

Cooling India

India's foremost Monthly dedicated to the growth of HVACR Industry



Cold Chain Industry in India



Environment Friendly Chillers

- Cold Chain Industry in India – The Way Forward
- Chilling of Food
- Remotely Connected Chiller Technology
- HVAC&R Control Systems
- Need for Holistic Approach
- Environment Friendly Chillers
- Utilisation of Ground Source Energy



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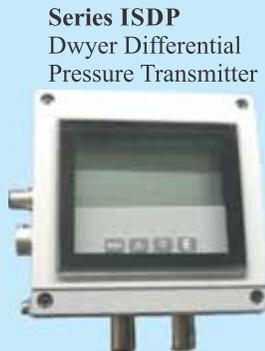
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Publisher's Letter

Momentum in Cold Chain Industry

Hello and welcome to another edition of Cooling India. A few days back Union minister Ram Vilas Paswan said the government will soon define portion sizes for food served in hotels, restaurants to preventing wastage of food. That's a good thought by the minister. Food should not be wasted. India is one of the largest food producers in the world and is the second largest producer of fruits and vegetables yet only 2.2 per cent of our fruits and vegetables are processed. Farmers are producing. Our demand is growing, but the unfortunate part is yet there is wastage of fruits and vegetables to the tune of Rs. 92,000 crore based on the wholesale prices of 2014. Efficient cold chains can help reduce this abundant wastage of food stuff rather than measuring what one eats.

Building cold chain infrastructure is the key to India's food security and public health for its more than one billion citizens. Existing cold storages are concentrated in few states and roughly 80-90 per cent are used for potatoes. Keeping this in mind the government has sanctioned 101 new cold chain projects to be set up by firms like Big Basket, Amul and Haldiram entailing Rs 3,100 crore in investments. These projects will create additional capacity of 2.76 lakh tonne of cold storage/controlled atmosphere/frozen storage, 115 tonne/hour of Individual Quick Freezing (IQF), 56 lakh litres per day of milk processing, 210 tonne per batch of blast freezing and 629 refrigerated/insulated vehicles.

Cold Chain industry has gained momentum with rise in urbanization leading to hike in demand for processed foods, quick serve restaurants (QSRs), and organized retail. The industry has evolved with rising income levels and growing awareness of hygiene, leading to a significant private investment in cold chain sector.

While financial investment in cold storage facilities and refrigerated transport is vital, some of the additional challenges faced by India's cold storage industry today are high lifecycle costs, uneven distribution of cold storages, low awareness of best storage and handling practices, frequent power outages, outdated refrigeration technologies resulting in high maintenance and high energy costs etc.

Moving ahead, the Government policies and schemes in the form of capital subsidies for setting up mega food parks (MFP), grant of infrastructure status and viability-gap funding have also helped cold chain industry. However, the right implementation of these initiatives and policies is the key to the exponential growth of the cold chain sector.

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3	Supply Temp. from CT / LTMCS	33°C	30°C
4	Approach to WBT	4°C	1°C
5	ΔT for Chiller	28°C	25°C
6	Chilled Water Compressor Motor Kw for 1200 TR	720	643
7	Energy Saved in %	-	10.7%
8	Energy Saved in Kw	-	77 Kw/Hr
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10	TOTAL POWER SAVED PER ANNUM	-	6,65,280 Kw



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Godrej's Most Power Saving Green Inverter AC

Godrej Appliances, one of India's leading players in the home appliances industry launched the nation's most power saving green inverter air conditioner with 5.8 ISEER under its premium sub-brand NXW. With this ISEER rating, Godrej NXW Inverter AC doesn't merely meet the 5-star



requirements of the current BEE energy rating norms; it also complies with the 5-star requirements of the proposed BEE energy table of 2019. This makes Godrej NXW AC India's most power saving AC. Concurrently the company also unveiled its brand philosophy 'Soch ke banaya hai'. Godrej Appliances has always endeavoured to push research and development in its relentless effort to ensure that products are thought through and delight the consumer through innovative, relevant and green technologies. The Godrej NXW Inverter AC comes with a unique green inverter technology. This clever combination of inverter technology and the green balance technology helps in achieving the highest energy efficiency in most eco-friendly way using the world's greenest refrigerant R290 which has zero ozone depletion potential and minimum global warming potential. The features of the company's products are based on the pillars of power saving along with eco-friendliness given the company's commitment to the environment. The new Godrej NXW AC, rated 5.8 ISEER, offers substantial reduction in power consumption as compared to any other AC in the market, thereby beating its own record of last year. ■

Efficient Heat Waste Recovery of Data Center

Mitsubishi Electric Hydraulics & IT Cooling Systems, through its brand Climaveneta has recently supplied two heat pumps for Fortum's district heating operations in Finland. Fortum, a Finnish energy company, will utilize the waste heat from a data center and supply the heat into a district heat network in a very innovative and sustainable way. The data center belongs to Ericsson, a multi-national networking and telecommunications



equipment and services company based in Sweden. The facility currently generates between 10,000 to 15,000 megawatt-hours of heat waste annually. The heat pumps will be used as a primary cooling method for the data center. Fortum's long-term goal is to serve all the district heating customers in Espoo, Kirkkonummi, and Kauniainen regions with carbon-neutral

district heat by 2030 at the latest.

Using the heat waste of a data center is a good example of how it is actively possible to move towards low-carbon district heating. Furthermore, as demonstrated in several projects throughout Europe, heat pumps are an energy efficient and economical solution for district heating systems. To recover the heat waste of the Ericsson data center and serve the district heating in Kirkkonummi, 2

Climaveneta FOCS2-W HFO/H/CA/S 5422 heat pumps have been supplied through Coromatic, the leading Nordic critical facility solutions provider. FOCS2-W HFO Climaveneta heat pumps have been selected for their efficiency and sustainability as they use HFO-1234ze refrigerant (1,3,3,3-Tetrafluoropropene), which has a minimal greenhouse effect. ■

China Hits Milestone with More Than 1,000 LEED-Certified Projects

The US Green Building Council (USGBC) announced that China has hit a major milestone and surpassed more than 1,000 LEED certified projects. "The exponential growth of LEED in the global marketplace and in China drastically helps mitigate climate change and positively affect the health and wellbeing of millions of people through our built environment," said Mahesh Ramanujam, President & CEO, USGBC. "LEED and other green building programs such as 3-Star have created a path forward for market transformation while changing the way we think about how buildings, communities and cities are planned, constructed, maintained and operated."

Today there are 1,013 certified LEED commercial projects in mainland China, 139 certified commercial projects in Hong Kong and four certified commercial projects in Macao. Adding in LEED residential and LEED for Neighborhood Development certified projects brings the

total to 1,207 certified projects in Greater China. Global green building is expected to double every three years, according to a Dodge Data & Analytics World Green Building Trends 2016 SmartMarket Report. The report found that emerging economies like China, India and Brazil will be engines of green growth with development varying from two to six-fold over current green building levels. Increased consumer demand has also pushed the world's green building market to a trillion-dollar industry, a surge that has led to a corresponding increase in the scope and size of the green building materials market. Earlier this year USGBC also announced that it was bringing Greenbuild Conference to China for the first time ever. It will be held October 17-18 in Shanghai. LEED is the world's most widely used green building rating system. The analysis used to develop the list ranks countries in terms of cumulative LEED-certified GSM space as of December 2016. ■

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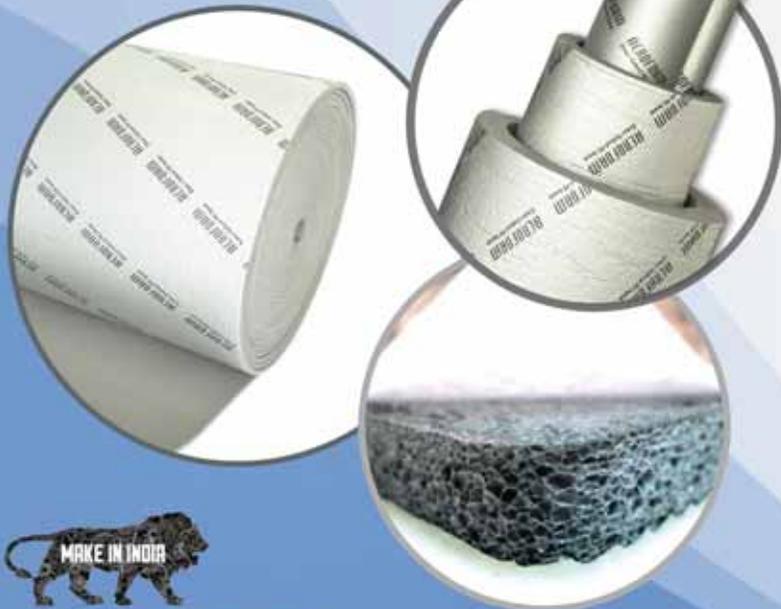
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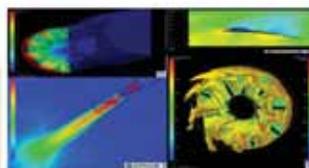


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Carrier Expanding Its AquaSnap Chiller Line

Carrier is expanding its water-cooled AquaSnap 30MP modular chiller line to offer a multi-chiller accessory that allows control of up to eight 30MP chillers simultaneously. When combined with the line's new ease of mobility, customers can now



maneuver 500 tons through tight spaces such as an elevator – making the line an ideal solution for replacement, retrofits and new construction applications. Carrier, a world leader in high-technology heating, air-conditioning (HVAC) and refrigeration solutions, is a part of UTC Climate, Controls & Security, a unit of United Technologies Corp.

The line's increased capacity, up to 500 tons, combined with its enhanced modular design provides customers greater choice in meeting their cooling needs. The system features enhanced mobility, including optional castors, as well as height adjustment capability that translates to improved ease of installation.

"We at Carrier are always working to help our customers maintain cost discipline with designs that reduce installation costs. In the past, large, expensive equipment was needed to install this level of tonnage," says Chris Opie, director, marketing, Carrier Commercial Systems. "We are committed to continually innovating and always listening closely to our customers to design and redesign our products to meet their needs." ■

Bitzer's 4-Cylinder Ecoline for Supermarkets

For the first time ever, BITZER is now presenting an ECOLINE+ 4-cylinder reciprocating compressor, which – like the rest of the series – offers optimal efficiency both for full- and part-load and at the same time is very easy to integrate into refrigeration systems. BITZER has improved the entire series in three ways. The ECOLINE+ reciprocating compressors are now equipped with new line start permanent magnet motors (LSPM), an enhanced motor technology

which forges ahead into better efficiency ranges. Mechanical capacity control for transcritical CO₂ applications is also new. This enables systems which are just as efficient for full- and part-load as is otherwise only possible today when using frequency inverters. So that users can fully exploit the potential of this technology, BITZER has also developed a new operating concept with intelligent (IQ) modules. "For us, environmentally friendly refrigerants, energy efficiency and ease of use have top priority. And the new ECOLINE+ series shows that these are not contradictory," says Rainer Große-Kracht, Chief Technology Officer at BITZER. "CO₂ is one of the refrigerants of the future – we at BITZER believe that wholeheartedly. With ECOLINE+ we have succeeded in

making efficient CO₂ technology simpler and easier to understand. This is the only way that we can encourage the increased use of this pioneering refrigerant. With its global warming potential (GWP) of 1, CO₂ is climate neutral and for just that reason it

offers users long-term planning security. After all with this refrigerant it is easy to meet long-term legal requirements such as the F-gas Regulation and the

Ecodesign Directive. Users can't use CO₂ more efficiently, more safely or more easily than with ECOLINE+."

One of the most important innovations in the ECOLINE+ series is the enhanced line start permanent magnet motor, which increases annual performance figures by more than 10 per cent. These motors can be directly connected to 50 or 60 Hz electrical supplies and, whether for full- and part-load, they offer a completely new level of efficiency. Apart from that, permanent magnet motors are extremely robust and easy to use. Over the past five years, BITZER has tested this technology and has used them in selected systems in the field. Since October 2016 LSPM units have been used in production for CO₂ applications. ■



Trane Ranked Most Trusted HVAC System

For the second consecutive year, Trane, a brand of Ingersoll Rand, has been named America's Most Trusted Heating, Ventilation, & Air Conditioning (HVAC) System by Lifestory Research. The study, based on 17,878 national consumer opinions, tracks how trust impacts consumers' evaluations of HVAC brands. Trane received an index score of 109.9 with the next best scores coming in at 102 or less.

"Trust is the new measure by which consumers evaluate brands and companies," said Eric Snider, Ph.D., president and chief research

officer, Lifestory Research. "Our consumer research finds that people buy new products that they trust. When people trust a brand like Trane, it provides them with the confidence in making a purchase decision." ■



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Ritchie Engineering Opens Office in The Netherlands

Ritchie Engineering Company, Inc., the leading manufacturer of Yellow Jacket products for HVAC&R professionals, is opening a new European office in Amsterdam, Netherlands. To support this new office, Ritchie Engineering has hired Marc Schumacher as its European Sales and Business Development Manager.



Schumacher will develop and support Ritchie Engineering's growing business in the Benelux (Belgium, Netherlands, and Luxembourg) and western German regions. He has an extensive background in refrigeration and refrigerants, having developed a successful refrigerant business in Germany and the Netherlands over the past nine years. Most recently, Schumacher sold industrial refrigeration systems in the meat, fish and soft fruit sectors. The opening of this new location in the Netherlands will allow Ritchie Engineering to expand its European sales operation, and in the wake of Brexit, the new office will serve as base for accessing the European Union market.

The Yellow Jacket brand name is synonymous with the highest quality and most complete line of HVAC/R tools in the industry. The brand's roots go back to 1946 when Ritchie Engineering Company, a manufacturers' representative organization, became a hose manufacturer. ■

AFPRO Filters Joins Eurovent Middle East

AFPRO Filters shares the vision of EUROVENT Middle East that high quality air filtration is key for the Middle East region. Therefore, we are proud to join the Eurovent Middle East as their newest member. AFPRO Filters stands out in the world of air filtration as it manufactures its own glass fibre filter media for a maximum Particulate Matter (PM1) / Fine dust protection according to the latest global ISO16890 standard.

Joost Verlaan, Vice President at AFPRO Filters says, "The partnership we have with Eurovent is a very strategic one for us and with this new membership with Eurovent Middle East we strengthen that relationship.

For us the Middle East region offers a huge growth opportunity that gets enforced by this partnership. We are excited to be

on board with Eurovent Middle East!"

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Besides the energy saving air filters and high quality products, AFPRO Filters stands out because of its excellent logistics and high quality service. AFPRO Filters also produces highly specialized customized work that meets the specific wishes of our valued customers. ■

Maersk Invests in Carrier's Natural Refrigerant Container Units

Striving to further reduce the environmental impact of its global shipping operations, Maersk Line, the world's largest container shipping line, has ordered the first 100 of a total of 200 refrigerated containers to be chilled by Carrier Transicold's NaturaLINE natural-refrigerant based system. Carrier Transicold is a part of UTC Climate, Controls & Security.

Carrier Transicold's highly efficient NaturaLINE is the first container refrigeration system to use the natural refrigerant carbon dioxide (CO2), which is a safe and non-ozone depleting gas with a global warming potential (GWP) of one. There is no additional global warming impact resulting from any potential refrigerant leaks, as is the case with traditional systems, since the NaturaLINE unit uses carbon dioxide repurposed from outdoor air. It is also unaffected by phase downs of hydrofluorocarbon (HFC) refrigerants and is relatively inexpensive. It is classified as A1 for low toxicity and no flame propagation. "To meet our sustainability goals and stay ahead of the new EU legislation, Maersk Line is keen to

carefully evaluate all alternatives to the current synthetic refrigerants," says Ingrid Uppelschoten-Snelderwaard, Head of Global Equipment, Maersk Line. "The



NaturaLINE system is an advanced technology with interesting potential for reefers. We chose it after laboratory testing of the unit's performance with perishable and frozen commodities and look forward to gaining further operational experience with the system. We are pleased that Maersk Line sees potential in the NaturaLINE unit to help it achieve its ambitious sustainability goals," says David Appel, President, Carrier Transicold & Refrigeration Systems. "Carrier shares Maersk Line's goals of improving the efficiency and sustainability of global container shipping, which protects the world's perishable food supply and other goods as they move through the cold chain to the consumer," he added. ■

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Emerson Opens Manufacturing Center in Singapore

With the goal of spurring innovation to address customers' engineering design challenges and accelerating speed to market for new, rigorously-tested products, Emerson opened an advanced additive manufacturing center at its Singapore campus. This is Emerson's second location to have additive manufacturing capabilities (making 3D objects from a digital model).

Additive manufacturing enables Emerson engineers to expand their thinking beyond the limits of standard manufacturing processes to develop cutting edge solutions to meet more demanding and stringent processes. Additive manufacturing also significantly accelerates the testing of multiple versions of a prototype product or part, and promises to greatly simplify the production supply chain. Through this center, Emerson will be using additive manufacturing technologies to produce special customized and application-specific parts and products which are impossible with traditional technology.

The Singapore center serves to strengthen Emerson's additive manufacturing program. Together, the Marshalltown and Singapore centers are actively working on research and development and pilot production services for all Emerson businesses around the world.

Singapore was selected for this additive manufacturing center because of its strong manufacturing ecosystem, favorable business climate, excellent transportation linkages, an educated workforce and good universities, and robust intellectual property protections. "This Singapore center, along with our Marshalltown center, will play a key role in helping Emerson move quickly to leverage the benefits of additive manufacturing to meet our customers' needs in Asia Pacific and around the world," said David Farr, chairman and CEO of Emerson. ■

P Ravichandran Elected as Chairman, CII Tamil Nadu

Danfoss Industries President P Ravichandran was elected as the Chairman, Confederation of Indian Industry, Tamil Nadu State council for the period 2017-18. Prior taking up the new role,

Ravichandran was the Vice-Chairman for the period 2016-17, a press release said.

Ravichandran also serves CII National



Council on Agriculture as its Member. Similarly, the Chairman and Managing Director of Chennai-based Pon Pure Chemical Ltd M Ponnuswami was elected as the Vice-Chairman, CII Tamil Nadu State Council.

Ponnuswami an active member of CII, was serving CII-Chennai Zone as its Chairman in 2016-17, it added. ■

NewCold Expands into Australia

NewCold Advanced Cold Logistics, which opened its first UK automated frozen food coldstore in 2015, is now building two new warehouses in Australia – including a chilled one for the first time. One of the sites in Truganina, near Melbourne, for frozen goods, will store products for new customer, McCain Foods, Australia along with Peters Ice Cream Australia, part of the Froneri group.

The 10-year deal, starting in July this year, is part of the food group's "ongoing effort to improve supply chain efficiencies to help customers meet consumer demands." The site, being built by storage equipment manufacturer Dematic, will consist of an integrated system combining automated pallet handling systems using in-house warehouse and control software developed in-house by NewCold. "The storage and handling of McCain's frozen products in the new automated facility will give us a more stable temperature regime and highly accurate stock control," said McCain Foods ANZ Supply Chain Director Taso Kourou.

The other site, also based in Truganina, will handle chilled and ambient product for dairy company Fonterra Australia which is consolidating its distribution network and six warehouses into the one facility. Opening in July, the 12-storey site will be capable of holding upto 1,10,000 pallets.

Fonterra Australia Managing Director, René Dedoncker, said: "The first of its kind in Australia, the facility is highly automated and, because of its technology, we can be more agile and responsive to our customers' needs, deliver smaller and more frequent orders and importantly, improve our service delivery." NewCold is able to handle major automated cold store projects worldwide having built up



experience in Europe where it now has sites in France, Germany and Poland as well as the highly automated, 40m high cold storage plant in Wakefield, UK. The phase one of the Wakefield warehouse had been completed and phase 2 – to expand the site – will take place next year. Jon Miles, NewCold UK's Country Manager, said: "We have years and years of experience in automation and that gives us the edge over someone who is building an automated warehouse for the first time." The new venture in Australia underlines the fact that NewCold is a "truly international temperature-controlled business", adds Miles. ■



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Les Simmons Joins Precision In Dubai

Precision has appointed Les Simmons as Managing Director of the company's Middle East sales office in Dubai. Les is one of the catering equipment industry's best known faces, having worked with some of its top refrigeration brands, including Scotsman and Hoshizaki, for over thirty years. Most recently he has represented Gram Hoshizaki in the Middle East. He retired in December 2016 – and decided it wasn't for him. "I still have fire in my belly," he says. He soon found he had several job offers, but Precision was the one that appealed most. "I met Nick Williams (Precision's Managing Director) about four years ago and we clicked. Of course his father Mike is a legend in the industry. What I like about Precision is the positive attitude



Les Simmons

throughout the organisation, the quality of the equipment, the impressive R&D, and the fact that they really listen to their customers. It's my type of company."

Nick Williams is delighted to welcome Simmons to the Precision family. "Our brand is still relatively new to the Middle Eastern market," he says. "However, we've made great inroads over the past couple of years, supplying equipment to some of the region's leading hotels, restaurants and fine dining establishments." Les has vast experience and knowledge of the Middle East market and we plan to build on this foundation to establish Precision as the "go to" company for quality refrigeration in the region. ■

BESA Appoints New Head of Wales

The Building Engineering Services Association (BESA) has appointed Cat Griffith-Williams as its new head of Wales following the retirement of Andrew Marchant. Cat joins from the communications agency Grayling, where she was responsible for its overall strategy in Wales and charged with enhancing the agency's offer to existing and new clients. She oversaw public affairs, strategic partnerships and stakeholder relations; helping organisations such as BT, the European Commission and the Landscape Institute in Wales maximise their communications potential. "I am looking forward very much to working with BESA members in Wales," she said. "Our local presence allows us to respond to the specific needs of the building



Cat Griffith-Williams

engineering sector here while also taking advantage of a national network that offers extensive technical and legal expertise." She said there was a huge amount of current business activity in Wales directly relevant to the work of BESA members and significant policy developments around training and apprenticeships that could be exploited to the benefit of members' businesses. "This is a key appointment for the Association," said BESA membership director Wayne Terry. "We have had a very strong local presence in Wales for many years and Cat is just the sort of person we were looking for to take our technical and policy agendas." Cat was previously deputy director and head of external affairs at the Campaign for the Protection of Rural Wales. ■

Kim Fausing Becomes New CEO of Danfoss

After nine years as the CEO of Danfoss, with impressive financial results, a high performing organization, increasing growth and a digital transformation on track, CEO Niels B Christiansen has decided to leave Danfoss. COO Kim Fausing, who has worked closely together with Niels B Christiansen in the Executive Committee, will become the new CEO. Chairman of the Board, Jørgen Mads Clausen praises Niels B. Christiansen's significant importance to Danfoss.



Niels B Christiansen (left) will be replaced by Kim Fausing (right)

financial figures are pointing in the right direction, the business is growing, and the organization is in great shape. I find it only natural that a CEO after 12 years at the helm would want new challenges and on behalf of the Board of Directors and myself, I would like to thank Niels for his outstanding leadership of Danfoss. At the same time, I am very pleased that we have such a highly competent successor

in Kim Fausing, who for the past nine years has also played an important part in driving the positive development of Danfoss," says Jørgen Mads Clausen. Niels B Christiansen says goodbye with pride in the results created during his time in Danfoss. ■

"Niels' mission in Danfoss is completed with honors. All



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Artus Hybrid Fan Coil Unit Winner at Ecobuild & M&S Big Innovation Pitch 2017

Airedale International Air Conditioning, in partnership with ARUP consultancy, was selected as joint winners at the Ecobuild and Marks & Spencer (M&S) - Big Innovation Pitch finals for their new product Artus, Hybrid Fan Coil Unit (FCU) recently. The Big Innovation Pitch, now in its third year, stems from M&S' Plan A commitment, which aims to help protect the planet with responsible sourcing, reduced waste and community support. It is an initiative designed to identify innovations across the sustainable design, construction and energy sectors.

Airedale and Arup vied for the accolade alongside four other retail engineering innovations ranging from heating and cooling systems to simulation software. From a shortlist of five finalists, the panel chose a joint entry from Airedale and Arup, and a second from Protomax Plastics.

Commenting on the decision to choose two winners, Imogen Cust, Engineering R&D Manager for Property, Development and Facilities Management at M&S, said, "The standard of entries was brilliant this year - so good we had to choose two. The winners stood out because they have used their industry knowledge and their passion to solve real life M&S challenges in two very different fields."

Commenting on behalf of the Arup and Airedale entry,



Roger Olsen, Associate Director at Arup, said, "We're so pleased that we've been chosen as a winner. Our solution could be used in many building sectors to make air conditioning much more energy efficient." Tony Cole, Managing Director, Airedale remarked, "To win such a coveted award and receive recognition from an international, multi-channel retailer such as Marks and Spencer, shows great potential for the Artus™ Hybrid Fan Coil Unit. Working in partnership with Arup to bring Artus™ to market in Summer 2017 is an exciting time for everyone involved and this is just the start." Airedale and Arup's winning product, the Artus™ Hybrid Fan Coil Unit, offers a fully-packaged, plug-and-play, single-supplier system and a host of benefits. These include self-access, reduced ceiling clutter and minimised ceiling void heights. As the unit is fully-packaged, there is no need for the specification of ancillary controls, valves, diffusers or spigots. ■

Former ASHRAE President Thomas Watson Awarded J&E Hall Gold Medal

Thomas Watson, a former ASHRAE president and retired chief engineer at Daikin Applied, recently received the Institute of Refrigeration's (IOR) J&E Hall Gold Medal Award for his ground-breaking work to improve the efficiency of chillers and industrial heat pumps. Watson's work included the introduction of large capacity oil-free magnetic bearing compressors and the first centrifugal chiller with zero-ozone depleting potential. He is currently working on the safe application of low GWP flammable refrigerants. "It was certainly surprising and overwhelming when I learned I would be receiving the award," said Watson.

"Everything you do requires dependence on those around you from your co-workers and your family to supervisors and the people that work for you. This honor is not just for me. To be singled out is of course a tremendous privilege, and sometimes I don't feel totally deserving because of all the



Thomas Watson

things people have done before that I have built on."

The J&E Gold Medal Award is one of the industry's most prestigious honors and recognizes the most noteworthy practical contributions in the field of refrigeration. Watson was presented with the gold medal and a check for £5,000 by IOR president Steve Gill at the IOR annual dinner in London in February.

"Thomas Watson has long been an icon within ASHRAE," said ASHRAE President Tim Wentz. One of Watson's major contributions

was the development of the Templifier industrial heat pump. He was the lead engineer on the project and worked with the Westinghouse Electric Research and Development Center on this innovative technology. The pump provides high-temperature hot water recovered from numerous sources such as heat normally rejected by cooling towers and condensers for process cooling. ■

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Cold Chain Industry in India

-- The Way Forward

The cold chain business all round is expected to grow at a CAGR of around 28% and to touch a market size of around Rs 750 billion in the current year. As a business opportunity therefore, this sector presents immense prospects for existing players to cash on the emerging opportunities as well as new entrepreneurs to develop new solutions...

India is one of the largest producers of agricultural products and one of the global leaders in the pharmaceutical sector. In spite of this, the country still has a fledgling cold chain, which results in supply chain losses of food and other resources. These losses have been stated to be as high as USD 8 to 15 billion per annum from the agriculture sector alone. According to industry estimates, approximately 104 million metric tons of perishable produce is transported in India between cities each year. About 100 million metric tons moves via non-refrigerated (referred to as reefer) mode and only four million metric tons is

transported by reefer. Even though, India has about 250 reefer transport operators (mostly small & non-integrated firms) who transport perishable products and less than 30,000 refrigerated vehicles currently ply in India. It has been observed that majority of the refrigerated vehicles (80%) are utilized for milk and milk products transportation. It is very clear that the high cost of transportation is a major challenge for refrigerated vehicles market. In India, at present, only 3.5% of perishable goods are transported in reefer trucks. As compared to this, the comparable figures are 75% for China and 85% in the US.

The cold chain business all round is

expected to grow at a CAGR of around 28% and to touch a market size of around Rs 750 billion in the current year. As a business opportunity therefore, this sector presents immense prospects for existing players to cash on the emerging opportunities as well as new entrepreneurs to develop new solutions.

While there are no two opinions on the need for developing a cold chain, the actual design of the cold chain depends on a number of specific factors viz, location, temperature, logistics infrastructure, warehousing etc. Fresh foods, like fruits, vegetables, meat, poultry and dairy, require an uninterrupted cold chain due to their perishable nature. By controlling parameters of temperature, humidity and atmospheric composition, along with utilizing proper handling procedures, cold chain service providers can increase the product life of fresh foods for days, weeks or even months. These services allow fresh products to hold their value longer, increasing their transportability and providing opportunities that expand their market reach.



Temperature requirements – indicative

Recommended temperature (degrees Centigrade)	Food product
> 18	<ul style="list-style-type: none"> • Processed foods (pickled, dried, cooked) • Cooking oils • Onions
10-18	<ul style="list-style-type: none"> • Sub-Tropical Fruits and Seeds Chocolate
0-10	<ul style="list-style-type: none"> • Fresh Fruits and Vegetables • Milk and Dairy Products • Flowers • Eggs
< 0	<ul style="list-style-type: none"> • Meat • Fish • Poultry • Frozen fruits and vegetables Ice Cream

Therefore, ideally, the cold chain for agricultural products should begin at the farm. In a modern cold chain, the produce at the harvest location is loaded onto a truck or other transportation unit designed to keep the produce protected from the sun and held within a desirable temperature range, as it travels to a processor facility or a temperature controlled warehouse. In less developed locations, transportation may be carried out on covered trucks or smaller carts; in more developed locations, these transportation solutions can include insulated reefer trucks. The exact structure of each cold chain varies significantly depending on product and customer requirements; however, the underlying objective of an efficient cold chain system is to safely transport temperature-sensitive products in such a way that it minimises wastage, maintains the quality and characteristics of the product and limits external or internal contamination. A complete cold chain system may include post-harvest pre-cooling or freezing, processing, temperature controlled warehouse or storage, retail or distribution and refrigerated transport between locations.

Parameters

As mentioned above, requirements for cold chain facilities vary based on the size, type and amount of product, along with the particular requirements of the customer. Fruits and vegetables often require cool facilities and are stored around 55°F. Most dairy products require temperatures just above freezing around 35°F. Meat and

poultry products are typically stored just below freezing at approximately 28°F. Ice cream and other frozen products may require deep freezing at temperatures that can range from -10°F to -150°F.

Key Challenges

The cold chain sector does face a number of challenges. If the need of the hour is to cut down on wastages of precious perishable products and ensure efficiencies in distribution, it is imperative to have an undisrupted, seamless and smooth functioning supply chain as the backbone. Today, the major challenges are typically both micro level (at the operational level) as well as macro level (policy level).

- India's supply chain today is still highly fragmented and there are numerous small time transport operators without the proper infrastructure for efficient logistics. A low level of organized 3PL sector means that as much as 75 percent of truck owners have a fleet of less than 5 vehicles. Most of these trucks are more poorly maintained and are more than a decade old.
- State-of-the-art cold chain infrastructure calls for capital investment which only the organised players and pan-India operators are presently willing to commit. At present, organised players contribute only around 8%–10% of the cold chain sector
- Sixty percent of freight moves on a road network with less than 5 percent

of those roads national highways.

- Experts have estimated that India has less than half the cold chain capacity necessary to meet its current needs and will require as much as USD 100 billion of infrastructure investment in the coming years
- Lack of good roads and highways and poor infrastructure, particularly in rural areas
- Awareness, knowledge dissemination and training are important for the correct handling of cold chain products – to maintain the quality and as well ensure economy of operations. The customers and operators should know that reefer is meant to maintain the product temperature within a range by taking away the incremental heat gain and not cool it down. This means pre-cooling is essential for the products getting loaded and also loading and unloading have to be done in the correct sequence to minimise the heat gain during the operations.

Addressing the Challenges

The importance of developing a robust cold chain has caught the attention of the policy makers. Industry too has always been upfront in investing and innovating in solutions that lead to lesser wastage, shortening the supply chain delivery period and value addition to the product. At the policy level, the government has taken initiatives in setting up cold storages and distribution centres. The Government of India is one of the driving forces in developing the cold-chain industry and supports private participation through various subsidy schemes and grants. Investment in cold-chain in India was also opened under the automatic route for 100% FDI participation.

Cold-chain is promoted by Ministry of Agriculture and Farmers Welfare as a thrust area to empower producers through modern logistics. Cold-chain is also supported by Ministry of Food Processing Industries to support the needs of food manufacturing projects as well as farmer producers. The National Centre for Cold-chain Development (NCCD) has been set



Refrigerated Warehouse Capacity Growth by Country	CAGR 2008-2014 (Percent)
India	43
China	35
Mexico	27
Brazil	26
USA	9

Source: Global Cold Chain Alliance

- Service Tax exemptions on construction, erection, commissioning or installation of post-harvest storage infrastructure or cold storages
- Excise duty reduced from 12.5 % to 6% on refrigerated containers
- Basic Custom Duty reduced on refrigerated containers from 10% to 5%

up by the Ministry of Agriculture with the overall mandate of promoting the cold chain sector in India.

There has been significant growth in the cold storage capacity in India and as per the Global Cold Chain Alliance figures, India had a total cold storage capacity of 131 million cubic meters in 2016. In terms of incremental growth of refrigerated warehouse capacity also, India has demonstrated a very high growth as compared to other countries.

Policy Initiatives

Food and agro-based processing unit and cold chain infrastructure have been classified under agriculture activities for Priority Sector Lending. This has led to availability of additional credit for food processing activities and development of infrastructure.

Cold-chain, is a modern agri-logistics service, and provides a safe mode to transfer value from producer to consumer. Strictly speaking, there is no value addition

to the produce in the cold chain and the various activities undertaken – preconditioning the produce for travel, the transport, buffer storage and retail – the cold-chain merely manages or safeguards the value in its custody in its passage to markets. This fact is recognised by the Finance Ministry and under the Finance Act, there is no value added tax or service tax on activities for handling, transporting, storage and marketing of agricultural produce. This is a big relief in terms of tax exemption to the cold chain operators as this facility was only available to the farmers at farm gate but not to the cold chain operators. This enhanced the viability of cold chain projects, encouraging more investment in the sector.

Following are the specific fiscal incentives given to the cold chain sector by the government:

- 100 % Income Tax Deductions on capital expenditure for cold chain or warehouse.

Growth Drivers

Just as the need for an efficient cold chain logistics sector cannot be overemphasised, the drivers to its growth are clearly visible.

- Growth of retail market in India and the entry of multinational retail giants will be a major driving force
- Increasing production of horticultural products that require cold storage facilities
- The growing demand for processed foods as a result of higher disposable incomes would lead to a requirement of robust cold chain distribution system
- Establishment of new and modern cold storage facility will necessarily push up demand for refrigerated vehicles ■

Sateesh Kulkarni
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Renewable Heat Incentive

The Renewable Heat Incentive (RHI) is the UK Government scheme set up to encourage uptake of renewable heat technologies among householders, communities and businesses through the provision of financial incentives...



With a target for 12% of heating to be supplied by renewable sources by 2020 UK Government believes introduction of RHI will strongly aid in achieving this target.

RHI domestic scheme supports air to water heat pumps; biomass only boilers and biomass pellet stoves with back boilers; ground and water source heat pumps; micro-CHP; flat plate and evacuated tube solar thermal panels. The scheme follows extensive consultation on how a financial incentive would work best for householders and takes into account lessons learned from the Renewable Heat Premium Payment grant scheme (RHPP) and the RHI non domestic scheme.

The Renewable Heat Premium Payment was a one-off grant designed to help towards meeting the costs of installing renewable technologies in your home. The grant ran until March 2014 when the Renewable Heat Incentive (RHI) was introduced for domestic customers.

After an exhaustive consultation, the government announced an increase of tariff rate of over 33% for installing ASHP starting in spring 2017. Those who apply

for the RHI after December 14th 2016, will be eligible for the current tariff rate and then for the increased tariff rate from the day it comes into force – subject to parliamentary approval.

Aquarea A2W Heat Pumps

Panasonic's Aquarea range of air to water heat pumps are market leaders in performance. Already proving extremely popular with homeowners, specifiers and contractors, the Aquarea range offers a heating and hot water solution with maximum energy efficiency, reliability and ease of use. With the RHI payments now based on the efficiency and performance of the heat pump, there is more of a reason to choose Panasonic and enjoy the full benefits it can provide. Aquarea is the most comprehensive, versatile and cost-effective range of air-to-water heat pumps on the market. It features heat pumps from 3 to 16 kW, single and three-phase alongside Monobloc, Split-Units & All In One units. Panasonic Aquarea heat pumps can be installed as hybrid units connected to boilers if required, cooling can be provided from Panasonic Aquarea heat

pumps. Air source heat pumps will have a payment cap for all application's once the new dRHI is in place, this capped figure will be the deemed gross figure from the EPC for the property.

The gross figure will be divided by the SCoP figure for the unit installed to confirm the renewable energy generated.

Example: 20,000kWh (deemed gross heat energy required from EPC for property)
4.33 SCoP (Panasonic WH-SDC09H3E5)
 $20,000 / 4.33 = 4,619$ kWh electric used to generate 20,000kWh heat.
 $20,000 - 4,619 = 15,381$ kWh renewable energy from heat pump.

$15,381 \times 10.01p$ (dRHI tariff rate) =
£1,539.64 (first year payment)

Tariff Payments

Payments are made on a quarterly basis for seven years. In most cases, payments are made based on an EPC stating the heat demand of the property. To further understand and drive improvements in the market, MMSP have been restructured. 50% of the payment (£805) will now be made upfront in first year RHI payment with the outstanding 50% over the remaining 6 year period. In addition, the reforms will also reduce the frequency with which metered data should be uploaded from weekly to monthly.

When the heat pump is installed in to a second home or alongside another energy system then an electric and heat metering package has to be installed, payments will be based on the actual system performance but capped to either a the total stated on EPC or 20,000kWh of energy; whichever is lower. Electrical metering is fitted on all installs as a minimum requirement to confirm running cost of system for end user. ■

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BITZER UK and G&O Refrigeration win ACR Project of the Year

Compressor specialist's BITZER British subsidiary BITZER UK and the company G&O Refrigeration were honoured with this year's National ACR and Heat Pump Award in the category "ACR Project of the Year". They won the award for a series of ice rink projects that have delivered dramatic energy savings for end users.



(From left to right): Paul Smith (Business Manager, Retail Support Team at Dean & Wood), James Ogden (Director of G&O Refrigeration), Kevin Glass (Managing Director of BITZER UK) and Justin Moorhouse (Guest Comedian) at the presentation of the „Project of the Year Award 2017“

The companies were presented with the prestigious Refrigeration Project of the Year Award in the National ACR Awards, staged in front of an audience of several hundred leading industry lights at a gala event in Birmingham Town Hall. The judges described the projects as a first for the industry, and the choice of compressors as "a pioneering decision for contractor G&O Refrigeration". It was the first time BITZER's CSV semi-hermetic screw compressors with integrated frequency inverter had been used in ice rink applications.

Reliable cooling and efficiency

Working with BITZER UK, G&O Refrigeration developed a new rink refrigeration plant called "Gorac chiller pack". Based on BITZER CSV compact screw compressors with integrated frequency inverter, it is designed to deliver exceptionally reliable cooling and significantly reduced energy costs. This is a major aspect since the energy required to form and maintain an ice pad is one of the most important elements in rink running costs. Reliability and efficiency

are absolutely vital for ice rinks. This was the reason the company selected BITZER CSV compressors to form the heart of its new approach to compressor pack design for rinks. Kevin Glass, Managing Director of BITZER UK, praises the excellent collaborative relationship: "We worked closely with G&O Refrigeration throughout to ensure they had the support and technical back-up they needed. The initiative has been an unqualified success, and is based on a willingness to innovate and move beyond established ways of doing things."

The CSV is a fairly recent addition to the BITZER range, and is a very efficient, robust and reliable compact screw compressor. The key to its efficiency is an integral inverter which precisely controls the speed of the motor in line with cooling demand. In addition to a built-in frequency inverter, the compressor has on-board

protection and monitoring sensors, magnetic valves for regulation and liquid injection, all in one pre-wired package.

Cooling energy costs more than halved

The compressors operate on R134a, which is normally associated with medium temperature applications, such as commercial air conditioning. However, the performance envelope is surprisingly wide, and the company was attracted by the fact they can evaporate down to -17°C , at a suction pressure of 0,5 bar.

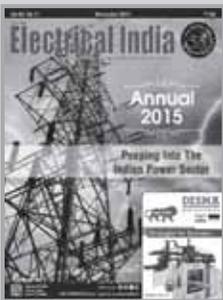
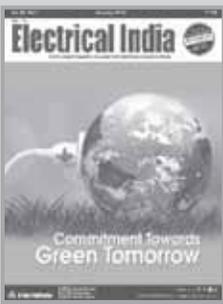
A pack replacement project at Milton Keynes rink carried out by G&O Refrigeration has more than halved cooling energy costs. The electricity bill with the previous system was £11.000 a month. Following replacement with the Gorac/BITZER system, costs have fallen to in between £4.000-£5.000 a month. Subsequent projects have confirmed average savings of between



A BITZER CSV screw compressor in the plant room of Milton Keynes

45-50 percent.

Following its success, G&O Refrigeration has now produced 10 Gorac packs for use in rinks across the UK. In addition to Milton Keynes, they have been installed at rinks in Hemel Hempstead, Swindon and Cardiff. This latter project is the largest to date, with two ice pads on site. The company is now attracting the attention of overseas ice rink operators, and is involved in supporting projects taking place in mainland Europe. ■



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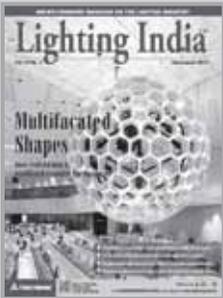
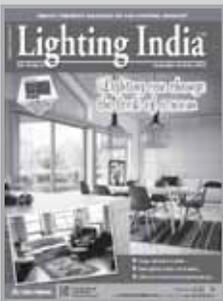
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- Lighting and Lighting Components
- Safety Devices
- Nuclear Energy
- Capacitors and Condensers
- HVAC
- Circuit Breakers & Relays
- Cables, Contractors and Accessories
- UPS

... and related accessories.

Professional Readers - EI

Industries:

- Manufacturers of Electrical/Electronic Goods
- Power Generation
- Fertilizers, Chemicals and Petrochemicals
- Oil and Gas
- Paper and Pulp
- Independent Power Producers
- Military / Defence
- Textile
- Drugs and Pharmaceuticals
- Sugar
- Construction & Packaging Industry
- Renewable Energy & SEB's
- Govt. and Semi-Govt. Bodies
- Institutions

Professionals:

- Engineers & Policy Makers
- Corporate Management
- Distributors, Traders, Contractors and Suppliers
- Wholesalers, Agents, Retailers
- Advisors / Consultants
- Purchase Managers & Diplomats
- Entrepreneurs & Investors
- Technical Management and Education / Research Training
- Architects

Several Others...

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Who can Subscribe?

Industries:

- Shopping Plazas, Cinema Halls and Theatres
- Entertainment Industry: eg. Hotels, Restaurants, Gymnasium & Malls
- Stage & Studio Lighting
- Automobile Industry
- Manufacturers
 - Lighting
 - Neon Lamp
 - Pole
 - Decorative Luminaire
 - Glass & Glass Furnace
 - Machine
 - LED
 - Switch & switchgear
 - Electric Measuring Instrument
- Suppliers
 - Chemical
 - Starter
 - Lighting Products
 - Brass Component
 - Plastic Component
 - Gas
 - Cable Wire
 - Lamp Component
 - Electric Component
 - Steel Component
- Research & Testing Laboratories
- Electronics in Lighting
- Furnace Refractories

... and related accessories.

Professional Readers - LI

Industries:

- Top Industrialists & Manufacturers
- Lighting Engineers & Designers
- Architects & Interior Designers
- Event Managers
- Consultants, Contractors & Traders, Project Managers
- Plant Engineers of Large Companies
- Builders & Developers
- Mechanical & Electrical Engineers
- Lighting Products Manufacturers, Suppliers & Distributors
- Entertainment Industry
- Construction Industry
- Hotels & Restaurants
- Fitness Centers
- Hospitals
- Airports Authority of India
- Importers & Exporters
- Municipal Corporations All Over India
- Government Utilities:
 - Ministry of Power
 - Electricity Utilities
 - Central Public Works Department
- Non-conventional energy providers
- Manufacturers from other allied industries
- Universities, Technical & Research Institutions

Several Others...

Draft on Food Processing Policy

Harsimrat Kaur Badal, Minister of Food Processing Industries unveils the Draft Food Processing Policy of India and shares the same with state government representatives...



Addressing a meeting with the State Food processing Ministers on World Food India, being organized by MoFPI during 3 – 5 November 2017, in New Delhi, Harsimrat Kaur Badal, Minister of Food Processing Industries unveiled the Draft Food Processing Policy of India and shared the same with state government representatives. The Minister said the National Policy apart from documenting footprints of the food processing sector has drafted considering best practices across states and the world. She said our government is poised to bring about comprehensive National Policy on food processing. We would like all states to follow and be part of the comprehensive National Food Processing Policy. We have brought an Approach Paper on the National Food Processing Policy which is uploaded on the website of Ministry and have invited suggestions from all stakeholders and general public.

Speaking at the session, Badal said India provides most conducive environment to food processing given parameters and conditions like abundance of food production, abundance of manpower

engaged in agriculture and low cost of processing. At the same time Government's initiative to make India Global Food Factory and Global Food Market brings immense opportunities for food processing sector. The Minister said India is ushering in an era of Zero Tolerance towards Post Harvest Wastage, Zero Tolerance on Delays in Commissioning of Food Processing Projects, Zero Tolerance in Delays in obtaining Licenses or Statutory Clearances for Food Processing or Food Retail Markets by Central or State or Local authority. She said, "We are bringing in National Food Processing Policy which shall focus on building India's National Food Grid and National Cold Chain Grid and create Retail Markets every nook and corner of the country. Badal said the government has introduced reforms like allowing 100% FDI in Multi Brand Retail. Additionally, Government has taken several initiatives and announced attractive incentives including capital subsidies, tax rebates, and reduced custom and excise duties.

Increasing focus is also being given to supply-chain related infrastructure, such as cold chains, abattoirs and food parks.

The whole idea is to spur greater growth in the food processing sector as well as connect farmers with the value chain to increase their returns. It is with this objective that the event 'World Food India' has been conceptualized to provide a platform to showcase India's strengths in the sector and to attract major investments in the sector. She said Government is organizing Biggest Ever Global Food Fair - World Food India 2017 – where all small, big and multi-national companies from world over would represent and meet Indian potential companies to partner with. At the same time we expect all state governments and their departments to allow single window clearances and other statutory clearances. Apart from this, all our raw produce and processed food shall be showcased. The Minister added that World Food India 2017 is the step aimed at creating India a Global Food Factory and Global Food Retail Market.

Badal, further shared that the Ministry of Food Processing Industries (MoFPI) was in the process of collating and addressing issues related to the sector, with an aim to facilitate investors and help build investors confidence to boost engagement of foreign investors, at the World Food India, later this year. It may be noted that World Food India 2017 - a three day flagship event is being organized by Ministry of Food Processing Industries in which CII will be event partner from 3-5 Nov 2017 at New Delhi. The event will focus on showcasing achievements and opportunities of the Indian Food Processing Sector and fostering maximum investment commitments. The event will also provide a platform for exhibiting innovative products and manufacturing processes showcasing the entire value chain of food processing industry with a vision to leverage innovation, technology, development & sustainability in the backdrop of achieving food security. ■

Chilling of Food

Chilling is one of the most common methods for preserving foods. Carried out correctly, it can provide a high-quality, nutritious and safe product for consumption with a long storage life. The principal factor controlling the safety and quality of a refrigerated (chilled) food is its temperature. In many cases, the time taken to reach the desired temperature is also important...

World agriculture faces a daunting array of apparently contradictory challenges. The sector must massively increase output by the middle of the century to reduce hunger and satisfy the demand of a global population that is predicted to swell to over 9 billion. At the same time farmers need to slash carbon emissions, which currently account for 30% of the global total, if countries have a

hope of complying with their Paris Climate Change Agreement obligations.

Until now, governments and companies alike have largely focused upon increasing the amount of food we grow, increasing intensity, boosting yields and investing in bio-technology. However, one approach that would help to achieve all goals simultaneously is simply to reduce the amount of food that is wasted. The

statistics are shocking. According to estimates from the UN Food and Agriculture Organization, 800 million people live in hunger. At the same time, up to a third of all the food produced worldwide, more than a billion tonnes, is wasted every year. One study has indicated that if we could only halve food wastage, then we could feed another one billion people without needing to plant any more crops, catch any more fish or feed any more animals.

“The amount of food wasted and lost globally is shameful”, says World Bank President Jim Yong Kim. “Millions of people around the world go to bed hungry every night and yet millions of tons of food end up in trash cans or spoiled on the way to market. We have to tackle this problem in every country in order to improve food security and to end poverty.”

Food wastage also has enormous



implications for the sustainability of agriculture and its carbon footprint. The FAO estimates that to grow the same amount of food that we currently waste would require a land area the size of Mexico; it would consume 250 km³ of water per year, which is three times the volume of Lake Geneva; and it would account for 3.3 billion tonnes of CO₂ emissions, making it the third largest carbon emitter after the US and China. So, any effort to reduce food wastage will not only help to reduce hunger but also improve resource efficiency and help to tackle climate change.

Food is wasted at all stages of the supply chain, from the farm gate to the back of our fridge. The balance of these losses varies by crop and region, but across the world the greatest proportion of food is lost between farm and retailer.

Addressing this challenge will require a multi-faceted approach. Like all thorny issues, there can be no quick fix. However, in order to ensure that more of the food we grow gets to be eaten, keeping it cool from the point where it is harvested to the shops can play an enormously beneficial role. In the most simplistic sense, this means introducing more refrigeration to the way we harvest, store, transport and retail food in order to extend shelf life.

However, conventional ‘cold chains’ of refrigerated warehouses and vehicles can be carbon intensive, highly polluting and damaging to human health. The task of developing and deploying innovative clean cooling technologies is, therefore, absolutely central to the future of civilization.

Two thirds of the world’s food wastage happens in Asia and Africa, and these are also the regions where cold chain capacity is often rudimentary or non-existent. The International Institute of Refrigeration has estimated that if developing countries had same level of cold chain as developed nations, they could save 200 million tonnes of perishable food each year.

Reducing wastage by building cold chains in developing countries would not only increase the food supply, but also help tackle poverty. Food prices can be reduced for consumers, because if

markets are better supplied, prices fall, and farmers’ incomes increase, because more of what they produce can be sold rather than discarded.

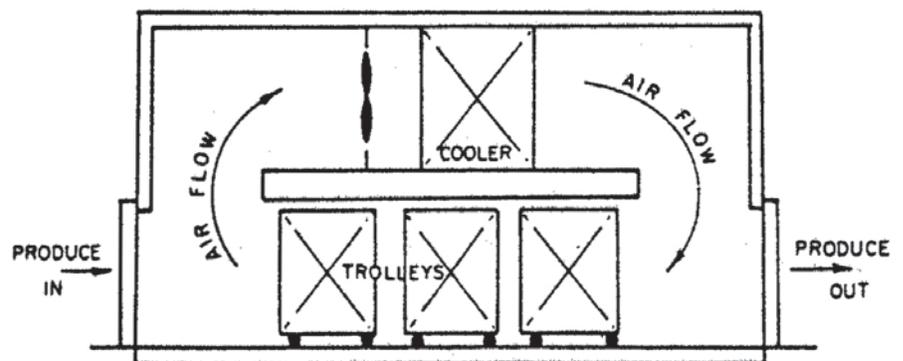
In fact, National Centre for Cold-chain Development (NCCD) has concluded that developing temperature controlled logistics in rural areas will be a critical factor in achieving the government’s target of doubling farmers’ income over the next five years. While various efforts are underway to incrementally reduce farmers’ costs, a transformative effect is expected to come from improving transport from farm-to-consumer. The NCCD points out that cold chain give farmers access to distant and potentially higher value markets, so increasing the incentives to raise production.

Demand for cold chain services is already beginning to surge in countries such as China and India as they become wealthier and more urbanized. However, emerging cold chains still rely on conventional and all too often highly polluting, diesel-powered transport refrigeration units (TRUs). These TRUs are not only carbon intensive, but also emit grossly disproportionate amounts of nitrogen oxides (NOx) and particulate matter (PM), the toxic pollutants that cause 3.7 million deaths worldwide each year. If cold chains continue to be built using conventional technologies and demand continues to boom as predicted, these countries will simply swap one set of problems for another.

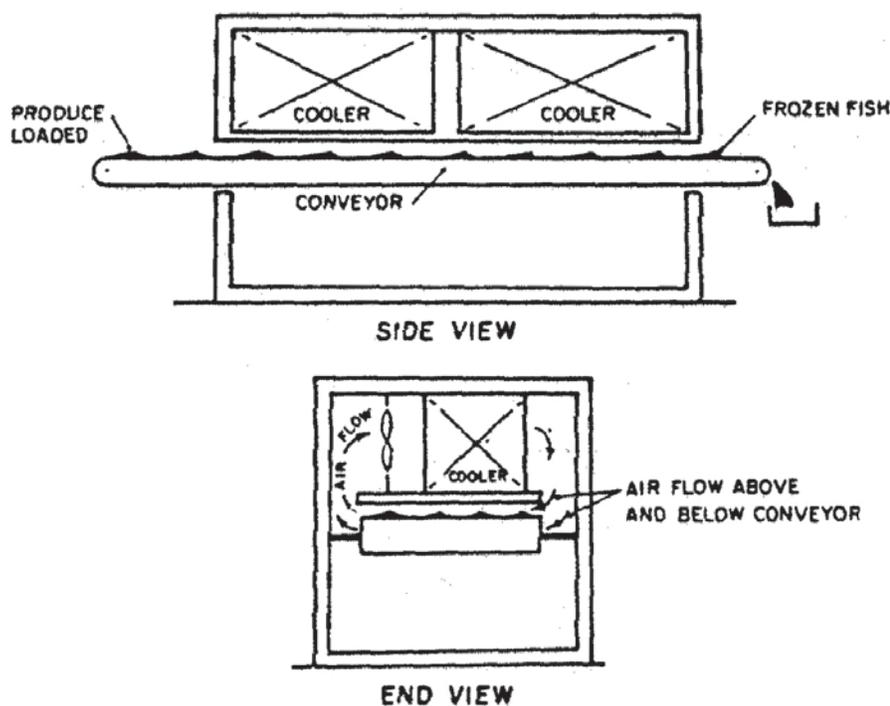
New clean cooling technologies are, however, now being commercialized, which could resolve this dilemma. This means it is finally possible to secure all the

benefits of reducing food waste – for food security, emissions and wider sustainability – without the downside. The challenge is now to deploy the new technologies urgently to prevent developing countries from adopting the old dirty technologies by default – locking in emissions for years to come.

Growth of cold chain in India, for example, has around 31 million tonnes of cold store capacity and perhaps 9,000 refrigerated trucks, whereas in France the balance is 5 million tonnes and 140,000 (India also has 27,000 milk tankers, but these are insulated and not refrigerated). The chief executive of India’s National Centre for Cold-chain Development, Pawanexh Kohli, says that this causes a ‘major breach of the cold chain’ and that there is ‘in effect no integration’. Kohli has also calculated that to make proper use of just 10% of India’s existing cold storage capacity, the country needs to build 30,000 new pack-houses with pre-cooling facilities, and 60,000 refrigerated trucks. By extension, making proper use of all of India’s cold storage capacity would require 600,000 refrigerated trucks. Taking a broader international perspective, if India had the same ratio of refrigerated vehicles to the value of its grocery market (\$375 billion in 2012) as Britain (\$243 billion), it would have 139,000 refrigerated vehicles, 18 times more than at present. And if it had the same ratio of refrigerated trucks to population as Britain, its fleet would number more than 1.5 million. The picture in China is similarly skewed. Demand for cold chain services has been building for longer in China than in India – fridge ownership among urban households, for example, rose



Air Chilling Systems



Contact Chilling Systems

from 7% in 1995 to 95% in 2007 – and yet the country still has much more cold storage than refrigerated vehicle capacity.

Chilling of food is a preservation technique in which the food either in raw form or in processed form is cooled to a temperature of 0°to -5°C. Chilling differs from freezing, in fact, that the temperature of food does not fall below one where ice is formed in the food. Many commercial chillers operate at higher temperatures of 10-12°C. So, both time and temperature of holding the chilled food determines the storage life of food.

The objective of chilling food is to

reduce or maintain the temperature of food so that changes occurring in food should be retarded or stopped. The changes include microbiological (microbial growth), physiological (ripening, senescence and respiration), biochemical (lipid oxidation and browning) and physical (moisture loss and weight loss).

So, in order to preserve the quality and achieve desired shelf life of fresh raw or processed product, a chill chain is introduced. Also the quality parameters like taste, smell, appearance and texture are also preserved to some extent by chilling of food.

Rates of chilling are governed by the laws of heat transfer. It is an example of unsteady-state heat transfer by convection to the surface of food and by conduction within food itself. The medium of heat exchange is generally air, which extracts heat from food and then gives it up to refrigerant in the evaporator. The rates of convection heat transfer from the surface of food and to the evaporator are much greater if the air is in movement, being roughly proportional to $v^{0.8}$.

To calculate chilling rates, it is therefore necessary to evaluate:

- Surface heat transfer coefficient,
- Resistance offered to heat flow by any packaging material that may be placed round the food,
- Appropriate unsteady state heat conduction equation.

Although the shapes of most food stuffs are not regular, they often approximate the shapes of slabs, bricks, spheres and cylinders.

Chilling Systems for Food

There are a large number of different chilling systems for food based on moving air, wet air, direct contact, immersion, ice, cryogenics, vacuum and pressure shift. For the majority of chilled foods, air systems are used primarily because of their flexibility and ease of use. However, other systems such as immersion, contact and cryogenics can offer much faster and more controlled chilling.

Air Chilling Systems

Air systems are most common type of systems as they are economical, hygienic and consist of relatively non-corrosive equipment. It consists of a fan which draws air through a refrigerated coil and blows the cooled air around an insulated room with a purpose-built conveyerized air-blast tunnels or spirals. The rates of heat transfer are relatively lower in air-cooled systems. The big advantages of air systems are their lower cost and versatility compared to immersion, contact and cryogenics, especially, when there is a requirement to cool a variety of irregularly shaped products.

One of the major disadvantages of air-



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Ice chilling system

cooling systems is their tendency to dehydrate unwrapped products. The alternate to this problem is to saturate the air with water. Wet-air cooling systems recirculate air over ice cold water so that the air leaving the cooler is cold (0–1 °C) and virtually saturated with water vapor (100% relative humidity, RH). An ice-bank chiller uses a refrigeration plant with an evaporator (plate or coil) immersed in a tank of water that chills the water to 0 °C.

Contact Chilling Systems

Contact refrigeration methods are based on heat transfer by the direct contact between products and metal surfaces, which in turn are cooled by either primary or secondary refrigerants. Contact cooling offers several advantages over air cooling, such as much better heat transfer and significant energy savings. Contact cooling systems include plate coolers, jacketed heat exchangers, belt coolers and falling film systems. Good heat transfer is dependent on product thickness, good contact and the conductivity of the product.

Plate freezers are often limited to a maximum thickness of 50–70 mm.

Immersion/Spray Chilling Systems

Immersion/spray systems involve dipping products into a cold liquid or spraying a cold liquid on food. Cooling using ice or direct contact with a cryogenic substance is essentially an immersion/spray process. This produces high rates of heat transfer due to the intimate contact between product and cooling medium. Both immersion and spray methods offer several inherent advantages over air cooling in terms of reduced dehydration and coil frosting problems.

It includes two systems:

- a) **Ice systems:** Chilling with crushed ice or an ice/water mixture is one of the simple, effective and commonly used methods for the cooling of food products. Ice has the advantage of being able to deliver a large amount of refrigeration in a short time as well as maintaining a very constant

temperature, 0 °C to –0.5 °C (where sea water is present).

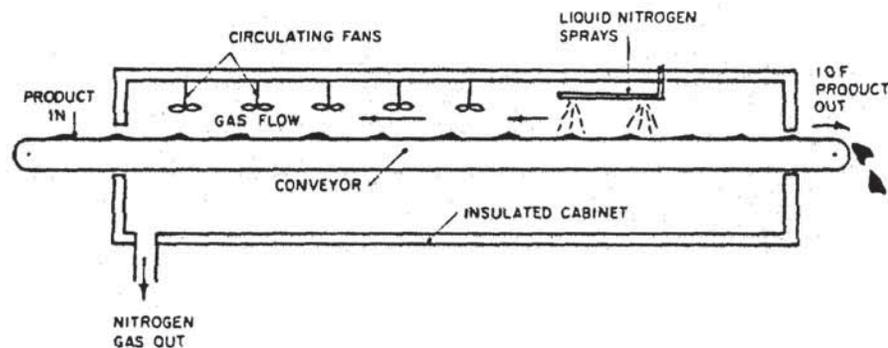
- b) **Cryogenic systems:** Direct spraying of liquid nitrogen on a food product whilst it is conveyed through an insulated tunnel is one of the most commonly used methods of applying cryogens. Due to very low operating temperatures and high surface heat transfer coefficients between product and medium, cooling rates of cryogenic systems are often substantially higher than other cooling systems.

Benefits of Chilled Foods

- Offers consumers the choice of a wide range of tasty and nutritious foods that are quick and easy to prepare.
- Provides convenience in buying, preparing and cooking food helping to reduce the amount of time and energy.
- Chilled foods also reduce waste by cutting down on the need for consumers to buy unnecessary or large amounts of ingredients.

Conclusion

Chilling is one of the most common methods for preserving foods. Carried out correctly, it can provide a high-quality, nutritious and safe product for consumption with a long storage life. The principal factor controlling the safety and quality of a refrigerated (chilled) food is its temperature. In many cases, the time taken to reach the desired temperature is also important. To provide safe, high-quality refrigerated food products, attention must be paid to every aspect of the cold chain from initial chilling or freezing of raw ingredients, through storage and transport, to retail display. ■



Cryogenic Cooling

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A fan for any scenario

Besides the required air flow, minimal noise emission and increased energy efficiency are key characteristics for axial fans used in evaporators, condensers and heat exchangers in ventilation, refrigeration and air conditioning systems. In the form of the AxiBlade, fan and motor specialist ebm-papst has developed a new generation of axial fans that exploit every last bit of optimization potential offered by the current state of the art.



The modular concept of the AxiBlade offers the user maximum flexibility so as to run the fan as close to the optimum level as possible in the typical operating range.

Modular concept

The AxiBlade concept is based on a modular system. This comprises fan housings of varying heights with an aerodynamically optimized inlet ring. These are complemented by profiled impeller geometry and winglets for maximum efficiency. The impellers have been designed for the various motors they are able to be combined with, which increases efficiency and reduces running noise. Exhaust turbulence and the resulting

dynamic losses can also be minimized thanks to the guide vanes. The guard grilles are matched to the various combinations and aerodynamically optimized. Not only do they protect against accidental contact, they also contribute to the high overall efficiency of the axial fans. Thanks to their modular concept, AxiBlade axial fans can operate in a wide variety of applications with an optimum efficiency of up to 54 %. In the process, a noise reduction of up to 8 dB(A) can be achieved

when compared with the standard program.

The right solution for every pressure range

The new axial fans can be ideally matched to the application in question. For example, the standard fan housing with a height of 190 mm and no guide vanes is suited to low to medium pressure ranges up to 200 Pa. In this case, the benefits of the guide vanes do not come into play. Even without them, the efficiency and operating noise are much better than the current industry standard. The guide vanes become interesting with the approx. 300-millimeter-high fan housing (depending on the size category) with integrated diffuser for high back pressures up to 290 Pa. Here, the guide vanes are essential for achieving such high efficiency. Suitable components can be combined depending on the pressure ranges required and the fans can be produced accordingly.

No design changes to the customer's unit required

Since the new axial fans' footprint corresponds to the current industry standard, virtually no design changes to the end unit are necessary. Besides the especially energy-efficient GreenTech EC motors, the new AxiBlade models are also available with the AC motors that are still widely used. Sizes 800 and 910 are currently available; an expansion of the series to include sizes 630 and 710 is planned for 2017. ■

“Our goal is to offer innovative and sustainable products”



Embraco is a multinational in the sector of hermetic compressors and cooling solutions for refrigeration and one of the world's largest manufacturers of this segment. Embraco's mission is to offer innovative solutions for a better quality of life. The compressor is the main component responsible for producing cold in the refrigeration system. With global operations and annual production capacity of 40 million units, Embraco offers solutions that are differentiated for their innovation, quality and low-energy consumption. **Luis Felipe Dau, CEO, Embraco** sheds light on Embraco's journey in India, products offered by the company, innovations, expansion plans and much more in an email interaction with **Cooling India...**

Can you please take us through Embraco's journey in India?

Our presence in India is aligned with Embraco's vision to be a leader everywhere and recognized by customers as the preferred partner by 2020.

Embraco has been in the Indian market since 2009 with a focus on special

applications for medical equipment. We have been learning a lot about the culture, end-users and about our customers' needs. Aiming to expand its participation in the Indian market, Embraco is increasing its distribution network and has had, since 2016, a sales team dedicated to the business in the country.

In 2016, we also announced our entry into the household and commercial refrigeration market in the region and we are one of the first companies to provide high-efficiency compressors using natural refrigerants for the commercial refrigeration market in India. During a recent trade show, Embraco showcased the first R290 (propane)

compressor for horizontal freezers in this market, highlighting the environmental and energy-efficiency benefits provided by using this natural refrigerant.

For 2017, we started at events on natural refrigerants in Japan (Atmosphere), and we have participated in ACREX, one of the top five biggest shows of the world with a customer-partnership strategy reinforcing our brand and products. Also, we have several other events planned for the year in other countries such as Indonesia, Australia and Thailand, as well as India. Embraco's greater presence in India aims to support our vision in this market and is in line with the country's objectives, which is to promote increasingly energy efficiency in a demanding market for refrigeration. We want to provide a better quality of life to Indian population through innovative solutions specific for the market.

What are the trends in current refrigeration market? How would you envisage the growth with particular emphasis on energy efficiency and sustainability in global refrigeration markets?

Variable speed compressors are current reality which will accelerate in the near future. We already see movements in the American, Asian and European markets with single speed compressors converting to Fullmotion, Embraco's variable speed technology. The motivation is the growing demand for refrigeration systems with higher energy efficiency, lower noise and those that preserve food longer. In addition, the inverter electronics protect the compressor against voltage variation and power shortage. So, the reliability of these compressors is also a differential for both manufacturers and consumers. Connectivity is another relevant trend closely related to the Internet of Things. In the case of refrigerators, new features will be developed to connect the user increasingly more with the equipment, bringing advantages in food preservation, equipment maintenance, and reduction of problems by product stock-outs among others.

The use of natural refrigerants is a success



case in many developed countries and it is on the agenda worldwide both for use in household refrigeration as well as for commercial. The United States, for example, is moving forward in the legal discussion of this issue and soon may require all household and light commercial refrigeration products to use natural fluids. The phase-in towards using these refrigerants already started in India, it involves investments to convert lines and equipment and we expect to see a fast conversion. Embraco's global team is highly experienced in natural refrigerants from product conception and development to line conversion and customization to our customers' applications. We truly believe we can add a lot of value to our customers by jointly working to help them succeed in this new refrigeration market.

What kind of technological innovations would you like to incorporate in your products considering rising global temperature?

Sustainable development is a driver in the company's strategy. We have the constant challenge of being at the forefront in developing new technologies and solutions that meet our customers' demands and that promote energy efficiency, reduce consumption of natural resources and create solutions that offer increasingly less environmental impact.

Sustainability goes beyond developing intelligent solutions and continuous improvement. It's part of the company's day to day and is present throughout the value chain including employees and suppliers. For the company, relationships and processes need to be sustainable, both for products, processes and manufacturing plants.

For more than 20 years, Embraco has used natural refrigerants in its compressor portfolio for commercial and household use as an alternative to reduce the negative effects on the ozone layer, greenhouse effects and to improve the equipment's efficiency index. Embraco believes that using natural refrigerants – especially hydrocarbons – is the ideal solution for the future of refrigeration by sustainably aligning economic and environmental needs. We are prepared to meet future legislation and best practices demanded by the market.

We have in our portfolio the Fullmotion technology, variable capacity compressors which use propane refrigerants that can save up to 40% of the energy when compared to conventional compressors. Recently, Embraco launched the Fullmotion X compressor - FMX, which combines value attributes for the end consumer, such as better food preservation, low noise, wide voltage range, easier customization to existing applications and

energy efficiency. It was launched during AWE Expo, the segment's largest trade show in Shanghai. We already showed applications in which Fullmotion X was in use. FMX also allows the use of R600a (isobutane), a natural refrigerant that is already a reality in markets such as India, Europe and China.

Fullmotion technology also brings more convenience to the consumer, as it reaches the ideal temperature for food and beverage quickly as well as offering more internal space in refrigerators if compared to conventional compressors. Fullmotion X, with our patented inverter technology, is confirming the trend of the technology worldwide in different segments and refrigerator models globally.

Another important initiative that Embraco owns and operates is Nat.Genius. Inspired

I would like to highlight two important technologies that Embraco has in its portfolio:

With innovative products and state-of-the-art technology, Embraco launches market trends. An example is Wisemotion, the first linear, oil-free household compressor that allows innovation in refrigerator design, given its small height and possibility to locate the compressor in the top of the refrigerator, for example. Wisemotion is 20% more efficient than the best-selling high-efficiency compressors worldwide.

Embraco also created Plug n' Cool, a simple and compact sealed unit for commercial refrigeration, which aims to optimize resources (time and operating cost) in installation and maintenance for manufacturers and contractors. The technology allows the use of R290 natural

In an ice cream freezer, there was a 16% reduction in energy costs, which means a real gain of USD 26 per year for the consumer and 1,954 kg less CO₂ in the atmosphere in 10 years, also proving an environmental gain.

How would you differentiate Indian refrigeration markets from Global markets particularly, European and American markets while offering your services and products? Do you face any competition in Indian markets?

Governments and entities have been working strongly on mechanisms to reduce energy consumption. New legislation, in both Europe and the United States, is advising manufacturers to be increasingly more concerned about launching high-efficiency products, which means more attention is aimed at designing solutions that meet these new requirements. Regardless of the current legislation in the various countries where Embraco operates and the imminent ban on the use of HFCs, the company is prepared to attend the global refrigeration market, which seeks to migrate to natural refrigerants.

With the world's second largest population, India's electricity cost is high and about 40% of food produced is wasted due to poor preservation. To address this issue, since 2013, the Indian Government has encouraged refrigeration development in the country, through fiscal reform, as well as product cost and tax reductions.

India has been on a growing path and consumers are increasingly demanding high quality, great service at value-based solutions. Embraco is truly a global company, a multi-national focused on innovation and one of the largest worldwide manufacturers of hermetic compressors for refrigeration. Embraco's experience in tailoring solutions to our customers, our global know-how, our complete portfolio of products and cooling solutions and especially the trust developed in different cultures in our 46 years of history make us more competitive and a differentiated player to win the trust of Indian consumers.



Wisemotion, the first linear, oil-free household compressor that allows innovation in refrigerator design, given its small height and possibility to locate the compressor in the top of the refrigerator, for example. Wisemotion is 20% more efficient than the best-selling high-efficiency compressors worldwide.

by nature, where all cycles are closed and all elements are reused at the end of their useful life, in 2014 we created Nat.Genius, a business unit that uses decades of reverse logistics expertise of our compressors. Currently, this operation works in Brazil in our recycling plant. We are more than willing to support our customers worldwide to be more sustainable with the expertise and services that we provide with Nat.Genius.

What are the products offered by the company and in particular catering to Indian markets?

Earlier, I mentioned what we have presented to the market, including India, such as natural refrigerants and Fullmotion technology. We constantly seek to develop co-development actions by combining the qualities and competencies of companies as well as promoting brands and generating business opportunities with competitive advantages.

refrigerant, making it possible for customers to comply with worldwide efficiency standards and refrigerant gases. To prove the efficiency of its compressors, Embraco constantly conducts tests with its customers. In the case of R290, we can illustrate three applications that attested to its effectiveness in replacing R404A for natural refrigerant. A test carried out in a glass-door freezer for the point of sale, the R290 achieved a 32% energy reduction, a real gain of USD 38 per year and, according to projections, would no longer emit 2,277 kg of CO₂ in 10 years. When the test was performed with a vertical freezer, the savings were even higher, a 43% reduction in electric energy consumption and a savings of USD 226 per year, with proven benefits to the environment, since changing the refrigerant indicated that 12,764 kg of CO₂ would no longer be released into the atmosphere in 10 years.

What are the growth drivers of your products in India?

There has been an ongoing trend for the Indian commercial refrigeration sector to migrate to R290-equipped compressors. Since 2016 Embraco has invested considerable efforts in India's market to promote R290 to become the mainstream refrigerant for light-commercial applications. These solutions are reaching manufacturers such as Western Equipment (part of Hoshizaki international group), which has become one of the country's largest in commercial refrigeration equipment.

In the household segment, as mentioned before, the trends toward energy-efficiency and food preservation will significantly support the massive usage of our Fullmotion applications bringing quality of life to Indian customers through a lower cost of energy bill, food better preserved, lower noise compared to a standard compressor, all of this with increased reliability.

Embraco invests annually in its technology DNA to propose new solutions to customers. For this region, Embraco is prepared to meet future legislation and best practices demanded by the market.

Embraco's portfolio is complete and the company is ready to offer products to India according to all government programs. For example, the BEE (Bureau of Energy Efficiency) regulations and the new trend of 'Make India Green', using HCs (R290 and R600).

How competitive and technologically superior are your products as compared to your peers?

One in five hermetic compressors in the world has the Embraco brand. As a multinational in the refrigeration segment, Embraco invests annually in its technology DNA to propose new solutions to customers and to keep this position as leader in technology. The level of quality

and reliability that Embraco products are known in the markets is a huge asset we provide to give peace of mind to our customers and to the end-users.

Additionally, one of our existing work stream is the Business Innovation team, when opportunities are mapped beyond manufacturing compressors. The company invests annually 3% to 4% of net revenue in research and development. About 600 professionals are dedicated exclusively to this department – with approximately 120 university partners. Additionally, Embraco has 47 research laboratories on four continents.

Embraco's pioneering research has led to the development of new technologies and solutions, such as variable speed solutions and products that use natural refrigerants. We are always transforming ourselves to



Fullmotion X compressor - FMX

meet market demand. It will not be different in India. More will come in the following years.

What are your expansion plans in India? What potential do you foresee for your company with the Indian Government's focus on development of infrastructure like smart cities, urban transportation projects?

Guided by the 2020 vision to be a leader everywhere and recognized by customers as a preferred partner, Embraco is always evaluating new opportunities for

partnerships, both in the commercial as well as the household segments.

As our mission states, we exist to provide innovative solutions for a better quality of life. So, in any potential opportunity which requires developing cooling solutions being it in infrastructure, smart appliances, etc, Embraco has the capability to make Indian population life better.

At the end, our goal is to offer innovative and sustainable products and solutions to make Embraco a benchmark not only in India but in other countries such as Japan, Thailand, Korea, among others.

How is Embraco preparing for the transformations the world will pass through in the upcoming years?

Technology and innovation are in our DNA and will remain being essential for our future, coupled with a very strong ability to quickly adapt to changes that the current market demands. The local and global socio-economic scenario guides our directives and makes us think daily about how we should act given a constantly changing market. We strongly believe in our mission to provide innovative solutions for a better quality of life!

We will grow in partnership with our customers and in high-growth potential markets. Besides the current business,

we're seeking to grow through our new businesses area, always looking at the emerging drivers for the end-users and jobs our customers need to be solved jointly.

Nothing is better than to look outwards and examine how we can apply new concepts and propose new solutions to customers in a simple and innovative way. Embraco's employees and partners understand the need for us to stay at least one step ahead of new market trends, both in household refrigeration and in commercial refrigeration, in order to drive our strategy, and therefore add value to our customers and shareholders. ■

Remotely Connected Chiller Technology

Remote connectivity of chillers can help to collect the entire set of data in short period. Most of the present chiller system has the capability to connect to centralised server, making, it the remote monitoring easy and affordable. The aim of connected chiller technology is to control the system from a central control point...

The chiller consumes 70% of the total energy of the building. This is very essential to optimize the operation of the chiller with high energy efficiency. Monitoring efficiency of the chiller needs a number of parameters to be measured at individual level of each chiller. This is not possible to collect these parameters in a required time period of limited number of resources. Hence, remote connectivity of these chillers can help to collect the entire set of data in short period. Most of the present chiller system has the capability to connect to centralised server, making, it the remote monitoring easy and affordable. In this discussion, we will try to give a present status of the "Remotely Connected Chiller

Technology". The aim of connected chiller technology is to control the system from a central control point.

Introduction to Technology

A traditional building automation system (BAS) provides alarms that identify problems in a chiller after they occurred based on system thresholds. The response thus happens after the fact when the fault already triggered and system effected. The BAS alarm requires further analysis by the facility manager to identify the fault and the way to fix the problem. In addition, BAS alarms primarily focus on critical failures or problems that will lead to significant comfort or repair issues.

Remotely connected and monitoring

technique gives customer access to the chiller anytime and anywhere. Remote connection can help determine when maintenance will be required. Maintenance –if it is done preventively at all rather than waiting for the failure. This also helps analysts in monitoring chiller performance and reports any abnormal operating conditions. Remote monitoring can often identify what is wrong with a system before it appears. Connected chillers address opportunities for accelerated growth of service repair and retrofit opportunities by leveraging data and analytics from connected installed base.

The remote analysis and diagnostics is shown in the Figure 1.

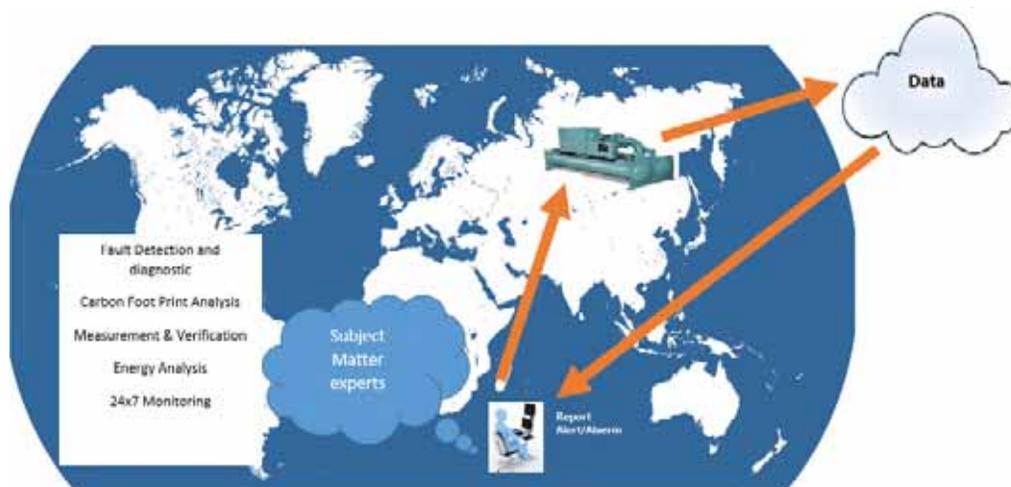
All the above functions are performed with the customized software that can collect the data and automatically analyze it. The results of the analysis are presented in the customized platform and automated report is generated through the software.

There are three steps in remote analysis of the chiller:

- a. **Data Collection:** The data can be collected from the individual chiller with installed communicable card within the chiller or through the BMS.

The available data point on the chiller need to be configured with the application software. This data collection requires a physical device to send the data to the server through internet.

- b. **Automated analytic:** The automatic analytic of the collected data is performed with the technique "Fault Detection and Diagnostic (FDD)". This is rule based technology to find out the abnormal condition of the chiller.



c. **Reporting:** With the software, customized report can be generated, which shows the present operating condition of the chiller based on the design or operating data.



Methodology for Remote Analysis

Chillers are remotely analyzed with the help of fault detection and diagnostics (FDD) technique, which detect the future fault based on the logic implemented in the connected chiller platform.

Fault detection and diagnostics (FDD) is a method to monitor a system, identify when a fault has occurred, and point out the type of fault and its location. This method improves comfort, and reduces the operation, maintenance, and utility costs, thus, reducing the environmental impact.

FDD system focuses on identifying non-critical deficiencies in which the chiller still performs. But it is not optimized to minimize energy or maintain expense. The FDD system can recognize when a condition is starting to deviate from the correct values, or when a system is operating sub-optimally, so that the facility manager can see the problem before it actually occurs. It can detect not only a

trend in an adverse direction, but also the cause of the trend, so that the facility manager can fix the problem quickly.

FDD software not only detects faults but also it instantly provides information based on analytics (e.g., energy or cost impacts of the fault) to help the building operator screen and prioritize which faults to fix based on safety, operational implications, code compliance, cost, impact on occupant comfort, and other factors. Without techno-commissioning, a facility manager’s maintenance strategy is strictly schedule-based and is not related to the actual operating conditions of the building and its equipment. With FDD, the analytics tell the manager what needs to be done today based on current system condition and performance, as well as what items can be deferred.

Future Technology

In future, the Internet of Things (IoT) and cloud computing is supposed to

dominate the connected equipment monitoring and diagnostic. This technology reduces the initial coat due to non-requirement of local sever and data in store in the cloud. This technology helps to access the data anytime, anywhere and with any device. Energy Management and Internet of Things will go hand-in-hand. Also IoT will play a very important role in making the consumption of resources efficient along with systems. This will eliminate the most of the physical sensor, wiring and sever and will lead to lower investment in connected technology.

The machine learning is one of the upcoming technologies that will leverage the existing connected chiller technology. This will make the present analysis more automated as it will be able to read the data and predict the future faults and failures. The technology has not been extensive used at present.

Conclusion

The connected chiller technology brings these chillers closer to the experts and helps the service peoples to get an idea before visiting any site. This also reduces the consulting charges of the chiller and no physical visit is required. Apart from many advantages, it is very important to provide the correct information to the expert seating remotely. A gap in the information will lead to misunderstanding of the equipment and its analytics results. ■

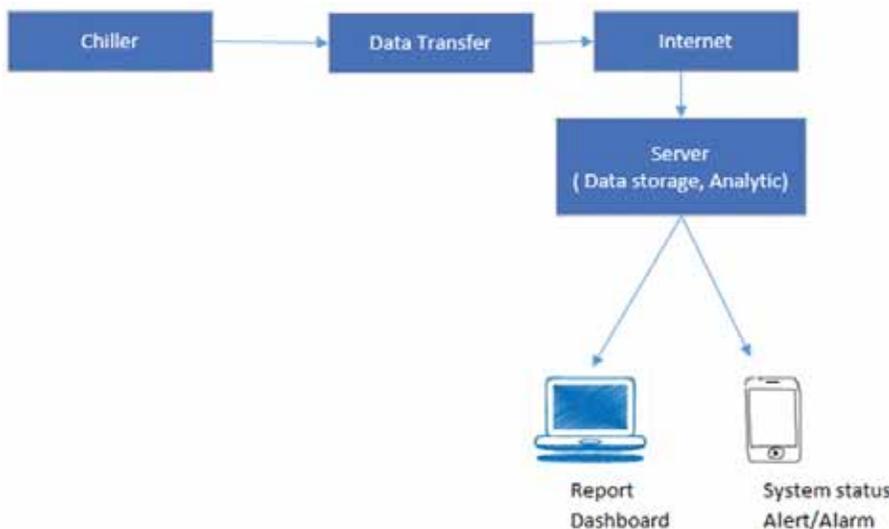


Figure 1: Remote analysis and Diagnostic system layout

Pranjal Dutta
India Engineering Centre,
Johnson Control India Pvt
Ltd, Mumbai



Smart World of Testo - Refrigeration Systems

Testo has introduced the technological leap in refrigeration industry with its new smart manifolds which works through an app on your smartphones or tablets making every day refrigeration tasks easier...



Digitisation is the new buzz in the market. Every industry has moved or is gradually moving towards digitisation from analog systems to keep the pace with the modern trade. Worldwide, the refrigeration industry is growing in a very big way in terms of warehousing, large buildings, malls, residential cooling and many more.

Apparently, industrial digitisation has also now started approaching the next level which is the blend of smart technology and digital processes to become not only digital but smart. And to infuse this concept of smart technology, the refrigeration industry is all geared up to welcome the smart processes and equipment to serve faster & better than ever before.

While talking about the refrigeration industry, digital manifolds are the most obvious part of the sector that grabs our attention. And thus, being the world leader in measurement technology, Testo has introduced the technological leap in refrigeration industry with its new smart manifolds which works through an app on your smartphones or tablets making every day refrigeration tasks easier. Smartphone operation allows you to manage everything at your finger tips with the most comfortable gadget that you deal with in your everyday life.

Smart Technology – new transition

This change from analog to smart measuring technology is particularly worthwhile for the refrigeration industry, because many different parameters, such as pressures and temperatures, along with



the superheating and subcooling of the system, have to be checked here. An analog manifold is not really much help with this, as it can actually only determine high and low pressure. For every other task, you need additional instruments and accordingly more expenditure, quite apart from the laborious handling and the frequent inaccuracies of measurement (according to a study by the US public body 'Energy Star', up to 74% of all refrigeration systems are incorrectly adjusted using analog measuring technology*).

In contrast, digital manifolds with app control such as the Testo 550 or the Testo 557 save you all other additional instruments and turn your smartphone or tablet into an efficient all-round tool instead. This means you can for example measure pressure and temperature values quickly and easily, or carry out a temperature-compensated tightness test, and read out the measuring values really conveniently on the smartphone, irrespective of the measuring location. Superheating and subcooling are also displayed automatically.

Where data have until now still been analyzed by printing out the measurement protocol and laboriously saved on the PC, all measurement results can now be

graphically displayed and immediately dispatched on site by e-mail - whether to the office or to the customer. And you can also update and extend the list of the most common refrigerants stored on the instrument at any time via the App. That sounds like a contemporary way of working, doesn't it?

As a habit to strive for more, Testo has also launched the Smart measuring instruments (known as Smart Probes) in addition to the Smart manifolds.

The professional and compact testo 549i high-pressure measuring instrument can be controlled via the testo Smart Probes App using your smartphone or tablet, and is ideal for carrying out servicing and troubleshooting on air conditioning and refrigeration systems. The App also enables evaporation and condensation temperatures to be calculated automatically. Testo offers you greater mobility when measuring: used in conjunction with your smartphone or tablet, the handy testo 549i high-pressure measuring instrument is suitable for carrying out wireless servicing and troubleshooting on air conditioning and refrigeration systems, as well as for installing them. The measuring instrument can be set up quickly and easily, directly at the pressure connection. The testo 549i

makes working on widely spaced pressure connections considerably easier thanks to wireless connection to a smartphone or tablet. Also practical: no hoses are required for measurements, meaning that no or only very little refrigerant is lost. When used in conjunction with the testo 115i clamp thermometer, individual refrigeration system parameters can also be calculated.

Combined with a smartphone or tablet, the testo 115i clamp thermometer is the ideal temperature measuring instrument for carrying out

servicing and troubleshooting on air conditioning and refrigeration systems, as well as for installing them. It can also be used to measure flow and return temperatures.

Professional measuring technology is now mobile: when it comes to temperature measurements at widely spaced measuring points in particular, the testo 115i makes things much easier – thanks to a wireless connection to the smartphone or tablet. When used in conjunction with the testo 549i pressure measuring instrument, individual refrigeration system parameters can also be calculated.

Let's summarize: refrigeration system maintenance is becoming almost as easy as writing WhatsApp messages, thanks to Testo's smart measuring technology. Because App-controlled manifolds make additional measuring instruments superfluous, streamline your entire work process and save a lot of effort as well as loads of valuable time. And your day-to-day work finally becomes part of your own smart world too. ■

*Source: www.energystar.gov

For more information write to
info@testoindia.com



“India offers potential for growth of cold chain industry”

Emerson has an unmatched array of products and solutions to support the Cold Chain Industry. The company offers the best-in-class global technologies, customized locally for the India Cold Chain market placing it in a unique position to serve the industry in an optimal manner. Emerson is already leveraging the Internet of Things to help the industry solve the challenge of food wastage and protect food safety by using real-time monitoring throughout the food cold chain informs **Sridar Narayanswami, Vice President and Managing Director of India, Emerson's Commercial & Residential Solutions** in an email interaction with **Supriya Oundhakar**.

What are the trends in Indian cold chain segment? What is the penetration level of temperature controlled cold storage in India?

Cold chain industry in India is evolving. With rising income levels and growing

awareness of hygiene, there is a change in consumption trend from conventional to processed foods. The food processing sector is witnessing double digit growth rate in the recent past. This has resulted in more than 20%+ growth across categories such as value-added dairy products,

ready-to-eat or ready-to-cook foods, breakfast cereals, confectionery items and fruit beverages amongst others. Thus, we see a significant private investment in cold chain in sectors like integrated packhouses & logistics warehousing, food processing & export oriented companies. To serve

this segment, there is an increased focus on providing reefer trucks and logistics with enhanced monitoring and tracking of food supply.

The govt is also playing an active role by initiating several measures such as recognizing the cold chain as a sub-sector of infrastructure, providing subsidies for food processing by setting up large scale mega food parks (MFP), Integrated Cold Chain Clusters etc.

Penetration

Though, India is the world's second largest producer of fruits and vegetables, only four percent of India's fresh produce is transported through cold chain. The rest has to be delivered locally and eaten quickly or it simply goes to waste. For that to change, the country faces the steep challenge of doubling its cold chain capacity. Adding to the challenge, more than half of India's 6,300+ cold storage facilities are concentrated in just five states. Building cold chain infrastructure and linking it effectively to regional demand is the key to India's food security and public health for its more than one billion citizens, as well as to its future as a world-class economy.

What role can organized retailers play in building cold chains in India?

While the government is seeking to increase investments in infrastructure and improve the food logistics chain, the adoption of proven and efficient technology solutions can help in reducing operating costs, improving quality of produce thereby helping to alleviate the food wastage problem. The government & private sector, through bodies like NHB NCCD, are already moving in the right direction with more and more emphasis on developing cold chain standards in terms of technology & efficiency.

Organized retail players who are already building complete cold chain infrastructure support backward integration. Organized retail can take stewardship in developing food traceability across the back end, optimize on operating expenditure across the supply cold chain, and specify energy efficient and environmental friendly

technologies so that these best practices can percolate throughout the back end infrastructure. Emerson is also leveraging the Internet of Things and intelligent store technology to help retail customers in optimizing operating costs and protect food safety by using real-time monitoring throughout the food cold chain.

What are the stumbling blocks faced during setting up of cold chain logistics infrastructure? How do you overcome these challenges?

Building cold chain infrastructure is the key to India's food security and public health for its more than one billion citizens, as well as to its future as a world-class economy. While financial investment in cold storage facilities and refrigerated transport is vital, some of the additional challenges faced by India's cold storage industry today are high lifecycle costs, uneven distribution of cold storages, low awareness of best storage and handling practices, frequent power outages, outdated refrigeration technologies resulting in high maintenance and high energy costs etc.



Though, India is the world's second largest producer of fruits and vegetables, only four percent of India's fresh produce is transported through cold chain. The rest has to be delivered locally and eaten quickly or it simply goes to waste. For that to change, the country faces the steep challenge of doubling its cold chain capacity.

To overcome such challenges, we at Emerson are offering project design services by our highly specialized and experienced team of design engineers that assist contractors, end users in ensuring that cold chain projects are optimally designed, focus on best lifecycle cost refrigeration solution. We also offer education and training services free of cost for contactors & technicians working in the industry. It combines class room training along with simulation equipment so that one learns best practices in terms of deployment of technology, troubleshoot,

and play around with the diagnostics to really understand how to operate the equipment. We had trained over 1500 engineers, technicians, contractors and end-users with topics ranging from basics of refrigeration to advanced cold storage design and maintenance practices.

India is one of the largest producers of agricultural products and one of the global leaders in the pharmaceutical sector. Yet, it is known to have fledging cold chain, which results in supply chain losses of food and other resources. So, what are the solutions offered by Emerson in order to stop these losses?

We need to shine the spotlight on food wastage and work together in finding ways to alleviate this problem. As a leading technology provider for the refrigeration and cold storage industry, Emerson wants to highlight how intelligent and energy efficient technologies can help India address these challenges.

Emerson is already leveraging the Internet of Things to help the industry solve the

challenge of food wastage and protect food safety by using real-time monitoring throughout the food "cold chain." We are working with retailers and end users globally to make it possible to preserve food safety by using technologies like Intelligent Store, ProActetc to constantly monitor the surface temperature of foods throughout the back end of supply chain. Energy efficiency is also paramount as much of the country experiences warm weather, frequent power outages and has to often rely on costly backup generators. To address that issue with energy-intensive process like chilling and freezing, Emerson

continues to focus on energy efficient technologies like Multi compressor racks with Variable Speed technology, Digital Scroll Mini Racks and condensing units which can save energy costs upto 25%.

The company has also invested in two dedicated Cold Chain Centers in Chakan, Pune, & Gurgaon, for project design and planning, locally develop and build the latest cold chain equipment, and provides training and aftermarket service support. The facility offers design and training support to cold chain operators and contractors to the most technologically advanced, reliable, and efficient cold room possible and maintain it at optimal cost and energy levels.

The Government of India launched 'Make in India' campaign in order to make the country manufacturing hub. So, what are the products that the company manufacturing in the country? Do you have any expansion plans?

Our main manufacturing plant is located at Atit, about 160 kms from Pune. It not only meets all our India reciprocating compressor requirement, a substantial portion of its production capacity is dedicated to serve the Middle East, Africa & Latin America markets. We manufacture more than two million compressors to cater to global markets.



Emerson constantly strives to innovate its products by including on-board diagnostics in our compressors and condensing units which can help in providing real time field support to our customers. This can help in reducing costly maintenance costs and increase uptime.

At Chakan, we design and manufacture energy efficient refrigeration units for the cold chain sector. All our products are manufactured in India using the latest energy efficient and quality components. These have been well received in the Indian market for their robust and reliable design. They are designed for diverse refrigeration applications like cold rooms,

banana ripening, fruits or vegetables, integrated logistics. We are clearly supporting the government's 'Make in India' plans.

Cold storages are dependent on steady supply of power. Apart from this, fuel constitutes a major portion of operating costs. So, what are measures taken by the company to make them energy efficient and superior?

For years Emerson's compressors and units have been the efficient choice for refrigeration applications. Copeland Scroll & Stream™ compressors have led the industry in terms of energy efficiency for decades. These also come with capacity modulation features like Digital technology which helps in saving on energy costs. At Chakan, we manufacture advanced refrigeration units like multi compressor racks with capacity modulation to allow end users to save on energy costs by responding smoothly to fluctuating demand, loading patterns, ambient temperatures etc.

Emerson constantly strives to innovate its products by including on-board diagnostics in our compressors and condensing units which can help in providing real time field support to our customers. This can help in reducing costly maintenance costs and increase uptime. For instance, The

CoreSense™ Diagnostics modules in Copeland Stream & Scroll® compressors are designed to help contractors troubleshoot refrigeration systems. The modules use the compressor as a sensor to deliver active protection and diagnostic capabilities improving overall system reliability.

By optimizing and combining refrigeration compressors, energy-conservation control

systems, remote network monitoring systems and flow control elements, Emerson's integrated solutions offer best-in-class performance and reliability to the cold chain solutions.

What are the technological innovations that you would like to bring in your company to make the operations of cold chain logistics more efficient?

Refrigeration systems are more energy-intensive in a tropical climate like India than in milder climates. Peak power outages are also routine, often forcing cold rooms to operate off costly backup generators. All of which is to say that energy efficiency is paramount. To address that issue with regard to compressors—a key, energy-intensive technology in chilling and freezing—Emerson has introduced Copeland Scroll compressors, which are designed specifically for refrigeration and therefore significantly reduce energy consumption. We are also investing in new technologies which help to save energy costs and Op-Ex costs like CoreSense™ Diagnostics allowing for compressor protection, predictive diagnostics, and communication with Emerson's supervisory controls, and refrigeration products with stepless capacity modulation through Digital & Variable Frequency Modulation.

Food safety is also more top-of-mind for consumers than ever. Each step on a food's journey introduces opportunities for foods to rise above safe temperatures, but advanced technology is making a major impact. Emerson recently bolstered its cold chain capabilities, making it possible to preserve food safety by using small, Internet of Things-enabled sensors to constantly monitor the surface temperature of foods. Imagine an exporter from India who is sending pomegranates or grapes from Maharashtra to a buyer in Europe. Customers want to make sure that an appropriate temperature is maintained throughout the journey. For this purpose, Emerson enable them to provide real-time temperature tracking and a full suite of temperature monitoring solutions to protect perishable goods through the

supply chain

Emerson is continually updating its Copeland compressor range in the light of the move to make the cold chain environmentally sustainable allowing the wider use of natural and alternative refrigerants like CO₂, propane, low GWP refrigerants like R407C, R407F, R448A and R449A etc.

What is your outlook for the sector for the fiscal 2017-18?

India offers immense potential for cold chain industry to grow. The changing consumption trend from conventional to processed foods is going to drive the growth of the food processing sector further. The Government of India envisages an action plan to double processed foods turnover from USD 280 billion to USD 480 billion. The government has identified food processing sector as one of the key sector and is focusing on growth of this sector. Till now India got 42 mega food parks with allocated investment of Rs 98 billion. India is expected to see an investment of between USD 6 billion and USD 10 billion over the next five to 10 years, excluding the cost of land and a few additional components. The Indian Cold Chain Industry is currently

valued at close to USD 6.5 billion which is expected to grow at a CAGR of 25%+ over the next 4-5 years due to substantial growth in the production of perishable products such as fruits and vegetables, meat, milk and pharmaceutical products (vaccines). Additionally, the rise would be complemented and supported by the rising retail in India which would generate huge infrastructural demand resulting in increased levels of revenue for the cold chain industry.

What are your expectations for the sector in order to bring the sector on growth trajectory?

Because of consumer perception about food in India, processed foods did not appear very attractive or delicious to Indian households. There was a belief that food had to be natural, prepared by hand and cooked. More recently, with increasing affluence and growing middle class, we are seeing a higher demand for processed foods. The journey has just begun. The government is also very committed and actively enabling the growth of the food processing industry and has committed to set up over 30 food parks in various states. The industry is moving in the right direction

with successive governments playing an active role by initiating several measures such as recognizing the cold chain as a sub-sector of infrastructure, providing subsidies for setting up mega food parks (MFP). We believe that government has created a lot of confidence in investors including cold chain investments. We believe that with right implementation of these initiatives, the cold chain sector will grow exponentially.

What are the expansion plans of Emerson in India?

There are quite a few verticals in the HVAC&R business at which we continue to look closely, to expand our business. After setting up our footprint in the cold chain business, we are looking at long distance railways and metro rail as areas of growth. We already have a solid presence in rail coach air conditioning business. As metro rail expands in India, we expect this to be an area of growth for us.

Over the last three years Emerson has invested USD 400 million dollars in our operations and plants here in India. We plan to invest an additional USD 200 million over the next few years. ■

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HVAC&R

Control Systems

An HVAC&R control system has to conform with stringent health and safety laws, and react accordingly when a state of emergency occurs, such as fire, smoke or flood. It must also interface with other systems in the same building - boilers, chillers, etc. Tailor made electrical control panels available will provide the information needed at the required time and at the right place. Control panel information includes instrumentation and controls geared to individual requirements.....

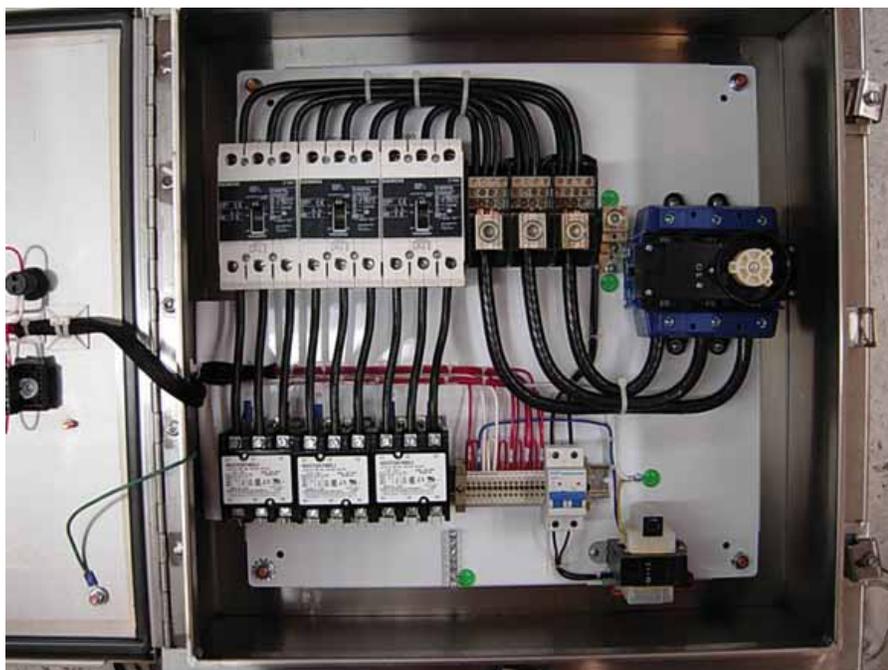
Heating, Ventilation, Air Conditioning & Refrigeration (HVAC&R) is the technology of indoor and vehicular environmental comfort. Its goal is to provide and acceptable indoor air quality. In present day of industrialization and modern living style, we are always in possession of any one of Heating, Ventilation, Air-conditioning or Refrigeration systems in our homes or in industry. HVAC&R is an important part of residential

structures such as single family homes, apartment buildings, hotels and senior living facilities, medium to large industrial and office buildings such as skyscrapers and hospitals, onboard vessels, and in marine environments, where safe and healthy building conditions are regulated with respect to temperature and humidity, using fresh air from outdoors. HVAC&R system design is a sub discipline of mechanical engineering, based on the

principles of thermodynamics, fluid mechanics, and heat transfer. The central functions of heating, ventilation, air conditioning and cooling are interrelated, especially with the need to provide thermal comfort and acceptable indoor air quality within reasonable installation, operation, and maintenance costs. Basic principles of equipment's working and performance along with its design and installation in a place (building), its control systems further play a great role in its working with respect to its efficiency and long life. Since last few decades, manufacturers of HVAC&R equipment have been making an effort to make the systems more efficient. This was originally driven by rising energy costs, and has more recently been driven by increased awareness of environmental issues. Additionally, improvements to the HVAC system efficiency can also help increase occupant health and productivity.

Basics of HVAC&R Control system

To keep customers satisfied, there is a need to supply robust machines that are energy-efficient and reliable all at a reduced cost and with short lead-times. Customers also expect the best service, anytime and anywhere in the world. Choice of control solutions is the key to distinguish at every stage of the process, from design and development, to implementation and machine maintenance. Electrical control system is an integral and important part of HVAC&R system. Any HVAC&R equipment needs a control system to regulate the operation of a heating and/or air conditioning system. Usually, a sensing device is used to compare the actual state (e.g. temperature) with a target state. Then the control system draws a conclusion



what action has to be taken. An HVAC&R control system has to conform with stringent health and safety laws, and react accordingly when a state of emergency occurs, such as fire, smoke or flood. It must also interface with other systems in the same building - boilers, chillers, etc. Tailor made electrical control panels available will provide the information needed at the required time and at the right place. Control panel information includes instrumentation and controls geared to individual requirements. This would include, but not be limited to:

- Motor and process control, environmental control (HVAC&R)
- Comprehensive local or remote, relay or PLC automatic controls

With all the necessary cable entries and correct instrumentation to suit the application and systems will be designed to interface with fire alarm, boiler, and chiller systems as required. Other features or integrated options will include alarm systems and annunciators. Need is to design a cost-optimized HVAC&R control system with onboard energy-efficiency solutions. Improve machine performance with innovative automation technology and dedicated HVAC&R application functions, supplemented with advanced drive technology, to increase energy efficiency while reducing maintenance and improving reliability with energy-efficiency related functions such as energy management, floating high-pressure control, and compressor management. The benefits of HVAC&R Control Systems can be summarized as:

- Lower energy cost
- Lower operations cost
- Increase flexibility
- Ensure quality building environment

Elements of HVAC&R Control System

HVAC control system, from the simplest room thermostat to the most complicated computerized control, has four basic elements: i) Sensors, ii) Controllers, iii) Controlled Devices and iv) Source of energy.

1. **Sensors:** Sensor measures actual

value of controlled variable such as temperature, humidity or flow and provides information to the controller. Type of Sensors: Different types of sensors produce different types of signals as follows:

- **Analog sensors** are used to monitor continuously changing conditions. The analog sensor provides the controller with a varying signal such as 0 to 10V.
- **Digital sensors** are used to provide two position open or closed signal such as a pump that is on or off. The digital sensor provides the controller with a discrete signal such as open or closed contacts.

Classification of Sensors

Typical sensors used in electronic control systems are:

Resistance sensors are 'Resistance Temperature Devices (RTD's)' and are used in measuring temperature. Examples are BALCO elements, Copper, Platinum, 10K Thermistors, and 30K Thermistors.

Voltage sensors could be used for temperature, humidity and pressure. Typical voltage input ranges are 0 to 5 Vdc (Volts direct current), 1 to 11 Vdc, and 0 to 10 Vdc.

Current sensors could be used for temperature, humidity, and pressure. The typical current range is 4 to 20 mA (milliamps).

Temperature Sensors

- Bi-Metallic Strip
- Sealed Bellows
- Bulb & Capillary Sensors

Electronic Sensors

- Resistance Temperature Devices (RTD)
- Thermistors
- Thermocouples

Relative Humidity Sensors

- Resistance Relative Humidity Sensor
- Capacitance Relative Humidity Sensor
- Temperature Condensation
- Condensation & Wetting
- Quartz Crystal Relative Humidity Sensor

Pressure Sensors

- Variable Resistance
- Capacitance

Flow Sensors

- Orifice
- Venturi Tube
- Flow Nozzles
- Vortex Shedding Sensors
- Positive Displacement Flow Sensors
- Turbine Based Flow Sensors
- Magnetic Flow Sensors
- Ultrasonic Flow Sensors

Air Flow Measurements

- Hot Wire Anemometers
- Pitot – Static Tube

Liquid Level Measurements

- Hydrostatic Sensors
- Ultrasonic Sensors
- Capacitance Sensors

2. **Controllers:** Controller receives input from sensor, processes the input and then produces intelligent output signal for controlled device.

Controller Types

- Temperature Controllers
- Relative Humidity Controllers
- Enthalpy Controllers
- Universal Controllers

Controlled devices: Controlled device acts to modify controlled variable as directed by controller.

Controlled Devices Types

- Control Valves
- Heating and Cooling Coils
- Dampers
- Actuators

3. **Source of energy:** Source of energy is needed to power the control system. Control systems use either a pneumatic or electric power supply.

Supervisory Control System

The role of supervisory control is to control the scheduling and interaction of all the subsystems inside a building to meet building needs with appropriate operator input. Supervisory control systems have many names; each used for a particular emphasis. Among the names and their acronyms are the following:

BMS: Building management system

EMCS: Energy monitoring and control system

FMS: Facility management system

EMS: Energy management system

BAS: Building automation system (The most generic of these terms)

BAS is where mechanical and electrical systems and equipment are joined with microprocessors that communicate with each other and possibly to a computer. This computer and controllers in the building automation system can be networked to the internet or serve as a standalone system for the local peer to peer controller network only. Additionally, the BAS controllers themselves do not need a computer to process the control functions as the controllers have their own internal processors.

Type of HVAC&R Control Systems

There are five different types of HVAC&R Control Systems as follows:

Direct Acting Systems: The simplest form of controller is direct-acting, comprising a sensing element which transmits power to a valve through a capillary, bellows and diaphragm. The measuring system derives its energy from the process under control without amplification by any auxiliary source of power which makes it simple and easy to use. The most common example is the thermostatic radiator valve which adjusts the valve by liquid expansion or vapor pressure.

Electric / Electronic Systems: Electric controlled devices provide ON / OFF or two-position control. In residential and small commercial applications, low voltage electrical controls are most common. A transformer is used to reduce the 115 volt alternating current (AC) to a nominal 24 volts. This voltage signal is controlled by thermostats, and can open gas solenoid valves, energize oil burners or solenoid valves on the DX cooling, control electric heat, operate two position valves and damper or turn on-off fans and pumps. A relay or

contactor is used to switch line voltage equipment with the low voltage control signal. An electronic control system can be enhanced with visual displays that show system status and operation.

Pneumatic Systems: The most popular control system for large buildings historically has been pneumatics which can provide both On-Off and modulating control. Pneumatic actuators are described in terms of their spring range. Compressed air with an input pressure can be regulated by thermostats and humidistat. By varying the discharge air pressure from these devices, the signal can be used directly to open valves, close dampers, and energize other equipment. The copper or plastic tubing carry the control signals around the building, which is relatively inexpensive. The pneumatic system is very durable, is safe in hazardous areas where electrical sparks must be avoided, and most importantly, is capable of modulation, or operation at part load condition. While the 24-volt electrical control system could only energize a damper fully open or fully closed, a pneumatic control system can hold that damper at 25%, 40% or 80% open. This allows more accurate matching of the supply with the load. Pneumatic controls use clean, dry & oil free compressed air, both as the control signal medium and to drive the valve stem with

the use of diaphragms.

Microprocessor Systems: Direct Digital Control (DDC) is the most common deployed control system today. The sensors and output devices (e.g., actuators, relays) used for electronic control systems are usually the same ones used on microprocessor-based systems. The distinction between electronic control systems and microprocessor-based systems is in the handling of the input signals. In an electronic control system, the analog sensor signal is amplified, and then compared to a set point or override signal through voltage or current comparison and control circuits. In a microprocessor-based system, the sensor input is converted to a digital form, where discrete instructions (algorithms) perform the process of comparison and control. Most subsystems, from VAV boxes to boilers and chillers, now have an onboard DDC system to optimize the performance of that unit. A communication protocol known as BACnet is a standard protocol that allows control units from different manufacturers to pass data to each other.

Mixed Systems: Combinations of controlled devices are possible. For example, electronic controllers can modulate a pneumatic actuator. Also, proportional electronic signals can be sent to a device called transducer, which converts these signals into proportional air pressure signals used by the pneumatic actuators. A sensor-transducer assembly is called a transmitter.

Future of HVAC&R Control System

The future of smart HVAC&R control systems is critical towards the comforts of life and the economy with the cost of natural resources, especially fossil fuels, undoubtedly set to rise over the coming years. Two futures are possible for HVAC&R controls. One is exciting; the other not so much so. In the



exciting scenario, controls rapidly evolve so that, in just a few years, building controls have extensive self-commissioning, self-tuning, self-diagnostic and correction, and even self-configuring features. HVAC&R systems simply require components to be connected together with a short list of parameters set, and the system takes off from there—notifying the commissioning agent, contractor, engineer and/or operator if it is meeting its specified high-performance criteria, or, if it is not, what corrective steps are necessary. Multi-variable relational control can greatly improve performance, energy efficiency, and system stability. But relational control offers much more. This multivariable method of control provides an ideal platform for extension into a type of artificial intelligence called neural net control, which will begin a new era in building control. Relational control allows the software designer to select a wide variety of system variables that may influence the optimal operation of a system. The multivariable relationships may be very basic, such as fluid mixing laws, or much more complex, such overall energy optimization via the equal marginal performance principle. The logical next step in HVAC&R control software development is software modules that will automatically discover other variables (and/or combination of variables) that will assist further in tuning, optimization, self-configuration, self-setup, and fault detection with prescribed corrective actions. It's becoming universally clear that such widespread implementation of advanced building control could cut total energy consumed by our buildings by about half, while at the same time improving occupant comfort.

Innovations That Will Change HVAC&R Forever

Innovative technologies are taking the world by storm. As high-tech gadgets and the latest smart phone innovations continue to improve our lives, people have something else to look forward to in terms of revolutionary HVAC&R technologies that could change how we heat and cool our comfort zones to industry. Many of these HVAC technologies are still on the drawing board, but there are some we can take advantage of now to boost HVAC&R comfort levels. These technologies are:

- Movement-Activated Air Conditioning
- Thermally Driven Air Conditioning
- On-Demand Hot Water Recirculator
- Ice-Powered Air Conditioning
- Sensor-Enhanced Ventilation
- Dual-Fuel Heat Pumps
- Geothermal Heat Pumps
- Smart Homes
- Fully Automated Homes
- 3-D Printed Air Conditioners
- Harnessing Heat from a Computer

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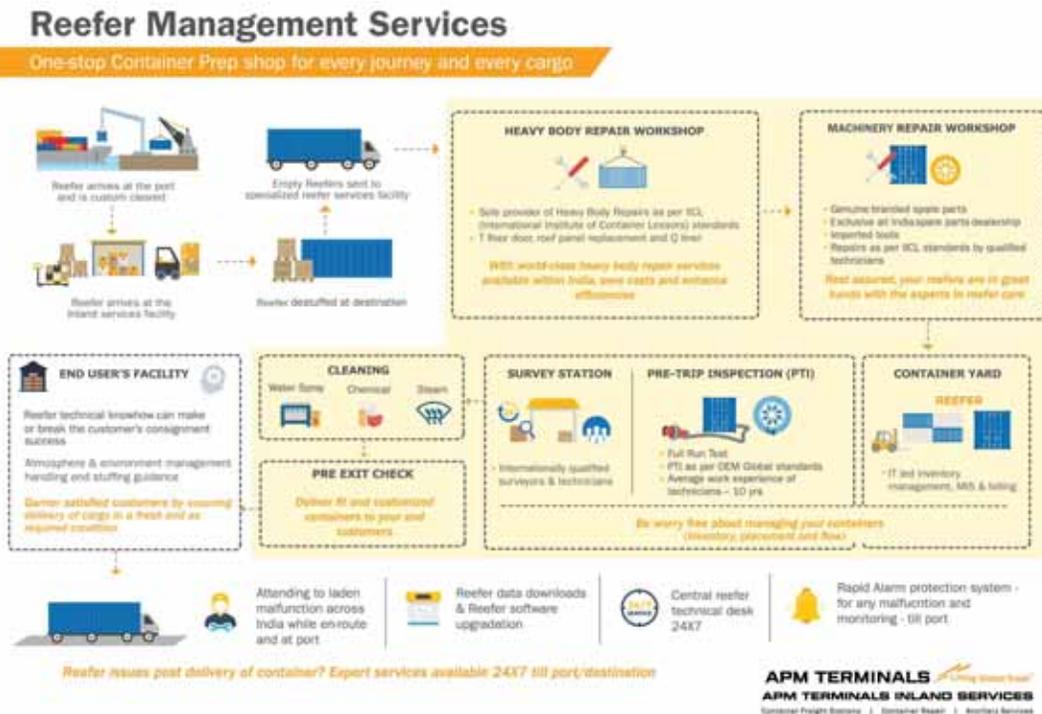
Need for Holistic Approach

Reefer consignments, unlike standard container shipments are extremely complicated and are far more skill and knowledge-intensive. It is essential that a strong awareness encompasses such crucial aspects as the specific atmospheric and environmental controls required for refrigerated containers, and the correct loading procedures...

responsibility to help improve this process. At APM Terminals Inland Services, we have been constantly working to improve our reefer management services, where global standards of customer-centric solutions are based upon a thorough understanding of the business environment, the customer's supply chain, and our own technical expertise. This is an ongoing challenge.

Advancements that can enable Indian farmers to deliver fresh alphonso mangoes too far off regions such as Europe, skill sets that ensure a shipment of

grapes is properly loaded and reaches its destination in the required condition, technology to ensure visibility of reefer container temperature and atmosphere throughout the trip are just some examples of where a joint effort by all stakeholders together can ensure success in the refrigerated supply chain. ■



India has over the years displayed a steady growth in its reefer trade, thanks to an expanded product base and improvements in transportation infrastructure. Indian imports of refrigerated cargo in 2016 grew by 19%, while the export of vegetables alone grew by 60% last year. Pharma exports have also risen consistently over the years. This growth is an indication of both the progress and potential India has in reefer trade; that said, there is still a long way to go.

Reefer consignments, unlike standard container shipments are extremely complicated and are far more skill and knowledge-intensive. It is essential that a strong awareness encompasses such crucial aspects as the specific atmospheric

and environmental controls required for refrigerated containers, and the correct loading procedures. A holistic and inclusive approach towards development of the cold chain and reefer trade for India is extremely important. The National Centre for Cold Chain Development has been making progress and is contributing significantly in this direction through initiatives such as skill building workshops, industry forums, the introduction of updated guidelines and, most importantly, by emerging as a leading and effective industry think tank.

All constituents in the supply chain - right from the farmer or producer to the transporter, truck driver, warehouse provider, reefer services providers and everyone in between- have an equal

Ajit Venkataraman
MD
APM Terminals India Pvt Ltd



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ABB Technology Ventilates Road Tunnel in J&K

ABB's technology is central to another major Indian infrastructure project. High power drives and motors run the ventilation system with specialized safety software, contributing to the efficient operations of this critical connectivity link.

The new 10.8 kilometre Chenani-Nashri tunnel in Jammu & Kashmir, the longest highway tunnel in Asia, will feature a state-of-the-art ABB ventilation system to ensure that users have access to fresh air as they drive through it. ABB India has partnered with IL&FS Transportation Networks Ltd. and Sterling & Wilson Ltd. in the development of yet another major Indian infrastructure project. "This is a proud moment for us," said Sanjeev Sharma, CEO and Managing Director, ABB India. "We are providing the muscles and lungs for this critical new tunnel."

ABB's technology sits at the heart of

some of the world's most complex and advanced infrastructure. ABB built the world's most powerful ventilation system for Gotthard Base Tunnel in Switzerland, which opened to the public in December 2016. It is the world's longest (57 kilometres) and deepest (8,000 feet maximum depth) train tunnel. From measuring devices in London Tower Bridge to the London Underground to the Statue of Liberty and Burj Khalifa, ABB technologies have been a part of landmark projects around the world.

In case of the new Chenani-Nashri tunnel, it will reduce the distance between state capitals by 30 km while ensuring safe and swift passage for commuters, even in adverse weather conditions. This tunnel is the India's first and the world's sixth road tunnel with a transverse ventilation system enabled by ABB drives and controlled by ABB software. For such long tunnels, ventilation systems are essential to maintain clean air, permissible carbon dioxide levels and expel harmful vehicle emissions. To ensure smooth travel and safety of commuters, ABB has designed, engineered and supplied low harmonics variable speed drive (VSD) system for tunnel ventilation. The VSDs and motors are installed at the North (Nashri) and South (Chenani) portals for air supply and exhaust.

These VSDs are also equipped with inbuilt redundancy to ensure minimum downtime.

Sharma said, "We have been present in India for more than a century now and have been partnering and contributing to critical infrastructure projects in the country with our global technological expertise. The new tunnel's safety controls were developed by ABB in India, for effectively mitigating any fire emergencies."

The Chenani-Nashri tunnel, at an altitude of 1,200 meters, is a part of National Highway Authority of India's (NHAI's) project between Jammu and Srinagar, along National Highway 44. The existing route between the towns of Chenani and Nashri passes through Patnitop and is prone to heavy snowfall and avalanches leading to frequent roadblocks and unsafe travel.

"Technologically this is one of the most advanced road tunnels built in the country, surmounting challenges of terrain and distance. We are proud that ABB technologies will save time and costs for the people of Jammu & Kashmir," said Subir Pal, President, Robotics and Motion, ABB India.

ABB is a pioneering technology leader in electrification products, robotics and motion, industrial automation and power grids, serving customers in utilities, industry and transport & infrastructure globally. Continuing more than a 125-year history of innovation, ABB today is writing the future of industrial digitalization and driving the Energy and Fourth Industrial Revolutions. ABB operates in more than 100 countries with about 132,000 employees. ■



Environment Friendly Chillers

They are used to lower the temperatures of all kinds of equipment and processes such as robotic machinery, semiconductors, injection and blow moulding machines; welding equipment, die-casting and machine tooling, paper and cement processing, power supplies, power generation stations, compressed air and gas cooling systems, medical imaging machines, chemical, drug, food and beverage production. This can even be used simply to cool potable water to desirable levels...

A chiller is a heat transfer device that uses refrigeration to remove heat from a process load and transfers the heat to the environment. So, chillers are the cooling machines used for various industrial, commercial, and institutional facilities. They are used to lower the temperatures of all kinds of equipment and processes such as robotic machinery,

semiconductors, injection and blow moulding machines; welding equipment, die-casting and machine tooling, paper and cement processing, power supplies, power generation stations, compressed air and gas cooling systems, medical imaging machines, chemical, drug, food and beverage production. This can even be used simply to cool potable water to

desirable levels. In all the applications and processes, water temperature control plays an important role in many of the activities that affect our everyday lives.

Types of Chillers

The different types of HVAC (Heating Ventilation and Air conditioning) chillers are classified as shown in figure 1. The two primary types of chillers are:

1. Absorption chillers.
2. Vapour Compression Chillers.

Absorption chillers use a heat source such as natural gas or steam to create a refrigeration effect. Refrigerant chillers use mechanical compression and are the most common. Refrigerant compression chillers consist of four main components - a compressor, an evaporator, a condenser and a valve metering system. The refrigerant compression chillers are mainly classified into air cooled chillers and water



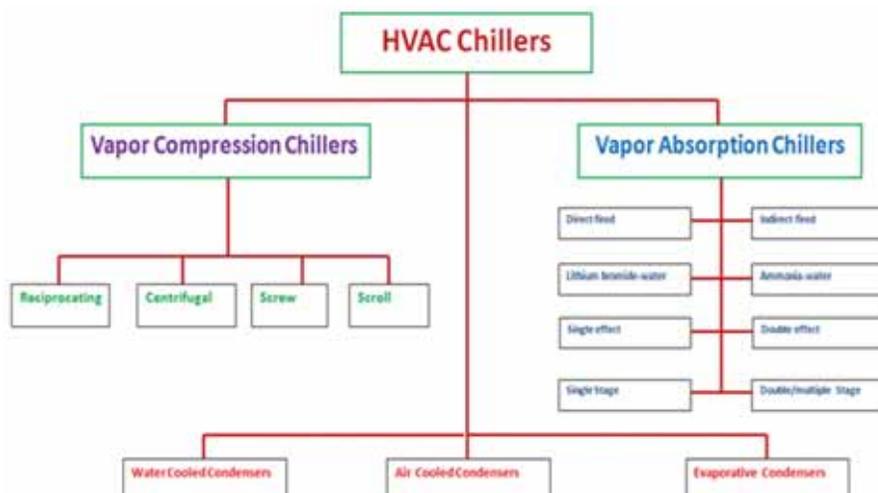


Figure 1: Classification of chillers

cooled chillers. Air condensers are cooled by utilizing the air, whereas water condensers are cooled by using water sources. Water cooled chillers are generally located within the building and use cooling towers, a pond, or river located near the building to reject water's heat from the condenser. Chillers with condensers cooled by air operate almost the same as those cooled by water regarding the refrigerant cycle except that the cooling medium on the condenser is air instead of water and are intended for outdoor installation and operation. They reject heat to the atmosphere by mechanical means such as circulation of

outdoor air by a fan directly through the machine's condenser. These types of condenser cooled units do not require a cooling tower unlike water cooled chillers, since the air rejects to the atmosphere. The refrigerant chillers can be further classified based on the type of compressors used like reciprocating compressors, centrifugal compressors, rotary screw compressors and rotary scroll compressors.

Absorption Cycle

Absorption chiller is a machine which operates based on absorption cycle. The absorption cycle consists of four major

heat exchangers, (generator, condenser, evaporator and absorber) with two kinds of solution, (refrigerant and absorbent). During this cycle high pressure will take place inside generator and condenser, while inside evaporator and absorber there will be low pressure. The cycle starts when we input waste heat into generator and as a result of this heat input, the solution inside will be separated into refrigerant and weak solution. The refrigerant part will enter into condenser where it will be cooled and changed into liquid and the solution part will enter absorber. The refrigerant will flow inside evaporator and will absorb heat from cooled water that is in circulation inside evaporator. As a result of this process, temperature of circulated water will decrease and is used for air-conditioning. The evaporated refrigerant will then enter absorber where it will be mixed with weak solution. The mixture will then get the liquid state and finally it will enter generator and the cycle is repeated. Schematic diagram of a vapour absorption chiller has been shown in figure 2.

The absorption chillers as compared to compression chillers provide certain disadvantages like lower response time, higher costs and a smaller Coefficient of Performance (COP) which makes absorption chillers less attractive. The advantage of absorption systems is that they can be used in an integrated way in energy cogeneration systems. Also, the thermal waste from these systems can be used to decrease the direct consumption of electricity for cooling, which is not the case when using compression refrigeration. Absorption chillers could also operate indirectly by providing hot water in the temperature range of 70 – 95°C by using solar energy to heat water.

Vapour Compression Chiller

Vapour-compression water chillers have been widely used to cool water or secondary coolant for air-conditioning and refrigerating applications in both commercial and industrial fields. Fig. 3 shows that the main components of a vapour-compression water chiller include compressor, condenser, throttling device,

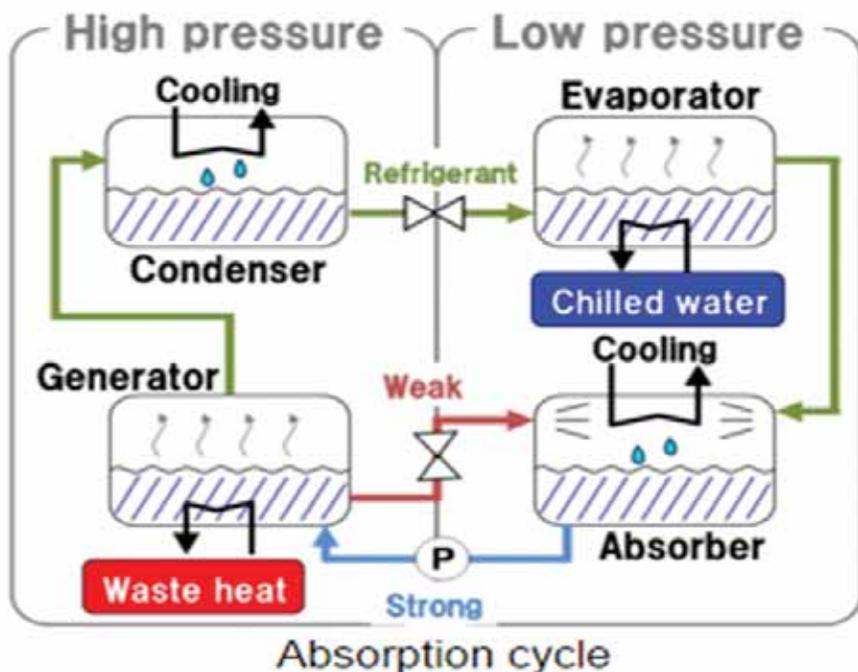


Figure 2: Vapour absorption cycle for chiller

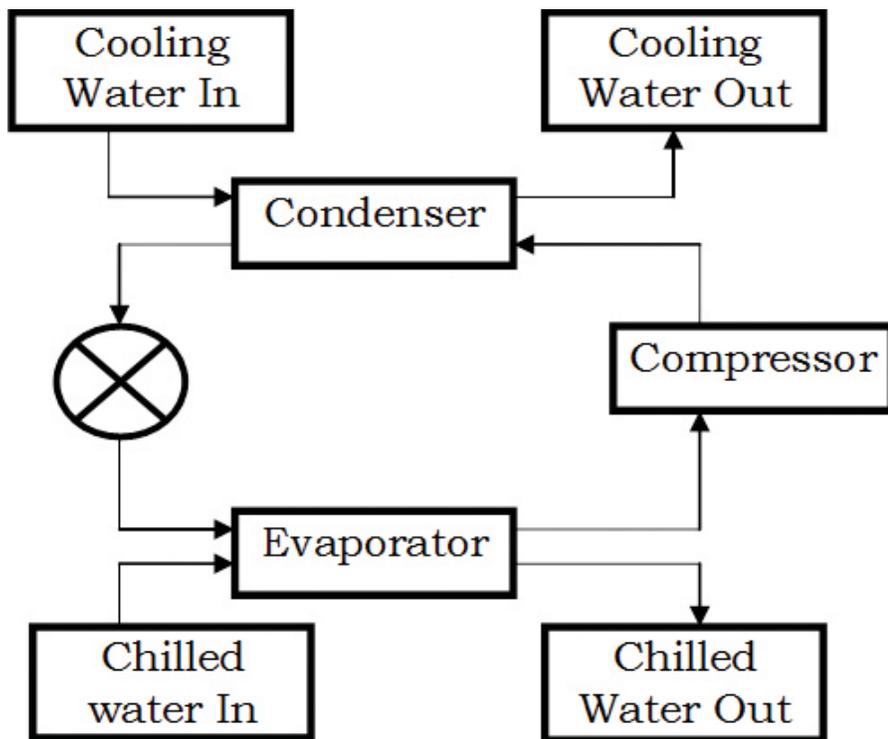


Figure 3: Schematic representation of vapour compression chiller

and evaporator (liquid cooler). The coefficient of performance (COP) for water chillers is defined as the ratio of the evaporator cooling capacity to the compressor input power.

Heat Addition to Refrigerant in Evaporator

Refrigerant gets vaporized by taking heat from chilled water in evaporator. It leaves the evaporator as vapours but on other side chilled water is produced. Thus, heat is added to refrigerant at constant pressure but is extracted from chilled water. Both refrigerant and chilled water don't get mixed and are separated by some solid wall in between them in evaporator like in shell and tube design. Refrigerant vapours come out of evaporator and then get compressed by chiller compressor to high pressure and temperature.

Compression of the refrigerant (2-3):

The refrigerant vapours from the evaporator get compressed to higher pressure in the compressor and then sent into the condenser to get converted into liquid phase by rejecting heat.

Heat rejection by refrigerant in condenser (3 - 4):

Refrigerant rejects its heat to outside cooling liquid or air. In this way, refrigerant gets condensed and outside media is heated. Outside media e.g. cooling water may be cooled by cooling tower and recycled again into condenser.

Expansion of refrigerant in expansion valve (4 - 1):

Refrigerant in condensed form coming out of condenser is expanded in expansion valve and its pressure and temperature is reduced to level of evaporator so that above cycle is repeated again.

Table 1: Comparison between R134a and R1234ze at $T_e = -13^\circ\text{C}$ and air inlet temperature to evaporator -5°C for internal load 600 W.

Variables	R134a	R1234ze
COP	2.175	2.2919
Compressor power [kW]	1.5168	1.1927
Evaporator capacity [kW]	3.2936	2.6464
Mass flow rate [kg/s]	0.02083	0.01855
Discharge pressure [kPa]	1076.22	901.77
Suction pressure [kPa]	310.65	163.07

Environmental Effect of Refrigerants

Vapour compression refrigeration systems (VCR) uses different refrigerants as working fluids to provide cooling effect. These refrigerants are a great threat to the environment. The two important parameters which are used to measure the impact of the working fluids on the environment are the ozone depletion potential (ODP) and the global warming potential (GWP). Various protocols and international agreements were signed as the part of steps taken to decrease the harmful effect of refrigerants on the environment. The protocol of Montreal in 1987 limited the use of the CFC and HCFC refrigerants while Kyoto protocol in 1998 was signed to check the CO₂ and the greenhouse gases emissions. The intension behind these agreements is to make countries reduce their greenhouse gas emissions by at least 5% compared with the level of 1990, during the period of commitment from 2008 to 2012. In 2015, the United Nations Climate Change Conference (COP21) was held in Paris, France. The objective of this conference was to achieve, a universal agreement on climate, from all the nations of the world, with the aim of keeping global warming below 2 °C. On April 2016, 174 countries signed the agreement and began adopting it. The current researches in VCR systems deal with the modelling and the exergy analysis of systems. The refrigerants with low GWP and zero ODP are the need of the hour.

Low GWP Refrigerants for Chillers

Midgley first discovered the excellent thermodynamic properties of halogenated CFC refrigerants. But in 1974 Molina and Rowland stated the adverse effects of these refrigerants category on environment which leads to banning of those CFC and HCFC refrigerants. Refrigerants such as CFCs and HCFCs including R11, R12, R22 and R502 have depleted the ozone layer for years and consequently lead to the greenhouse effect on the climate. Hence, efforts are being made in order to find out alternative refrigerants to replace the present high GWP refrigerants. Kabeel et

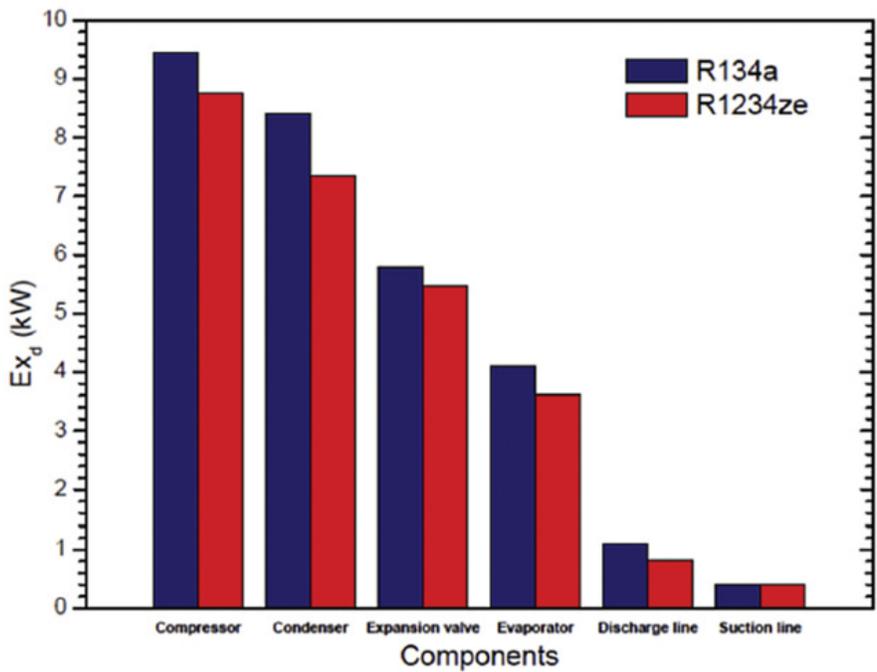


Figure 4: Exergy destruction for different components

al. suggested R1234yf and R1234ze as alternative refrigerants for R134a, which has a GWP of 1430. The alternative refrigerants R1234ze and R1234yf have zero ODP and the GWP values of 6 and 4 respectively with mild flammability and low toxicity. They observed greater value of COP and lower values of compressor power, evaporator capacity, mass flow rate, discharge pressure and suction pressure using R1234ze as shown in table 1. There are many other researches which proposed alternative refrigerants. Leighton et al. found through steady state analysis of domestic refrigerator-freezer that, for

R1234ze, the evaporator capacity was decreased by about 21.5% and the COP was increased by about 7.9%. Francisco et al. introduced a theoretical energy performance evaluation of different single stage vapor compression refrigeration configurations using R1234yf and R1234ze(E) as working fluids. They noticed that, there was an increment increase of 9% to 15% for R1234yf and 11% to 20% for R1234ze on COP with respect to basic cycle. However, the main disadvantage of these refrigerants on the system was the increase in complexity of the system and increase of cost. Though

the alternative refrigerants like R1234yf and R1234ze which belong to the hydro-olefin family of refrigerants offer the above said disadvantages, necessary steps should be taken to overcome them because these refrigerants offer very less harmful environmental effect in terms of ODP and GWP as compared to the conventional refrigerants with high GWP values.

Radhouane Ben Jemaa et al considered an air-cooled vapour compression chilled water (VCCW) system and carried out energy and exergy analysis using working fluid R1234ze as alternative to R134a. They developed a thermodynamic model using the Engineering Equation Solver (EES). They investigated the effect of evaporator temperature and ambient temperature on the energy and exergy efficiencies, the total exergy destruction and the exergy losses in different components of the system. The exergy destruction for different components has been shown in figure 4. It was observed that the exergy destruction was less in all the components for R1234ze as compared to that for R134a. Also, the maximum exergy destruction was observed in the compressor. The effect of evaporator temperature and ambient temperature on COP has been shown in figures 5(a) and 5(b) respectively. In both the cases there was only slight difference in COP for R1234ze and R134a. For both refrigerants, no important differences are observed between the energy and the exergy

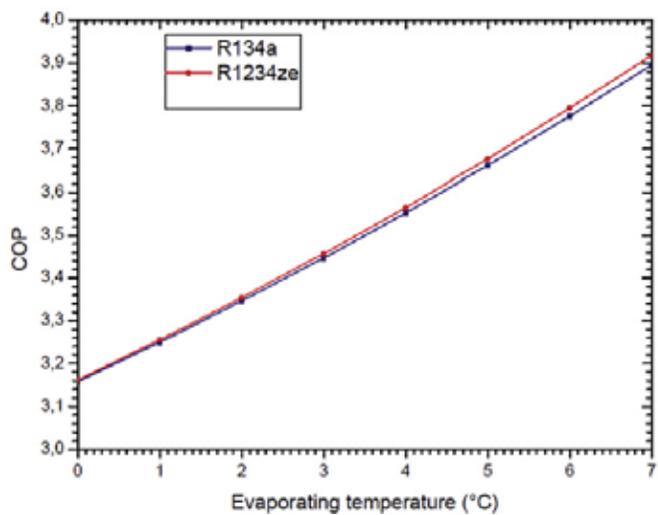


Figure 5(a): COP vs. evaporating temperature

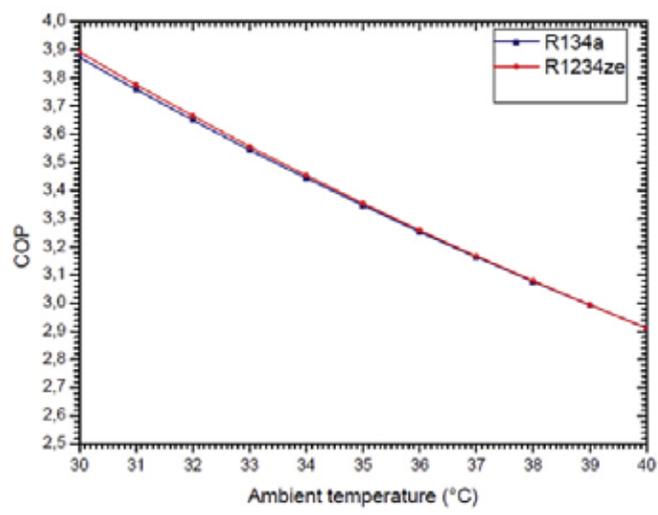


Figure 5(b): COP vs. ambient temperature

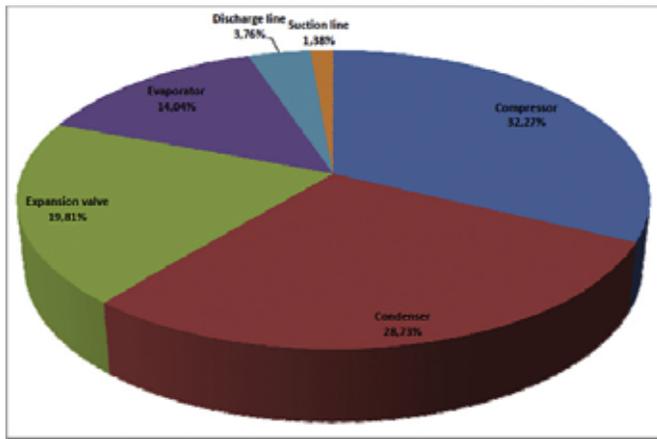


Figure 6(a): Relative irreversibility of different components (R134a)

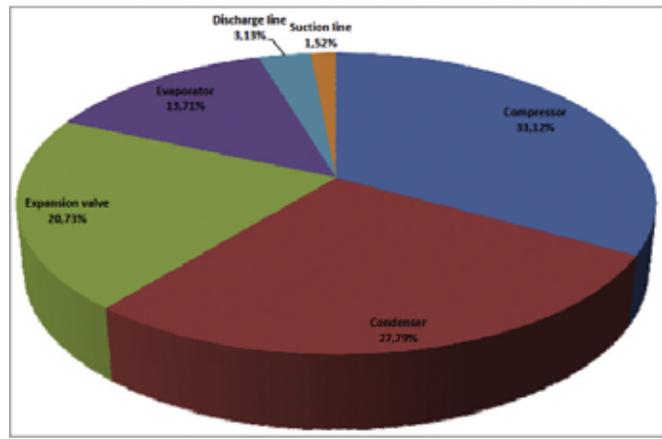


Figure 6(b): Relative irreversibility of different components (R1234ze)

efficiencies. The relative irreversibilities for different components using R134a and R1234ze have been shown in figures 6(a) and 6(b) respectively. The irreversibility obtained in the unit using R1234ze is lower than the R134a. R1234ze is a good alternative to R134a in the VCCW systems.

Variable Speed Control Chillers

The operation of chillers commonly used in central air-conditioning systems consumes the large amount of electricity in commercial buildings. The reduction in power consumption can be achieved by using variable speed control applied to system components as building cooling demand varies with weather conditions. Al-Bassam and Alasserri identified energy savings of 5.8% when dual speed control was replaced by variable speed drives for evaporative cooling tower fans in a chiller system operating for summer seasons in Kuwait. Hartman proposed an equal marginal performance principle to optimize

the energy performance of chiller systems with variable speed control for chillers, condenser water pumps and cooling tower fans. Bahnfleth and Peyer analyzed how variable speed control for chilled water pumps helped save pumping energy while maintaining proper temperature difference across the supply and return headers of a chilled water circuit. Oil-free magnetic bearings are used in the chiller compressors to give friction-free rotation which brings improved compressor efficiency at speed regulation. Heat transfer effectiveness at the evaporators can be maximized as no lubricating oil is brought in the refrigerant. Yu et al. examined the energy improvement of using oil-free chillers in a system retrofit. They found that by using oil-free chillers with variable speed control brought an energy saving of 9.6% in the total electricity consumption of a shopping arcade when they operated for a wide range of system cooling demands. The monthly total electricity consumption saving by using

oil-free chillers has been shown in figure 7.

Conclusions

1. Hydrocarbons as refrigerants offer the possibility of good efficiencies. HFOs will become the new mainstream refrigerants of choice for chillers if necessary changes in the system are made.
2. The development of oil-free centrifugal compressors, where magnetic bearings replace the use of oil for lubrication has seen even greater increases in efficiency and lower operating costs.
3. The advantage of absorption refrigerants that they can be used efficiently in integrated co-generation systems should be considered. ■

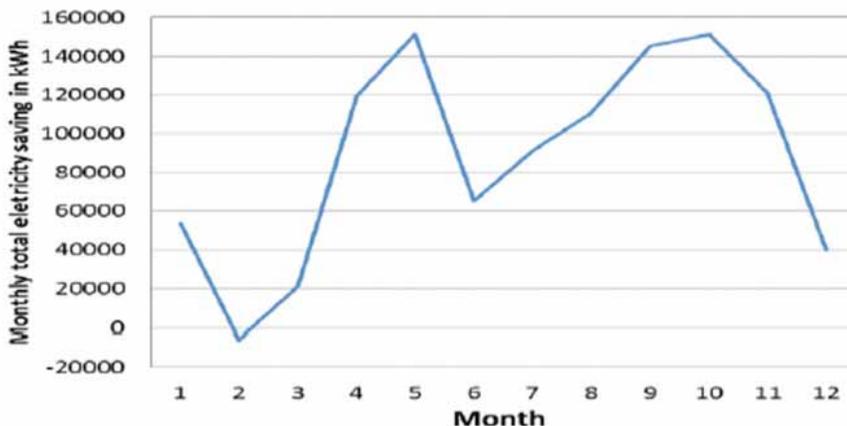


Figure 7: Monthly total electricity consumption saving by using oil-free chillers

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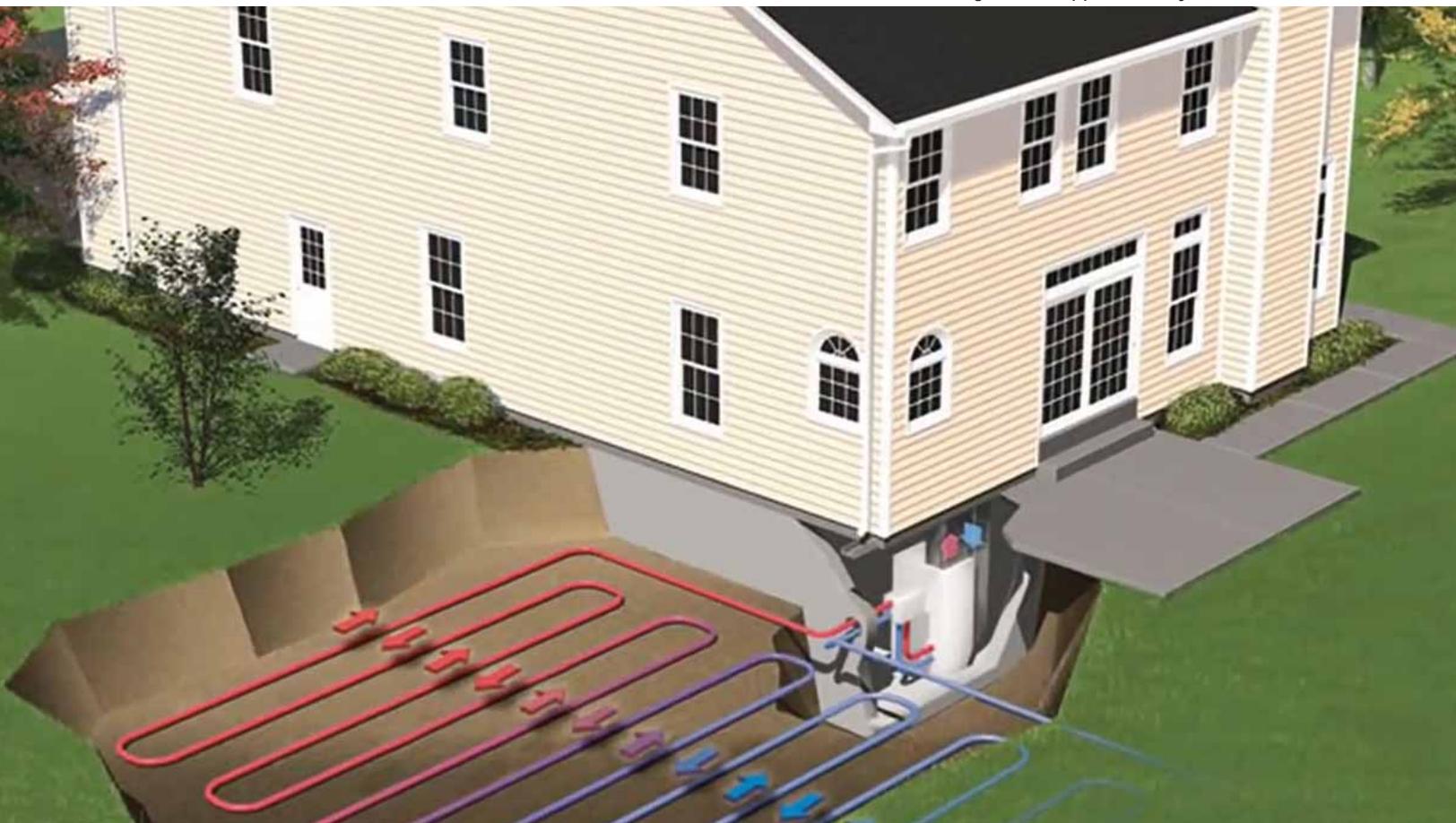


Utilisation of Ground Source Energy

Part 2

The main goal of this study is to stimulate the uptake of the GSHPs. Recent attempts to stimulate alternative energy sources for heating and cooling of buildings has emphasised the utilisation of the ambient energy from ground source and other renewable energy sources. The purpose of this study, however, is to examine the means of reduction of energy consumption in buildings, identify GSHPs as an environmental friendly technology able to provide efficient utilisation of energy in the buildings sector, promote using GSHPs applications as an optimum means of heating and cooling, and to present typical applications and recent advances of the DX GSHPs...

Geothermal heat pumps (GSHPs), or direct expansion (DX) ground source heat pumps, are a highly efficient renewable energy technology, which uses the earth, groundwater or surface water as a heat source when operating in heating mode or as a heat sink when operating in a cooling mode. It is receiving increasing interest because of its potential to reduce primary energy consumption and thus reduce emissions of the greenhouse gases (GHGs). The main concept of this technology is that it utilises the lower temperature of the ground (approximately $<32^{\circ}\text{C}$), which



remains relatively stable throughout the year, to provide space heating, cooling and domestic hot water inside the building area. The main goal of this study is to stimulate the uptake of the GSHPs. Recent attempts to stimulate alternative energy sources for heating and cooling of buildings has emphasised the utilisation of the ambient energy from ground source and other renewable energy sources. The purpose of this study, however, is to examine the means of reduction of energy consumption in buildings, identify GSHPs as an environmental friendly technology able to provide efficient utilisation of energy in the buildings sector, promote using GSHPs applications as an optimum means of heating and cooling, and to present typical applications and recent advances of the DX GSHPs. The study highlighted the potential energy saving that could be achieved through the use of ground energy sources. It also focuses on the optimisation and improvement of the operation conditions of the heat cycle and performance of the DX GSHP. It is concluded that the direct expansion of the GSHP, combined with the ground heat exchanger in foundation piles and the seasonal thermal energy storage from solar thermal collectors, is extendable to more comprehensive applications.

Applications for Earth Energy

The decision to use geothermal heat pumps should be based on the results of geotechnical or hydrogeological investigations. Sites may be encountered that are inappropriate for geothermal heat pumps. The geothermal heat-pump system is an all-electric system. A life-

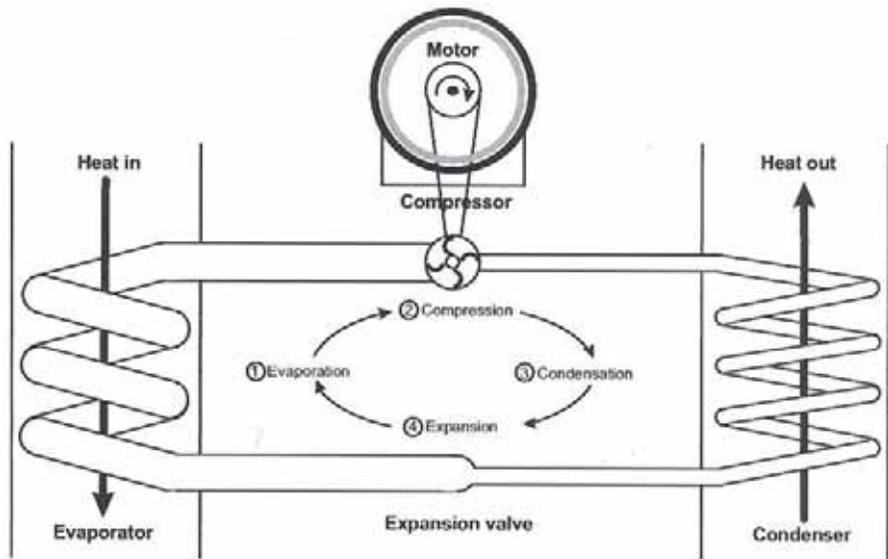


Figure 1. Ground source heat pumps

cycle analysis, using gas and electric rates, initial costs, maintenance costs, and replacement costs, must be conducted before selecting these systems. These systems may not be cost effective in locations with high electric rates and inexpensive gas. The geothermal heat-pump concept is not a good candidate for buildings that are not expected to have heating loads. EE units can be used for the dehumidification of indoor swimming pool areas, where the unit can dehumidify the air and provide condensation control with a minimum of ventilation air. The heat recovered from the condensed moisture is then used for heating domestic/pool water or for space heating. EE systems are also used as heat recovery devices to recover heat from building exhaust air or from the wastewater of an industrial process. The recovered heat is then supplied at a higher temperature at which it can be more readily used for heating air or water.

Thermal Storage

If the use of peak electricity and want to ensure the even distribution of hot water, then it is worth considering a thermal store. The water, which is heated by the heat pump, can be stored in a large insulated tank at about 50°C and only used when needed. The thermal store can also link into solar water panels providing an additional source of renewable energy. Thermal storage requirements will vary in size depending on house construction and insulation.

The key to the diffusion of any innovation is the ability to reduce the uncertainty or risk associated with the innovation. There are several diffusion attributes of a technology that help us identify the technology's ability to overcome uncertainty and achieve potential adoption. The key attributes have been divided into five categories, presented below with our assessment of the status of GSHP relative to these attributes (Table 1).

Table 1: Key attributes have been divided into five categories, presented with assessment of the status of GSHP relative to these attributes

Perceived Attribute	Description	GSHP Residential	GSHP Non-Residential
Relative advantage	The degree to which GSHP will perform better than any other space conditioning system.	Opportunity	Opportunity
Divisibility	Ability to try on a limited basis before full adoption.	Barrier	Neutral
Communicability	How well does the technology communicate benefits?	Barrier	Barrier
Compatibility	How closely does a GSHP system compare to conventional HVAC systems?	Barrier	Barrier
Complexity	How easy is it to understand both the benefits and features of the technology?	Barrier	Barrier

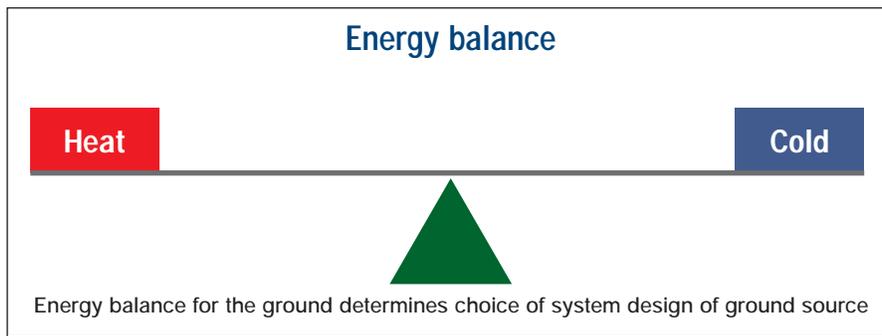


Figure 2: Energy balance for ground

Efficient heating performance makes EE a good choice for the heating and cooling of commercial and institutional buildings, such as offices, stores, hospitals, hotels, apartment buildings, schools, restaurants and penitentiaries. EE systems can heat water or heat/cool the interior space by transferring heat from the ground outside, but they can also transfer heat within buildings with a heat-producing central core. The technology can move heat from the core to perimeter zones where it is required, thereby simultaneously cooling the core and heating the perimeter.

Heating and Cooling

A GSHP extracts solar heat stored in the upper layers of the earth; the heat is then delivered to a building. A re-circulating piping system connects the heat pump. The piping system adds or removes heat to the circulating water. GSHPs can reduce the energy required for space heating, cooling and service water- heating in commercial/institutional buildings by as much as 50% (Figure 1). GSHPs replace the need for a boiler in winter by utilizing heat stored in the ground; this heat is upgraded by a vapour-compressor refrigeration cycle. In summer, heat from a building is rejected to the ground. This eliminates the need for a cooling tower or heat rejecter, and also lowers operating costs because the ground is cooler than the outdoor air.

Water-to-air heat pumps are typically installed throughout a building with ductwork serving only the immediate zone; a two-pipe water distribution system conveys water to and from the ground-source heat exchanger. The heat exchanger field consists of a grid of vertical boreholes with plastic u-tube heat exchangers connected in parallel. Simultaneous heating and cooling can occur throughout the building, as individual heat pumps, controlled by zone thermostats, can operate in heating or cooling mode as required. Unlike conventional boiler/cooling tower type water loop heat pumps, the heat pumps used in GSHP applications are generally designed to operate at lower inlet-water temperature.

The GSHP are also more efficient than conventional heat pumps, with higher COPs and EERs. Because there are lower water temperatures in the two-pipe loop, piping needs to be insulated to prevent sweating; in addition, a larger circulation pump is needed because the units are slightly larger in the perimeter zones requiring larger flows. GSHPs reduce energy use and hence atmospheric emissions. Conventional boilers and their associated emissions are eliminated, since no supplementary form of energy is usually required. Typically, single packaged heat pump units have no field refrigerant connections and thus have significantly lower refrigerant leakage compared to

central chiller systems. GSHP units have life spans of 20 years or more. The two-pipe water-loop system typically used allows for unit placement changes to accommodate new tenants or changes in building use. The plastic piping used in the heat exchanger should last as long as the building itself. When the system is disassembled, attention must be given to the removal and recycling of the HCFC or HFC refrigerants used in the heat pumps themselves and the anti-freeze solution typically used in the ground heat exchanger.

Radiant Heating & Cooling

There is an alternative source of heat beneath our feet. GSHPs are 380% efficient, 75% renewable and 100% reliable. The land absorbs radiant energy from sun, even on the darkest days (Figure 2). This is stored, every day, and all for free. Solar energy from above and geothermal heat from below maintains the subsurface UK ground temperature within a range of approximately 10°C – even in winter. GSHPs tap this low-grade energy and turn it into usable heat through the simple principle refrigeration- an idea recognised as long ago.

Conventional radiators have been used for many years to heat buildings. The radiators are located around the building perimeter. Because of the small surface area of the radiators, they must be operated at a high temperature to deliver sufficient heat. Modern systems are different in that they cover a large area of floor or ceiling and operate at temperatures much closer to room air temperature, approximately 15°C in cooling mode and 35 to 50°C in heating mode. The system cannot be operated at lower temperatures in cooling mode without the risk of condensation (Figure 3). The small temperature difference means that about 30% to 50% of the ceiling or almost the entire floor area must be available as heat transfer surface. Ventilation air is provided by a small-dedicated ductwork system and works particularly well with displacement ventilation concepts. Several companies have developed metal radiant panels that can be ceiling mounted, either attached directly to the ceiling or as part of a T-bar suspended ceiling. For floor systems,

Table 2: Design load and criteria

Design loads	Capacity (kW)	Annual energy load (MWh)
Heat load winter	410	925
Heat load summer	160	50
Cool load winter	90	190
Cool load summer	330	305

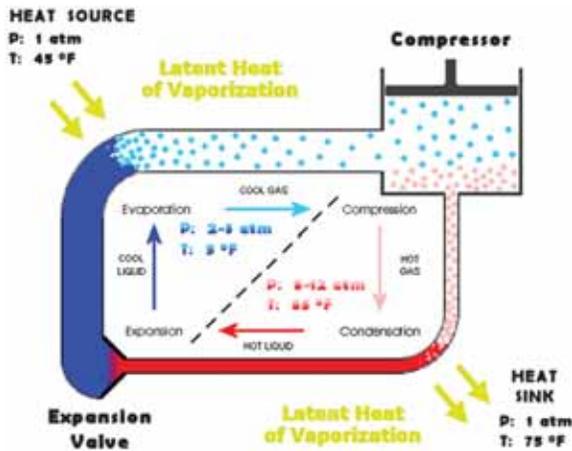


Figure 3: Heat pump works by promoting the evaporation and condensation of a refrigerant

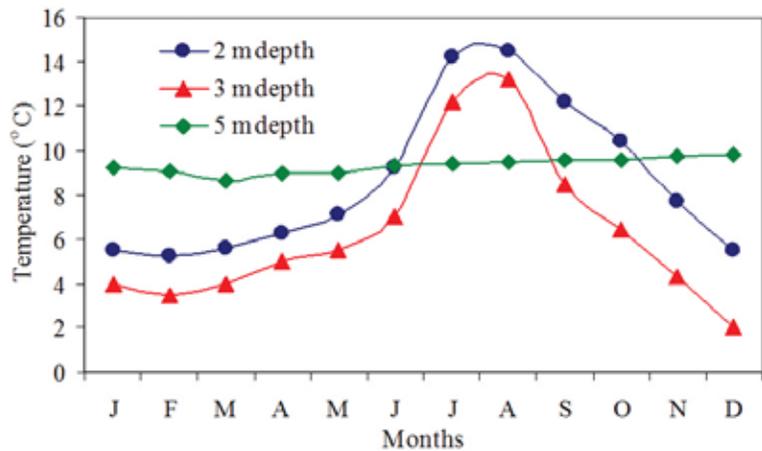


Figure 4: Ground temperatures throughout the year

flexible plastic piping is embedded in the concrete floor or in gypsum topping on a wooden sub-floor. Ceiling mounted systems are usually best for combined heating and cooling systems. Floor systems are best for heating-only systems (provided the floor isn't covered with heavy carpets). The amount of heat transfer depends on the direction of heat flow. Air in contact with a cooled ceiling panel will naturally fall as it is cooled increasing the movement of air over the panel. Conversely, air in contact with a warm ceiling will stratify at the ceiling and have low convective heat transfer. As a guide to system sizing, the total heat transfer rate (combined radiation and convection) is about 11 W/m²/°C temperature difference for cooled ceilings and heated bare floors. This value drops to 6 W/m²/°C for heated ceilings and cooled floors. Floor coverings such as carpeting reduce the output of heated floors. Radiant systems are more energy-efficient than air-based systems. They require less parasitic energy (pump and fan energy) to deliver heat. The low operating temperatures mean that boilers can operate more efficiently. Finally, because the walls are radiantly heated, the air temperature can be cooler to achieve the same level of comfort. These lower air temperatures result in lower heat losses to the outdoors (Table 2).

Heat Distribution System

The heat pump works by promoting the evaporation and condensation of a refrigerant to move heat from one place to another (Figure 4). A heat exchanger transfers heat from the water/anti-freeze

mixture in the ground loop to heat and evaporate refrigerants, changing them to a gaseous state. A compressor is then used to increase the pressure and raise the temperature at which the refrigerant condenses. This temperature is increased to approximately 40°C. A condenser gives up heat to a hot water tank, which then feeds the distribution system. Features include: Lower utility bills, less maintenance, no visible outdoor plant, reduction in emissions, and versatility of system.

Because GSHPs raise the temperature to approximately 40°C they are most suitable for under floor heating systems, which require temperatures of 30 to 35 °C, as opposed to conventional boiler systems, which require higher temperatures of 60 to 80°C. GSHPs can also be combined with radiator space heating systems and with domestic hot water systems. However, top-up heating would be required in both cases in order to achieve temperatures high enough for these systems. Some systems can also be used for cooling in the summer. Geothermal heat pumps are the most energy efficient, environmentally clean, and cost effective space conditioning systems available according to the Environmental Protection Agency in the United States of America. Ground Source Geothermal heating and cooling is a renewable resource, using the earth's energy storage capability. The earth absorbs 47% of the sun's energy amounting to 500 times more energy than mankind needs every year.

The closed loop portion of a ground source heat pump system consists of polyethylene pipe buried in the ground and

charged with a water/antifreeze solution. Thermal energy is transferred from the earth to the fluid in the pipe, and is upgraded by passing to a water source heat pump. One 100 metres vertical closed loop borehole will typically deliver 14000 KWh of useful heating energy and 11000 KWh of useful cooling energy every year for life. For typical commercial building early trials indicate annual HVAC energy consumption in the order of 75 kWh/m² compared with 156 kWh/m² 'good practice target', and 316 kWh/m² typical consumptions published by the Department of the Environment in Energy Consumption Guide No.19. Low energy consumption means associated lower CO₂ emissions than from conventional systems.

Energy savings of 40% compared with air source heat pumps and by over 70% compared to electric resistance heating are being achieved, and CO₂ emissions are reduced to 40 kg/m², less than half that associated with DOE typical HVAC design. With the heat source buried in the ground, the system is both invisible and silent. There is no need for boiler, flue, cooling tower, water treatment or associated plant rooms, and the total building resource content is reduced.

This invention relates to a cooling and heating system, which operates on the absorption and phase change heat exchange principle. More particularly it relates to a continuous heat actuated, air cooled, double effect generator cycle, absorption system. In further aspects, this invention relates to a system constructed for use with an absorption refrigeration solution pair consisting of a non-volatile

absorbent and a highly volatile refrigerant, which is highly soluble in the absorbent. A disclosed refrigerant pair is ammonia as the refrigerant and sodium thiocyanate as the absorbent. An absorption cycle is disclosed using the thermo physical properties of sodium thiocyanate/ammonia, absorption/refrigerant pair. Also disclosed is the construction and configuration of a reverse cycle air cooled double effect generator absorption refrigeration system for use with the sodium thiocyanate/ammonia refrigeration pair, as well as sub-compositions, subsystems and components that improve the system efficiency and reduce cost.

At a depth of 5.5 metres the earth's temperature will be constant at a temperature equal to the average mean ambient temperature throughout the year in any location meaning temperature in winter higher than the air temperature, and in summer lower than air temperature, thereby, providing higher efficiencies in both heating and cooling modes and ensuring a lower peak load throughout the year (Figure 4).

There is unlikely to be a potentially larger mitigating effect on greenhouse gas emissions and the resulting global warming impact of buildings from any other current, market-available single technology, than from ground-source heat pumps. Over its first year of operation, the ground source heat pump system has provided 91.7% of the total heating requirement of the building and 55.3% of the domestic water-heating requirement, although only sized to meet half the design-heating load. The heat pump has operated reliably and its performance appears to be at least as good as its specification. The system has a measured annual performance factor of 3.16. The occupants are pleased with the comfort

levels achieved and find the system quiet and unobtrusive. The heat pump is mounted in a cupboard under the stairs and does not reduce the useful space in the house, and there are no visible signs of the installation externally (no flue, vents, etc.). The ground source heat pump system is responsible for lower CO₂ emissions than alternative heating systems (the emission figures for an all-electric system and oil- or gas-fired boilers are given in table 4). For example, compared with a gas-condensing boiler, the heat pump system resulted in 15% lower CO₂ emissions (assuming a CO₂ emission factor for electricity of 0.46 kg/kWh). When compared with a new oil-fired boiler system or an all-electric system, the emissions of CO₂ are cut by over 40% and nearly 60% respectively. Annual fuel costs, based on the fuel prices and are about 10% higher than those for a gas condensing boiler and about 20% higher than for a new regular oil boiler, but servicing costs are likely to be lower. Running costs are substantially cheaper than for an all-electric heating system. At present, suitable products are not readily available in the UK, so the heat pump had to be imported. This had some drawbacks, e.g., limited documentation in English and possible difficulty in obtaining spare parts. The controller supplied with the heat pump was not designed for use with an Economy 7 type tariff structure. There is, however, potential to improve the operation of the system by scheduling more of the space and water heating duty during the reduced tariff period. The performance of the heat pump system could also be improved by eliminating unnecessary running of the integral distribution pump. It is estimated that reducing the running time of this pump, which currently runs virtually continuously, would increase the overall

performance factor to 3.43. This would improve both the economics and the environmental performance of the system. More generally, there is still potential for improvement in the performance of heat pumps, and seasonal efficiencies for ground source heat pumps of 4.0 are already being achieved. It is also likely that unit costs will fall as production volumes increase. By comparison, there is little scope to further improve the efficiency of gas- or oil-fired boilers.

Conclusions

Conventional heating or cooling systems require energy from limited resources, e.g., electricity and natural gas, which have become increasingly more expensive and are at times subjects to shortages. Much attention has been given to sources subject to sources of energy that exist as natural phenomena. Such energy includes geothermal energy, solar energy, tidal energy, and wind generated energy. While all of these energy sources have advantages and disadvantages, geothermal energy, i.e., energy derived from the earth or ground, has been considered by many as the most reliable, readily available, and most easily tapped of the natural phenomena. This study has dealt with the modelling of vertical closed-loop and ground source heat pump system. The challenges associated with the design of these systems originate from the fact that they present a unique type of heat transfer problem. First, there are inherent inabilities to make direct observations in the subsurface environment with respect to both space and time. Second, heat transfer within the subsurface environment can be highly transient. Consequently, a considerable amount of research in the past decade has been geared towards optimising the design

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and performance of GSHP systems and this study is part of those efforts.

The installation and operation of a geothermal system may be affected by various factors. These factors include, but are not limited to, the field size, the hydrology of the site the thermal conductivity and thermal diffusivity of the rock formation, the number of wells, the distribution pattern of the wells, the drilled depth of each well, and the building load profiles. The performance of the heat pump system could also be improved by eliminating unnecessary running of the integral distribution pump. This would improve both the economics and the environmental performance of the system.

The results of soil properties investigation have also demonstrated that the moisture content of the soil has a significant effect on its thermal properties. When water replaces the air between particles it reduces the contact resistance. Consequently, the thermal conductivity

varied from 0.25 W/m/K for dry soil to 2.5 W/m/K for wet soil.

However, the thermal conductivity was relatively constant above a specific moisture threshold. In fact, where the water table is high and cooling loads are moderate, the moisture content is unlikely to drop below the critical level. In

Nottingham, where the present study was conducted, soils are likely to be damp for much of the time. Hence, thermal instability is unlikely to be a problem. Nevertheless, when heat is extracted, there will be a migration of moisture by diffusion towards the heat exchanger and hence the thermal conductivity will increase. ■

Nomenclatures

ACH	Air changes per hour	DTI	Department of Trade and Industry
GSHP	Ground source heat pump	AFUE	Annual fuel utilisation efficiency rating
HRV	Heat recovery ventilator	ARI	The Air-conditioning and Refrigeration Institute
DC	Direct current	COP	Coefficient of performance (%)
HSPF	Heating season performance factor	GHP	Geothermal heat pump
SEER	Seasonal energy efficiency ratio	GL	Ground loop
Btu	British thermal unit	HP	Heat pump
EER	Energy efficiency rating	N	Air change per hour (ACH) (h ⁻¹)
DX	Direct expansion	P	Pressure (Pa) (kPa)
GS	Ground source	Q	Heat (thermal energy) (J)
EPA	Environmental Protection Agency	Q _c	Capacity (thermal power) (W)
HVAC	Heating, ventilating and air conditioning		
DETR	Department of the Environment Transport		

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Government Okays 101 Cold Chain Projects

The Government sanctioned 101 new cold chain projects being set up by firms like Big Basket, Amul and Haldiram entailing Rs 3,100 crore in investments -- a move aimed at reducing wastage of fruits and vegetables. Announcing this decision, Food Processing Minister Harsimrat Kaur Badal said the ministry's grant-in-aid for these projects will be Rs 838 crore, while the remaining over Rs 2,200 crore will come from the private sector. When asked about the companies which have bagged these projects, Joint Secretary Anuradha Parasad named Big Basket, Haldiram, Gujarat Cooperative Milk Marketing Federation's (Amul) milk unions. Some of the other players include Hatsun Agro, Sterling Agro, Prabhat Dairy, Balmer Lawrie, Tirumala Milk, Desai Brothers and Falcon Marine (Odisha). The maximum number of cold chain projects will come up in Maharashtra at 21, followed by Uttar Pradesh 14, Gujarat 12 and Andhra Pradesh 8 projects. Punjab and Madhya Pradesh will have six projects each. "We have sanctioned 101 new cold chain projects across the country with a capacity of 2.76 lakh tonnes. Wastages are high due to lack of cold chain infrastructure," Badal said. "In these 101 cold chain projects, Rs 3,100 crore investments will come in, including our ministry's grant of Rs 838 crore," she said, adding that these projects will come up in the next two years. Of the total projects sanctioned, 53 are in fruits and vegetables sector, 33 in dairy and 15 in meat, poultry and marine. About 2.6 lakh farmers are expected to benefit from these projects, which would also provide direct/indirect employment opportunities to 60,000 people. Badal said the number of cold

chain projects sanctioned so far has gone up to 234 now and the government plans to sanction 50 more cold chain projects.

Citing a CIPHET study conducted by the ministry, Badal said the total wastage of fruits and vegetables was at Rs 92,000 crore based on the wholesale prices of 2014.

She said 4.7 million tonnes of agri and horticulture produce worth Rs 12,000 crore will be processed in these cold chain projects and reduce the wastages by 13 per cent.

"Farmers are producing. Our demand is growing and yet there is wastage of fruits and vegetables," she said. As many as 308 applications were received for these 101 projects. Badal noted that the country is one of the largest food producers in the world and is the second largest producer of fruits and vegetables yet only 2.2 per cent of our fruits and vegetables are processed. The minister also said the existing cold storages are concentrated in few states and roughly 80-90 per cent are used for potatoes. These projects will create additional capacity of 2.76 lakh tonne of cold storage/controlled atmosphere or frozen storage, 115 tonne or hour of Individual Quick Freezing (IQF), 56 lakh litres per day of milk processing, 210 tonne per batch of blast freezing and 629 refrigerated or insulated vehicles. Badal said the government intends to create a National Food Grid through these cold chain and mega food park projects to bring down the wastage and post-harvest losses. "We are trying to improve the supply chain from farm gate to processing to marketing," she said, while highlighting that the government had last year approved 100 per cent FDI in marketing of food products manufactured and produced in India. ■

North American Top 25 List of Refrigerated Warehousing & Logistics Providers

The International Association of Refrigerated Warehouses (IARW) publishes the IARW North American Top 25 List of the largest refrigerated warehousing and logistics providers in Canada and the United States. The list is determined by total capacity of temperature-controlled space operated by IARW Warehouse Members.

2016 IARW North American Top 25 List

	Company Name	Locations	Cubic Feet	Cubic Meters
1	Americold Logistics	Canada and United States	907,552,901	25,707,689
2	Lineage Logistics	United States	609,276,429	17,252,759
3	Preferred Freezer Services	United States	277,315,385	7,852,697
4	United States Cold Storage, Inc.	United States	260,000,000	7,362,368
5	VersaCold Logistics Services	Canada	115,203,748	3,262,201
6	AGRO Merchants Group, LLC	United States	113,693,701	3,219,442
7	Interstate Warehousing, Inc.	United States	100,227,481	2,838,122
8	Cloverleaf Cold Storage Co.	United States	74,776,899	2,117,442
9	Burriss Logistics	United States	62,329,576	1,764,974
10	Frialsa Frigorificos S.A. De C.V.	Mexico	60,892,278	1,724,274
11	Henningsen Cold Storage Co.	United States	53,756,309	1,522,207
12	Congebec Logistics, Inc.	Canada	49,660,000	1,406,212
13	Hanson Logistics	United States	43,818,540	1,240,801
14	Conestoga Cold Storage	Canada	39,526,536	1,119,265
15	Allied Frozen Storage, Inc.	United States	29,455,115	834,075
16	Trenton Cold Storage, Inc.	Canada	28,335,972	802,384
17	Confederation Freezers	Canada	28,316,000	801,819
18	Zero Mountain, Inc.	United States	26,184,664	741,466
19	MTC Logistics	United States	25,206,254	713,760
20	East Coast Warehouse & Distribution Corp.	United States	25,000,000	707,920
21	Brookfield Cold Storage	Canada	23,300,000	659,781
22	Interstate Cold Storage, Inc.	United States	21,403,000	606,064
23	Midwest Refrigerated Services, Inc.	United States	21,351,000	604,592
24	Hall's Warehouse Corp.	United States	20,625,304	584,043
25	Nor-Am Cold Storage, Inc.	United States	20,523,000	581,146

(Source: www.gcca.org)

Mighty Foot – The 2 minute installation!

The Mighty Foot Modular Framework for HVAC Equipment helps you to install a VRV outdoor unit in a matter of few minutes.

- Simple, Easy & Sturdy.
- No penetration of roof slab is needed, hence no damage to water proofing.
- It includes Anti Vibration Pads and is perfectly suitable for VRV, VRF, Evaporators, Condensers, Splits, Chillers, Pipe & Ductwork, etc.
- Available in various sizes as well as for Customized designs; Modular

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- Hot Dip Galvanized Metalwork.
- The Legs can be removed individually for re-roofing / other works without dismantling the machine.
- Includes adjustable condenser clamps to keep the unit tightly in place.
- The height of the bars & horizontal distance between bars can



be adjusted according to individual unit size. No welding needed. ■

Climaveneta's BRH 0011 – 0121 Water cooled chiller

BRH is a range of water-source liquid chillers operating with R410A refrigerant. These are indoor units with hermetic Scroll compressors and Full Floating technology. The latter is an intelligent electronic unit providing the perfect answer to residential market requirements: compactness, ease of installation and quietness.

Features

- Structure and base in hot-dip galvanised steel with epoxy powder paint finish.

- High-efficiency plate exchangers in AISI 316 stainless steel with low pressure drops (exchanger on plant side fitted with heating element for frost protection).
- External access to control with anti-tamper device.
- The safety of the unit is guaranteed by a door lock isolator on the electrical power switchboard and by active protection devices on the



main components.

The circuit includes:

- Modulating valve to reduce water consumptions (source side, FF versions only).
- Circulating pump (plant side, FF versions only).
- Air vent valve (plant side).
- Expansion vessel (plant side).
- Safety valve (plant side).
- Differential pressure switch on plant circuit only.
- Drain valve on both the plant and the source circuits. ■

Trane's XV20i TruComfort™ Variable Speed

The XV20i True Comfort Variable Speed unit is one of the industry's most efficient variable speed air conditioners. Even on the hottest days, it cools your home with precision, keeping you comfortable throughout the day.

The Trane TruComfort™ systems give you precise comfort by running at the exact speed needed to keep your home comfortable. This allows the compressor, outdoor fan, and indoor fan to vary operating speed and BTU as the temperature outside changes, slowing down or speeding up gradually in as little as 1/10 of 1% increments to keep comfort within 1/2° of the thermostat setting.

The XV20i air conditioner



is one of the industry's most efficient systems, with ratings up to 22 SEER. With Trane TruComfort™ technology, the 22-SEER air conditioner automatically adjusts itself while maintaining constant and consistent speeds to avoid temperature swings.

ComfortLink™ II communicating technology (available when matched with communicating indoor units) connects all of your key components so your system automatically configures and calibrates for optimal performance and efficiency through the lifetime of your products.

Rigorously tortured and tested for long-lasting durability, you can be sure this system will hold up to anything, without holding up your bank account.

Every Trane matched system is packed with high-quality components. Each helps ensure that time after time, your unit will provide total comfort your family can rely on. The XV20i air conditioner includes:

- ComfortLink™ II Communicating Capability and Unique Refrigerant Cooled Inverter Drive
- Climatuff™ Variable Speed Compressor
- Compressor Sound Insulator
- All-aluminum Spine Fin™ coil
- WeatherGuard™ II Top
- DuraTuff™ Rustproof Basepan
- Integrated Fan System
- Simplified Two-Wire Connection
- Full-sided Louvered Panels
- Powder-Paint Finish
- WeatherGuard™ Fasteners ■

Forthcoming Events At A Glance

2017 ASHRAE Annual Conference

Venue: Long Beach, CA
Date: 24th to 28th June 2017
Website: www.ashrae.org/longbeach

ASHRAE Annual Conference 2017

Venue: Hyatt Regency Long Beach, CA, USA
Date: 24th to 28th June 2017
Website: www.ashrae.org

Cleanroom Guangzhou 2017

Venue: China Import and Export Fair Complex
Date: 16th to 18th August 2017
Website: www.clcte.com

Mostra Convegno Expocomfort 2017

Venue: Marina Bay Sands, Singapore
Date: 12th to 14th September 2017
Website: www.mcexpocomfort-asia.com

SIFA 2017

Venue: Les Dock De Paris, France
Date: 3rd to 5th October 2017
Website: www.expo-sifa.com

2018 AHR Expo

Venue: Chicago
Date: 22nd to 24th January 2018
Website: ashrae.org/AHRExpo2018

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Cooling India invites HVACR professionals and industry experts to write articles on their area of expertise and interest.

Best Innovative Green Building Award for Museum of Tomorrow

Opened in 2015, the museum was commended for initiatives such as the use of the icy waters from the bottom of the Guanabara Bay for the air-conditioning system and special solar power panels. The Museum of Tomorrow, in Rio de Janeiro, was recognised as the Best Innovative Green Building of the planet during the MIPIM Awards. The award is given during the most important exhibition of the real estate sector in the world, which takes place in the city of Cannes (France). The museum defeated important landmarks such as the 119 Ebury Street building in London, the

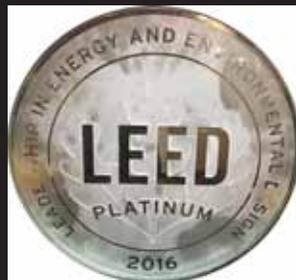


Siemens headquarters building in Munich and the Värtan Bioenergy CHP-Plant in Stockholm. For Tourism Minister Marx Beltrão, the award consolidates a winning model for the use of urban spaces. Opened in 2015 at the Pier Mauá, The building also stands out for its sustainability initiatives, such as its solar power capture system (it uses fin-like panels that follow the sun throughout the day) and the use of the icy waters from the bottom of the Guanabara Bay to feed its air-conditioning system. The museum covers an area of 15,000 square metres. ■

PDDU Urja Bhawan Receives LEED Platinum

Oil and Natural Gas Corporation's (ONGC) state-of-the-art corporate office *Pandit Deen Dayal Upadhyay Urja Bhawan* in New Delhi has been bestowed with the Leadership in Energy and Environmental Design (LEED) India 'Platinum' award by US Green Building Council (USGBC). The building is registered as a Clean Development Mechanism Project with the United Nations Framework Convention for Climate Change (UNFCCC), with Carbon Emission Reductions (CER) of 5,944 metric tons CO2 equivalent per annum. The unique environmental sustainability features of this building are:

- Energy Performance Index



(EPI) of less than 150 kWh/sqm/year as compared to the average baseline of over 300 kWh/sqm/year in commercial buildings in India.

- A per square feet energy consumption of around 0.6 W, almost half the national norm of 1 W, thanks to features like the 1.8 km earth air tunneling of air-conditioning system that is the only such pre-cooling technology in Delhi.
- This building harnesses solar energy to a substantive amount: apart from a 250 KW photovoltaic power generation and solar hot water system, 76.5 per cent of the occupied building space is lit by sunlight .
- This is an intelligent 'live' structure, capable of continuously optimizing its performance in response to the variable energy load, thanks to the state-of-the-art occupancy, energy and CO2 sensors. ■

Climaveneta Units Installed at Gran Theatre De Rabat

Mitsubishi Electric Hydronics and IT Cooling Systems, through its brand Climaveneta, supplied the air conditioning units to the Grand Theatre de Rabat, which is under construction in Morocco. The futuristic building was designed by Zaha Hadid and its shape was inspired by the nearby Bouregreg River. The project, part of a national programme of cultural development, includes a 1800-seat theatre, an open-air amphitheatre with a capacity of 7,000 people, a second experimental performance or rehearsal spaces, and a restaurant for 350 people.



To combine perfect internal comfort and high energy performance of the building, the HVAC system was designed starting from Climaveneta high efficiency units: 2 multi-purpose heat pumps NECS-Q/B 3218 and 1 air cooled chiller NECS/B 3218. The system is therefore able to provide the ideal temperature and humidity level inside the building all year round, even producing simultaneous cooling and heating when necessary, thanks to the multi-purpose units installed. The system has a total cooling capacity of 2,500 kW, granting an ideal temperature even in the Moroccan hot summers. ■

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