Case Study

Load Shifting at a Meat Processing Plant

Key Opportunity

Peak loads can be reduced by pre-cooling the warehouse at night and allowing the temperature to rise slightly during the afternoon (within acceptable tolerances).

Peak demand savings potential: 200 kW

Expected cost: $25,000

Expected payback: 0.7 years

Applicability: This load shifting measure is expected to be widely applicable in the meat processing industry.

Introduction

The meat processing sector comprises mainly of livestock slaughter, carcass dressing, and packaging of meat products for retail sale. The industry relies heavily on hot water and steam for cleaning and sterilizing the carcasses, as well as refrigeration for cooling the carcasses before they are processed into prime cuts.

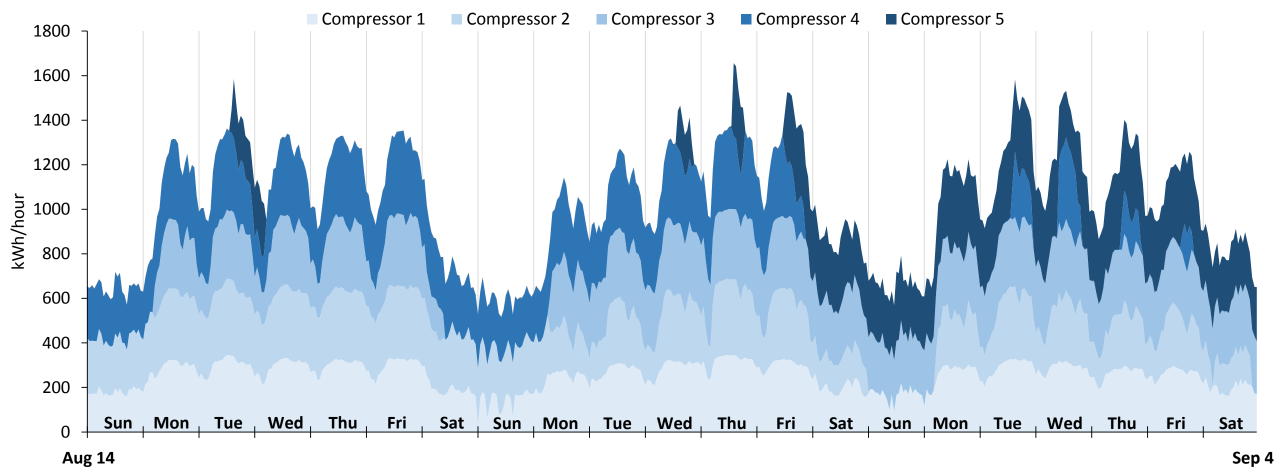
The Energy Pathfinder Research Initiative installed sub-meters at a meat processing plant to monitor the energy consumption of the following systems:

- Refrigeration compressors (5 sub-meters)
- Air compressors (1 sub-meter)
- Hot water (1 sub-meter)
- Motor control center (1 sub-meter)
- Mains (1 sub-meter)

Energy Analysis

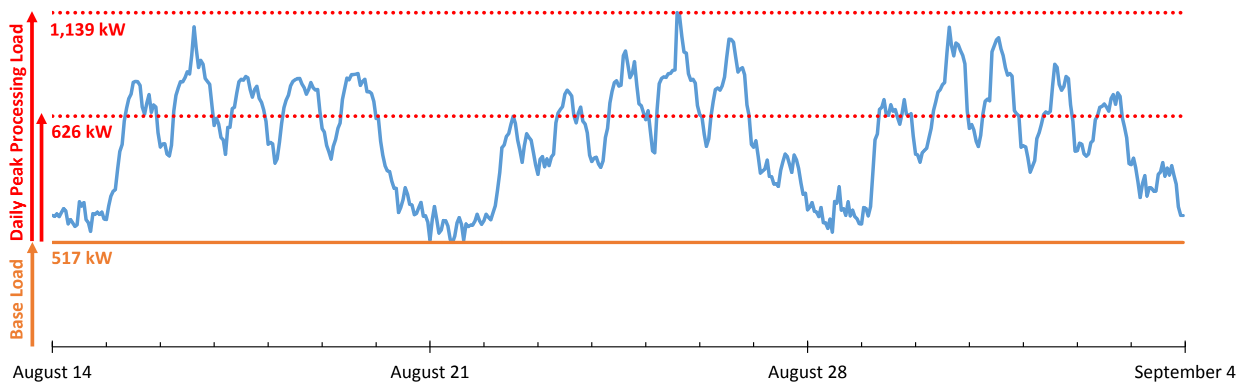
The largest electrical loads measured at the facility were the refrigeration loads. Exhibit 1 shows the load variation of each of the five individual refrigeration compressors over a three week period. The weekdays show an increasing load at the beginning of the day followed by a drop in the refrigeration load during the night shift, while the weekend loads remain fairly stable at base load. However, it should be noted that the overnight load between processing days exceeds the weekend load, indicating that significant heat is still being removed from carcasses within the warehouse between successive processing days. It is also evident that compressors 1-3 run nearly continuously while compressors 4-5 mainly come online only to meet peak refrigeration loads. All of the compressors have some variable load control but are limited to a slide valve control of the gas pressures.

Exhibit 1 Energy Consumption of Individual Refrigeration Compressors (kWh/hour)



To get a better understanding of how the refrigerant system works as a whole, the total refrigeration load can be broken down into two primary loads, as presented in Exhibit 2. First, a 517 kW base load reflects the energy consumption of the refrigeration system in the absence of any processing loads, and mainly consists of removing heat introduced to the warehouse via infiltration, ventilation, or heat transfer through the building envelope. Therefore, the base load is mostly driven by changes in outside air temperature and will rise and fall seasonally. However, it should be noted that the base load also includes the dead load of the compressors circulating refrigerant around the cooling system. The second primary load is the processing load, which entails cooling the livestock entering the warehouse from 95°F to 40°F over the course of two days. The peak daily processing load was observed to vary between 626 kW and 1,139 kW, likely as the result of variations in the quantity and size of livestock being processed each day.

Exhibit 2 Total Refrigeration Load (kWh/hour)



Opportunities for Energy Cost Reduction

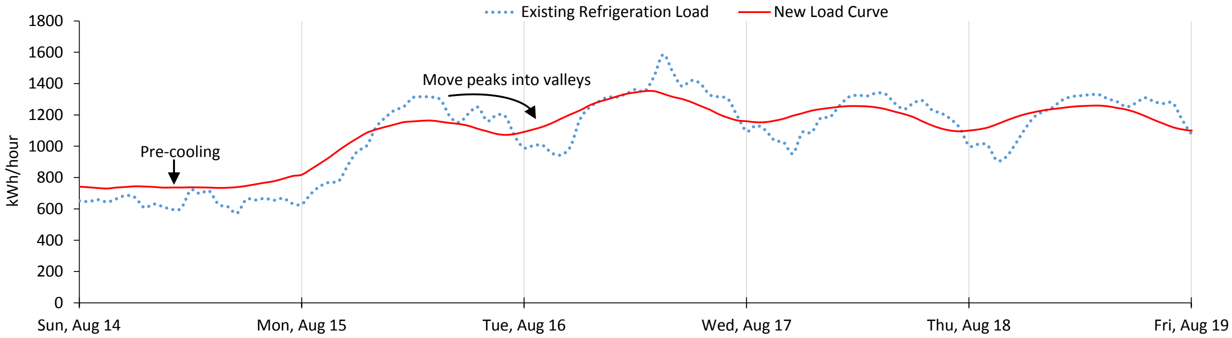
Load Shifting

Generally speaking, the refrigeration load is driven by the number of livestock being processed which in turn is set by the demands of the market, employment hours, cleaning cycles, and other business considerations. While time of use (TOU) pricing for electricity is not usually a large enough factor to change these business patterns, cost benefits can still be realized by changing the operating strategy of the refrigeration system without disrupting the established operating schedules of the business.

An emerging strategy for peak demand shaving and load shifting is the use of thermal mass as an energy storage device. In this case, the large size of the warehouse will moderate the load swings from daily temperature cycles (daily batches of warm product brought in to be cooled), as can be seen on the weekend periods where night to day patterns are not obvious. Therefore, pre-cooling the warehouse at night and raising the set-point temperature slightly (within acceptable tolerances) in the afternoon would result in a more even electricity demand profile and lead to lower energy costs by shifting energy consumption from high TOU rates to low TOU rates.

In order to execute the load shifting strategy, the plant will need to upgrade its existing slide valve controls to variable speed drives. This would allow for the implementation of a master control strategy for the refrigeration system, wherein the temperature set-points would be programmed to change depending on the time of day, resulting in a flattened daytime peak and a rise in night time consumption, as shown in Exhibit 3. With a monthly peak demand charge of $14/kW, the implementation of this low-cost opportunity could save the meat processing facility $33,600 annually.

Exhibit 3 Load Shifting Potential (kWh/hour)



Dead Load Reduction

The introduction of variable speed drives may also have an effect on the dead load, since the compressors are currently being cycled on and off to meet the refrigeration demand. Although the current system possesses some potential for load control through adjustments to the slide valve position, variable speed drives would more effectively increase and decrease the compressor capacity as needed to match demand. The resulting reduced power consumption would be most prominent during low demand periods such as the weekends and will be most noticeable in the base load profile.

Other influences on dead load are the ventilation, air infiltration, warehouse insulation, and cooling piping. Ventilation of the cooled areas should ideally include a heat exchanger between the incoming fresh air and the exhaust air to minimize additional cooling costs for make-up air brought into the cooled spaces. Reducing uncontrolled air infiltration will also lower the cooling load, as will maintaining the warehouse insulation and sealing any air leaks through the building envelope.

Exhibit 4 Summary of Energy Saving Opportunities

Opportunity	Capital Costs	Energy Savings (kWh/year)	Peak Demand Savings (kW)	Annual Energy Cost Reduction	Payback Period
Load shifting	$25,000	-	200	$33,600	0.7 years
Dead load reduction	$12,000	54,000	-	$7,500	1.6 years

How many energy efficiency best practices has your facility adopted?
Find out by downloading and completing the CME Pathfinder benchmarking survey (by clicking here). This Excel-based survey covers important best practices associated with process heating, process cooling, machine drives, HVAC systems, lighting, and compressed air. Completing the survey will provide your facility with insights into where it can focus its future efforts to improve energy efficiency.

CME Energy Pathfinder Research Initiative

The Energy Pathfinder Research Initiative is designed to explore, define, and quantify low cost opportunities to improve, control, or optimize specific end uses and energy intensive processes for selected industries within the Ontario industrial and manufacturing sector. The project is unique in that it ***focused on the identification of operational opportunities rather than upgrading inefficient assets*** and aims to identify new best practises for waste energy reduction, realigning energy consumption to correct drivers, and identifying opportunities for load shifting or shedding for lowering peak demand and demand response.

Prepared by **ICF** and
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