ENGINEERING
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Whitepaper | Supermarket energy savings

How supermarkets can **boost energy savings** with **proper rail heat control**

Rail heat, or anti-sweat, control, has been a part of supermarket control systems for years. But why is this energy saving feature often disabled or poorly set-up?

Learnings from the Danfoss Smart Store show significant energy saving potential all without compromising robust control at high humidity levels. At the same time, data shows that rail heat control alone cannot compensate for deficiencies in the design or control of the building HVAC-R system.

smartstoreadc.danfoss.com

Rail heat explained

Supermarkets aim to keep room temperature below 25°C, and most refrigerated display cases are designed for a maximum relative humidity (rh) of 60% (according to the EN ISO 23953 standard, Climate class 3 guidelines). If the relative humidity reaches the maximum level and the room temperature is at 25°C, condensate will rapidly accumulate on the display case's cold surfaces and glass. At room temperature below 25°C condensate is generated even before the relative humidity level reach 60%. This creates a few issues. One, it's difficult for consumers to see what's in the display case when the glass is clouded, and when they open the case, they risk getting wet. Two, and perhaps the most worrisome, condensate on the inside of the display case can cause bacteria to grow. If the water then drips down into the case, it can contaminate the food inside.

To prevent condensation, most display cases are designed with a type of heating element, which heats the display case rails and glass. This is known as rail heat.

A look at rail heat control in the Danfoss Smart Store

In the Smart Store, we have four groups of low temperature display cases controlled by eight AK-CC55 case controllers (See Figure 1, #21-28). According to specifications from the supermarket chain that operates our Smart Store, rail heat should be set with 30% pulsing at night and 80% during the day.

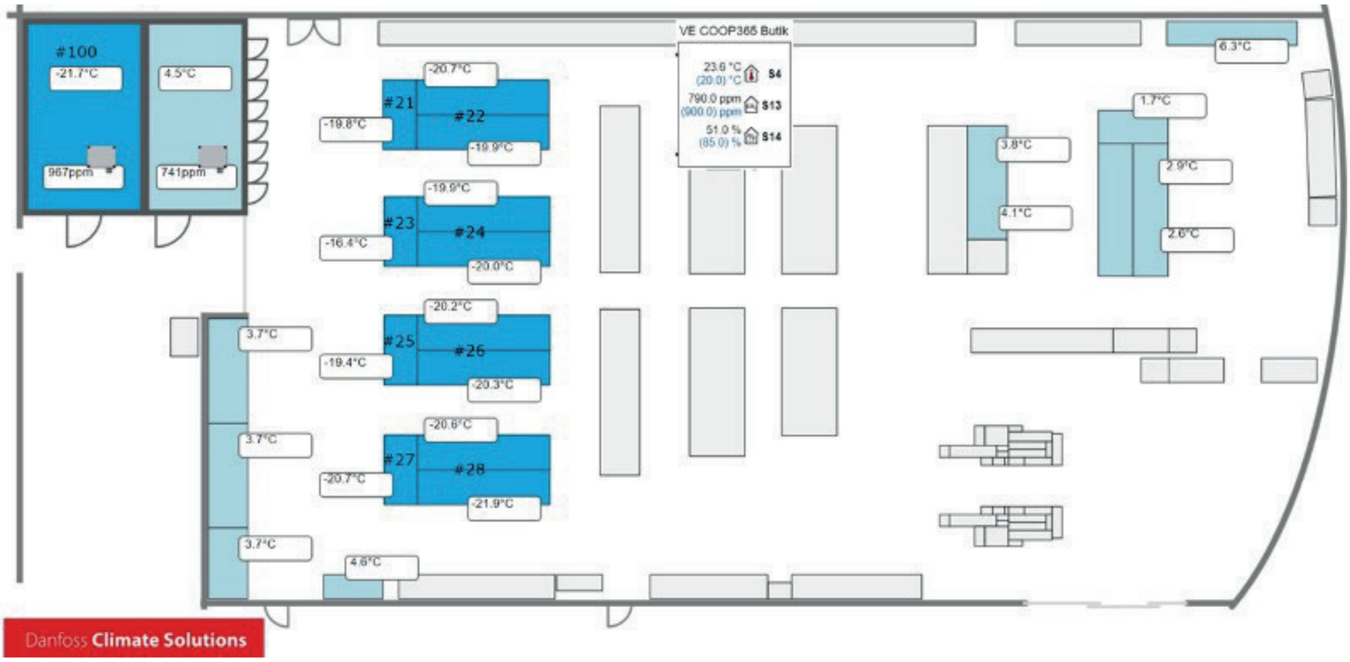

Figure 1.

In the summertime in Denmark, humidity levels are so high that we need to control rail heat at a higher level than the specifications. During the wintertime, on the other hand, humidity levels are so low that we can control rail heat at the minimum level, even during the day. To give us better rail heat control, we chose the dew point control mode in the case controller. This mode controls the rail heat intensity based on the humidity level and store temperature instead of fixed daytime/nighttime settings (see Figure 2).

o85 Railh. mode	Dewpoint ctrl.
o41 Railh.ONday%	80 %
o42 Railh.ONngt%	30 %
o43 Railh.cycle	10 min
o88 Rail Min ON%	30 %
o86 DewP Min lim	2.0 °C
o87 DewP Max lim	11.0 °C

Figure 2.

How much energy does rail heat consume?

If we look at the Smart Store's total energy consumption, low temperature display cases and low temperature cold room account for 14% of the overall energy used. Rail heaters account for a considerable portion of that 14%. (See Figure 3).

Store energy separation (1st half 2024)

Energy breakdown smart store (january - june 2024)

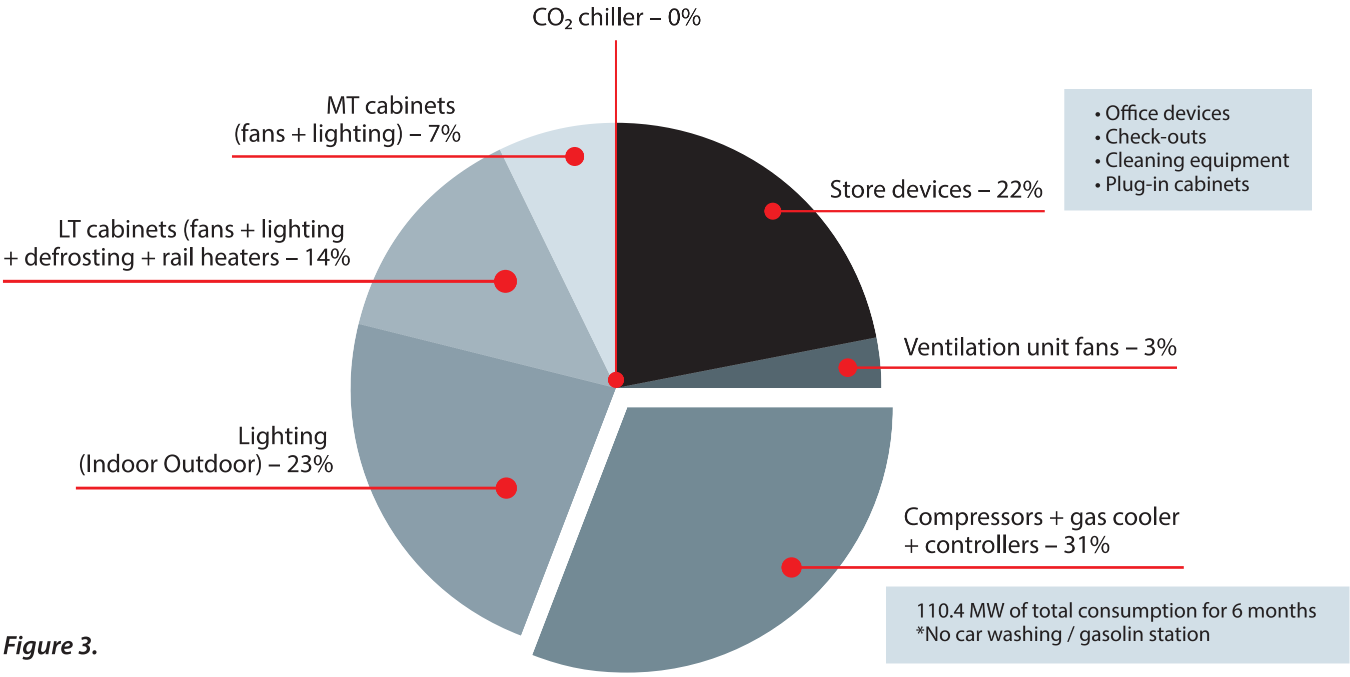

Figure 3.

In the Smart Store, we've installed 50 energy meters across electricity, hot water (for space heating) and chilled water (for air conditioning), and 3 meters for tap water. One of the electricity sub-meters is installed in front of the four groups of low temperature display cases (see Figure 1, #21-28) and the low temperature cold room (Figure 1, #100). This meter measures energy consumption for the fans, defrost, lights, rail heat and the controller/valve. By manually switching between 0 and 100% rail heat on the four groups of low temperature display cases, we measured the rail heat load at 2.6 KWh. This means that if rail heat is at 100% ON all year, the energy consumption for these four groups of low temperature display cases would be 22,776 KWh per year[1]!

As mentioned earlier, we need to control rail heat robustly when humidity levels are high. To find the robust setting, we set rail heat to minimum 100% on two groups of low temperature display cases (Figure 1, #25-28), while we controlled the other two groups (Figure 1, #21-24) using dew point control. By regularly comparing the moisture level in the display case where rail heat was set to 100% with the others with dew point control enabled, we could find the robust dew point settings for the minimum and maximum rail heat.

Based on this test, we set up rail heat control with a minimum 30% rail heat at 2°C dew point controlled proportionally up to 100% at 11°C dew point. Figure 4 shows the energy consumption results for the first eight months of 2024.

[1]2.6*24*365 = 22,776 KWh/year

	Avg Monthly Dewpoint	Avg Rail Heat	Consumption for Rail Heat 100% ON	Consumption for Rail Heat Dew point control	Saving compared to 100% on
	History data AK-SM880	% ON	% ON	KWh	KWh
January 2024	5.05	55%	1934	1064	870
February	5.65	60%	1747	1048	699
March	5.34	65%	1934	1257	677
April	7	70%	1872	1310	562
May	9.56	85%	1934	1644	290
June	10.21	90%	1872	1685	187
July	11.59	95%	1934	1838	97
August	11.98	95%	1934	1838	97
September	Estimated	90%	1872	1685	187
October	Estimated	75%	1934	1451	484
November	Estimated	60%	1872	1123	749
December	Estimated	55%	1934	1064	870
Yearly			22776	17007	5769

Figure 4.

Based on the estimations shown above, we estimate we can save at least 25% of the yearly rail heat energy consumption with our current settings when compared to a rail heat setting of 100% ON.

You need 15% more refrigeration energy to remove rail heat

In the period from November 13-20, 2023, we tested the energy consumption of rail heat at a minimum of 30% vs rail heat at 100% ON (See Figures 5 & 6).

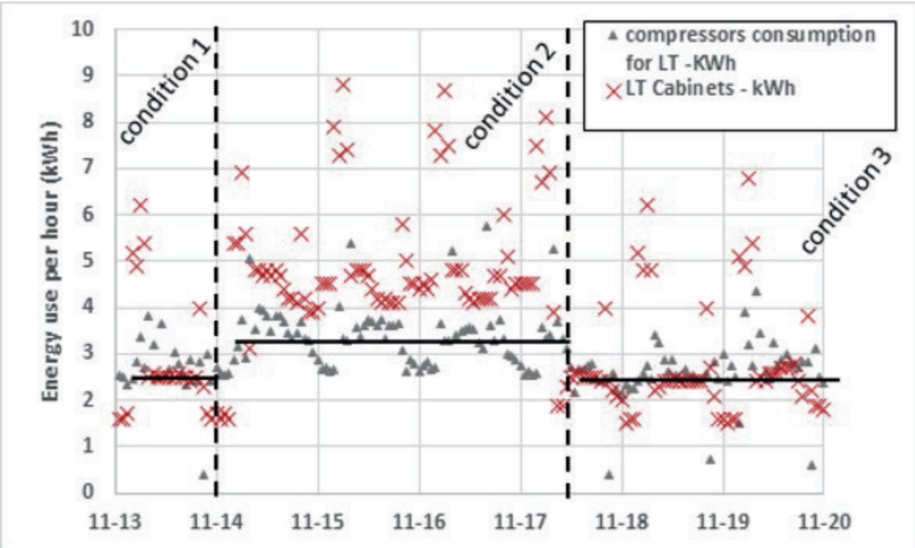

Figure 5. *Condition 1: Rail heat minimum 30%; Condition 2: Rail heat minimum 100%; Condition 3: Rail heat minimum 30%.*

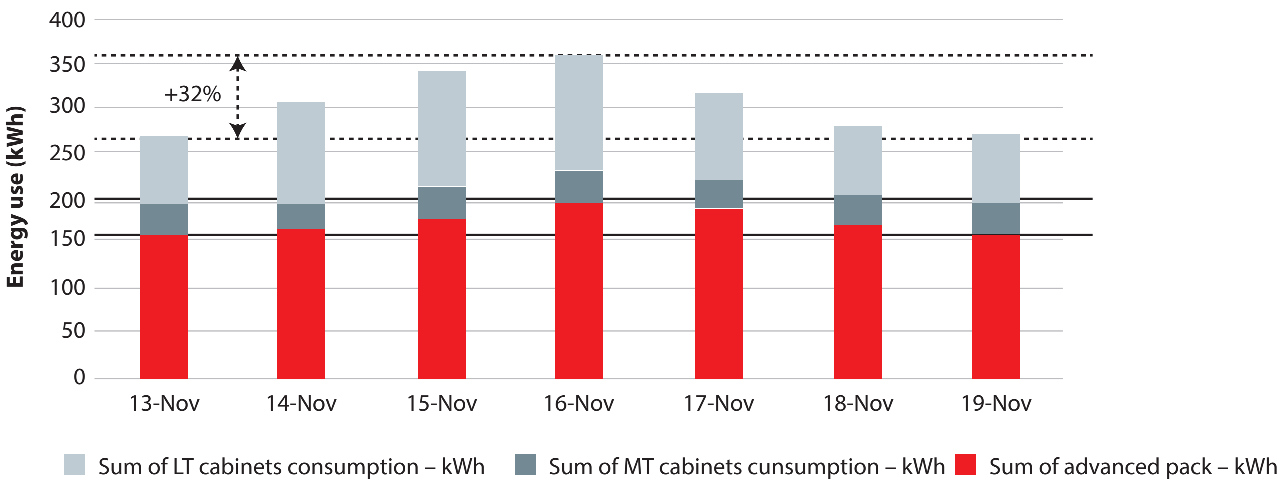

Figure 6.

When we measured energy consumption in the CO_2 refrigeration pack during the test period, we found that the pack used 15% more energy just to remove the extra heat generated from running rail heat at 100% instead of the minimum 30%!

As shown in figure 6, on the balance of refrigeration system energy consumption, cabinets and pack, we could save up to 32% energy on days running dewpoint control vs. 100% on.

Conclusion: Robust dew point control of rail heat saves energy

Overall, our test results show that supermarkets can save significant amounts of energy by using robust dew point control of rail heat, both in terms of rail heat's energy consumption and the total CO2 pack's energy consumption as well. By choosing this option, supermarkets can avoid paying for energy twice – once when they heat the rails and again when the refrigeration pack removes the heat from the display case.

The HVAC system design is just as important

The tests we ran at our Smart Store also taught us a valuable lesson about the importance of HVAC system design. On the display cases where rail heat was set at minimum 100%, we observed condensate on the glass surfaces when humidity levels reached 60% rh. Since we had already activated dew point control, and it was controlling rail heat at 100%, there was nothing more we could do from a rail heat standpoint.

What often mistakenly happens in supermarkets when condensate is observed on glass surfaces is that a service engineer simply overrides the dew point control by setting minimum rail heat at 100%. Ideally the HVAC system should be investigated, ensuring minimal ingression of humid air and optimal control considering desiccant wheels and other efficient control methods. Perhaps because the refrigeration service engineer has no access to the HVAC system and vice versa?

Author - Ejnar Luckmann, Technical Manager, Danfoss Smart Store ADC.

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