

Volume 3 Number 2



E360 Outlook

Balancing All Aspects of the
Commercial Refrigeration Industry

Navigating the New Refrigerant Landscape

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impacting commercial refrigeration

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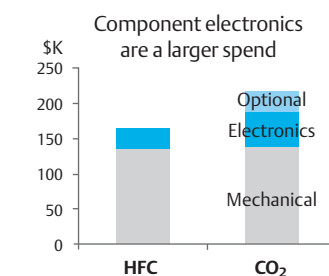
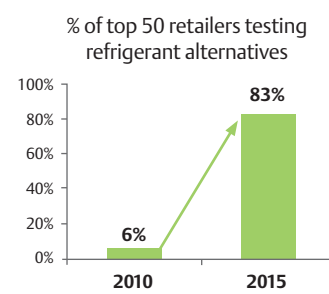
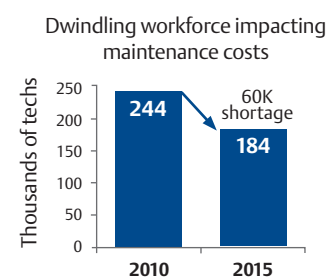
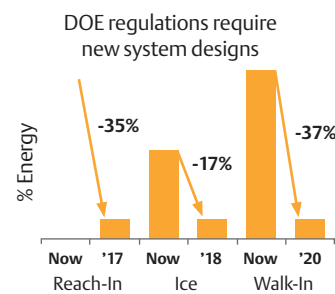


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Emerson's E360 platform was launched to emphasize the importance of meaningful dialogue in the commercial refrigeration industry to address current challenges.



FIRST WORD



by DON NEWLON

The Wheels Are Set in Motion

For the past few years, Emerson has closely watched regulatory developments as they've unfolded. Through our E360 stewardship efforts, we've helped provide clarity on the broad implications of these regulations and started an industry-wide conversation about how to best tackle their many related challenges. Now, with March 2017 marking one of the most significant deadlines impacting commercial refrigeration — the Department of Energy's (DOE) efficiency mandate on stand-alone equipment and the Environmental Protection Agency's (EPA) requirement to halt usage of R-404A in new supermarket racks — the wheels of change and progress are most certainly in motion.

As we've discovered along this journey, stakeholders throughout our industry are impacted differently by this transition. And, in this edition of *E360 Outlook*, we have two clear examples of how operators and OEMs are responding to the challenges before them.

First, there's the case of New Seasons Market, whose pledge of environmental sustainability has led to the installation of an all-natural, CO₂-based refrigeration system that helped earn them a GreenChill Platinum Certification by the EPA. Their energy-efficient, environmentally friendly CO₂ system is one of several of its kind being deployed in supermarkets across North America.

Then, there's the story of JSI Store Fixtures, a specialty manufacturer of stand-alone commercial refrigeration display units who chose to take a proactive approach to meet both EPA and DOE requirements in the same design cycle. Working closely with Emerson's Design Service Network (DSN), the forward-thinking manufacturer chose one of the EPA's newly listed A1 refrigerant alternatives to get out in front of their 2019 regulation, a decision that will impose little to no disruptions to its customers' current operating procedures.

While these are only two examples of the many options available to operators and OEMs today, they are also indicative of Emerson's commitment to helping our customers implement solutions that most closely align with their unique objectives. Whether it's through the design, engineering and testing assistance of the DSN, the continued stewardship of our E360 initiative, or the two Helix Innovation Centers respectively located at the University of Dayton and Georgia Tech, Emerson will continue to offer the guidance and assistance that our customers and partners need to make the most informed decisions for their businesses.

Don Newlon, Managing Editor, E360 Outlook
V.P./G.M., Refrigeration Marketing, Emerson

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Navigating the New Refrigerant Landscape

How the global HFC phase-down is impacting commercial refrigeration



By Dr. Rajan Rajendran

Vice President, System Innovation Center and Sustainability
Emerson





The commercial refrigeration industry is undergoing a massive transition in the types of refrigerants that can be used across a wide range of applications. At the heart of this shift is an environmental initiative to limit the use of hydrofluorocarbon (HFC) refrigerants with high global warming potential (GWP) and replace them with lower-GWP synthetic and natural alternatives. In the U.S., the Environmental Protection Agency (EPA) has spearheaded this effort through its Significant New Alternatives Policy (SNAP), which set forth an HFC “change of status” schedule in its landmark ruling in July 2015.

This regulation created a ripple effect throughout the commercial refrigeration industry, mainly because the refrigerants identified for a status change from “acceptable” to “not acceptable” were among the most commonly used, including: R-404A/507A, R-410A, R-407A/C/F and HFC-134a. Among these, R-404A/507A has the highest GWP of 3,922. These HFCs comprise the complete spectrum of commercial refrigeration applications, from supermarket racks, remote condensing units and walk-ins to low- and medium-temperature, stand-alone units. In other words, virtually every

refrigeration application will be impacted by this ruling, sometime between January 2017 and January 2020.

In September 2016, the EPA finalized a second ruling that broadened the HFC change of status into additional commercial refrigeration and air conditioning applications. With these new applications now included, the HFC impact schedule was extended into the 2024 time frame.

But this HFC initiative extends well beyond U.S. borders. In May 2014, the European Union’s F-Gas regulation went into effect, calling for refrigerant GWP reductions down to 150 in self-contained and centralized refrigeration applications by 2022. Environmental Canada (EC) has developed its own F-Gas proposal that also calls for significant reductions.

And, in October 2016, the Kigali Amendment to the Montreal Protocol—an international treaty that was originally formed in 1987 to protect the stratospheric ozone layer from damage caused by chlorofluorocarbon (CFC) refrigerants—formed a consensus among 197 countries to progressively phase down HFC refrigerants over 30 years. This amendment, which has yet to be approved or implemented, provides a degree of certainty that this global effort will continue for the foreseeable future.

What’s the alternative?

So, as many of the industry’s common refrigerants are targeted, the question on everyone’s mind is, “Which new refrigerants will replace them?” As part of its SNAP rulings, the EPA has also put forth a list of refrigerant alternatives. Since the 2015 ruling, the agency has published subsequent updates that deem certain new and natural refrigerants as “acceptable for use, subject to use conditions” in specific applications. Many chemical manufacturers are currently working with the EPA to get their new synthetic refrigerant blends placed on this list of emerging alternatives.

Outside of GWP considerations, refrigerants are typically evaluated by their operating performance (pressure or capacity) and safety classification as defined by the American Society of Refrigeration, Heating and Air-Conditioning Engineers (ASHRAE). To govern the safe use of refrigerants, ASHRAE has designated safety classifications that denote varying degrees of toxicity and flammability. Refrigerants used in commercial refrigeration generally fall into the following four categories:

- **A1:** lower toxicity; no flame propagation
- **A2L:** lower toxicity; lower flammability
- **A3:** lower toxicity; higher flammability
- **B2L:** higher toxicity, lower flammability

Many of the refrigerants targeted for phase-down are classified as A1 refrigerants, and were widely adopted due to their performance characteristics. But, in light of the current regulatory climate, the environmental qualities of these refrigerants were deemed unacceptable. However, to limit the amount of changes to refrigeration equipment and system architectures, their performance characteristics are used as a baseline for the development of a new class of lower-GWP alternatives. In fact, some new synthetic refrigerants are even designed to be “near drop-ins” to their higher-GWP counterparts, requiring minimal equipment and application design changes.

Synthetic blends

Leading chemical manufacturers have answered the call for alternative A1 refrigerants, starting with the development of a series of lower-GWP synthetic blends (HFC/HFO) that the EPA has already listed as acceptable for use. R-448A/449A and R-449B are among the “R-404A like” (medium-pressure) options, while R-513A and R-450A are “HFC-134a like” (low-pressure) substitutes. These all have relatively lower GWPs than their HFC counterparts, ranging from 350 to 1,300.

These manufacturers also have several “future proof”, very low-GWP

Updates to safety standards underway

To help ensure the safe use of A2L and A3 refrigerants, national and international governing bodies are currently evaluating safety standards and charge limits. These efforts include:

Review A2L safety standards:

- U.S.: UL 1995, ASHRAE 15; target date is late 2017
- International: ISO 5149, IEC 60335, EN378; target date is late 2017

Update building codes:

- Building codes for mildly flammable (A2L) refrigerants are being expedited for adoption in the 2021 code cycle

Evaluate A3 charge limits:

- U.S.: raising the A3 charge limit from 150g to 300g–500g

Flammable refrigerant study:

- \$5.2M partnership by AHRI, ASHRAE and DOE to study flammable refrigerant behavior in real-world applications

options (<150) currently undergoing the EPA’s SNAP approval process. However, to achieve extremely low GWP levels, these HFO blends all fall under the A2L (mildly flammable) classification. As such, studies are currently underway by the governing bodies to develop safety use standards for this emerging class of refrigerants (see Safety Standards side bar). Among the medium-pressure alternatives include R-455A, R-454C and R-457A, while HFO-1234yf/ze and ARM-42

comprise the low-pressure refrigerant options. As these compounds navigate the EPA approval process, look for future SNAP ruling updates to verify their specific use parameters.

Natural refrigerants

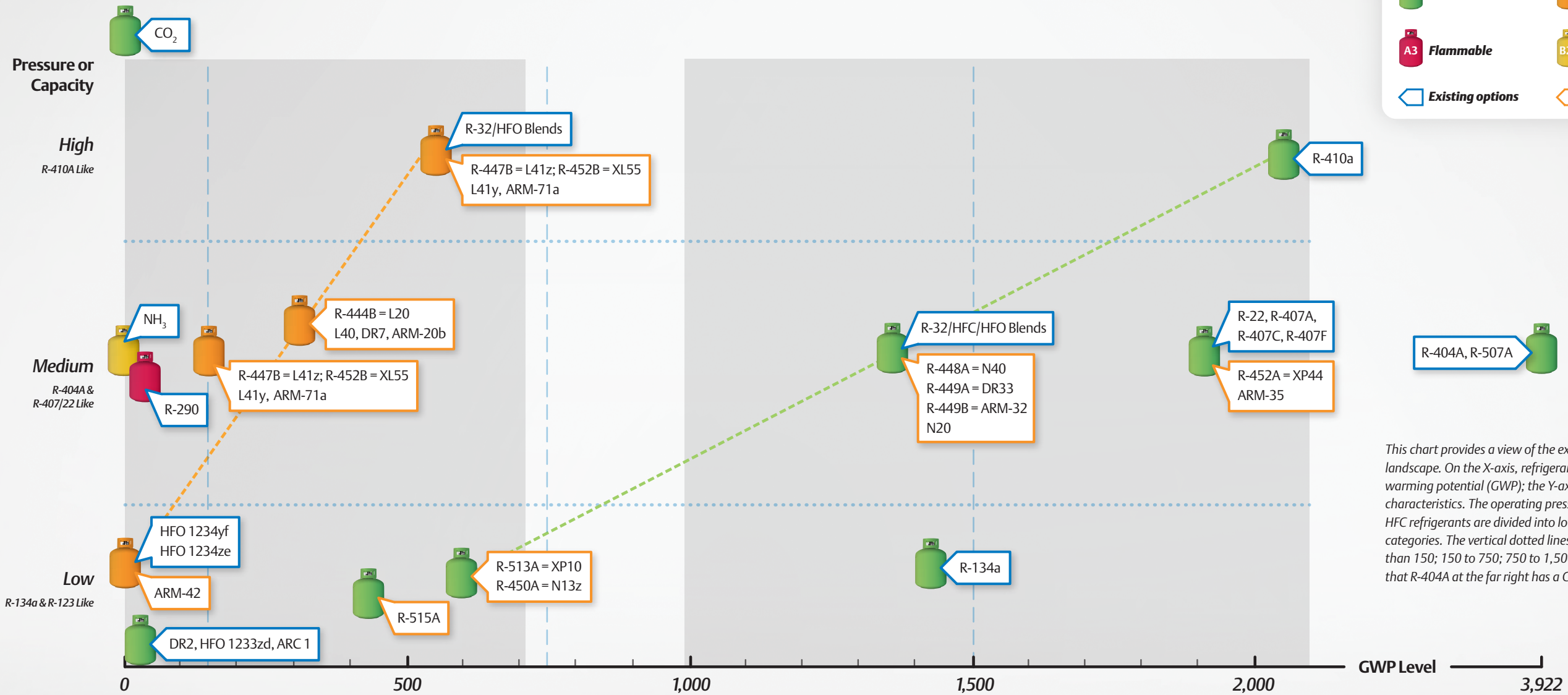
Aside from these synthetic blends, there are also a few high-performance natural refrigerant alternatives that are not only very low-GWP options, but acceptable for use per the EPA’s SNAP ruling. Ammonia

EPA’s Final Rule, July 20, 2015: HFC Phase-out Schedule

Phase-out Refrigerant	*Final Rule: July 20, 2015								*Final Rule: September 26, 2016				
	Super-market New	Super-market Retrofit	Remote CDU New	Remote CDU Retrofit	MT <2,200 BTU/hr. and not contain flooded evap. New	MT >2,200 BTU/hr. with or without flooded evap. New	LT New	LT and MT Retrofit	Refrigerated food processing and dispensing equipment New	Cold storage warehouses New	Ice machines Retrofit	Very low-temp. refrigeration New	Positive displ. chiller New
R-404A/507A	Jan. 1, 2017	July 20, 2016	Jan. 1, 2018	July 20, 2016	Jan. 1, 2019	Jan. 1, 2020	Jan. 1, 2020	July 20, 2016	Jan. 1, 2021	Jan. 1, 2023	OK	OK	Jan. 1, 2024
R-410A	OK	–	OK	–	Jan. 1, 2019	Jan. 1, 2020	Jan. 1, 2020	–	Jan. 1, 2021	Jan. 1, 2023	OK	OK	Jan. 1, 2024
R-407A/C/F	OK	OK	OK	OK	Jan. 1, 2019	Jan. 1, 2020	Jan. 1, 2020	OK	Jan. 1, 2021	R-407C/F: OK R-407A: Jan. 1, 2023	OK	R-407C only	Jan. 1, 2024 R-407C
HFC-134a	OK	OK	OK	OK	Jan. 1, 2019	Jan. 1, 2020	OK	OK	OK	OK	OK	–	–

*Chart shows the compliance dates by which targeted refrigerants for phase-down must comply and the range of applications affected. Note that these rulings apply only to new and retrofit systems as designated; pre-existing systems are not affected.

Emerging Refrigerant Options



This chart provides a view of the existing and emerging refrigerant landscape. On the X-axis, refrigerants are evaluated per their global warming potential (GWP); the Y-axis measures pressure or capacity characteristics. The operating pressures of today's commonly used HFC refrigerants are divided into low-, medium- and high-pressure categories. The vertical dotted lines denote the ranges of GWP: less than 150; 150 to 750; 750 to 1,500; and greater than 1,500. Note that R-404A at the far right has a GWP of 3,922.

(NH₃ or refrigerant name R-717), propane (refrigerant name R-290) and carbon dioxide (CO₂ or refrigerant name R-744) are all refrigerants that occur naturally in the environment and have a long history of use in refrigeration applications.

Ammonia has excellent thermodynamic properties and was among the first refrigerants used in refrigeration applications. As a B2L refrigerant, R-717 use requires careful adherence to safe application procedures. Ammonia's suitability in low-temperature applications has made it a mainstay in industrial, process cooling, cold

storage and ice rink applications. Today, some environmentally conscious supermarkets are trialing all-natural NH₃/CO₂ cascade systems to significantly reduce their carbon footprints.

Propane is a hydrocarbon that was also identified in the early days of refrigeration as a high-capacity, energy-efficient refrigerant with superior performance characteristics. The advent of synthetic A1 refrigerants moved the industry away from R-290. But since the 2000s, R-290 has been regaining global popularity as a lower-GWP, effective alternative to HFCs

such as R-404A and HFC-134a. R-290 applications typically have a charge limit of 150 grams, making it especially well-suited for a wide range of low-charge, reach-in display cases. Regulatory bodies that govern refrigerant safety standards are currently evaluating expanding its charge limits (see Safety Standards side bar).

CO₂ is a non-flammable and non-toxic refrigerant that has proved a very effective alternative in both low- and medium-temperature applications, especially in regions with lower ambient temperatures. Its low critical point and high operating

pressure (around 1,500 psig or 103 bar) dictate that CO₂ refrigeration strategies must be designed to account for these unique characteristics. CO₂ cascade, secondary and transcritical booster systems have been successfully deployed in commercial and industrial applications in Europe for nearly two decades. Recent environmental regulations have driven the wider adoption of these systems in North America.

A fluid situation

The EPA's 2015 refrigerant ruling marked the beginning of a major transition for the U.S.

commercial refrigeration industry. While several new A1 alternatives have been introduced as viable in some applications, there is still quite a bit of work needed to meet the needs of the wide range of refrigeration applications and achieve desired reductions in GWP. Globally, the industry can expect continued regulatory activity in the coming years, especially with the introduction of new lower-GWP alternatives.

It's also important to remember that many operators are also stating corporate sustainability objectives, while others wish to put an end to compliance concerns once

and for all. To implement truly "future proof" refrigeration systems, many operators are trying to limit their carbon footprint with refrigerants that do not exceed the 150 GWP threshold. Today, natural refrigerants are the best way to achieve this goal, even though they present their own unique operating challenges. As A2Ls make their way through environmental regulations and safety standard approvals, operators will have a broader range of options from which to choose.

It remains to be seen which refrigerant alternatives will become the go-to options of the future. 🌍

Going With the Grain

Specialty wood fixture refrigeration
OEM exceeds regulatory mandates

When it comes to complying with Environmental Protection Agency (EPA) and Department of Energy (DOE) regulations, OEMs of self-contained commercial refrigeration equipment were among the first to face this challenge. But when you're an OEM whose core principles are based on environmental sustainability — e.g., JSI Store Fixtures of Bangor, Maine — clearing these regulatory hurdles is just the cost of doing business.

So, in 2014, when the DOE mandated 30–50 percent reductions in energy consumption on stand-alone commercial refrigeration equipment by March 27, 2017, leadership at JSI saw the new efficiency standard as an opportunity to revamp its refrigeration platform. Duane Hallowell, JSI's director of refrigeration, said that the regulation was in alignment with the goals of the company's commercial refrigeration business unit.

"While we were eager to get out in front of the regulatory deadline, we were even more motivated by the prospect of reducing energy for our customers," said Hallowell.

The OEM began working with its component suppliers in 2014 to begin the design, testing and DOE certification processes. At the same time, the EPA proposed the phase-out of commonly used HFCs in stand-alone commercial refrigeration equipment — a ruling that would become final in the summer of 2015 with a



JSI fixtures help to improve the presentation of a grocer's produce section while preserving food quality.

compliance date of 2019. For OEMs like JSI, this presented a design dilemma: comply with each regulation separately or combine compliance efforts into a single design cycle.

Hallowell said that Emerson's stewardship in the regulatory arena, combined with its proven expertise in compressor and electronic controls technology, helped enable the JSI team to tackle both DOE and EPA compliance requirements in the same design cycle. JSI tapped the resources of Emerson's Refrigeration and Integrated Products group to develop an optimized, high-efficiency condensing unit that would serve as the basis of its wooden refrigeration fixture platforms.

The condensing unit features Emerson components, including: compressor, flow control and unit controller to facilitate tighter refrigeration control and an efficient assembly process into JSI's refrigeration equipment. To make sure the new units met required energy objectives, JSI also utilized the DOE test validation and certification services of Emerson's Design Services Network (DSN).

"We needed a partner that understood the two sides of this equation and could lead us down both paths in parallel," stated Hallowell. "We worked closely with all our component suppliers to make sure we were using the best equipment available to meet these challenges," he added.

Completion of design, testing and certification

By the end of Q4 2016, JSI had completed the DOE certification process on 46 of its standard products, well ahead of the 2017

deadline. The effort required the commitment and dedication of the OEM's strategic suppliers and partners, including an electronically commutated evaporator fan motor manufacturer, a third-party testing provider and Emerson's DSN resources. In addition, JSI invested in an in-house testing facility where its units were ultimately rated for final certification.

To get out in front of the EPA's HFC refrigerant ban in 2019, JSI opted to design its new stand-alone units to be "R-448A ready" — as the industry waits for the EPA to list new refrigerants R-448A/449A as acceptable for use through its Significant New Alternatives Policy (SNAP) program. Hallowell said this decision was based on a desire to align with the general direction the industry was heading and not impose difficult operating and servicing requirements to their customers.

"There's still no clear leader in the new refrigerant race, but with Emerson's guidance, we thought R-448A seemed to make the most sense and would cause the least disruptions to our customers' current infrastructures," said Hallowell. Until the SNAP listing is received, JSI continues to use R-404A in the production of its products today.

Hallowell added that once they had achieved the energy efficiency threshold, completing the certification and submittal process proved to be equally challenging. Per DOE standards, this required the building of an alternative efficiency determination method (AEDM) database on the new equipment. Each base model had to be tested twice, and any variations to these models had to be

documented. And since JSI also sells to customers in Canada, they were tasked with complying with Natural Resources Canada as well. The final step in the process was registration in the DOE's compliance certification management system (CCMS) database — a step that must be completed for qualifying models each year.

Hallowell said that without the support of Emerson's DSN and other provider partners, completing this process

would have been nearly impossible.

"When you stop and think about all that's required — electrical safety, sanitation listings, DOE compliance, EPA readiness — covering all those bases is not something many smaller OEMs are equipped to handle," explained Hallowell. "For other OEMs going through this process, I would urge them to lean on the expertise and best practices of their own supplier networks," he added. 🌱

Carving out a green niche in commercial refrigeration



JSI is a relatively recent entrant into the commercial refrigeration market. The company's background in wood store furnishings for merchandising enabled them to quickly carve out a specific niche in refrigeration. In just a few short years, this niche has led to an ever-expanding customer base that spans the continental United States and extends north into Canada. Grocers use JSI's beautiful, eye-catching display cases to improve point-of-sale product merchandising and preserve food quality. From the careful

selection of wood types and grains to decisions impacting a fixture's design, JSI considers every detail when producing these state-of-the-art refrigeration units.

When Hallowell joined the company in 2013, JSI was just beginning to formalize their refrigeration offerings. Since that time, he has helped the company implement lean manufacturing principles to improve production efficiencies and develop strategic partnerships with leading component suppliers to leverage their technologies and insights. These

actions have led to the development of standardized product lines with an increased emphasis on quality, all while keeping costs down for their growing customer base. With a doctorate in environmental sustainability and background in refrigeration, Hallowell is committed to instilling these core values in the company's refrigeration division.

Hallowell explained that the process of achieving regulatory compliance translated into a 300 percent increased investment in engineering resources.



Natural Born Chillers

Grocer's new CO₂ refrigeration system earns EPA GreenChill award



Natural refrigerant adoption is on the rise, and supermarket retailers are leading the charge. Driven by corporate sustainability objectives and the desire to achieve EPA and DOE regulatory compliance, these forward-thinking operators are turning to environmentally friendly options like CO₂ to reduce their carbon footprint. Such is the case with New Seasons Market, a northwestern U.S. grocer that was recently awarded the EPA's GreenChill Platinum Certification in its newest store for installing a transcritical CO₂ booster system.

New Seasons partners with local farmers, ranchers and producers to offer the best of the region, and sells these homegrown, organic favorites along with grocery store staples. With 20 locations in the states of Washington, Oregon and California, the chain's recently launched 37,000-square-foot store in Mercer Island, Wash., was the first to earn this distinction from the EPA.

According to Beau Butler, New Seasons' director of construction and facilities, the new refrigeration system represents the fulfillment of a sustainability goal.

"We are very proud and honored to receive this award from the EPA's GreenChill Partnership. We have been wanting to do a 'greener' refrigeration system project, and the Mercer Island store provided us the opportunity to do so by installing a transcritical CO₂ refrigeration system, which removes HFCs from our store and reduces our business' carbon footprint," Butler stated.

100 percent natural refrigeration

The all-natural transcritical CO₂ refrigeration system is based on the Hussmann Purity platform, featuring Emerson's compression and system controls technology.

The New Seasons construction team partnered with its



engineering firm, CTA, to ensure that the natural CO₂ refrigeration system met all of its sustainability objectives. The system uses one transcritical CO₂ rack paired with a roof-mounted gas cooler. The gas cooler utilizes energy-efficient, low-velocity, variable-frequency drive (VFD) fans to reduce overall energy usage. The transcritical CO₂ rack consists of six compressors — three of which are low-temperature Copeland Scroll Digital™ CO₂ compressors — with digital capacity modulation to provide energy-efficient refrigeration for the entire store. The system is charged with 1,100 pounds of CO₂ (R-744).

Managing the system is Emerson's E2 RX refrigeration controller, complemented by Emerson case controls in the store fixtures.



Together, these tools enable the ease of system setup while ensuring the ongoing performance optimization of the transcritical CO₂ refrigeration system. The E2 RX utilizes sophisticated control algorithms to maintain consistent temperatures throughout the store, thereby minimizing product shrink and preserving food quality. These controls also generate error messages

to minimize compressor downtime and increase asset life. Seamless integration with monitoring and remote service offerings further reduces operational costs.

The Mercer Island store is located at the site of a former Albertsons supermarket that used an HFC refrigeration system. The EPA GreenChill Platinum Certification recognizes New Seasons' efforts in revamping the store's refrigeration system to a CO₂ architecture and reducing refrigerant emissions by at least 95 percent.

While CO₂ is an extremely efficient refrigerant, the key difference between traditional HFC and CO₂ systems is operating pressures. Typical CO₂ systems have operating pressures two to three times higher than standard HFC systems. The higher pressures require more robust piping and components, resulting in slightly increased first costs. But over the long term, these costs are offset by installation savings, reduced maintenance, lower cost of refrigerant and improved energy efficiencies — all with a much smaller equipment footprint. By comparison, a direct-expansion HFC refrigeration system would have required three racks with 15 compressors, and three roof-mounted condensers.

The success of the Mercer Island store has opened the door for additional CO₂ systems in the near future. New Seasons is

planning the construction of two new stores in 2018 that will also rely on a transcritical CO₂ booster system architecture.

“This is our first transcritical CO₂ system, but hopefully will not be our last,” said Butler.

Emerson CO₂ solutions

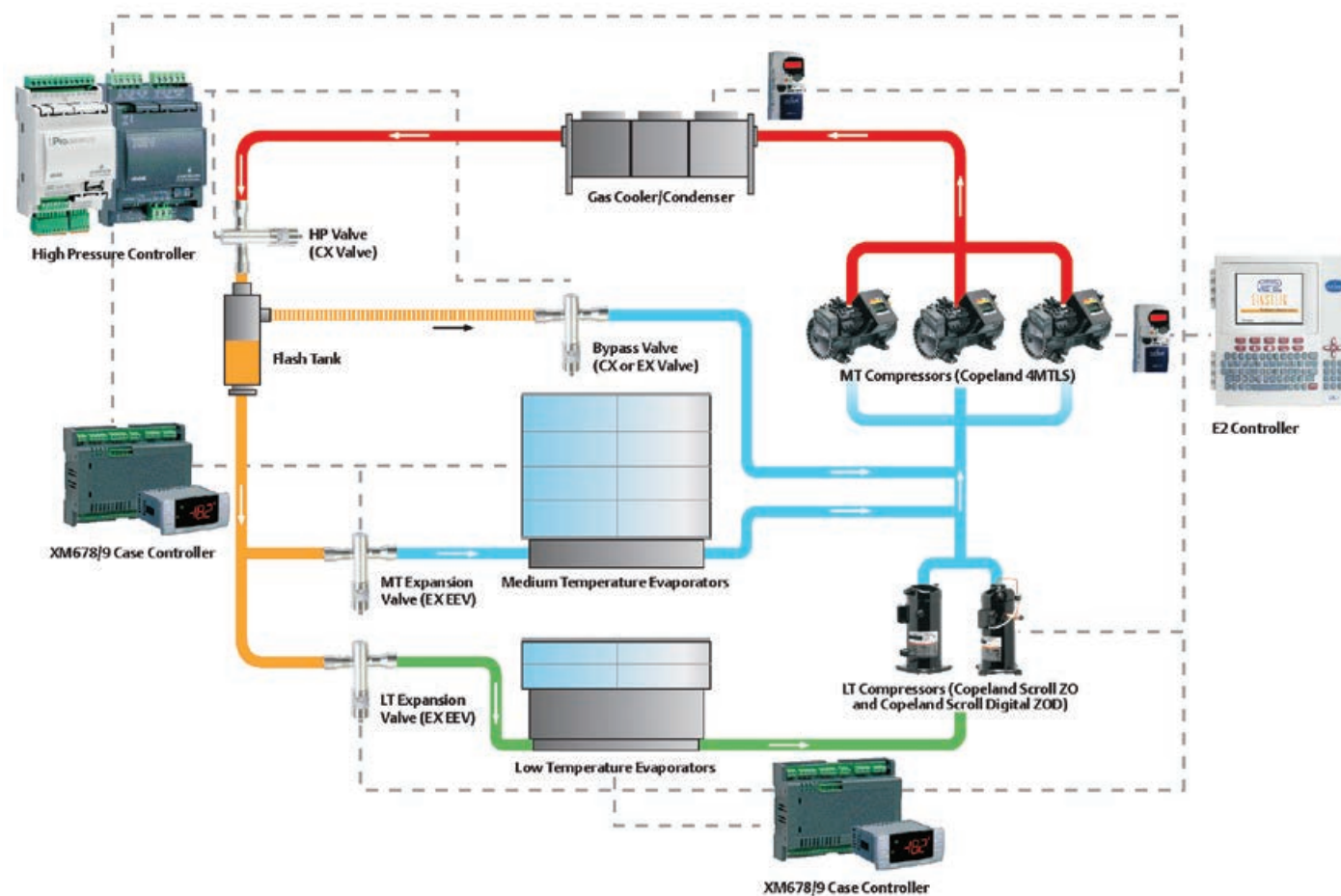
Mercer Island is an example of Emerson’s comprehensive solutions for environmentally friendly CO₂ refrigeration applications. Emerson offers a unique advantage by providing customers with a suite of CO₂ components consisting of compressors with piston and scroll technologies, on-board compressor electronics, digital capacity modulation, flow controls and electronic controllers. For supermarket operators seeking high operational performance, safety and increased system uptime, Emerson provides complete transcritical CO₂ booster and hybrid system technologies.

To learn more about our complete CO₂ system product portfolio and identify what you need to make the move to CO₂, check out our CO₂ Information Tool at Emerson.com/CO2.

Transcritical CO₂ booster system benefits

- Near-zero GWP refrigerant delivers up to 30% lower total equivalent warming impacts (TEWI)
- Completely natural refrigerant solution
- Lowest total cost of ownership solution
- 95% less refrigerant emissions compared to previous HFC system
- Minimal greenhouse gas emissions
- Superior energy efficiency

Transcritical CO₂ booster system



New Refrigerant Alternatives Available Today



The transition to the new lower global warming potential (GWP) refrigerants is underway. Since the Environmental Protection Agency's (EPA) 2015 decision to change the status of hydrofluorocarbon (HFC) refrigerants, commercial refrigeration equipment manufacturers have been busy qualifying their equipment for use with a growing list of acceptable refrigerant alternatives. End users will soon have to choose which new refrigerant will be the basis of their new refrigerated equipment platforms.

Selecting an alternative refrigerant is no easy decision. From installation and servicing requirements to performance, environmental and economic impacts, there are a number of factors to consider — including the complexities of the regulatory climate. Not only do the specific change of status dates vary among the different classes of equipment, there are multiple refrigerant options available with each specific application. As these dates approach, we expect that the EPA will continue to introduce through its Significant New Alternatives Policy (SNAP) program new synthetic alternatives that offer incremental reductions in GWP levels.

It's a lot to keep track of, and easy to see why the refrigerant issue — including past, current and future options — has proved particularly difficult for our industry to sort out. To help you analyze the available options and evaluate how they will impact you, we've assembled a list of refrigerant alternatives per commercial refrigeration application, as defined by EPA equipment classifications.

Regardless of potential updates to environmental regulations in the coming years, Emerson will continue to closely monitor all regulatory activity and keep you informed of their implications. These updates will likely introduce lower-GWP alternatives — such as the A2Ls discussed herein — that will help the industry continue to evolve toward more energy-efficient and lower life cycle climate performance (LCCP) systems and fluids. There's no question that the timing of the HFC status changes will continue to present challenges throughout the commercial refrigeration supply chain. Emerson will continue to keep an eye on these developments and provide guidance about which refrigerants are available to help you make the transition.

Future A2L alternatives

Currently, all the A2L refrigerants are still in the "future alternatives" category. This is because none have yet to be listed as acceptable for use in commercial refrigeration applications by the EPA. While various chemical manufacturers will be submitting these blends for SNAP approval, it's important to remember that a degree of flammability is a result of attempts to reach the very low GWP levels of these refrigerants.

A2L	Refrigerant designed to replace	GWP
ARM-25	R-404A	< 150
R-454A	R-404A/R-22	238
R-454C	R-404A/R-22	148
R-457A	R-404A/R-22	139
R-515A	HFC-134a	392
R-516A	Near drop-in for HFC-134a	131
R-1234yf	HFC-134a	1
R-1234ze	R-404A/R-22	1

Refrigerant safety classifications

The American Society of Heating, Refrigeration and Air-Conditioning Engineers (ASHRAE) has created safety classifications that denote varying degrees of toxicity and flammability.

Safety class	Definition
A1	Lower toxicity; no flame propagation
A2L	Lower toxicity; lower flammability
A3	Lower toxicity; higher flammability
B2L	Higher toxicity, lower flammability

Dr. Rajan Rajendran is one of the most respected, global authorities on alternative refrigerants and their applications across a variety of industries. As Emerson's Vice President, System Innovation Center and Sustainability, Rajan helps steer the company's strategic direction, research and product development.

Refrigerant transition from HFCs to available alternatives	Supermarket systems (new)	Remote condensing units (new)	Stand-alone equipment (new medium-temperature)	Stand-alone equipment (new low-temperature)	Refrigerated food processing and dispensing equipment (new)
HFC change of status date	R-404A/507A are not allowable after Jan. 1, 2017.	R-404A/507A are not allowable after Jan. 1, 2018.	R-404A/R-507A, R-410A, R-407A/C/F and HFC-134a will not be allowable after Jan. 1, 2019 (for units with < 2,200 BTU/hr.) and Jan. 1, 2020 (for units with > 2,200 BTU/hr.).	R-404A/R-507A, R-410A and R-407A/C/F will not be allowable after Jan. 1, 2020.	R-404A/R-507A, R-410A and R-407A/C/F will not be allowable after Jan. 1, 2021.
HFCs still allowable	R-410A, R-407A/C/F, HFC-134a	R-410A, R-407A/C/F, HFC-134a	n/a	HFC-134a	HFC-134a
Available A1 alternatives	R-448A, R-449A, R-449B, R-450A, R-513A, R-515A	R-448A, R-449A, R-449B, R-450A, R-513A, R-515A	R-450A, R-513A	R-448A, R-449A, R-449B, R-450A, R-513A	R-448A, R-449A, R-449B, R-450A, R-513A
Available natural alternatives	R-290, R-744, R-717	R-290, R-744	R-290, R-744	R-290, R-744	R-290, R-744
Future A2L alternatives	ARM-25, R-444B, R-454A, R-454C, R-455A, R-457A, R-459B, R-1234yf, R1234ze	ARM-25, R-444B, R-454A, R-454C, R-455A, R-457A, R-459B, R-1234yf, R-1234ze	ARM-25, R-444B, R-454A, R-454C, R-455A, R-457A, R-459B, R-1234yf, R-1234ze	ARM-25, R-444B, R-454A, R-454C, R-455A, R-457A, R-459B, R-1234yf, R-1234ze	ARM-25, R-444B, R-454A, R-454C, R-455A, R-457A, R-459B, R-1234yf, R-1234ze
Application note	The EPA is allowing high-GWP HFC refrigerants in supermarket systems for service.	The EPA is allowing high-GWP HFC refrigerants in remote condensing units in service.	While R-448A and R-449A are currently not allowable in medium-temperature, they are both allowable for low-temperature units in this class.	R-448A and R-449A are both allowable for low-temperature units in this class.	The EPA is still allowing HFC-134a refrigerants in new refrigerated food processing equipment.

R-290 Ready

Condensing units designed to achieve compliance and exploit propane's proven efficiencies

Why R-290?

The demand for energy-efficient and environmentally friendly commercial refrigeration equipment has led to the resurgence of the natural refrigerant propane (R-290). Spurred by the Environmental Protection Agency's (EPA) listing of R-290 as an acceptable refrigerant substitute and the Department of Energy's (DOE) call for more efficient compression technology, R-290 has reemerged as one of the few alternatives that meets both objectives.

Businesses in Europe, and more recently the U.S., view R-290-based refrigeration systems as true "future proof" refrigeration options — eliminating current regulatory compliance concerns and meeting corporate sustainability objectives.

To support our OEM customers who are responding to this market demand, Emerson offers a line of condensing units

aimed to maximize R-290 efficiencies. As a class A3 refrigerant, R-290's charge limit of 150g has largely constrained its use to smaller, self-contained applications. This makes reach-in applications an ideal candidate for the use of R-290.

As the first class of commercial refrigeration equipment to be impacted by the DOE efficiency mandate, reach-in units must adhere to 30–50 percent reductions in energy consumption beginning March 27. And in 2019, the EPA will begin phasing out commonly used HFC refrigerants in

this same class of equipment. The timing of these regulations is forcing foodservice OEMs to consider meeting both requirements in the same design cycle. Currently, R-290 is a leading option for accomplishing both objectives.

Condensing units designed to comply with DOE and EPA regulations

Copeland™ M-Line condensing units provide all the technological improvements needed to help OEMs achieve regulatory compliance while giving end users



Model ASE — R-290 compressor

High performance, low environmental impacts

Even in the early days of refrigeration, R-290 was recognized for its excellent thermodynamic properties. Emerson's test labs confirm that R-290 yields more than 20 percent energy-efficiency improvements compared to R-404A, a commonly used

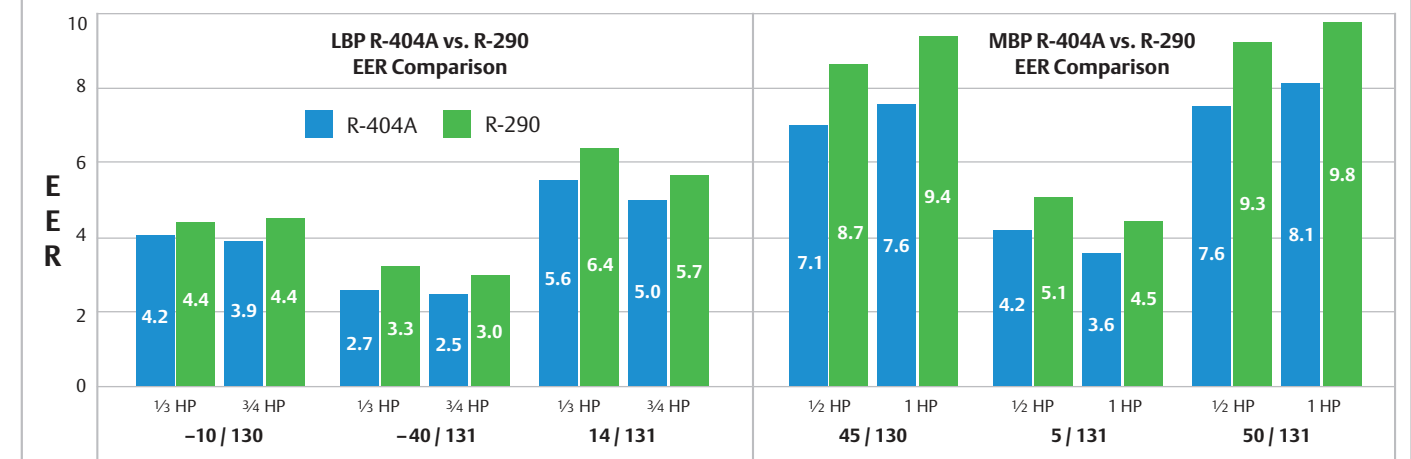
hydrofluorocarbon (HFC) refrigerant targeted for phase-down by the EPA.

From an environmental perspective, R-290 delivers the following advantages:

- Naturally occurring, hydrocarbon
- Global warming potential = 3

- Ozone depletion potential = 0
- Readily available and affordable
- Listed by the EPA as an acceptable refrigerant substitute
- Exempt from EPA's Section 608 venting prohibition

R-404A and R-290 EER comparison



Results from Emerson's test labs, comparing the Energy Efficiency Ratio (EER) of R-404A to R-290 in medium (MBP) and low back pressure (LBP), show a significant improvement when using R-290.

optimal performance in low- and medium-temperature refrigeration applications. Designed to deliver energy improvements up to 30 percent, M-Line condensing units are built on the following improvements:

- Latest generation of Copeland hermetic compressors
- Electronically commutated fan motors (as an optional feature)
- Condenser coil tubing design that enables additional coil rows

Next generation compression technology

Emerson has been testing alternative refrigerants for years to help OEMs make the transition to DOE- and EPA-compliant compression technology. Emerson offers A*E and R*T compressors rated for use with R-290 and available in fractional horsepower options to serve as the basis of Copeland M-Line condensing units. Designed with OEM and end user concerns in mind, these compressors deliver the following benefits:

- Minimal sound output for quiet operation
- More than 20 percent energy efficiency improvements compared to R-404A
- Little to no environmental impacts

Enhanced serviceability via electronic unit controls

An optional electronic unit controller is available on M-Line condensing units to help end users and contractors improve the usability and serviceability of reach-in units. Features include:

- Quick and easy setup
- Improved set-point accuracy
- Troubleshooting and diagnostics
- Additional system safeguards

The widening adoption of R-290 is evidence that the commercial refrigeration

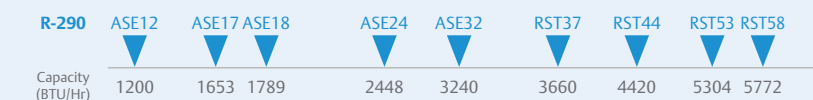
Industry has become more comfortable with the natural refrigerant alternative. Although OEMs and operators alike have accepted its 150g charge limit, even incremental charge increases would enable significant advances in system design and efficiencies. This charge limit is currently under review by building codes and standards makers. If (and when) charge limits are increased, Emerson will be prepared to make the necessary updates to our compression technology.

EMERSON PROPANE COMPRESSOR LINEUP

Low-Temperature



Medium-Temperature





Answering the Call

Coalition takes first steps in addressing the growing technician shortage

As we've discussed previously in this magazine, the growing shortage of qualified technicians is perhaps the greatest challenge facing the HVACR industry. Solving this problem will require a holistic approach that mobilizes all stakeholders — from contractors and wholesalers to technical colleges, trade associations and equipment manufacturers. It will call for the commitment of a dedicated organization to drive this effort to a resolution.

Emerson is answering that call.

At our latest E360 Forum in Tucson, Ariz., Emerson launched this important initiative by hosting a half-day symposium entitled "Industry Challenge: Addressing the Technician Shortage." The meeting assembled nearly 50 contractors, wholesalers and Emerson leadership team members to take the first steps toward forming a consensus on how to address the problem. The format of the meeting was designed to allow attendees to participate in small group ideation sessions that focused on four key aspects of the challenge: awareness, recruitment, training and retention.

Small group insights

Upon completion of the ideation sessions, each small group presented its insights. It quickly became apparent that several common themes were surfacing regardless of the group's focus, all based on the importance of appealing to the current field of job market entrants. Specifically, attributes

that the millennial generation considers important employment criteria include:

- The desire to have a meaningful career that contributes to the betterment of society
- The preference for working with modern technology
- The importance of selecting a career path that has both long-term security and growth potential

It was the opinion of each focus group that a technician career not only fulfills these attributes for millennials, but also provides an evergreen employment opportunity for those re-entering the job market. What follows is a summary of each focus group's insights.

Awareness. Ron Carter of Johnstone Supply Knoxville presented this group's keys to raising awareness of the shortfall and, as importantly, exploring some of the roots of the problem. He observed that the modern culture is not set up to encourage vocational occupations, and the natural tendency to want each generation to have ever-improving employment options has contributed to many overlooking the HVACR technician career. Thus, even students with an aptitude for technical trades are not encouraged to pursue vocational/technical training. To overcome this trend, Ron stressed the importance of making students and faculty understand that this career path is a viable alternative to a four-year college degree.

Recruitment. The theme of appealing to the younger generation of job entrants continued with this group's insights. Emerson's Ani Jayanth discussed the critical role technology will play in helping millennials see the "wow factor" currently missing from this career. He explained the importance of highlighting the societal contributions that HVACR technicians can make, including: food safety, human comfort, energy efficiency and environmental sustainability. Emerson's Larry O'Day then spoke about the many practical benefits of an HVACR career, including: competitive compensation, job security, career growth and low competition. To augment the two-year degree and help prepare students for day-to-day challenges, he also recommended implementing co-op programs as part of the training.

Training. Led by Emerson's Todd DeVore, this group provided insights on improving the training process. To help ease the process of earning a certification, Todd talked about the need to make training classes both more convenient (with either online or evening classes) and more affordable. Todd also noted the need to keep curriculum up to date — utilizing the latest technologies, refrigerants and equipment — so that entrants are aware of the specialization required and prepared for the many refrigeration scenarios. The group also felt that improved marketing efforts were needed to attract entrants to this promising field.

Retention. When it comes to retention, Jim Coats of Coapico Technologies said that getting entrants in the door is one thing; keeping them engaged is another. To improve retention, Coats' group felt it necessary to make technicians aware of the bigger purpose, meaning and value they provide — other than just their

daily tasks. Achieving a proper work-life balance, charting a path for career progression and ensuring continuous progress toward that goal were also mentioned as keys for retention. Emerson's Don Newlon then pointed out that many contracting business owners need help in cultivating this environment for their technicians. He suggested establishing training courses geared toward helping them run their businesses effectively, with the end goal of creating great workplaces that keep technicians engaged.

Next steps

Another common theme that came out of these discussions was the need for stakeholder participation and engagement. It will require investments in time, money and resources by all to start taking these ideas and putting them into action. And it will take Emerson's continued leadership to move this effort forward.

It's important to remember that turning the tide on the technician shortage will not happen overnight. In the meantime, we all have a responsibility to maintain awareness of the issue and look for solutions in our day-to-day activities. Regardless of your role in the commercial refrigeration supply chain, we urge you to share your ideas with us. To contribute to this import effort, please email the Emerson team at e360.climate@emerson.com.

Understanding what's at stake

Aging baby boomers and a new generation of job entrants wary of pursuing skilled trades have created a void in the HVACR industry. Recent estimates by the HVACR Workforce Development Foundation and the U.S. Department of Labor verify the extent of the problem:

- 115,000 HVACR technicians will be needed by 2022 to fill industry jobs
- Only 21,000 students graduated from post-secondary HVACR programs in 2015
- In 2014, more than 100,000 job openings were posted for HVACR technicians
- HVACR technician jobs are estimated to increase by 21 percent by 2022

While these stats paint a stark picture, the bright side of the story is that the HVACR job market promises to be hot for the foreseeable future. And with annual salaries averaging more than \$49,000 for jobs that don't require a bachelor's degree, it's a career path with significant opportunity for high school students, veterans and second-career adults.



Ecosystem of Innovation

New Helix Innovation Center at Georgia Tech extends collaborative capabilities



When Innovation Director John Wallace steps off the elevator in the building where the new Helix Innovation Center is located, he never knows who he's going to run into. That's because it's located in the heart of Georgia Tech's "Tech Square" district in Atlanta, an entrepreneurial hub for other corporate innovation centers, educational institutions and technology start-ups. Supporting this thriving ecosystem is the Atlanta Technology Development Center (ATDC), whose offices are also located in the same building as The Helix.

"As I make my way around the Tech

Square district, there's a good chance that I'll run into another innovation center leader or a start-up working on an interesting project," said Wallace. "In this environment, we're always open to share ideas and see if there's an opportunity for collaboration," he added.

Recently opened in September 2016, The Helix at Georgia Tech is a 1,600 square-foot facility operated under Emerson's Retail Solutions umbrella that features the latest technologies for in-person and virtual collaboration. Utilizing a relatively small staff of employees and interns from Georgia Tech, Wallace says that

the Innovation Center was designed to complement the extensive capabilities of The Helix Innovation Center in Dayton, Ohio — not from an equipment and capabilities standpoint, but as an innovation incubator and outreach center into the Tech Square ecosystem.

"Working within this dynamic environment allows Emerson to establish new relationships and tap into fresh ideas and outside perspectives that we can then bring back into our business," said Wallace. "In the relatively short time we've been open, I've had opportunities to exchange ideas with several innovation

leaders and start-ups," he added.

Wallace said that what makes the Tech Square district truly unique is the fact that it is a non-competitive environment; organizations are primarily interested in looking for new technologies and partnerships that could expand their own capabilities.

Wallace said that The Helix at Georgia Tech is still in its early phases of acclimation to the Tech Square ecosystem.

"It takes time to meet other companies and build these relationships, but we're interested in making those connections

and exploring technologies that might be a good fit with our own technology base," said Wallace. He explained that the only way to do this is to share the Emerson story and learn more about what other technology companies have to offer.

Local educators and trade organizations are helping to facilitate these connections. Georgia Tech hosts innovation roundtables every other month, where leaders set the agenda and then gather to exchange ideas. The Technology Association of Georgia, the largest technology trade association

in the Southeast, also organizes meetups for business across Georgia. Mark Dunson, group president, electronics and solutions, for Emerson's Commercial and Residential platform, recently gave a talk on IOT at one of these sessions to nearly 500 attendees. Efforts like these will only speed up the acclimation process and lead to greater opportunities for collaboration.

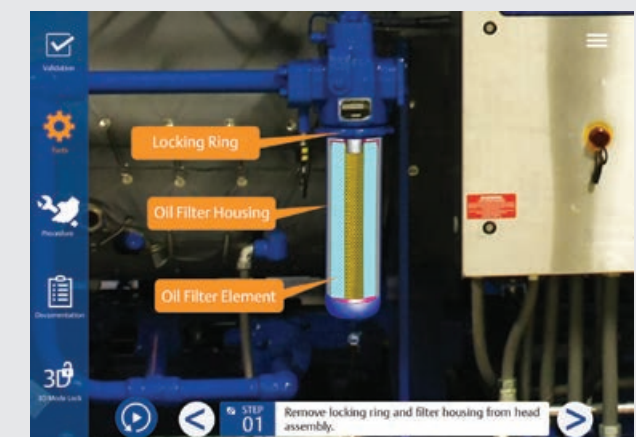
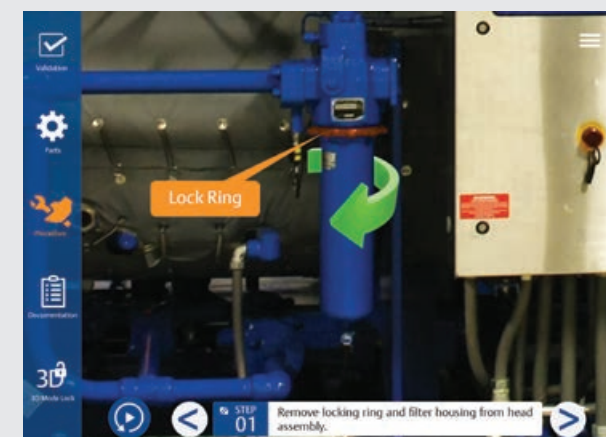
As new innovations emerge from The Helix Innovation Center at Georgia Tech, look for more information in future editions of *E360 Outlook*.

The benefits of collaboration

One example of how this facility extends the capabilities of The Helix Innovation Center in Dayton is from a recent project to update the user interface on the controls unit for a variable air volume (VAV) system. Two of The Helix Georgia Tech interns worked with engineers at The Helix in Dayton to develop a prototype that would enable visibility into VAV system insights and then integrate this data into the control's user interface.

Utilizing an agile development process that resulted in several iterations, the interns created a new information flow and interface for the VAV system that presents all the required system data on one screen. Not only did this new interface help The Helix staff in Dayton see interoperability across different systems to aid in their experiments, it is also being incorporated into the standard user interface for the controls.

Another example of collaboration stems from a current engagement with a neighboring start-up company with expertise in augmented reality (AR) technologies. After vetting their capabilities and the applicability of the technology, The Helix Georgia Tech — working with the engineers at The Helix in Dayton — tapped the start-up to develop an augmented reality app for chiller maintenance which will be used at The Helix in Dayton. The app will provide an end user with a "real time" view inside the chiller via smartphone or tablet, which will assist technicians as they perform maintenance tasks. Using the app will allow engineers to gain valuable experience with AR technology and learn how it can be utilized to help customers. Both examples are evidence of the potential for innovation and collaboration between the two Helix Innovation Centers.



Cooking up Energy Efficiencies

Commercial kitchen module helps restaurants optimize equipment



It's estimated that the kitchen is responsible for up to 70 percent of a facility's total energy consumption in a typical quick service restaurant (QSR). From grills, ovens and deep fryers to reach-in coolers, walk-in freezers and ice makers, these densely packed food factories are furnished with a mix of hot- and cold-side equipment — all needed to store, prepare and stage food offerings. Maintaining energy efficiencies in this environment calls

for specific strategies to mitigate heat, preserve the cold and minimize impacts on the facility's HVAC system. In the commercial kitchen module at The Helix Innovation Center, designers and engineers liken the process of regulating the precise interplay of this equipment to orchestrating a symphony.

The commercial kitchen module is a fully equipped, functional prototype of a modern restaurant, complete with a kitchen and



dining area. Unlike a typical QSR, this kitchen is also a research and development facility, allowing staff to isolate the energy and environmental impacts of every piece of equipment via carefully planned test scenarios. In this way, it serves as the baseline for real-life testing of computer model projections.

In the short time since it's been open, The Helix operators have learned much about best practices in kitchen energy management — and engaged leading foodservice retailers in conversations about existing and emerging options at their disposal. These discussions have been as important for The Helix operators in giving them further insights into the many challenges retailers face across their store networks.

Taking the heat out of the kitchen

Managing the heat that's radiating from hot-side kitchen equipment is one of the major areas of focus for engineers in the commercial kitchen module. Two of the most common challenges are the griddle and the deep fryer, both of which expel a significant amount of radiant heat. The research process involves documenting the radiant heat of each fixture, then experimenting with a variety of heat management techniques.

Sometimes the most common-sense solutions can have significant impacts — and are often overlooked. For example, leaving a walk-in freezer door open for a period of 20 seconds can result in significant temperature losses. Not only can this affect food quality, but it also adds unnecessary strain on the refrigeration system to pull temperatures back down to normal. Along those lines, putting a lid on the deep fryer is a simple heat management technique that many restaurants ignore.

Restaurant efficiency drivers

Retailers have a variety of motivations for optimizing the interplay of kitchen equipment and reducing energy consumption. To name a few of the leading drivers:

- **Preserving food quality:** maintaining the highest standards of food quality and safety is a retailer's top priority; any operational change must not interfere with this objective.
- **Cutting operating costs:** if efficiency measures and best practices can be repeated across a network of stores, restaurants can net significant savings.
- **Controlling comfort levels:** by effectively managing hot- and cold-side requirements, operators can maximize comfort levels for kitchen staff and patrons alike.
- **Staying ahead of regulations:** the California Energy Commission has made a commitment for achieving zero net energy in commercial buildings by 2030; many QSRs are actively pursuing means of achieving this goal.

Many retailers are also stating a sustainability objective as consumers increasingly prefer fresh food options sourced from "green" supply chains.



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our market-proven compressors, controls, thermostats and related equipment. Learn more at Emerson.com.

Emerson Climate Technologies is now part of the Emerson Commercial and Residential Solutions business platform. Leading product brands include: Copeland Scroll™, ProAct™, Sensi™, RIDGID® and InSinkErator®. Commercial and Residential Solutions offers a

true solutions approach:

- Ensuring human comfort and health
- Protecting food quality and sustainability
- Advancing energy efficiency and environmental conservation
- Creating sustainable infrastructure
- Continuing momentum at The Helix Innovation Center




We'd like to hear your feedback.

Thank you for reading this edition of *E360 Outlook*! At Emerson, we believe the challenges faced by the refrigeration industry cannot be solved in a vacuum. Only through collaboration and a commitment to innovation will we discover answers to the difficult questions before us.

We hope the information provided here will spark conversations and open all of our eyes to new perspectives. But for that to happen, we all need to contribute. And that starts with you. Feel free to contact us with your feedback, questions and insights. We look forward to hearing from you.


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