

FROM ITALY TO THE WORLD

Natural refrigerants
in the home of innovation

Many Italian companies have played a central role in developing new innovations for natural refrigerants – from transcritical CO₂ racks or propane cabinets to low-charge ammonia systems. *Accelerate Italy* reports from the home of innovation.

– By Charlotte McLaughlin

Italy has enjoyed a reputation as a home of innovation for hundreds of years. In the 20th Century, Italy gave the world the fashion houses of Milan and the Memphis Group (the design and architecture group founded in Milan in 1982 by Ettore Sottsass, from which this magazine takes its inspiration), and in the 15th and 16th Centuries birthed the Renaissance – one of the most productive periods of architecture, art and science in history. Today it is also known for great food, even better wine, long summer days, and fast cars.

Yet in this celebration of all things Italian, it is easy to overlook that Italy is a world leader in the field of engineering. The Italian Trade Agency (ITA) estimates that 60% of the country's exports today come from industrial manufacturing including the HVAC&R sector.

Michele Scannavini, president of the Italian Trade Agency (ITA), said in 2017 that 4,600 companies in Italy make technology products, employing nearly 180,000 people.

Italy's significance to the HVAC&R industry cannot be ignored. It is hard to get exact data on the number of companies working in HVAC&R in each European Union member state, but it is reasonable to estimate that a large proportion of them are Italian.

"Italy is one of the leading countries in HVAC&R due to the great number of companies based here," Giovanni Dorin, marketing director of compressor manufacturer *Officine Mario Dorin*, told *Accelerate Italy*.

The new EU F-Gas Regulation obliges European companies to register their activities with f-gases. Of the 1,279 companies reporting their f-gas activity in 2016, the majority come from Italy, according to a 2017 report by the European Environment Agency.

The work Italian companies do to push innovative technology working with CO₂, hydrocarbons and ammonia is made possible by the country's strong HVAC&R tradition.

Go to any HVAC&R tradeshow in Europe, and you cannot miss the large number of Italian companies.

Italian firms accounted for 15 out of 69 (21%) of the companies working with natural refrigerants at EuroShop 2017 (source: *GUIDE EuroShop 2017*, produced by sheccoBase, the market development arm of *Accelerate* publisher shecco). Chillventa 2016 boasted similar numbers: 23% of the 190 companies working with natural refrigerants at that show were from Italy (a total of 44).

Northern Italy has hosted much of the country's manufacturing base, around cities like Turin and Milan, since the 19th Century. Today many HVAC&R companies are based in the so-called industrial triangle made up of the Lombardy, Veneto and Emilia-Romagna regions of the north.

Some consider the Italian capital of refrigeration to be a small northern town called Casale Monferrato, between Turin and Milan – according to Marco Buoni, technical director of Italian HVAC&R research and training institute *Centro Studi Galileo*, which is located there.



A LONG HISTORY

Most of the companies *Accelerate Italy* spoke to have been around for at least 30 years. *Officine Mario Dorin*, based in Compiobbi on the outskirts of Florence, is celebrating its centenary this year.

Founded in 1918, Dorin has been active in the field of refrigeration since 1932 (see special feature on [Dorin, page 42](#)). “We are one of the oldest companies manufacturing compressors globally,” Giovanni Dorin told *Accelerate Italy*.

Arneg s.p.a., located in Campo San Martino, Padova in the region of Veneto, is steeped in Italian history “because Italian character is tradition and innovation, creative genius, craftsmanship and the instinct to survive and invent. In other words, the Italian character is the emblem of excellence,” the company states on its website.

The global HVAC&R firm focuses on the commercial retail sector, a market in which it has been active for over 50 years and “is one of the leaders,” according to Enrico Zambotto, customer & product support, Arneg.

CAREL s.p.a., founded in the province of Padova, has also been in the market for a long time. It started manufacturing steam humidifiers in the 1970s. In the 1980s, it branched out into controls for refrigeration and air conditioning.

Heat exchanger manufacturer LU-VE, listed on the Milan Stock Exchange, is headquartered in Uboldo, Varese in the Italian region of Lombardy. It has 10 production units around the world and has been in the sector for over 30 years.

“We have one of the biggest R&D laboratories in our sector in Europe and we have been collaborating closely for over 30 years with the Polytechnic University of Milan and 21 other universities all over the world,” Livio Perrotta, marketing manager, cooling systems business unit, LU-VE GROUP, told *Accelerate Italy*.

This focus on R&D has allowed the company to become one of the world’s leading manufacturers of heat exchangers.

Alessandro Vitri, vice-president of Rivacold – located in Vallefogli, a town in the Marche region located just below Emilia-Romagna – told *Accelerate Italy* that his company boasts a 50-year tradition in HVAC&R as part of the Vitri Alceste Group (VAG). “We are very proud,” Vitri says.

“VAG has operated within commercial and industrial refrigeration with the Rivacold brand since 1966, in a competitive market that we lead thanks to investments in advanced technology, lean production and people’s knowhow,” he says.

SCM FRIGO S.p.A., a leading manufacturer of refrigeration systems established in 1979, has had almost 40 years’ experience working in its Venice location in the Veneto region. “Our company will soon celebrate 40 years in refrigeration, the last 15 years with natural refrigerant CO₂,” Nicola Pignatelli, managing director of SCM Frigo, told *Accelerate Italy*.

The manufacturer has been part of Beijer Ref – a leading Swedish HVAC&R multinational – since 2011.

There is a long tradition of collaboration between Italian and Swedish manufacturers. “Alfa Laval is a Swedish company with a long tradition in Italy,” says Stefano Meloni, Alfa Laval’s product manager (heat exchangers) in the Adriatic region. “The first Italian office was opened in 1911 and today we have several

production, commercial, engineering and research & development facilities with a total of about 1,000 employees.”

The production facility is located in Monza, just northeast of Milan in the Lombardy region, where the firm manufactures heat exchangers used in refrigeration, air conditioning, and heat pumps working with CO₂, ammonia and hydrocarbons.

EXPORT-LED, HOME-GROWN

Most of these companies export the majority of their natural-refrigerant products to the rest of Europe, where demand for these technologies is higher.

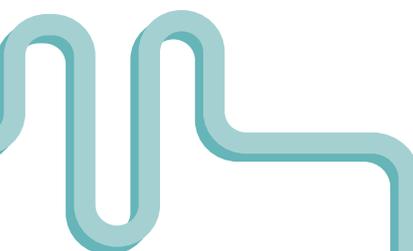
“The overall situation of the Italian market is more conservative in terms of volumes compared to the other European countries, where there has been a lot of growth in natural refrigerants,” argues Rivacold’s Vitri.

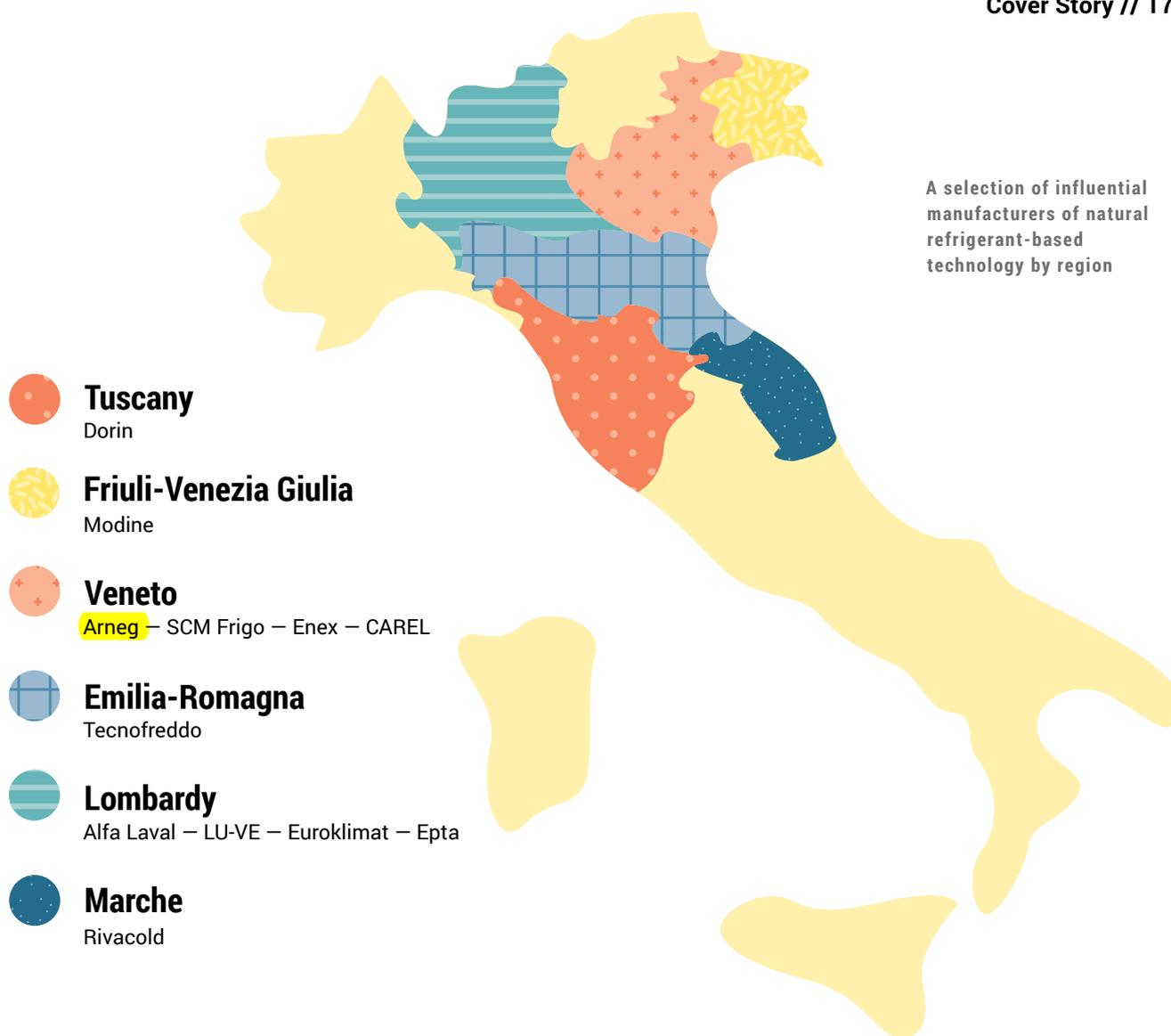
Italian HVAC&R controls manufacturer CAREL, based in Brugine, Padova in the Veneto region, would agree.

Last year, the group reported that 80% of its total sales in 2016 came from exports. Most export sales were to Europe, with an overall average increase of 19%. It also performed strongly in Asia (an increase of 8%).

“The focus of our innovation continues to be improved efficiency and sustainability in the air-conditioning and refrigeration sectors,” says CAREL Group Managing Director Francesco Nalini. CAREL has recorded a significant spike in sales thanks to its low-GWP technology innovations.

“Our growth in 2016 is the result of the most innovative solutions in these areas, and shows how our R&D efforts are focused in the right direction,” Nalini says.





CAREL reports a strong market for natural refrigerant technologies beyond Italy's shores. "It can be said that R744 got initial fast traction in low-temperature latitudes (e.g. northern Europe) due to the more suitable ambient temperatures," Alessandro Greggio, group head of marketing refrigeration and retail, CAREL, told *Accelerate Italy*.

"The Italian market has been typically very strong in small hydrocarbon applications, since the beginning, and several OEMs have been investing and become capable in CO₂ applications," Greggio says.

Similar to CAREL, much of LU-VE's focus is outside of Italy – it exported 80% of its production to 100 countries in 2016, meaning much of its consolidated sales revenues of €251.3 million came from outside Italy.

For some, the story is more complex.

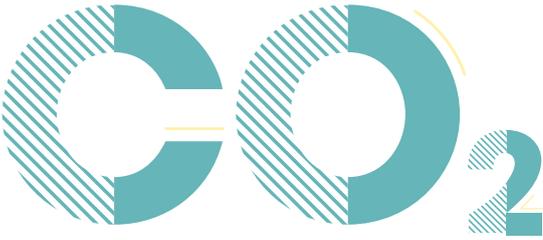
"We have been more successful outside of the Italian market because CO₂ in refrigeration was more used in northern Europe," Pignatelli of SCM Frigo told *Accelerate Italy*.

Much of this growth, he estimates, has been down to governments in these northern countries accelerating the switch to natural refrigerants through taxes; such has been the case in Denmark ([see Accelerate Europe, issue #7](#)).

"But in the last 24 months we see increasing demand in terms of quotes and orders for CO₂ units also in Italy, and we expect a huge increase of sales in CO₂ in our domestic market," he adds.

Officine Mario Dorin also notes growth in natural refrigerant technology sales nationally and globally. Giovanni Dorin expects Italy's positive economic growth only to add to this: "Although the economy is timidly restarting with growth in the national GDP of some percentage points, the Italian HVAC&R sector will definitely take a very strong step in the next few years," he predicts.

He nonetheless sounds a cautious note. "Obviously on the international market, there are more players – large and middle-sized ones – giving more opportunities to our sales growth. Hence the success of our CO₂ products is global."



**CO₂ TRANSCRITICAL:
AN ITALIAN EXPORT**

Norwegian scientist Gustav Lorentzen, a professor at the University of Trondheim, rediscovered how CO₂ could be used as a refrigerant in heating and cooling applications in the 1980s.

Lorentzen developed the modern thermodynamic transcritical CO₂ cycle in 1988-1991, heralding a crucial breakthrough that has led supermarkets to opt for transcritical CO₂ systems across Italy and the rest of Europe.

Today, over 12,000 European supermarkets use CO₂ transcritical systems, according to the latest data from sheccoBase, the market development arm of shecco, publisher of this magazine.

Much of this growth was driven by innovative Italian companies, including Enex (see interview with company founder Sergio Giroto, [page 36](#)). While working for Italian company Costan – part of the Epta Group – Giroto asked Dorin to produce a CO₂ compressor back in 1996.

Testing of these compressors, beginning in 1997, paved the way for Dorin to become one of the biggest advocates of CO₂ technology. “The process is reinforced by the determined adoption of CO₂ technology as a long-term solution,” says Giovanni Dorin.

The compressor manufacturer has heavily invested in developing CO₂ compressors for industrial applications.

“Dorin is investing every year a lot in innovating its compressors, either with new products or by renovating previous models,” Giovanni says. “For our CO₂ ranges alone – Series CD transcritical and CDS subcritical – we are already in the 4th generation of the models.”

“Our feeling is this will be a reliable alternative to ammonia,” said Giovanni Dorin at this year’s AHR Expo in Chicago. “Ammonia has issues with safety.”

Dorin’s new semi-hermetic reciprocating compressors, marketed under the CD500 line and originally mentioned at Chillventa 2016, feature six cylinders, 50-80 HP and displacements of 40-60 m³/h. Like the two-year-old CD400 line, the CD500 compressors are designed such that the manifold is outside the crankcase, rather than inside, and the two are separated by a pocket of air. This allows the CO₂ gas to cool before being discharged by the compressor, lowering the temperature of the oil inside the crankcase and increasing efficiency and reliability, he said.

“This [design] is totally unique in the market,” Dorin said. The high capacity of the CD500 line means fewer compressors are needed for an application, reducing costs, added Giacomo Pisano, Dorin’s sales manager, CO₂ compressors.

Modine Manufacturing Company’s Commercial & Industrial Solutions (CIS) division has its EMEA

1988

1996

1997



1988-1991
Gustav Lorentzen rediscovers how CO₂ can be used as refrigerant in heating and cooling applications. Lorentzen develops modern thermodynamic transcritical cycle.

Sergio Giroto, working for Costan, asks Italian manufacturer Dorin to produce a CO₂ compressor.

Dorin tests CO₂ compressor in factory conditions.

regional headquarters in Pocenia (Udine), in Friuli-Venezia Giulia region in north-eastern Italy. It is also investing in transcritical CO₂ for industrial applications.

“We’re proud to have supplied seven large transcritical gas coolers with ‘V’ configuration heat exchangers to our Advansor customer for the realisation of the largest transcritical CO₂ installation in the world (3.4 MW), for Staay Food Group in the Netherlands,” says Umberto Di Barbora, global product manager, commercial coolers, commercial and industrial solutions (CIS), Modine.

“It was certainly being part of this project that made us realise that the CO₂ boundaries are not limited to commercial refrigeration but can also be extended to the most challenging industrial refrigeration projects.”

Modine CIS is one of the world’s largest heat exchanger manufacturers. With a workforce of 3,500 in CIS and an additional 7,500 employees in other divisions, it has been working with CO₂ for some time. It provided the first heat exchangers, in the early- and mid-1990s, to European CO₂ test labs like the Danish Technology Institute (DTI) in Aarhus.

Similarly LU-VE, which closely collaborates with universities in Milan and around the world, was one of the first companies to work with CO₂. “Our first CO₂

plant dates back nearly 14 years to Switzerland (Zürich),” says LU-VE’s Perrotta. “We provided the gas cooler with spray system.”

In 2010 the company decided it would start Europe’s first CO₂ test plant for CO₂-based finned heat exchangers, and also “to test CO₂ unit coolers and gas coolers in both subcritical and transcritical operation”.

“The new testing plant enabled the launch of a specific project for a CO₂ fin-and-tube heat exchanger, with the primary aim of improving knowledge of heat exchange phenomena in evaporation, condensation and during transcritical gas cooling,” Perrotta says.

“The influence of oil on the internal heat exchange coefficient also enters the scope of the research. We have the opportunity to calibrate our software that calculates product performance, and potential improvements to products. It is possible to calibrate a specific method able to consider the behaviour of the fluid during transcritical cooling, properly considering all the parameters affecting real performance.”

LU-VE has adapted water injector systems developed in 1997 to modern CO₂ systems. “EMERITUS® is the latest innovation developed for the range of condensers, dry coolers and gas coolers manufactured by LU-VE Exchangers. This new technological advance (patent pending) is the result of collaboration with the Polytechnic University of Milan and brings together the benefits of spray systems and adiabatic pre-cooling,” he says.

“When EMERITUS® is applied to CO₂ gas coolers, higher system [coefficient of performance] can be achieved even during the hottest hours of the year,” he adds.

This investment in learning lessons from the past and applying them to new technology is part of the company’s motto. “The future has an ancient heart,” Perrotta says.

The Italian HVAC&R industry first manufactured CO₂ products for the commercial arena. “The first approach was with supermarkets, then a logistics plant, and now there are industrial applications,” says SCM Frigo’s Pignatelli.

SCM Frigo has put racks and condensing units in supermarkets, logistics centres, ice rinks and small stores throughout the world. The company boasts over 2,000 CO₂ installations globally, some of which are subcritical.

SCM Frigo began working with CO₂ in 2004, developing cascade systems for customers in its largest market of Scandinavia. At the time, the company was responding to growing customer demand for alternative refrigerants.

“There was a need for CO₂ units because of the huge taxes they had to pay for using HFCs in the European Nordic countries,” says Anna Stella, key account manager, SCM Frigo.

In response, the company – just one year later in 2005 – began developing transcritical CO₂ systems. Asked why SCM Frigo had committed so strongly

1998



1997-1998: Giroto installs subcritical CO₂ cascade systems in supermarkets in Italy (Conegliano, Treviso) and the UK (Harlesden, London), while at Costan.

1999



Giroto designs the first-ever CO₂ transcritical system (Costan), fitted in a small supermarket without a compressor rack.

2001



Giroto installs the first-ever CO₂ transcritical system (Costan) in a large supermarket, presenting a paper on the installation at the International Institute of Refrigeration Congress in Washington, D.C. in 2003.

to CO₂, SCM Frigo Technical Director Mirko Bernabei explains that they believed it to be the best long-term solution at the time.

“We decided on CO₂ because we were convinced that CO₂ was easiest to manage,” Bernabei says. Customers were looking for a solution that was easy, reliable, and would be future-proof and provide long-term certainty.

This commitment to CO₂ has paid off. SCM Frigo has seen a lot of success in Europe and beyond. It brought its new CUBO₂ Smart CO₂ condensing unit (CDU) to Australia last year.

The company was also heavily involved in the first transcritical CO₂ system in China’s retail sector, for which it produced the rack, in a METRO wholesale store in Beijing.

The controls were provided by CAREL, which has also been at the forefront of developing the CO₂ market. “CAREL, being a solutions provider and an enabler of multiple ways of natural refrigerant adoption, values not only the final user and market demands but also the large OEM customer base,” Greggio says.

Alfa Laval is also experienced in working with the high pressure of transcritical CO₂. “We have certainly been helped by customers who have believed in CO₂ since 15 years ago,” says Meloni.

“By the time the [EU F-Gas Regulation came into force with] restrictions on the use of synthetic refrigerants, we were ready with full ranges,” he adds.

Though these innovators were at the forefront, many more have since emerged on the scene to work with CO₂ in different applications. Arneg’s Zambotto says the company had tried on many occasions to kick-start its CO₂ business, adding that the increasing cost of HFCs since the introduction of the EU’s F-Gas Regulation gave the market the important push it needed to take off.

Rivacold, similarly, has found the journey difficult. Italian industry’s “very first approach was a general caution on pressure levels and effective efficiency on high ambient temperature operations,” according to Vitri.

The company started working with CO₂ 15 years ago, and admits to having difficulty getting components standardised and validated at first.

Rivacold now boasts a full CO₂ transcritical product range, from condensing units and evaporators to rack systems. “New condensing units and mini-packs for medium and low-temperature applications will cover small capacities for convenience stores with very high performance,” Vitri notes.



2004

2006

2007



Giotto founds Enex. Bitzer follows Dorin into CO₂ compressor market. Carrier installs its first CO₂ transcritical system, in a Migros supermarket in Switzerland.

Enex installs its first CO₂ transcritical system.

Advansor founded.

HYDRO CARBONS

A MAJOR PLAYER IN THE NATREF GAME

Hydrocarbons have also had a long tradition in Italy. "The Italian market was typically very strong in small hydrocarbon applications and, since the beginning, several OEMs have also been investing and become capable in CO₂ applications," says CAREL's Greggio.

Rivacold is one of the pioneers of propane condensing units and packaged units for cabinets and cold rooms. The company covers medium and low-temperature refrigeration applications.

"The volumes of Rivacold propane products are already at a top level within the market in Europe," Vitri says.

The company also sells heat exchangers, for propane and CO₂ (gas coolers up to pressures of 130 bar and evaporators up to 75 bar).

Originally, Rivacold's heat exchanger arm provided these products only internally. It is now part of two separate divisions that supply remote condensers and static and air-cooled evaporators to OEMs outside the company.

"Propane has become rather popular in commercial refrigeration, especially for refrigerated display case counters," says Modine's Di Barbora.

Arneg, meanwhile, is a leading manufacturer of propane-based (R290) plug 'n' play cabinets in supermarkets.

Getting propane into the HVAC sector may prove to be trickier. "As far as air conditioning is concerned, the issue is a little more delicate, since only recently have more manufacturers come up with R290 [and other low-GWP refrigerants] pushed by the EU F-Gas Regulation," according to Alfa Laval's Meloni.

Italian regulation remains highly restrictive for flammable refrigerants in public buildings ([see page 48](#)). Manufacturers like Modine think this will soon change. "We expect that the directives, especially the ones referring to hydrocarbons, will begin to take shape and be implemented at government level, in order to avoid dangerous interpretations," Di Barbora says.

Propane chillers are one option for air conditioning in which Italian companies Euroklimat, based near Milan in the Lombardy region, and Tecnofreddo, based in Modena in Emilia-Romagna, are investing ([see Technology Focus on page 54](#)).



AMMONIA

BUILDING ON TRADITION

Ammonia (NH₃) has long been used in industrial applications throughout Europe. Italian companies are pushing the boundaries of what this refrigerant can achieve, particularly at lower charges.

“We are continuing our development of very-low-refrigerant-charge solutions for NH₃,” says LU-VE’s Perrotta.

Since 2005 LU-VE has boasted a range of pumped ammonia LSA (large surface area) unit coolers that perform similarly to traditional ammonia products but with a lower charge. “Low refrigerant charge means a reduction of installation costs, a more compact separator, and lower operating costs,” he adds. “In addition to savings in refrigerant, it means higher levels of safety.”

Alfa Laval has used ammonia for a long time. “We are European pioneers and have always used this natural refrigerant,” Meloni says. “Alfa Laval developed a plate application in

flooded systems, replacing the traditional and cumbersome shell and tube.”

“In the industrial sector the competence of installers, contractors and manufacturers is very high with NH₃,” Meloni says. He reports strong growth of this refrigerant in the Italian market.

Yet others lament comparatively low uptake of ammonia in Italy compared to other European countries. “In Italy the use of ammonia for industrial refrigeration installations is low,” says Modine’s Di Barborà. Giovanni Dorin agrees: “NH₃ is not very common in Italy.”

COMING HOME

Natural refrigerant uptake, then, has perhaps been slower to take off in the country whose companies are manufacturing much of the technology to harness them. Yet there are signs of change.

Rivacold ran several workshops during 2017 focused on transcritical CO₂ in Italy. “We mainly dedicate them to installers. However, we also communicate from time to time our technology to other players such as contractors, system designers and end users,” Vitri says.

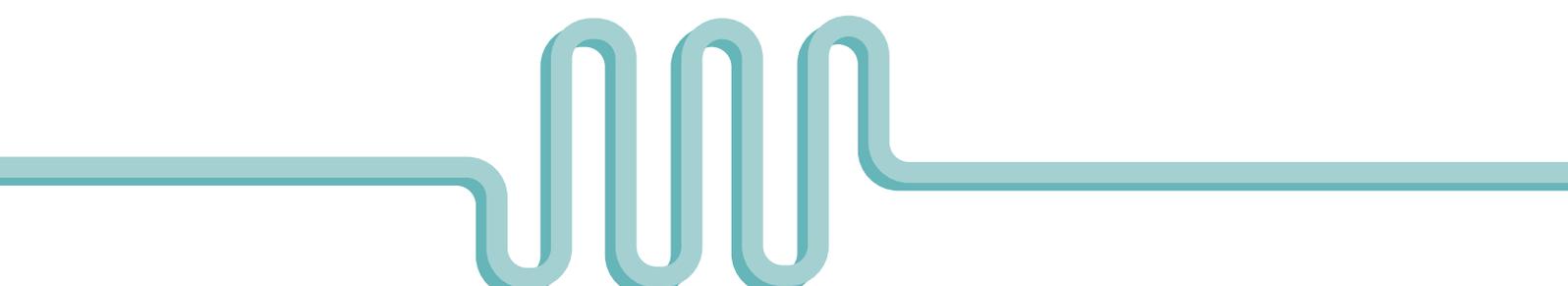
Other market players are optimistic about the domestic market.

“The Italian market for natural refrigerants has seen a significant increase in recent years, albeit starting from a very low level – especially now that the technology has made solutions available for warm climate countries,” notes Modine’s Di Barborà.

A new Iper hypermarket in Milan – the largest hypermarket in Italy and one of the largest in Europe – opened its doors in April 2016. The CO₂ transcritical system uses ejector technology from Danish multinational Danfoss. Arneg provided the system itself.

Convinced by the results of numerous tests in recent years, Arneg decided to go for an ejector to enhance the hypermarket’s energy efficiency.

Analysis from one year of operations in comparison to an HFC-CO₂ cascade



system was provided by Chiara Tognoli, customer technical support engineer at Arneg, at the ATMOsphere Europe conference in Berlin, Germany in September 2017.

The CO₂ transcritical system with an ejector (in the 10,000m² Iper hypermarket) was compared to an HFC-CO₂ cascade (in a 9,500m² supermarket also located in northern Italy).

The energy performance of the systems was measured (with Arneg supervision system IRIS) during the period August 2016 to August 2017, when ambient conditions reached 40°C during the summer months, according to Tognoli.

The CO₂ transcritical system was found to save 9% energy over the twelve-month period (saving 60,300 kWh/year), which translates into a €10,800 annual saving for the end user compared to the HFC-CO₂ cascade system. "This makes CO₂ competitive in warmer climates," Tognoli declared.

"Ejectors have given us a great results in terms of energy consumption, installation and reliability. The results we had last summer have been fantastic," says Arneg's Zambotto.

"Last year the Italian market speeded up the introduction of CO₂ in the supermarkets in medium-temperature applications," he says.

Perrotta from LU-VE, which also worked on the Milan project, is conscious of the challenges of adapting CO₂ to warmer climates.

"One of the factors that influences efficiency in a transcritical installation is the ability of the gas cooler to cool the CO₂ temperature as much as possible, especially on the warmest days of the year," Perrotta notes. "To this purpose, CO₂ heat exchangers must be designed taking into consideration many important precautions compared to an HFC solution. Moreover, other complementary technologies help in overcoming this challenge: i.e. spray and adiabatic systems."

SCM Frigo, which has installed CO₂ transcritical systems with parallel compression and integrated air conditioning in Italy, is eyeing new such projects.

Work on a huge logistics centre in northern Italy (2.4 MW) using transcritical CO₂ will begin in summer 2018, according to Pignatelli.

"How did this come about? Thanks to a system designer who has known SCM Frigo for a long time," he says.

Italy, with its long history at the forefront of the HVAC&R industry, has long taken advantage of the European market for natural refrigerant-based technologies. Now there are signs that the domestic market is following suit. ■ CM

LU-VE TAKES CO₂ TO INDIA

LU-VE, located in the Italian region of Lombardy, has had great success working with universities to push the boundaries of what CO₂ technology can achieve.

The company is a partner of INDEE, an Indo-Norwegian project backed by the Norwegian Ministry of External Affairs and led by SINTEF (Foundation for Scientific and Industrial Research at the Norwegian Institute of Technology) and the Norwegian Technical Institute (NTNU), both located in Trondheim.

"An INDEE industrial workshop at IIT Madras in March highlighted the possibilities of using CO₂ refrigeration technology in India," says LU-VE's Livio Perrotta. "The purpose of INDEE is to demonstrate the applicability of natural working fluid refrigeration technology in developing countries with high ambient temperatures."

INDEE has designed and built a test facility where interested parties can simulate supermarket operations.

"The gas cooler and the desuperheater both have CO₂ tube-and-fin heat exchangers from LU-VE," says Perrotta. "Performance evaluations will be carried out in high ambient conditions using CO₂ as the refrigerant."

