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Retrofit for Sustainable Supermarket Refrigeration

Strategies for reducing your total equivalent warming impact and growing your bottom line

By Andre Patenaude
Director — Solutions Integration
Emerson

Perhaps more than any time in history, supermarket operators are re-evaluating their legacy refrigeration systems. Retail market drivers — including regulatory mandates, sustainability objectives and the emergence of e-commerce fulfillment models — are dictating changes to refrigeration architectures. But when implementing refrigeration retrofits to meet sustainability objectives, food retailers must remember that this effort is a two-sided coin.

Because refrigerant leaks can result in direct emission of greenhouse gases (GHGs), supermarket owners/operators often focus primarily on the transition from hydrofluorocarbons (HFCs) with high global warming potential (GWP) to alternative refrigerants with lower GWP. While this is a critically important step in any retrofit, many often overlook the energy efficiency of the system or its potential for indirect GHG emissions.

According to the Environmental Protection Agency (EPA), supermarkets are the most electricity-intensive of all commercial buildings[1]. Among facility systems that consume electricity, commercial refrigeration systems account for 40–60 percent of supermarket energy consumption — and are by far the greatest contributor to indirect GHG emissions[2]. Combined, direct and indirect emissions make up the true measure of sustainability, or a system's total equivalent warming impact (TEWI).

But remodeling comes at a cost, and food retailers also must ensure their investment delivers long-term viability and returns to their bottom line. The Department of Energy (DOE) estimates that every dollar saved in electricity is equivalent to increasing sales by $59[3].

Today, most supermarkets still utilize large, centralized direct-expansion (DX) refrigeration rack systems that have been in operation for more than a decade. Even so, owners and operators have opportunities to retrofit these systems to meet their sustainability objectives while maintaining a familiar operational footprint. In a competitive retail market with slim profit margins, retailers need options that provide the lowest possible cost per GWP reduction.

Transition to lower-GWP refrigerants

Considering today's global environmental concerns, the transition away from high-GWP refrigerants and those with ozone depletion potential (ODP) is all but inevitable. Legacy refrigerant options such as the common HFC R-404A will be phased down, while hydrochlorofluorocarbons (HCFCs) such as R-22 are being phased out. But that doesn't necessarily mean end users must immediately transition to an alternative refrigerant that forces a complete refrigeration rebuild.

Lower-GWP A1 refrigerants, like hydrofluoroolefin (HFO) blend R-448A/R-449A, are available that would allow end users to retrofit their existing system, reduce GWP from direct emissions by 60 percent, and maintain a very low operational footprint, very similar to the one they have today.

For those using R-22, the transition to R-448A/R-449A is relatively straightforward and requires very few substantive architecture changes, other than making minor system adjustments such as proper superheat settings. In addition, compressor capacity using these A1 alternatives is comparable to R-22 in medium-temperature applications. However, it's important to use the approved lubricants from the compressor's original equipment manufacturer (OEM) and consult with their guidelines for specific retrofit procedures.

The transition from R-404A to R-448A/R-449A is slightly more involved but can still be accomplished without significant architectural changes. R-448A/R-449A produces compressor discharge temperatures that run approximately 10–12 percent higher than R-404A[4]. This may require additional compressor cooling mitigation such as head cooling fans, demand cooling modules, or a liquid or vapor injected scroll compressor. Thermal expansion valves (TXVs) may need to be changed and refrigerant charges may need to be updated. Consult your compressor OEM's guidelines for specific retrofit procedures.

Whether you're transitioning from R-404A or R-22, these refrigerant retrofit options allow operators to preserve their existing investment while transitioning to a much lower-GWP refrigerant — and a much lower potential for direct emissions.

Upgrade for energy efficiencies

The other side of the refrigeration retrofit coin is to reduce indirect emissions by improving refrigeration energy efficiencies. While it makes sense to undertake this in conjunction with a refrigerant transition, energy optimization best practices can — and should — be performed periodically on all systems.

This process starts by performing a system assessment to determine your current performance baseline. It's very common for refrigeration systems to drift steadily from their original performance baselines after commissioning. So before considering any retrofit options, make sure the system is operating as efficiently as possible.

On its own, recommissioning a system back to its original factory specs — by fixing any underlying issues and re-establishing setpoints — can deliver significant energy efficiency improvements up to 20 percent (specific savings will vary per system). It is also a best practice to implement a formal measurement and verification (M&V) program during the recommissioning process. M&V programs provide the data needed to potentially qualify for energy incentive and rebate programs should you need to replace or upgrade inefficient equipment with newer, energy-efficient models.

The next step in the energy optimization process is to enable a variable-capacity modulation strategy to ensure maximum energy efficiencies. This is accomplished by either upgrading to a digitally modulated compressor or adding a variable-frequency drive (VFD) to a fixed-capacity compressor. *Note: VFDs can be added to legacy Copeland™ Discus and Copeland Scroll™ fixed-capacity compressors (refer to AE21-1369 R4 Application Engineering Bulletin).*

Variable-capacity modulation provides significant system improvements, not only to energy efficiency but also to overall refrigeration system performance, reliability and lifespan. Benefits include:

- Precise matching of capacity to changing refrigeration loads
- Tight control over suction manifold pressures, allowing increased setpoint and energy savings
- Improved case temperature precision
- Reduced compressor cycling (on/off)

In a typical rack system, the ideal candidate for replacement is most often a fixed-capacity compressor that is either underperforming or is the smallest displacement compressor in the low- and/or medium-temperature rack. This compressor is then replaced by a variable-capacity digital compressor (such as the Copeland Discus Digital) to serve as the lead compressor.

Replacing an underperforming, fixed-capacity compressor with a variable-capacity compressor can result in an additional 4 percent energy savings — even before activating digital modulation capabilities. And once digital modulation is activated, operators can expect an additional 12 percent energy savings (see sidebar).

Digital retrofit case study[5]

To test the validity of these prescribed energy-saving measures, Emerson performed recommissioning and digital compressor upgrades on a 20-year-old, 45,000-square-foot retail store. Each step of the process delivered the following results:

- ***System recommissioning —*** led to an **18 percent reduction** in energy costs
- ***Replacing one fixed-capacity compressor —*** on the low- and medium-temperature racks with a digital compressor delivered **additional 4 percent energy efficiency improvements**
- ***Activating digital modulation —*** netted an **additional 12 percent energy efficiency gain**
- ***16 percent reduction in energy —*** from digital compressor retrofits delivered roughly **$17,000 a year in energy savings**
- ***Rebate qualifications —*** total energy improvements met qualifications for a local energy incentive program

Energy management controller optimization

To maximize refrigeration system energy efficiencies, operators should connect their new digital compressors to a facility/energy management controller. Emerson's E2 or Site Supervisor utilize specific algorithms designed to provide optimum control over digital compressors and optimize refrigeration system performance, including:

- Enhance suction control to stabilize suction pressure
- Advanced circuit control of cases and main breakers[6]
- Condenser control of up to four condenser fan groups containing up to eight total condenser fans[6]

It is important to remember that other types of energy management controllers are not designed for maximum digital capacity optimization and may not be as effective in controlling digital compressor operation. In supermarkets that already utilize their own legacy energy management control systems and/or sensors, the E2 can be retrofitted to assume control over these legacy platforms to:

- Enhance the energy efficiencies of digital compressors
- Lower total facility energy costs
- Optimize HVAC (rooftop unit and demand control ventilation) and lighting

In fact, even without swapping out a fixed-capacity compressor with a digital compressor in each rack, E2 upgrades have shown more than 10 percent energy improvements[7] while providing all-important leak management capabilities. E2s are designed for flexible integration, providing forward- and backward-compatibility to controls infrastructures.

Determine your path forward

As we move into an uncertain regulatory future, supermarket refrigeration retrofits provide retailers with an opportunity to lower their TEWI without having to invest in a completely new system. Whether you are considering a retrofit or looking to remodel with an emerging, lower-GWP architecture, Emerson can help you make the best decision and estimate retrofit and remodel costs per total GWP impact reduction. We also can help you calculate how to achieve both your environmental and economic objectives while providing a clear path toward your future refrigeration system.

References

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