

SPECIAL ISSUE #112

ACCELERATE

ADVANCING CLEAN COOLING

Cooling in 2021





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2021: The Year of Clean Cooling

— By Marc Chasserot



Marc Chasserot,
Publisher

After the great COVID-19 “pause” of 2020, 2021 will be the year of Clean Cooling. That is my prediction, leading off this Special “Cooling in 2021” Issue of *Accelerate*.

This issue truly is special, in that it is the first time we have ever dedicated an entire publication to looking ahead to the coming year in order to provide a sense of where the natural refrigerant and sustainable cooling market is heading, across multiple business sectors and geographic regions.

We’ve taken our inspiration from *The Economist*, which publishes an annual year-end issue looking at the world in the coming year. We want to bring the same kind of analysis and forward-looking approach to our readers, the progressive part of the cooling industry.

In assembling this issue, we reached out to dozens of key thought leaders and stakeholders across the globe, inquiring about their plans and predictions for 2021 in regard to every key application and trend impacting our industry. To our knowledge, it is the first time this has ever been done, and we plan to do it on an annual basis.

Returning to my own prediction, here is why I think 2021 will be all about Clean Cooling. First, the European Commission will be releasing a proposal in the fourth quarter updating the EU F-Gas Regulation for the third time. This will further accelerate the phase down of HFCs and the uptake of natural refrigerants and other Clean Cooling solutions in what is one of the world’s top-three economies (China and the U.S. are the other two), setting the global standard.

Second, the new U.S. President, Joe Biden, will return America to the Paris accord and get behind an aggressive zero-emissions plan that will include support for Clean Cooling. And third, the 500g charge-limit standard for hydrocarbons in commercial display cases, approved by the International Electrotechnical Commission (IEC) in 2019, will finally be adopted to various degrees by individual regions.

These three occurrences will together provide a huge boost to commercial and industrial suppliers of natural refrigerant-based refrigeration equipment.

But 2021 will not just be about advances in refrigeration. It will also be about the “big elephant” in the room – air conditioning, the largest cooling market of all, which is growing much larger as a result of the climate crisis. Clean Cooling suppliers will start turning their attention to the need for efficient cost-effective AC equipment that uses natural refrigerants and doesn’t pollute the environment.

This will be reminiscent of 2006, when the first EU F-Gas Regulation went into effect and kick-started the move to sustainable refrigeration systems in supermarkets and warehouses. This time, the proposed third F-Gas Regulation will finish the job on refrigeration, and start the job on air conditioning. Add to that the IEC’s planned standard update increasing the amount of hydrocarbons allowed in room air conditioners. All of this promises to make 2021 the year when the global changeover to sustainable ACs really takes off.

You may not agree with all of our predictions. Either way, we welcome your feedback – and wish you happy and safe holidays and a successful 2021. ■ MC

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Looking Forward to 2021

— By Michael Garry



Michael Garry
Editor in Chief

In November of 2016, after eight years of the Obama administration, the U.S. was engaged in strict regulation of high-GWP refrigerants, banning a number of HFCs in a variety of applications via the Environmental Protection Agency's Significant New Alternative Policy (SNAP) program.

The U.S. Secretary of State at the time, John Kerry, had just returned from Kigali, Rwanda, where he helped lead the creation of the Kigali Amendment to the Montreal Protocol, a global plan to phase down HFCs.

The prospects were good for the accelerated adoption of low-GWP replacements for HFCs, including natural refrigerants.

But on November 8, 2016, Donald J. Trump was elected U.S. president. For the next four years environmental regulations, not just for refrigerants but for anything related to climate change, would be rolled back or ignored.

As the saying goes, elections have consequences. But this year, that line will apply to the new U.S. president, Joe Biden, who will take office in January 2021.

Biden's inauguration is just one of the events that will impact the sustainable cooling industry in 2021. In this Special Issue of *Accelerate*, you will learn about many more, as well as find informed speculation on what might happen in the global HVAC&R industry. We cover a wide range of topics, from the basics – refrigeration, air conditioning and heat pumps – to many other pertinent areas, including policy/standards, digitalization, servitization, HFOs, alternative technology and Clean Cooling. Importantly, we look at the prospects for the updated EU F-Gas Regulation, which will shape the cooling industry not only in Europe but globally. The last section discusses our least favorite topic, COVID-19, with the hope

that it will be a lot less consequential in 2021 than it was this year.

As a U.S. citizen, I am guardedly optimistic that, despite lingering partisan rancor, the Biden administration will get a lot done in the environmental sphere, and many others.

With regard to the climate crisis, Biden has made clear that his approach will be comprehensive, targeting net-zero emissions across the entire U.S. economy by 2050. He has already named Kerry special presidential envoy for climate, a new cabinet-level position with a seat on the National Security Council.

Upon taking office, the new president will return the U.S. to the Paris accord, and is expected to soon send the Kigali Amendment to the U.S. Senate for ratification, which has bipartisan support.

After ratifying the Kigali Amendment, the Senate will need to empower the EPA to once again regulate HFCs; there is already bipartisan legislation in the Senate and House designed to do just that. A bill should pass, regardless of which party ends up controlling the Senate in January.

Also in his environmental plan, Biden will establish ARPA-C, a new, cross-agency Advanced Research Projects Agency focused on climate. This initiative will target “affordable, game-changing technologies,” including “refrigeration and air conditioning using refrigerants with no global warming potential (GWP).”

This suggests that Biden will support the development and adoption of natural refrigerant-based technologies with refrigerants that have zero GWP (ammonia) or near-zero GWPs (CO₂ and hydrocarbons).

There is much to look forward to in 2021. Meanwhile, happy and safe holidays to all of our readers worldwide! ■ MG

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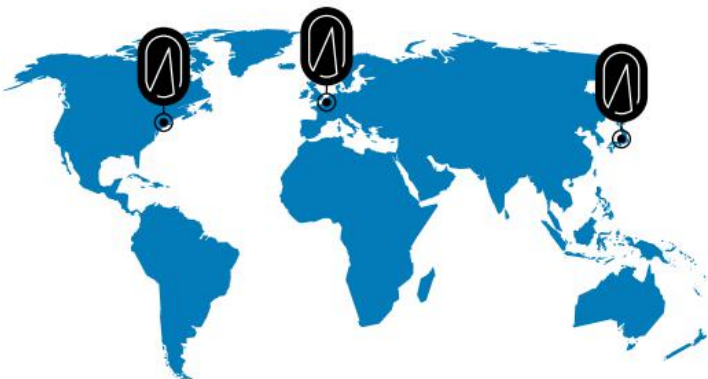
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ABOUT ACCELERATE

Brought to you by the worldwide experts in clean cooling news, *Accelerate* is the first global publication written for and about the most progressive business leaders working with clean cooling solutions, including natural refrigerants and other sustainable technologies and resources, in all HVAC&R sectors. It builds on the legacies of *Accelerate Magazine* and six regional magazines: *Accelerate America*, *Accelerate Europe*, *Accelerate Australia/New Zealand*, *Accelerate Japan*, *Accelerate China* and *Accelerate Asia*.

ABOUT ACCELERATE24.NEWS

Accelerate24.news is a 24-hour global website providing up-to-the-minute news on clean cooling solutions, including natural refrigerants and other sustainable technologies and resources, in all HVAC&R sectors. Leveraging the expertise of our journalists and analysts in North America, Europe and Japan, Accelerate24.news builds on the expertise and reach of R744.com, Hydrocarbons21.com and Ammonia21.com, the leading marketplace websites on CO₂, hydrocarbons and ammonia over the past decade.

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Editorial Calendar for Accelerate Special Issues, 2020-2021

Each Special Issue of *Accelerate*, published six times annually, addresses a specific topic aimed at advancing Clean Cooling – sustainable cooling for all – in commercial, industrial and residential HVAC&R markets around the world.

These Special Issues target end users and other key stakeholders, including manufacturers, contractors, policy makers, the financial community, academic experts and others.

Each Special Issue will take a deep dive into a particular topic, with a main story and secondary articles, guest writers, thought leader interviews, infographics, surveys and market research.

In addition to the topics listed at right, other potential topics include: technology innovations, mobile air conditioning (MAC), data center cooling, ice rink refrigeration, servitization of cooling, digitalization of cooling, alternative cooling technologies, renewable energy and HVAC&R, and regional HVAC&R markets.

The Special Issues are available online at <https://bit.ly/3841iCJ>; in addition print copies are distributed at major industry trade shows and conferences.

Accelerate Special Issues take full-page advertising as well as fractional ads

The editorial calendar is subject to change by the publisher.



SPECIAL ISSUE #111

October 2020

Food Retailers Pursuing Clean Cooling Around the World

SPECIAL ISSUE #112

December 2020

A Look Ahead at the Major Clean Cooling Trends for 2021

SPECIAL ISSUE #113

March 2021

Industrial Refrigeration Operators Pursuing Clean Cooling Around the World

Ad Deadline: March 9

Publication Date: March 16

SPECIAL ISSUE #114

May 2021

The Growing Use of Natural Refrigerants in Air Conditioning

Ad deadline: May 11

Publication Date: May 18

SPECIAL ISSUE #115

July 2021

Training Best Practices Around the World

Ad deadline: July 13

Publication Date: July 20

Three predictions for Cooling in 2021

Expect more of the following: net-zero emissions action by cooling companies, Kigali ratifications and ambition, and National Cooling Action Plans by governments.

— By Dan Hamza-Goodacre

The challenges of 2020 have been well documented and I don't think I have ever looked forward to a new year more than now.

On top of everything COVID-19 related, 2020 saw a number of heat records broken around the world, more relentless heat waves (including in the Arctic Circle) and another ominously high temperature of 54.4°C (129.9°F) in Death Valley, California (U.S.) It is, therefore, unsurprising to learn that 2020 is on course to be the hottest year since records began. While 2020 is likely to be an anomaly in many ways, with regards to the rising mercury, it is not.

With this trend of increasingly frequent and lengthy heat waves being experienced in virtually every part of the world, we are seeing a growing demand for cooling, especially for the most vulnerable communities. The loss of lives and productivity due to heat is already too high, and is only expected to grow if we don't act now.

It is not just keeping ourselves cool that's becoming increasingly important; the refrigeration of medicines – vaccines in particular – has been of significant interest this year. The COVID-19 pandemic has shone a light on socioeconomic inequities, and as we approach the final stages of vaccine development, certain communities face the possibility of further inequalities relating to access to sufficient cold-chain infrastructure for vaccine distribution.

As I write this, there are at least three promising candidates for a COVID-19 vaccine: one from Pfizer and BioNtech, one from Moderna, and one from Oxford University and AstraZeneca. While this is all clearly fantastic news, we're not out of the woods just yet. According to Sustainable Energy for All (SEforALL)'s recent "Chilling Prospects" report, delivering a vaccine typically requires storage at temperatures between 2°C and 8°C (35.6°F and 46.4°F). To do this for 4.7–5.5 billion people within 12–18 months would require a massive expansion in medical cold chains, energy and refrigerants. You can just imagine



the scale of the challenge if a vaccine requires relatively constant temperatures of -20°C (-4°F) or -70°C (-94°F), Moderna's and Pfizer/BioNtech's respectively. Oxford/AstraZeneca's vaccine suddenly looks more attractive, at least from a distribution and certainly from a climate perspective.

While significant attention is rightly focused on these immediate challenges, much of life goes on as normal, so let's dedicate some energy to different, but related matters – the cooling of vaccines yes, but cooling in the context of the climate crisis. What can we expect from 2021 and what can we hope for? It is now time to pick up the pace. Here are my top-three predictions for 2021.

The cooling sector will feel the heat from the “Race to Zero”

Over 80 countries and more than 2,000 businesses, investors, cities and universities have already committed to the [United Nation's Race to Zero carbon emissions campaign](#). In the run-up to next November's 26th UN Climate Change Conference of the Parties (COP26) in Glasgow, Scotland, we will see numerous additional net-zero emissions pledges being made from both the private and public sectors. Over the last year, the number of commitments has doubled. Very few, however, are from cooling sector manufacturers, but some clear leaders have emerged – Danfoss, Electrolux, and Schneider Electric.

One major milestone for 2021 will be a net-zero commitment from U.S. President-elect Joe Biden. He has been vocal about his plans to act on climate, including rejoining the Paris Agreement, pledging net-zero emissions by 2050, and pushing to “dramatically increase global climate ambition.” Greater action from the incoming administration will encourage domestic action; as the world's second-largest source of energy-related emissions from stationary air conditioning, the U.S. has a major role to play.

“ From healthcare and agriculture, to transportation and buildings, the environmental performance of cooling impacts many sectors' pathways to zero carbon emissions.

– Dan Hamza-Goodacre, K-CEP

”

The U.S. is also home to some of the world's largest cooling manufacturers – Trane Technologies, Carrier, Johnsons Control, and Lennox International. If the U.S. makes significant commitments in the form of its Nationally Determined Contribution (NDC) to the Paris accord and a net-zero pledge, these companies will fall into line.

U.S. action will also spur action across the world from businesses (competitors and franchises) as well as governments. Cooling will feature increasingly in countries' NDCs and in their long-term plans (e.g. for 2050). And action on cooling will go way beyond the cooling industry. From healthcare and agriculture, to transportation and buildings, the environmental performance of cooling impacts many sectors' pathways to zero carbon emissions – we won't get to net-zero without concerted action on cooling.

The Kigali Amendment will see more ratifications – and greater ambition

Since coming into force in January 2019, 111 countries and the European Union have ratified the Kigali Amendment to the Montreal Protocol, which aims to reduce HFC consumption by at least 80% by 2047. These ratifications represent around 57% of the 197 parties (plus the EU) that enacted the amendment. According to UN estimates, the full implementation of the Kigali Amendment would avoid up to 0.4°C (0.72°F) in global warming by 2100.

Of the remaining 86 parties, two of the world's largest consumers of HFCs (the U.S. and China) have yet to ratify the amendment. The former is likely to rectify this in early 2021 (pending Senate approval) following President-elect Joe Biden's inauguration in January.

There is increasing recognition that the Kigali Amendment is necessary for effective climate action, so we will likely see an uptake in ratifications in 2021. And while clear progress is being made here, there is skepticism as to whether Kigali targets go far enough and fast enough. As more countries and companies join the Race to Zero campaign, they will begin to move above and beyond the Kigali Amendment with regards to the production and consumption of HFCs in order to meet their net-zero targets. This shift will drive a greater demand for natural refrigerants (such as ammonia, CO₂ and hydrocarbons) and require synthetic refrigerants to have a much lower GWP, i.e. under five. Net-zero will force a more ambitious adjustment of the Kigali Amendment.

More National Cooling Action Plans will be enacted at national and subnational levels

Throughout 2021, rising temperatures, COVID-19 vaccine cooling needs, the looming climate negotiations and awareness of the key role that cooling plays for food and productivity will put cooling higher up the political agenda and encourage better planning to meet cooling needs in a climate-friendly way. Much planning will happen through the development of National Cooling Action Plans (NCAPs) at both the national and subnational levels.

Back in 2018, India became the first country to develop such a plan. Since then, China, Rwanda, Trinidad and Tobago, Cuba and Panama have published NCAPs, and 21 other countries are in progress, all with the support of [Kigali Cooling Efficiency Program](#).

National action is being complemented by action at the subnational level, such as in Ahmedabad, India; its Heat Action Plan has saved thousands of lives and inspired similar action in 30 cities across the country. If countries and sub-national entities fail to plan, they are planning to fail.

All in all, there are reasons for hope in 2021. Much-needed climate action will spur much-needed economic activity and jobs. A renewed U.S. government, the Race to Zero and the clear economic benefits of climate action will underpin an ambitious COP26 and help get us back on the necessary pathway to limit global temperature rises to 1.5°C (2.7°F).

I think 2021 will be another tough year, but it will also be a year of increased ambition, action, and progress; it simply has to be. As Karl Popper said, "Optimism is a duty. The future is open." ■ DHG



Dan Hamza-Goodacre is a Chartered Environmentalist and Fellow at the Institute of Environmental Management & Assessment (IEMA), with 23 years of experience spanning 60+ countries. He is currently on the 2020+ COP26 Champions Team, and Non-Executive Director of Kigali Cooling Efficiency Program (K-CEP), a US\$60 million program supporting over 60 developing countries on energy efficient, climate-friendly cooling. From 2017 to 2020, he was Executive Director of K-CEP.



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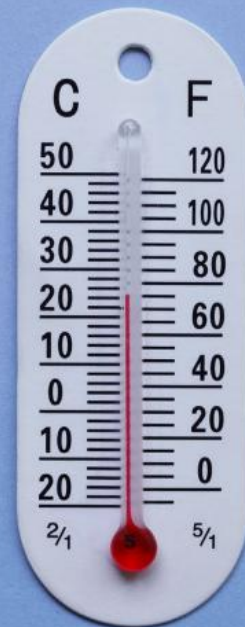
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How the Cooling Industry Can Turn Down the Global Temperature



The HVAC&R industry needs to implement critical changes to build back better – and help turn the tide on global warming.

– By Avipsa Mahapatra

As 2020 comes to a close, many of us are reflecting on lessons learned during what was indubitably a difficult year that brought unprecedented global challenge.

The COVID-19 pandemic has presented a massive new global health crisis, on top of the ongoing global climate crisis, exposing vulnerabilities in social, political, and economic systems. The widespread uncertainty surrounding the pandemic, the resulting economic hardship, and the contentious recent elections have all further exacerbated historic, pre-existing inequalities and environmental injustice.

For the past few decades, we have made little of the much-needed progress towards reducing the emissions that cause global warming. The significant but temporary emission reductions that have resulted from the COVID-19 lockdown will unfortunately not be enough to change the trajectory we are already on. We are well on our way to a planet that is estimated to be over **3°C (5.4°F) hotter**, resulting in irreversible and catastrophic global changes.

This year, yet again one of the hottest years on record, has also inarguably shown us that cooling is an essential service, not simply to derive ambient comfort but also to cool our food and vaccines for extended periods. Unfortunately, and unnecessarily, the refrigerants often used to keep us cool continue to be the very same refrigerants that are contributing to our climate crisis.

However, despite all the uncertainty of this year and a cloudy crystal ball for 2021, three things are clear:

POLITICAL WILL HAS TO MATCH CLIMATE SCIENCE

Climate science unequivocally tells us there is no time left to waste: global greenhouse gas emissions need to drop by half by 2030 AND reach net-zero by mid-century to avoid the worst climate impacts. Cooling has to be a key part of any net-zero targets. U.S president-elect Joe Biden must take decisive early action in 2021 to turn the most ambitious climate platform ever proposed into the most ambitious climate action ever enacted. Simply put, 2021 is the point of no return. The next administration must prioritize allocating federal dollars towards fighting climate change.

There is strong bipartisan support for federal policies to address HFCs, given the win-win scenario of more American jobs, retaining industry competitiveness and the lowering of climate impact. And regardless of the political makeup of the Senate come January, the Biden-Harris Administration must prioritize rejoining the Paris climate agreement and sending the Kigali Amendment to the Senate for ratification on their very first day in office, while simultaneously working to reverse Trump's environmental rollbacks. However, they must also do a lot more than that, making up for lost time, while ensuring that environmental and social justice remain crosscutting elements in all initiatives and measures.

We all need to ensure that climate-friendly cooling is incorporated into the "build back better" stimulus and associated green building and transportation programs. It is also vital that we address HFC refrigerant banks and support meeting net-zero building emissions.

PEOPLE CARE ABOUT THE CLIMATE

One promising sign of progress in the past years is the willingness of people, especially young people, to show the world that they aren't afraid to use their voices and stand up for what they believe in. There has been a surge in climate activism around the world and we have heard, loud and clear, that global civilians, including Americans, care about this planet. In addition, they are not afraid to voice their support of environmental policy progress and call for corporate change.

As just one example, the Environmental Investigation Agency (EIA) routinely receives crowdsourced submissions to our [climate-friendly supermarkets](#)



Avipsa Mahapatra is Climate Campaign Lead, Environmental Investigation Agency (EIA), U.S.

“People are impatient for a radical change and no one wants the same world back again.”

— Avipsa Mahapatra, EIA

map from citizen investigators who are learning about the climate impact of cooling and checking if their neighborhood store is HFC-free. We also routinely field inquiries on which is the best [climate-friendly refrigerator](#) someone can buy!

WE HAVE TO BUILD BACK BETTER, CLEANER AND MORE EFFICIENT

It is critical that climate concerns be embedded in national policy responses to COVID-19 as well as in the national fiscal stimulus packages being rolled out in response to the pandemic and consequent economic crisis.

As stimulus packages get implemented, governments around the world can deliver stronger, more inclusive and resilient growth by increasing the share of climate-friendly measures in those packages. Learning from the past decade, governments should focus on projects that can be scaled up quickly, avoiding transitional technologies that would need to be replaced in a few years.

The pandemic has also underlined the need and enhanced the interest in energy efficiency. The cooling industry needs to employ all the tools at its disposal to bring clean, efficient and sustainable technologies faster to the market, at scale. As the demand for cooling rises, end-users, both commercial and residential, are seeking better efficiency to save on costs, to their wallet and our environment, over the long term.

It is vital now to ensure that the cooling industry leads the global industrial response to an inclusive and green recovery, instead of simply continuing business as usual. People are impatient for a radical change and no one wants the same world back again. While adequately tackling climate change requires deep structural, economic, and societal shifts, the cooling industry has the unique ability to quickly reshape itself – hopefully fast enough to help prevent our physical world from being reshaped irrevocably. ■ AM

Bullish on Low-Charge Ammonia

Based on documented energy-efficiency gains, centralized, low-charge DX ammonia systems will continue to gain momentum, says Australian NatRef pioneer Stefan Jensen.

— By Michael Garry

Stefan Jensen, Managing Director of North Murarrie, Australia-based Scantec Refrigeration Technologies, is not shy with his viewpoints on refrigeration.

Considered a pioneer and expert in energy-efficient systems and natural refrigerants, Jensen has delivered presentations on the topic at conferences around the world and is frequently quoted in trade journals.

A native of Denmark, he has more than 40 years of experience in refrigeration and heat exchanger design, and is a board member of the U.S.-based International Institute of Ammonia Refrigeration (IIAR).

His company, Scantec, which designs and manufactures industrial and commercial refrigeration equipment, is focused on environmentally friendly systems, predominantly employing natural refrigerants ammonia (R717) and CO₂ (R744).

In particular, Scantec specializes in designing and building energy-efficient, centralized low-charge ammonia systems. "We are the first company globally to demonstrate, by way of energy performance records, the significant energy performance penalty associated with liquid-overfeed as compared with dry expansion in a large ammonia refrigeration plant," says Scantec on its website.

In addition, "we are the first Australian industrial refrigeration company to prove that centralized, low-charge NH₃ systems are a viable alternative to medium-size, industry-standard, air-cooled HFC based systems and a viable alternative to industry-standard transcritical CO₂ systems," the website says.

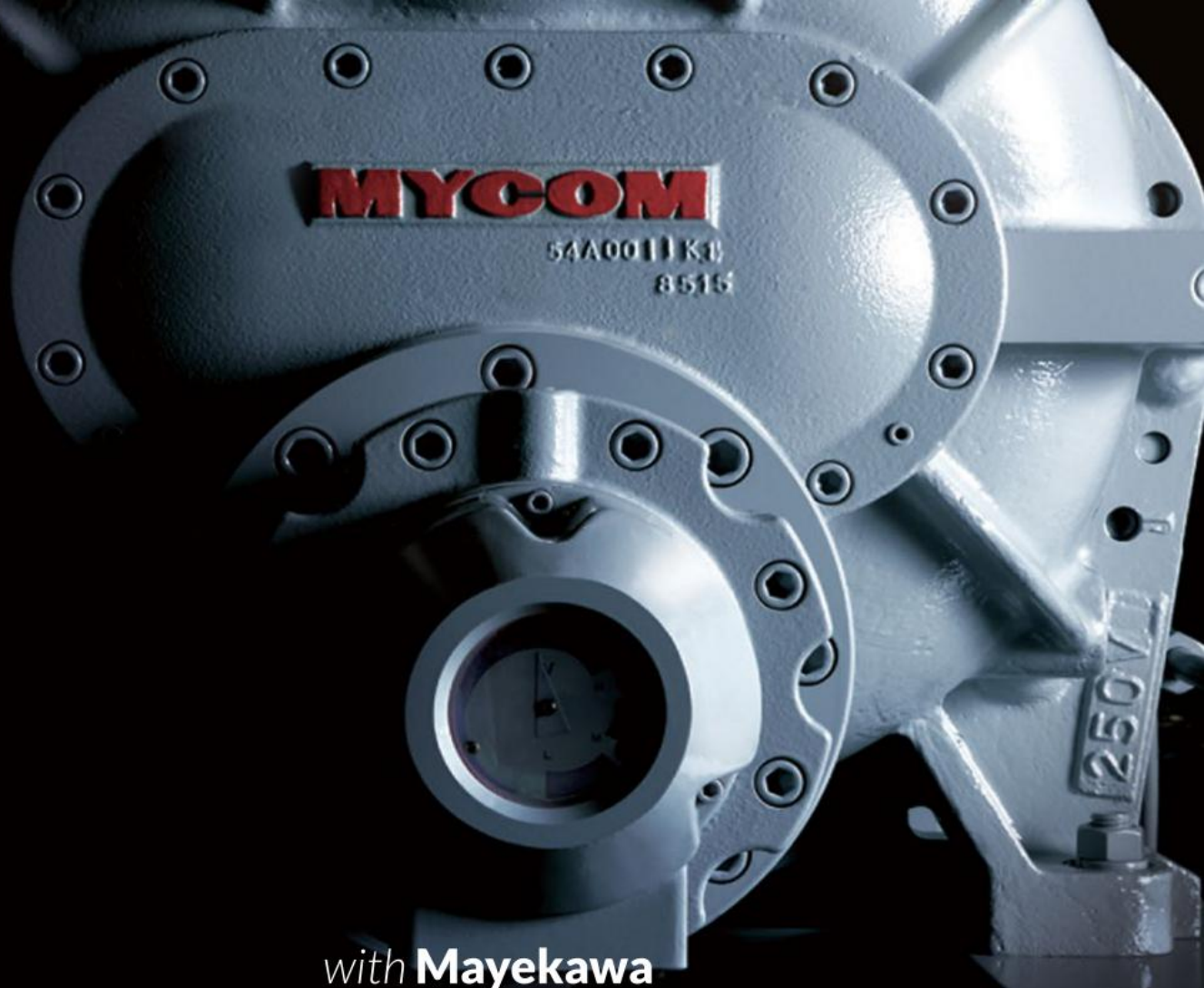
Accelerate asked Jensen to share his thoughts on the direction being taken by industrial and commercial refrigeration.

// Accelerate: Where are natural refrigerant-based systems – CO₂, hydrocarbons and ammonia – heading in 2021?

Jensen: Retail and foodservice applications will continue their adoption of CO₂-based refrigeration



Stefan Jensen, Scantec



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systems. This is not because of energy efficiency. It is because it is easier for stakeholders with experience in HFC-based installations to transition towards CO₂ than towards any other natural refrigerant.

An added dimension is the continued marketing of CO₂ as a safe and green refrigerant belonging to the A1 flammability category. In other words, the past stigmas pertaining to ammonia and hydrocarbons created by the synthetic refrigerant industry are being transitioned across to the CO₂ industry.

As Dan Hamza-Goodacre of K-CEP correctly points out, there is a real risk that the world literally transitions from the ashes to the fire unless the transformation to natural refrigerants is accompanied by some form of mandatory best-practice energy-performance benchmarking.

The increase in maximum hydrocarbon inventories will most likely steal some market share from CO₂ in the retail segment – particularly at the smaller end. Small self-contained hydrocarbon-based display cabinets are far simpler than a transcritical CO₂ centralized plant. In the event of break-downs, the shop owner can install a spare display unit without assistance from a service provider.

Water-loop systems with a central low-charge NH₃ plant absorbing the heat rejection from water-cooled hydrocarbon-based display cabinets on the retail floor will probably gain momentum due to simplicity, low energy consumption, and lower life-cycle cost than an equivalent centralized transcritical CO₂ plant.

Centralized, low-charge NH₃ plants with a dry expansion refrigerant feed will continue to gain momentum. This is simply because the energy efficiency of these systems – when designed correctly – is superior to all other refrigeration concepts. Recent practical energy performance records between conceptually identical NH₃ plants indicate that the energy performance penalty caused by the presence of liquid in the suction line network of traditional liquid overfeed plant is about 30%.

This is for the situation where the only difference between the systems compared is the refrigerant feed method – pumped versus dry expansion. For liquid overfeed systems with extensive use of wet risers and a significant element of oversizing, the energy performance penalty caused by the presence of liquid in the suction gas can be much higher than 30%. This is relatively new knowledge. Because there are no reliable

correlations available for modelling wet-riser pressure drops in situations where flow reversal has occurred or is about to occur, these operating situations are difficult, if not impossible to model.

// Accelerate: Will the cost of natural refrigerant-based equipment come down in 2021?

Jensen: It is quite clear that it is necessary to offset the relatively high capital costs of a centralized, low-charge NH₃ plant against reductions in operating costs. A centralized low-charge NH₃ plant – when designed correctly – delivers Specific Energy Consumption (SEC) values (kWh.m-3.year-1) in mixed refrigerated warehouse applications that are 1.4 to eight times lower than those of most other refrigeration concepts, including ammonia liquid overfeed. This is documented.

Unless the refrigeration system provider is prepared to “put his money where his mouth is,” these claims are hardly ever believed by potential buyers of these systems – particularly if they already possess what they believe to be a well-functioning plant causing few technical problems.

There are numerous examples of existing NH₃-based liquid overfeed plants consuming so much energy that a complete replacement of the existing system with a new, centralized low-charge NH₃ plant delivers simple payback periods of less than five years based on Australian electrical energy prices. There are practical elements that often prevent complete plant replacements, but it is nevertheless a financially and environmentally sound consideration.

// Accelerate: Will the efficiency of natural refrigerant-based equipment improve in 2021?

Jensen: The introduction of best-practice energy performance benchmarking by application is the key driver for continuous improvement in energy efficiency generally. As far as the Australian market is concerned, landlords, tenants, owners, system providers, specifiers, consultants and the government have no energy-performance standards or benchmarking in the refrigerated warehouse industry that can be referred to or that systems can be rated on. We therefore have an environment where the lowest capital cost concept is often installed to the detriment of energy efficiency. This may also be referred to as a mechanism for energy waste. Minimization of capital costs is of course important, but capital cost comparisons excluding life cycle costs only tell about 20% of the story. ■ MG

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Emerson to Continue Pushing NatRefs

A new CO₂ research lab, and new CO₂ and R290 components are planned for 2021, says longtime NatRefs expert Andre Patenaude.

— By Michael Garry

Andre Patenaude, a Canada-based, 36-year veteran of Emerson Commercial and Residential Solutions, has been the HVAC&R component company's go-to authority on CO₂ (R744) and other natural refrigerants.

That began when he served as Director CO₂ Business Development from February 2014 to September 2017. In that role, he developed a global CO₂ refrigeration strategy for Emerson, including marketing initiatives, channel training and customer support.

He has given many industry presentations and submitted numerous articles on CO₂ and other natural refrigerants to Accelerate and other publications.

In his current role as Emerson's Director of Solutions Integration, Emerson, he continues to track the natural refrigerant marketplace, and manage Emerson's role in it.

Patenaude shares Emerson's plans for natural refrigerant systems in the following interview.

// Accelerate: Where are natural refrigerant-based systems — CO₂, hydrocarbons and ammonia — heading in 2021 in terms of installations in your market.

Andre Patenaude: We expect the installation of natural refrigerant-based systems to continue to increase in 2021. This will be the case especially in California, where retailers will be preparing to meet the 2022 CARB (California Air Resource Board) regulations. Outside of California, many retailers will continue trials of natural refrigerant systems as potential strategies for meeting their sustainability targets. Whether it is a transcritical CO₂ booster system or microdistributed R290 integrated display cases, these architectures give retailers viable options for utilizing refrigerants with the lowest-possible GWP.

// Accelerate: What is your organization planning regarding natural refrigerants in 2021?

AP: Emerson will continue to invest heavily in the research and development of natural refrigerant technologies. In 2021, we will complete the construction of a new transcritical CO₂ test lab at our main campus in Sidney, Ohio (U.S.). In addition to our current CO₂ test lab located at the Helix Innovation Center in Dayton, Ohio, this will be our second dedicated CO₂ R&D facility. These labs are designed to accelerate product development, collaborate with OEM partners and end-user customers, and help deliver simplified CO₂ solutions for the industry.

We will also continue our development of compression technologies, controls and valves for CO₂ in commercial refrigeration. Among these solutions is a new CO₂ rack supervisor and facility management controller for transcritical CO₂ booster systems, built with native applications, that helps to manage not only all of the standard system operation requirements, but also addresses high-ambient strategies, while providing enhanced integration with our CO₂ case controls. On the industrial side of things, we will continue investing in the development of CO₂ compressors, including a new heat pump CO₂ compressor.

With respect to propane (R290), we will continue to add compression technologies, valving and electronic controls specific to R290. This includes the addition of R290 to our Copeland low-profile scroll compressor portfolio that includes fixed- and variable-speed technologies and covers a capacity range from 3/4HP to 4HP. We have also recently launched the Copeland variable-speed hermetic reciprocating compressor line that utilizes R290 in fractional horsepower ranges from 1/8HP to 7/8HP. These are designed to deliver game-changing efficiency and

performance improvements for commercial refrigeration reach-in OEMs as well as environmental life sciences, medical and pharmaceutical applications.

// Accelerate: Will the cost of natural refrigerant-based equipment come down in 2021?

AP: From a cost perspective, I think we can expect marginal reductions in natural-refrigerant-based component costs. Over the past several years, our industry has learned a lot of lessons related to the installation, commissioning and lifecycle costs of these systems — especially as they compare to those of traditional HFC systems. As natural systems become more widely used and familiarity with them increases, equipment costs are becoming more competitive because there is a better understanding about what the actual costs are. We expect that this trend will continue into 2021 and beyond.

// Accelerate: Will the efficiency of natural-refrigerant-based equipment improve in 2021?

AP: Generally speaking, if we compare the current installed base of natural refrigerant systems with what we expect to see in 2021, energy efficiency levels should theoretically increase. One main reason for these improvements is that most new systems will utilize variable-speed drives on their lead compressors — which has immediate impacts on energy efficiencies.

Another design specification that may become standard in transcritical CO₂ booster systems is parallel compression. By default, parallel compression may give you significant energy savings when it is in operation. The other key to energy efficiency is sustaining these improvements over time — and to do that requires the system to have controls that provide continuous performance monitoring. If operators allow their systems to drift from their optimal efficiencies, they are essentially negating some of the positive impacts of natural refrigerant-based systems.

// Accelerate: Will training opportunities and the number of trained technicians for natural refrigerant-based equipment increase in 2021?

AP: Due to the fact that more natural refrigerant systems are being installed, it's inevitable that training opportunities will rise and more technicians will need to become educated on natural refrigerant technologies. And as these installations increase, the opportunities for hands-on, on-the-job training will be invaluable for the current generation of technicians.

Of course, OEMs and component manufacturers like Emerson will continue to lead the charge to promote natural refrigerant education. While our mobile CO₂ training unit will likely continue to be curtailed due to COVID-19 restrictions, we have experienced exponential participation increases in our distance learning options, which will likely last well into 2021.

// Accelerate: Will maintenance activities increase or decrease in 2021?

AP: The reality is that in the food retail space, where grocers have seen historic spikes in profits and sales due to the pandemic, system maintenance is one area that might get overlooked. Grocers are simply so busy, that in many cases they're taking an all-hands-on-deck approach to keeping their stores running — especially while juggling the unprecedented increase in e-commerce demands and logistics.

But there are often potential downsides to redirecting resources toward sustaining daily operations. The possibility of system failure could potentially disrupt operations much more than a temporary pause from planned maintenance. Postponing maintenance schedules may also cause systems to drift from their commissioned state and drive up energy consumption. In some instances, grocers may have to delay planned equipment upgrades or retrofits. While these initiatives are typically top priorities for most grocers, they may be temporarily on hold while they perform the essential activities related to meeting customer demands.

// Accelerate: Will your organization offer any integrated refrigeration/heating/AC equipment or components in 2021?

AP: Through the combination of our controls and compressor platforms, we can help retailers integrate heating, refrigeration and air conditioning systems. This would include our E2 facility management system, new CO₂ rack supervisor controller and CO₂ compressors — including parallel compressor applications — which are rated to operate at higher suction pressures to handle not only refrigeration requirements but serve air conditioning systems, should a retailer also want to go that route.

// Accelerate: Will more refrigeration systems leverage waste heat in 2021? If so, how and for what applications?

AP: Indeed, heat reclamation is not only a trend we're seeing throughout our industry, but it has also become a requirement under California's Title 24



Andre Patenaude, Emerson

regulation for supermarkets with refrigeration racks. With CO₂ applications this has become a necessity due to the amount of heat these systems generate — which typically require a single- or a dual-stage heat reclamation component. In addition, operators can leverage this waste heat for a variety of purposes, such as preheating hot water or store heating.

In distributed architectures, systems can be configured to utilize a shared water loop that extracts heat from the refrigeration units and diverts it to a remote condenser. This is a strategy we recommend to retailers using the Copeland indoor modular solution.

// Accelerate: How will COVID-19 impact your business in 2021?

AP: As we discussed, some of the retrofit and remodel projects — either to improve energy efficiencies or transition to a lower-GWP refrigerant — may have been placed on hold by some retailers during this period of high-volume food retail sales. As a result, we expect many of these remodel efforts to take place only when and if they are absolutely necessary. At the same time, many grocers are also investing in technologies to shore up their e-commerce fulfillment activities, and this may also further divert their attention away from these planned retrofits. But there is also a refrigeration component to these emerging e-commerce strategies — such as staging click-and-collect orders — and we will be helping our end-user customers to deploy new refrigeration equipment to augment their current systems. ■ MG

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Climate Change, Biden Administration to Spark NatRef Adoption in '21

But the extent of COVID-19 mitigation will tell the tale.

— By Michael Garry

Over the past 15 years, natural refrigerants – particularly CO₂ (R744) and propane (R290), as well as ammonia (R717) – have become recognized as the most environmentally friendly and future-proof replacement for HCFCs and HFCs in commercial and industrial refrigeration.

The change began in Europe, prompted by the advent of the EU F-Gas Regulation in 2006, and caught on in Japan, where CO₂ had already made its mark in heat pump water heaters. Other regions like the U.S., Australia/New Zealand and South Africa have come later to the party.

In 2021, two world-historical events should help drive uptake in installations of natural refrigerant-based systems throughout the world. First is the growing urgency of the climate crisis, as the prevalence of wildfires, droughts, extreme storms, rising sea levels and other damaging effects becomes inescapable. The other is the replacement of climate denialist Donald Trump as president of the U.S. by Joe Biden, who has promised an ambitious program to tackle climate, including many refrigerant-related initiatives ([see page 52](#)).

Of course, the pace of adoption will be impacted by the status of a third world-historical event – the COVID-19 pandemic. As the clock ticks toward January, the emergence of vaccines provides hope that the pandemic will be controlled, if not eliminated, in 2021.

And natural refrigerants will continue to face fierce competition from chemical companies promoting and selling HFOs and HFO blends, marketed as low- or lower-GWP replacements for HFCs.

János Maté, Senior Policy Consultant for NGO Greenpeace, believes that natural refrigerant-based systems are poised to make “exponential inroads” in the global cooling market. “As the climate crisis unfolds at an alarmingly faster pace than was foreseen even a few years ago, the pressure will mount to globally phase out HFCs faster than currently legislated under the 2016 Kigali Agreement,” he said. “Natural refrigerants are the most sensible alternatives to HFCs. They are climate friendly with low GWP, environmentally safe, efficient and increasingly cost effective.”



Dario Ferlin, Woolworths



Wynand Groenewald, Future Green Now

EXPLOITING WASTE HEAT

Will more waste heat from natural refrigerant systems be used for productive heating in 2021?

“I believe it must,” said Wynand Groenewald, Founder of Future Green Now, a South Africa consultancy. “Why use energy to generate heat when there is already ample heat available somewhere else?”

According to Groenewald, a small retail refrigeration system requiring about 100kW (28TR) of cooling generates enough heat to fulfill the hot-water bathing requirements of 200 to 300 households.

The food industry has a great interest in electrification, “and waste heat plays a big part in this,” said Claus Schøn Poulsen, Center Manager, Danish Technological Institute.

The opportunity of recovering waste refrigeration heat from transcritical CO₂ systems “should not be overlooked,” said Dario Ferlin, National Sustainable Engineering Manager Format & Network Development, Woolworths, Australia.

Around a dozen of Woolworths’ transcritical CO₂ systems feature waste heat recovery for space heating, “and we get better at it each time,” said Ferlin. “We plan to continue exploiting this opportunity.”

Woolworths, a major chain of supermarkets in Australia, is an example of an end user driven to natural refrigerants by its overall sustainability strategy. "Just days ago we publicly committed to sourcing all our power from renewable sources by 2025, reduce our 2015 baseline emissions by 63% by 2030 and reach net positive emissions by no later than 2050," said Dario Ferlin, National Sustainable Engineering Manager Format & Network Development, Woolworths, Australia

The commitment to an HFC phase down by nations that have ratified the Kigali Amendment is helping to boost natural refrigerant adoption, noted John Ackermann, South Africa-based Owner, Jack Agencies, and former Publisher/Editor of the *Cold Link* newspaper.

"Since the signing of the Kigali amendment [in South Africa], the continued availability of synthetic refrigerants is very doubtful," said Ackermann. "As production declines, prices will increase and availability become more difficult. The sooner the change towards natural refrigerants, the shorter the recovery of the additional capital cost of change."

But Ackermann believes that awareness campaigns are needed to promote the long-term benefits of a switch from HFCs to natural refrigerants "and should be the prime focus during 2021."

That awareness has already been – and is continuously being – created, "as we can see an increase in OEMs and contractors backing natural refrigerants instead of going against it, which was the case a few years ago," said Wynand Groenewald, Founder of Future Green Now, a South Africa consultancy. "This is giving the end user much more options and peace of mind, and we are finding that naturals are competing against naturals, and not against HFC or HCFC-based technologies."

In Europe, the F-Gas Regulation's HFC phase down in 2021 will reduce the available HFC quota in the European Union by 55% vs. the baseline. "This major reduction will definitely result in an increased demand for natural refrigerant-based equipment," said Thomas Bartman, Sales Director, German OEM Efficient Energy. "We have already faced a strong increase in demand

Where are natural refrigerant-based systems – CO₂, hydrocarbons, ammonia, water – heading in 2021 in terms of installations in your market?

Much more

43%

More

50%

Same

8%

Less

0%

shecco
Base

40 respondents; rounding to 101%

for our water-only chillers this year and we expect this upward trend to continue in 2021."

David Schalenbourg, Director Architecture, Construction & Maintenance, Delhaize Belgium sees a "steady evolution" towards more sustainable solutions in Europe, with natural refrigerants "becoming standard and being imposed by regulation" as part of national and EU efforts to target reductions of CO₂ emissions.

Delhaize Belgium, which has installed natural refrigerants in 121 company-operated stores out of about 800, intends to become carbon neutral as soon as the end of 2022 by opting for natural refrigerants, using green energy and reducing energy consumption in all operations (stores, warehouses and offices), said Schalenbourg.

Belgium retailer Colruyt Group, which has installed R290 systems in numerous corporate stores, will work on making its experience available to the independent shop owners of Retail Partners Colruyt Group (RPCG), which comprises 385 stores, said Collin Bootsvelde, Project Engineer, Colruyt Group.

These store owners "have, on average, been lagging behind in terms of the shift to natural refrigerants," he said. "We plan to translate our experience with all

three natural refrigerants (R290, CO₂ and ammonia) into a concept that works best for these independent shops."

Colruyt also plans to include targeted maintenance of dry coolers to increase the efficiency of its installations. "We will vary the cleaning interval, depending on the local level of pollution, mostly from vegetation," said Bootsvelde.

Italian OEM Epta sees a growing demand for natural refrigerant-based systems in Europe and all over the world, "at different speeds, of course," said Francesco Mastrapasqua, Epta's Institutional Affairs Manager. "We believe natural refrigerant [technology] is the only way for commercial refrigeration to substantially contribute to the goals of the [European] Green New Deal, i.e. to become the only climate-neutral continent in the world by 2050."

Lithuanian OEM Freor has installed the majority of its green refrigeration store equipment, including its Hydroloop system and R290-based refrigeration equipment, in the Scandinavian region and Switzerland – "countries that are global leaders in sustainability," said Donatos Plauska, Freor's Head of Sales Department. "Store owners realize they can make a huge impact on the environment by choosing alternative, nature-friendly refrigeration solutions, and it becomes a value or a new norm."

In the U.S., Richard Wayne Gilles, Senior Product Leader – Distributed Solutions for OEM Hussmann, predicts “a dramatic increase in natural refrigerant system installations in 2021.” He bases this on upcoming HFC regulations in California from the state’s Air Resources Board, as well technology gains that “have made the installations more appealing to a [broader] base of customers.”

On the other hand, one California grocer who declined to be named believes natural refrigeration installations will be limited in the state. That’s because “many will want to get the last of the synthetic refrigerant systems permitted and installed before 2022,” when a 150-GWP cap on refrigerants in new commercial systems is expected to go into effect. In addition, fewer installations should be expected if fewer new stores are built next year because of the COVID-19 pandemic, he said.

The U.S. food retail industry also continues to suffer from industry inertia. “Investment is very often prioritized on projects that drive retail sales, rather than provide operational savings or address longer term public policy issues,” said James Knudsen, Vice President of Sales, Kysor Warren Epta.

But new bipartisan federal legislation in the U.S. that targets HFCs – and will ultimately increase their costs – could change that dynamic ([see page 52](#)).

“
We will see more
commercial
refrigeration systems
applying CO₂ in 2021
across the world as this
technology outperforms
the previous technology
both regarding energy
efficiency and total
investment costs.

– Armin Hafner,
Norwegian University of
Science and Technology



Armin Hafner, NTNU

MORE ONSITE RENEWABLES

2021 will see more natural refrigerant systems tied to renewable power.

“We continue expanding renewable energy with solar panel installations on the roof of our supermarkets and warehouses,” said David Schalenbourg, Director Architecture, Construction & Maintenance, Delhaize, Belgium. “In 2021 maybe for the first time [we will have] a wind turbine on the parking lot of one of our stores.”

Woolworths in Australia has made significant investments in solar panels on the roofs of its stores. A store in Orange was the 140th site generating energy from solar power, and to mark the occasion, 357 panels were “laid out in the shape of the Woolworths logo!” said Dario Ferlin, National Sustainable Engineering Manager, Format & Network Development, Woolworths, Australia.

“Our commitment to using 100% renewable power by 2025 will only accelerate this trend,” he said.

Armin Hafner, professor in refrigeration in the Department of Energy and Process Engineering at the Norwegian University of Science and Technology (NTNU), agrees that the integration of local renewable energy and thermal storage will be key in many installations, “as peak power demand is costly and the transition away from fossil fuels has just started.”

BULLISH ON CO₂

According to data presented in October 2020 by sheccoBASE (the research arm of shecco, publisher of *Accelerate*), Europe leads the world in transcritical CO₂ installations with 29,000. It is followed by Japan (5,000), U.S. (650), Canada (340), South Africa (220+), New Zealand (100), Australia (95) and South America (75), and scattered installations elsewhere.

How will this picture change in 2021?

Armin Hafner, professor in refrigeration in the Department of Energy and Process Engineering at the Norwegian University of Science and Technology (NTNU), and a longtime expert in CO₂ refrigeration, is bullish on its prospects.

"We will see more commercial refrigeration systems applying CO₂ in 2021 across the world as this technology outperforms the previous technology both regarding energy efficiency and total investment costs," Hafner said. "The end users are aware of the advantages of the CO₂ technology globally and are pushing the local suppliers to deliver this technology whenever ready and possible." The main bottleneck: "training and knowledge transfer."

One major end user, Australian retail giant Woolworths, has made great strides since installing its first transcritical CO₂ system in 2017, reaching 20 stores (all but one new) with transcritical CO₂ by the end of this year, double its original goal, said Ferlin.

Of the 20, 19 are large-footprint supermarkets (averaging 3,200m²/34,445ft² in trading area) that use two large booster systems. A number of the stores have space heating managed by the refrigeration systems and three feature full space-heating and space-cooling integration. "We expect this trend to continue into 2021 and beyond," with plans to increase the number of integrated systems "where it's feasible to do so," Ferlin said.

2021 PLANS: DELHAIZE BELGIUM

All of the 22 supermarkets Delhaize Belgium will be equipping with transcritical CO₂ systems – 17 existing stores and five new – will be getting integrated systems combining refrigeration, air conditioning and heating.

Large supermarket chains in Australia like Woolworths have engaged in a large uptake of CO₂ systems by "overcoming some of the challenges posed by our high ambient temperatures," said Tony Gleeson, CEO and Company Secretary, Australian Institute of Refrigeration, Air conditioning and Heating (AIRAH).

According to the latest edition of "*Cold Hard Facts*," a report on Australia's refrigerant bank, the volume of CO₂ refrigerant was estimated at about 215 metric tons in 2019. "We expect this trend to continue as CO₂ solutions are further rolled out by the large supermarket chains and equipment is developed for smaller applications," said Gleeson.

European retailers will continue to lead the world in CO₂ installations and development in 2021.

All of the 22 supermarkets Delhaize Belgium will be equipping with transcritical CO₂ systems in 2021 – 17 existing stores and five new – will be getting integrated systems combining refrigeration, air conditioning and heating, said Schalenbourg.

Integration, said South African consultant Groenewald, "decreases the initial CAPEX requirement, decreases the operational cost of a facility, and reduces the heating and cooling waste of equipment drastically."

German wholesale giant Metro AG, which has installed 114 transcritical CO₂ systems, will "accelerate" its rollout in 2021 in furtherance of its F-Gas Elimination Program (FEP), said Olaf Schulze Metro AG's Director for Energy, Facility and Resource Management. The only caveat is the general economic state of the hospitality sector, Metro's target customer, which has been hammered by the COVID-19 pandemic in 2020.

In Europe, CO₂ is becoming "more and more a commodity in refrigeration," said Andreas Meier, Managing Director, German OEM Teko. He expects strong growth in 2021 in retail and industrial applications. "In industrial applications, we see that CO₂ will substitute [for] some ammonia market share."

Teko is planning to roll out CO₂ condensing units for commercial applications between 1kW (0.3TR) and 8kW (2.3TR) "in order to provide the lower end of the capacity range applications with nonflammable, but natural, solutions," said Meier.



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► Teko is also working to bring a portfolio of commercial CO₂ chillers to market as an alternative to R290 chillers. "For some applications, flammable refrigerants like R290 cannot be used, or the end user does not want to use it," Meier said. In addition, the energy efficiency (SEER value) in some applications with CO₂ is higher than for other refrigerants.

In the U.S., Weis Markets has decided to install a transcritical CO₂ refrigeration system in two new stores next year, based on the energy savings and overall performance of its [initial transcritical system](#) at a store in Randolph, New Jersey (U.S.),

Weis's 54,000ft² (5,017m²) store in Randolph opened in July 2018, with an Advansor transcritical CO₂ rack from Hillphoenix, and two adiabatic gas coolers from Baltimore Aircoil (BAC). The two new stores will use transcritical racks from Zero Zone, and BAC adiabatic gas coolers, noted Paul Burd, Manager, refrigeration engineering for Weis.

[After acquiring U.S. refrigeration manufacturer Kysor Warren](#), Italian OEM Epta has been supplying transcritical CO₂ (R744) systems incorporating efficiency-enhancing FTE (Full Transcritical Efficiency) technology in the U.S.

Now, following "very good acceptance of FTE," Epta plans to launch its ETE (Extreme Temperature Efficiency) system, recommended for very warm climates, even over 40°C (104°F), in the U.S., said Mastrapasqua at Epta.

In general, Epta will also aim its CO₂ technology at small stores, "proximity stores," and city stores, said Mastrapasqua. "In this market segment we feel there is still a need for new solutions to cover some specific gaps, such as space constraints, cost and reliability."

But Joe Kokinda, President/CEO, Professional HVAC/R Services, a U.S. contractor for food retailers, believes that major OEM's and their larger super-market clients in the U.S. "are only dangling a toe in the ocean at this point, so I do not believe that 2021 will be a breakout year for larger CO₂ or cascade type systems."

On the industrial side, Hillsboro, Oregon (U.S.)-based Henningsen Cold Storage, acquired this year by Lineage Logistics, has installed transcritical CO₂ systems at two facilities, and is "exploring transcritical CO₂ further as a possible replacement for existing aged NH₃ systems," said Pete Lepschat, Henningsen's longtime Director - Engineering.



Ady Vyas, Neelands Group

In Canada, CO₂ installations in stores are increasing, said Ady Vyas, Vice President of Energy and Digital Services for Neelands Group, an Ontario contractor. "We continue to push CO₂ as the primary refrigeration, even when RFPs [requests for proposals] call out for HFCs."

2021 PLANS: ARNEG CENTRAL AMERICA

Arneg Central America plans to install transcritical CO₂ systems with parallel compression and integrated AC in 10 new Riba Smith and eight new Marche Service convenience stores.

Canadian industrial contractor Cimco is also seeing a rise in CO₂ installations, said Benoit Rodier, its Director of Business Development. "We still are largely promoting ammonia and CO₂ system over synthetic."

Arneg Central America, based in Panama City, has found a way to market transcritical CO₂ refrigeration in warm climates like Central America and the Caribbean, as well as Ecuador in South America, which the earth's Equator cuts through. The secret is that its transcritical CO₂ systems typically include parallel compression and often ejectors as well.

In 2021, Arneg Central America plans to install transcritical CO₂ systems in numerous stores, said Pablo Buchko, its Regional Manager. These include 10 new





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► Riba Smith and eight new Marche Service convenience stores, all with parallel compression and integrated AC; two refurbished Riba Smith stores in Panama with parallel compression; and a Carrefour Marina in Guadeloupe with parallel compression and ejectors.

Arneg Central America expects to complete a CO₂ training facility in Panama before January 2021 and “hopefully begin training soon after that, at least with local technicians,” said Rolando Bissot, its Engineering and Maintenance Manager. “It all depends on [COVID-19] travel and meeting restrictions.”

In South Africa, “the swing towards CO₂ installations in the commercial sector is on the increase,” said Ackermann. But due to the sluggish market during 2020, “installations in 2021 will show a slight increase on that during 2019.”

The prospects for transcritical CO₂ in China appear to be more limited.

German OEM Metro AG installed the first transcritical CO₂ system in China, at a new store in Beijing in January 2018, and then two others at existing stores in Beijing and Chongqing in June 2019.

However, since October 2019, those stores have been 80% owned by Chinese retailer Wumart and 20% owned by Metro AG. The combined entity, Metro Wumart, has no plans currently to install transcritical systems at other stores,” said Alan Lin, Head of Facility Management.

With the smaller presence of Metro and the departure of other overseas retailers, the use of natural refrigerants in China “will be seriously affected in the retail industry,” said David Zhang, Owner of Shanghai Fute Refrigeration & Electrical Engineering Co, Ltd, adding, “I hope that Sam’s Club and Costco will help promote the use of natural refrigerants in the near future.”

Also, the availability of components and trained technicians in China, although improved, “will continue to hinder the use of natural refrigerants,” Zhang said.

Robert Jiang, GM-Sales/Marketing/Service, Jiangsu Cryotek Refrigeration Equipment Co., Ltd., agreed that foreign retailers have been the technology leaders in China while local players “focus more on profitability and survival.”

But Cryotek will do some “basic work” in 2021, including building natural refrigerant systems for educational purposes in schools, and continuing to offer “proposals” to customers.

CSF Market, a Beijing, China-based chain, installed a transcritical CO₂ system in 2018, but does not plan to install another, said Du Li Li, Overseas Sales Director, Panasonic Appliances Refrigeration System (Dalian) Co., Ltd.

“We want to find another supermarket to install a CO₂ system,” said Du. “We want to continue to push this technology development in China.”

The obstacles to adoption of CO₂ systems in China remain high initial cost, and lack of government subsidies, said Du. Long delivery time for some components imported from overseas is also a challenge to development, she noted.

But Panasonic plans to continue making transcritical systems in China for export. The company manufactured 20 CO₂ units this year that were exported to Japan, and expects to exceed 30 units next year, said Du. “Our company will be committed to pushing CO₂ systems all over the world,” she said. “We have mature technology in booster, parallel [compression] and ejector CO₂ systems. We will design [a] cold-hot integrated comprehensive utilization CO₂ system next year.”

Japan has been a world leader in the installation of CO₂ condensing units in convenience stores and in the uptake of CO₂ residential heat pump water heaters.

Over the past few years, the competition in the Japanese industrial sector between transcritical CO₂ systems and low-charge ammonia (R717) systems has increased, and this is expected to continue in 2021.

For example, in October, Japanese OEM Panasonic shipped its first 80HP transcritical CO₂ rack systems in Japan. The racks will be installed by Benirei Logistics, a Japanese cold-storage warehouse operator and logistics company.

In addition, Italian CO₂ refrigeration system manufacturer SCM Frigo (a subsidiary of Swedish manufacturer Beijer Ref) recently confirmed that it has signed a sales partnership agreement with a Japanese company (that has not been named) to ship three industrial CO₂ transcritical refrigeration systems to Japan.

In a statement released on December 1, Japanese OEM Mitsubishi Heavy Industries Air-Conditioning and Refrigeration (MHI) announced the addition of an 80HP model to its lineup of C-Puzzle CO₂ (R744) condensing units, targeting the food manufacturing industry. The unit will go on sale only in Japan in the summer of 2021.



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► HIGHER CHARGE TO BOOST R290 SYSTEMS

Along with transcritical CO₂, hydrocarbons, primarily propane (R290) have emerged in the last several years as a viable refrigerant for supermarkets.

Thousands of stores worldwide have deployed plug-in air-cooled R290 display cases at the

“*The simpler the system, the better it will fare, and R290-based systems fit that niche.*”

— Joe Kokinda,
Professional HVAC/R Services

point-of-sale or in other spot merchandising capacities. On top of that, a growing number of supermarkets, usually on the smaller side, have been installing water-loop R290 case lineups throughout their frozen-food sections, or the entire store. These trends are expected to continue apace in 2021.

Moreover, the higher charge limit (500g, up from 150g) approved for R290 in commercial cases by the International Electrotechnical Commission (IEC) last year is now being adopted in varying degrees by regional standards bodies (see page 52). This is expected to spark further adoption of R290 systems as single-circuits will be able to replace multiple circuits in larger cases.

“The simpler the system, the better it will fare, and R290-based systems fit that niche,” said Kokinda at Professional HVAC/R Services. R290 systems are becoming more and more variable in style, “with motors and compressors ramping up and down as needed,” said Kokinda. “This will be beneficial to the end users on energy use, but the initial cost is much higher.”

However, if R290-operated equipment can be used with higher charge limits, it will mean “[fewer] refrigeration cycle components, fewer compressors, and that can lower the cost of the final product,” said Plauska at Freor.

Kokinda observed that many independent retailers, while “flush with cash” from COVID-19 sales bumps, are still “dragging their feet on CO₂” installations.

Instead, most are looking at hydrocarbon units, he said, adding, “We have seen that gain traction in California.”

But Kokinda also pins further growth in hydrocarbon units on the adoption of higher charge limits by regional authorities. “Not many customers see the benefit in cabinets that have more than one compressor, which I agree with,” he said.

Knudsen at Kysor Warren Epta, believes that plug-in R290 cabinets represent the natural refrigerant application with greatest opportunity in 2021, followed by water-loop R290 systems for small venues and remodels, and transcritical CO₂ for new and remodeled central systems.

Hannaford, a chain in the northeast U.S., has been testing water-loop R290 low-temperature cases in new stores. Now the retailer is considering installing them in existing stores in a retrofit. “We have a couple of existing stores we’re looking at for next year,” said Joshua Smith, Manager of Refrigeration & HVAC Service, Hannaford. The roof of these stores would have to support a fluid cooler, he noted.

In one new store in Vermont (U.S.), Hannaford has installed an R290 low-temperature lineup with a transcritical CO₂ glycol chiller for medium-temperature cases. The combination of R290 frozen-food cases and secondary glycol medium-temperature

2021 PLANS: AHT USA

AHT Cooling Systems USA is planning to install R290 water-loop cases in a multi-use retail project at a Piggly Wiggly store in Georgia.

cases represents “a significant improvement over what we have, and moves us toward the end game,” said Harrison Horning, Director of Energy & Facilities, Hannaford.

Other U.S. retailers exploring R290 lineups include ALDI US, which said it anticipates testing AHT Cooling Systems USA’s R290 semi-plug-in cases with water-loop cooling, as well as air-cooled R290 display cases and cold-room packaged units. AHT is also planning an installation at a Piggly Wiggly store in Georgia in which “our R290 water-loop [cases] were selected over traditional DX remote for a multi-use retail project,” said Drew Tombs, President, AHT Cooling Systems USA.

In Belgium, Colruyt Group aims to eventually convert all of its stores to R290 refrigeration. The number of R290 stores was expected to rise to 132 by the end of the 2020, out of 413 stores in total (mostly in Belgium), Bootsvelde said. "All new systems will have natural refrigerants and we will continue to convert existing HFC equipment in 2021," he said.

Colruyt uses an unconventional R290 system, which comprises two or three "ventilated enclosure" compact R290/glycol chillers, depending on the size of the store. They serve a cold room open to shoppers for produce, dairy and other medium-temperature products; they also support the butcher/deli in the main store area. Stand-alone chest freezers employ isobutane (R600a) or R290 as the refrigerant.

Freor expects to see a growing number of R290 plug-in refrigerated cabinets in tandem with water-loop systems for small to medium stores, and CO₂ remote systems for large sales areas, in the coming years, said Plauska at Freor. "R290 will be dominating plug-in and semi plug-in showcases, especially with higher charge limits under a revised standard in commercial refrigeration in Europe."

Freor is expanding its R290 product line to accommodate the new IEC charge limit for R290 of up to 500g. "We also invest in developing more energy-efficient refrigerated display cabinets," said Plauska.

R290 cases offer "space-saving, lower installation, and maintenance costs, and the possibility for residual heat reuse, [which] is becoming more and more important for store owners," said Plauska.

Though the foodservice industry has struggled this year because of the COVID-19 pandemic, it was already turning significantly toward the adoption of R290 fridges and freezers. True Manufacturing, a major provider to both foodservice and retail outlets, has "already converted to hydrocarbons on all products," said Todd Washburn, Director Sales & Marketing – Retail Division. "So for True, this is a done deal."

R290 technology is mature and already very efficient, and R290 components are already scaled to volume, noted Washburn, adding, "Pricing in the market is parity to legacy HFC."

But the market will continue to see component manufacturers and cabinet manufacturers pushing for product improvements in a competitive environment, Washburn said.

While home fridges around the world have been using R600a as a refrigerant for many years, in the U.S. this only began happening for regular-sized units in 2018, when since the EPA raised the charge limit for home refrigerators and freezers to 150g from 57g.

The U.S. home appliance industry "is continuing its transition out of very high GWP HFC refrigerants" to R600a, said Kevin Messner, Sr. Vice President of Policy & Government Relations at Association of Home Appliance Manufacturers. "Many states are requiring compact products to be out of these refrigerants by January 1, 2021, and then the larger products will be fully transitioned out over the next couple of years."

To help U.S. consumers identify home fridges that use R600a, the Environmental Investigation Agency (EIA) [began a website](#) this year listing such models.

In China, the adoption of hydrocarbon cases has been slow, though some local supermarkets have installed water-loop systems this year, said Du of Panasonic.

Zhang of Shanghai Fute Refrigeration is not optimistic about the use of hydrocarbon cases in China, "unless it is proven that the cost of using hydrocarbons as a refrigerant product is competitive, and the safety of use and maintenance is guaranteed."

In Japan, where CO₂ outdoor condensing units have long been popular in the commercial refrigeration sector, hydrocarbon-based systems have made significant progress, and this trend is expected to continue in 2021.

In 2020, on the trade show floors of Japan's two largest food retail and food service exhibitions, Supermarket Trade Show (SMTS) and HCJ, several of Japan's biggest names in commercial refrigeration exhibited hydrocarbon equipment aimed at the Japanese market for the first time.

Major Japanese end users are also taking notice and implementing the hydrocarbon-based equipment. In September, Japanese convenience store chain Lawson opened its first freon-free store, where it is using hydrocarbons for the first time for its smaller plug-in upright and under-counter refrigerators and ice makers.

Japanese OEM Hoshizaki, which has long been a provider of hydrocarbon equipment overseas, supplied hydrocarbon plug-in equipment for the first time in Japan at the Lawson store.

MORE LOW-CHARGE AMMONIA CHILLERS

The movement to low-charge ammonia industrial systems, driven by safety and regulatory factors, will continue to gain traction in 2021.

Both packaged and centralized low-charge options have emerged in recent years. While the latter are well-suited for large-capacity applications, the former, in the form of multiple units, have been installed to handle a range of capacities.

According to Travis Kissner, Vice President of Industrial Services for Kentucky (U.S.)-based C&C Industrial, low-charge ammonia packaged options "are ruling the present cold-storage market."

In Australia, low-charge ammonia is starting to be used more widely in chillers, said Gleeson of AIRAH, citing the "Cold Hard Facts" report.

U.S. OEM Evapco introduced its LCR-C line of low-charge ammonia chillers in 2017. Early next year, Evapco will unveil the latest addition to the LCR-C line, its first air-cooled model, according to Kurt Liebendorfer, Evapco's vice president.

"The current models are water-cooled, so bringing the air-cooled models to market in just a few months will be a great addition," he said.

The creation of the air-cooled chiller line, along with others under development, was partly driven by "expectations they will provide a lower overall cost solution than current solutions," Liebendorfer noted.

The air-cooled units will be available in different configurations. "We expect them to be very popular due to their complete plug-and-play nature and high efficiency," said Liebendorfer.

2021 PLANS: EVAPCO

Evapco will unveil its first low-charge ammonia chiller that is air-cooled.

"Low-charge ammonia packaged options are ruling the present cold-storage market."

— Travis Kissner,
C&C Industrial

In general, Liebendorfer said he sees an increasing number of low-charge ammonia installations, "and we expect this to expand in 2021."

One of the leading manufacturers of low-charge centralized systems is Australian OEM Scantec Refrigeration Technologies. Stefan Jensen, its Managing Director, said the company will "continue the pursuit" of centralized, low-charge ammonia systems, but with more emphasis on its ScanPAC unit, which brings the flexibility of packaged systems to a centralized format. Scantec will also pursue alternative ownership models and capital cost reductions "through the use of more standardized plant room enclosures as opposed to bespoke units," he said.

On its [website](#) Scantec describes ScanPAC "as a small-scale packaged centralized low-charge ammonia refrigeration system that does not require a separate plant room." An individual ScanPAC suits a small to medium-sized facility of around 30,000m³ (1.06 millionft³) or less; for larger facilities multiple ScanPACs can be used.

As a small-scale packaged design, ScanPACs are "relocatable if necessary," with "documented annual energy performance improvements of up to 67% compared with single-stage, multiplexed, air-cooled HFC based systems with electric defrost." It also uses three to five times less ammonia than equivalent conventional R717 systems with liquid overfeed.

■ MG

NATREF EQUIPMENT COSTS: UP AND DOWN

One topic about which there is considerable disagreement among stakeholders is the direction that natural refrigerant equipment costs will take in 2021.

The continuing HFC phase down in the EU required by the F-Gas Regulation will lead to “more and more [installations of] chillers based on natural refrigerants, said Thomas Bartman, Sales Director, German OEM Efficient Energy. “This will, in consequence, lead to decreasing production costs and sales prices.”

Armin Hafner, professor in refrigeration in the Department of Energy and Process Engineering at the Norwegian University of Science and Technology (NTNU), also expects equipment costs to come down as market shares and competition rise. He added that end users should also consider the advantageous operation and service costs of natural refrigerant systems.

Yet Olaf Schulze, Metro AG’s Director for Energy, Facility and Resource Management, expects equipment to be more expensive next year.

While Donatas Plauska, Freor’s Head of Sales Department, expects competition between different types of natural refrigerant-based systems to intensify, “we see it more as an accelerator to increase performance rather than reduce costs.” The rising costs of labor and quality components “tend to increase end product prices.”

Andreas Meier, Managing Director, German OEM Teko, expects a variety of costs, depending on the application. “In some applications below 20 kW (5.7TR), the prices will further drop in 2021,” he said. “On the component side, 2021 will be a stable price year.”

Natural refrigerant-based technology costs in South Africa have “stayed neutral” over the last few years, noted Wynand Groenewald, Founder of Future Green Now, a South Africa consultancy. “However, I foresee that we are close to seeing a decrease in cost as the demand for these systems increases.”

Simplicity of design will also lower costs, Groenewald added. “The more OEMs and contractors get used to technologies using natural refrigerants, the easier it gets to not implement all the ‘bells and whistles’ within a system, which is only there as a precaution.”

System costs in the U.S. are declining, but slowly because production volumes continue to be low, “with incremental, but not order of magnitude increases,” said James Knudsen, Vice President of Sales, Kysor Warren Epta “The payback on these systems is there, but first-cost motivation continues to drive the industry.”

Still, given that current systems seem to gain 10% efficiency improvements with each cycle, “smart retailers will begin to update their estates to lower operational cost for competitive advantage,” said Knudsen.

On the other hand, Richard Wayne Gilles, Senior Product Leader – Distributed Solutions of U.S. OEM Hussmann sees a continuing drop in equipment prices “as manufacturers’ designs mature and there is greater availability of components produced in higher volumes.”

In Canada, Benoit Rodier, Director of Business Development, Cimco, sees a decrease in the cost of industrial CO₂ rack systems by about 5% to 10% per year. “Manufacturers get more savvy and strongly focus on manufacturing efficiency,” he said, “and more suppliers are offering CO₂ products.”

But for commercial equipment, costs in Canada remain 10%-20% higher than average, said Ady Vyas, Vice President of Energy and Digital Services for Neelands Group, who tries to explain to end users that total costs (labor, material, refrigerant, equipment) are “actually at par or even lower.”

In China, there is “no possibility of reducing the cost of building a natural refrigerant system due to the scarcity of trained technicians as well as higher tariffs on products imported from the U.S.,” said David Zhang of Shanghai Fute Refrigeration & Electrical Engineering Co, Ltd.





NatRefs' Growing Role in Efficient AC

Air conditioning represents the next great opportunity for natural refrigerant adoption as global temperatures rise.

— By Michael Garry

In a warming world, air conditioning (AC) use is expected to skyrocket. According to the International Energy Agency (IEA), the energy needs for space cooling will triple by 2050, with nearly 70% of the growth coming from the residential sector.

This means that energy-efficient AC systems will be a vital part of any plan aimed at curbing energy use and carbon emissions.

Natural refrigerants-based AC systems, in addition to eliminating high-GWP refrigerant emissions, have proven to be highly efficient, and figure to play a key role in the transition to more efficient AC over the next decade. Indeed, this represents the next great opportunity for natural refrigerants, following their more widespread adoption in refrigeration and heat pumps for hot water generation.

As an indicator of the efficiency of natural refrigerants in room air conditioners (RACs), propane (R290) is being used by two of the eight finalists – Godrej-Boyce and S&S Design Startup Solution Pvt. Ltd. – in the competition for the US\$1 million Global Cooling Prize. ([See page 42.](#))

R290-based RACs have already begun to gain traction in some markets. Godrej sold 650,000 units between 2012 and 2019, 95% in India, said Santosh Salian, Product Group Head – Air Conditioners, Godrej Appliances, in an interview last year. “But, over the next five years, we are looking at key markets like [South Asia], Europe and the Middle East for exports of our AC products.”

Godrej phased out its fixed-speed R290 ACs and has been focusing on inverter units, which have ISEERs (Indian Seasonal Efficiency Ratios) ranging

from 4.55 to 6.15. This puts them in “one of the highest ISEER rating categories in the Indian market,” said Salian.

“With its GWP as low as three, zero ODP, non-toxicity and excellent thermodynamic properties, [R290] is the future of the residential room AC industry,” he added.

The R290 charge in Godrej ACs is in line with European EN378 Standards and ranges from 300g to 380g, said Salian. But the charge limit for RACs is expected to increase next year with a change in the International Electrotechnical Commission (IEC)’s safety standard. (See page 52.)

Chinese manufacturers have also begun to produce R290 RAC units, with 276,250 units made as of October, according to Li Xiaoyan, program officer at China’s Ministry of Ecology and Environment/Foreign Economic Cooperation Office (MEE/FECO). The manufacturers are Gree, Midea, Haier, Hisense, Changhong, TCL, Aux and Yair.

R290 RAC units are slowly emerging in Europe. In March, a briefing paper, “HFCs and HFC alternatives in split air conditioning systems,” touted the potential of R290 AC for the European market.

“It seems technically possible to avoid f-gases today in new single split A/C with a cooling capacity below 7 kW [2TR] by using the refrigerant R290, unless where national legislation or codes prohibit its use, at good energy efficiency and at a very modest price increase that would likely disappear due to economies of scale if used at large scale,” wrote the authors, Barbara Gschrey and Julia Kleinschmidt of German researcher Öko-Recherche, and Stéphanie Barrault of environmental firm CITEPA.

To that end, an EU-backed project called LIFE ZEROGWP plans to come to market in 2021 with a monobloc double-duct RAC that uses R290. Launched in 2018, the project has an end date of June 30, 2021. “ZEROGWP project aim is to demonstrate the technical feasibility, full safety and commercial viability of an innovative monobloc residential air conditioning system, called Double Duct (DD) technology, that can be charged by R290 with unprecedented environmental performance,” said the project website.

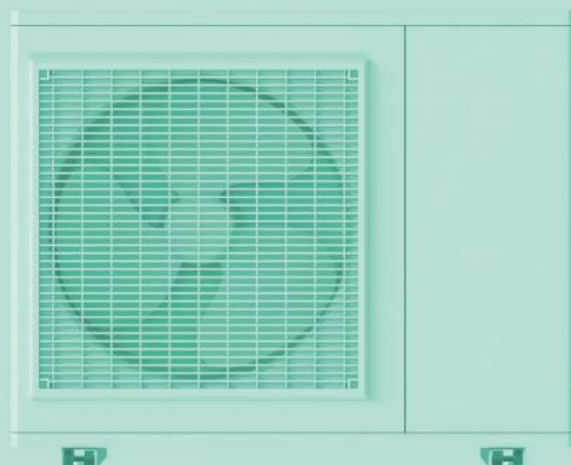
A Midea R290 split air conditioner is also expected to enter the European marketplace, according to speakers at the online ATMO/DTI Technical Conference in June (organized by shecco, publisher of *Accelerate*.) The Midea unit is the only room AC to earn Germany’s highly demanding “Blue Angel” ecolabel.

Collin Bootsvelde, Project Engineer, Belgium grocer Colruyt Group is looking forward to the availability of R290 ACs “I think that the most impactful

“ I think that the most impactful development in 2021 will be the introduction of R290-based split air conditioning.

– Collin Bootsvelde, Colruyt Group

”



development in 2021 will be the introduction of R290-based split air conditioning," he said. "A British web shop already started selling these in the summer of 2020 and they have a monoblock version, for which you only need to drill two ventilation holes through the wall."

"It is long overdue that Europe takes the lead here," Bootsvelde added, pointing to the positive environmental impact that R290 ACs could have if they become a worldwide standard.

Colruyt Group is also running a "non-CE prototype" from Godrej in its labs. "We have been giving feedback to them in terms of serviceability and the needs from a Western European perspective," said Bootsvelde, who is preparing a "business case" for R290 AC.

For commercial building applications, Polaris Technologies, an Australian HVAC OEM, launched hydrocarbon-based air-conditioning units in 2018. The units use M60, a hydrocarbon refrigerant blend from Engas consisting of under 35% propane, more than 60% propylene, less than 5% isobutane, and less than 1% butane.

Polaris has installed more than 65 hydrocarbon systems in Australia in light-commercial applications, according to Tony Power, its Managing Director. A new version is being developed.

"We are in development after success of our initial release," said Power. "We will be concentrating on hydrocarbon HVAC with special focus on built-in safety beyond the current ISO standards and, of course, high efficiency."

Power sees manufacturers improving the technologies on all natural refrigerant [HVAC] systems, and he expects "significant energy efficiency gains beyond the high level that currently exists."

Another natural refrigerant used in Australia in commercial AC, to a much lesser extent than R290, is ammonia. A prime example is a water-cooled ammonia chiller system that has provided air conditioning at the Council Administration Center in Logan City, Australia, since 2011. It is one of the few ammonia-based air-conditioning systems in Australia.

The ammonia chiller replaced an R22-based system. The reduction in energy consumption offered by the system was estimated to be from 900 to 1,400MWh per year, said Stefan Jensen, Managing Director of Scantec Refrigeration Technologies, which installed and has carried out maintenance for the system.

In North America, low-charge ammonia chillers are starting to be installed for commercial AC applications. OEM Azane installed one at a [Campbell Soup plant in Ohio](#), and Canadian contractor/OEM Cimco plans for ammonia-based low-charge AC chillers to be "part of our next development," said Benoit Rodier, Director of Business Development.

CO₂ in integrated systems

CO₂ (R744) is also playing a growing role in the development of air conditioning, particularly at the commercial level.

For example, Swiss OEM Biagini Frigoriferi has started installing for retailer Migros Ticino (part of Swiss retail giant Migros) a large CO₂ air-conditioning system, expected to be ready by March-April 2021, said Luca Rossi, a Project Manager with Biagini Frigoriferi.

Next year, Biagini Frigoriferi plans to add to its CO₂ product range, "from small capacities up to huge capacities, and from commercial refrigeration, to industrial and HVAC," said Rossi.

In supermarkets, a more common scenario has been the installation of fully integrated transcritical CO₂ systems, which incorporate AC and heating (through heat reclaim) in the core refrigeration system.

For example, in 2018, Migros Ticino, which operates 33 grocery stores among other businesses, began using its first fully integrated CO₂ system, also provided by Biagini Frigoriferi, at a store in Riazano, Switzerland. The store is Migros Ticino's 21st to employ a transcritical CO₂ system.

Pleased with the success of its initial integrated system, Migros Ticino plans to install it in projects planned for 2021, said Rossi, who added that the system has become the retailer's "new standard."

“*Behavior change of our collaborators, associates and clients stays a challenge.*”

– David Schalenbourg,
Delhaize Belgium

”

A number of other European OEMs also offer integrated transcritical CO₂ systems. For example, Italian OEM Epta has supplied integrated systems for many years on demand. “CO₂ offers a lot of exhaust heat that can be used for space heating, so it is an opportunity that can in some cases improve the total cost of ownership of the system,” said Francesco Mastrapasqua, Epta’s Institutional Affairs Manager.

German OEM Teko has also provided integrated systems, for nearly 10 years. “What we see is that the reliability of such systems needs to be improved, especially on the component side,” noted Andreas Meier, Managing Director. In addition, the local staff has to be trained to understand that “it is not only a refrigeration system – it is also a heating system and an air-conditioning system.”

Also in Europe, the [MultiPACK project](#), an EU-sponsored initiative, is supporting the development of integrated transcritical CO₂ systems. Launched in 2016, the project is expected to wrap up in September 2021.

Another HVAC application where CO₂ has started making progress is motor vehicle air conditioning (MAC). In 2017, as an alternative to the widely used R1234yf, Daimler’s Mercedes-Benz S-Class Coupé (S 400 Coupé) became the first series-production car worldwide to offer CO₂ air conditioning. This was followed by other models in the S and E class.

However, because CO₂ “has not yet established itself with conventional drives in the volume segment across all manufacturers, we decided to omit this option in the face-lifted current E-Class

and the new S-Class model,” said René Olma, Global Communications, Mercedes-Benz Cars, Stuttgart, Germany. “We will closely monitor further developments on the market.”

Nonetheless, CO₂ MAC has another route to more widespread implementation – as a heat pump providing both heat and AC in the fast-growing electric vehicles market. When used as a heat pump in a car, CO₂ offers a competitive advantage in terms of energy efficiency compared to other refrigerants; it is estimated to increase driving ranges of electric cars by up to 38%, according to Sanden International, which makes CO₂ compressors for mobile air-conditioning systems.

Volkswagen is one of the first car makers to include a CO₂ heat pump in electric vehicles. “All models of the new ID [Intelligent Design] like ID.3 and ID.4 are equipped with an R744 AC and heat pump,” said Christian Buhlmann, Head of Communications, Technology and Innovation, for the company. In September, Volkswagen released the ID.3 and ID.4 electric vehicles. “We are also looking at equipping other models with R744 ACs as well in the future,” added Buhlmann.

Mitigating cooling demand

In addition to exceptional efficiency and the use of natural refrigerants, one of the hallmarks of Clean Cooling ([see page 70](#)) is the mitigation of cooling demand through such means as enhanced insulation, high-performance glass, green roofs, behavior change (like raising temperature set-point) and even shading and natural ventilation. The industry can expect to see more such measures in the future, reducing the need for mechanical AC.

For example, Delhaize Belgium, a division of Ahold Delhaize, integrates green roofs, natural ventilation in covered carparks, and high-performance glass at its stores, said David Schalenbourg, Director Architecture, Construction & Maintenance, though “behavior change of our collaborators, associates and clients stays a challenge.”

Key Date: June 30, 2021, when the LIFE ZEROGW concludes with a new R290 AC design.

Another European retailer embracing cooling-demand mitigation is German food wholesale specialist Metro AG, one of the leading users of natural refrigerants, with 114 stores running transcritical CO₂ systems.

One of those transcritical CO₂ stores, located in St. Pölten, Lower Austria, has the further distinction of being Metro's first store to aim for net-zero energy-consumption, with a goal of using only renewable energy created on site with a 6,000m² (64,583ft²) photovoltaic system on the roof. The St. Pölten store also utilizes natural ventilation to reduce HVAC demand, which is part of Metro's F-Gas Exit Plan (FEP), as well as high-performance glass, said Olaf Schulze, Metro's Director, Facility, Energy and Resource Management. Curtains are used for store-front windows at Metro stores, he added.

Natural ventilation is also employed at Metro's head office in Düsseldorf, Germany. Both the head office and the St. Pölten store are certified by BREEAM (Building Research Establishment Environmental Assessment Method).

While Metro Cash & Carry Stores do not have green roofs, they have or will have solar panels, which block the sun's rays from the roof, noted Schulze.

“*This demonstration as to what is possible – including the announcement of the winner or winners of the prize – will allow policy makers and market shapers to know where the current ceiling of RAC performance is.*

– Iain Campbell, RMI

Highlight of 2021: Finding Out the Winner of the Global Cooling Prize

The [Global Cooling Prize](#) was launched in November 2018 “with the aim of spurring the development of a radically more efficient, climate-friendly residential cooling solution,” said its organizers.

Those organizers include the Department of Science and Technology, Government of India; the Rocky Mountain Institute (RMI), a U.S.-based global research institute; and Mission Innovation, a global initiative of 24 countries and the European Union to accelerate global clean-energy innovation.

The evaluation of the eight finalists for the US\$1 million prize is entering the home stretch, with field testing completed in October, and lab testing in progress until January. The winner will be named at an online ceremony in March 2021.

The eight finalists are Godrej-Boyce, S&S Design Startup Solution Pvt. Ltd., Transeara, Kraton Corporation, M2 Thermal Solutions, Barocal Ltd, Gree and Daikin. Information on the eight prototypes and their design teams can be found on the [Global Cooling Prize website](#).

Two of the finalists (Godrej-Boyce and S&S Design Startup Solution Pvt. Ltd.) are incorporating propane (R290) in their systems.

Two others (Kraton Corporation and M2 Thermal Solutions) are employing water in their technologies. Barocal Ltd's system utilizes an organic solid-state material (neopentylglycol).

To find out about how the Global Cooling Prize will impact the RAC marketplace next year, *Accelerate* interviewed Iain Campbell, Senior Fellow at RMI.

// Accelerate: How do you think the announcement of the winner of the Global Cooling Prize will impact the global market for highly efficient RACs in 2021?

Iain Campbell: The current phase of the Global Cooling Prize is the “show me” phase where our finalist prototypes are tested under three testing protocols in order to demonstrate performance in relation to the prize threshold goal of five-times lower climate impact as compared to the typical units being sold in the market today.

The first testing phase, concurrent field testing conducted in a vacant mid-rise apartment building



Iain Campbell, RMI

in India, was completed in the month of October and anonymized data snapshots of performance for each day indicate two prototypes consistently performing beyond the threshold target.

This demonstration as to what is possible – including the announcement of the winner or winners of the prize – will allow policy makers and market shapers to know where the current ceiling of RAC performance is. It will allow them to set policy and prime markets in relation to the ceiling of what is possible and not just fixate in the floor of performance and current minimum energy performance standards (MEPS) where such standards exist.

The more immediate market opportunity, though, will come from the segment of the market that procures on the basis of life-cycle cost. The combination of the prize's climate impact and affordability criteria would deliver a technology that has a first cost no more than twice that of the typical unit, but would use at least one-quarter of the electricity. (The energy savings and low/no GWP refrigerant would together deliver five-times lower climate impact.) This would deliver cooling equivalent to that of the typical unit, but with approximately half the life-cycle cost.

Demand aggregation and bulk procurement programs for government and institutions that are long-term owners/occupiers of their buildings are the most likely first-movers for these solutions. Government programs and public-private partnerships, such as those operated by Energy Efficiency Services Limited (EESL) in India, would be prime

candidates to take this up, and are already a strong collaborator with the prize.

// Accelerate: What will the next steps be for the winner of the prize following the announcement?

IC: The first immediate step would be to take receipt of the US\$1 million check and enjoy the recognition of winning such a high profile, global prize and exceeding performance criteria that the majority of those we spoke to felt was not possible. Steps beyond this will depend on the profile of the finalist – whether they are a start-up and need to use their success in the prize to secure investment for product commercialization, or whether they are an industry incumbent able to move all or just select components of their design into their product portfolio. We will be able to answer this more fully come March 2021.

// Accelerate: How will consumers, particularly in developing countries, be helped to purchase the prize-winning AC?

IC: This will vary by country but our initial focus will be on India, where through the good work of EESL we see an opportunity for a combination of utility subsidy/financing of the incremental first cost through a stipulated pay-as-you-save program. Involvement of the utility aligns well with the whole system impact of cooling, whereby cooling drives peak-load demand, requiring unprofitable utility investments in capacity that only operates through summer peaks.

// Accelerate: How will the other finalists be helped to market their systems?

IC: We have established an investor marketplace for those looking to invest in the cooling space, matching them up with start-ups and others seeking investment. Outside of that, we do not see our role as supporting individual participants after the conclusion of the prize. Rather we will focus on work to stimulate the demand for super-efficient and low-polluting equipment by influencing policy and demonstrating viable financing approaches, with a focus on developing-market needs. ■ MG

Key Date: March 2021, when the winner of the Global Cooling Prize will be announced.

NatRef Heat Pumps to the Rescue

Regarded as a climate-friendly alternative to fossil-fuel boilers, heat pumps using natural refrigerants are expected to see growing adoption in 2021.

— By Tine Stausholm



The global building sector uses about 32% of all energy generated on Earth, with more than a third of it going to heating and cooling.

Buildings are thus an obvious target for solutions to the climate crisis, according to Project Drawdown, a global climate research project.

This is where heat pumps enter the picture, as they are very energy efficient compared to traditional fossil-fuel boilers, and have dramatically reduced GHG emissions, approaching zero if renewable electricity is used. Therefore, if we only use high-efficiency heat pumps going forward, the energy expenditure for buildings could be reduced by 30% to 40%, Project Drawdown says.

Currently only 3% of global delivered heat comes from heat pumps, but Project Drawdown expects this to increase to 20%-40% by 2050, saving up to 9.3 gigatons of CO₂e emissions.

Claus Schøn Poulsen, Center Manager at the Danish Technological Institute, agrees. "A widespread growth for heat pumps is expected [in 2021] as we turn our focus to electrification, and we are about to kick in the door when it comes to small heat pumps for residential housing," he said.

End users also see the potential in heat pumps. German wholesale giant Metro AG has adopted a Heat Exit Program, to "step out" from using fossil fuels for heating. "Focus is on heat recovery, heat pumps, concrete core activation and natural ventilation," said Olaf Schulze, Director for Energy, Facility and Resource Management at Metro.

However, it is not enough to switch to heat pumps; they need to be natural refrigerant heat pumps, not HFC ones, according to Menno van der Hoff, Chief Executive Director of TripleAqua Licensing, a Dutch heat pump manufacturer. There is a "future necessity" to use natural refrigerants in HVAC due to tightening f-gas regulations, [van der Hoff](#) said during the ATMO/DTI Technical Conference in June 2020, stressing that manufacturers are already adapting and launching more natural refrigerant models. (The conference was organized by shecco, publisher of *Accelerate*.)

All of the most commonly used natural refrigerants are suitable for heat pumps, according to Poulsen. "Natural refrigerants such as hydrocarbons, CO₂ and ammonia (R717) will in particular apply to large heat

“Electrification is driving the heat pump water heater (HPWH) market upwards but probably not at the rate it would be pre-COVID.”

— John Miles, Eco2 Systems

pumps, whereas smaller heat pumps will involve the use of hydrocarbons and to some extent CO₂."

"In certain cases, safety issues related to the use of natural refrigerants lead to HFO refrigerants," Poulsen added. "These refrigerants can be a stepping stone towards natural refrigerants, but if there's ever any doubt, the environment should get the benefit of the doubt. The end game should be to use natural refrigerants in all installations."

R290 WELL ESTABLISHED

Propane (R290) heat pumps have already made great strides forward in both commercial and domestic applications in the last few years. Belgian retailer Colruyt Group, for example, has [started using R290 heat pumps](#) from French manufacturer Auer for store heating, as a supplement to heat recovery from its R290 refrigeration systems.

The heat pumps from Auer are available in capacities ranging from 11-35kW (3.1-10TR), and up to 140kW (39.8TR) when installed in cascade, making them suitable for both domestic and commercial use. They are also highly efficient, with a COP up to 4.9, and capable of producing hot water up to 70°C (158°F), even in ambient temperatures down to -20°C (-4°F).

R744 EXPANDING TO NEW AREAS

R744 heat pumps are becoming increasingly popular, particularly in the European and Japanese markets, for both heating and cooling. In 2021, "we will see an uptake of CO₂ heat pump chillers, as these new products can provide both heating and cooling in a very compact and energy efficient way, not depending on flammable refrigerants," said Armin Hafner, Professor of Refrigeration at the Norwegian University of Science and Technology.

The U.S. market has been slower to jump on the heat pump trend but here, too, the industry is expecting an increased uptake of CO₂ heat pumps next year.

"Electrification is driving the heat pump water heater (HPWH) market upwards but probably not at the rate it would be pre-COVID," said John Miles, Managing Director, Eco2 Systems. "I would anticipate a 25% increase in the overall HPWH market to 125,000 systems [in 2021]." Next year, Eco2 Systems is planning to introduce a new generation of its CO₂ HPWH product line that is 15% more efficient, but the COVID-19 pandemic means the launch is "very delayed."

There are issues to confront in the U.S. market, one being lack of competition to drive down prices and increase adoption. "There is still a pressing need for more competition in the U.S. market for manufacturers of commercial-size CO₂ heat pump systems," said Andy Baker from Seattle-based YourCleanEnergy. "Unitary cabinet-type CO₂ heat pump systems are still limited to Japanese manufacturers with high up-front cost." For larger systems (approaching 100TR/352kW), U.S. manufacturers can be competitive, according to Baker, though they are often still reliant on foreign-made components.

There is plenty of potential, though, in the U.S. market, Baker said, particularly in his own region, the Pacific Northwest. "There are areas in this region with low-cost clean hydro-electricity; facilities with these energy resources can realize the greatest return from a CO₂ heat pump system."

NEW APPLICATIONS

R744-based heat pumps are also expanding from commercial and domestic uses into much larger industrial applications. "Increasing capacities of the CO₂ components opens new markets and applications," said Kim Christensen, Managing Director of Danish start-up Fenagy. "[For] industrial refrigeration and heat pumps above 500kW (142.2TR), there is a great potential for CO₂, to some extent competing with ammonia, of course." Fenagy is developing a portfolio of R744 solutions ranging from 300kW-2MW (85TR-569TR), with the first products launching before Christmas 2020.

The cost per kW of capacity will still drop, "especially in the higher capacity range, due to the larger capacity [CO₂] components," Christensen said.

Fenagy also expects the efficiency of natural refrigerant-based equipment to improve in 2021 as



Andy Baker, YourCleanEnergy

suppliers and manufacturers strive to optimize. "We have not seen the full impact of using ejectors and expanders yet," Christensen said.

The U.S. market is also expecting efficiency increases in the coming year. "For transcritical CO₂ heat pump systems, we see the largest increase in efficiency coming from smarter integration of this equipment into new or existing facilities, specifically the increased use of low-grade waste heat as a source," Baker said. "Automatically selecting the lowest-cost source of heat at all the right times brings down operation cost and drives up system COP," he added, concluding that "it all comes down to good system design."

R717 MAKING INROADS

R717 hasn't been forgotten by the heat pump market either. "There is growing interest in low-charge ammonia heat pumps, particularly for [government-run] aquatic centers, which are huge users of energy," said Tony Gleeson, CEO and company secretary for the Australian Institute of Refrigeration, Air conditioning and Heating (AIRAH).

Alternatives to traditional R717 compressor-driven heat pumps are also popping up. U.S. manufacturer Stone Mountain Technologies (SMTI) is developing an ammonia-water absorption heat pump, which is triggered by natural gas, to generate space heating and hot water. The unit is meant to compete with gas-fired boilers, and uses only half the gas of a boiler, while having twice the efficiency, according to SMTI's CEO Michael Garrabrant.

The units are planned for sizes from 10,000BTU/hour to 140,000BTU/hour, with COPs expected from 1.6 to 2. The absorption heat pumps were originally planned to hit the market in the beginning of 2021, but due to the COVID-19 pandemic the launch has been postponed to 2022, according to SMTI's Vice President for Strategy and Marketing Scott Reed.

■ TS



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More NatRef Training Options Expected in 2021

Demand for natural refrigerants is driving growth in educational and certification programs among OEMs, schools and associations.

— By Franco D'Aprile

Technical training is the backbone of the HVAC&R industry, and what enables it to continue evolving and embracing new technologies. Indeed, it is the lack of confidence in technicians' training and qualifications that is cited by many industry players as a key deterrent to the adoption of natural refrigerant-based technology.

But as other factors drive the uptake of natural refrigerant systems, greater attention is being given to training. That trend will continue in 2021, with many stakeholders, from OEMs to schools and associations, stepping up their training offerings for natural refrigerants.

Across the industry, many OEMs that provide natural refrigerant equipment to supermarkets are confident that training opportunities will increase. "Green technologies are on the rise, and there will be a higher demand for trained technicians and a higher number of trained staff as a consequence," said Donatas Plauska, Head of Sales for Lithuanian OEM Freor.

The increasing number of CO₂ (R744) and propane (R290) installations will naturally go hand in hand with more training opportunities, noted Richard Gilles, Senior Product Leader, Distributed Solutions for Hussmann, a St. Louis, Missouri (U.S.) OEM that provides training for its supermarket equipment.

Andreas Meier, CEO of Teko, a German commercial and industrial OEM, is confident that the number of trained technicians will increase rapidly as more training is offered on natural refrigerant technology around the world. According to Meier, this is leading to natural refrigerant training becoming a commodity.

For industrial operators, U.S. OEM Evapco offers a training program called ACES (Apply, Construct, Execute & Service) for its packaged, low-charge ammonia Evapcold products. Kurt Liebendorfer, Vice President of Evapco, said the company is investing in expanding its operator and technical training opportunities, spurred by its increasing market share and interest from customers.

U.S. OEM Heatcraft Worldwide Refrigeration has received many training requests and will be offering more opportunities in 2021, along with specific training and commissioning after the launch of new systems, said Greg Minch, Key Account Manager for Heatcraft.

Canadian industrial refrigeration contractor Cimco, which has numerous ammonia and CO₂ installations at ice rinks and industrial locations, will be "widely spreading our training in every region" as "some regions have more knowledge than others," said Benoit Rodier, Director of Business Development at Cimco.

More certifications

OEMs' focus on natural refrigerant training should pressure educational institutions to increase training offerings that include certifications, said Wynand Groenewald, Founder of Future Green Now, a South African consultancy. "I am sure that training institutions are not seeing the business potential [of being] certified on naturals. That is why I am confident that training opportunities will increase."

That's happening in Estonia, where technicians must reapply for certification every five years. By the end of 2020, the country's Environmental Research Centre, will be offering a new course enabling technicians to specialize and be certified in CO₂, ammonia, or hydrocarbons. Stanislav Štökov, Specialist at the Centre, believes that, along with an increased focus on natural refrigerant training, an f-gas recycling system must be created for those "whose financial state isn't the strongest to invest in alternatives at the moment."

Collin Bootsvelde of Colruyt Group, a Belgium-based food retailer, credits RealAlternatives4Life, an EU-backed multi-stakeholder program, for disseminating natural refrigerant training information. In Belgium, the program partners with UC Leuven-Limburg, a major university with which Colruyt has cooperated on setting up training on flammable refrigerants. Colruyt donated a propane compact chiller to the university, which "serves as a platform for teaching and testing," he said.

The COVID-19 pandemic has cut into in-person training opportunities this year, moving some to the Internet, and this will no doubt continue in 2021. At the Danish Technological Institute (DTI), Claus Schön Poulsen, Center Manager, said he feels fortunate that DTI is still able to deliver physical training throughout Denmark that provides hands-on experience.

In Australia, Stefan Jensen, Managing Director of Brisbane-based Scantec Refrigeration, contends that the country's failure to provide adequate training "is now starting to have a significant impact on Australia's ability to transition away from HFC refrigerants and towards natural refrigerants in a timely fashion."

There are, however, advancements being made. AIRAH (Australian Institute of Refrigeration, Air conditioning and Heating), plans to offer training that will include hydrocarbons, said Tony Gleeson, CEO and Company Secretary for AIRAH.

AIRAH is also supporting a project to build training pods where students will be taught to handle natural refrigerants. And it is advocating for HVAC&R trade licensing to cover all refrigerants in order to "significantly increase demand for technicians trained in handling natural refrigerants," Gleeson said. ■ FD

"Green technologies are on the rise, and there will be a higher demand for trained technicians as a consequence."

— Donatas Plauska, Freor

RETA: Training the Next Generation

The Refrigerating Engineers & Technicians Association (RETA), an Albany, Oregon (U.S.)-based trade group that trains and certifies technicians working with ammonia (R717) and CO₂ (R744) in industrial refrigeration, will be expanding its training programs in 2021.

That effort began last year, when RETA created the RETA Training Institute (RETA-TI), a 501-3(c) organization with a mission to support and expand the industrial refrigeration workforce.

"We expect the training opportunities and number of trained technicians to increase in 2021 because of the work RETA and RETA-TI are doing to support and provide the training," said Lois Stirewalt, Workforce Development Program Director at RETA.

"As the industry ages and experienced individuals retire, RETA and RETA-TI are working diligently to ensure the transfer of knowledge to the next generation," she added.

While the COVID-19 pandemic has forced training to become virtual or operate under new restrictions, it has not stopped, Stirewalt noted. RETA testing centers where technicians can receive credentials were closed but most have since reopened.

RETA offers credentialing programs that cover a wide range of technician levels, from entry level (Certified Assistant Refrigeration Operator, CARO) to RETA Authorized Instructor (RAI). "A single RAI can train hundreds of individuals a year and there are currently 20 RAI's creating a large impact on the training needs of the industry," said Stirewalt.

RETA expects the number of RAI's to increase in 2021 through a memorandum of understanding with the United Association (UA), a labor union representing workers in plumbing and pipefitting. The UA is utilizing RETA's educational materials, including a CO₂ handbook, as part of its apprenticeship training program for service technicians, she noted.

RETA's national conference in Schaumburg, Illinois (U.S.) in November 2021 will include a comprehensive program of educational and training opportunities for refrigeration technicians. This will include hands-on classes, manufacturer-specific training, white paper presentations, and an exhibition hall.



Lois Stirewalt, RETA

The 2021 conference's call for papers will include specific requests for presentations on low-GWP refrigerants, new and emerging refrigeration-related technology, and "light" industrial refrigeration. In addition, in 2021, the RETA Conference and Education Committees will begin the process of developing CO₂ hands-on training.

Training veterans

Complementing RETA's activities, RETA-TI oversees programs for military veterans ([REDWHITEandCOOL](#)), Women in Natural Refrigerants (WiNR), and Youth and Young Adults (YaYA).

Launched this year, REDWHITEandCOOL is designed to recruit, train and hire military veterans to work as technicians in industrial refrigeration, focusing on ammonia and CO₂ refrigerants. In January 2021, the program will host its first four-week cohort of transitioning military veterans on base at Ft. Eustis in Virginia (U.S.) through support from Smithfield Foods, Tyson Foods, and the contractor Wagner-Meinert. "This first cohort is only the beginning, with an initial goal of quarterly cohorts at Ft. Eustis as well as expanding to other bases," said Stirewalt.

REDWHITEandCOOL aims to attract people already equipped with skills prized by the HVAC&R industry, thereby helping companies struggling with the shortage of qualified refrigeration technicians.

"If you've worked on aircraft, or if you've worked on a ship, then you've got that technical skillset already, so it would be a perfect transition," said Stirewalt, who was one of 29 women profiled in *Accelerate Magazine's* "[Women in Natural Refrigerants](#)" cover story in the January 2020 issue. ■ MG

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MAJOR CHANGES IN STORE FOR POLICY AND STANDARDS IN 2021

A proposal for updating the EU F-Gas Regulation, a climate-friendly U.S. administration, and impending changes in hydrocarbon charge limits – all are coming next year.

– By Franco D'Aprile and Michael Garry

Regulations and standards – whether carrot or stick – are generally credited with being the biggest motivator of natural refrigerant adoption. The two regions with the most adoption – Europe and Japan – have also enacted the most influential policies, the EU F-Gas Regulation (stick) and Japan's generous subsidy program (carrot).

For the global HVAC&R industry, refrigerant policy is advancing unevenly throughout the world, but it is heading in the direction of reducing f-gases, which will be a boost for natural refrigerants. This is particularly true in the two biggest economies, the EU and the U.S.

In Europe, 2021 will be a crucial year as the European Commission (EC) reviews feedback on the F-Gas Regulation and prepares to release a proposal for a new version.

In the U.S., President-Elect Joe Biden's upcoming administration is widely seen as an opportunity for the U.S. to catch up on f-gas regulation and other critical climate measures.

And 2021 will be a big year for hydrocarbons in both commercial display cases and room air conditioning, as regions adopt higher charge limits for the former, and the International Electrotechnical Commission (IEC) pursues higher charge limits for the latter.

EU F-GAS EXPECTATIONS

In 2020, the EC, the executive branch of the European Union (EU), began seeking feedback on the effectiveness of the F-Gas Regulation for its review of the legislation, originally enacted in 2006 and last updated in 2014.

The initial deadline for feedback on a roadmap was September 7, but the EC [is accepting additional feedback in public consultation until December 29.](#)

The EU's impetus for updating the F-Gas Regulation is to reflect progress made in HVAC&R technology, and to stay in harmony with the European Green Deal and the Kigali Amendment to the Montreal Protocol, the global agreement to phase down HFC production and use by 85% by 2047 (by 2036 in the developed world).

In 2021, the EC will seek further feedback and complete an evaluation and impact assessment of f-gas rules, before releasing a proposal for a revision in the fourth quarter of the year.

The EC remains confident in this process. "I can assure you that our plans regarding timing of the f-gas review have not changed," said Bente Tranholm-Schwarz, Deputy Head of Unit, DG Clima at the EC. "We still plan to put forward a commission proposal before the end of 2021."

Key date: Q4 in 2021, when the EC will deliver a proposal for an updated F-Gas Regulation.

[A new market study by shecco](#) (publisher of *Accelerate*) has shed light on the direction stakeholders would like the f-gas revision to go.

The study found that 87% of respondents believe that "increasing the ambition of the F-Gas Regulation through further bans, a more ambitious phase down, and strong measures to combat illegal trade should be an essential component of the EU's 2030 climate ambition strategy."

“*I can assure you that our plans regarding timing of the f-gas review have not changed.*

— Bente Tranholm-Schwarz,
European Commission



Clare Perry, EIA

According to Clare Perry, Senior Campaigner for the Environmental Investigation Agency, the review is coming at a good time, as she feels the current legislation needs to be strengthened. She warned, however, that the review could distract from implementation of the current regulations.

The current rules, for example, call for a reduction of the available HFC quota in the EU by 55% vs. the baseline in 2021. And in 2022, bans on using certain HFCs with GWPs above 150 in new centralized and plug-in commercial refrigeration equipment will go into effect.

But Perry also views an accelerated timeline as possible, crediting the high-GWP servicing ban in supermarkets for reducing the demand for HFCs.

Francesco Scuderi, Deputy Secretary General for Eurovent, thinks that only by properly taking into account energy efficiency and the current state of technological development could the f-gas phase down progress.

The Paris-based International Institute of Refrigeration (IIR) believes that an acceleration in the phase down would lead end users to use less-efficient HFO blends with GWPs of 1,200 or more.

"You will encourage companies to rapidly use drop-in solutions [like R448A and R449A] and not to plan a better conversion," said Deonie Lambert, Communications and Event Coordinator for IIR.

"A lot of companies already have a plan for the current decade to progressively replace their installations with investments, based on the current F-gas regulation," Lambert added. "If you suddenly accelerate the constraints, they will be obliged to find transitory solutions which will be worse."

But Collin Bootsvelde, Project Engineer for Belgium retailer Colruyt Group, pointed out that ultra-low-GWP natural refrigerants would be a more efficient replacement for HFCs. "From my understanding,

from studies, literature and in practice, natural refrigerants are at least as efficient and often more efficient than chemical refrigerants.” A faster phase down using natural refrigerants “would then have a positive impact,” he said.

The F-Gas Regulation is not the only policy for which a faster phase down of f-gases is desired. The NGO Greenpeace wants the HFC phase-down schedule set by the Kigali Amendment to be accelerated, ideally phasing out HFCs by or before 2030. János Maté, Senior Policy Consultant for Greenpeace, points out that an accelerated implementation of Kigali could avoid a 0.05°C global temperature increase, on top of the 0.4°C possible under the current schedule.

Given that global temperatures are already 1°C above pre-industrial level, and the Paris climate accord wants to limit the increase to 1.5°C, the 0.05°C would represent 10% of the remaining 0.5°C budget, noted Maté.

ILLEGAL HFC IMPORTS

For the EU, there is an added layer of complexity to the F-Gas Regulation – illegal imports of HFCs.

“There continues to be a significant level of illegal trade in HFCs in Europe, despite the pandemic,” said Perry of the EIA. While the pandemic may have initially reduced the smuggling activity due to decreased demand and more controlled borders, the situation now may have changed, she explained. The economic downturn, plus an increase demand for ventilation systems to fight the virus, may be resulting in an uptick in the smuggling of cheap HFCs.

However, Perry does credit the EU Anti-Fraud Office (OLAF) with the increased number – and importance – of seizures in 2020, such as the recent seizure of 19 metric tons of illegal refrigerants in Spain.

The other part of the import story is the prosecution of smugglers. Perry believes that EU-wide minimum penalties are needed to deter future illegal imports. “Merely seizing illegal HFCs is not enough.”

BIDEN PROMISES CHANGE

The election of Joe Biden as president of the U.S. figures to bring radical change to the environmental and climate policies pursued by the federal government, including those pertaining to refrigerants.



Joe Biden, U.S. President-Elect

Under the Trump administration, the U.S. government has not regulated HFCs under the U.S. Environmental Protection Agency’s SNAP (Significant New Alternatives Policy) program, nor has it sent the Kigali Amendment to the Montreal Protocol to the U.S. Senate for ratification. But both of those policies are expected to be reversed under Biden, according to his own pronouncements and observations made by cooling industry stakeholders. That may be true whether or not the Democratic Party controls the Senate, which won’t be known until two Senatorial run-off elections take place in the state of Georgia on January 5.

Already, in a wide-ranging plan for “a clean energy revolution and environmental justice” posted on his website, President-Elect Biden says he intends to “embrace” the Kigali Amendment to the Montreal Protocol and its HFC-reduction scheme in his first 100 days. With the bipartisan support for HFC regulation that exists in the U.S. Senate, it’s likely that the U.S. will join the list of countries that have ratified the amendment.

Biden may also be able to sign bipartisan HFC-regulation legislation, which was proposed in 2020 in both chambers of the U.S. Congress (Senate bill S.2754 and House bill H.R. 5544). “I think it is probably not important who comes in in January, said Rajan Rajendran, Vice President, Systems Innovation Center and Sustainability at Emerson’s Helix Innovation Center, during ATMOSphere America 2020 on October 21. “Regardless of that, I think this bill will find its way out.” (ATMOSphere America was organized by shecco, publisher of this website.)

Christina Starr, Senior Policy Analyst for the U.S. office the Environmental Investigation Agency (EIA) believes Kigali will get ratified with bipartisan support in 2021, additionally supported by individual states’ own new legislation. She says that f-gases are a “low hanging fruit to act on quickly,” for the Biden administration.

Key date: January 20, 2021, when Joe Biden will be sworn in as the 46th U.S. president.

“ *F-gases are a low hanging fruit to act on quickly for the Biden administration.* ”

— Christina Starr, EIA

Morgan Smith, Manager of Programs & Operations for the North American Sustainable Refrigeration Council (NASRC) believes that while the bipartisan support for the Kigali Amendment means it will most likely get ratified, it is too soon to predict what other HFC regulations could develop as the senatorial majority is still pending. In any event, NASRC hopes the new administration will produce “new funding opportunities for natural refrigerants” as part of its climate regulations.

Lowell Randel, Vice President of Government and Legal Affairs, Global Cold Chain Alliance (GCCA), said he expects to see “efforts to ratify Kigali and potentially more HFC legislation, as well,” adding, “I believe this is likely, regardless of whether Republicans or Democrats claim control of the Senate next year.”

The emphasis on climate change, Randel added, means that “there will be an opportunity to promote the use of natural refrigerants.”

Also in his environmental plan, Biden will establish a new, cross-agency Advanced Research Projects Agency (ARPA-C) focused on climate. This initiative will target “affordable, game-changing technologies to help America achieve our 100% clean energy target.” One of the technologies cited: “refrigeration and air conditioning using refrigerants with no global warming potential (GWP).”

[Ammonia (R717) is the only refrigerant with zero GWP; he may have meant zero or “near-zero” GWP refrigerants like CO₂ (R744) and propane (R290).]

Two refrigerant-related rollback actions that the Trump Administration took may also come under review. One is the EPA’s rule, announced in February, rescinding a 2016 Obama administration rule that extended refrigerant leak repair requirements to HFCs and HFOs for equipment containing more than 50lbs (23kg) of refrigerant. The other is the EPA’s decision last year to rescind nearly all of the significant Obama administration amendments to the Risk Management Program (RMP), which governs operations using more than 10,000lbs (4,536kg) of ammonia.

The state level is where most of the actions to reduce HFCs has been focused in recent years. Sixteen states have either passed or are pursuing legislation to adopt HFC limits based on U.S. EPA SNAP rules 20 and 21.

On December 10, California approved further limits on HFCs, including a 150-GWP cap on refrigerants used in new commercial systems.

REGIONS TO ADOPT HC CASE STANDARD

In 2021, updates in regional and global standards for hydrocarbons in commercial display cases and room air conditioners are expected to allow more refrigerant charge to be safely used in these appliances.

In 2019, the International Electrotechnical Commission (IEC) voted to update the IEC 60335-2-89 standard to increase the allowable charge of hydrocarbons like R290 in commercial cases from 150g to 500g. The next step is for individual countries and regions to adopt their own version of the IEC standard, using it as a model.

In Europe, CENELEC’s work on converting the IEC 60335-2-892-89 standard into a harmonized standard within the EU Machine Directive is ongoing, said Marek Zgliczynski, R&D Director in Embraco North America (part of Nidec Global Appliances), and Chairman of the IEC/SC61C subcommittee for refrigerant safety standardization. The target date for a final vote is currently March 2021.

In the U.S. and Canada, a working group is aiming to update the relevant Underwriters Laboratory (UL) and Canadian Standards Association (CSA) standards by the end of 2021. However, the new North American standards are expected to contain several deviations from the IEC version.

One of the main deviations is in the charge amount allowed. The IEC standard allows 500g of R290; while the UL proposal would allow this for open cases, it would permit only 300g if the equipment has doors or drawers (like ice makers).

In Japan, the Japan Refrigeration and Air Conditioning Industry Association (JRAIA) has said that it is working on the Japanese Industrial Standard (JIS) version of the IEC 60335-2-892-89 standard, with experts predicting its publication in 2021. JRAIA also announced that it would issue its official guideline on the safe use of hydrocarbons in 2021.

IEC TO UPDATE AC STANDARD

The global standard IEC 60335-2-40 for room air conditioners (RACs) is being updated to allow a greater amount of hydrocarbons to be used. The plan is to publish a final standard by the end of 2021, “even if it will be a challenge,” said Asbjørn Vonsild, head of Vejle, Denmark-based Vonsild Consulting, and convener of the working group behind the proposed changes.

Vonsild explained that the maximum hydrocarbon charge in a very large room is not being changed in the proposal, and for hydrocarbons in indoor appliances it is still around 1kg (2.2lbs) per circuit. “What is being changed is the amount that can be used in an ordinary size room,” he said.

Under the proposal, Vonsild noted, the primary means for increasing the amount of hydrocarbon refrigerant that can be used are circulation airflow, safety shut-off valves, and additional construction requirements “for a robust design.”

An updated IEC charge standard for hydrocarbons in RACs could lead to more efficient air-conditioning units and heat pumps using R290, said Starr of EIA. In addition, she said, legislators could start to place more GWP restrictions on refrigerants used in air conditioning. In the EU, a GWP limit of 750 in split ACs is already scheduled to take effect in 2025.

In Europe, diverse building codes and safety standards at the national, regional, and sometimes local levels represent another barrier for hydrocarbon-based solutions. Perry of EIA hopes the EU will swiftly adopt updated IEC charge limits for ACs “through harmonization into EN [European standards] and national safety standards and building codes.”

ECODESIGN IN MARCH

Ecodesign and Energy Labelling Regulations will come into effect March 2021, promising stricter energy efficiency requirements for the commercial refrigeration industry.

The new labels will “eliminate non-energy-efficient products from the market,” said Donatas Plauska, Head of Sales Department of Lithuanian OEM Freor.

“The new Ecodesign and Energy Labelling Regulations which were adopted last year are game-changers for the commercial refrigeration sector,” said Eurovent’s Scuderi. “They are expected to result in a phase out of certain products on the European market and increase the demand for the best market-available technologies.” ■ FD & MG

“The plan is to publish a final AC standard by the end of 2021, even if it will be a challenge.”

— Asbjørn Vonsild, Vonsild Consulting





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A 'Banner Year' Expected for Digitalized Controls in 2021

Climate goals, COVID-19 and technician shortage are all driving further investments in advanced HVAC&R monitoring.

— By Tine Stausholm

Digitalization of the refrigeration industry has been moving forward at warp speed for the last few years, a trend that is expected to continue unabated, as the Internet of Things (IoT), automation and artificial intelligence (AI) open up new avenues for digital controls.

"We will without a doubt see an increased use of digitalized controls in 2021," said Claus Schön Poulsen, Center Manager at the Danish Technological Institute.

The energy savings enabled by advanced monitoring systems will be an important element of reaching 2030 climate goals, he noted. "This is where digitalized and intelligent controls will make a difference."

Turner Anderson, Lead Sales Engineer at U.S. digitalization specialist Axiom Cloud, also expects 2021 to be a "banner year" for digitalization technology in the cooling industry. "Between rising energy costs, ongoing technician shortages, and

aging compressor racks in many supermarkets and grocery stores across the country, there's never been a better time to invest in digitalization," he said.

Axiom Cloud uses digitization technology to autonomously reduce energy and maintenance costs of commercial refrigeration systems, thereby "allowing store owners to improve their bottom lines while spending more time on the activities that are most important to them," Anderson explained.

"At Axiom Cloud," he added, "our entire business model is built around the assumption that the cold chain, and particularly retail grocery, is ready to take advantage of digitalization, artificial intelligence, automation, and the Internet of Things to tackle their biggest energy and maintenance challenges."

The COVID-19 pandemic might help drive the digitalization trend to new heights, given the increased opportunities for



“

Between rising energy costs, ongoing technician shortages, and aging compressor racks in many supermarkets and grocery stores across the country, there's never been a better time to invest in digitalization.

— Turner Anderson, Axiom Cloud

”

Detecting outliers

A retailer already experienced in employing digital controls is Belgium-based Colruyt Group, which has used them as standard in all new commercial installations for 10 years, and even longer in its industrial operations.

A new development for Colruyt is the introduction of an AI-based software solution to monitor the company's propane chiller installations. “We now automatically detect outliers in terms of functioning, so we can send a technician and change any faulty components,” said Collin Bootsvelde, Project Engineer at Colruyt Group. “Our cooling systems are modular so we can do this relatively easily.”

In 2021, Colruyt is planning to increase AI-based maintenance. The company's goal is to halve its chemical refrigerant losses in the next two years, according to Bootsvelde. This is supposed to happen through faster leak detection and a reduction in the filling level of the company's remaining HFC cooling installations. The present level of refrigerant loss is 4%.

Other companies foreseeing increased levels of digital controls in 2021 include Evapco, a U.S.-based manufacturer of evaporators and condensers, which is planning to roll out its own remote energy monitoring program; and Belgian retail giant Delhaize, which intends to introduce a new cloud-based building management system that offers remote control as well.

German wholesale retailer Metro AG is also planning to optimize maintenance and energy demands as well as cut food

waste with digitalized controls, according to Olaf Schulze, Director of Energy Management Investments & Technical Solutions at Metro.

It is not just within commercial refrigeration that digitalization is picking up speed. U.S.-based Azane, which produces industrial ammonia (R717) chillers and freezers, is now equipping every system it delivers with parent company Star Refrigeration's ETHOS Software package as standard.

The ETHOS software is more than just a data-collection and energy management tool, according to Caleb Nelson, Azane's Vice President of Business Development. “It has been programmed uniquely to act as a 24/7/365 commissioning technician watching over the system,” he explained. “It gives you insights into the system performance based on the data it collects, and furthermore gives you recommendations for intervention based on the insights, and finally, it tells you how much money is being wasted for not intervening. This last point is often the most important as there needs to be a mechanism to drive action and justify the approval of maintenance dollars.”

Another industrial player, Canadian contractor Cimco Systems has developed its own digital product line called “Smart Controls” and plans to introduce “Smart Hub connecting all pieces of equipment together,” said Benoit Didier, Director of Business Development. ■ TS

remote monitoring, and the reduced health risks for technicians, this offers. “We foresee many customers leveraging digitization in 2021 for the remote monitoring benefits alone,” Anderson said, “but expect that they will be pleasantly surprised by the multitude of other benefits that are enabled by the proper infrastructure.”

Another factor driving increased uptake of digital tools in HVAC&R is the lack of qualified technicians, said Richard Wayne Gilles, Senior Product Leader for Distributed Solutions at U.S. OEM Hussmann.

“Maintenance activities will continue to change to more sophisticated tools and new diagnostic algorithms,” Gillies said. “This represents the necessary change to deal with a dwindling service personnel base.”

Growing Cooling-as-a-Service Trend Expected to Accelerate Uptake of NatRef Systems

Dimitris Karamitsos of BASE sees great potential for the CaaS model to aid in post-COVID-19 recovery.

— By Ilana Koegelenberg

The cooling-as-a-service (CaaS) servitization model works by allowing end users to pay only for the cooling they actually use, without the need for a large up-front investment.

One of the primary supporters of the CaaS model is Switzerland-based Basel Agency for Sustainable Energy (BASE), the leader of the Cooling as a Service Initiative along with the Kigali Cooling Efficiency Program (K-CEP). The Initiative aims to decrease energy consumption and GHG emissions from cooling by promoting a pay-per-service mode to finance efficient cooling systems like those using natural refrigerants.

To get a sense of where the CaaS model is going next year, *Accelerate* spoke with Dimitris Karamitsos, Senior Energy Efficiency Business Developer for BASE.

//Accelerate: How will the CaaS servitization model influence the number of natural refrigerant installations in 2021?

Dimitris Karamitsos: We expect servitization to accelerate the adoption of natural refrigerant installations in 2021, as these cooling systems are typically characterized by higher upfront costs but lower operating costs thanks to improved energy efficiency, and maintenance and operation cost savings. The model is a market mechanism that naturally promotes the most efficient systems, simply because the life-cycle cost of more efficient systems is lower. As long as the total cost of ownership of natural refrigerant installations are indeed lower than conventional technologies, taking into account the operation and disposal phase, the market will move to those solutions. Indeed, providers have no incentive to offer CaaS with a cheaper and less-efficient system for which they then need to cover all the operating costs.

//Accelerate: What is the CaaS Initiative planning in 2021?

DM: The CaaS Initiative started in 2018 with the purpose of mainstreaming the adoption of the business model by building the required tools (pricing model and standardized contracts) and creating the momentum for the market players to adopt the model into their operations. To support in accelerating the latter, BASE created the CaaS Alliance, which today has more than 50 members on board supporting the model. BASE has

also raised market awareness through articles, webinars, videos, case studies, and more. The CaaS Initiative has also been supporting the implementation and promotion of pilot projects across various industries and sectors, from commercial and industrial air conditioning and refrigeration to agricultural and medical cold chains.

Through 2021, the CaaS Initiative will finalize preparing the ground to ensure the CaaS model grows sustainably throughout actors in the market: solution providers, investors and end users.

BASE, the not-for-profit organization behind the initiative, is pursuing several other projects and opportunities to mainstream the servitization business model in – and beyond – the cooling sector.

BASE also sees an important opportunity to tailor the CaaS model further to address issues like vaccine distribution, and to integrate the business model with digitalization and data solutions to strengthen agricultural supply chains.

//Accelerate: What is the opportunity for servitization in 2021 in relation to COVID-19 recovery?

DM: Servitization with CaaS and beyond represents an effective way to accelerate the investments in energy efficiency





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needed for achieving a low-carbon economy, while also helping the economy to recover faster from the COVID-19 pandemic.

Indeed, CaaS stands out as a particularly interesting solution during this health crisis, since many companies are now, more than ever, cash-constrained, needing to invest elsewhere, while at the same time looking for means to reduce their operating expenses.

At BASE, we have seen a massive uptake of interest and demand for energy efficiency through the pandemic. The servitization model is a key enabler of bringing clean and sustainable technologies faster to the market, while increasing savings of end users due to better efficiency and utilization rates, hence enabling them to re-accelerate their growth post-COVID-19.

//Accelerate: What cooling servitization trends can be expected in 2021?

DM: In 2021, we expect a growth in servitization within the cooling, lighting, heating, and solar photovoltaics (PV) sectors – but also in e-mobility.

Within the cooling sector, we trust CaaS will positively impact the market by drastically increasing the uptake of cleaner



Dimitris Karamitsos, BASE

and more energy-efficient solutions. We believe the model will create a strong market barrier towards "dirtier," less energy-efficient systems.

Within cooling, we are currently aware of approximately US\$50 million worth of HVAC&R assets already under management of the CaaS model (excluding district cooling plants). We expect this to grow rapidly with large numbers of new players working on the implementation of CaaS.

Within the next three years, we expect approximately US\$300 million of operating assets under management under the CaaS model (cumulative); within the next five years, US\$1.5 billion; and within the next 10 years, US\$8 billion

■ IK

What Do Others Say about Servitization in 2021?

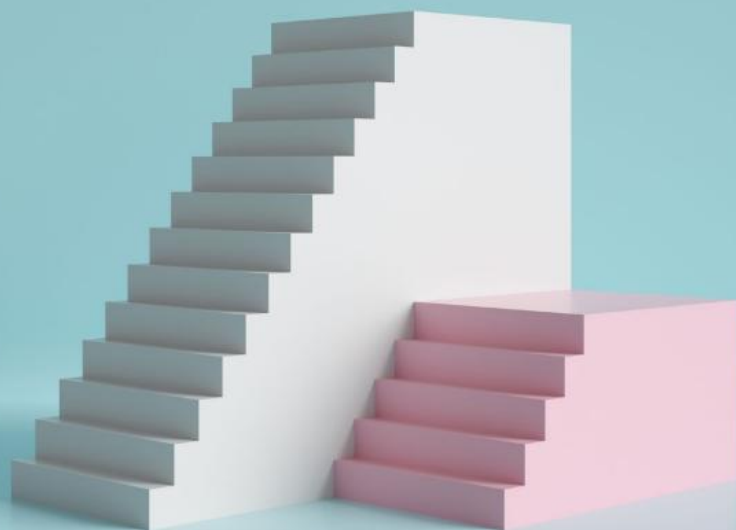
"End users will give more consideration to cooling-as-a-service to avoid investment of capital." - **John Ackermann, Owner, Jack Agencies; former Publisher/Editor of the Cold Link newspaper, South Africa**

"We are starting to see the emergence of cooling-as-a-service, with one company already using a servitization model in Australia and another looking at entering the market." - **Tony Gleeson, CEO and Company Secretary, Australian Institute of Refrigeration, Air conditioning and Heating (AIRAH), Australia**

"We are looking at being our own bank and offering cabinets through a lease-to-own process." - **Joe Kokinda, President/CEO, Professional HVAC/R Services, U.S.**

"For heat pumps, we already offer 'heat as a service' where we own the heat pump and sell heat to the end user. Fenagy offers service agreements containing 'operational performance optimization' remotely. This will secure that running systems perform well and performance is not degraded over time." - **Kim Christensen, CEO, OEM startup Fenagy, Denmark**

"We evaluate that equipment will be more expensive in 2021. Therefore, we want to go into long-term cooperation to avoid spot market risk in CAPEX and maintenance OPEX. Our focus will become lease options." - **Olaf Schulze, Director, Facility, Energy and Resource Management, Metro AG, Germany.**



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ACCELERATE
ADVANCING CLEAN COOLING

German Study of HFOs and TFA Due in Early 2021

Research project will focus on the refrigeration/air conditioning sector, amid growing industry concerns about the long-term environmental impact of TFA.

— By Michael Garry

When it escapes into the atmosphere, the HFO R1234yf – used widely in motor vehicle air conditioning and in food retail applications in blends with HFCs – lasts only up to two weeks. It then breaks down completely into trifluoroacetic acid (TFA), a highly durable and mobile substance.

TFA descends via rainfall as a form of “acid rain” to the earth; there it accumulates in various bodies of water, including rivers, streams, lakes and wetlands.

Numerous studies have been done about TFA’s potential for environmental harm. The consensus is that, for the foreseeable future, the accumulation of TFA will be too small to pose a threat to the environment and humanity.

But in sufficient quantities, TFA can be a destructive substance. In pure form, it is harmful when inhaled, and causes severe skin burns; in concentrations as low as that approaching 1mg/l, it may be toxic to some aquatic life forms.

Given the durability of TFA, and the growing use of R1234yf throughout the world in different applications, will there be a point when enough TFA has accumulated to harm the environment? How long would it take?

While R1234yf is allowed in Germany, the German Environment Agency (Umweltbundesamt or UBA) has been carefully monitoring the concentration of TFA in drinking water. The maximum TFA concentration in freshwater has been set to 60 µg/l; however, the UBA recommends not exceeding 10µg/l.





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► Meanwhile, the German Federal Government is funding a research project that will study HFOs and TFA, with a focus on the refrigeration/air conditioning sector. The study is called "Persistent degradation products of halogenated propellants and refrigerants in the environment: type, environmental concentrations and fate with special consideration of new halogenated substitutes with a low global warming potential."

"We hope to have it published beginning of [2021]," said Gabriele Hoffmann of the UBA. "There will be also an English version."

Why risk it?

Many stakeholders throughout the global HVAC&R industry have expressed concerns about the potential environmental, health and safety impact of HFOs in the future as their usage continues to grow in 2021 and beyond.

Large-scale emissions of HFOs that convert to TFA could result "in yet another environmental crisis," said János Mate, Senior Policy Consultant, Greenpeace. "Why take such risks? Have we not learned the key lesson the ozone and global warming crises have taught us: it is much easier to break than to restore nature's balance."

"We do not know the long-term effect of these HFO refrigerants," said Claus Schön Poulsen, Central Manager, Danish Technological Institute. "The environment should have the benefit of the doubt."

"There is a natural refrigerant available for every application that has been tried and tested and without any harm to the environment," noted Wynand Groenewald, Founder of Future Green Now, a South African consultancy.

Collin Bootsvelde, Project Engineer, Belgium grocer Colruyt Group, pointed out that it's not just R1234yf (the HFO with the greatest conversion to TFA) but HFCs still in use like R134a and R143a that break down into TFA. "I suggest we add TFA to the existing list of ODP and GWP in order to evaluate chemical refrigerants," he said.

Given the uncertainty around their future environmental impact, "I see some market skepticism about HFOs, and the belief that they will eventually end up

with their own phase-down situation in the future just like HCFCs and HFCs," said Kurt Liebendorfer, Vice President of U.S. manufacturer Evapco.

"It's difficult to have confidence in something that is relatively new compared to natural refrigerants, which have a long history of use and are already so abundant in the environment," noted Caleb Nelson, Vice President of Business Development for Azane, a U.S. manufacturer of low-charge ammonia systems. "It's obvious that even the HFO producers have a history of not knowing what they don't know in terms of side effects of their chemicals."

High GWP

Mate observed that HFO blends have a high GWP compared to natural refrigerants, such as R449A with a GWP of 1282 and R513A with GWP of 573. "But the chemical industry masquerades all HFOs as low-GWP refrigerants," he said.

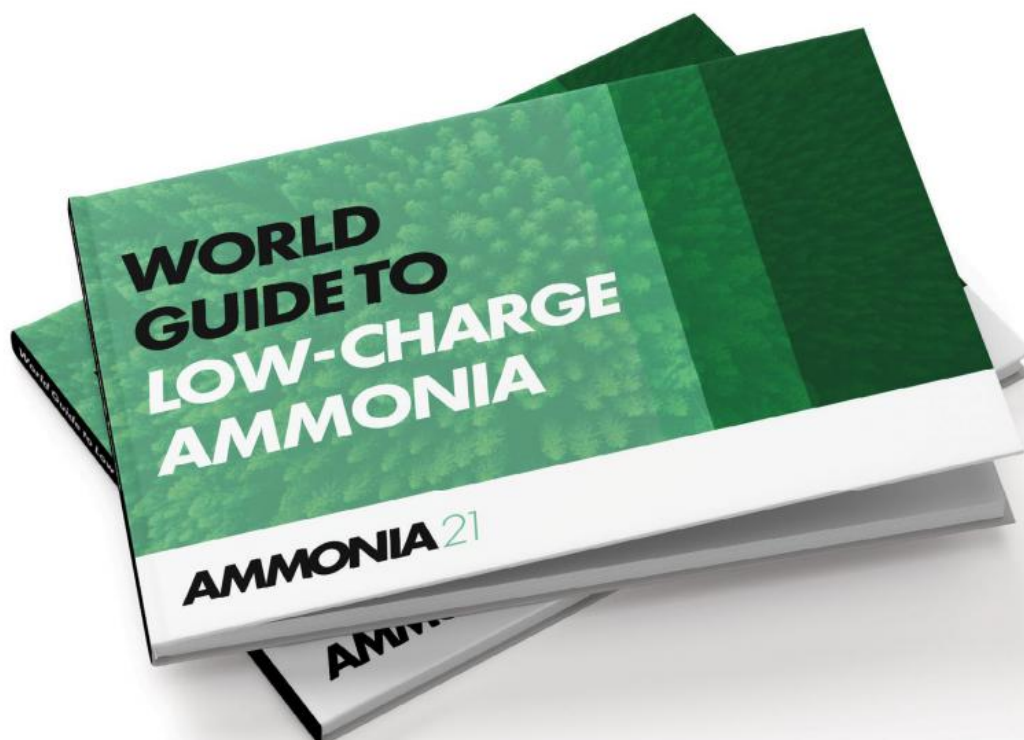
Those HFO blends are being aggressively promoted in the North American ice rink industry, with the support of the National Hockey League (NHL). Canadian contractor Cimco Refrigeration has been "fighting the very competitive push by HFO [blends] into the rink market," said Benoit Rodier, its Director of Business Development. "The NHL's position is hard to understand. They have been widely using natural refrigerants with no impact on the environment and now they are turning towards synthetic solutions with 700-GWP solutions."

Some observers believe that HFO blends, particularly as drop-in replacements for HFCs, will serve as a bridge to natural refrigerants. "These refrigerants may be necessary for some customers to reduce the number of current systems using refrigerants such as R22 and R404," said Richard Wayne Gilles, Senior Product Leader – Distributed Solutions for U.S. OEM Hussmann.

Stefan Jensen, Managing Director of Australian OEM Scantec Refrigeration Technologies, noted that mounting evidence suggests HFOs should be an interim solution only. He alluded to another concern about R1234yf – the production of the acid HF upon combustion. "It is believed that the combustion products of HFOs should be one of the factors that are considered in the standards and codes of practice regulating their use." ■ MG

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Competing with Vapor Compression

The number of alternatives to traditional vapor compression cooling continues to increase.

— By Tine Stausholm

The history of vapor compression refrigeration goes back to 1805, when American inventor Oliver Evans described the first closed vapor compression system. It has been the dominant method for a variety of cooling needs for more than a century.

However, over the last 10 years or so, creative minds have come up with a variety of alternative – and environmentally friendly – methods, using both brand new technology and well-known principles applied in new ways.

Many of these are now on the brink of commercial breakthroughs. Perhaps 2021 will be the year where we see alternative refrigeration technologies beginning to make a real difference in the efforts to combat the climate crisis.

Radiative Cooling

Radiative cooling is one of the oldest cooling technologies around; the ancient Persians used the technology to create ice. It works by exposing certain materials to the night sky, where they emit more thermal (infrared) radiation than they take in, thereby becoming colder than the ambient air.

U.S.-based [SkyCool Systems](#) has developed a system in which mirror-like reflective panels, made of special materials, leverage the radiative cooling not only at night but also during the day to passively cool water. The work has been funded by the U.S. Department of Energy.

SkyCool's customers so far include a Grocery Outlet store in Stockton, California (U.S.), and a Circle K convenience store in Sacramento, California, according to [SkyCool's website](#). It is also suitable for cooling data centers.

At the Grocery Outlet, the SkyCool system cools the condenser of an HFC system, cutting energy costs by 15% annually. At the Circle K outlet, the system subcools a walk-in cooler, and replaces the condenser for an ice machine, cutting energy consumption by 15% and 25%, respectively.

Magnetocaloric Refrigeration

In magnetocaloric refrigeration, a suitable material heats up when subjected to a magnetic field, and cools down when removed from it, chilling a secondary glycol fluid. The technology is being promoted particularly for medical and commercial refrigeration.

Now-defunct French company Cooltech, which was a leader in the development of magnetocaloric technology, claimed its system achieved energy savings of 30% to 40% compared to R404A systems.

This year, another French company, Ubiblu, [licensed Cooltech's patents](#) from French intellectual-property specialist France Brevets. Ubiblu is planning to market modules of 2kW (0.6TR), 20kW (5.7TR) and 100kW (28.4TR), and aims to be ready for small-scale serial production in 2022-2023.

Magnetocaloric technology is also being pioneered by other organizations, including the Fraunhofer Institute for Physical Measurement Techniques in Freiburg, Germany.

Thermoelectric Cooling

Solid-state cooling (and heating) is a technology based on small thermoelectric chips. The chips are made of copper-lined ceramic pads, connected by "legs" made of two different types of semiconductor materials. When an electric current is sent through the semiconductor legs, the dissimilar materials create a temperature difference, making one side of the device hot and one side cold.

U.S. company [Phononic](#) has commercially available thermoelectric refrigerators up to 5.5ft³ (0.2m³) in volume, with the technology capable of being scaled up to 10ft³ to 20ft³ (0.3m³ to 0.6m³). Phononic's equipment is "price competitive in the market across both the life sciences and healthcare, and food and beverage segments," a company representative said last year.

For food stores, Phononic has partnered with Unilever to provide countertop ice cream freezers for placement at the checkout. Pepsi Bottling Ventures has installed Phononic refrigerators at the end of aisles near registers in some North Carolina supermarkets and convenience stores, according to CNBC.

Other partners include PNC Arena, a professional sports facility in Raleigh, North Carolina (U.S.), and Bryte Labs, which is using the Phononic system to create cooling and heating zones in its BRYTE Bed.

A year ago, Phononic, in partnership with Temasek Foundation, announced that it had installed eight solid-state bladeless fan cooling units at Jurong Lake Gardens and Clarke Quay, two outdoor tourist attractions in Singapore.

To attract more partners, Phononic last year created a "Design with Phononic" platform that seeks collaboration with engineers, industrial designers and manufacturers.

Thermoacoustic Cooling

Dutch company [SoundEnergy](#) has developed a cooling unit, called THEAC-25, which utilizes thermoacoustic principles, and the Stirling cycle. It is capable of delivering a -25°C (-14°F) cooling output using only waste heat and almost no electricity.

THEAC-25 has been commercially available since 2018, and it is in use in several countries, including Dubai, where the government has bought a unit to cool a plant that condenses drinking water from the air.

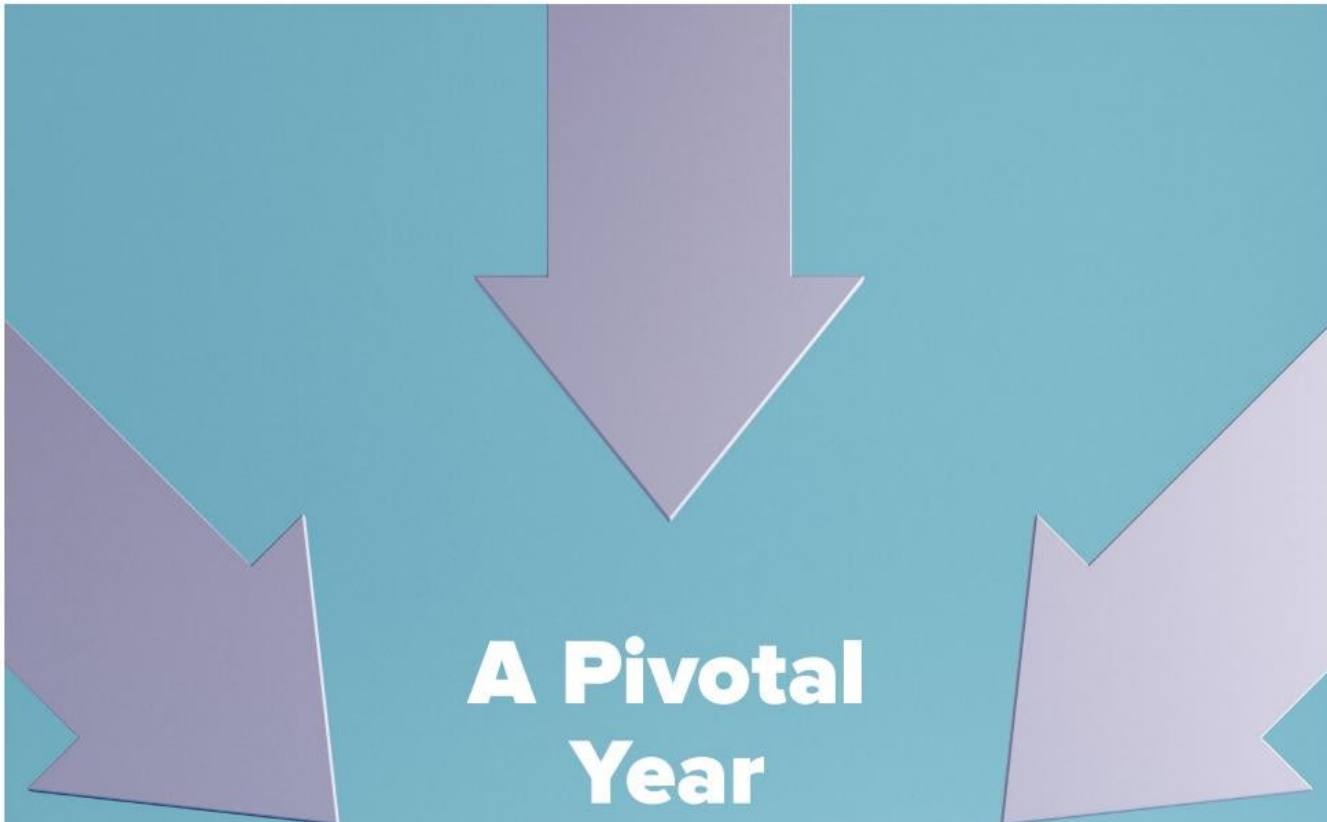
In 2019 SoundEnergy "got a lot of traction" in the food-and-beverage sector (such as bakeries and coffee roasting companies), heavy metal companies (die cast and metal hardeners), hydrogen production, off-grid applications like expeditionary compounds, and marine off-shore applications, SoundEnergy Chairman of the Board Herbert Berkhout said last year.

In March of 2020, SoundEnergy announced that it had its system on the roof of IKC Magenta, a school in Delden, The Netherlands, to provide solar-assisted cooling to the building.

Twistocaloric Refrigeration

In a study published in the October 11, 2019, issue of the journal *Science*, an international team led by researchers at the University of Texas (UT) at Dallas and Nankai University in China demonstrated "[twistocaloric](#)" refrigeration via twisting materials as diverse as natural rubber and ordinary fishing line.

The work at UT is supported by the Air Force Office of Scientific Research, The Welch Foundation, and the National Science Foundation. But the timing for commercialization of the technology is still to be determined. ■ TS



A Pivotal Year

In 2021 a number of Clean Cooling projects will be implemented in developing countries, says Professor Toby Peters, who first defined the concept.

— By Michael Garry



If Toby Peters has his way, Clean Cooling will change the way society approaches the deployment of air conditioning and refrigeration systems.

Peters, Professor in Cold Economy at the University of Birmingham, U.K., and Co-Director of the Birmingham-based Centre for Sustainable Cooling, first defined Clean Cooling several years ago, and has since written and spoken extensively about it.

Clean Cooling encompasses many dimensions but, in its essence, it means "resilient cooling for all who need it, without environmental damage and climate impact and with the optimal use of natural and thermal resources throughout the lifespan of the cooling system," Peters said.

While this includes using the most efficient cooling equipment with the lowest GWP refrigerants, it also calls for an assessment of the amount of cooling needed, and how much of it can be met non-mechanical means like white roofs, shading and natural ventilation.

The concept of Clean Cooling continues to be refined by Peters and colleagues in concert with shecco, publisher of *Accelerate*, and in discussion with external experts. Its current definition can be found [here](#). Peters expects the definition to evolve over time as cooling solutions and strategies improve.

Peters and shecco are also leading a collaborative project to develop a standard Clean Cooling process – in effect, a series of questions by which cooling projects can be audited. This process could be employed by a variety of stakeholders, including end users, planners, banks and governments. Peters and shecco will welcome industry feedback on the definition and standards that are developed.

In the following interview, Peters looks at the prospects for Clean Cooling in 2021.

//Accelerate: In general, how much progress will be made by stakeholders in adopting Clean Cooling practices or pursuing Clean Cooling goals in 2021?

Toby Peters: I think 2021 will be a pivotal year as we see cooling and cold chain as key priority areas for climate and social goals, and a range of initiatives really start to gather momentum. Key, though, to the goal of delivering Clean Cooling – and a pathway to net-zero cooling – are policies and strategies stretching ambition to the real level of system intervention needed to deliver economically, socially and environmentally sustainable cooling.

//Accelerate: What are some examples of regions or stakeholders that will adopt these practices or pursue these goals in a significant way next year?

TP: While the focus will, of course, be on India and China as the big cooling markets, I think we are going to see some really exciting, foundational initiatives in the newer but fast-growing markets. This will be particularly true for Sub-Saharan Africa, where we can leap from no cooling to Clean Cooling through initiatives like the African Centre of Excellence for Sustainable Cooling and Cold-Chain.

I also think we shall see regions like the GCC (Gulf Cooperation Council: Saudi Arabia, Kuwait, the United Arab Emirates, Qatar, Bahrain, and Oman) really start to focus on the opportunities of Clean Cooling as they look to economic resilience and opportunities beyond fossil fuels. Within this, COVID-19 has shown us the need for resilient global cold chains for food and vaccines, which forward-looking countries will want to invest in and lead.

//Accelerate: How will Clean Cooling practices help in the distribution of a COVID-19 vaccine next year?

TP: Clean Cooling per se is not required in the distribution of a COVID-19 vaccine – we can do that by deploying more high-emissions technology. Equally, we can solve the challenge with some interventions which are marginally greener. Or



Toby Peters, University of Birmingham, U.K.

we can rise to the challenges and really think about how do we solve the need for the cold chain to meet COVID-19 distribution but in ways which actually leave a lasting legacy for society, the environment and the investment.

//Accelerate: How much will the announcement of a Global Cooling Prize winner in 2021 advance Clean Cooling?

TP: This is a game-changer which shows governments and the public what can be achieved now, which are not simple incremental improvements in efficiency. The issue then is whether we use this to set real targets for efficiency improvements which will have a game-changing environmental impact on cooling in the next decade, or continue with easy wins which do not move the dial.

//Accelerate: At this point, 111 countries (plus the EU) out of 197 have ratified the Kigali Amendment. How much will Kigali ratifications move the needle on Clean Cooling in 2021?

TP: We need to go further faster.

//Accelerate: What will the biggest obstacle to Clean Cooling be in 2021?

TP: Continuing to set the bar too low and allowing unsustainable equipment to be embedded in the system today which will be operation in the 2030s, not just this decade. ■ MG

The Cooling Industry's Vital Role in the Wind Down of COVID-19

Vaccine distribution and safety indoors will depend on access to HVAC&R technology.

— By Michael Garry



With multiple vaccines on the horizon, there is real hope that the world will gain the upper hand on the COVID-19 pandemic in 2021.

To make that happen, the HVAC&R industry will play a key role. In particular, it will provide the fridges needed to keep some of the vaccines at their required ultra-low temperatures. And many of those fridges utilize natural refrigerants.

For the Pfizer/BioNTech vaccine, which needs to be stored at -70°C (-94°F), one available refrigeration system is made by [Mirai Intex](#), a five-year-old Austrian engineering and manufacturing company. Mirai Intex's ultra-low-temperature systems use air (R729) from the atmosphere as its refrigerant to deliver temperatures down to -110°C (-166°F), according to the company.

Athens, Ohio (U.S.)-based [Stirling Ultracold](#) makes a novel cooling technology that can accommodate the Pfizer/BioNTech vaccine as well as a vaccine from Moderna that requires storage at -20°C (-4°F).

Stirling Ultracold's fridge employs a "free-piston Stirling engine" design that uses a reciprocating piston and displacer to compress and expand 10g of helium (R704), along with a continuous, gravity-driven thermosiphon to chill 90g of the hydrocarbon ethane (R170).

Other ultra-low-temperature (down to -86°C / -123°F) freezer providers that use natural refrigerants (propane/R290 and R170) include ThermoFisher Scientific and PHC Corporation of North America (PHCbi).

In addition to the cooling technology itself, an adequate cold chain will be required to distribute vaccines to the 60-70% of the world's population (4.7-5.5 billion people), noted a new study from the University of Birmingham (U.K.) called "[Understanding the cold-chain challenge for Covid-19 vaccination](#)." In particular, developing countries often lack "seamless, fully integrated functioning cold chains," the report noted.

Helpful to the cold chain will be the [SolarChill Project](#), a 20-year collaboration among several international organizations, including Greenpeace. Today there are approximately 100,000 installed SolarChill vaccine cooler units, powered by solar energy and using hydrocarbons (isobutane/R600a) as a refrigerant to maintain temperatures between 2°C (36°F) and 8°C (46°C). "It is expected that the technology will in coming years replace kerosene and solar/battery coolers in parts of the world that have no secure electrical supply," said Janos Maté, Senior Policy Analyst for Greenpeace.

While vaccines are being distributed, mitigation measures to limit COVID-19 infections will continue to be needed in 2021. One of those is ensuring adequate ventilation in indoor spaces, such as adjusting (if possible) centralized HVAC units to pull in more outdoor air, and inserting MERV (13 and above) or HEPA air filters into HVAC units, or using stand-alone HEPA units. Another strategy is to keep the relative humidity in a room between 40% and 60%, particularly during the winter when indoor humidity drops.

Professional HVAC/R Services, a U.S. contractor, has helped develop a unit that sanitizes the air in hotel rooms. It "fits inside the room HVAC unit and runs only when the fan is on," said Joe Kokinda, President/CEO.

Elon Musk, CEO of electric auto maker Tesla, has reportedly expressed interest in developing a highly efficient, next generation HVAC system that features an advanced HEPA filter.

"COVID-19 has raised public awareness about the importance of HVAC systems, which may lead to more demand for our sector's services," said Tony Gleeson, CEO and Company Secretary for AIRAH (Australian Institute of Refrigeration). In Australia, the government is aiming some of its recovery programs at upgrading HVAC&R equipment, "which augurs well for our sector," he added.

Impact on business

COVID-19's direct impact on business has varied by sector, and will continue to do so.

The commercial and industrial refrigeration sector – essential for the processing, storage and distribution of food – has been less affected, noted John Ackermann, owner of South Africa-based Jack Agencies, and former Publisher/Editor of the *Cold Link* newspaper.

On the other hand, the opening of new supermarkets and refurbishments averaged 30% to 35% of the 2019 level in South Africa, he noted. "Recovery of this sector may still be slow in 2021 due to the saturation of supermarkets per capita."

Industrial refrigeration "has fared much better" due to some large projects, including distribution centers for supermarket groups, large food processing plants and third-party refrigerated warehouses," Ackermann said, adding, "This trend is expected to continue in 2021."

In Canada, contractor Neelands Group, serving mostly supermarkets, has not seen a major impact on service from COVID-19, said Ady Vyas, its Vice President of Energy and Digital Services. "But from a new construction perspective, we do see some customers holding off on purchase orders, and deferring them to a later date."

U.S. industrial OEM Evapco, which provides packaged low-charge ammonia (R717) systems, expects business "to rapidly grow as the impact of the pandemic fades in 2021," said Kurt Liebendorfer, Vice President. "We see many large capital projects that have been put on hold as a result of COVID, and expect many of them to be taken off hold once it starts to diminish."

Companies that serve the hospitality and restaurant sector have taken a greater hit than those supporting food retail. "It has a deep impact to our operations," said Olaf Schulze, Director, Facility, Energy and Resource Management, German wholesale retailer Metro AG. For example, it has reduced the speed of Metro's F-Gas Exit Program (FEP) and its rollout of transcritical CO₂ systems, he noted.

Like many companies, German OEM Efficient Energy, makers of water-only chillers, has been constrained in its marketing efforts by the cancellation of live events, trade shows or customer appointments. But the company has taken to focusing on alternatives such as virtual events, online webinars and social media, noted Thomas Barton, Sales Director.

"Our digital product launch was a great success and we had positive feedback from all angles," he said. "This is an important encouragement to continue our digital sales and marketing journey to make Clean Cooling accessible to a wider audience all over the world." ■ MG



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