

A New Way to Boost Transcritical Efficiency

At a Whole Foods store in San Jose, Calif., a transcritical CO₂ system using an absorption chiller outperformed other natural refrigerant systems

By Elise Herron

In a study of five systems installed at stores in California, Whole Foods Market – one of the leading users of natural refrigerant systems in the U.S. – determined that a transcritical CO₂ system equipped with a lithium bromide absorption chiller was the most efficient across a range of locations.

The findings were presented last month by Tristam Coffin, director of sustainability and facilities for Whole Foods Market, in a webinar hosted by the Environmental Protection Agency's GreenChill Partnership. Coffin was joined by Mike Harvey, engineer for DC Engineering, and Tom Wolgamot, principal, DC Engineering.

In June, at the 2017 ATMosphere America conference in San Diego, Coffin and Wolgamot presented a similar presentation about the efficiency and performance of different natural refrigerant-based system architectures in California Whole Foods stores.

Coffin said that building type and climate zone are the two most important considerations when deciding which type of refrigeration system to use. He added that the many microclimates in California make the state an effective place to conduct case studies on how different systems work in varied environments.

He is a firm believer that there is no one "silver bullet" solution for every store.

STORE COMPARISONS

The five Northern California stores using natural refrigerants all opened between 2013 and 2016, within a 40-mile radius of each other. They include:

- » A four-year old cascade system, with CO₂ on the low side (DX for low temperatures and liquid overfeed for medium temperatures) and R407A on the high side, at a Castro (San Francisco) location.
- » A three-year old transcritical CO₂ system with an air-cooled gas cooler at a Berkeley location.



Tristam Coffin,
director of
sustainability and
facilities,
Whole Foods
Market

- » A two-year old cascade system with R717 (ammonia) on the high side and a Castro-type CO₂ arrangement on the low side at a Dublin (Bay Area) location.
- » A year-old cascade system with R290 (propane) on the high side and a Castro-type CO₂ arrangement on the low side at a Santa Clara location.
- » A three-year old transcritical CO₂ system with a de-superheater (subcooler) via an absorption chiller (driven by waste heat from combined heat and power) for high-side heat rejection at a San Jose location.

At the ATMosphere America presentation, Coffin and Wolgamot included a store in Fremont, Calif., using an R407A DX system as the baseline.

The study showed that the transcritical system at the San Jose store – which was able to remain in subcritical mode when the absorption chiller was in operation – was more efficient than any of the other systems across a range of temperatures. It was significantly more efficient than the standard transcritical system in Berkeley and the cascade systems using ammonia and propane, and slightly more efficient than the cascade systems using R407A.

For example, at 60°F, the San Jose system consumed 1.0 kWh/MBH while the Berkeley system used 1.75 kWh/MBH. At 80°F, the numbers were 1.75 and 2.50, respectively. At 70°F, the San Jose system was at about 1.3 kWh/MBH, compared to 1.5 for the R407A/CO₂ cascade system and about 2.1 for both the ammonia and propane cascade systems.

In a look at projected energy use, the San Jose system was less than the baseline R407A baseline system at 65°F, 1.25 to 1.4; even at 90°F, they both consumed the same energy (1.75).

Coffin noted that other technologies that enhance the efficiency of transcritical systems include parallel compression, ejectors, adiabatic condensers and other types of subcooling.

Coffin also stressed the importance of calculating the Total Equivalent Warming Impact (TEWI) of refrigeration systems, which include both indirect emissions from power consumption and direct emissions from refrigerant leaks. Systems with high-GWP HFCs have much higher TEWI values than natural refrigerant systems.

"I think there's a lot of important detail that goes into the energy analysis," Coffin said. "But it's important that we're looking at TEWI, and our impact overall from both direct emissions and indirect emissions. Natural refrigerants emit about 1,500 times less CO₂e than R407A."

He also noted the importance of reliability. "Obviously the major end-goal is to sustain operations for the folks that are intending to sell broccoli in the stores," Coffin said.

Coffin compared the costs of the natural refrigerant-based systems with the baseline R407A DX system. He found the R407A/CO₂ cascade system 10% higher, the transcritical systems about 60% higher and the cascade systems with ammonia and propane more than 100% higher.

While natural refrigerant-based systems cost slightly more than the baseline store on average, Coffin said the price difference is starting to narrow as installations become more widespread.

"Generally speaking," he added, "on the transcritical side of things, we've seen that come down significantly in the last two to three years."

In closing his ATMOSphere presentation, Coffin



Tom Wolgamot,
principal, DC
Engineering

advocated for more widespread adoption of natural refrigeration systems. He hopes to bring more people to the table discussing implementation and optimization of these systems.

"Custom systems are going to come at a premium," he said, "but standardization and wider adoption is really going to drive the cost down.

"It's in large part the reason why I'm really encouraging folks to get out there and take these presentations, and the lessons that you've learned and bring them to the folks that aren't at the table so that we can hopefully have them sitting at the table next year and in days to come" ■ EH

NATIONAL RECOGNITION

One of the benefits of being environmentally minded is recognition from federal partnerships like EPA's GreenChill program.

"As a GreenChill partner [Whole Foods has] 10 platinum certifications, five gold and six silver certifications currently," said Tristram Coffin, director of sustainability and facilities for Whole Foods Market, during a 2017 ATMOSphere America presentation. "We're hoping to increase those numbers every year. Energy efficiency, and overall reduced consumption, is really one of our major end goals."

The GreenChill certification program, according to the EPA's website, "recognizes individual stores for using environmentally friendlier commercial refrigeration systems."

And Whole Foods recently earned yet another GreenChill award, which was presented at Food Market Institute's Energy and Store Development Conference in Orlando, Fla. in September. This time the award was for Store Re-Certification Excellence – which recognizes supermarkets that have renewed GreenChill store certification for five consecutive years.