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Cooling India

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

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Publisher's Letter

Hello and welcome once again to **Cooling India**, the leading monthly magazine on the HVACR industry in the country. As I write this piece for this issue, India Cold Chain is underway in Mumbai and your magazine is present at the event.

Why is Cold Chain so important? The world demand for frozen and cold food is growing by the day and expected to increase by another 20% in the next three years. That said, infrastructure – be it road network or logistics plays an important role in the growth of cold chain industry. The problem faced by India is no different from other developing economies, including that of China. According to a research report on the cold chain logistics industry in China, published by Market Research Reports Store, over 130 million tons of goods were transported through cold chain logistics last year. And this, according to MRRS, was scarce. Only 20% of perishables transported there are refrigerated. Compare this with 80-100% in the US.

India's cold chain industry, with over 6,300 cold storage facilities, is a combination of surface and refrigerated transport. Cold storages are major revenue contributors to the country's cold chain industry. New cold chain technologies can help overcome the infrastructure problems. Most of the cold storages in the country are concentrated in the northern belt, especially UP, Uttaranchal, Gujarat, Punjab and Maharashtra. Things are changing, however, due to shift in focus from increasing the production to better storage and transportation facility of the commodity. This year, the country's logistics performance improved from 54 to 35 under World Bank Logistics Performance Index (LPI). The government expects the Indian logistics sector to almost double from the current Rs 12,000 crore to Rs 23,000 crore in the next decade. For this the Centre has defined 'logistics infrastructure' to include a multimodal logistics Park comprising a cold chain facility with a minimum investment of Rs15 crore and minimum area of 20,000 sq. ft and a warehousing facility with a minimum investment of Rs 25 crore and a minimum area of 100,000 sq ft.

Finally, due to growing private investments and demand for cold storage facilities and logistics from pharma sector, the market is expected to witness consolidation from the current unorganized and fragmented set up. Hope you enjoy reading this issue as much as we have in putting this together for you. Do send in your comments to me at pravita@charypublications.in.

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"We're committed to providing high energy-efficient products"

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Vice President of Business & Marketing
Embraco

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Trane Acquires CALMAC Corporation

Trane, a leading global provider of indoor comfort systems and services and a brand of Ingersoll Rand, announced that it has acquired CALMAC Corporation, a privately held company specializing in cool energy technologies including IceBank storage tanks. CALMAC ice storage tanks are integrated with Trane commercial heating, ventilation and air conditioning (HVAC) systems to take pressure off of the energy grid. The ice storage tanks store energy, similar to a battery, and use that energy to cool commercial buildings during times when the cost of energy is high. This reduces the strain on public utilities, reduces operating costs for building owners and allows for better use of renewable forms of energy. "We are pleased to incorporate CALMAC solutions into our leading portfolio of energy efficient systems and services," said Donny Simmons, President of the Commercial HVAC business of Ingersoll Rand. "With CALMAC, we are well positioned to offer customers even greater choices for reducing energy and operating costs and capitalizing on the multi-billion energy services market opportunity."

"CALMAC is pleased to be part of Trane," said Mark MacCracken, Chief Executive Officer of CALMAC. "We know that with the support and investments from Trane and its parent, Ingersoll Rand, CALMAC can expand the availability and distribution of our products, serving new and existing customers with the energy storage and ice solutions they demand."

More than 4,000 businesses and institutions in 60 countries rely on CALMAC's thermal energy storage to cool their buildings, including some prominent buildings in US such as Rockefeller Center and the Credit Suisse Building in New York City and an Ingersoll Rand North America headquarters. ■

Belimo provides Innovations in Energy Efficiency & Safety for Buildings

For over 40 years, Belimo successfully focuses on the heating, ventilation, and air conditioning markets providing quality solutions that will increase energy efficiency; reduce installation cost with the fastest delivery times in the industry. Our innovative products have always been designed to help achieve objectives better, faster and more economically. Investing in new technology is a key to our success, and Belimo will continue to offer products to help businesses succeed.

Belimo has earned the place of the market leader by valuing ingenuity and craftsmanship and never resting on our accomplishments. Very simply, we strive to build damper actuators, control valves and sensors that solve comfort and energy challenges, perform flawlessly and earn your trust through a long and productive life. ■

Disneyland Shuts Down Cooling Towers over Legionnaires' Cases

Disneyland Park has shut down two cooling towers at its park in Southern California following an outbreak of Legionnaires' disease. Orange County health officials said nine people who visited the Anaheim theme park in September developed the disease. An additional three people who had been to Anaheim but not Disneyland got sick, said Jessica Good, a spokeswoman for the Orange County Health Care Agency (OCHCA). One patient, who had not visited the park and had additional health issues, died, she said. The 12 patients are between ages 52 and 94, and 10 were hospitalized, she said.

According to Dr Pamela Hymel, Chief Medical Officer for Walt Disney Parks and Resorts, the towers were shut down after Disney was contacted by the county health care agency on October 27 about increased Legionnaires' cases in Anaheim. "We conducted a review and learned that two cooling towers had elevated levels of Legionella bacteria," Hymel said.

"These towers were treated with chemicals that destroy the bacteria and are currently shut down. We have proactively shared this information with OCHCA and given our actions, they have indicated there is no longer any known risk associated with our facilities."

Good also said there was "no known ongoing risk with this outbreak. To date, no additional Legionella cases have been identified with potential exposure in Anaheim after September," Good said. Legionnaires disease is a severe form of pneumonia caused by Legionella bacteria, sometimes found in water systems. It is typically contracted by breathing mist from the water that contains it. The source of the mist can be air conditioning units in large facilities, showers or hot tubs. Legionnaires' disease is not contagious between humans. County health officials identified Disneyland Park as a common location of eight of the cases last month, and have been working to identify potential sources, Good said. ■

BESA Launches Ventilation Hygiene Elite Scheme

The Building Engineering Services Association (BESA) has launched a scheme to help ventilation hygiene specialists demonstrate their competence, quality and standards. With building owners and operators becoming more aware of the fire risks posed by poorly cleaned and maintained systems, there has been growing demand for a robust process to verify the quality of cleaning – particularly of grease extract systems used by commercial kitchens.

This growing awareness has created a booming market, which has attracted some non-specialist hygiene providers who don't necessarily understand their responsibilities; or the importance of delivering clean systems, good advice and proper post-clean reporting to clients. This has led to increased scrutiny by insurance companies alarmed by the high number of claims following building fires. BESA, therefore, launched the 'Ventilation Hygiene Elite' scheme at its recent national conference in London. The scheme, which is approved and administered by the Association's independent certification arm BESCA, is based on BESA's long-established best practice standard TR19.

BESCA will audit firms' work to ensure standards are maintained and manage a database of post-clean reports, which can be used as an auditable trail by the member firm; their clients and insurers. BESCA will also carry out ongoing surveillance of each registrant to confirm continuing compliance. The amount of surveillance may reduce year-on-year if the company continues to display a high standard of work. A BESCA certificate for all notified cleans that meet the requirements will be automatically generated for issue to the end client. Since it was first developed in 1998 by BESA's specialist ventilation hygiene group, TR19 has been widely accepted by the building engineering services sector and British insurers . ■

Kaltra Opens a New Manufacturing Facility in Slovenia

Kaltra is proud to announce the opening of a brand-new manufacturing plant in Slovenia. The facility consists of 4000 square meters of manufacturing space, a test lab, and offices. Approximately 30 employees will work in the new location initially and it is expected to grow to around 80 within the next two years.

The demand for Kaltra products has grown significantly, including revenue growth of 60% in 2016, and new state-of-the-art factory will allow Kaltra to expand annual production capacity by more than 30% in 2018. Slovenian factory intended to produce the new lineups of condensers, dry coolers, air coolers, small to medium capacity chillers, and precision air conditioning units based on microchannel evaporators. ■

Mitsubishi Electric Participating in High Performance Housing Programs

Mitsubishi Electric US, Cooling & Heating Division (Mitsubishi Electric), a leading manufacturer of Zoned Comfort Solutions™ and Variable Refrigerant Flow (VRF) cooling and heating systems, announces its involvement with several new US Department of Energy (DoE) projects and initiatives through 2019. The DOE awarded USD 3.7 million in funding for high performance housing projects through its Building AmericaSM program. The initiative selects project teams that focus on developing and implementing solutions to three interrelated core technical challenges: high-performance building envelope assemblies and systems; optimal comfort systems for heating, cooling, air distribution and humidity control; and high-performance ventilation systems and indoor air quality strategies.

Mitsubishi Electric is participating with the University of Central Florida's (UCF) Florida Solar Energy Center (FSEC) as one of six teams selected to develop and implement energy efficient solutions related to high-performance building envelopes, indoor air quality baselines and strategies, high-performance ventilation, and comfort systems for residential applications. UCF's FSEC and Mitsubishi Electric will team up on two projects: one of the selected projects will refine a new approach to using mini-split heat pumps in existing homes and the second will conduct baseline studies to better characterize indoor air quality, ultimately, leading to more energy efficient solutions.

With the new funding, UCF's FSEC will focus on using a single, centrally located Mitsubishi Electric mini-split heat pump as the primary system, while only using the existing, lower-efficiency central system as needed. Previous FSEC research documented 34 percent average heating and cooling energy savings for Florida homes that use this innovative approach. ■

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SA, Energy for Smart Building Solutions

The General Services Administration and the Department of Energy issued a request for information for new technology to help improve federal building efficiencies. The request, which is part of GSA's Proving Ground and DOE's High Impact Technology Innovation Catalyst programs, is focusing on renewable and smart energy systems for federal properties. The Proving Ground program began in 2011 with the goal of identifying technologies to make federal buildings more energy efficient while reducing the government's carbon footprint. Coupled with the HIT Catalyst program's goal of incorporating building systems optimization, GSA officials said the GPG program has deployed nine of its 20 identified technologies and saved $7.8 million in costs. The new solicitation seeks information for behind-the-meter technology to promote energy efficiency at federal buildings, as well as technologies that can identify when smart design buildings are functioning within energy-saving parameters.

"Technologies appropriate for measurement and verification performance studies must be either 'pre-commercial,' defined as technology that is not yet fully available on the open market and has a value proposition or price that is still being defined, or 'early commercial,' defined as technology whose value and risks are understood by specialists for some applications but the supply chain and/or full-scale production have not yet been fully established," the RFI said. ■

Danfoss Talks to Indian Firms on Hybrid Car Power

Danish company Danfoss A/S is looking at the Indian automobile sector in a major way and is in talks with some automobile makers for providing its solutions for hybrid cars, said a top official. The 5.3 billion euros turnover privately held company is a world leader in heating, ventilation and air conditioning (HVAC) sector. The company's business segments are classified under Power Solutions, Cooling, Drives and Heating. "We are looking at anybody making hybrid cars. We have power module solutions that have 15 times more life than others," Kim Fausing, President and CEO told IANS. While Danfoss is having talks with Indian companies, Fausing declined to reveal their names. "We have proprietary technology. Already our solutions have been put in around 25 million cars in Europe. We are looking at hybrid and electric cars. We work with German auto makers and US OEMs (original equipment manufacturers)," Fausing added.

Danfoss has invested in a power module plant in the US at an outlay of around USD 100 million. The company is also mulling to invest in China, a major market for its products. "We bring in innovation in energy efficient solutions. We focus on application of equipment and build efficiency in that," he added.

Fausing said Danfoss has big focus in the American and Chinese auto sector. The Danish company makes power modules for inverters and others and is part of its drives business. Danfoss' power modules are used in farm machines with hydraulic motors, earthmoving equipment and others.

According to a Danfoss official, automobile sector is a related business for the company and is part of its drives business. For instance, batteries of electric cars should be cooled quickly for fast charging and Danfoss has the solution as it is a major in the HVAC segment. The Indian Government is for electric mobility. Recently, Energy Efficiency Services Ltd a joint venture company of undertaking coming under the Indian Power Ministry decided to buy 10,000 electric vehicles. Fausing said Danfoss is also looking out for acquisitions in India in the technology space. Speaking about Danfoss' operations in India, Fausing said India figures in the top eight-nine market for the company globally. "For us India is important like China and the US. India can be top three markets for Danfoss after US and China," Fausing said. Major customers for Danfoss in India are Blue Star, Mahindra and others. Major customers for Danfoss in India are Blue Star, Mahindra and others. On Danfoss global business, Fausing said the group logged 13 per cent growth of which nine per cent is organic and the balance four per cent is from acquisitions. ■

Consultation on new Penalties for F Gas Infringement

Defra is consulting on the introduction of civil penalties in England, Scotland and the marine areas. These measures are being considered to address concerns about whether the current penalty system provides sufficient deterrence against non-compliance.

This is a public consultation and it is open to anyone with an interest to provide comments. It should be of particular interest to those operating in the sectors of refrigeration, air-conditioning, insulation foams, electrical switchgear equipment, aerosol sprays, medical inhalers, solvents and fire extinguishers.

It may also be of interest to environmental groups. ■

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Johnson Controls Launches Enhanced Version of Smart Building Automation System

Johnson Controls, a global diversified technology and multi-industrial leader, has launched BCPro™, their smart Building Automation System (BAS) designed for conventional commercial buildings. BCPro™ is the latest release of what was launched as Building Control Manager (BCM) in 2014. BCPro™ provides simple but powerful tools for fast and easy set-up, reducing system configuration time by 50 percent and workload of user interface (UI) configuration by 90 percent, unleashing the full ability and efficiency of BAS operations.

BCPro™ offers a new graphic display with editing, illumination and customization functions, allowing building operators to quickly access and view data, as well as makes changes to the system, lowering the UI configuration workload by as much as 90 percent. This intuitive design not only makes it easy for users to monitor, control and manage building facilities, but also trims the time needed for them to master the system. In addition, the HTML5-based UI enables users to access the system from any device with any web browser, at any place and time.

BCPro™ comes with technological updates that greatly enhance the system software and its communication process with the controllers, ensuring greater system stability and reliability. The system architecture is also streamlined, making installation simpler, more efficient and cost-effective while maintaining reliable operation of critical building functions.

The Engineering Tool (ET) feature, which allows users to program all aspects of the system, has been upgraded. Its built-in templates of the most common heating, ventilation and air-conditioning (HVAC), plumbing and lighting systems can automatically translate data input by users into control functions, charts, summaries and reports, reducing system configuration time by 50 percent. ■

Bacharach Adds New Refrigerant Gas Options

Bacharach, a leading manufacturer of refrigerant and gas leak detection, from monitoring instruments and data solutions, to combustion and emissions analyzers, announces the addition of two new gas options, R514A and R452B for its MGS-250 infrared refrigerant gas detector product family.

This non-dispersive infrared sensor technologyoffers significant user benefits when detecting either of these twogases.The major benefit is theelimination of cross-interference from other gases and the elimination of cross-interference from changes in temperature and humidity providing the user with peace of mind knowing the reading he sees is accurate and stable. Other benefits include added sensor life of 5 – 7 years and reduced maintenance. Modbus RTU protocols,analog and relay outputs enable easy integration with building management systems and industrial automation system controls for refrigeration systems operating with R514A or R452B. Bacharach continues supporting the cooling and refrigeration industries by extending its library of refrigerant gases which can be detected and monitored, as the refrigeration industry moves toward use of refrigerants less harmful to the environment. R514A is a refrigerant with a very low GWP of under 2, and is targeted as a replacement for R123 in centrifugal chiller applications. It is a blend of HFO 1336mzz(Z) (74.7%) with trans-1,2-dichloroethene (25.3%), a gas not previously used in refrigerants. ■

Air Handling Units Market worth USD 12.91 bn by 2026

The report 'Air Handling Units Market by Application (Commercial, Residential), Type (Packaged, Modular, Custom), Capacity, Region - Global Forecast to 2026', is projected to reach USD 12.91 Billion by 2026, at a CAGR of 5.7% from 2016 to 2026. The increase in demand of air handling units from the application sectors such as commercial buildings, industries, hospitals, universities, data centers, laboratories, and server rooms is propelling the growth of this market.

Custom air handling units is the fastest-growing type segment of the global air handling units market. The custom air handling units segment is estimated to account for the second-largest share of the air handling units market in 2016, and is projected to be the fastest-growing type segment from 2016 to 2026. The growth is mainly attributed to the rising demand of custom air handling units from the commercial application sectors such as pharmaceutical industries, shopping malls, hospitals, and universities.

15001 - 30000 m^3/h capacity segment is anticipated to grow at the highest CAGR from 2016 to 2026. These are medium size air handling units which are used in commercial applications such as hospitals, shopping malls, commercial buildings, data centers, and laboratories. Due to the increasing awareness regarding the impacts of pollution on environment and human health, there is a high rise in the use of air handling units. Air handling units are not only used for cooling and heating purpose, but also for providing fresh air, humidification, and controlling relative humidity. These features contribute towards the growing demand of 15001 - 30000 m3/h capacity air handling units. The commercial segment is estimated to account for the largest share of the air handling units market in 2016. ■

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Andrea Belloni is new Sales Director Western Europe, Güntner

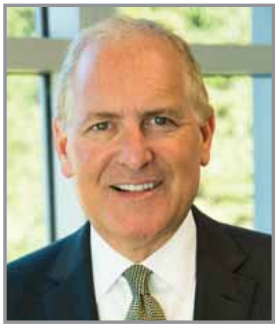
Andrea Belloni is our new Sales Director for Western Europe. He takes over the task of Miguel Garrido who joined our US sales office. Following the significant recovery of economy accompanied by increased investment activity, the sales area Western Europe plays an important role.


Andréa Bellona

Andréa Bellona has been responsible for Gunner's global Energy & Process Cooling(EPC) sector since 2015. He will continue to manage this area. He also continues to assume his task as Sales Director Far East Asia. Güntner GmbH & Co KG is a world leader in the manufacture of refrigeration and air conditioning equipment components. With approx. 3,000 employees worldwide and production sites in Germany, Hungary, Romania,Indonesia, Mexico, Brazil and Russia, the company shows a strong presence for their partners in all markets. Decades of experience in the industry and the consistent integration of the latest technologies and research findings ensure the high-quality standard of Güntner solutions. The international areas of application comprise energy & process cooling projects, industrial and commercial applications in the field of food production and storage as well as HVAC applications for buildings and specific applications such as server room cooling. ■

Gary Michel is new CEO of Honeywell's Home and Building Technologies

Effective immediately, Gary Michel will serve as president and CEO of Honeywell's Home and Building Technologies (HBT) strategic business group. Michel will report to Adamczyk and serve as a company officer. Michel succeeds Terrence Hahn, who will move to a leadership role reporting to Adamczyk and will help prepare the Homes and ADI businesses for the spin.


Gary Michel

Michel joins Honeywell from Ingersoll-Rand Company, where he has held a series of large leadership roles over the past 32 years. Most recently, he served as senior vice president and president, residential HVAC and Supply, which he transformed to deliver substantial improvements in revenue and market share, operating income, commercialization processes, and technology platforms. Michel has also led Ingersoll-Rand's Club Car; Road Development - Construction Technologies; and Utility Equipment - Construction Technologies businesses. Michel has held several other roles, including executive director, Corporate Development, and general manager, Aftermarket Division, for Europe, the Middle East and Africa. Michel earned his B.S. in mechanical engineering at Virginia Tech and his M.B.A. at the University of Phoenix.

"Gary has proven himself to be an innovative and energetic leader with a deep understanding of his customers and end markets and the ability to translate this knowledge into technology-differentiated offerings that bring value to customers," Adamczyk said. "Gary is a welcome addition to our team and will help Honeywell continue to be a leader in connected technologies, building on our great positions in growing industries." ■

SCHOTT UK Appoints new Sales Manager

SCHOTT UK appoints new Sales Manager, Jacob Wrigglesworth as the UK representative for our range of glass doors for refrigeration and freezer cabinets – Termofrost. Jacob began his career in Germany managing a number of international accounts for a subsidiary of Hyundai. He then returned to the UK and began working for a German manufacturer of vehicle valeting solutions in a business development capacity. SCHOTT are excited for Jacob to bring his experience to his new role within the UK team and meet the demands of this growing market.


Jacob Wrigglesworth

SCHOTT is a leading international technology group in the areas of specialty glass and glass-ceramics. The company has more than 130 years of outstanding development, materials and technology expertise and offers a broad portfolio of high-quality products and intelligent solutions. SCHOTT is an innovative enabler for many industries, including the home appliance, pharma, electronics, optics, life sciences, automotive and aviation industries. SCHOTT is committed to innovation and sustainable success. ■

CIBSE Yorkshire Award for Airedale

Nearly 400 people from all parts of the construction industry gathered at the New Dock entertainment suite, Royal Armouries, Leeds. The evening featured three fantastic speakers. These included, Kayley Lockhead, (From NG Bailey) who spoke about STEER Group mentoring, resulting in over 40 offers of support on the night. Martin Brown (from Fairsnape) then identified the different ways in which we can all develop sustainability within the built environment, going beyond energy efficiency. Finally, Prof Peter Head CBE FREng FRSA shared projects that he is involved with to achieve sustainable development around the world.

Following on from the guest speakers, awarding took place in 12 categories. These ranged from Yorkshire Region Project of the Year to the CIBSE Yorkshire Region Student Award, where their college or University nominated students. Airedale is humbled and proud to have won the CIBSE Yorkshire Region Manufacturers Award category for its multiple-award-winning Artu – hybrid low energy fan coil unit. A system conceptualised, designed and manufactured in partnership with Arup consultancy. Artus™ has already won two awards in 2017 and continues to impress judges with its potential, challenging existing solutions and meeting industry needs.Tony Cole, Managing Director, Airedale commented, "We are thrilled to be crowned CIBSE Yorkshire Region Manufacturers of the Year. It means so much to us to receive this prestigious accolade."

"As the judges commented, the category was beyond strong. That makes it all the more pleasing and humbling to have won the award. It is certainly a testament to the talented

Airdale team with CIBSE Yorkshire Award

female and male problem-solvers that we employ here at Airedale, and who have brought this product to market."

Airedale'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. Artus unlocks multiple benefits for a range of users. From building developers,M&E consultants, contractors, and commissioning/FM engineers, Artus™ is a high-quality, low-energy system, compact, Part L building regulation compliant and BREEAM credit contributing. Artus™ uses just 1/3 of the specific fan power of a typical fan coil unit (FCU).

It is perfect for both; cost-sensitive new-builds, height constrained refurbishments and energy conscious end-users. With sustainability, innovation and efficiencyat its heart, Artus™ combines the flexibility of traditional fan coil units with the low-energy usage of chilled beams, at a cost, comparable with FCUs. ■

Marco Nocivelli is Winner of EY Family Business Award

Marco Nocivelli, President and CEO of the EPTA Group, has won the 21st edition of the EY Entrepreneur of the Year Award in the Family Business category. This is a prestigious acknowledgement reserved for Italian entrepreneurs at the head of companies with a turnover of at least 25 million euros, who have managed to create value, possess an innovative spirit and strategic vision, and contribute to the growth of the economy, in Italy and around the world.

The winners were chosen by an independent panel of judges made up of well-known representatives from the world of economics and entrepreneurship, who awarded the EPTA CEO "for the determination and ambition with which he leads the family group every day, always seeking an opportunity to develop, with the goal of consolidating the competitive advantage, focusing on innovation, product design, and the optimization of the processes, creating synergies arising from growth for external lines."

Marco Nocivelli, President and Chief Executive Officer of the EPTA Group, said: "This award is a major accomplishment for


Marco Nocivelli, President & CEO of the EPTA Group with the award

the family and for the company, and it attests to the commitment of every single person that has contributed towards the success of our company over the years." He continued: "It is an acknowledgement that I want to share with all our teammates, who have worked with us to transform EPTA into what it is today: the image and symbol of the wealth of the land and the "get-up-and-go" that characterizes Italy. Our real success is the ability to count on our valued collaborators." ■

Refrigerant Market worth US$ 18.05 bn by 2022

The Asia-Pacific is projected to be the largest market for refrigerants from 2017 to 2022. Factors contributing to market growth in this region are the rise in demand for consumer appliances in emerging countries, growing urbanization, and the growing cold chain market...

Rising end-use applications such as refrigerants, large-scale refrigerators, chillers, air conditioners, and heat pumps are driving the market for refrigerants. Along with these, the growing demand for consumer appliances and the cold chain market are also driving the market.

Air conditioners application accounted for the largest share in 2016

The air conditioners segment is projected to be the largest market for refrigerants from 2017 to 2022, owing to its rapid growth in the Asia-Pacific. Factors such as rising disposable incomes; rising living standards; flexible government taxation policies; rapid technological advancements in products & product offerings, by major international and domestic players, at competitive prices; are a few of the major factors driving the market for the air conditioners application. These factors, along with upcoming infrastructure projects on transport networks, institutional sites, and residential projects are also expected to drive the refrigerants market in the air conditioner application.

Hydrocarbons are expected to be the fastest growing segment in the refrigerants market

The main reason for the high demand for hydrocarbons can be attributed to the increasing consumption of refrigeration and AC equipment, which are its largest applications. Additionally, the demand for fluorocarbon refrigerants is expected to decline in the near future mainly due to the required 100% phase-out of HCFC by 2040 and 85% phase-out of HFC by 2047, which is expected to lead to an increase in the demand for alternative refrigerants. Thus, the growth of inorganics and hydrocarbons is expected to remain high between 2017 and 2022.

Asia-Pacific was the largest refrigerants market in 2016

The Asia-Pacific is projected to be the largest market for refrigerants from 2017 to 2022. Factors contributing to market growth in this region are the rise in demand for consumer appliances in emerging countries, growing urbanization, and the growing cold chain market. These factors, along with upcoming infrastructure projects in energy, transport networks, institutional sites, and residential projects are expected to drive the refrigerants market across various applications in the region. Large-scale investments along with the increasing standards of living provide opportunities for infrastructure developments that are expected to lead to the high growth of the refrigerants market.

The global refrigerants market has a large number of market players; however the market is led by some of the major players, such as The Chemours Company (US), Honeywell International Inc. (US), Arkema S.A. (France), Dongyue Group Co. Ltd (China), Asahi Glass Co., Ltd. (Japan), Daikin Industries Ltd. (Japan), Sinochem Corporation (China), Mexichem SAB de C.V. (Mexico), The Linde Group (Germany), and SRF Ltd. (India), among others. ■

Solstice® N40 Refrigerant for Energy Efficiency

Honeywell's Solstice® N40 (R-448A) is a new, reduced-GWP refrigerant for commercial refrigeration, now available in the Asia Pacific region. Supermarkets, convenience stores, cold storage warehouses, and other applications that require low- and medium-temperature refrigeration equipment can now reduce their environmental impact and energy consumption with Solstice N40...

Background

In October 2016, parties to the Montreal Protocol convened in Kigali, Rwanda and successfully negotiated an amendment to the treaty that would phase down the use of compounds known as hydrofluorocarbons (HFCs), greenhouse gases with high global-warming-potentials (GWPs). Developed countries are committed to reducing the use of HFCs incrementally, starting with a 10 percent cut by 2019 and reaching 85 percent by 2036. Most developing countries have committed to freezing the production and import of HFCs starting in 2024 and the remainder will begin in 2028. All of these actions will expedite the transition to next-generation refrigerant replacements.

As the commercial refrigeration industry moves away from ozone-depleting and high-GWP hydrochloro fluorocarbons (HCFCs) and high-GWP HFCs, environmental impact, safety and energy efficiency have become the three most frequently discussed topics as users seek new alternatives that meet the requirements of the Kigali amendment and can be used safely and effectively to retrofit existing equipment or in new installations.

Solution

Honeywell's Solstice® N40 (R-448A) is a new, reduced-GWP refrigerant for commercial refrigeration, now available in the Asia Pacific region. Supermarkets, convenience stores, cold storage warehouses, and other applications that require low- and medium-temperature refrigeration equipment can now reduce their environmental impact and energy consumption with Solstice N40.

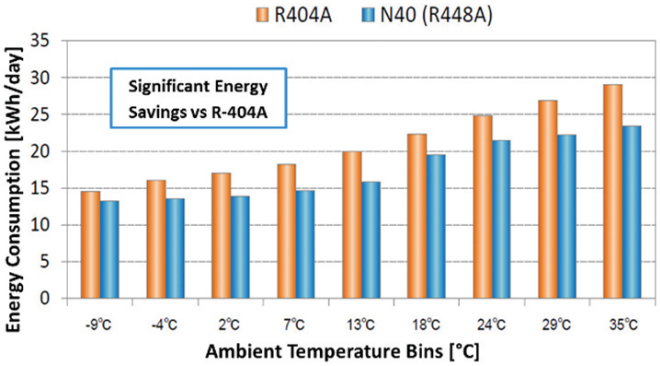
As the lowest-GWP, non-flammable, retrofit refrigerant available today, Honeywell's Solstice N40 is designed to provide customers with a near drop-in replacement for previous-generation solutions such as R-22 and R-404A. In supermarket trials conducted in the US and Europe, Solstice N40 demonstrated 3 percent lower energy consumption in low-temperature applications, and 5 to 16 percent lower energy consumption in medium-temperature applications compared with R-404A.

Challenge

Supermarkets and convenient stores have challenging tasks of minimizing operation costs, ensuring food quality, maintaining store operations, and meeting environmental commitments. Refrigerant customers in the Asia Pacific region seek new solutions to further improve energy efficiency and optimize system performance. For many stores, the energy cost for keeping perishable foods at proper temperature can be as high as 50 to 60 percent of their total energy costs, making energy efficiency is one of the most critical needs for supermarkets and convenience stores.

Benefits

- Solstice N40 has a GWP of 1273, which is 68 percent lower than R-404A's 3943.
- It reduces operating costs by helping stores reduce their energy consumption by up to 16 percent.
- It is expected to achieve upto a 40 percent reduction in carbon dioxide (CO_2) emissions in four years' term.
- As the equipment design for Solstice N40 is similar to R-404A and R-22, it enables continual use of existing hardware and can, therefore, support retrofitting or renovation of stores, in addition to new installations.
- Solstice refrigerant solutions are next-generation products that are safe for the intended use and capable of making a significant positive environmental impact.



Growing Demand

By the end of 2017, more than 7,500 Solstice N40 installations will be completed globally, making it the most widely accepted, lower-GWP product for supermarket refrigeration. Furthermore, the refrigerant is also supported by leading system and showcase OEMs including Danfoss, Emerson Climate Technologies and Bitzer, in the European Union, United States, Japan, and Asia Pacific.

Customers need refrigeration technologies that provide the optimal energy efficiency, are easy to implement and maintain, have minimal impact on the environment, and lower total cost of ownership.

To meet regulatory requirements and achieve the economic benefits of Solstice N40, supermarkets are accelerating conversion from R-404A to R-448A as the lowest possible GWP and non-flammable replacement. Honeywell has robust supply capacity in the Asia Pacific region and estimates that there will be at least 1,000 more installations of Solstice N40 by end of this year.

Honeywell's Fluorine Products business has been at the forefront in developing today's next-generation, non-ozone-depleting and lower-GWP solutions to meet energy and environmental needs. Honeywell's solutions are commercially available worldwide to help customers quickly and efficiently transition to next-generation technologies that meet their environmental commitments.

Delivering Customer Value

Most recently in August 2017, Tesco Lotus, a leading supermarket retailer in Thailand and part of Tesco Group, converted 900 Tesco Lotus Express stores to Honeywell's Solstice® N40 refrigerant to voluntarily reduce carbon emissions. It was the first implementation in Asia of Solstice N40. By converting all of its 1,500 Express stores in Thailand over the next two years to Honeywell's Solstice N40 (R-448A), the retail giant aims to achieve energy savings of up to 10 percent.

"Honeywell's Solstice N40 meets our key criteria for energy efficiency and performance. It is also an easy replacement for our current refrigerant, ensuring no disruption for the 15 million customers we serve on a weekly basis," said Mr. Miroslav Friml, Property Director, Tesco Lotus.

Coborn's Inc, a US supermarket chain with 52 supermarkets and 120 standalone retail locations across the Midwest, embarked upon an exciting project to build a 45,000-square-foot, next-generation supermarket in Isanti, Minn. After completing a comprehensive cost-benefit analysis, Coborn's decided to install a new refrigeration system using Honeywell's Solstice N40 refrigerant. Estimates showed that the cost of a CO_2 transcritical design and equipment would be 20 to 30 percent greater.

"The decision to go with a Solstice N40 refrigerant system was easy because it was significantly more cost effective than CO_2 and offered terrific energy efficiency," said Chris Braun, project manager for Construction, Refrigeration and Maintenance, Coborn's.

Solstice N40 is a non-flammable, reduced-GWP hydrofluoroolefin blend refrigerant designed for low-and medium-temperature commercial refrigeration applications such as supermarkets and convenience stores. It is suitable for R-22 and R-404A retrofits and new installations. Solstice N40 has a GWP of 1273 and provides 68 percent GWP reduction and up to 16 percent lower energy consumption compared with R-404A. ■

Natural Choice – Ammonia

Ammonia is used in industrial refrigeration systems with requirements down to -50°C evaporator temperatures. However, most applications employ evaporator temperatures of -40°C up to +15°C. With the proper selection of lubricants, temperatures down upto -50°C present no lubricant management problems if the system is property designed and installed. There is a movement among industrial companies that now use HFC & HCFC to convert their existing systems to ammonia. Many food freezing systems that use HFC & HCFC as a refrigerant are in the process of converting to conventional freezing systems using ammonia as the refrigerant...

Often, I hear people refer to ammonia as an alternative refrigerant, like they are settling for second best. I don't understand that kind of thinking. Recently, many people started talking about ammonia, ammonia is back etc. I don't agree with them. In fact, Ammonia is one of the first widely used mechanical refrigerants. Other industrial refrigerants to come along since actually are alternatives to ammonia. Ammonia has been used as a refrigerant for more than 160 years; Ammonia was used for refrigeration in 1876, for the first time in a vapour compression machine by Carl Von Linde.Other refrigerants like CO_2, SO_2 also were commonly used till 1920s.

1980s the harmful effects of CFC refrigerants became apparent and it was generally accepted that the CFC refrigerants are contributing to depletion of ozone layer and to global warming. Finally, resulting in Montreal protocol (1989) where almost all countries agreed to phase out CFCs in a time bound program. In view of seriousness of damage to atmosphere and resulting dangers due to CFC/HCFC emissions as also due to global warming effects, the revisions in Montreal protocol (1990), 1992(Copenhagen) and 1998 Kyoto Japan demanded accelerated phase out schedule. Even HCFC's are also to be phased out and Europe has taken the lead.

Many countries in Europe have stopped use of HCFC refrigerants, and new refrigerants as well as well-tried and trusted refrigerants like Ammonia and Carbon Dioxide are being considered for various new applications as well.

Ammonia as refrigerant has been popular in India for more than 100 years. In India Association of Ammonia Refrigeration (AAR) was formed in 2012. The association started promoting safe and efficient use of Ammonia and immediately become popular. This has attracted many organizations to promote Ammonia Refrigeration, who were dead for Ammonia Refrigeration for years. Now everyone is talking about Ammonia as a Natural Refrigerant: Natural choice. All credit goes to AAR activities.

Please refer to table 1 for refrigerant time line graph in figure 1. The graph shows Ammonia as refrigerant exist for almost 160 year and going to continue for years ahead because of following advantages of Ammonia.

Advantages of Ammonia

Ammonia Is Less Expensive

Ammonia is one of the natural refrigerants. It exists in nature here on earth and on many of the known planets. Of its many uses, fertilizer is by far the largest. Because ammonia is manufactured

Table 1: Ammonia COP (Efficiency) Comparison with Other Refrigerants for Various Applications (*New Equipment banned from 2016)

Refrigerant	Condensing Temperature + 40°C			
	Evaporating Temperature 2°C	Evaporating Temperature -5°C	Evaporating Temperature -25°C	Evaporating Temperature -40°C
Ammonia - R717	6.2	4.965	2.91	2.06
R410A	5.43	4.8	2.5	1.75
R134a	5.88	4.67	2.7	Not Used
R404A	5.18	4.07	2.26	1.52
R22*	5.93	4.74	2.79	1.98

in huge quantities, it is by far the least expensive alternative refrigerant and it will remain that way. The cost of ammonia (cost/kg) is significantly less than CFC, HFC & HCFC refrigerants.

Ammonia Is an Efficient Refrigerant

Thermodynamically, ammonia is the most efficient refrigerant with the application range from high to low temperatures. With the ever increasing focus on energy consumption, ammonia systems are a safe and sustainable choice for the future. Typically, a flooded ammonia system would be 15-20 % more efficient than a DX R404A counterpart. Please refer to table 1. The table shows that for various operating conditions ammonia has best COP (Coefficient of Performance) as compared to all HFC & HCFC refrigerants.

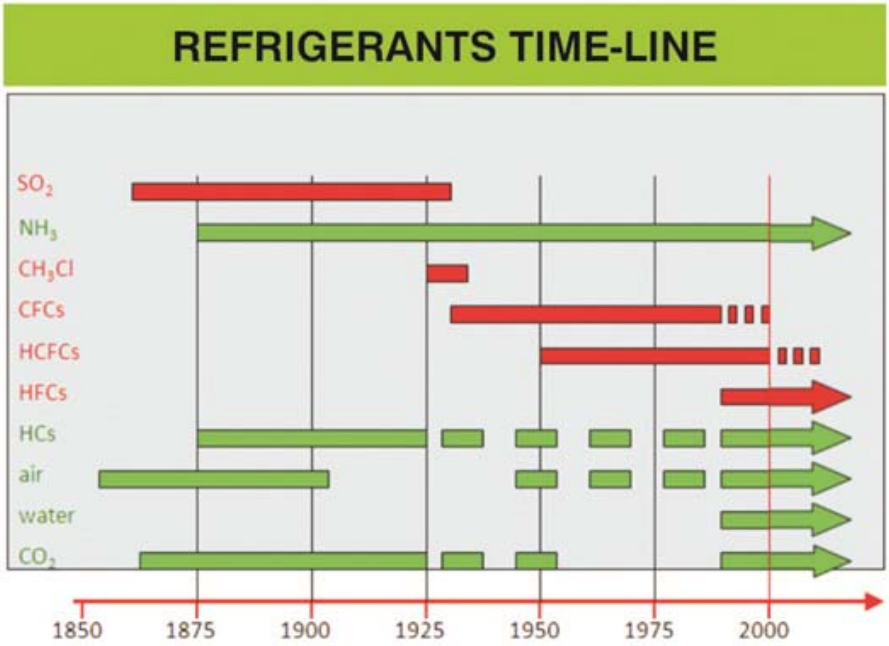


Figure 1: Ammonia as refrigerant exist for almost 160 year

Ammonia Has High Heat Transfer Characteristics

Ammonia has better heat transfer properties than most of chemical refrigerants and therefore, allow for the use of equipment with a smaller heat transfer area. Thereby, plant construction cost will be lower and these properties also benefit the thermodynamic efficiency in the system. Ammonia has higher heat transfer coefficients other than water. The latent heat comparison @ 4°C is given in table 2.

Ammonia Has No Effect on 'Ozone Layer' 0 ODP &<1 GWP

Since, ammonia is biodegradable when properly vented it combines with carbon dioxide and other components in the atmosphere to form an innocuous compound. It has about a two-week life according to the EPA. Please refer to table number 3 for effects of various refrigerants i.e. Global Warming Potential and Ozone Depletion Potential

Ammonia Leaks are 'Self-Alarming'

Ammonia leaks to the atmosphere are easily detected. Many people refer to ammonia as "self-alarming" - you don't need a leak detector to determine that there is ammonia present. This is an important advantage over HCFC, HFC refrigerants where large quantities could escape without detection. Ammonia leaks are found quickly and repaired.

Ammonia Systems can Tolerate Moisture

When refrigeration systems operate in a vacuum, air is drawn into the system, where HCFC & HFC are used and the system operates below freezing (0°C), this moisture must be removed promptly as it will freeze and block control valves. In an ammonia system, the water forms aqua ammonia (ammonia hydroxide) which, being heavier than ammonia will migrate to the coldest spot in the system (evaporator) and remain at that point until drained from the system. The freezing point of this solution is below -73°C. Of course, moisture should be removed from the system as it will affect the thermodynamic properties of the refrigerant effectively reducing the system capacity. Simple to use Ammonia Dehydrators can separate and remove water online. Please refer to figure 2.

Ammonia is Thermodynamically Stable Refrigerant

As a single component refrigerant, ammonia is thermodynamically stable, condensing and evaporating at constant

Table 2: Refrigerant Latent Heat Comparison

Refrigerant	Latent Heat kJ/Kg
Water R-718	2489.04kJ/kg
Ammonia – R717	1247.85kJ/kg
R410A	214.48kJ/kg
HCFC 22/R22	201.79kJ/kg
HFC 134a/R134a	195.52kJ/kg
R404A	162.03kJ/kg

temperatures. Many new refrigerant blends are not as thermodynamically stable, complicating heat exchanger and system design.

Ammonia is not Miscible with Paraffin 1c and Napthenic Lubricants

This characteristic of non-miscibility makes lubricant management in ammonia systems quite simple. The very small amount of lubricant that escapes the lubricant separator will be released by the ammonia in the evaporator and it can be removed (drained) easily. This characteristic is ideal for industrial systems. Oil return from the evaporator to the compressors can be automatic or semiautomatic.

Figure 2: Ammonia Dehydrator Installation

Ammonia System Components may be smaller than those employed In HCFC, HFC systems

Due to the high latent heat capacity of ammonia less mass of refrigerant is circulated in the system. Thus, the piping, stop valves, and control valves are smaller. Due to the high heat transfer characteristics of ammonia, the heat exchangers may be smaller. For "a one of a kind" industrial refrigeration system installation where an HCFC, HFC system is compared to an ammonia system, the ammonia system cost could be as much as 20% less.

Refrigeration Grade Ammonia is Available throughout India

Ammonia is available in cylinders, and in bulk transports throughout India. Since ammonia is employed throughout the food processing and distribution industry, the ammonia distribution system is in place.

No Need to Write off Investment of Ammonia Plant due To Environmental Concerns

In most cases, a company using an ammonia refrigeration system will not have to write off the investment due to environmental concerns and high costs. Companies using chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (HCFCs) will have to face these issues as a these refrigerants are phased out of production under the Montreal Protocol and become even more expensive.

Smaller System Component for Ammonia as Compared to CFC, HCFC and HFC systems

Generally speaking, ammonia system components are smaller than those used in CFC, HCFC and HFC systems. Ammonia's high latent-heat capacity means that less refrigerant circulates in the system; thus, the piping, stop valves and control valves are smaller. And, because of ammonia's heat transfer characteristics, heat exchangers usually are smaller. Based on system component cost alone, ammonia system installation costs typically are 10 to 20% less than an identical HCFC/HFC system. Ammonia refrigeration system components are reliable. They are built to industrial standards, and must be designed to run continuously (8,760 hrs/yr). Most CFC, HCFC, and MFC systems have components built to commercial-grade standards, which means they are designed to run only 2,000 hours per year. When used in industrial cooling applications, these commercial-grade components will break down or wear out more frequently.

Table 3: ODP/ GWP of Refrigerants

Refrigerant		Atmospheric Lifetime (Years)	Ozone Depletion Potential (ODP) (100 Year)	Global Warming Potential (GWP)
Ammonia	R-717	–	0	<1
CFC (no more)	CFC-11 (Baseline ODP)	50	14000	
	CFC -12	102	1	10900
HCFCs	HCFC-22	13.3	0.055	1820
	HCFC-123	1.4	0.02	93
	HCFC-141b	9.4	0.11	630
HFCs	HFC-134a	14.6	0	1300
	HFC-245fa	7.3	0	820
	R-32	–	0	675
HCs	HC-290 (Propane)	–	0	3
	R-1270 (Propelene)	–	0	<2
HFC Blends	R-404A	–	0	3260
	R-407A	–	0	1770
	R-407C	–	0	1530
	R-410A	–	0	1730
CO2	R-744	–	0	1
HFOs	1234yf, 1234ze	–	0	4,7

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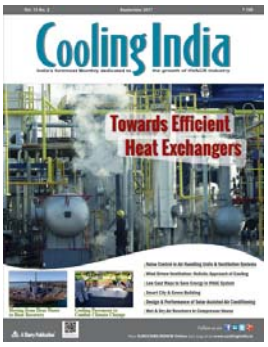

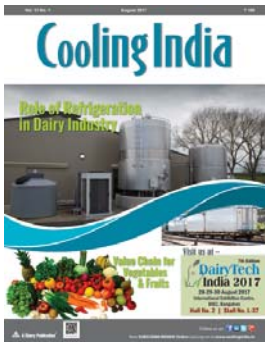

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Table 4: Informal Test Of Reactions To Short-Term Exposures To Ammonia Concentration

AMMONIA CONCENTRATION, PPM	EFFECTS
150 to 200	Affected eyes to a limited extent after about a 1 -minute exposure, but vision not seriously impaired; breathing not affected.
440	Affected eyes more quickly, but not sufficiently to impair vision seriously.
600	Eyes streamed within about 30 seconds; still breathable.
700	Tears to eyes in a few seconds; still breathable.
1000	Eyes streamed instantly and vision impaired but not lost; breathing intolerable to most subjects; skin irritation after several minutes.
1500 or greater	Instant reaction was to get out of the area.

Present Users of Ammonia

The sale of ammonia refrigeration systems has continued to increase each year, for many years. Why? Because of all the advantages previously listed.

Some 80 to 95% of the following industries use ammonia as their refrigerant: wineries; cold storage warehouses; vegetable and fruit freezing plants; meat processing plants; fresh vegetable processors; shrimp processors; fish (seafood) processors; commercial ice plants; dairy and ice cream plants; prepared food processing plants; concrete cooling plants (ice and water); breweries and beverages, condensing carbon dioxide in merchant carbon dioxide plants; barges and ships used to transport ammonia.

Other users of ammonia as the refrigerant of choice are chemical plants, pharmaceutical plants, and petro-chemical plants.

Ammonia is used in these industrial refrigeration systems with requirements down to -50°C evaporator temperatures. However, most applications employ evaporator temperatures of -40°C up to +15°C. With the proper selection of lubricants, temperatures down upto -50°C presents no lubricant management problems if the system is properly designed and installed.

There is a movement among industrial companies that now use HFC & HCFC to convert their existing systems to ammonia. Many food freezing systems that use HFC & HCFC as a refrigerant are in the process of converting to conventional freezing systems using ammonia as the refrigerant.

Most of the chemical, dyestuff and pharmaceutical companies uses Ammonia as refrigerant for their industrial cooling requirements.

Concerns for Toxicity of Ammonia

Obviously, toxicity must be addressed by any user. However, much of the concern is based on the fear of ammonia that has been generated by ammonia's competitors.

Ammonia has a pungent odor, but that's not all bad. It warns you to take the necessary steps to stop leaks. The American Conference of Industrial Hygienists (ACGIH) publishes a booklet that lists the maximum threshold limit values. The threshold limit values (TLVs) consist of two components- the time weighted average (TWA) concentration and the short-term exposure limit (STEL). The TWA is the time-weighted average concentration for a normal 8-hour work day and a 40-hour work week. The STEL is a 15- minute, time-weighted average exposure that should not be exceeded at any time during a work day, even if the 8-hour TWA is within the TLV. The TWA of ammonia is 25 ppm. The STEL for ammonia is 35 ppm, which is only slightly higher than the TW A Other studies, some of them informal, have been conducted on the reactions of people to ammonia. A typical study is shown in Table 1. These observations were made during short exposures (1 to 3 minutes) of seven volunteer subjects (humans) to ammonia. The concentrations are higher than the TLVs, (recommended by the ACGIH) which are probably intentionally conservative. Please refer to table 4 for details.

Concerns for Flammability of Ammonia

Ammonia is classified as Class B2L

Table 5: Misconception about Ammonia when used as a Refrigerant

Misconception	Fact
Ammonia is Toxic	• Ammonia has a pungent odour and even small leaks as low as 5 PPM is detectable by smell and serves as an early warning, so that the maintenance staff can arrest them. • Almost all human beings can detect levels up to 25 PPM and continuous exposure to 50 PPM levels is permitted in most countries for 8 hours per day per week. • Laboratory trials have proved that continuous exposure levels for 10 to 15 years up to and exceeding 24 PPM has no adverse effect on human beings. • Installation of ammonia leak detection sensors assists in ensuring safe operation.
Ammonia is Flammable	• Ammonia is extremely hard to ignite even up to 650 °c. Ammonia breaks at 450 °c. Flammable limit by volume in air at atmospheric pressure is as high as 16% to 28% concentration. • It is now classified as a B2L, which is less flammable as compared with many hydrocarbons and other fuels which are used in day to day life. • Due to the high affinity of ammonia for atmospheric humidity, it is rated as hardly flammable.
Ammonia cannot be used for air cooled applications	• Ammonia air cooled condensers are available and also hybrid (Evaporative + Air cooled) Condensers are becoming popular around the world.
Ammonia systems are flooded operation and require lot of refrigerant as compared to other refrigerants	• Low charge factory made packaged refrigeration systems of less than 0.3kg of ammonia ITon or Refrigeration are available.
Small capacity & Direct expansion Ammonia systems are not available	• Ammonia compressors with 7kW capacity have been developed for small capacity package units. • Semi hermetic as well as hermetic compressors using aluminum winding motors are now developed. • Direct expansion systems with miscible oils using electronic expansion valves are available.
Ammonia cannot be used for air conditioning	• Due to increased use of natural refrigerants and due to its excellent energy saving properties, many countries are using ammonia with secondary fluids like water, brines and $C0_2$ in air conditioning plants. • Some of them listed below: - Oslo Airport -Norway - Heathrow Terminal- 5 - Singapore Airport - Stuttgart Airport Terminal-3
Ammonia plants cannot be made automatic and requires team operators	• Fully automatic Ammonia refrigeration plants are being used all over the world and as well in Ind ia since last 30 years. • These plants are remote controlled from central control panel.
Ammonia is going to be banned	• This is a myth. In fact, the man made refrigerants are on the way out in most of the developed countries. • Ammonia is not going to be banned. Manufacturers of synthetic refrigerants and manufacturers of air conditioning and refrigerant systems suitable tor only synthetic refrigerants are trying their best to safeguard their products by spreading drawback of Ammonia. This is a futile attempt hopefully till they are geared up to start using Ammonia. Recently being introduced so called "safe and nature friendly synthetic refrigerants" are petroleum based which have its own drawbacks. • Being natural refrigerant, its use is increasing globally.

and hence not considered as highly flammable refrigerant. Pure ammonia is considered flammable between the 16% and 27% atmospheric pressure. There have been many experiments performed in this area. Ammonia in vapor state will not sustain a flame. In the industrial refrigeration industry, many engineers believe that the presence of oil in the ammonia is the culprit, where ammonia has been blamed for an explosion. Oil in vapor state is relatively easy to ignite and it will sustain a flame. Modem plants employing highly efficient coalescing separators reduce the amount of oil in the system and thus diminish the possibility of a fire or explosion.

The best deterrent would be a non-flammable lubricant. This would further diminish the possibility. A non-flammable lubricant for ammonia systems is now in the final development stage.

Misconceptions about Ammonia When Used as a Refrigerant

Many misconception about Ammonia as refrigerant exist due its popularity and some of the heavy lobbying of synthetic

refrigerant manufacturers and equipment producers. Please refer to table 5.

New Applications

Ammonia for Air-conditioning

Water chillers employing helical screw compressors providing conventional 7°C water for air conditioning. These units would be installed in a building separated from the air conditioned building or possibly on the roof. The chiller would be designed with a minimal ammonia charges low as 0.25 kg of Ammonia for 1 kW refrigeration load. In Europe, many plants are now operational with Ammonia as refrigerant for air conditioning such as KWN Engineering Vienna (1998), Saab Sweden (1999), Frigopol (2000), Berlin Ostbahnh of Train Station (2000), Stuttgart Airport (2004) Roche's HQ London (2005), Dutch ABN Amro Bank London (2006), Mulligan Letter Sorting Center Switzerland (2008), Ozeaneum Stralsund (2010), Heathrow Airport terminal 4, Oslo Airport, terminal 3 and many more.

Thermal Storage

A static ice storage system employing ammonia as the refrigerant. This system freezes ice on tubes (pipe) over a period of 24 hours. The ice accumulated is then melted by water which is recirculated to the air conditioning system. This is a demand leveling system. This unit would be installed in a building that is separated from the air conditioned building.

Secondary Refrigerant

A dual temperature Brine chilling system for supermarkets employing ammonia (minimal charge) as the refrigerant. This could be a package design in an enclosure that would be roof mounted.

Heat Pump

With the increased emphasis on energy savings, market opportunities exist for NH_3 heat pumps. Therefore, the newly identified market and products are primarily for small and medium capacity (~50 to ~2000 kW) liquid and water chillers for air-conditioning, industrial and commercial refrigeration applications, and occasionally including heat recovery. New ammonia products are packaged chillers because indirect cooling systems are safer for small systems. This tendency to indirect cooling is not limited to ammonia. This is a general trend to improve the charge containment with any refrigerant including HFCs.

Each of these systems can be designed in accordance with AAR-01. Since ammonia is a group B2L refrigerant, the safety code is restrictive in the area of refrigerant change and equipment room design.

We can conclude that with increase awareness for energy efficiency, eco friendliness and availability of knowledge through AAR the use of Ammonia as refrigerant is every growing in India. Also, we have to acknowledge Indian Refrigeration industry which is self-reliant and manufacture all equipment & components for Ammonia Refrigeration Industry in India. Unlike other synthetic refrigerant based equipment manufacture who mostly import equipment and components from counties like China. The high-quality standard maintained by these companies has opened doors for Indian products to international markets. I am glad to see many of such companies participating in International show with proudly displaying make in India brand. ■

Anand Joshi
Immediate Past President
Association of Ammonia Refrigeration, Member ASHRAE (USA), IIAR (USA), IGCC, IETE, IDA, RATA, Pune

"We're committed to providing high energy-efficient products"

Embraco's greater presence in India aims to support our vision in this market and is in line with the country's objectives, which promote increasingly more energy efficiency in an ever more demanding refrigeration market, informs **Marcio Schissatti, Vice President of Business & Marketing, Embraco** in an interaction with **Cooling India**...

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

In 2016, we announced our entry into the household and commercial refrigeration market in the region, but Embraco has been in the Indian market since 2009 with a focus on special applications. To become leader in this market, we're launching a solutions portfolio which fits the region's requirements completely and we're reinforcing our local team to better serve our Customers in India. We've developed technical support professionals, supporting trainings and marketing actions for example, as well as increasing the sales team dedicated to the business. This way, Embraco is strengthening the commercial relationship with several customers and increasing partnerships with its distributors.

In 2017, we attended several events in India, in addition to Japan and Thailand, with a customer-partnership strategy. We intend to continue with this strategy in 2018, including participation in ACREX, the largest international exhibition on air conditioning, refrigeration and building services, taking place in India. We will attend this event with a strong presence in our own booth.

Embraco's greater presence in India aims to support our vision in this market and is in line with the country's objectives, which promote increasingly more energy efficiency in an ever more demanding refrigeration 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?

Awareness for a better environment has driven more energy-efficient systems, better acoustic solutions and an increasing appeal for health, which translates into food preservation. Technologies such as variable speed compressors and connectivity, with Internet of Things solutions, are the ones that will be predominant in the future and will add value for the end user. We believe in natural refrigerants as a success case in many developed countries and it's on the agenda worldwide, both for use in household and commercial segments. Hydrocarbons, for example, are the winning solution for the future of refrigeration by sustainably aligning economic and environmental needs.

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

Sustainability is a driver in the company's strategy and goes beyond developing intelligent solutions and continuous improvement. We've done a comprehensive environmental assessment to understand the full impact in the product life cycle. It brought several insights which we've implemented in our product development cycle.

As technology leader in the industry, we are the pioneer in developing a natural refrigerant portfolio and variable speed technologies and, therefore, our solutions are now being used for both commercial and household refrigeration markets in India (HCs - R290 and R600a). Embraco has used natural refrigerants for more 20 years, which are the solution to reduce the negative effects on the ozone layer, greenhouse effects and to improve the equipment's energy efficiency.

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

We have a complete and the most updated portfolio for the Indian market, which attends upto 1.5 HP. As the pioneer in inverter type compressors for refrigeration, we are proud to provide our most efficient variable speed compressors, which are the most efficient and silent in the market. I would like to highlight special solutions which attend wide voltage ranges such as Fullmotion Inverter Technology, both for Household and Light Commercial use. Embraco has been

Fullmotion X compressor for refrigerators and freezers with an extremely high energy efficiency

investing in Fullmotion variable frequency technology since 1998 and this technology brings energy savings of upto 40% compared to conventional compressors when applied with natural refrigerants such as R290 and R600a. In the household segment, we've launched the family called 'Fullmotion X' compressor for refrigerators and freezers with an extremely high energy efficiency for cooling systems.

In the light commercial segment, we have the most complete portfolio of single speed compressors for R290, considered the world's most efficient portfolio for this segment.

> India has been growing and the customers are demanding more than competitiveness, but also energy-efficient products and robust solutions for voltage fluctuation.

Another technology Embraco has developed is plug n' cool a solution that reduces the physical area in supermarkets, for example. It's 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. This technology allows food retailers to reduce the total cost of ownership, increase revenues, leverage flexibility while fitting different applications and store formats.

For commercial, I also highlight the recently launched FMFT Bivolt, an intelligent and fast-cooling solution for light commercial applications such as freezers and vertical refrigerated display cabinets. The FMFT Bivolt, a very robust solution for voltage fluctuation, employs Variable-Speed Inverter Technology that enables the machine to reach a target temperature quickly, helping to ensure better food preservation and reduce thermal fluctuations. This product is able to operate at many different speeds, allowing it to

Plug n' cool is a simple and compact sealed unit for commercial refrigeration

reach target temperatures more efficiently, which can help reduce energy consumption by up to 30 percent.

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?

Globally, most governments have been working to reduce energy consumption. In Europe and Asia, manufacturers are more concerned about launching high-efficiency products as well as competitive solutions. In the various countries where Embraco operates, the company is prepared to attend the global refrigeration market, which seeks to migrate to natural refrigerants. India has been growing and the customers are demanding more than competitiveness, but also energy-efficient products and robust solutions for voltage fluctuation. As a global company and a multinational focused on solutions for refrigeration, Embraco has a complete portfolio of products and cooling solutions which attend different cultures and regions, such as India. Our 46 years of history make us more competitive and a differentiated player to win the Indian market's trust.

What are the growth drivers of your products in India?

As I mentioned earlier, we're committed to providing high energy-efficient products and solutions for voltage fluctuation according to all present and future regulations in India. There has been an ongoing trend for the Indian commercial refrigeration sector to migrate to R290-equipped compressors. In the household segment, the trends toward energy-efficiency and food preservation will significantly support the massive usage of our Fullmotion Inverter applications bringing quality of life to Indian consumers, through reduced electricity costs, better preserved food as well as lower noise compared to a standard compressor.

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

We invest a substantial part of our resources to research and develop technologies to be launched in the next 10 to 20 years. This is one of the reasons why Embraco is the pioneer in bringing the best and most innovative solutions to the market.

In addition, one in five hermetic compressors in the world has the Embraco brand. As a multinational in the refrigeration segment, Embraco invests annually 3% to 4% of net revenue in Research and Development – its technology DNA – to propose new solutions to customers. We are committed to maintain partnerships with several high technology universities and institutes around the world, operating approximately 50 research laboratories on all continents.

We have global operations and annual production capacity of 40 million units and the company holds over 1,700 patents. With 11 business units located in Brazil, China, Italy, Mexico, Slovakia, USA and Russia, we are present in more than 80 countries with solutions.

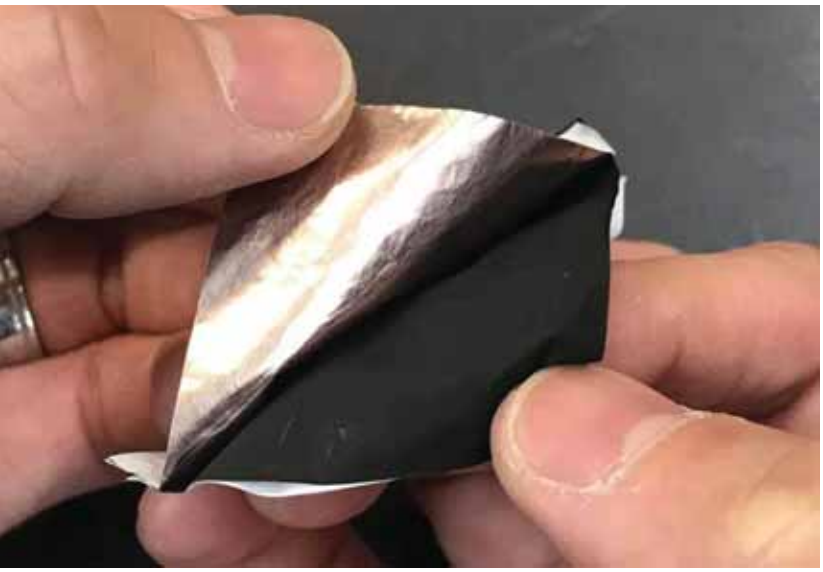
What are your expansion plans in India? What potential do you foresee for your company with the Indian Government's focus on development of infrastructure like smart cities, urban transportation projects?

We're playing to win over the market in India, developing our distributors' network, offering all technical support with a specialized team. We have the goal to help our customers succeed, evaluating new opportunities for partnerships, in light commercial and household segments to provide innovative solutions for a better quality of life.

Aiming to expand our market share in the Indian market, we're looking to add even more value and differentiation for our customers through strategies that focus on the end user. 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, Embraco has the capability to provide a better quality of life for the entire Indian population. ■

Double Duty Textile Could Warm or Cool Wearers

Double-duty textile developed by Stanford researchers could warm or cool. Clothing made from a reversible fabric could warm or cool wearers and keep them comfortable, bringing down buildings' energy costs.



Two layers of material with different abilities to release heat energy are stacked together and sandwiched between layers of polyethylene. (Image credit: Yi Cui Group)

Stanford researchers have developed a reversible fabric that, without expending effort or energy, keeps skin a comfortable temperature whatever the weather. A new textile made from a reversible fabric could warm or cool wearers and keep them comfortable. Two layers of material with different abilities to release heat energy are stacked together and sandwiched between layers of polyethylene.

In a paper published Nov 10 in *Science Advances*, a team led by Yi Cui, professor of materials science and engineering, created a double-sided fabric based on the same material as everyday kitchen wrap. Their fabric can either warm or cool the wearer, depending which side faces out. This project came out of Cui's interest in energy efficiency and his expertise in manipulating nanoscale materials. He thought if people could be more comfortable in a range of temperatures, they could save energy on air conditioning and central heating. "Why do you need to cool and heat the whole building? Why don't you cool and heat individual people?" asked Cui. Thirteen percent of all of the energy consumed in the United States is simply dedicated to indoor temperature control. But for every 1 degree Celsius (1.8 degrees Fahrenheit) that a thermostat is turned down, a building can save a whopping 10 percent of its heating energy, and the reverse is true for cooling. Adjusting temperature controls by just a few degrees has major effects on energy consumption.

Cooling kitchen wrap

Our bodies have many ways of controlling our temperature. When it's cold, hair in our skin stand out to trap warm air. Eventually, we may start shivering to produce more radiant heat in our muscles. When it's hot, we release heat as infrared radiation from our skin, and if we're still warm we start to sweat. Water evaporating away from our bodies carries a large amount of heat with it. But those mechanisms only help within a few degrees. Get outside the temperature range to which our bodies can adapt, and we reach for the dial on the heating or air conditioning. In 2016, the team announced a first step toward a solution: fabric that allowed the body's heat to pass through, cooling the skin. Although they were inspired by transparent, water-impermeable kitchen wrap, their new material was opaque, breathable and retained its ability to shuttle infrared radiation away from the body. Compared to a cotton sample, their fabric kept artificial skin 2 C cooler in a laboratory test – possibly enough to stop a person from ever reaching for a fan or the building thermostat. The team's first textile could save a building full of workers 20 to 30 percent of their total energy budget.

Reversible Progress

"Right around when we figured out cooling, then came the question: Can you do heating?" said post-doctoral fellow Po-Chun Hsu, who was first author on the recent paper. It was a particularly chilly winter, and he was headed to a conference in Minneapolis with a carry-on bag full of coats. Could he create an article of clothing that would serve him in a crowded warm conference room as well as on the frosty street?

Hsu realized that controlling radiation could work both ways. He stacked two layers of material with different abilities to release heat energy, and then sandwiched them between layers of their cooling polyethylene. On one side, a copper coating traps heat between a polyethylene layer and the skin; on the other, a carbon coating releases heat under another layer of polyethylene. Worn with the copper layer facing out, the material traps heat and warms the skin on cool days. With the carbon layer facing out, it releases heat, keeping the wearer cool. ■

Aspects of Refrigerators, Heat Exchangers, & Fans (Part 1)

New types and blends of refrigerant with minimal negative impacts are being developed. A correctly fitted system will also greatly reduce the potential for leakage, which is why using a professional installer is highly recommended. Significant CO_2 savings can be gained by displacing fossil fuels. Even compared to the most efficient gas or oil condensing boilers, a well-designed heat pump with COP of 3-4 will reduce emissions by 30-35%. Further, carbon savings can be made if the electricity used to power the pump comes from a renewable energy source such as photovoltaic or a renewable electricity tariff. Also, measures can be taken to reduce the impact of pollution from using grid electricity generated through fossil fuel...

Over the years, all parts of a commercial refrigerator, such as the compressor, heat exchangers, refrigerant, and packaging, have been improved considerably due to the extensive research and development efforts carried out by academia and industry. However, the achieved and anticipated improvements in conventional refrigeration technology are incremental since this technology is already nearing its fundamentals limit of energy efficiency is described in 'magnetic refrigeration' which is an evolving cooling technology. The word 'green' designates more than a colour. It is a way of life, one that is becoming more and more common throughout the world. An interesting topic on 'sustainable technologies for a greener world' details about what each technology is and how it achieves green goals. Recently, conventional chillers using absorption technology consume energy for hot water generator but absorption chillers carry no energy saving. With the aim of providing a single point solution for this dual purpose application, a product is launched but can provide simultaneous chilling and heating using its vapour absorption technology with 40% saving in heating energy. Using energy efficiency and managing customer energy use has become an integral and valuable exercise. The reason for this is green technology helps to sustain life on earth. This not only applies to humans but to plants, animals and the rest of the ecosystem. Energy prices and consumption will always be on an upward trajectory. In fact, energy costs have steadily risen over last decade and are expected to carry on doing so as consumption grows. Refrigerants such as hydrochloroflurocarbons (HCFCs) are present in the ground source heat pump (GSHP) systems and can pose a threat to the environment through being toxic, flammable or having a high global warming potential.

However, new types and blends of refrigerant with minimal negative impacts are being developed. A correctly fitted system will also greatly reduce the potential for leakage, which is why using a professional installer is highly recommended. Significant CO_2 savings can be gained by displacing fossil fuels. Even compared to the most efficient gas or oil condensing boilers, a well-designed heat pump with COP of 3-4 will reduce emissions by 30-35%. Further, carbon savings can be made if the electricity used to power the pump comes from a renewable energy source such as photovoltaic or a renewable electricity tariff. Also, measures can be taken to reduce the impact of pollution from using grid electricity generated through fossil fuel. For example, one can purchase dual tariff green electricity from a number of suppliers. However, even if ordinary grid electricity is used to run the compressor, the system will still produce less CO_2 emissions than even the most efficient condensing gas or oil boiler with the same output. The term "vapour compression refrigeration" is somewhat of a misnomer, it would be more accurately described as 'vapour suction refrigeration'. Vapour compression is used to reclaim the refrigerant and is more aptly applied to heat pumps. Vapour compression refrigeration exploits the fact that the boiling temperature of a liquid is intimately tied to its pressure. Generally, when the pressure on liquid is raised its boiling (and condensing) temperature rises, and vice-versa. This is known as the saturation pressure-temperature relationship.

One of the most energy efficient methods of domestic heating is to use heat pumps. Heat pumps use electrical energy to reverse the natural flow of environmental heat from cold to hot. A typical heat pump requires only 100 kWh of electrical power to turn 200 kWh of freely available environmental heat into 300 kWh of useful heat. In every case, the useful heat output will be greater than the

energy required to operate the pump itself. Heat pumps also have a relatively low carbon dioxide output, less than half that of oil, electric and gas heat production.

Heat pumps for domestic heating are a relatively new concept in Britain; however, the technology is widely used in an industrial capacity. Across Europe, hundreds of thousands of domestic heat pump units are in use, and the technology is tried, tested and reliable.

Ideally, a refrigerant will have the following characteristics:

- Non-toxic - for health and safety reasons.
- Non-flammable - to avoid risks of fire or explosion.
- Operate at modest positive pressures - to minimise pipe and component weights (for strength) and avoid air leakage into the system.
- Have a high vapour density – to keep the compressor capacity to a minimum and pipe diameters relatively small.
- Easily transportable - because refrigerants are normally gases at SSL conditions they are stored in pressurised containers.
- Environmentally friendly - non-polluting and non-detrimental to the atmosphere, water or ground.
- Easily re-cycleable.
- Relatively inexpensive to produce.
- Compatible with the materials of the refrigeration system - non-corrosive, miscible with oil, chemically benign.

In practice, the choice of a refrigerant is a compromise, e.g., Ammonia is good but toxic and flammable. R12 is very good but detrimental to the Ozone layer. An air-source heat pump is convenient to use and so, it is a better method for electric heating. The ambient temperature in winter is comparatively high in most regions, so heat pumps with high efficiency can satisfy their heating requirement. On the other hand, a conventional heat pump is unable to meet the heating requirement in severely cold regions anyway, because its heating capacity decreases rapidly when ambient temperature is below -10°C. According to the weather data in cold regions, the air-source heat pump for heating applications must operate for long times with high efficiency and reliability when ambient temperature is as low as -15°C. Hence, much researches and developments have been conducted to enable heat pumps to operate steadily with high efficiency and reliability in low temperature environments. For example, the burner of a room air conditioner, which uses kerosene, was developed to improve the performance in low outside temperature. Similarly, the packaged heat pump with variable frequency scroll compressor was developed to realise high temperature air supply and high capacity even under the low ambient temperature of –10 to –20°C. Such a heat pump systems can be conveniently used for heating in cold regions. However, the importance of targeting the low capacity range is clear if one has in mind that the air conditioning units below 10 kW cooling account for more than 90% of the total number of units installed in the EU.

Energy Efficiency Considerations in Heat Exchangers Designs

Heat exchangers are devices, designed to efficiently transfer heat, from one medium to another, i.e., water-to-air, refrigerant-to-air, refrigerant-to-water, stream-to-water. Heat exchangers are widely used in power engineering, chemical industries, petroleum refineries, food industries and in HVAC technology. Therefore, heat transfer and the design of heat transfer equipment continue to be a centrally important issue in energy conservation. With increasing worldwide awareness of the serious environmental problems due to fossil fuel consumption, efforts are being made to develop energy efficient and environmentally friendly systems by utilisation of non-polluting renewable energy sources, such as solar energy, industrial waste heat or geothermal water. The GSHPs are suitable for heating and cooling of buildings and so could play a significant role in reducing CO_2 emissions. Ground source or geothermal heat pumps are a highly efficient, renewable energy technology for space heating and cooling. This technology relies on the fact that, at depth, the Earth has a relatively constant temperature, warmer than the air in winter and cooler than the air in summer.

Heat Transfer Mechanisms

- Single-phase convection on both sides
- Single-phase convection on one side
- Two-phase convection on other side
- Two-phase convection on both sides

Examples: condensers, boilers, evaporators and radiators (Figure 1).

Naturally, it would be preferred, for comfort reasons that this index would be small, preferably nil. It may be seen that the variable is directly related to temperature discomfort: the larger the value of the index, the farthest will inside conditions be from expected wellbeing. Also, the use of electricity operated air conditioning systems will be more expensive the higher this variable is. Hence, energy expenditure to offset discomfort will be higher when comparing two index values; the ratio of them is proportional to the expected energy savings.

When the external shade blocks the windowpane completely, the excessive heat gains belong to the lowest values in

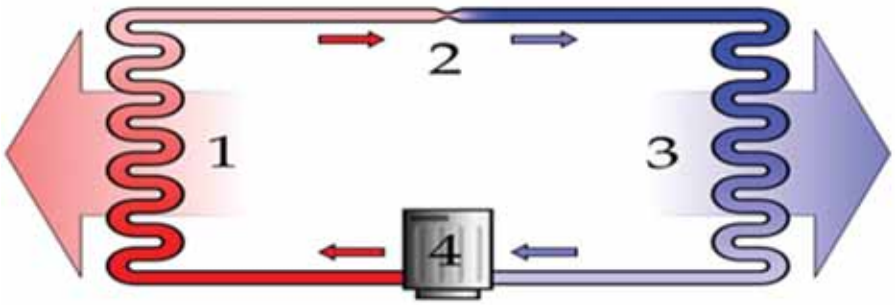


Figure 1: Diagram of a phase change heat pump: 1) condensator coil 2) expansion valve 3) evaporator coil and 4) compressor.

Figure 2: Shows the heat exchanger.

the set, and the dimensionless index will be constant with orientation. For the climate conditions of the locality, it can be seen that a naked window can produce undesirable heat gains if the orientation is especially unfavourable, when the index can have an increase of up to 0.3 with respect to the totally shaded window.

Brief Methodology of Heat Exchanger Design Based on the Log Mean Temperature Difference (LMTD) and Effectiveness

A heat exchanger is usually referred to as a micro heat exchanger (μHX) if the smallest dimension of the channels is at the micrometer scale, for example from 10 μm to 1 mm. Beside the channel size, another important geometric characteristic is the surface area density *p* (m^2/m^3), which is defined as the ratio of heat exchange surface area to volume for one fluid. It reflects the compactness of a heat exchanger and provides a criterion of classification. Note that the two parameters, the channel size and surface area density, are interrelated, and the surface area density increases when the channel size decreases. The exchangers that have channels with characteristic dimensions of the order of 100 μm are likely to get an area density over 10 000 m^2/m^3 and usually referred to as μHXs.

By introducing *efficiency* (α) in the specific heat exchanger performance equation, the volumetric heat transfer power *P/V* (W/m^3) can be expressed as follows:

$$P = FUA\,\Delta T_m = FUA\,\rho\,\alpha\,V\,\Delta T_m \quad (1)$$

$$P/V = \rho\,FU\,\Delta T_m \quad (2)$$

$$\Delta T_m = \frac{[(T_{h,out} - T_{c,out}) - (T_{h,in} - T_{c,in})]}{Ln\left[(T_{h,out} - T_{c,out}) - (T_{h,in} - T_{c,in})\right]} \quad (3)$$

where, U, ΔT_m and F refer to the overall heat transfer coefficient (W/m^2 K), the mean temperature difference (K) and the dimensionless mean temperature difference correction factor for flow configuration respectively. A is the heat transfer surface area. Note that for a specific heat exchanger performance, high values of α lead to a corresponding high volumetric heat transfer power, larger than that of the conventional equipment by several orders of magnitude. As a result, heat exchanger design by miniaturisation technology has become a common research focus for process intensification.

The main advantages of the μHX design are "compactness, effectiveness and dynamic". These properties enable exact process control and intensification of heat and mass transfer:

Compactness: The high surface area density reduces the volume of the heat exchanger needed for the same thermal power substantially. As a result, the space and costly material associated with constructing and installing the heat exchanger could be reduced significantly. Moreover, the fluid hold-up is small in a μHX; this is important for security and economic reasons when expensive, toxic, or explosive fluids are involved.

Effectiveness: The relatively enormous overall heat transfer coefficient of the μHXs makes the heat exchange procedure much more effective. In addition, the development of microfabrication techniques such as LIGA, stereolithography, laser beam machining, and electroformation allows designing a μHX with more effective configurations and high pressure resistance.

Dynamic: The quick response time of a μHX provides a better temperature control for relatively small temperature differences between fluid flows. The quick response (small time constant) is connected to the small inertia of the heat transfer interface (the small metal thickness that separates the two fluids). On the other hand, the exchanger as a whole, including the "peripheric" material, usually has a greater inertia than conventional exchangers, entailing a large time-constant. Thus, the response of one fluid to a temperature change of the other fluid comprises two "temperature-change waves", with very distinct time-constants. In conventional exchangers, it is possible that the two responses are blurred into one.

However, the μHXs are not without shortcomings. On the one hand, the high performance is counterbalanced by a high pressure drop, a rather weak temperature jump and an extremely short residence time. On the other hand, those fine channels

Figure 3: Shows the connections of the heat exchanger, water pump, heat rejection fan and expansion valve.

Figure 4: Shows the connections of the heat exchanger and expansion valve.

Figure 5: Shows the power supply to heat injection fan.

(~100 μm) are sensitive to corrosion, roughness and fouling of the surfaces. Moreover, the distinguishing feature of the μHXs is their enormous volumetric heat exchange capability accompanied with some difficulties in realisation. The μHXs design optimisation lies, on the one hand, in maximising the heat transfer in a given volume taking place principally in microchannels, while, on the other, minimising the total pressure drops, the dissipations, or the entropy generation when they function as a whole system. Moreover, difficulties such as the connection, assembly, and uniform fluid distribution always exist, all of which should be taken into account at the design stage of the μHXs. All these make the optimisation of the μHXs design a multi-objective problem, which calls for the introduction of multi-scale optimisation method in order to bridge the microscopic world and the macroscopic world. In recent years, the fractal theory and constructal theory were introduced to bridge the characteristics of heat and mass transfer that mainly takes place in micro-scale and the global performance of the heat exchanger system in macro-scale.

The concept of multi-scale heat exchanger is expected to have the following characteristics:

- A relatively significant specific heat exchange surface compared to that of traditional exchangers;
- A high heat transfer coefficient, as heat transfer is taking place at micro-scales and meso-scales;
- An optimised pressure drop equally distributed between the various scales;
- A modular character, allowing assembly of a macro-scale exchanger from microstructured modules.

Some difficulties still exist. On the one hand, the properties of flow distribution in such an exchanger are still unknown. A lot of research work still needs to be done for the equidistribution optimisation. On the other hand, 3-D modelling of heat transfer for such an exchanger requires a thorough knowledge of the hydrodynamics and profound studies on elementary volume (smallest scale micro channels). Finally, maintenance problems for this type of integrated structures may become unmanageable when fouling; corrosion, deposits or other internal perturbations are to be expected. Figures 2-4 show the connections of the heat exchanger, water pump, heat rejection fan expansion valve, and the power supply to heat injection fan (Figure 5).

Renewable energy is the term to describe a wide range of naturally occurring, and replenishing energy sources. The use of renewable energy sources and the rational use of energy are the fundamental inputs for a responsible energy policy. The energy sector is encountering difficulties because increased production and consumption levels entail higher levels of pollution and eventually climate changes, with possibly disastrous consequences. Moreover, it is important to secure energy at acceptable cost to avoid negative impacts on economic growth. On the technological side, renewables have an obvious role to play. In general, there is no problem in terms of the technical potential of renewables to deliver energy and there are very good opportunities for renewable energy technologies to play an important role in reducing emissions of greenhouse gases into the atmosphere-certainly far more than have been exploited so far. However, the biggest problem with replying on renewables to deliver the necessary cuts in greenhouse gas emissions is more to do with politics and policy issues than with technical ones.

The single most important step governments could take to promote and increase the use of renewables would be to improve access for renewables to the energy market. That access to the market would need to be under favourable conditions and possibly under favourable economic rates. One move that could help-or at least justify-better market access would be to acknowledge that there are environmental costs associated with other energy supply options, and that these costs are not currently internalised within the market price of electricity or fuels. It could make significant difference, particularly if, appropriate subsidies were applied to renewable energy in recognition of environmental benefits it offers. Cutting energy consumption through end-use efficiency is absolutely essential. And this suggests that issues of end-use consumption of energy will have to come onto the table in the foreseeable future.

Thermal comfort is an important aspect of human life. Buildings where people work require more light than buildings where people live. In buildings where people live the energy is used for maintaining both the temperature and lighting. Hence, natural ventilation is rapidly becoming a significant part in the design strategy for non-domestic buildings because of its potential to reduce the environmental impact of building operation, due to lower energy demand for cooling. A traditional, naturally ventilated building can readily provide a high ventilation rate. On the other hand, the mechanical ventilation systems are very expensive. However, a comprehensive ecological concept can be developed to achieve a reduction of electrical and heating energy consumption, optimise natural air condition and ventilation, improve the use of daylight and choose environmentally adequate building materials. Energy efficiency brings health, productivity, safety, comfort and savings to homeowner, as well as local and global environmental benefits. The use of renewable energy resources could play an important role in this context, especially, with regard to responsible and sustainable development. It represents an excellent opportunity to offer a higher standard of living to local people and will save local and regional resources. Implementation of the ground source heat pump systems offers a chance for maintenance and repair services. It is expected that the pace of implementation will increase and the quality of work to improve in addition to building the capacity of the private and district staff in contracting procedures. The financial accountability is important and more transparent.

Various passive techniques have been put in perspective, and energy saving passive strategies can be seen to reduce interior temperature and increase thermal comfort, and reducing air conditioning loads. The scheme can also be employed to analyse the marginal contribution of each specific passive measure working under realistic conditions in combination with the other housing elements. In regions where heating is important during winter months, the use of top-light solar passive strategies for spaces without an equator-facing façade can efficiently reduce energy consumption for heating, lighting and ventilation. The use of renewable energy resources could play an important role in this context, especially, with regard to responsible and sustainable development. It represents an excellent opportunity to offer a higher standard of living to local people and will save local and regional resources. Implementation of the GSHPs offers a chance for maintenance and repair services.

An annual sinusoidal ambient temperature profile and an exponentially decaying sinusoidal temperature profile as a function of depth are assumed. Temperature at any given depth in a moment can be estimated on the basis of the following equation.

$$T(x,t) = A_s e^{-x\sqrt{\frac{\Pi}{365\alpha}}} \cos\left[\frac{2\Pi}{365}\left(t - t_o - \frac{x}{2}\sqrt{\frac{365}{\Pi\alpha}}\right)\right] \quad (4)$$

where:

T(x, t) is the soil temperature at the depth (x) and time (t) (oC), T_m is an average soil temperature (oC), A_s is the thermal wave amplitude (oC), x is the depth (m), t is the day of year (in days, where t=0 at midnight on 31 December), t_o is the phase constant (days), and α is the apparent thermal diffusivity (m^3/day).

The heat exchanger effectiveness is defined as the ratio of actual heat transfer versus maximum possible heat transfer. The actual heat transfer may be computed by calculating either the energy lost by the hot fluid or the energy gained by cold fluid. For counter flow and parallel flow heat exchangers it is given as:

$$Q = (mc_p)_h (T_{h,in} - T_{h,out})$$
$$= (mc_p)_c (T_{c,out} - T_{c,in}) \quad (5)$$

The maximum possible heat transfer expressed as:

$$Q = (mc_p)_{min} (T_{h,in} - T_{c,in}) \quad (6)$$

The minimum fluid may be either the hot or cold fluid, depending on the mass flow rates and specific heats. For counter flow heat exchanger, the effectiveness is given as:

$$\varepsilon = \frac{(mc_p)_c}{(mc_p)_{min}} \frac{(T_{c,out} - T_{c,in})}{[(T_{h,in} - T_{c,in})]}$$

$$\varepsilon = \frac{(mc_p)_c}{(mc_p)_{min}} \frac{(T_{c,in} - T_{c,out})}{[(T_{h,in} - T_{c,in})]} \quad (7)$$

For given effectiveness and maximum heat transfer rate, actual heat transfer rate be obtained from:

$$Q = \varepsilon (mc_p)_{min} (T_{c,in} - T_{c,in}) \quad (8)$$

The number of heat transfer units designates the non dimensional heat transfer size of the heat exchangers is defined as:

$$NTU = UA/C_{min} \quad (9)$$

Defining capacity rate as the product of mass flow rate and specific heat as:

$$(mC_p)_c = C_c \text{ and } (mC_p)_h = C_h \quad (10)$$

According, C_{min} and C_{max} will be minimum and maximum capacity rate respectively. The relationship between effectiveness and number of heat transfer units, NTU is given for counter flow heat exchanger configuration as follows:

$$(\varepsilon) = \frac{1 - e^{-NTU(1 - C_{min}/C_{max})}}{1 - (C_{min}/C_{max}) e^{-NTU(1 - C_{min}/C_{max})}} \quad (11)$$

Compared to the LMTD method of analysis of heat exchanger, effectiveness- NTU method provides a direct solution. LMTD method requires the outlet temperature of both the streams which is not so in effectiveness- NTU method.

Thermodynamic Efficiency Analysis of Heat Exchanger

The maximum useful work that could be obtained from the system at a given state in a specified environment is known as exergy also called available energy. The property exergy serves as a valuable tool in determining the quality of energy and comparing work potential of different energy sources or systems. From the second law point of view, a measurement procedure is required to compare the performance of different processes or equipment.

The type of exergy efficiency called the rational efficiency is defined by Kotas, 1985 as the ratio of desired exergy output to exergy used:

$$(\Psi) = \frac{E_{desiredoutput}}{E_{used}} \quad (12)$$

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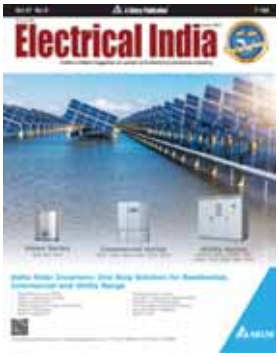

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Ψ is the sum of all exergy transfers from the system, which must regarded as constituting the desired output, plus any by-product, which is produced by the system. The desired output is determined by examining the function of the system. E_{used} is the required exergy input for the process to be performed which can be expressed in terms of irreversibilities as:

$$E_{used} = E_{desiredoutput} + I \quad (13)$$

Alternative form of the rational efficiency can be obtained from:

$$(\Psi) = \frac{E_{desiredoutput}}{E_{used} + I} \quad (14)$$

From the consideration of the heat exchanger, Kotas considered that the desired exergy output as the increase of the thermal component of exergy of the cold stream:

$$E_{desiredoutput} = E_c^T \quad (15)$$

where:

$$E_c^T = E_{c,out}^T - E_{c,in}^T \quad (16)$$

with reference to equation (12), in which rational efficiency is formulated, the following identify the required exergy input, E_{used} as:

$$E_{used} = E_{ht}^T + E_c^P + E_h^P \quad (17)$$

By using equation (12) and equation (14), the rational efficiency of the heat exchanger is obtained as:

$$(\Psi) = \frac{E_h^T}{E_h^T + E_c^P + E_h^P} = \frac{E_c^T}{E_c^T + I} \quad (18)$$

The exergy change of the hot and cold streams can be written with the help of ideal gas relations as follows:

$E_{out} - E_{in} = m\,[h_{out} - h_{in} + T_o\,(s_{out} - S_{in})]$

$= mCp\,(T_{out} - T_{in}) - To\,mCp\,Ln\,(T_{out}/Tin) + mT_oR\,Ln\,(P_{out}/P_{in})$ (19)

The desired exergy output which is the increase of the thermal component of exergy of the cold stream is obtained by equation (19) as:

$$E_c^T = (mC_p)_c[(T_{c,\,out} - T_{c,\,in}) - ToC_pLn(\frac{T_{c,\,out}}{T_{c,\,in}})] \quad (20)$$

Expressing the outlet temperature in terms of inlet temperature and effectiveness from equation (7), the above equation becomes:

$$E_c^T = Cc\,[\varepsilon\,C_{min}/\,C_c(T_{c,\,in} - T_{c,\,out}) - T_cLn[1 + \varepsilon C_{min}/\,C_c(\frac{T_{c,\,out}}{T_{c,\,in}} - 1]] \quad (21)$$

The irreversibility, also called exergy destruction or exergy loss, is calculated by exergy balance and taking the difference between all incoming and outgoing exergy flows given by Kotas, 1985:

$I = \sum E_{in} - \sum E_{out}$ (22)

Another way of calculating the irreversibility can be done by the Gouy-Stodola formula, in which the entropy generation rate is multiplied by the environmental temperature as:

$I = T_o\,S_{gen}$ (23)

which, in turn can be written in terms of summation of irreversibilities due to temperature difference between the fluid streams and pressure drop respectively as:

$$S_{gen} = (mC_p)\,Ln(\frac{T_{c,\,out}}{T_{c,\,in}}) + (mC_p)_c\,Ln(\frac{T_{c,\,out}}{T_{c,\,in}}) - (mR)_c\,Ln\,(P_{c,\,out}/P_{c,\,in}) - (mR)_h\,Ln\,(P_{h,\,out}/P_{h,\,in}) \quad (24)$$

The entropy generation rate in the heat exchanger is formulated using first and second law statements:

$I = I_{\Delta T} + I_{\Delta P}$ (25)

Defining entropy generation number by dividing entropy generation by minimum heat capacity, i.e., C_{min} as given by:

$N_s = S_{gen}/C_{min}$ (26)

This number is second-law 'relative' of the order concept of the NTU, which is used in traditional first-law analyses of heat exchangers. N_s represent a high or a low entropy generation rate depends on the following factors:

- The size of heat exchanger N_s that can be economically tolerated;
- On the magnitude of the remnant irreversibility, N_s, imbalance;
- On the entropy generation levels shown by the other components that make up the greater system.

Heat exchangers are generally inefficient from an energy conservation point of view because they have been designed in the past on the basis of low cost that dictates a minimum-size unit. To achieve the small-size heat exchanger, the temperature difference between the fluid streams is maximised.

However, the larger is the temperature difference in a heat exchanger, the greater will be the loss during heat transfer. Also, capacity mismatch is used between the streams to increase the performance.

Stored Energy

Thermal (internal) energy is caused by the motion of molecules and/or intermolecular forces. Potential energy (PE) is caused by attractive forces existing between molecules, or the elevation of the system.

PE = mgz (26)

where: m is the mass; g is the local acceleration of gravity; and z is the elevation above horizontal reference plane.

Kinetic energy (KE) is the energy caused by the velocity of molecules and is expressed as:

$KE = ½mV^2$ (27)

where: V is the velocity of a fluid stream crossing the system boundary.

Flow work is energy carried into or transmitted across the system boundary because a pumping process occurs somewhere outside the system, causing fluid to enter the system. Flow work also occurs as fluid leaves the system (Figure 6).

Flow work (per unit mass) $= pv$ (28)

Enthalpy h is an important property that includes internal energy and flow work and is defined as:

$h = u + pv$ (29)

First Law of Thermodynamics

The first law of thermodynamics is often called the law of conservation of energy. The following form of the first-law

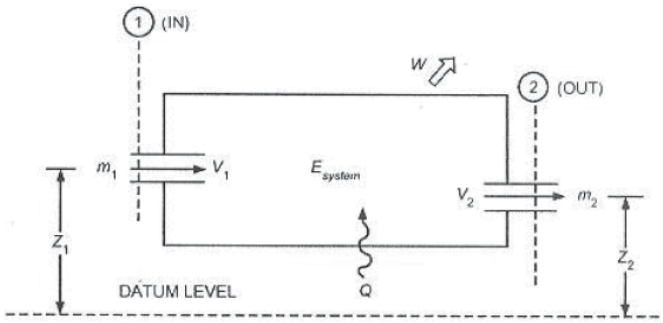

Figure 6: Energy flows in general thermodynamic system.

equation is valid only in the absence of a nuclear or chemical reaction.

Based on the first law or the law of conservation of energy for any system, open or closed, there is an energy balance as:

[Net amount of energy added to system] = [Net increase of stored energy in system] (30)

or

[Energy in] – [Energy out] = [Increase of stored energy in system] (31)

For the general case of multiple mass flows with uniform properties in and out of the system, the energy balance can be written:

$$\sum m_{in}(u + pv + \frac{V^2}{2} + gz)_{in} - \sum m_{out}(u + pv + \frac{V^2}{2} + gz)_{out} + Q - W = [m_f(u + pv + \frac{V^2}{2} + gz)_f - m_i(u + pv + \frac{V^2}{2} + gz)_i]_{system} \quad (32)$$

where subscripts i and f refer to the initial and final states respectively.

Nearly all important engineering processes are commonly modelled as steady-flow processes. Steady flow signifies that all quantities associated with the system do not vary with time. Consequently:

$$\sum_{allstreamsentering} m_{in}(h + pv + \frac{V^2}{2} + gz)_{in} - \sum_{allstreamsleaving} m_{in}(h + \frac{V^2}{2} + gz)i_n + Q - W = 0 \quad (33)$$

where: h = u +pv as described in equation (48).

A second common application is the closed stationary system for which the first law equation reduces to:

$Q - W = [m (u_f - u_i]_{system}$ (34)

Second Law of Thermodynamics

The second law of thermodynamics differentiates and quantifies processes that only processed in a certain direction (irreversible) from those that are reversible. Reducing total irreversibility in a cycle improves cycle performance. In the limit of no irreversibilities a cycle attains its maximum ideal efficiency. In open system, the second law of thermodynamics can be described in terms of entropy as:

$$dS_{system} = \frac{\delta Q}{T} + \delta m_i s_i - \delta m_e s_e + dI \quad (35)$$

where: dS_{system} is the total change within system in time dt during process; $\delta m_i s_i$ is the entropy increase caused by mass entering (increasing); $\delta m_e s_e$ is the entropy decrease caused by mass leaving (exiting); $\delta Q/T$ is the entropy change caused by reversible heat transfer between system and surroundings at temperature T; dI is the entropy change caused by irreversibilities (always positive).

Equation (35) accounts for all entropy changes in the system, Rearranged, this equation becomes:

$$\delta Q = T[(\delta m_e s_e - \delta m_i s_i) + dS_{system} - dI] \quad (36)$$

Thermodynamics and Refrigeration Cycles

In integration form, if inlet and outlet properties, mass flow and interactions with the surroundings do not vary with time, the general equation for the second law is:

$$(S_f - S_i)_{system} = \int \frac{\delta Q}{T} + \sum (ms)_{in} - \sum (ms)_{out} + I \quad (37)$$

In many applications, the process can be considered to operate steadily with no change in time. The change in entropy of the system is therefore zero. The irreversibility rate, which is the rate of entropy production caused by irreversibilities in the process, can be determined by rearranging equation (37):

$$I = \sum (ms)_{out} - \sum (ms)_{in} - \sum \frac{Q}{T_{surr}} \quad (38)$$

Equation (37) is commonly applied to a system with one mass flow in, the same mass flow out, no work and negligible kinetic or potential energy flows, combining equation (33) and (37) yields:

$$I = m(s_{out} - s_{in}) - \frac{h_{out} - h_{in}}{T_{surr}} \quad (39)$$

In a cycle, the reduction of work producing by a power cycle (or the increase in work required by a refrigeration cycle) equals the absolute ambient temperature multiplied by the sum of irreversibilities in all processes in the cycle. Thus, the difference in reversible and actual work for any refrigeration cycle, theoretical or real, operating under the same conditions, becomes:

$$W_{catual} = W_{reversible} + T_o \sum I \quad (40)$$

Thermodynamic Analysis of Refrigeration Cycles

Refrigeration cycles transfer thermal energy from a region of low temperature T_R to one of higher temperature.

Usually the higher temperature heat sink is ambient air or cooling water, at temperature T_o, the temperature of the surroundings. The first and second laws of thermodynamics can be applied to individual components to determine mass and energy balances and the irreversibility of components.

Performance of a refrigeration cycle is usually described by a coefficient of performance (COP), defined as the benefit of the cycle (amount of heat removed) divided by the required energy input to operate the cycle:

$$COP = \frac{Ue}{Ne} \quad (41)$$

where: U_e is the useful refrigeration effect, and N_e is the net energy supplied from external sources.

$$COP = \frac{Q_{evap}}{W_{net}} \quad (42)$$

In an absorption refrigeration cycle, the net energy supplied is

usually in the form of heat into the generator and work into the pump and fans, or:

$$COP = \frac{Q_{evap}}{W_{net} + Q_{gen}} \quad (43)$$

In many cases, work supplied to an absorption system is very small compared to the amount of heat supplied to the generator, so the work term is often neglected. Applying the second law to an entire refrigeration cycle shows that a completely reversible cycle operating under the same conditions has the maximum possible COP. Departure of the actual cycle from an ideal reversible cycle is given by the refrigerating efficiency:

$$\eta_R = \frac{COP}{COP_{rev}} \quad (44)$$

The Carnot cycle usually serves as the ideal reversible refrigeration cycle. For multistage cycles, each stage is described by a reversible cycle.

Conclusion

The building sector is a major consumer of both energy and materials worldwide, and the consumption is increasing. Most industrialised countries are in addition becoming more and more dependent on external supplies of conventional energy carriers, i.e., fossil fuels. Energy for heating and cooling can be replaced by new renewable energy sources. New renewable energy sources, however, are usually not economically feasible compared with the traditional carriers. In order to achieve the major changes needed to alleviate the environmental impacts of the building sector, it is necessary to change and develop both the processes in the industry itself, and to build a favourable framework to overcome the present economic, regulatory and institutional barriers. Today, buildings are largest consumers of energy. Air conditioning and heating consume about 40% of the power in the buildings. Demand to conserve energy has become necessity as there has been rising costs of energy consistently and this make us to think to go green and innovate the greener concept for buildings. A green building uses less water, optimises energy efficiency, conserves natural resources, generates less waste and provides healthier spaces for occupants. And, a green home can have benefits, such as reduction in water and operating energy costs of the building. This may also mean refrigerant-based chillers and compressors to be shut off or to be operated at reduced capacity. With the environmental protection posing as the number one global problem, man has no choice but reducing his energy consumption, one way to accomplish this is to resort to passive and low-energy systems to maintain thermal comfort in buildings.

Naturally, it would be preferred, for comfort reasons that this index would be small, preferably nil. It may be seen that the variable is directly related to temperature discomfort: the larger the value of the index, the farthest will inside conditions be from expected wellbeing. Also, the use of electricity operated air conditioning systems will be more expensive the higher this variable is. Hence, energy expenditure to offset discomfort will be higher when comparing two index values; the ratio of them is proportional to the expected energy savings. When the external shade blocks the windowpane completely, the excessive heat gains belong to the lowest values in the set, and the dimensionless index will be constant with orientation. For the climate conditions of the locality, it can be seen that a naked window can produce undesirable heat gains if the orientation is especially unfavourable, when the index can have an increase of up to 0.3 with respect to the totally shaded window. ■

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Cooling of Electronics using Phase Change Materials

In the recent years, PCM based cooling has emerged as a potential technique that can be applied to dissipate heat from the chip effectively...

Floating Balls of Rotterdam cooled by Phase Change Material

Thermal management of electronics is becoming an important and concerned issue due to the compactness, complexity of new generation of electronic devices. An electronic device fails to fulfil its intended function when its application or environmental condition exceeds its application limit. Theoretically, electronic components are said to be reliable at recommended operating temperatures if they can be operated continuously for a long duration. However, adverse environment and unusual operation reduces the effective operating time. It has been found that a 1°C decrease in a component temperature may lower its failure rate by as much as 4% and 10°C to 20°C increase in component temperature can increase its failure rate by 100%. Hence, there is a tremendous need for innovative cooling technologies.

Various cooling techniques are broadly classified into two groups, viz. (a) active cooling and (b) passive cooling. Active thermal management requires external energy to be applied to remove heat from an electronic device. The following types of techniques can be classified as active thermal management:

- Forced convection air
- Forced convection liquid
- Liquid flow through modules
- Heat sinks with forced convection cooling
- Thermoelectrics
- Micro-refrigerators

In case of passive techniques, the removal of heat from an electronic device does not need any external energy to maintain the coolant flow. Different passive cooling techniques such as heat sinks cooled by natural convection, heat pipes, thermosyphons and phase change cooling are used to satisfy performance, reliability and ergonomic constraints. Phase change cooling is one of such technique, which has been widely used as an alternative cooling method for various applications such as wearable computers, power electronics, communication equipment, space craft and avionics etc., where heat dissipation is time-varying or periodic. Phase change material (PCM) plays the key role in the phase change cooling technique.

PCMs are highly effective heat storage materials that undergo a phase change at a certain key temperature and are commercially available for a range of phase change temperatures. Typical phase change temperatures range from –15 to 190°C, giving a wide choice of PCMs for any specific cooling requirement. The kind of heat that is stored in PCMs is the latent heat of fusion along with sensible heat. The latent heat of fusion of PCMs is relatively high. Consequently, only a small quantity is needed to meet storage capacity requirements for a majority of applications.

PCM-based Cooling Technique

The phase change process of PCM is shown in figure 1. When a PCM is heated, the temperature of PCM rises and it absorbs heat as sensible heat. Once the

melting temperature of PCM is reached, the PCM starts melting and absorbs heat as latent heat. During this period, the PCM temperature remains constant. After the completion of PCM melting, the temperature of liquid PCM rises again. Hence, the stabilization period can be obtained until the PCM melts completely. The same process is followed in reverse direction during solidification of PCM. Generally electronic devices do not dissipate high heat rates for all the time which is ideal for PCM application. Therefore, PCMs are used in constant power/cyclic cooling for short term thermal management. It cannot be used for the equipment which is in continuous operation.

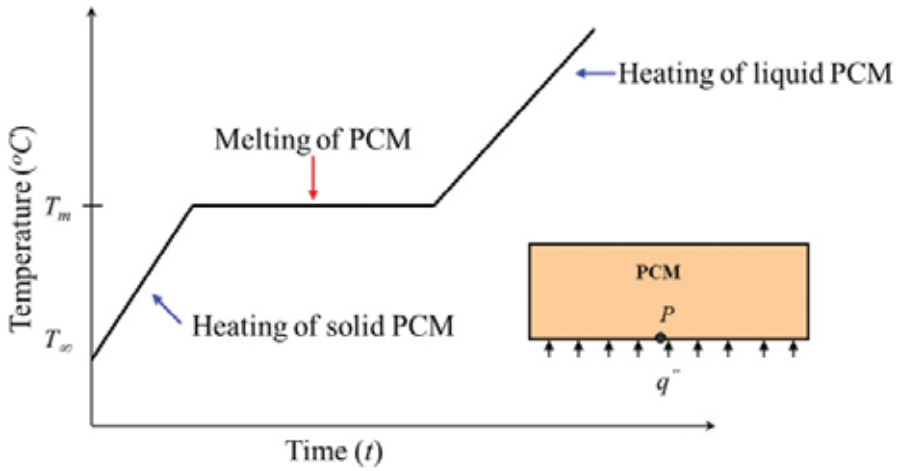

Figure 1: Phase change process of PCM

Phase Change Materials

Phase Change Material (PCM) used in cooling applications should possess some desirable thermophysical, kinetics and chemical properties. The PCM melting temperature should be below the device's maximum operating temperature. The latent heat of fusion must be high, so a small amount of PCM can store a large amount of energy. It should have high specific heat which will provide additional sensible heat storage capacity. High thermal conductivity is desirable which makes the PCM melting and solidification homogenous and could also prevent potential PCM overheating. PCM should be chemically stable, so that it will not be changed periodically. The PCM must be non-poisonous, non-flammable, and non-explosive. The most critical properties are PCM's melting temperature and latent heat of fusion while selecting PCMs for a particular application.

There are a large number of PCMs available either commercially or technical grade for a wide range of melting point and these can be broadly grouped into organic and inorganic. The classifications of PCMs which undergo solid to liquid phase change are shown in figure 2. The organic based PCM is paraffin which is flammable and cannot be exposed to high temperature. Several paraffin and non-paraffin based PCMs have a melting point within the desired range and high latent heat would satisfy the storage requirements. Inorganic PCMs include salts hydrates which are non-flammable, have high of heat fusion, and their melting temperatures range from 18.5°C to 116.0°C making them ideal for thermal design considerations of electronic devices. However, salts hydrates are highly corrosive in nature and a special attention is required while selecting the storage container. A few of PCMs along with their properties are listed in table 1.

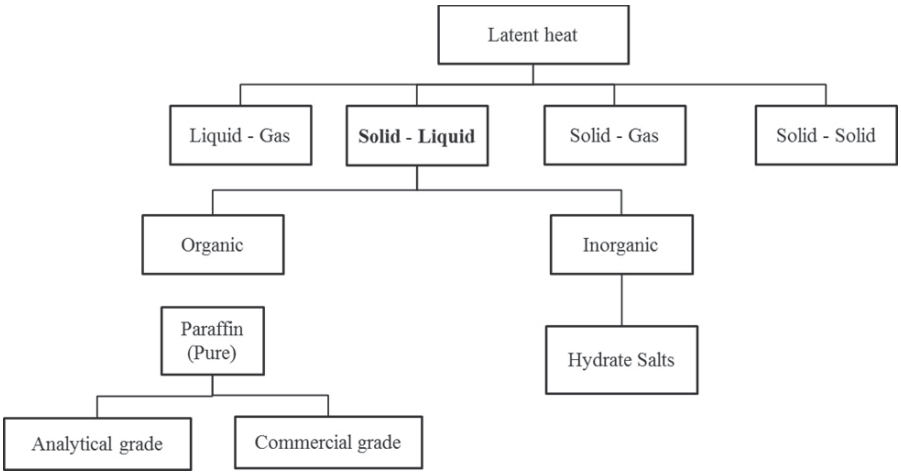

Figure 2: Classification of PCMs undergoing solid–liquid phase change

Design of PCM Heat Sink

The design of a PCM based heat sink needs a careful approach. A typical PCM based heat sink used for electronic cooling is shown in figure 3. The heat sink is a rectangular cavity which is fabricated by gluing thin metal or insulation sheets to the metallic base plate. The top surface can be either covered or exposed to ambient depending on the application. The amount of PCM, to be poured, is governed by the time required to stabilize the chip temperature. An important issue in designing PCM based heat sink is leakage of molten PCM at high temperature as the attached sheet may separate. The most convenient way of filling of PCM based heat sink is to keep the PCM on the heat sink and then heat it such that the material melts and fills the heat sink. Care has been taken to accommodate volume change of PCM due to phase change and expansion of the liquid subsequently. Hence, sufficient space has to be provided to accommodate the PCM in liquid state (coefficient of thermal expansion of n-Eicosane is 1.0×10^{-3}/°C). The filling is done to no more than 90% of the enclosed volume for the purpose of containment.

The PCM-based heat sink sits over an electronic chip which generates heat.

Table 1: Typically used PCMs and their properties

PCM	Melting temperature (°C)	Latent Heat (kJ/kg)	Density (kg/m³)	Thermal Conductivity (w/m-K)
n-Octadecane	28.0	244	865 (solid) 780 (liquid)	0.358 (solid) 0.148 (liquid)
n-Eicosane	37.0	241	810 (solid) 770 (liquid)	0.39 (solid) 0.157 (liquid)
Capric	31.5	153	884 (40°C)	2.0
Caprilic	16.3	149	1033(10°C) 861 (80°C)	2.0
$Zn(NO_3)6H_2O$	36.4	147	2065 (solid)	0.31
Lauric acid	41.5	178	800	0.2
Paraffin wax	49-62	210	916 (solid) 770 (liquid)	0.346 (solid) 0.167 (liquid)
RT27	26-28	179	870 (solid) 750 (liquid)	0.2
RT25	25	147	804 (solid) 763 (liquid)	0.19 (solid) 0.17 (liquid)
P116	47.0	225	830 (solid) 773 (liquid)	0.24

Initially, the whole system is at the ambient temperature. The heat sink is considered to be subjected to either constant power or cyclic loading from the chip. The process of heating causes *(i)* sensible heating of PCM for a short duration, *(ii)* melting of PCM, and *(iii)* sensible heating of the melt. During the cooling period, the same processes occur but in reverse order.

Performance of PCM Heat Sink

A comparison can be drawn between two cases; *(i)* chip attached with a base plate and *(ii)* chip mounted under the PCM based heat sink. Figure 5 shows the temperature histories of chip generating 4 W of constant power. The PCM used in this case is *n*-Eicosane and the thickness of PCM is 5 mm. The heat sink dimension is 42 × 42 × 7 (height) mm with the base plate thickness of 2 mm. The chip is 3 mm thick. The base plate is made of Aluminium. The chip temperature at 900 s in case of PCM based heat sink is lower than the without PCM case as the PCM absorbs major portion of heat while melting and keeps the chip temperature lower.

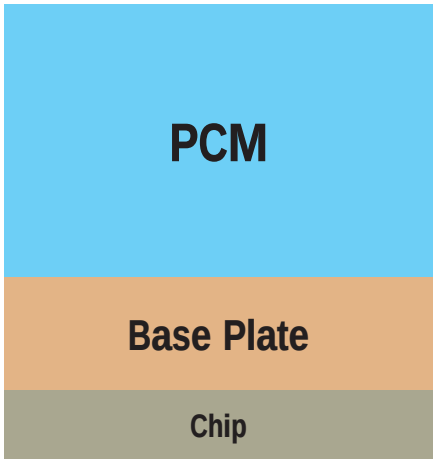

Figure 3: Schematic diagram of a PCM based heat sink

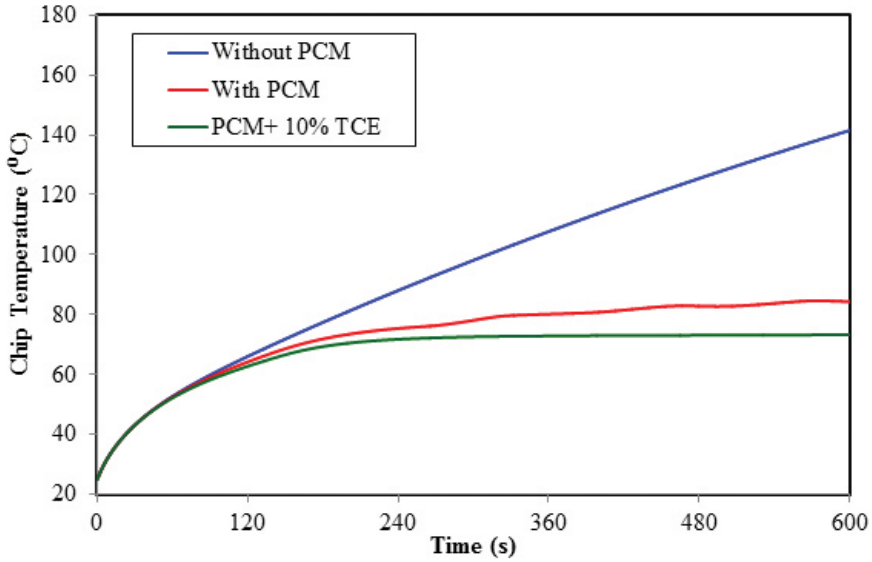

Figure 4: Chip temperature histories for three cases (a) Without PCM, (b) with PCM and (c) with PCM and 10% of TCE

Enhancement techniques of heat transfer in PCM

One important issue needs to be addressed, is the thermal conductivity of organic PCM that is low (~0.2 W/m.K) and as a result, heat transfer rate is slow within PCM during melting and solidification. The improvement of heat transfer can be

achieved by inserting high thermal conductivity materials, known as thermal conductivity enhancer (TCE) into the PCM. The TCE could be in the form of metal matrix, hollow spherical metallic balls, plate or pin fins and graphite flakes. Figure 5 shows the picture of typical TCE used for heat transfer enhancement in PCM.

A small percentage (10%) of aluminium particles is uniformly dispersed in the PCM-based heat sink to augment the heat transfer. Figure 5 shows the variation of chip temperature with time for without and with TCE distribution in PCM. With the addition of TCE, the chip temperature decreases as the effective thermal conductivity of PCM increases.

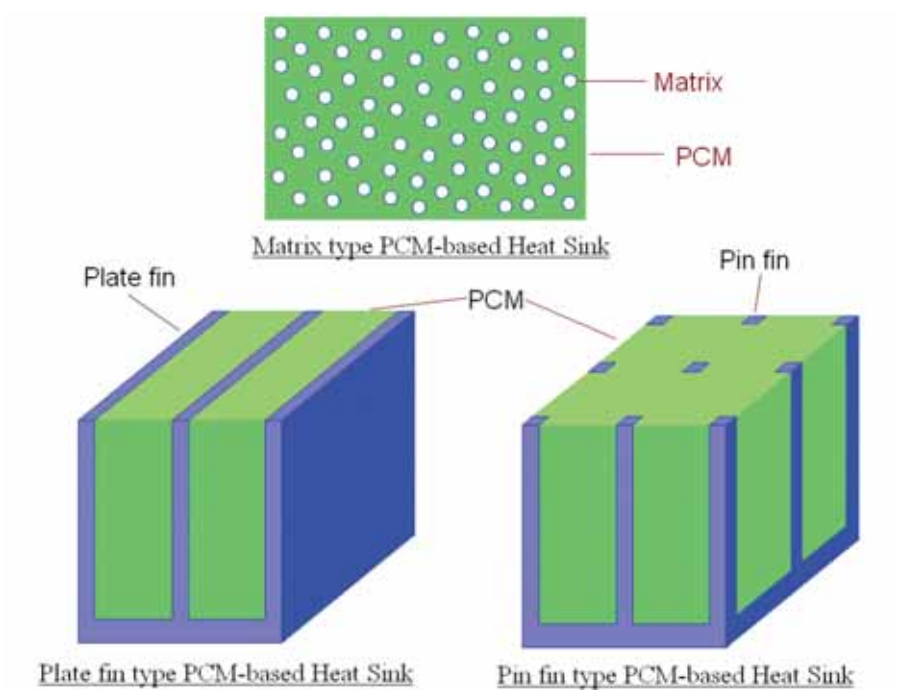

Figure 5: Typically used TCEs

Thermal Management

In electronic applications, the chip normally operates on a base load and does not produce high heat rates all the time. However, the chip may dissipate extra heat load for a certain period of time for various reasons. This extra high heat rate needs to be transferred from the chip efficiently to maintain its temperature below the critical limit above which chip will start malfunctioning. A cooling system designed both for base load as well as peak load tends to be overdesigned, bulky and expensive. Therefore, special and efficient cooling techniques can be used to tackle that extra high heat load. The PCM based cooling technique can be effectively employed in this type of application. Figure 6 shows such an example where the chip was operating on a base load and suddenly there is a peak load of 10 W for 90 seconds. In this example, the thickness of PCM (*n*-Octadecane) is 1 mm and the base load is taken as zero for simplicity. The design of PCM based heat sink for such application is critical and should be optimized to meet the need of the requirement.

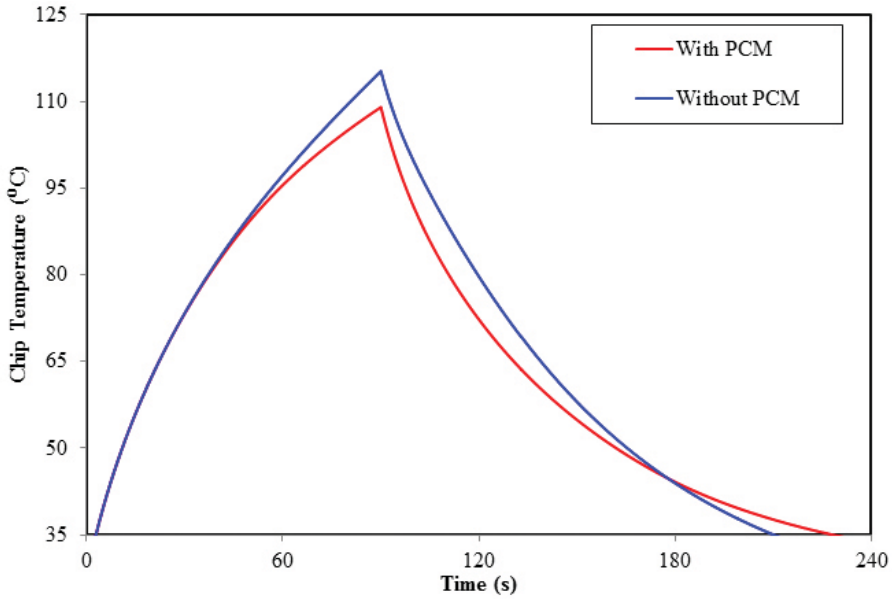

Figure 6: Variation of chip temperature for (a) Without PCM, (b) with PCM under peak load

Conclusions

As the chip level heat flux has gone up significantly, conventional air cooled designs are no longer adequate and an increasing number of packaging failures are directly linked to inadequate thermal management. Hence, researchers are investigating several alternative cooling techniques those can be used in cooling of electronics equipment. In the recent years, PCM based cooling has emerged as a potential technique that can be applied to dissipate heat from the chip effectively. The main advantages of PCM based cooling technique is that its light weight compared to metal, abundant availability and large heat storage density per unit mass. However, unfortunately the most organic PCMs possess low thermal conductivity which needs to be enhanced by incorporating high thermal conductivity materials. This technique can be used to keep the chip temperature at desired limit for certain period under constant power operation. Also, it can be employed during peak load where extra high heat load can be absorbed by PCM for safe operation of chip. ■

Sandip Kumar Saha
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A fan for Any Scenario

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...

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.

> AxiBlade axial fans can operate in a wide variety of applications with an optimum efficiency of upto 54 %. In the process, a noise reduction of upto 8 dB(A) can be achieved when compared with the standard program.

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 upto 54 %. In the process, a noise reduction of upto 8 dB(A) can be achieved when compared with the standard program.

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.

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 approximately 300-millimeter-high fan housing (depending on the size category) with integrated diffuser for high back pressures upto 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. ■

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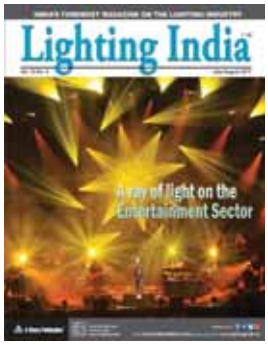

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Making Sector Competent

"There is a need for policy intervention and field level changes for India to develop global competitiveness in many related sub-sectors and ensure that they are firmly entrenched in global value chains," noted the study titled, 'Food processing sector-Challenges & growth enablers,' jointly conducted by ASSOCHAM and Grant Thornton.

While the $121 billion food processing industry in India presents an opportunity for growth, the sector needs to focus on product conformity with global standards and quality together with factors like logistics traceability and safety, quality of packaging and delivery, noted an ASSOCHAM-Grant Thornton joint study. "There is a need for policy intervention and field level changes for India to develop global competitiveness in many related sub-sectors and ensure that they are firmly entrenched in global value chains," noted the study titled, 'Food processing sector-Challenges & growth enablers,' jointly conducted by ASSOCHAM and Grant Thornton.

It, however, noted that significant reforms undertaken by both central and state governments be it 100 per cent foreign direct investment (FDI) under government approval route for trading, including through e-commerce, in respect of food products manufactured or produced in India; enhanced investment in food processing; proactive steps simplifying 'ease of doing business', delisting of horticulture crops and insurance schemes to support the vulnerable farmers will make the sector more competitive and market oriented.

The report stated that even marginal reductions in post-harvest losses of fruits and vegetables which are to the tune of about 25-30 per cent are bound to give better returns and improve farmers' level of incomes. It also said that there is a huge scope for large investments in food processing technologies, skill development and equipment as total food production in India is estimated to double in next 10 years. The ASSOCHAM-Grant Thornton report further noted that fast growth in food processing and simultaneous improvement in the development of value chain are of great importance to achieve favourable terms of trade for India's agriculture sector both in domestic and international markets.

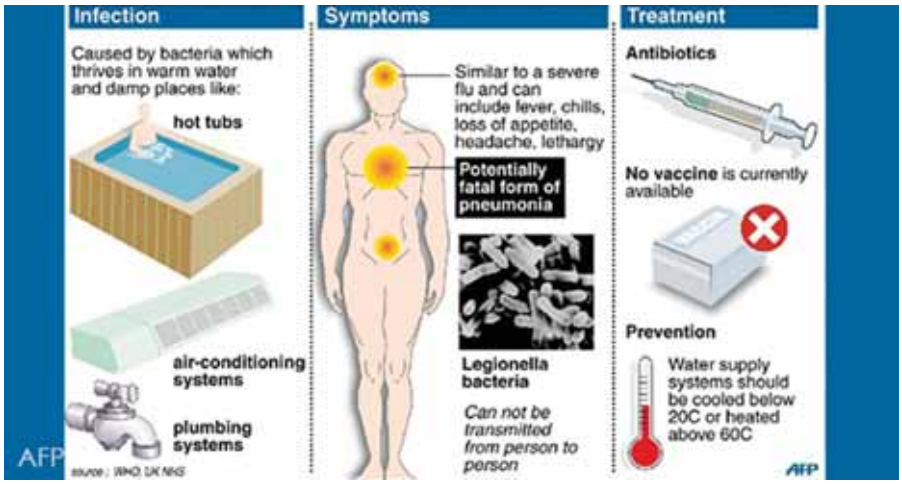
"Given the trade in production of food commodities, the food processing industry in India is on an assured track of growth and profitability," the study said. "It is expected to attract phenomenal investment in capital, human, technological and financial areas."

According to the joint study, Indian food and retail market is projected to touch $482 billion (bn) by 2020 from $258 bn in 2015. It also said that Indian food processing sector has potential to attract $33 bn of investment and generate employment of 9 million (mn) persons' days by 2024.

With globalisation and increasing trade across the borders approximately about 460 million tonnes (MT) of food valued at $3 bn is traded annually. India has, thus, a great potential for global trade in agricultural and processed food products. The share of food processing exports in total exports was around 12 per cent in the last few years. During FY11-15, India's exports of processed food related products have been growing at a CAGR (compounded annual growth rate) of 23.3 per cent. ■

Legionnaires' Disease & AC Systems

There is a risk that the bacteria Legionella pneumophila could flourish in the air conditioning systems of ships and buildings. The organisms breed in stagnant water or in wet deposits of slime or sludge. Possible locations for bacteria colonies are mentioned as being at the air inlet area and below the cooler (stagnant water), in the filter, in humidifiers of the water spray type and in damaged insulation...



What is Legionnaires Disease?

Legionnaires' disease is a form of a typical pneumonia caused by any type of *Legionella* bacteria. Over 90% of cases of Legionnaires' disease are caused by the bacteria *Legionella pneumophila.* Other types include *L. longbeachae*, *L feeleii*, *L micdadei*, and *L anisa*.

There is a risk that the bacteria could flourish in the air conditioning systems of ships and buildings. The organisms breed in stagnant water or in wet deposits of slime or sludge. Possible locations for bacteria colonies are mentioned as being at the air inlet area and below the cooler (stagnant water), in the filter, in humidifiers of the water spray type and in damaged insulation.

Provision of adequate drainage is recommended to remove stagnant water.

Regular inspections and cleaning as necessary of filters and other parts, using a 50ppm super-chlorinated solution as the sterilizing agent is required. The solution is to be used also on the cooler drain area at not more than three month intervals. Regular sterilization is necessary for water spray type humidifiers (steam humidifiers being preferred).

The bacterium is found naturally in fresh water. It can contaminate hot water tanks, hot tubs, and cooling towers of large air conditioners. It is usually spread by breathing in mist that contains the bacteria. It can also occur when contaminated water is aspirated. It typically does not spread directly between people and most people who are exposed do not become infected. Risk factors for infection include older age, history of smoking, chronic lung disease, and poor immune function. It is recommended that those with severe pneumonia and those with pneumonia and a recent travel history be tested for the disease. Diagnosis is by a urinary antigen test and sputum culture.

There is no vaccine. Prevention depends on good maintenance of water systems.

Epidemiology

The number of cases that occur globally is not known. It is estimated that Legionnaires' disease is the cause of between two and nine percent of pneumonia cases that occur in the community. There are an estimated 8,000 to 18,000 cases a year in the United States that require hospitalization. Outbreaks of disease account for a minority of cases. While it can occur any time of the year it is more common in the summer and fall. .

Legionnaires' disease acquired its name in July 1976, when an outbreak of pneumonia occurred among people attending a convention of the American Legion at the Bellevue-Stratford Hotel in Philadelphia. Of the 182 reported cases, mostly men, 29 died. On January 18, 1977, the causative agent was identified as a previously unknown strain of bacteria, subsequently, named *Legionella*, and the

species that caused the outbreak was named *Legionella pneumophila*.

Outbreaks of Legionnaires' disease receive significant media attention. However, this disease usually occurs in single, isolated cases not associated with any recognized outbreak. When outbreaks do occur, they are usually in the summer and early autumn, though cases may occur at any time of year. Most infections occur in those who are middle-aged or older. National surveillance systems and research studies were established early, and in recent years improved ascertainment and changes in clinical methods of diagnosis have contributed to an upsurge in reported cases in many countries. Environmental studies continue to identify novel sources of infection, leading to regular revisions of guidelines and regulations. About 8,000 to 18,000 cases of Legionnaires' disease occur each year in the United States, according to the Bureau of Communicable Disease Control.

Between 1995 and 2005, over 32,000 cases of Legionnaires' disease and more than 600 outbreaks were reported to the European Working Group for Legionella Infections. Data on *Legionella* are limited in developing countries and *Legionella*-related illnesses likely are underdiagnosed worldwide. Improvements in diagnosis and surveillance in developing countries would be expected to reveal far higher levels of morbidity and mortality than are currently recognised. Similarly, improved diagnosis of human illness related to *Legionella* species and serogroups other than *Legionella pneumophila* would improve knowledge about their incidence and spread.

A 2011 study successfully used modeling to predict the likely number of cases during Legionnaires' outbreaks based on symptom onset dates from past outbreaks. In this way, the eventual likely size of an outbreak can be predicted, enabling efficient and effective use of public health resources in managing an outbreak.

The first recognized cases of Legionnaires' disease occurred in 1976 in Philadelphia, Pennsylvania. Among more than 2000 attendees of an American Legion convention held at the Bellevue-Stratford Hotel, 182 attendees contracted the disease and 29 of them died.

In April 1985, 175 people in Stafford, England, were admitted to the District or Kingsmead Stafford Hospitals with chest infection or pneumonia. A total of 28 people died. Medical diagnosis showed that Legionnaires' disease was responsible and the immediate epidemiological investigation traced the source of the infection to the air-conditioning cooling tower on the roof of Stafford District Hospital.

In March 1999, a large outbreak in the Netherlands occurred during the Westfriese Flora flower exhibition in Bovenkarspel; 318 people became ill and at least 32 people died. This was the second-deadliest outbreak since the 1976 outbreak and possibly the deadliest as several people were buried before Legionnaires' disease had been diagnosed.

The world's largest outbreak of Legionnaires' disease happened in July 2001 with people appearing at the hospital on July 7, in Murcia, Spain. More than 800 suspected cases were recorded by the time the last case was treated on July 22; 636–696 of these cases were estimated and 449 confirmed (so, at least 16,000 people were exposed to the bacterium) and six died, a case-fatality rate around 1%.

In late September 2005, 127 residents of a nursing home in Canada became ill with *L. pneumophila*. Within a week, 21 of the residents had died. Culture results at first were negative, which is not unusual, as *L. pneumophila* is a fastidious bacterium, meaning it requires specific nutrients and/or living conditions in order to grow. The source of the outbreak was traced to the air-conditioning cooling towers on the nursing home's roof. As of 12 November 2014, 302 people have been hospitalized following an outbreak of Legionella in Portugal and 7 related deaths have been reported. All cases, so far, have emerged in three civil parishes from the municipality of Vila Franca de Xira in the northern outskirts of Lisbon, Portugal and are being treated in hospitals of the Greater Lisbon area. The source is suspected to be located in the cooling towers of the fertilizer plant Fertibéria.

Twelve people were diagnosed with the disease in the Bronx, New York, in December 2014; the source was traced to contaminated cooling towers at a housing development. In July and August 2015, another, unrelated outbreak in the Bronx killed 12 people and made about 120 people sick; the cases arose from a cooling tower on top of a hotel. At the end of September another person died of the disease and 13 were sickened in yet another unrelated outbreak in the Bronx. The cooling towers from which the people were infected in the latter outbreak had been cleaned during the summer outbreak, raising concerns about how well the bacteria could be controlled.

On August 28, 2015, an outbreak of Legionnaire's disease was detected at San Quentin State Prison in Northern California.

Between June 2015 and January 2016, 87 cases of Legionnaires' disease were reported by the Michigan Department of Health and Human Services for the city of Flint, Michiganand surrounding areas. 10 of those cases were fatal.

Legionella is a naturally occurring bacterium and can be found in low concentrations in soil and water. In manmade structures and warm environments (35-46 degrees), the bacterium thrives and can multiply to levels dangerous to humans.

When the bacterium becomes airborne, carried in water particles, it can be inhaled into the lungs, causing Legionnaires' disease, a highly virulent form of pneumonia. It has been found that while the bacteria will not grow in cold conditions, it can survive freezing. If the bacterium is present in the water system used by the ice machine, it can be encased in the ice and released as the ice thaws.

Just as a building's water pipes placed too close to sources of heat can lead to Legionella growth, ice dispensers contain compressors that can also warm the machine's incoming water lines, allowing Legionella bacteria to thrive if the systems are not properly tested and treated.

The use of chlorine is a common treatment to prevent Legionella growth in water systems. Charcoal filters used to remove chlorine from the cold water line to make it more palatable for drinking can, however, also leave that water susceptible to Legionella contamination.

People with compromised immune systems are particularly at risk of contracting Legionnaires' disease, a severe form of pneumonia that can prove deadly given the patients' already existing health problems.

Severely, ill patients are often offered ice to suck on to rehydrate and moisten their mouths, which leads to aspiration (the breathing in of the water particles), and infection where those water particles are contaminated with Legionella.

The risk of Legionella contamination in ice machines is well documented. South Australia had several cases of Legionella related to ice machines ten years ago and it has also been documented overseas.

While most hospitals and facilities have measures of testing and prevention in place, ice and water dispensers should be included in any risk assessment for Legionella in all health care facilities.

Australian publication titled "Guidelines for the Control of Legionella in the operation and maintenance of water distribution systems in health and aged care facilities" recommends all water systems in a health or aged care facility be assessed and controls put in place to minimise patients' risk of exposure to this highly preventable, but often deadly disease.

Vulnerability of Water and Ice Dispensers

1) The ice dispenser's compressor can heat the piping inside the machine and warm the cold water supplied. This supports Legionella growth.
2) The charcoal filter on the cold water line removes the chlorine in the water therefore removing any residual to disinfect.
3) The bacteria can multiply.
4) The water becomes ice with the bacteria present (alive but not multiplying).
5) Patients in hospital, suck on the ice, which leads to aspiration (breathing in of the water droplets). This is a very direct route & therefore, presents a very high risk for patients. When the patient's immune system is suppressed the Legionella can quickly hide and mimic some of the remaining immune cells in the patient's immune system to proliferate. Hence, the patient has very little ability to fight the infection.
6) Ice and water dispensers should be included in any risk assessment for Legionella in all health care facilities.

Vulnerability of Cruise Ship Industry

There has been a tremendous amount of bad press for the cruise ship industry recently. Ships have exposed passengers to danger by traveling through hurricane-level sea on the Royal Caribbean Anthem of the Seas, and on the Celebrity Infinity with outbreaks of norovirus.

Cruise ship hot tubs can create potential of an exposure to Legionnaires' disease if not regularly drained and properly maintained.

There can be no doubt that cruise ship companies make every attempt to provide pleasant cruises for its passenger-customers. Indeed, there are many great features and amenities to a cruise for the traveler. For example, here is a list of those features in a review of the Celebrity Silhouette. Regardless of the intent for customer comfort and safety, cruises as vacation destinations throughout the world are also a common setting for exposure to communicable diseases such as legionella, norovirus, and other serious illnesses.

With the entrance of the largest ship to the vacation cruising fleet, the Harmony of the Seas, we should consider the risks of the outbreaks of communicable diseases while aboard cruise ships.

Swimming Pools & Hot Tubs on Cruise Ships

A passenger on a certain cruise ship recently explained that he and his family are regulars on cruise ships, and they routinely take cruises more than once or twice a year. Unfortunately, there was an exposure to legionella on a most recent cruise. It appears that while most ships drain their pool and hot tub between ports, and commonly use salt water in the pools, this ship used a chlorine-based pool and did not drain and clean the pool between ports. While the CDC has outlined safety regulations for cruise ship swimming pools, if a cruise ship fails to drain the and test the pools during the voyage, it is certain to raise the potential of an exposure to legionnaires disease.

In fact, a 1994 Outbreak of Legionnaires Disease aboard the Celebrity Cruise Ship Horizon resulted in a multi-million dollar award in damages. The case was retried, resulting in a reduced award in the tens of millions of dollars. In the case, at least 16 persons who had sailed on nine separate week-long cruises were subsequently found to have Legionnaires' disease, according to the U.S. Centers for Disease Control. One of the passengers later died. Essef Corp, provided a defective filter in the ship's hot-tub system, which the CDC linked to the outbreak. The outbreak of Legionnaires ultimately resulted in a number of personal injury suits and a class action suit by passengers against Celebrity.

Center for Disease Controls Reports and Recommendations

A review of the Center for Disease Controls website includes a database of reports of norovirus and legionnaires cases per year.

The CDC specifically advises that:

More than 20%–25% of all Legionnaires' disease reported to CDC is travel-associated. Clusters of Legionnaires' disease associated with hotel or cruise ship travel are difficult to identify, because travelers often disperse from the source of infection before symptoms begin. In evaluating cruise travelers for Legionnaires' disease, clinicians should do the following:

- Obtain a thorough travel history of all destinations from 10 days before symptom onset (to assist in the identification of potential source of exposure)
- Collect urine for antigen testing
- Collect respiratory secretions for culture, which is essential for identifying the pathogen

Vulnerability of Hotel Industry

Bacteria causing a sometimes deadly type of pneumonia were found in the water system of the famed Las Vegas Rio All-Suite Hotel and Casino.

The Southern Nevada Health District announced two separate guests who stayed at the hotel at different times in March and April contracted Legionnaires' disease, which is caused by the Legionella bacteria.

The US Centers for Disease Control and Prevention describes Legionnaires' disease as a type of bacterial pneumonia, which causes coughing, shortness of breath, fever, muscle aches and headaches. Health officials said the disease can sometimes result in death.

The hotel and the health district are investigating the two cases, remediating the problem and reaching out to past and current guests.

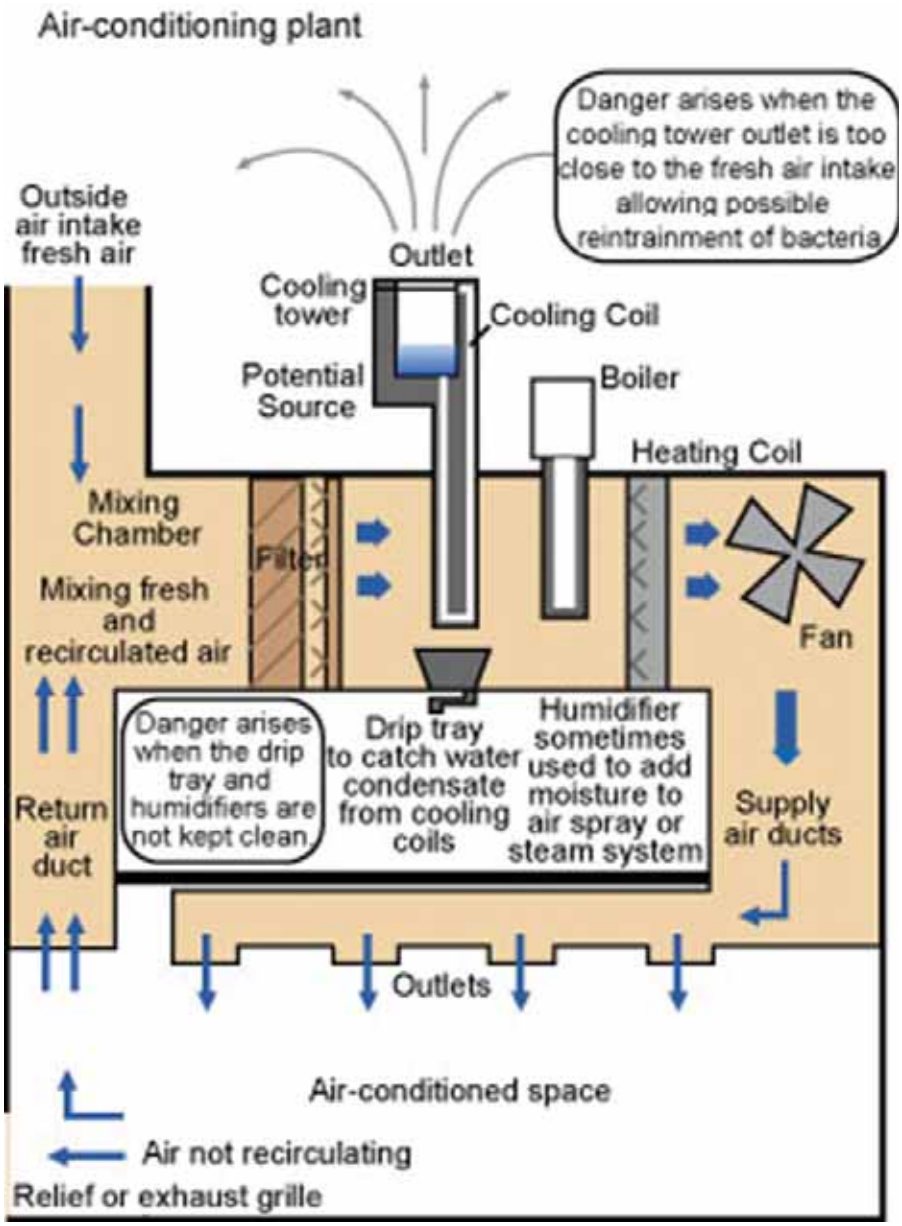
After the two cases were reported, officials took a water sample, which showed Legionella existed throughout the facility's water system.

People take in the bacteria by breathing in small contaminated droplets of water. Showers, faucets, hot tubs and fountains can carry the bacteria.

The Rio hotel, like other Las Vegas hotels, offers gambling buffets, shows and a pool. The magicians Penn & Teller perform there, so do the Chippendales dancers.

Heating, Ventilating, and Air Conditioning (HVAC) Systems

Legionnaires' disease bacteria (LDB) cannot survive without water, and a properly operated, well-maintained HVAC system is unlikely to be a source of problems unless water contaminated with the bacteria enters the system. Air



conditioning units without humidifiers have not been identified as sources of LDB. For a Legionnaires' disease outbreak to be linked directly with the HVAC system, LDB-contaminated water must enter the system, be aerosolized, and be delivered to building occupants.

Design

Operate and maintain all HVAC equipment as originally designed, and maintain it so that it can perform as designed. Test all HVAC equipment periodically to ensure that it is performing as designed. Consider the following issues while designing HVAC systems; most apply to all types of microbial contamination:

- Minimize use of water reservoirs, sumps, and pans.
- Provide a way to drain water sumps when not in use, such as, an electric solenoid valve on the sump drain.
- Provide a bleed for water sumps so that dissolved solids do not form sediments in the sump.
- Slope collection pans and drain sumps from the bottom so that all the water can drain out and allow the pan to dry.
- Locate HVAC fresh-air intakes so that they do not draw the mist from a cooling tower, evaporative condenser, or fluid cooler into the system. When evaluating this path, consider:
  - Prevailing wind direction and velocity.
  - Building effects such as low-pressure zones on leeward sides of buildings and on roof.
  - Architectural screen walls.
  - Distance from tower to intake.
- Design indirect evaporative cooling systems with the knowledge that the failure of the heat exchanger will allow wet systems to mix with the air-distribution systems.
- Do not use raw steam from the central heating boiler to humidify air because it contains corrosion inhibitors and anti-scaling chemicals.
- Atomizing humidifiers should have contaminant-free water.

Maintenance

Inspect the entire air distribution system (including return and exhaust systems) for visual evidence of water accumulation.

- Properly drain all sumps and permanently drain inactive sumps to prevent accumulation of sediments.
- If an HVAC sump is used during the hours when a building is occupied, drain the sump during unoccupied hours.
- Maintenance failures can produce stagnant water that can become an ideal environment for LDB growth if sufficiently warm (such as heated by sunlight).

Control of Contamination

To effectively control contamination, be aware of the conditions that may promote growth and distribute LDB:

External sources may emit contaminated aerosolized water that is drawn into a system's fresh-air intake. Consider the following:

- Fresh-air intake airways, typically concrete plenums located at grade level, supplying fresh air to air handlers in the basement or lower levels of buildings can collect organic material (such as leaves and dirt).
- Aerosols from spray irrigation.
- Open windows.

Internal sources may provide

contaminated aerosolized water that is then disseminated by the air-distribution system. Consider the following:

- HVAC system humidifiers are potential sources of aerosol exposure if contaminated with LDB.
- Direct evaporative air coolers with sprays or misters used as humidifiers include sumps, which may stagnate when not in use.
- Indirect evaporative air cooling systems using water coils may develop a leak that may inject cooling tower water directly into the supply air stream.
- Air-to-air heat exchangers may develop leaks, which may allow the wet air stream to mix with supply air and cause problems if the wet air stream is contaminated with LDB
- Wet evaporative coolers, slinger air coolers, and rotary air coolers with improperly operated and maintained systems that use warm, stagnant sump water may be potential sources of LDB.
- Residential humidifiers, such as free-standing or portable units, often contain sumps that are frequently contaminated with LDB.
- Computer room air conditioners may contain a humidifier sump filled with contaminated water.

Improperly drained condenser pans may produce tepid conditions that can encourage microbial and fungal growth.

Treatment of a Contaminated System

In the event LDB is detected, follow these steps for treatment:

- Eliminate all water leaks and remove any standing water found in the system to ensure future drainage.
- Replace or eliminate any water-damaged insulation in the system.
- Operate the HVAC system using 100 percent outside air for eight hours before returning the building to normal operation.

When the building is returned to normal operation, keep outside-air supply rates as high as possible for one month. At a minimum, the outdoor air requirements of ASHRAE Ventilation Standard 62-2001 should be met. ■

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LG Unveils LGRED Technology

LG Air Conditioning Technologies is adding LG 'Reliable to Extreme Degrees' (RED) heating technology to more of its products, including the Multi F and Multi F MAX multi-zone outdoor units. LGRED technology not only delivers heat when traditional models are unable, but also does so with remarkable energy efficiency offering comfort to users living in even the coldest climates, the company said in a release. LGRED is industry-leading heat technology that provides 100-percent-rated heating capacity down to 5 degrees Fahrenheit with continuous operation down to -13 degrees, offering comfort to users living in even the coldest climates. "LGRED is an exceptional development in the HVAC industry, allowing LG's residential and light commercial systems to be installed in a wide variety of climates – including those areas with extremely cold temperatures," said Kevin McNamara, senior vice president and general manager for air conditioning technologies for LG Electronics USA. "LG is dedicated to providing the best technologies and systems for our customers, and LGRED allows us to deliver unparalleled comfort in areas that were underserved because conventional systems have limited performance in those conditions."

LGRED is a key performance-enhancing feature of the compact yet powerful LG Multi F and Multi F MAX outdoor units. Created for residential and light commercial installations, these robust multi-zone systems have the option to be installed fully ductless for optimal performance or combined with ducted systems, including the new LG 4-Way Vertical Air Handler Units (VAHUs), for increased design flexibility.

The LGRED Multi F systems also feature a SEER rating of up to 21, qualifying them for ENERGY STAR certification, as well as eligibility for participating local utility company rebates.

LGRED also is available on LG's Art Cool Premier indoor units, including the 9K, 12K, 15K and 18K Btu/h models. Art Cool Premier, which earned the coveted ENERGY STAR "2017 Most Efficient" designation, features a sleek design, which seamlessly integrates into any home décor. Art Cool Premier systems also feature a SEER rating up to 27.5 – one of the industry's highest – for low operating costs and optimal performance. ■

Cool Roofs Have Water Saving Benefits

New Berkeley Lab study finds that in reducing air temperatures, cool roofs can also reduce outdoor water use...

The energy and climate benefits of cool roofs have been well established: By reflecting rather than absorbing the sun's energy, light-colored roofs keep buildings, cities, and even the entire planet cooler. Now, a new study by the Department of Energy's Lawrence Berkeley National Laboratory (Berkeley Lab) has found that cool roofs can also save water by reducing how much is needed for urban irrigation.

Based on regional climate simulations of 18 California counties, Berkeley Lab researchers Pouya Vahmani and Andrew Jones found that widespread cool roof adoption could reduce outdoor water consumption by as much as 9 percent. In Los Angeles County, total water savings could reach 83 million gallons per day, assuming all buildings had reflective roofs installed. Their study, "Water conservation benefits of urban heat mitigation," was published in the journal Nature Communications.

"This is the first study to look at the link between water and heat mitigation strategies in urban areas," Vahmani said. "You might not do cool roofs just to save water, but it's another previously unrecognized benefit of having cool roofs. And from a water management standpoint, it's an entirely different way of thinking – to manipulate the local climate in order to manipulate water demand." One impetus for the study was to investigate how a future warmer climate would affect the demand of water, especially, as more cities are seeking out climate mitigation and adaptation strategies. "While urban heat mitigation strategies have been shown to have beneficial effects on health, energy consumption, and greenhouse gas emissions, their implications for water conservation have not been widely examined," Vahmani and Jones write in their study.

Cool roofs can reduce water demand by reducing the ambient air temperature – this study found urban cooling ranging from 1 to 1.5 degrees Celsius – which means lawns and other landscaping need less water. The scientists, both in the Lab's Climate and Ecosystem Sciences Division, acknowledge that modification of human behavior may be needed in order to realize this water-savings benefit. "There is a key assumption in here that people would adjust their irrigation behavior in response," Jones said. "In order to reap the benefits, we would need people to be aware of the appropriate amount of water, or else use sensors or smart irrigation systems, which are a good idea anyway." Furthermore, they found that the water-savings benefit was even stronger on hotter days. "So that's an indication that in a future climate, where hot days are occurring much more frequently, the added benefit of doing cool roofs might be even more dramatic," Jones said. "But that has yet to be investigated." Vahmani and Jones used a high-resolution regional climate model for their analysis; Vahmani then added a component to the model to account for irrigation water. "It basically adjusts soil moisture to mimic irrigation events," Vahmani said. "We also used remote sensing data to improve the representation of physical characteristics of the land surface, which resulted in improved model performance."

The model was validated with data from Northern California's Contra Costa Water District for customers who were irrigation-only users. "The irrigation water demands simulated by the model were matched quite well by the customer data, given the complex nature of urban irrigation," Vahmani said. Model simulations were run over 15 years in 18 counties in Northern and Southern California, assuming a control scenario that reflects the current status of the urban areas, and a cool roof scenario in which all buildings had commercially available cool roofs installed. Countywide irrigation water savings ranged from 4 percent to 9 percent, with per capita savings largest in medium density environments, or those with a mix of buildings and landscaping. "It's in the suburban areas where you see the most water savings," Jones said. The study also confirmed a finding that has been emerging: that water conservation measures that directly reduce irrigation, such as drought-tolerant landscaping, can have the unintended consequence of increasing temperatures in urban areas. Vahmani and Jones ran a simulation of the most extreme case – a complete cessation of irrigation – and found a mean daytime warming of 1 degree Celsius averaged over the San Francisco Bay Area. ■

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Schneider Electric Unveils EcoStruxure™ Building

Collaborative smart building platform and open system architecture allowing developers and partners to interact, share data and develop apps, increasing efficiency up to 30 percent and ensuring optimal comfort for occupants...

Schneider Electric, the leader in digital transformation of energy management and automation announced the introduction of EcoStruxure™ Building, an open, collaborative Internet of Things (IoT) platform for smart buildings that delivers significantly enhanced value across the building ecosystem. By utilizing the latest in digital technology and solutions, EcoStruxure Building is specifically designed to meet the requirements of building owners, real estate developers, system integrators, facility managers and building occupants.

EcoStruxure Building is the latest addition to Schneider Electric's EcoStruxure, its IoT-enabled, plug-and-play, open architecture, which delivers end-to-end solutions in six domains of expertise – power, IT, building, machine, plant and grid – for four end markets, building, data center, industry and infrastructure. EcoStruxure is driving digital transformation for Schneider Electric clients globally, enabling them to be competitive in today's digital economy. With an open architecture, developers, partners and customers can securely interact with and share data via SDK and API.

By 2020, nearly 30 percent of devices within buildings will be connected to the internet, providing significant opportunities for efficiency gains. An innovative, agile solution that combines proven building management software with hardware, EcoStruxure Building enables users to gain valuable insights from building data to make building environments smarter, more secure and comfortable and up to 30 percent more efficient. By connecting everything from sensors to services, this comprehensive solution integrates key building systems such as energy, HVAC, lighting, fire safety, security and workplace management to make the most of new opportunities presented by the IoT.

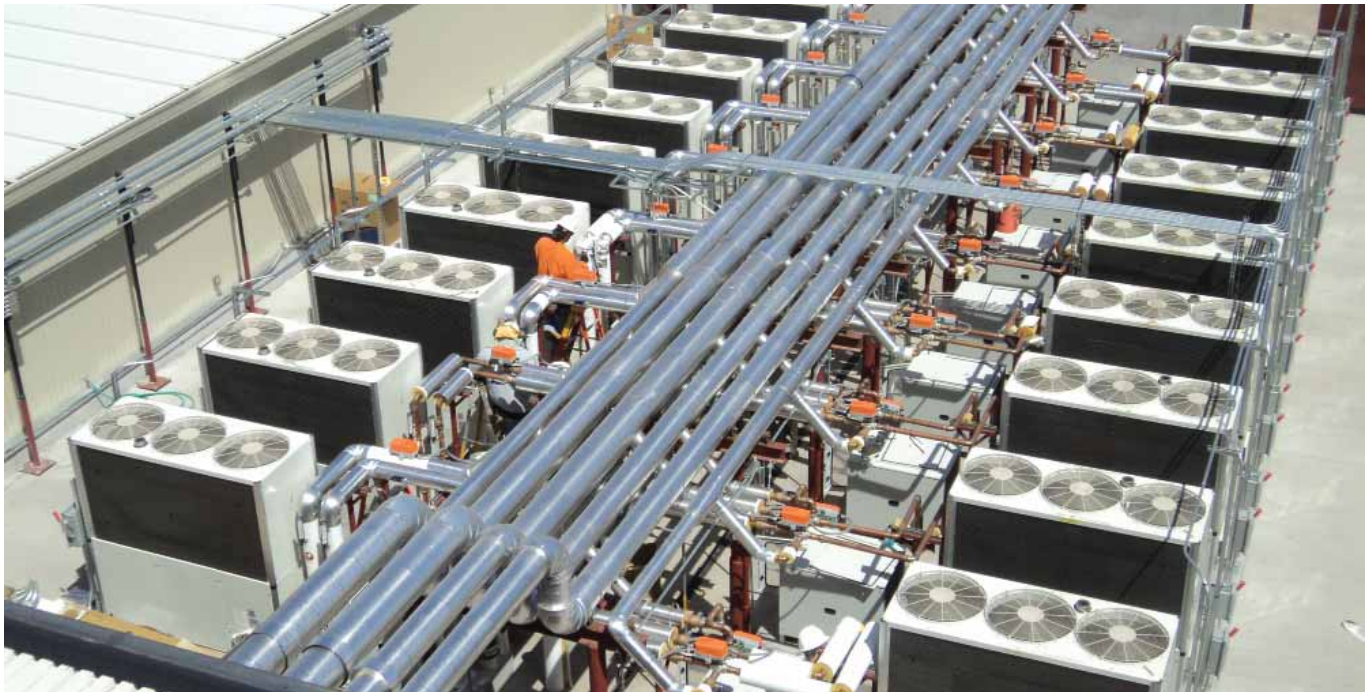
"Today our customers have a significant opportunity to improve their buildings' lifetime efficiency, occupant comfort and productivity thanks to EcoStruxure Building," said Philippe Delorme, Executive Committee member and EVP, Building & IT Business, Schneider Electric. "The proliferation of connected, intelligent systems and devices generates mountains of data which our customers and partners can now leverage, making buildings as easy as ABC." EcoStruxure Building is designed to meet the unique needs of today's businesses with options to deploy on the cloud and/or on premise and the ability to readily scale from medium to large, multi-site building enterprises. Additionally, EcoStruxure Building is backed by advanced cybersecurity and supports industry standard and IP-based open protocols to facilitate the secure exchange of data and analytics between critical buildings systems from both Schneider Electric and third-party providers.

As the world's population continues to grow at an accelerated rate, global building stock will increase by 13 percent by 2024. This next generation of buildings will continue to be more electric and need to operate smarter and more efficiently to handle increased demand from an ever-expanding occupant base. EcoStruxure Building improves overall cost of ownership with easy access to analytics and reporting through a comprehensive smart building portfolio of offers that includes:

- EcoStruxure Building Operation: building management software that integrates system and application data to make building operations easier to monitor, manage and optimize
- EcoStruxure Building Operation – Energy Expert: building management energy module that tracks power consumption, allocates billing costs and conserves energy
- EcoStruxure Security Expert: security solution that drives efficiencies by creating secure business environments that unify access control and intrusion detection
- EcoStruxure Fire Expert: fire solution that saves time by providing immediate access to fire system data in the cloud
- EcoStruxure Building Advisor: continuously monitors building performance, proactively diagnoses issues and provides actionable intelligence that helps improve occupant comfort while lowering energy and maintenance costs up to 30 percent
- EcoStruxure Workplace Advisor: optimizes facility usage by better understanding space utilization and making data-driven decisions that maximize real estate value and improve the employee experience
- EcoStruxure Apps Studio: application development platform for the creation of sleek, secure mobile applications that ensure comfort by providing occupants with easy access and control of room temperature, lighting, blind controls and other user-related conveniences ■

Optimizing HVAC System Performance through Innovation

The case study presented in this article describes how the energy management team of a large portfolio of buildings did what engineers do best – study the design, identify gaps and then implement cost effective solutions to improve efficiency as well as reduce cost...



Air condition systems in modern, glass enclosed buildings are essential for business operations as well as human comfort. While every effort is made at the design stage to put in the most optimum air conditioning capacity, during the operational phase of building, most building owners and occupiers see the set points drift from the design values and internal ambient temperatures not being maintained as per the original design or as per the expectations of the occupants (too hot or too cold!)

The HVAC team has the difficult task of balancing between the cost of operations of the HVAC system (one of the highest costs in an operational building) and the human comfort. The typical approach of the maintenance team is to run more capacity to meet the change in requirements, which tend to increase cost of operations. The case study presented in this article describes how the energy management team of a large portfolio of buildings did what engineers do best – study the design, identify gaps and then implement cost effective solutions to improve efficiency as well as reduce cost.

Background Information of HVAC System

The HVAC system for five large multi tenanted building complexes consists of water cooled centrifugal chillers with VFD control. The portfolio covers approximately 10 million square ft. of office space in the NCR and east regions. A total of 59 chillers are installed across the portfolio with capacities of the chillers ranging from 450TR to 800TR. The chillers are distributed in 19 banks in the 5 complexes.

The chilled water circuit is primary-variable secondary catering to AHU's located in different floors. The chilled water circuit is primary-variable secondary catering to AHU's located in different floors.

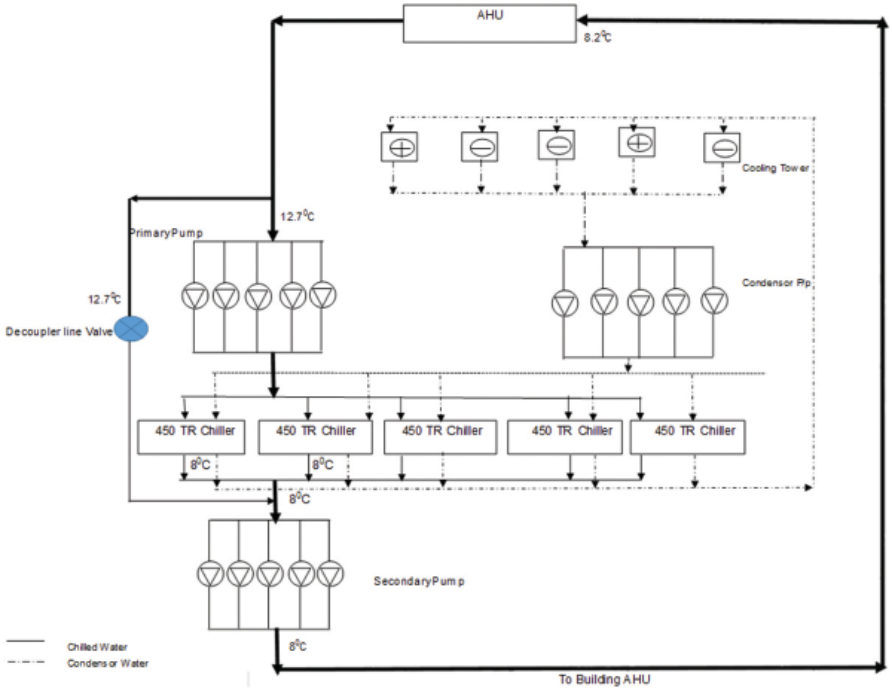
Operational Challenge Faced by Maintenance Team

Although the HVAC systems for each building complex have capacity control systems with BMS integration of the air handling units, the complaints from occupants of inadequate cooling leading to higher ambient temperatures were increasing, resulting in tenant dissatisfaction. The building maintenance team's initial approach to address the issue was to increase the chiller banks in operations to reduce the AHU chilled water temperature. However, this increase the cost of operations considerably and also did not seem to be improving the operations to a great extent.

Root Cause Analysis

The task of finding a more cost effective and long lasting solution was entrusted to the energy management team of maintenance department. The data for one building was initially analyzed using both the system generated BMS data as well as manual data collection to corroborate the design inputs. The key observations deduced from the detailed review of system data were

- Temperature of the chilled water flowing to the first AHU is on the higher side.
- Temperature difference between chilled water outlet & first AHU inlet is around 3°C.



- Mixing of chilled water happening through the de-coupler line from primary suction header to secondary suction header because of head difference in between the headers.

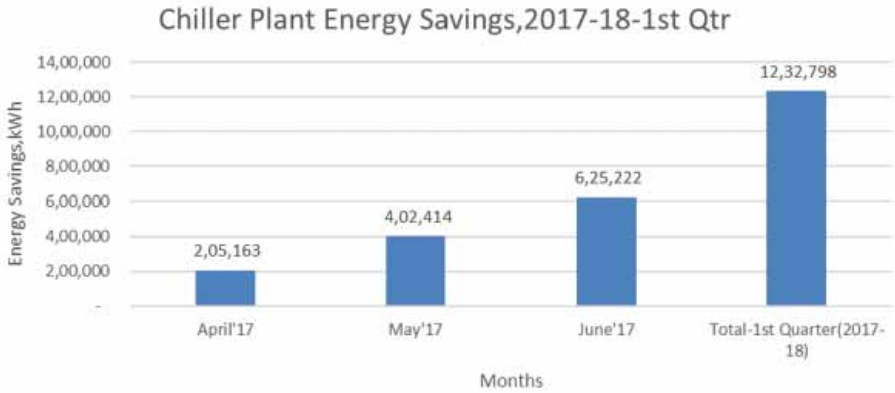
The main reason for the relatively higher chilled water temperature reaching the AHU's was identified as the mixing of the chilled water supply and return streams. This was on account of incorrect balancing in the headers leading to warmer supply water going into the supply line. The schematic of the chilled water supply line arrangement is shown in figure 1.

Addressing the Problem

The maintenance team and the energy management reviewed the current arrangements and identified the following ways to prevent mixing of primary & secondary chilled water:

- Motorized de-coupler valve has been installed in all the plant rooms to segregate primary & secondary chilled water circuits.
- The valve has been closed maintaining the desired chilled water flow through the chillers.
- Butterfly valves present in the standby chillers are completely closed in order to avoid mixing of return & supply chilled water.
- During winter season the motorized de-coupler valve will be adjusted based on frequency of VFD present in the secondary pumps.
- At a later stage the motorized de-coupler valve will be integrated with the BMS system & secondary pump VFD so that operation of the same gets controlled automatically.

The changes made the system are shown in figure 2 in bold lines.



Cost Benefit Analysis

The energy consumption of the chillers was closely monitored for the next three months to assess the impact of the change. The chart below shows the trend of energy savings achieved in 1st quarter of 2017-18

The return of investment for the change

worked out to be less than a month. Considering an average unit cost as Rs.10/kWh (includes Grid & DG cost), the calculations for the payback are as follows:

Energy savings for 1st quarter of 2017-18	=	1232798 kWh
Unit cost	=	Rs.10/kWh
Monetary savings achieved for 1st qtr. 2017-18	=	Rs.123.27 Lakhs
Investment in de-coupler valves	=	Rs.19.28 Lakhs
Payback period	=	14 days

Direct Benefits Achieved:

- Lesser running hours of chillers.
- Lesser running hours of primary, secondary & condenser water pumps.
- Lesser running hours of cooling tower.

Intangible Benefits Achieved:

- Tenant satisfaction
- Reduced maintenance cost of equipment (chiller, pumps, cooling tower) because of lesser running hours.
- Lesser man hour wastage because of lesser HVAC complains from tenants.

Conclusion

Energy is a major component of the opex costs in a building. With the increasing cost pressures on occupiers to keep costs low, the maintenance teams have to find innovative ways to optimize the use of energy and thus, reduce costs. The team was faced with increasing costs as well as increased occupant discomfort due to the higher chilled water temperatures at the AHU inlet. By studying the system in detail, the energy management as well as maintenance teams jointly worked out a solution that was cost effective and easy to implement. This resulted in considerable savings to the landlord as well as the occupiers in addition to achieving the result of satisfied occupants of the building. ■

Aneesh Kadyan
Sr Director - Operations,
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services firm

'Contemporarily Cool' Program of Amul

The demand for milk by 2050 would touch 540 million litres and to meet India's demand in the coming years there is a need to make the dairy industry commercially viable for India's youth. Amul is launching innovative programmes like the 'cow to consumer' to make the dairy sector 'contemporarily cool' and commercially viable for today's youth who are moving to cities and reluctant to join the milk industry, the dairy giant's Managing Director Rupinder Singh Sodhi has said. In 1970, per capita of milk consumption in India was 111 gm and today it is 350 gm, it is growing at the rate of 2 percent per annum. The demand for milk by 2050 would touch 540 million litres and to meet India's demand in the coming years there is a need to make the dairy industry commercially viable for India's youth, said Sodhi.

"By 2050, 50 percent of India would be urbanised, which means that we would have more mouths to feed and less hands to produce. In case of shortage of milk, we would become dependent on milk from edible oil and pulses," Sodhi told PTI.

What is required is how to make dairy 'contemporarily cool' and 'commercially viable' business for today's youth who are drifting to cities and reluctant to join the dairy industry, he said on the sidelines of the International conference on South-South and Triangular Cooperation here. "We are trying mordernise dairy farming using milking machines instead of hand milking; we are also using bulk milk coolers, modern sheds, modern watering system etc. The idea behind propagating a commercial dairy farm is to attract today's youth," 57-year-old Sodhi said.

Listing, the programmes introduced by the company to modernise dairy farming, Sodhi said the biggest innovation that Amul is bringing in India's dairy industry is through 'Cow to Consumer'. Under the 'Cow to Consumer' program, Amul creates a digital account for a farmer. When a farmer goes to deposit milk at a collection centre, the quality and quantity of milk is assessed and updated on the card that comes with the account. Based on the quantity and quality, money is transferred to the account of the farmer immediately which could be accessed by him through a mobile app, he said. ■

Clinic That Takes its Patients to Heart

In healthcare facilities, the HVAC system has an essential role not only in guaranteeing the well-being of patients, but also and above all, in supporting medical activities...

Mitsubishi Electric Hydronics & IT Cooling Systems, through its brand Climaveneta, has supplied the HVAC system to the Casa di Cura Montevergine S.p.A. in Mercogliano, a private clinic specialized in cardiovascular diseases. The hospital is located in a hilly area in the historic town of Mercogliano, a well-known climatic small town in Irpinia, not far from the city center of Avellino. The complex has 120 beds and consists of a main building, divided into 4 levels with a total internal surface area of 5,700 sqm dedicated to health activities and a secondary building, where the administrative offices, the medical management and support works offices are located. A green area of approximately 7,000 sqm equipped with a garden and two large parking lots complete the block, built in the second half of the '60s. In 2017, for the second consecutive year, Montevergine S.p.A. ranked third in the best clinics in Italy in terms of number and quality of surgical procedures. This is the result of a continuous investment in technological innovation, training of professionals, and work organization, which has enabled Montevergine to become a national excellence.

Technological Innovation

The clinic is technologically advanced even from a MEEB (Mechanical and Electrical Equipment for Buildings) point of view, thanks to the renovation of the HVAC system. The progressive efficiency reduction of existing chillers on one side and the need to optimize the energy performance of the whole building on the other side, led to the installation of a new HVAC system to meet the new demands. The use of the buildings and the characteristics of the existing systems, along with the objective to grant high energy performance without affecting the internal comfort, led to the choice of air cooled chillers. The HVAC plant designer therefore chose 2 Climaveneta TECS XL CA 0512 high efficiency chillers, air source for outdoor installation in super low noise version, featuring oil-free centrifugal compressors with magnetic levitation.

Choice of the HVAC Units

The choice of chillers featuring magnetic levitation compressors was made to grant high efficiency, reliability, and low noise emissions of the HVAC system. The installation of this high efficiency (Class A) air source chiller led to an energy consumption reduction, as they easily adapt themselves to different thermal load conditions thanks to the precise thermoregulation together with the use of inverter technology, and this also led to a running costs reduction.

Each chiller supplies, under project conditions, approximately 525 kW with an outside temperature of 35 ° C. The HVAC plant designer, talking about the project says, "the air conditioning system is managed by a BMS. To maximize the energy efficiency of the system, thus, reducing the clinic's running costs, the system independently sets chillers switching on and off, on the basis of the real building's needs. In addition to the high energy efficiency achieved, the plant fully meets the customer's needs in terms of reduced noise levels, to avoid any obstacle to the delicate activities taking place inside the building, and any concern to the patients of the Clinic".

Climaveneta Units: Efficiency & Reliability in Healthcare

In healthcare facilities the HVAC system has an essential role not only in guaranteeing the well-being of patients, but also and above all, in supporting medical activities. Since medical activities are carried out throughout the day and all year round, the air conditioning units must be reliable and with an easy service to minimize any possible interference with the indoor activities. The reliability of Climaveneta units and the flexibility of their operation make the HVAC system easy both in terms of installation and maintenance. ■

Energy-Efficient Green Buildings

Green building standards focus on making residential and commercial buildings more environmentally friendly, sustainable and healthier for their occupants. The basic principles are maximum resource conservation, and to maximize use of renewable forms of energy as well as to recycle and reuse resources...

A green building uses less energy, water and natural resources, creates less waste or no waste (Zero Discharge) and is healthier for the people living inside compared to a standard building.

There is a rapidly expanding market for green building materials. Green building provides suitable environment by controlling solar radiation, temperature, energy efficiency, water conservation using domestic treatment plant and indoor air quality. The main aim of green buildings is to reduce the environmental impact of new buildings. The sustainability in the environment can be well achieved by reducing the energy emission and consumption by the buildings. Sustainability means using the energy efficiently. Green building refers to a structure that is environmentally responsible and resource-efficient throughout a building's life-cycle. Solar panels and wind mills are used to produce efficient energy. Highly efficient gadgets are used like 20W BLDC fans, 5 star fridge, LED bulbs, Inverter type solar air-conditioners & five-star hospital-equipment.

Green building starts with efficient use of water and use of recycled or recyclable materials, and provision for healthy indoor air quality. Buildings are responsible for 40 per cent of the world's energy consumption. The green building concept helps to conserve energy.

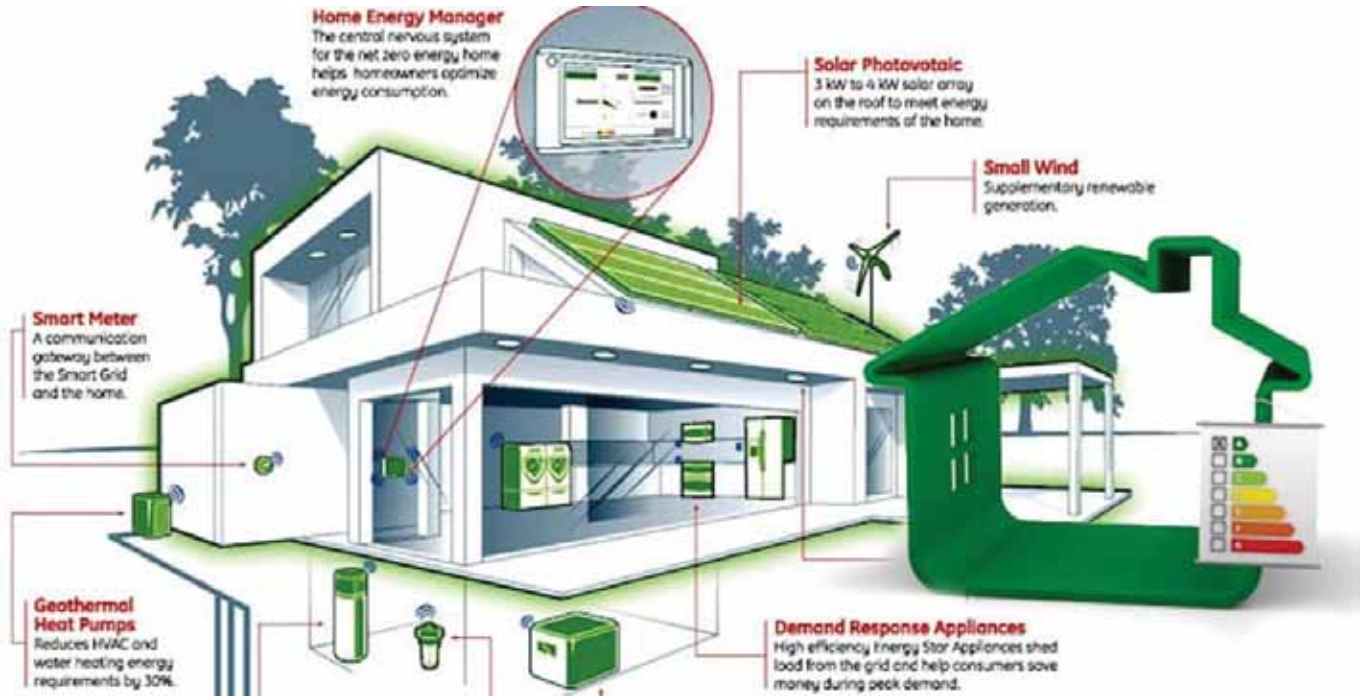
Features

It includes natural lighting in the building, which results in substantial savings in energy consumption.

- Insulated walls and double-glazed glass windows for lower energy consumption.
- A green lawn around the building improves the quality of air inside the building premises.
- Use of non-toxic house-keeping materials - green seal approved products. Natural manure for plants such as neem-based pesticides.
- Water recycling.

Sustainable Features

Buildings achieve a 50% reduction in



energy use and utilize their electrical power from a renewable energy supply. The building incorporates many energy-conserving features:

- A well-insulated building shell
- Energy efficient window systems
- Supplemental passive solar heating
- Extensive use of natural ventilation and day lighting
- Use of latest solar high-tech technology like BIPV solar panels with 21% efficiency. Solar-powered sterilizers, operation-rooms, preheated hot water upto 90^{0}C for cooking & other applications.

Rat – Trap Bond Wall

It is a cavity wall construction in a modern technique that offers unique combination of strength lightweight thermal and sound insulation fix resistance and resistance to water penetration and reduction in the quantity of bricks required for masonry work.

The main features of Rat-trap bond wall are:

- Strength is equal to standard 10" (250 mm) brick wall, but consumes 20% less bricks.
- The air medium or cavity created in between the bricklayers helps in maintaining a good thermal comfort inside the building. This phenomenon is particularly helpful for tropical climate of South Asian and other countries.
- As the construction is done by aligning the bricks from both sides with the plain surfaces facing outwards, plastering is not necessary except in a few places. The finished surface is appealing to the eye from both internally & externally.

Preserve and protect vegetation and soil from degradation during construction

Preservation and protection of existing vegetation, particularly, mature trees, is highly recommended. This is done by avoiding cut and fills in the root zones, delineating and fencing the drip line of all trees or a group of trees. Trees should also protect against damages from carving, nailing, fires or heat emitting construction activity. The top soil, in most cases, is the most nutrient rich layer that supports vegetative growth.

Reduce hard paving

Hard paved parking lots, pathways, plazas and courts should be minimized. Hard paved areas enhance imperviousness of the sit and generate a heat island effect, which causes a sharp microclimate temperature rise. By reducing penetrability of the site, hard paving also lowers the localized aquifer recharge potential. Dark colored and constructed surfaces absorb solar energy and radiate it back when the ambience is cooler.

Energy Efficiency

One of the primary requirements of a green building is that it should have optimum energy performance and yet should provide the desirable thermal and visual comfort. Energy efficiency can be maximized by utilizing materials components, and systems that help reduce energy consumption in buildings and facilities. To increase the efficiency of the building envelope, they may use high-efficiency windows and insulation in walls, ceilings, and floors. Another strategy, passive solar building design, is often implemented in low-energy homes. In addition, effective window placement can provide more natural light and lessen the need for electric lighting during the day. Solar water heating further reduces energy loads. Onsite generation of renewable energy through solar power, wind power, hydro power, or biomass can significantly reduce the environmental impact of the building. BIPV type solar-panels can be used as façade projection, allowing sunlight during daytime & also producing electricity.

Water Efficiency

Reducing water consumption and

Sawali Nursing Home

protecting water quality are key objectives in sustainable building. Use of water may be minimized by utilizing water conserving fixtures such as ultra-low flush toilets and low-flow shower heads. Point of use water treatment and heating improves both water quality and energy efficiency while reducing the amount of water in circulation. Water can be re-circulated for other applications & zero-discharge concept can be achieved.

Indoor Air Quality (IAQ)

IAQ can be affected by microbial contaminants (bacteria), gases (including carbon monoxide, radon and volatile organic compounds), particulates, or any mass or energy stressor that can induce adverse health conditions. Indoor Air Quality (IAQ) is enhanced by utilizing materials that meet the following criteria:

- Low or non-toxic: Materials that emit few or no carcinogens, reproductive toxicants, or irritants as demonstrated by the manufacturer through appropriate testing.
- Moisture resistant: Products and systems that resist moisture or inhibit the growth of biological contaminants in buildings.
- Systems or equipment: Products that promote healthy IAQ by identifying indoor air pollutants or enhancing the air quality.

Case Study

Sawali Nursing Home, Kolhapur Executed by M/s. Solar Electronics

Sawali Nursing Home, Kolhapur is a unique case of green building, the main design features are:

1. All electrical gadgets like special ceiling fans (20W power consumption, quantity 200 nos.), lights, lifts, TV sets (approx. 100 nos.), CCTV camera systems, hospital equipment etc are 100% solar-powered during daytime, battery or wind-mill powered during night-time & conventional electric supply is a stand by option, along with diesel-generation. The expected saving per month is approximately Rs 1.5 lakh. The expected environmental saving is precious.
2. Preheated water upto 90^{0}C is used for cooking purpose by latest technology developed by M/s. Solar Electronics. Cooking gas is produced by human-waste chamber & kitchen waste. Hence, conventional cooking gas is not used. Expected saving is to the tune of Rs 2 lakh per month. Pre-heated water is also used for floor-cleaning & washing utensils.
3. The output drain water is recycled & reused. There is practically no output discharge from the hospital but the same is used for gardening purpose.
4. Healthy air-circulation is maintained inside the hospital by planting indoor plants of special category. ■

S D Bandal
Managing Director
Solar Electronics
Solapur

Unique Opportunity for India's Housing Market

EDGE is a green building certification system focused on making buildings in more than 130 emerging markets more resource-efficient. It was created by IFC, a member of the World Bank Group, to address the challenges emerging markets face, such as lack of affordable green housing...

Over the past two decades, India has experienced rapid urbanization, which has created serious challenges such as air quality issues, energy shortages, water scarcity, waste accumulation, chronic diseases and an affordable housing crisis. We know that as a direct result of urbanization, more and more people will be moving into cities, and this means more buildings will be needed.

Rapid Growth Prompts Rapid Construction

By 2030, it is expected that the world will have 8.6 billion people, and 1.5 billion of them will reside in India. In fact, India alone is expected to double its building stock by 2030, and 70 percent of those buildings still haven't been built.

Urbanization has created a huge demand for new construction, especially, in the residential market, because more housing will need to be constructed to keep pace with the rapidly increasing population. According to some figures, as much as three-quarters of all new construction in India in the next few years will be residential. India's growing residential market is also one of the highest contributors to the country's carbon emissions, accounting for 22 percent of India's total annual carbon emissions. Furthermore, buildings account for up to 40 percent of the total energy consumption in India, and residential real estate alone accounts for over 60 percent of this.

Given all of this, buildings that are developed sustainability and with resource efficiency in mind are key in urban India, and India needs to move toward green housing projects in order to keep pace with market trends. Enter EDGE—a fast, simple and affordable way to scale up buildings in emerging markets. EDGE is a green building certification system focused on making buildings in more than 130 emerging markets more resource-efficient. It was created by IFC, a member of the World Bank Group, to address the challenges emerging markets face, such as lack of affordable green housing.

EDGE has great potential for the housing market in India because it simply makes economic sense. The rating system provides a quantifiable business case that resonates with sectors of the market that have been slow to change, encouraging more affordable housing in high-growth, urban areas and making green building and design accessible for middle and low-income housing. Deployed at scale, it can also help build more sustainable cities. Taking into account occupancy, the owner's income level and unit sizes, EDGE creates a benchmark model for either landed homes or apartments. A developer's design team can then select from such practical solutions as reflective paint, energy-efficient ceiling fans and water-conserving fixtures to create homes of outstanding value. Each homeowner receives an EDGE certificate as proof of delivery on the promise to build green.

Consider the fact that those living in traditional, low-income housing in India often spend a high proportion of their disposable income on their utility bills. By making the right choices at the design stage through EDGE, we can lower utility bills, develop affordable homes and command a higher resale price at the same time. EDGE also enables communities to reduce their carbon footprint through lower greenhouse gas emissions, while also helping emerging market regions save money by minimizing operating costs and boosting efficiency.

Impact of EDGE

Homeowners of the EDGE-certified Kolkata West International City will save anywhere from 300 to 800+ rupees per month on their utility bills, compared to a conventional home. Owners of Kesar City's EDGE-certified, resource-efficient two-bedroom apartments are kept comfortable through practical strategies like reducing the amount of glass on the façades and using reflective paint on roofs instead of air conditioning, saving more than 200 rupees per month in lower energy and water costs.

Value Budget Housing Corporation's flagship project, Vaibhava Bangalore, is a residential complex that combines high-quality construction with affordable pricing, reinforcing VBHC's belief that quality living should be within everyone's reach. ■

By Sarah Buente, GBCI

Horticulture

Area & Production of Flowers Statewise

(Area in '000 Hectare); (Production : Loose '000 Tonne), (Production : Cut in lakh Nos)

State/Union Territory	2007-08			2008-09			2009-10			2010-11		
	Area	Production		Area	Production		Area	Production		Area	Production	
		Loose	Cut		Loose	Cut		Loose	Cut		Loose	Cut
Andhra Pradesh	23.5	106.8	3	19.5	125.0	3	21.4	130.3	6202	21.8	133.7	6202.0
Arunachal Pradesh	-	-	-	-	-	-	1.22	-	2860	1.2	-	2860.0
Assam	-	-	-	-	-	-	-	-	-	-	-	-
Bihar	0.2	2.3	11	0.2	2.3	11	0.20	2.3	11	0.20	2.3	11.0
Chhattisgarh	2.4	6.9	-	2.4	6.9	-	4.09	13.5	-	6.9	27.1	-
Goa	-	-	-	-	-	-	-		-	-	-	-
Gujarat	9.7	49.5	5063	9.7	49.5	5063	12.53	49.5	5063	12.5	49.5	5063.0
Haryana	6.1	61.8	1053	5.5	53.9	929	6.2	60.3	1084	6.2	60.3	1084.0
Himachal Pradesh	0.6	3.4	566	0.6	3.4	566	0.68	0.6	605	0.7	0.6	605.0
Jammu & Kashmir	0.3	1.3	218	0.1	-	20	0.13	0.2	66	0.1	0.2	66.3
Jharkhand	0.1	0.2	73	1.6	22.0	1711	1.60	22.0	1711	1.60	22.0	1711.0
Karnataka	25.1	180.0	5700	26.0	203.9	5867	27.01	203.9	5860	27.0	203.9	5860.0
Kerala	-	-	-	-	-	-	-	-	-	-	-	-
Madhya Pradesh	2.6	1.5	-	3.0	1.8	-	6.59	5.0	-	7.7	6.0	
Maharashtra	16.7	69.5	5728	16.4	89.4	5728	17.51	91.1	7914	17.5	91.1	7914.0
Manipur	-	-	-	-	-	-	-	-	-	0.0	0	-
Meghalaya	-	-	-	-	-	-	-	-	-	-	-	-
Mizoram	0.05	-	76	0.215	-	168	0.04	-	142	0.1	0	162.0
Nagaland	0.02	-	17	0.019	-	17	0.02	-	17	0	0	17.0
Odisha	2.4	7.0	-	5.7	23.4	-	7.11	25.3	5356	7.4	3.7	5911.0
Punjab	1.0	77.9	-	1.7	82.0	-	1.7	82.0	-	1.7	82.0	-
Rajasthan	4.3	6.2	-	3.4	4.9	-	3.28	4.9	-	5.4	9.6	-
Sikkim	0.1	-	45	0.151	-	66	0.18		200	0.2	-	230.0
Tamil Nadu	26.7	214.4	-	29.1	233.7	-	31.97	247.3	-	32.0	247.3	
Tripura	-	-	-	-	-		-	-	-	-	-	-
Uttarakhand	0.9	0.7	1456	0.9	0.6	2056	1.29	1.0	3414	1.3	2.3	3416.0
Uttar Pradesh	10.3	17.5	2928	13.5	24.3	3467	10.38	17.6	2958	10.4	17.6	2958
West Bengal	27.4	48.4	19680	21.1	52.0	21232	21.94	55.2	22170	23.1	59.2	23919.0
Union Territory:												
A. & N. Islands	0.03	4.7	-	0.035	0.34	-	0.03	0.3		0	4.7	-
Chandigarh	-	-	-	-	-	-	-	-	-	-	-	-
D. & N. Haveli	-	-	-	-	-	-	-	-	-	-	-	-
Daman and Diu	-	-	-	-	-	-	-	-	-	0	0	-
Delhi	5.5	5.7	1038	5.5	5.7	1038	5.5	5.7	1038	5.5	5.7	1038.0
Lakshadweep	-	-	-	-	-	-	-	-	-	-	-	-
Puducherry	0.3	2.7	-	0.286	2.4	-	0.29	2.4	-	0.3	2.4	-
All India	166.3	868.4	43654	166.5	987.4	47942	182.9	1020.6	66671	190.8	1031.2	69027.3

State/Union Territory	2011-12			2012-13			2013-14			2014-15@		
	Area	Production		Area	Production		Area	Production		Area	Production	
		Loose	Cut		Loose	Cut		Loose	Cut		Loose	Cut
Andhra Pradesh	64.2	389.0	7099.4	35.0	224.4	6909.0	20.4	136.3	3900.0	14.4	103.3	2757.0
Arunachal Pradesh	1.2	0.0	2860.0	0.0	0.0	297.0	0.0	0.0	297.0	0.0	0.0	297.0
Assam	-	-	-	2.0	11.7	3750.0	3.0	20.0	5000.0	3.5	22.8	5051.2
Bihar	0.9	8.7	1285.0	1.0	10.2	324.0	0.8	7.6	254.0	1.4	13.7	255.9
Chhattisgarh	8.4	32.9	0.0	10.0	37.8	0.0	10.1	45.7	0.0	11.0	50.0	0.0
Goa	-	-	-	-	-	-	0.0	0.0	17.5	0.0	0.0	21.0
Gujarat	16.0	135.5	0.0	17.0	149.0	0.0	17.3	163.6	0.0	17.3	163.6	0.0
Haryana	6.3	64.2	1269.5	6.0	64.7	1270.6	6.5	65.5	1271.0	6.1	62.9	561.0
Himachal Pradesh	0.9	35.3	1948.1	1.0	37.7	1760.3	0.8	28.1	1916.2	0.8	27.2	1953.0
Jammu & Kashmir	0.2	1.1	155.9	1.0	0.4	222.1	0.8	0.420397	237.41	0.5	0.3	0.0
Jharkhand	1.6	22.0	1711.0	2.0	22.0	1711.0	1.6	22.0	1711.0	1.6	22.0	9506.0
Karnataka	29.2	211.5	10388.0	30.0	207.5	9441.8	30.6	211.5	9723.9	30.9	220.0	9353.0
Kerala	-	-	-	-	-	-	0.0	0.0	0.0	13.4	0.1	5915.5
Madhya Pradesh	15.6	150.7	0	17.0	193.0	0.0	17.1	200.394	0	17.8	206.0	0.0
Maharashtra	18.9	104.0	7914.0	22.0	119.0	7914.0	23.0	122.7	7914.0	7.3	38.5	0.0
Manipur	0.0	0.0	0.0	0.0	0.0	0.0	0.8	0.3	1.8	0.8	0.3	0.0
Meghalaya	-	-	-	-	-	-	0.1	0.0	408.2	0.1	0.0	451.0
Mizoram	0.1	0.0	349.0	0.0	166.8	605.2	0.2	171.6	199.8	0.2	181.5	295.4
Nagaland	0.0	0.0	15.4	0.0	0.0	96.7	0.0	0.0	56.3	0.0	0.0	0.0
Odisha	7.5	26.1	6020.0	8.0	26.2	6040.0	7.4	37.4	6017.5	7.5	25.9	5956.6
Punjab	2.1	10.1	0.1	2.0	10.5	0.0	1.4	10.5	0.0	1.4	10.7	0.0
Rajasthan	2.5	2.7	0.0	3.0	3.7	0.0	2.5	2.7	0.0	2.7	2.9	0.0
Sikkim	0.2	26.0	209.1	0.0	26.5	214.1	0.2	16.0	233.9	0.2	16.5	229.0
Tamil Nadu	32.3	332.81	0	29.0	313.0	1168.0	55.0	343.65	2317.304	55.0	343.7	2317.3
Tripura	-	-	-	0.0	-	-						
Uttarakhand	1.5	1.8	3567.6	2.0	1.8	3633.0	1.4	2.0	1522.0	1.6	2.1	1863.0
Uttar Pradesh	14.5	27.05	4194	16.0	31.5	4908.0	16.6	32.159	5037	17.2	34.3	5.0
West Bengal	23.9	63.9	25042.1	24.0	65.1	25429.1	24.9	66.5	26135.0	25.3	68.2	26645.0
Union Territory:												
A. & N. Islands	0.0	0.3	0.0	0.0	0.4	0.0	0.1	0.3	0.0	0.2	0.2	0.0
Chandigarh	-	-	-	-	-	-						
D. & N. Haveli	-	-	-	-	-	-						
Daman and Diu	0.0	0.0	0.0	0.0	0.0	0.0				0.0	0.0	0.0
Delhi	5.5	5.7	1038.0	6.0	5.7	1038.0	5.5	5.7	1038.0	0.0	0.0	0.0
Lakshadweep	-	-	-	-	-	-						
Puducherry	0.1	0.4	0.0	0.0	0.4	0.0	0.1	1.2	0.0	0.2	1.5	0.0
All India	253.6	1651.7	75066.2	234.0	1729.0	76731.9	255.0	1754.5	79860.6	245.8	1638.8	74484.0

Source : Horticulture Statistics Division,Department of Agriculture,Cooperation and Farmers Welfare.
@ 3rd Advance Estimate

FLIR DM166 - Imaging TRMS Multimeter

The FLIR DM166 is the most affordable multimeter with built-in thermal imaging – a must-have tool for commercial electricians, automation, electronics, and HVAC technicians. Featuring Infrared Guided Measurement (IGM™) powered by an 80 x 60 FLIR thermal imager, the DM166 visually guides you to

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Email: flirindia@flir.com.hk

Reversible Heat Pump with Inverter Compressor from Climaveneta

The new i-NRG heat pump provides exactly the energy required by the system, perfectly following the real load of the building, thanks to the modulation of the DC inverter fan. One single unit for the highest efficiency, sustainability and huge savings, thanks to the advantages of DC frequency driven fans and circulating pumps (inverter) for both plant and domestic hot water circuits. i-NRG is the new generation heat pump for all year round operation in any operating mode: single cycle (air conditioning, heating, domestic hot water) as well as combined cycle in total heat recovery (domestic hot water together with cooling). Domestic hot water production is guaranteed by the dedicated

exchanger for heat recovery: total, for free domestic hot water production, or partial. Domestic hot water is stored in a properly dimensioned storage tank. The unit can be installed indoor or outdoor, thus ensuring complete flexibility. Extended operating limits for all year, specially in heating. Structure and base in hot-dip galvanised steel with epoxy powder paint finish. High efficiency and low pressure drop stainless steel AISI 316 plate exchangers (at the domestic hot water side). It is positioned next after the compressor and it ensures the domestic hot water production. THigh efficiency and low pressure drop stainless steel AISI 316 plate exchangers meet the supply of both hot and cold water for the facility, regardless of the domestic hot water. DC inverter scroll compressor with self-adaptive capacity adjustment. Reduced inrush current due to modulation by an inverter.

Website: www.climaveneta.com

Emerson Launches Propane-ready Condensing Unit Solutions

Emerson announced it has launched R-290 (propane) ready models for its Copeland M-Line condensing unit platform. The propane-ready solution helps customers use an Environmental Protection Agency (EPA) approved natural refrigerant substitute while also helping to answer the Department of Energy's (DOE) call for more efficient compression technology.

The DOE's mandate for reach-in units requires a 30 to 50 percent reduction in energy consumption which began on March 27. Additionally, the EPA will begin phasing out commonly used hydrofluorocarbons (HFC) in 2019. R-290 is one of the leading natural refrigerant options to those being phased out, and the newest models of the M-Line condensing unit platform are not only

designed to significantly increase R-290 efficiencies, they are also designed to deliver energy improvements of up to 30 percent. "Emerson continues to focus its efforts on solutions that help our customers make the transition to DOE- and EPA-compliant technology," said Allen Wicher, foodservice director of marketing, Emerson's Commercial and Residential Solutions platform. The M-Line condensing unit platform offers minimal sound output for quiet operation. With an optional electronic unit controller, additional benefits include quick and easy setup; improved set-point accuracy, troubleshooting and diagnostics; and additional system safeguards to help end users and contractors improve usability and serviceability. ■

Website: www.emerson.com

Forthcoming Events At A Glance

ACREX 2018
Venue: BIEC, Bengaluru
Date: 22nd to 24th February 2018
Website: www.acrex.in

Global Logistics show
Venue: Bombay Exhibition Centre, Mumbai
Date: 22nd to 24th February 2018
Website: http://globallogisticsshow.com

ISK-SODEX Istanbul
Venue: TÜYAP Fair Convention and Congress Cente
Date: 7th to 10th February 2018
Website: http://www.sodex.com.tr

FoodTech Pune 2018
Venue: Pune
Date: 23rd to 25th February 2018
Website: http://foodtechpune.com

Indoor Air 2018
Venue: The Pennsylvania Convention Center, Philadelphia
Date: 22nd to 27th July 2018
Website: http://mms.isiaq.org

DairyTech India 2018
Venue: Bangalore International Exhibition Centre (BIEC)
Date: 31st to 2nd September 2018
Website: www.dairytechindia.in

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DLF Becomes LEED certified Green Commercial Space

LEED (Leadership in Energy and Environmental Design) is the world's most widely used and recognised green building rating system. DLF's 31 office buildings across major cities and a shopping mall at Noida, comprising a total of 28.5 million sq ft area, have 'LEED' certification, becoming a leading provider of green commercial space. LEED (Leadership in Energy and Environmental Design) is the world's most widely used and recognised green building rating system.

DLF, in a statement, said the company is the only commercial real estate entity to have 31 office buildings and country's largest mall constituting to 10.7 million sq ft LEED Platinum and 17.8 million sq ft LEED Gold Certifications. DLF's rental business has recently got '2017 Greenbuild Leadership Award' from US Green Building Council (USGBC). On getting this award, DLF Rental Business MD Sriram Khattar said, "Being a responsible commercial

real estate organisation, environment sensitivity and the importance of sustainability are paramount to us. The adoption of these practices not only creates healthier and more productive workplaces but also reduce the operating costs for our clients while protecting the environment at large," he added. ■

3,000 Govt Buildings to go Green in Maharashtra

Around 3,000 government buildings in Maharashtra will become green with a proposal to retrofit lighting and cooling appliances with energy efficient ones. An agreement to this effect was signed between Energy Efficiency Services Ltd (EESL) and the state government which would be implemented under a joint venture by the Union Ministry of Power. EESL would install around 26,500 energy efficient air-conditioners, 1.1 million LED lights, and 250,000 ceiling fans resulting in about 120 million unit savings – or around 48 percent reduction from baseline consumption. This initiative, likely to be completed by 2019, is expected to entail savings of Rs 115 crore annually for the government. Revenue and Public Works Department Minister Chandrakant Patil said in the agreement, the EESL would bear the entire upfront investment of around Rs 3.07 billion (Rs 307 crore) and the PWD would repay it from the savings in power bills accrued over a five-year period. "I am happy that various state government departments are coming forward to adopt energy efficiency and help check the country's energy consumption. ■

Microsoft's Sustainable Campus

Microsoft has started construction on its new campus in Silicon Valley designed to achieve net-zero, non-potable water certification as a response to California's water shortage. The new 643,000-square-foot Silicon Valley campus in Mountain View will have an integrated water management system that will operate on the guiding principle of putting non-potable water into service more than once. The ultimate goal is to not waste any drinkable water resources in the operations of the offices such as plumbing, sewage systems and in irrigation. Freshwater from the municipality will only be used for drinking fountains and sinks. Kevin Scott, Microsoft's Chief Technology Officer wrote: "California continues

to face increased demand for limited water and energy resources. We took these challenges into account when we began our design plans. We started with the biggest challenge for the region — water". The first step is to deploy rigorous conservation measures to reduce water demand, including advanced irrigation systems and low flow fixtures. Rainwater, storm water, and wastewater will be harvested and treated by an onsite wastewater plant. After filtration, this water will be re-used for irrigation and plumbing. Rainwater will be collected from clean roofs and solar panels; wastewater will be processed from campus kitchens and bathrooms; storm water will be retained on the living roof and collected from the paved areas. ■

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