounds C/pound propane
× 0.4536 kilograms/pound
× 44 kg CO_2/12 kg C
× 1 metric ton/1,000 kg
= 0.024 metric tons CO_2/cylinder

Let's take the WHRL Solutions case study, as an example:

- Inputs:
  - $25,000 saved in propane costs
  - Estimate $1.99 per gallon for propane

[16] http://www.milkproduction.com/Library/Scientific-articles/Management/Dairy-farm-energy-efficiency

While beneficial electrification efforts will increase member-consumers' electric bills, the conversions should yield substantial offsetting benefits.

It is important for the cooperative to develop the necessary relationships with members, so it can be part of replacement decisions.

- Calculations of GhG avoided:
  - 25,000/1.99 = 13,158 gallons of propane
  - 4.2 pounds of propane per US gallon
  - 4.2 × 13,158 = 55,263 pounds of propane
  - 55,263/18 = 3,070 cylinders
  - 3,070 × 0.024 = 73.68 metric tons of CO_2 removed

WHAT CHALLENGES MIGHT THE CONVERSION POSE?

Assessing challenges and performance requires close cooperation with the member to collect the necessary data to make an accurate estimate of the benefits to the conversion. When it comes to associated costs, there are a number of factors that need to be addressed and emphasized with the member to avoid unpleasant "surprises" either during or following the conversion.

Characteristic of all beneficial electrification efforts is the fact that the member's electric bill will increase. While the total impact of the conversion should yield substantial offsetting benefits to the member, the electric bill is singularly visible and the increase needs to be communicated before, during, and after the conversion to reinforce the benefits gained.

Second, care must be taken to determine how the member operates. For example, if a cooperative has time-of-use rates, is there a potential for increases in electric use by dairy operations to coincide with times of peak electric demand and lead to a massive bill for the member? Understanding how and when the member operates the new equipment provides an opportunity to get creative with rate design, developing one that maximizes the benefit to both the co-op and the member.

Third, is the existing electric infrastructure serving the member capable of handling the increased load represented by the new equipment? For instance, some equipment may require or benefit from three phase service. The contribution from the new load must be matched against the costs incurred by the co-op to improve facilities to support it. This allows management to make the best decision for the co-op as a whole.

Fourth, the life of equipment can be quite long depending upon maintenance practices, operating environment, and the quality of the equipment purchased. As a result, once purchased, it will likely be a long time before equipment is replaced again. It is important for the cooperative to develop the necessary relationships with members, so it can be part of replacement decisions.

Aside from these more tangible potential issues are the less tangible:

- Preconceived notions regarding electric versus fossil fuel performance
- Decision makers being entrenched in old methods processing milk and milk products
- Existing relationships with equipment suppliers who prefer fossil fuel
- Lack of budget to move the project forward
- No local decision-making authority (e.g. corporate dairy operations)

Fortunately, most of these less tangible issues can be overcome during the sales cycle and with the use of accurate and compelling data documenting the benefits to the member.

HOW DOES THE COOPERATIVE MAKE THE SALE?

Success in using beneficial electrification to improve operational efficiency for member dairies and increase load for the co-op requires preparation, proper timing, trust, and the capabilities to design and deliver the proper solution for each member.

Preparation

The first step is the **identification** of all the dairy operations on the co-op's lines:

- Each dairy should be classified and ranked in terms of kWh use, revenue, payment history, and any other criteria the co-op feels important to include.
- Contacts at the dairy should be confirmed as current.
- List all other programs each member has participated in and technology involved.
- Work with trade allies to determine the local trends in equipment replacements; take the electric equivalent and estimate the size of the potential load available for conversion or retention.

Education of co-op personnel who will be contacting the members is essential. Education should include understanding:

- The issues and challenges dairies face and which are the most critical. Where does beneficial electrification fit within this ranking?
- The basics of water heating in milk production
- What alternatives are available
- How dairies make financial investment decisions
- Who the dairies turn to for advice on technical matters
- Need identification

When talking about educating personnel, this is not to imply that any become industry experts in dairy water heating operations. It is recommending that those individuals responsible for interacting with the member with the intent of replacing fossil fuel equipment with electric alternatives have a working understanding and are able to articulate their understanding using the correct terms.

Educational resources include university dairy programs, extension services, equipment vendors, and dairy associations. In researching this topic, the most beneficial information was gathered from the resources just named, especially university and extension sources. These two have a wealth of localized information and should be engaged as a partner when promoting these conversions. In addition, they likely already have existing relationship with the dairy operations which can be helpful to the overall process.

Timing and **trust** are somewhat more nebulous in terms of readying a program for implementation.

- Timing depends in large part on the individual financial situation of each dairy and their plans/feelings about making changes.
- Trust is generally high between members and their co-op because of the long-term relationship and the nature of the co-op business model. However, that trust may be limited to the provision of electric service and not extend to trusting the co-op for guidance in improving the water heating process. Listening carefully to the needs, concerns, and practices of the member and then bringing appropriate resources to bear will go a long way towards building trust in matters on the member's side of the meter.

ASSESSING BOTTOM LINE BENEFITS

Data necessary to provide an accurate assessment of the bottom line benefits the member can expect include:

- Operational goals
- Financial goals
- Issues with current water heating equipment
- How critical the water heating issues are relative to other challenges
- Goals concerning reduction of GhG and increasing energy efficiency
- Other intangible factors noted earlier in this article

Design and Deliver

Here is where strong relationships with universities, extension services, and trade allies come into play. When a member has been identified as a potential opportunity, the co-op needs to be able to put together the right team to address the unique needs of the member. The team might consist of the local Extension rep, the local equipment supplier, and an engineering firm — and for the next project, the mix might be different.

Having these relationships is important as it extends the capabilities of the co-op, bringing in the people with the detailed understanding of the performance benefits delivered by the electric heating options. Many manufacturers also have in-house design and sizing capabilities that can offset the need for the involvement of an engineering company.

It is important not only to learn from these resources (see **Education section** on previous page), but to keep them up to date on what the co-op is doing in terms of the beneficial electrification of dairies. These allies are looking to enhance their own relationships with the dairy operators and of course to make sales. As a result, when they are knowledgeable about the co-op's efforts, the number of eyes and ears in the field seeking opportunities increases dramatically.

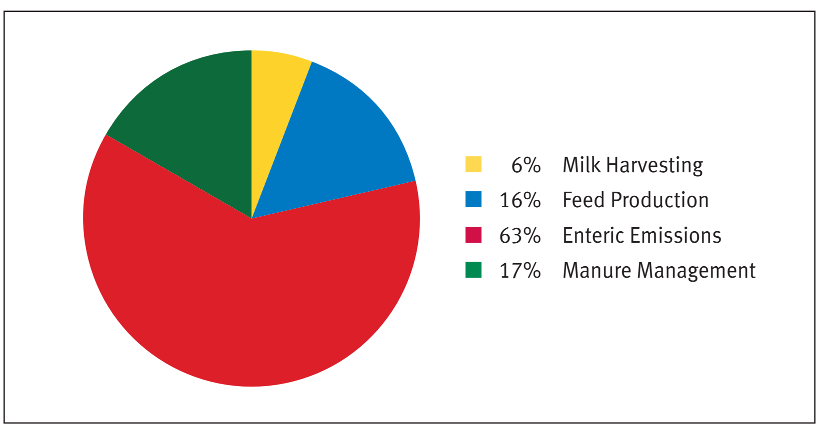

FIGURE 4: Contribution to Emissions by Source

Things that you would keep these allies up to date on include:

- Any incentives to offset equipment costs or reduce/eliminate any CIAC costs
- Special rates to further reduce costs or capitalize on renewable energy
- Processes for evaluating existing distribution facilities
- Any special terms and conditions

Working with trade allies is a proven method of extending the capabilities and effectiveness of the co-op's own promotional efforts, but a word of caution is warranted. These trade allies are in business to make the sale. If it is a bid situation, if there are fossil fuel alternatives in specifications, or if the ally feels the sale will be lost if they promote electric options, they are likely to go with the fossil fuel alternative.

WHAT DO COOPERATIVES NEED TO KNOW?

The cooperative needs to decide if the dairy opportunity in its service area warrants attention with respect to implementing a beneficial electrification program for water heating.

In addition, the co-op needs to evaluate how the opportunity meshes with strategic goals and other initiatives. For example, interest in the use of renewable energy in dairy operations is growing as operators seek to offset the GhG emissions that come from all operations (Figure 4[17]).

Is the projected addition to load and revenue sufficient to offset all related costs including rates, CIAC, incentives, and implementation?

Finally, are there regulatory hurdles or opportunities that need to be considered? There is growing recognition within various regulatory groups that replacing fossil fuel technologies with electric alternatives is an important way to reduce GhG.

[17] U of MN data from their research dairy operation, Appendix A

GOING FURTHER

The primary focus of this report has been on water heating for sanitation and washing purposes. In the course of researching the report, it became clear that there are a number of additional opportunities for beneficial electrification in dairy operations, as shown in Table 5 repeated from earlier in the report. Those opportunities are discussed in the Appendices to this report.

There is also an excellent reference online[18] that the co-op can use to explore in quite a bit of detail the other conservation/efficiency opportunities and lays out a basic dairy energy audit. ■

TABLE 5: Benefits of Efficient Electric Solutions

Challenge	Technology/Solution
Maintaining animal welfare in erratic weather patterns, especially heat and drought	Fans, misters, water reuse
Increasing productivity in winter months	LED lighting
Improving efficiency of operations	LEDs, VFDs on pumps and motors, heat exchangers, sanitation & cleaning methods
Meeting regulatory, environmental, and other requirements	All the foregoing, renewable energy, nutrient management programs,
Declining prices from overproduction, new competition internationally	All the foregoing

[18] http://www.milkproduction.com/Library/Scientific-articles/Management/Dairy-farm-energy-efficiency

APPENDIX A TACKLING THE EFFICIENCY CHALLENGE — UNIVERSITY OF MINNESOTA EXAMPLE

The University of Minnesota (U of MN) West Central Research and Outreach Center (WCROR) operates a dairy in Morris, MN that milks 250 head of cattle two times a day, representative of the size of a mid-size dairy operation in the American Midwest. According to their website:[19]

> *"The goal of our project is to increase renewable electric energy generation on Minnesota dairy farms by establishing a "net-zero" energy milking parlor. As the research goes forward, we are beginning to add new energy savings equipment, renewable energy production, and practices to help lower the energy requirements for our dairy operations."*

According to analysis conducted by the WCROR, energy use in milking operations breaks down in the operational categories shown in Figure 5. Emissions from milking operations break down as shown in Figure 6.

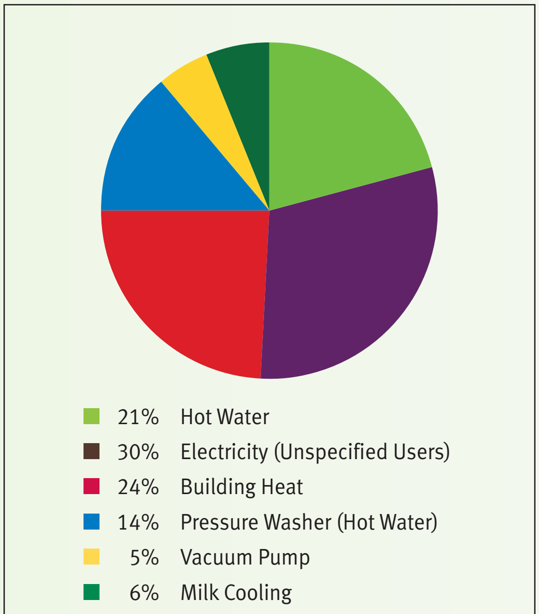

FIGURE 5: Energy Use in Milking Operations

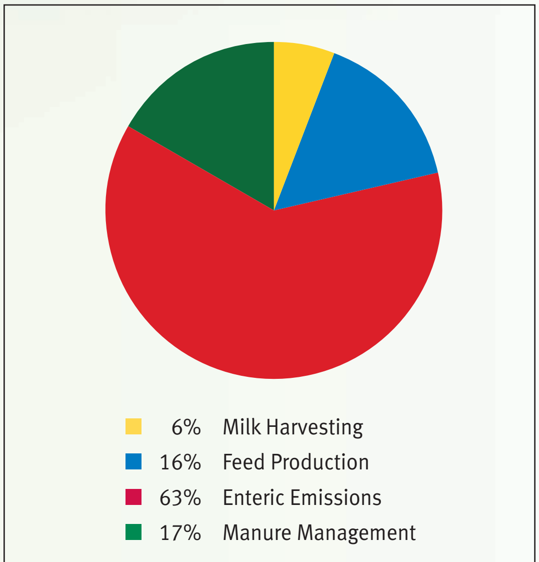

FIGURE 6: Emissions from Milking Operations

In terms of fossil energy use at the WCROR dairy, milking operations use more than feeding and herd management combined, suggesting room for improvement in terms of lowering emissions by utilizing renewable energy sources and more efficient electric technologies.

Two examples from the dairy involved replacing a standard vacuum pump with a VFD, and replacing a failed piston compressor with a scroll model. For the pump replacement, daily kWh use dropped from an average of 60 to 15 kWh, a reduction of 75 percent. In the case of the compressors, the new scroll model uses 15 kWh per day as compared to the remaining reciprocating compressor that uses 40 kWh daily, a savings of 62.5 percent.

The WOROC is employing wind and solar energy for onsite installations and have installed heat pumps for water heating, and are evaluating LED lighting for reducing costs and increasing herd productivity. ■

[19] http://www.extension.umn.edu/agriculture/dairy/facilities/energy-usage-carbon-emissions/index.html

APPENDIX B WATER REUSE – VIRGINIA TECH EXAMPLE

According to Shane Brannock, Manager of the Virginia Tech Dairy Science Complex/Kentland,[20] it pays to take care of the herd if for no other reason than stressed animals are less productive. Mr. Brannock stated the sources of stress for the herd include ambient temperature, feed adequacy, the conditions of the dairy, and disease. As a result, great care is taken to ensure as close to optimal conditions as possible for the cattle. Adequate water of the right temperature contributes significantly to animal welfare and productivity.

FIGURE 7: Kentland Milking Parlor

KENTLAND OPERATION OVERVIEW

- The operation uses 10,000 gallons of water daily for all purposes.
- Milk 250-260 head twice daily.
- Total herd size is approximately 550 head.
- Milk sampled for the presence of CFU. Average for Kentland is 2,500, maximum permissible is 70,000.
- Milk is stored in a refrigerated tank and picked up every two (2) days.
- Milk lines are cleaned following each milking.
- Alleys are flushed every four (4) hours. Note: *Flushing alleys is not a universal practice especially in areas with very cold winters.*
- 80 percent of the sand used in feeding area beds is recovered from the cells and lagoon operation and reused.
- Solids are used as fertilizer. Note: *their chemical content must match the existing soil chemistry.* In what is called a nutrient management plan. Here, nutrients used must match those naturally occurring to avoid soil chemistry imbalances.
- Electricity averages ~5 percent of total costs.
- Propane use peaks at 450 gallons per month during the winter.

Growing attention is being paid to the amount of water being taken from the water supply. Droughts in various areas of the country along with general concern for the long-term availability of water are increasing the focus on every type of water use. For dairy operations, there are numerous opportunities to reuse water. Even if the operation uses its own unmetered wells, water conservation and reuse makes sense.

[20] https://vaes.vt.edu/college-farm/facility-use.html

Continued

APPENDIX B WATER REUSE – VIRGINIA TECH EXAMPLE (CONT.)

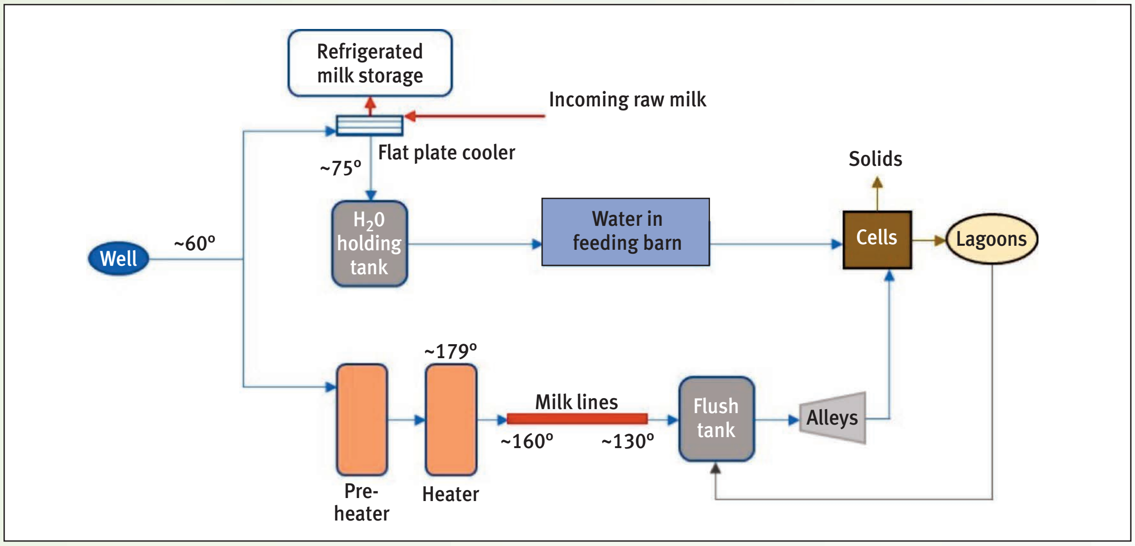

FIGURE 8: Kentland's Water Usage

Figure 8 illustrates how the Kentland facility uses its water.

As the diagram illustrates, the Kentland facility makes multiple uses of its water. Even though it has its own wells, Kentland is required to report water use daily to the State of Virginia.

Flush water is sent via gravity to a series of cells and lagoons. In the cells, solids are separated, along with 80 percent of the bedding sand, and the water is pumped into the lagoons. Following a settling period, the lagoon water can be reused for alley flushing or for crop watering. The bedding sand is reused and the solids serve as fertilizer following testing to be sure the nutrients they put into the soil match the nutrients that naturally occur. This last step is part of a nutrient management plan.

Herd Water and Animal Welfare

Cattle drink large quantities of water, on average about 4 to 5 gallons per gallon of milk produced. On average, a cow will produce 6 to 7 gallons[21] per day, or as high as fifteen (15) when lactation first begins. That equates to 24 to 35 gallons per head per day.

Cows actually prefer warm to cold water. The warm water is easier on their stomachs and keeps beneficial bacteria more active than when they consume well temperature water. When the cows are more comfortable (no stomach distress), they remain most productive.

Producing warm water for the herd to drink is not economical if done solely for that reason.

[21] https://www.midwestdairy.com/farm-life/common-questions

Continued

APPENDIX B WATER REUSE – VIRGINIA TECH EXAMPLE (CONT.)

However, reusing the water from the precooling process before it enters the storage tanks is an ideal option. Rather than pump it into a holding tank for use in flushing, as in the Kentland example, it could be pumped to an insulated tank for use in herd watering.

Reducing Water Use

Some studies are showing that the use of a cooler temperature flush before the high temperature sanitizing flush of milk lines produces better results. The cooler temperature first flush does not leave as much milk solids behind, which improves the efficacy of the hot flush. This reduces hot water demand.

Companies are also working on single cycle solutions that rely on specific chemicals to accomplish the flushing and sanitization. ■

[22] http://www.animalhealthinternational.com/getattachment/a387c3e9-95d7-4ec6-b27e-da2dd0a2704f

APPENDIX C ADDITIONAL DAIRY RESOURCES

http://www.milkproduction.com/Library/Scientific-articles/Management/Dairy-farm-energy-efficiency Detailed look at dairy energy conservation with farm audit at the end

https://www.ers.usda.gov/topics/animal-products/dairy.aspx USDA Dairy Stats

http://www.wadairy.com/blog/whats-all-that-water-for Water reuse information

https://mrec.org/agricultural-energy-efficiency Midwest Renewable Energy Council

https://www.ers.usda.gov/data-products/milk-cost-of-production-estimates.aspx Spreadsheet and information regarding the costs of cleaning dairy operations

http://www.milkproduction.com/Library/Scientific-articles/Milk--milking/Milking-machine-use-and-maintenance

http://membranes.com/docs/tsb/TSB202.pdf

https://www.cdfa.ca.gov/dairy/dairycop_annual.html

U of MN Details on the WOROR Operation

http://www.extension.umn.edu/agriculture/dairy/business

http://www.extension.umn.edu/agriculture/dairy/facilities

Cornell University

https://dairyextension.foodscience.cornell.edu/resources/food-safety/good-manufacturing-procedures/buildings-and-facilities Information on water temps, sanitation practices, etc.

U of WI

https://www.cdr.wisc.edu Center for Dairy Research

https://cdp.wisc.edu Center for Dairy Profitability

https://ces.uwex.edu Additional resources from the U of WI ■

About the Author

Tom Tate has been in the electric utility world for 25 years, working in various capacities for both IOU and cooperative operations and is well versed in the municipal business model. With experience in every member service, marketing, and sales management role, Tom discovered a passion and talent for writing about technology in a manner that makes complex concepts easily understandable for members and customers. Today, he runs his own freelance writing company and provides content for a number of cooperative and industry operations from his adopted home of Minneapolis, MN.

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- To find more resources on business and technology issues for cooperatives, visit our **website**.

BUSINESS AND TECHNOLOGY STRATEGIES
DISTRIBUTED ENERGY RESOURCES WORK GROUP

The Distributed Energy Resources (DER) Work Group, part of NRECA's **Business and Technology Strategies** department, dentifying the opportunities and challenges presented by the continued evolution of distributed generation, energy storage, energy efficiency and demand response resources. For more information, please visit www.cooperative.com, and for the current work by the Business and Technology Strategies department of NRECA, please see our **Portfolio**.