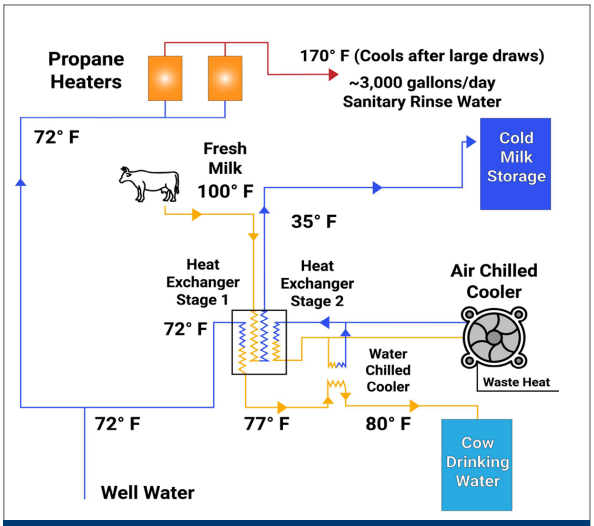
Webb Basin Dairy Case Study

Summary

This project demonstrates how dairies can reduce energy costs and increase operational efficiencies with a commercial heat pump water heater (HPWH) system. Webb Basin Dairy's existing propane water heating system was at the end of life and very costly to operate. To address this, the dairy installed a Colmac water source heat pump (WSHP), designed to meet four key objectives: reduce propane usage, reduce chiller energy consumption, reduce upfront costs, and reduce equipment downtime.

The propane savings exceeded expectations as the efficient electric WSHP completely displaced the propane load. The chiller savings fell short as the WSHP was optimized for sanitation water heating and not optimizing chiller performance. The project's payback period increased from an estimated 3.5 years to ~7 years because of additional upfront costs and bundled upgrades such as system controls and water softeners. Despite the longer payback, the system's combined Coefficient of Performance (COP) was ~4.9, which demonstrates the high efficiency and potential for WSHPs to provide substantial energy savings.

- **Total Project Cost:** $188,088
- **Annual Energy Savings:** 214,546 kWh
- **Annual Cost Savings:** $31,000



Baseline System Diagram.

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Project Overview

Located near American Falls, Idaho, in Raft River Electric's service territory, Webb Basin Dairy is a family-owned farm housing 1,600 cows. It requires ~3,110 gallons of hot water daily for sanitization. Like many dairy farms, it previously relied on propane. It used two 199,000 BTU/h propane heaters that charged a 400-gallon hot water storage tank and cost $1,400-$2,000 a month to operate. With design support from Bonneville Power Administration (BPA), Webb Basin Dairy implemented an efficiency upgrade using a Colmac WSHP. This innovation increased both the efficiency and productivity of the dairy by integrating its existing refrigeration and water heating systems.

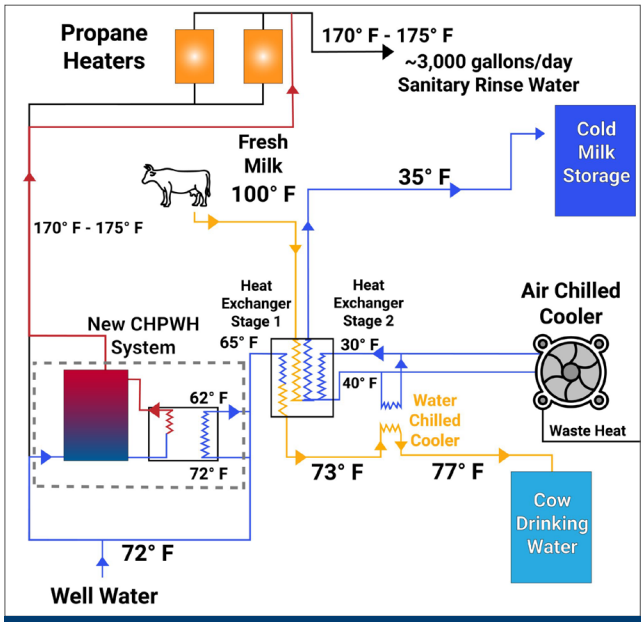
Original propane water heaters kept as backup.

System Design

The Colmac CxW-20 modular WSHP efficiently heats the water to 175°F. It was installed directly upstream of the dairy's existing propane unit, which remains in place as a backup heater. Paired with a 1,000- gallon storage tank, the WSHP effectively manages the demand for sanitary rinse water during milking cycles, ensuring there is always enough hot water available.

Webb Dairy uses the warm groundwater in four ways. First, the CxW-20 transfers heat and creates hot water heat for sanitizing milking equipment. Second, the cooled groundwater passes through a heat exchanger and pre-cools milk from 100°F to ~70°F. Third, it passes through condensers of water-cooled chillers that further cool the milk to 35°F. At this point, the milk is transferred to one of two milk storage tanks until it's ready for transport. Fourth, the groundwater provides a drinking water supply for the cows.

Before the retrofit, the warm groundwater was used to pre-cool the milk via the heat exchanger. In the final upgraded design, the WSHP system was plumbed upstream of the existing heat exchanger, allowing even cooler groundwater to more effectively pre-cool the milk. This design was the least disruptive for this dairy.



Improved System Design.

Commercial HPWH system with Colmac CxW-20.

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Other dairies can also adopt a similar efficient design integrating heat pumps, chillers, and variable frequency drives to optimize energy loads and operations. Regardless of climate or groundwater temperature, a WSHP can be used to pre-cool milk, heat sanitation water, and achieve chiller savings.

The CxW-20 was sized for the dairy's hot water demand of ~3,110 gallons per day. The inlet supply, a geothermal groundwater, maintains year-round temperatures of 70-75°F. To protect the WSHP from mineral scaling, four commercial-grade water softeners were installed.

Milk silos and refrigeration truck.

Measurement and Verification

A comprehensive monitoring system was installed to validate the WSHP system performance, including:

- BTU meters on hot and cold loops to monitor heat delivered and recovered.
- Flow meters and temperature sensors.
- Power meters on the WSHP and chillers.
- Centralized data acquisition system.

The system was monitored for a period of 12 months and confirmed that the Colmac CxW-20 WSHP reliably maintained hot water temperatures above 170°F during peak demand rinsing cycles with minimal performance variation. Annual electric energy savings were 214,546 kWh, which was lower than the originally projected 274,000 kWh due to design choices that limited chiller offset. Only 15 percent of the heat pump's cooling contributed to reducing chiller load as most of the cooling was used to pre-cool the groundwater and reduce propane water heating load rather than to directly cooling the milk. The total site peak demand increased by ~22 kWh because of simultaneous use of WSHP and chillers. Overall, the system operated reliably and eliminated all propane usage for water heating, which validated the improved system's success in meeting performance and energy reduction goals.

Conclusion

The retrofit system at Webb Dairy demonstrates that WSHPs can reliably deliver high-temperature water for sanitization. Given the rising costs in dairy operations, implementation of WSHP technology can help reduce operational expenses, maximize efficiency, improve profit margins, and increase dairy farm viability. The projected chiller savings were less than the original estimates because of design choices. The final design simplified installation, minimized operations disruptions, and performed reliably.

The measurement and verification results suggest future designs can be improved through chiller staging and alternative heat exchanger configurations. This project provides a scalable blueprint for other dairies and highlights the importance of optimizing the entire dairy operation as a holistic energy system.

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