Vol. 10 No. 12 July 2015 ₹ 100

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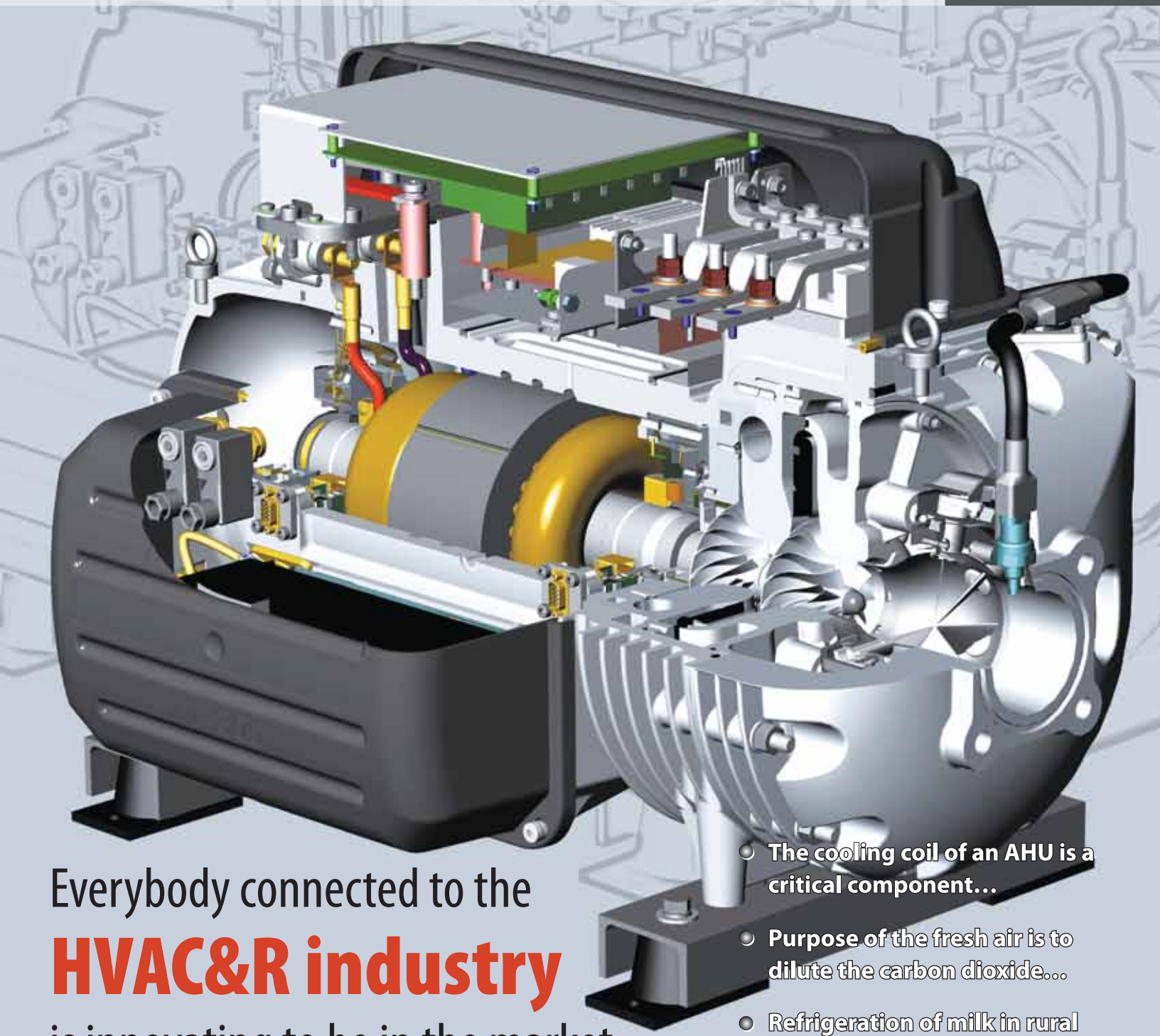

Everybody connected to the HVAC&R industry is innovating to be in the market

- The cooling coil of an AHU is a critical component...
- Purpose of the fresh air is to dilute the carbon dioxide...
- Refrigeration of milk in rural India is very difficult...

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Publisher's Letter

Energy Saving In India

Is the Indian HVAC market cool? Of late owing to global warming and growing atmospheric pollution – coupled by several socio-economic factors like, increasing disposable income among the middle class citizens, changing taste of the Indian young generation and so on… demand for residential HVAC systems is growing very fast.

There are some other factors too that are adding to the growth of the industry. According to TechSci Research, HVAC systems are becoming one of the key building blocks in modern infrastructure. These systems are found in almost all upcoming commercial as well as residential buildings. Rise in infrastructure, rapid urbanisation and growth in commercial properties are some of the key factors fuelling the market for HVAC systems in India. With healthy growth anticipated in the real estate sector, the country is expected to witness strong infrastructure development, which would boost the market for HVAC systems over the next five years.

In their research report titled "Global HVAC Equipment Industry 2014-2019: Trends, Forecasts and Opportunity Analysis for the $107 Billion industry," the market research firm – Research and Markets also states that residential HVAC equipment market will remain strong due to increasing demand from China and India.

However, in actual practice in India, in all states beside the latest energy efficient products' market, a parallel market is running for the discarded or second hand products. HVAC equipment are sold there at a very affordable rate. Due to lack of awareness and shortage of money, a good chunk of consumers buy products from that market and save in their initial investment. However, when it comes to the running cost – they end up paying more and more.

What's the result of this from the national point of view? Inefficient products are just changing their places of use. Overall national energy saving for HVAC purpose is growing instead of falling.

Please send your comments at pravita@charypublications.in

Pravita Iyer
Publisher & Director

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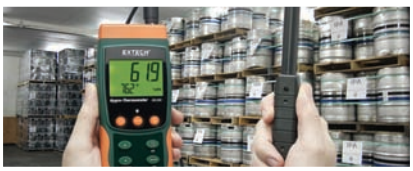

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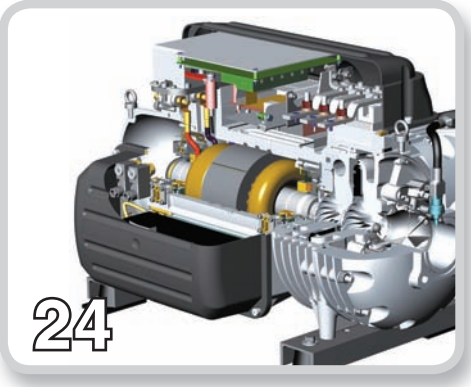

The Innovation Wave

Everybody connected to the HVAC&R industry is innovating to be in the market. Trade fairs are the best places where most of the innovative technologies are displayed first...

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Peeyush Gupta
Director - Sales & Marketing
Underwriters Laboratories, India

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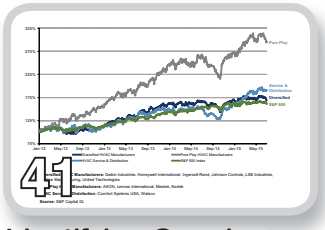
Managing AC Systems Efficiently

Energy Efficient Systems

Solar Air Handing & Distribution Systems

Best Practices In Maintenance Of AHUs



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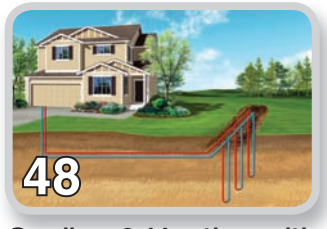
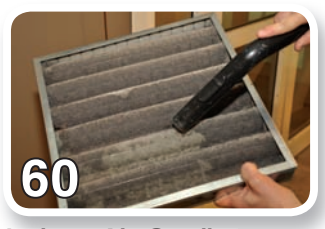


Cooling & Heating with Ground Source Energy



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R410A

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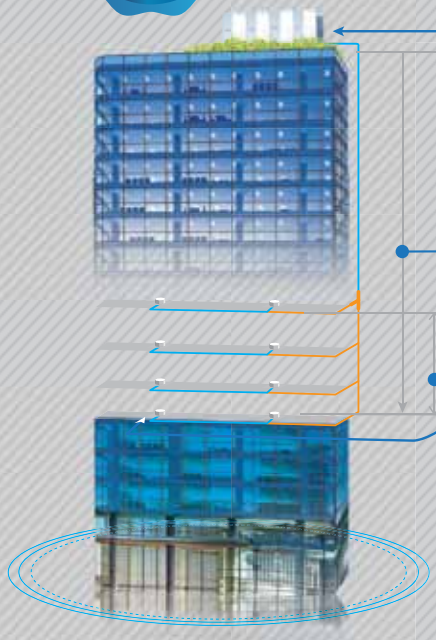
1000m The solution offers a piping length of 1,000m and level difference of 110m, making it perfect for large projects.



110m
Max.110m level difference between IDU~ODU

175m
Max.175m actual piping length

30m
Max.30m level difference between IDU~IDU

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FROM THE EDITOR

Intelligent Action Needed

Awareness is essential, however, mere awareness serves no purpose. Intelligent action is required. Exactly the same is true as far as energy conservation is concerned in the HVAC&R plants. Especially, when the environment is not conducive to business or hope for growth comes to a standstill, any prudent business leader is supposed to use the time to build his capability for future. Literally, this is the time to build the inner strength through applied innovations to emerge as a leader with the change in market scenario.

Examples are not rare where almost 40% or more of energy used by a company goes for the HVAC&R systems. As long as the business runs on top gear, most of the business decision makers deliberately ignore this huge money drainage. But they focus on this area during slack times. When they notice the cumulative figure with back calculations, they create a mess – and new rules are announced – which are often opposed by the employees – as such a hasty policy decision includes several funny or impractical things. So, what should exactly be done?

Examples are not rare where almost 40% or more of energy used by a company goes for the HVAC systems....

The best way is to redesign the entire system after thorough study and analysis. All aged or deteriorating components should be replaced with high efficiency, smart components. For example: even today, in many old control systems, fluid couplings are being used, they all need to be replaced by VFDs. Different types of sensors are also available these days. An accurate demand-based operation of the HVAC system generates saving without sacrificing the purpose.

If not always, many a time minor issues are highlighted in corporate world and meticulous actions are taken for small things, whereas the actually responsible facts remain aside or unnoticed. Attempts must be made in circling those areas, and take actions to eliminate those causes. If in-house analysis is difficult, hiring HVAC experts may help in the mission.

Pl. send your views at pkchatterjee@charypublications.in

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Editor: P K Chatterjee

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Danfoss India extends its inverter scroll compressor range VZH with permanent magnetic motors

Danfoss extends inverter scroll family...

Danfoss India, a well known player in the climate and energy space, has extended its inverter scroll compressor range VZH with permanent magnetic motor with three new models.

As per the company, designed for rooftops, air handling units, close control, process cooling and ground source heat pumps, the new Danfoss inverter scroll compressor, VZH, delivers cooling capacities between 4 to 7 tons, and up to 13 tons in manifold configurations and between 3 to 25 kW of heating capacity.

The inverter scroll compressor, VZH, is the second generation of scroll compressors offering variable speed technology for commercial applications in air conditioning with a mature, existing inverter scroll platform ranging from 13 to 26 TR. The expanded range is now from 4 to 26 TR (14 to 4 kW) and up to 52TR in manifold configuration. The company completes its portfolio of inverter solutions that include Danfoss Turbocor oil-free centrifugal compressors and consolidates its leadership in commercial A/C with the widest portfolio for superior part-load efficiency.

As per Danfoss, Indian market is witnessing growing demand for energy efficient infrastructure like green buildings, net zero buildings and also IT infrastructure in terms of data centres and cloud computing – all these require high efficiency air conditioning. Danfoss Inverter Scroll Compressor technologies help in meeting or exceeding the new standards – and thereby achieving the lowest energy consumption. ■

Japan recognises Honeywell's products with low GWPs

Honeywell's Solstice line of refrigerants, insulation materials, aerosols, propellants and solvents have been designated as 'Non-Flon.' It is an important environmental designation in Japan that excludes these products from a new environmental regulation due to their low Global Warming Potentials (GWPs). The regulation, called the Act on Rational Use and Proper Management of Fluorocarbons, was enacted in April and mandates stricter controls and the phase down of certain Hydro-FluoroCarbons (HFCs) with high GWP.

Honeywell's Solstice products are based on HydroFluroOlefins (HFOs), and received a 'Non-Flon' designation from Japan's Ministry of the Economy, Trade and Industry (METI), meaning they are not subject to regulation under the Act. The company's HFOs join hydrocarbons and carbon dioxide in the 'Non-Flon' category. "Honeywell is proud to help Japan drive actions that will prevent global warming, " said K Takise, Asia Business Director, Honeywell's Fluorine Products business. ■

SECOP honoured with innovation awards

The AURELIUS subsidiary SECOP, a specialist in advanced compressor technology, was honoured for its successful research and development with the Innovation Award 2015 at the trade exhibition – China Refrigeration Exhibition 2015 in Shanghai.

The company also received this year's Environmental Pioneer Award for its pioneering role in the development of environmentally friendly technologies.

"We are delighted to have been honoured again with innovation awards for our products, and especially for winning both awards this year. There is tremendous future potential for new compressor products that sustainably protect the environment, are energy-efficient and quiet, operate with environmentally friendly refrigerants, and are built with less materials," said Mogens Søholm, Speaker of the Management of SECOP.

"These features address the global megatrend, and that is our mission at SECOP," he added. ■

ATE group displays its innovative products

A view of the stall of A.T.E. group in the first Smart Cities India Expo...

The A.T.E. group participated in the first Smart Cities India Expo, which was recently held at Pragati Maidan, in New Delhi. The expo was organised in the wake of the Indian government's plans to build 100 new smart cities and drive infrastructure development for 500 cities with an allocation of $60 billion for the Smart Cities project in the 2015-16 budget.

The group participated in the exhibition with the thought-provoking theme of 'Ideas that impact India.' It has a wide range of technologies to make smart cities environmentally and economically sustainable. A.T.E. had on display its IoT-based remote monitoring solution, its revolutionary FAAC (Fresh Air Air Conditioning) cooling solution, a comprehensive range of wastewater treatment solutions, a range of high performance pumps and booster systems, as well as a Concentrated Solar Thermal (CST) system.

HMX (A.T.E. group) designs and manufactures energy efficient products that provide (as per the company) 100% fresh, clean, cool air for people and process comfort. HMX's indirect evaporative cooling products have an innovative, patented (US and Australian patents granted) heat exchanger technology DAMA (or Dry Air Moist Air) at their core. HMX's products comprise two broad product families – HMX-Ambiator and pre-cooling fresh air units – that improve indoor air quality inside factory sheds, office buildings, and education and healthcare facilities. They also provide significant savings in power consumption and reduce the use of refrigerants. According to A.T.E., with more than 20 million CFM spread over 4 million square feet, HMX has the world's largest indirect evaporative cooling installation base. ■

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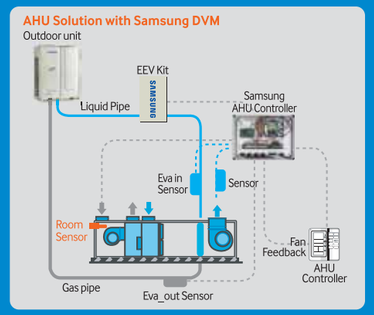

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Emerson bags the best cold chain solution provider award

The 'Best Cold Chain Solution Provider Of The Year' award...

Emerson Climate Technologies, a business segment of Emerson, has received the 'Best Cold Chain Solution Provider Of The Year' award at the 4th Cold Chain Strategy Summit, which was recently held in Mumbai. As per the company, the award reinforces Emerson's leadership position in providing reliable, energy efficient and environmentally responsible solutions that help in developing an efficient cold chain logistics system for the country. This award comes on the heels of Emerson winning the 'Green Product' award at ACREX 2015 for its Copeland Scroll large commercial R410A compressors. The Copeland Scroll variable speed compressor for residential air conditioning was also recognised at the awards in the 'Energy Savings' category for its outstanding performance.

In October 2014, Emerson also won Confederation of India Industry's (CII) -15th National Award For Excellence In Energy Management. The award rated Emerson Climate Zenith (ECZ) series of reciprocating compressors as the 'Most Innovative Energy-Saving Product.'

Sridar Narayanswami, Vice President and Managing Director of Emerson Climate Technologies, India, said, "The awards Emerson has won across various categories validates the efficacy of our products and the trust our customers have placed in us. As India has a significant amount of food wastage, estimated at INR 440B worth of fruits, vegetables and grains every year, the cold chain industry is bound to grow. Emerson is committed to continue to provide intelligent and energy-efficient solutions right from harvest to feed, customised for the India market,"

The company provides a full range of solutions for cold storage, from compressors, condensing units and flow controls for refrigeration applications, to integrated control systems and remote monitoring systems that deliver intelligent and energy-saving solutions. It has also invested in a state-of-the-art Cold Chain Centre of Excellence at Chakan, Pune. ■

Atlas Copco receives ISO 22000 certification

Atlas Copco has recieved ISO 22000 certification by Lloyds Register for its production facility in Antwerp, Belgium. ISO 22000 specifies the requirements for a food safety management system where an organization in the food chain needs to demonstrate its ability to control food safety hazards in order to ensure that food is safe at the time of human consumption.

Most of the leading food manufacturers across the globe are getting more and more stringent about the quality at source and proud to create a benchmark for compressed air industry. Thanks to this auditable ISO standard with clear requirements, the customer can tangibly rely on Atlas Copco as a compliant compressed air manufacturer for their products and processes.

"We were able to demonstrate after intensive workshops and thoroughly executed audits by Lloyd's Register that Atlas Copco is ready to comply with the highest standards in the food industry with its Oil-free compressors," said Chris Lybaert, President, Oil-free Air division. ■

Gree to distribute through Klima-Therm

Chinese manufacturer Gree has appointed Klima-Therm, the expanding chiller and air conditioning specialist, as distributor for their pioneering photovoltaic-powered VRF air conditioning and split systems. Klima-Therm will stock all popular models of Gree VRF and split air conditioning, plus spares. It is expanding its air conditioning team and recruiting new staff to support the roll-out.

Klima-Therm is now the only supplier in the UK offering the manufacturer's full range of industry-leading products. The Gree name may not yet be very well known in the UK. However, the company combines impressive scale as a manufacturer – now producing one in three of all AC units sold in the world. ■

Nexia rolls out remote heating, air conditioning diagnostics

Nexia, a brand of Ingersoll Rand, has launched advanced diagnostic features for Heating, Ventilation and Air Conditioning (HVAC) systems to give homeowners added peace of mind that their systems are performing optimally. When a homeowner opts in to Nexia Diagnostics, he/she allows remote HVAC system monitoring by his/her preferred HVAC dealer, which can help prevent minor issues from turning into major repairs.

The diagnostic features are free for homeowners and their HVAC dealers. Available with Trane and American Standard Wi-Fi-enabled thermostats and a free Nexia account, the diagnostic features extend the value of the Nexia Home Intelligence System – by providing HVAC technicians real-time and historical performance data on one of the home's most expensive and complicated pieces of equipment.

Once a homeowner opts in, the local dealer can access a secure website with real-time intelligence about how the customer's system is performing. System alerts, from routine maintenance needs to system malfunctions, are automatically sent to the dealer, who can then proactively notify customers and address the issue quickly.

The ability to diagnose issues remotely enables technicians to arrive on-site with the proper parts to expedite repairs, if necessary. Some issues may even be resolved remotely, eliminating the need for an on-site service call altogether.

"Convenience is one of the primary benefits of a smart home, and the addition of diagnostic capabilities to Nexia Home Intelligence gives homeowners the unprecedented option of having heating and air conditioning issues addressed proactively before experiencing downtime. That's a win for busy homeowners, who can rest easy knowing their system will alert technicians to issues in real time. And our dealers appreciate the ability to diagnose an issue in advance so they can make house calls more efficient and cost effective for their customers," said George Land, Head of Nexia Home Intelligence. ■

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Airedale is awaiting more industry awards

British cooling systems manufacturer Airedale International is again on the shortlist to pick up more trophies following the recent announcement of the contenders for this year's RAC Cooling Industry Awards, which champion the leading innovations and environmental successes in the refrigeration and air conditioning industry.

The AireFlow indirect adiabatic air handling unit (100-440kW) is one of the products shortlisted for 'Air Conditioning or Heat Pump Innovation of the Year'. Having already picked up the title of 'Datacentre Cooling Product of the Year' in the 2015 Data Centre Solutions awards announced earlier this year, the AireFlow was developed to provide an ultra-high efficiency solution that addresses the challenges of AHU cooling. The British designed and manufactured unit is capable of delivering 100% free-cooling under ASHRAE conditions with 32% reduction in air volume, saving fan power input.

Airedale is also shortlisted in four separate categories for its work with BAE Systems, Warton, where it has helped the global defence, aerospace and security business achieve annual energy savings of 70 to 80% on its computer room air conditioning, equivalent to £350,000.

BAE Systems expects to recoup the costs of the project within just 15 months, well ahead of the typical payback period that could be expected of a project of this type. The year-long programme, which included component upgrades to more than 70 Airedale and Denco Precision Air Conditioning (PAC) units, controls integration expertise and other system enhancements, has also improved resilience and reduced the risk of downtime. ■

Suntory Products to use Susterra

Suntory Products Limited's Tennensui Hakushu plant in Japan has adopted a renewable heat transfer fluid based on Susterra 1,3-propanediol in collaboration with DuPont Tate & Lyle,. Susterra propanediol offers food and beverage processing companies a high-performing, food safe glycol with excellent low-temperature performance that improves pumping efficiency.

Susterra is certified 100% biobased by the U.S. Department of Agriculture, making it attractive for companies seeking to add renewable content to their products. A peer reviewed Life Cycle Assessment (LCA) demonstrates that the production of biobased propanediol offers significant environmental benefits including up to 40% less greenhouse gas emissions and 40% less non-renewable energy used in production versus petroleum-based glycols.

Additionally, since Susterra offers good viscosity even at low temperatures, using Susterra in heat transfer fluid in food and beverage manufacturing equipment reduces the amount of electricity consumed. ■

Gibraltar Industries acquires Rough Brothers

On June 2015, Rough Brothers Inc.,(RBI) was acquired by Gibraltar Industries. For over 80 years RBI has serviced the greenhouse industry with a timeless philosophy of providing the highest level of service and highest quality products. This philosophy has helped Rough Brothers grow and expand its design, engineering, manufacturing, distribution, and installation services.

To service the greenhouse market, RBI has added three additional manufacturing facilities and acquired two companies to broaden the company's product offerings. The acquisition positions the company to continue its growth into the future. Partnering with Rough Brothers ensures to work with the most dependable and knowledgeable greenhouse and conservatory representatives in the industry. RBI representatives use their floriculture experience to help its customers identify the best greenhouse solution and work through any challenge they may encounter throughout the process. ■

Avoid major air conditioning problems: Behr Hella Service

Every object has to be serviced at some point of time. After continuous wear and tear, the life period of the particular object reduces. Therefore, thermal management expert Behr Hella Service recommends drivers to have their vehicle's air-conditioning systems serviced regularly. There are three important reasons for that.

Firstly, a properly functioning air-conditioning system helps the driver to concentrate, literally to keep cool even in stressful situations. This in turn increases the safety of all road users.

Secondly, it helps in rendering harmless the bacterial and fungal spores that progressively build up in the air-conditioning system and may cause sudden coughs or sneezes and other allergic reactions.

Finally, regular maintenance enables you to avoid high repair costs, because every air-conditioning system loses up to 10% of its refrigerant every year, which not only leads to impaired cooling performance and possible damage to individual components, it can sometimes cause the entire system to completely fail. These are the suggestions from Jörg Laukenmann, Marketing Expert, Behr Hella Service.

To prevent this last situation from occurring, Behr Hella Service recommends motorists to have their air-conditioning systems checked once a year or every 15,000 km. This check includes replacing the cabin air filter, also inspection and testing of all the components and the air-conditioning system as a whole. ■

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GEA strengthens its position through acquisition of Hilge

Hilge, a leading supplier of hygienic pumps, has been acquired by GEA as a strategy to increase its present stand in the market.

The company has a product range complementary to the offering of GEA's flow components portfolio, and is based at Bodenheim, Germany. The transaction remains subject to approval by the anti-trust authorities.

"With the acquisition of Hilge, we continue implementing our M&A strategy to fill technological gaps by acquiring accretive specialist companies, which complement our product portfolio. Hilge strengthens our position as a leading supplier of equipment and provider of solutions in hygienic and aseptic process environments", commented Juerg Oleas, CEO of GEA.

"Hilge has been a part of the Grundfos Group since 2004. Nevertheless, the increased focus for Grundfos on core business has led to the conclusion that the sanitary business is not a strategic focus area. GEA is a strong strategic fit for Hilge with strong synergies expected given GEA's focus on the processing industry, including food and beverage. Everyone wins! GEA expands in its focus area, Grundfos concentrates on its core business, and Hilge joins an organization where it will play a strong strategic role," says Executive Vice President Lars Aagaard, Head of Business Development of Grundfos. ■

Johnson Controls introduces Champion brand of products

Johnson Controls has rolled out the new Champion brand of residential and light commercial Heating, Ventilation and Air-Conditioning (HVAC) products, designed to deliver reliability, energy efficiency and comfort. Champion HVAC products are available exclusively from WinWholesale, a leading supplier of residential and commercial construction and industrial supplies and materials. The product line includes models in a variety of tonnages, fuel sources and configurations for the commercial and residential markets. The heating and cooling equipment is rated in accordance with AHRI Standard 210/240 and 340/360 at AHRI conditions. The Champion product line also meets relevant ASHRAE 90.1, ENERGY STAR and EPACT 2005 standards. "Like a true champion, this line of products is built to meet the challenge with steadfast performance. It reinforces our commitment to supply quality products..." said Bobby Leggett, Distribution Sales Manager, National Accounts at Johnson Controls. ■

CORRIGENDUM

Referring to
Cooling India June 2015 issue

Dear Readers,

On page 16 of Cooling India, June issue, under the heading "Godrej rolls out next generation refrigerators," the image was wrongly printed. That image was a part of the news item titled "Quality conscious Indian OEMs offer 100% copper advantage ACs," which was printed on page 14.

We are sorry for the wrong placement.

Thank you.
EDITOR, COOLING INDIA

Whirlpool acquires American Dryer Corporation (ADC)

Whirlpool Corporation has purchased American Dryer Corporation (ADC), a privately held company that manufactures and markets coin-operated, on-premise, industrial and specialty laundry equipment. The acquisition gives Whirlpool Corporation's commercial laundry business a platform to reach new countries and channels, while building on a strong foundation of industry-leading innovation, quality, and service.

"Acquiring ADC strengthens our commitment to the commercial laundry industry and is aligned to our objectives of driving growth in adjacent businesses. We believe this investment nicely complements our leadership position in the overall laundry category," stated Jeff M. Fettig, Whirlpool Corporation Chairman and Chief Executive Officer.

"Our Maytag and Whirlpool brands have a strong heritage in commercial laundry," said Brett Dibkey, Vice President, North American Integrated Business Units. "The addition of ADC is yet another step toward our goal of building the industry's best, most reliable full line of commercial laundry equipment," he added.

Whirlpool Corporation expects integration activities to happen throughout the balance of 2015. ADC is headquartered in Fall River, MA and is home to approximately 230 employees, a 300,000 square foot manufacturing facility and a state-of-the-art engineering and design center. This facility will become a valuable part of the Whirlpool manufacturing portfolio. ■

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James B Gamache
President
US Operations
CarrierWeb

Jim has extensive transportation industry experience having served at YRC for 30 years...

CarrierWeb appoints new president

James B. ('Jim') Gamache has been appointed as the new President of U.S. operations for CarrierWeb, a provider of real-time mobile communications, electronic logging and refrigerated telematics technology for private and for-hire fleets.

The appointment of Jim, comes during a period of sustained, rapid growth for CarrierWeb. Sales volumes have increased by a record 40% last year. R. Fenton-May, the previous President of CarrierWeb, will remain as Chairman and continue as Chairman and CEO of the parent company e*freightrac based in Atlanta, Georgia.

Jim has extensive transportation industry experience having served at YRC for 30 years in a number of executive and leadership roles across the U.S., and more recently as the CEO of Pace Transportation in Stratford, Connecticut.

"As the transportation industry continues to seek technology, we continue to experience a growth in new business. The momentum in the industry and our company's value proposition of providing actionable business intelligence are attracting great talent – and we are delighted to welcome a seasoned transportation industry executive to support our customer base and lead our company to the next level," said R. Fenton-May.

Jim said, "I'm excited about joining CarrierWeb and leading the company and look forward to providing our customers with new levels of innovation and service." ■

Sunil D'Souza
Managing Director
Whirlpool India

Sunil was the Head of PepsiCo's VIMAPS Business Unit based out of Malaysia...

Whirlpool India welcomes new MD

Sunil D'Souza has taken over as the Managing Director of Whirlpool India. While commenting on Sunil's appointment, Arvind Uppal, President – Asia Pacific, Whirlpool Corporation and CMD Whirlpool India Limited, said, "Sunil's rich and diverse experience across general management, strategy, sales, marketing and innovation in consumer driven industries, coupled with his proven track record in leading and growing large businesses, makes him highly suited to lead Whirlpool India."

Sunil has come to Whirlpool from PepsiCo. He was the Head of PepsiCo's VIMAPS Business Unit based out of Malaysia. In his 15 years with PepsiCo, Sunil held various senior management positions in Malaysia, Philippines, Vietnam and India. ■

Emile Bado
Regional Manager
Ferguson Group
Middle East and
North Africa

Bado has led engineering companies throughout the Middle East in the last ten years...

Emile Bado joins Ferguson Group

Emile Bado has been appointed as Regional Manager, Ferguson Group, Middle East and North Africa.

The global suplier of DNV 2.7-1/ EN 12079 offshore containers, tanks, baskets, refrigerated/ freezer modules, workspace and accommodation modules has expanded its Gulf operations in the recent years, opening a Dubai base and facilities in Abu Dhabi, whilst forming working relationships in the surrounding emirates and countries.

"We are very excited by the prospects presented by the market in the Middle East. Emile's skills will support our continued expansion of Ferguson Group here in the Gulf and beyond. His experience in leading multi-disciplinary, international teams coupled with his strong engineering background will make him a valuable addition to the senior management team in the Middle East," said Richard Smith, CEO, Ferguson Group.

Bado has led engineering companies throughout the Middle East in the last ten years, most recently with a German engine manufacturer. A fluent Arabic speaker, he has worked both in the Gulf and the USA. ■

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Smart Building Market To Witness 38% CAGR Till 2020

According to a recently published report by Markets and Markets, Europe is expected to be the biggest market for 'smart buildings' – on the basis of adoptions of building technology. Also, APAC is estimated to be the fastest-growing region with a CAGR of 47.8%...

The smart building market is in high demand due to government initiatives and the rising cost of energy. It is expected that energy demand would increase by 40% between 2010 and 2040, which is likely to enhance the growth of the 'smart building'market – as it plays a vital role in contributing to energy saving. Smart building helps tackle the energy crisis problems in developing as well as developed countries. With the increasing demand of energy management solutions implementation in building, major players are also investing a major portion of their revenue in the research and development of new and innovative products related to the market. Key government initiatives include the regulation of Commercial Building Initiatives (CBI) by the U.S. government to make commercial buildings completely energy independent by 2025.

As on date the key players in this smart building market include ABB, Cisco, Delta controls, Schneider Electric, Siemens, General Electric, IBM, Accenture, Johnson Controls & Honeywell. ■

Food Service Equipment Market Charts A CAGR of 4.8%

The food service equipment (commercial refrigeration) market is primarily being driven due to extensive growth in the hospitality industry…

Transparency Market Research's new report titled 'Food Service Equipment - Global Industry Analysis, Size, Share, Growth, Trends and Forecast 2014 - 2020,' states that global food service equipment (commercial refrigeration) market was valued at USD 31,544 million in 2013, growing at a CAGR of 4.8% from 2014 to 2020 to account for USD 44,326 million in 2020.

The food service equipment (commercial refrigeration) market is primarily being driven due to extensive growth in the hospitality industry. Moreover, the changing food habits is also attributing to the growth of the market. The busy lifestyle of the working population is creating the need for ready to cook food that can be stored in refrigerators. This in return is fuelling the growth of commercial refrigeration market. In addition, the continuous advancement in the cooling technologies is ensuring the need for energy efficient refrigeration in the hospitality sector. Furthermore, the growth in retail outlets and supermarkets is also attributed to the growth in the market. The market has been segmented in two parts: by types and regions. By types, the walkins coolers and freezers held the highest market revenue accounting for USD 5,287.7 million in 2013. By volume, walkins registered 990,790 units sales in 2014. The demand for walkins are attributed to growth of hotels and restaurants in the hospitality industry. In addition, walkins are also used to store vaccines in healthcare industry. This factor is also leading to the growth in the market and North America is expected to dominate the market during the forecast period. ■

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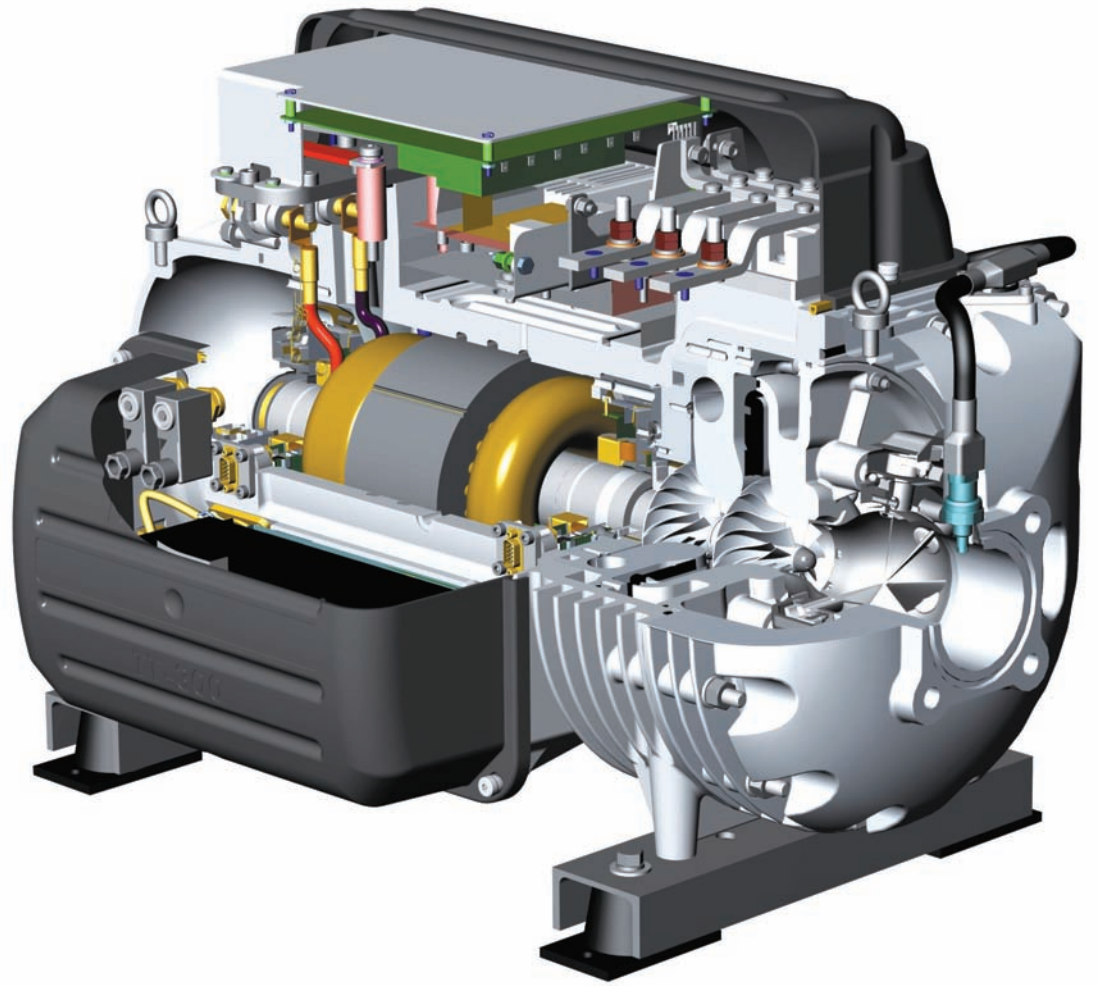
The Innovation Wave

Everybody connected to the HVAC&R industry is innovating to be in the market. Trade fairs are the best places where most of the innovative technologies are displayed first...

Innovation is not a term from another planet. It's one of the very fundamental inherent qualities of human nature. Its continued manifestation has brought the entire human civilization to the state where we are standing today. As far as the HVAC&R industry is concerned, in its true sense, everybody connected to the industry is innovating to be in the market – because today it's not only the issue of cost competitiveness, but also the field presents a bouquet of challenges.

It goes without saying that right now the epicentre of the challenging waves in the field of HVAC&R is the concern about the environment. The regulatory changes that are being brought in almost all countries are making the business owners, scientists, designers as well as users think of innovation. Although all countries are not yet at par as far as the steps towards this is concerned, globally the process of rethinking has started.

Let us now see a few innovative products that have been recognised by the global experts in the recent past. Trade fairs are the best places where most of the innovative technologies are displayed first. So, I am choosing some examples from the renowned trade shows. Contextually, I have already stated that innovation is happening everywhere in the HVAC&R industry, but everything



In Danfoss' Turbocor technology, magnetic bearings and bearing sensors enable precisely controlled frictionless compressor shaft rotation on a levitated magnetic cushion...

cannot be covered within one small article. Therefore, I am going to talk about only a few innovative technologies.

Award winning reversible hybrid heat pump

This year the CLIMATIZACIÓN 2015 was held in Madrid. In the IFEMA's exhibition, 590 companies connected to the HVAC&R field displayed their products in front of 44,693 professionals from 65 countries. The figures indirectly reflect one thing that globally the number of people who are seriously concerned about the developments in the HVAC&R segment is increasing.

Technological innovation, efficiency, environmental commitment, design and comfort were the main points of focus for CLIMATIZACIÓN 2015. The regulatory changes that affect the industry also received a great deal of prominence in the event. The list of innovative products that attracted people's attention in the exhibition and got

AQUACIAT 2 HYBRID...

selected by Climatización 2015's technical committee for the 6th Innovation Gallery – included Ciat's AQUACIAT2HYBRID and AQUAIR PREMIUM.

Aquaciat 2 HYBRID is the first range of packaged, outdoor, reversible hybrid heat pumps that house an integrated natural-gas-powered condensation boiler module. This new range combines the benefits of both technologies in a single package that is compact and – particularly easy to install. With a total of eight possible combinations available and three 45 to 80 kW boilers, Aquaciat 2 HYBRID meets the heating and air-conditioning needs of new and existing tertiary-sector buildings ranging from 500 to 1500 square metres. Engineered using eco-design principles, the entire range is at least 85% recyclable. Aquaciat 2 HYBRID also won the Silver Trophy in the HVAC category at the Innovation Awards held during the Interclima trade show in Paris last year.

> *"There is a strong need to reduce the level of energy usage. A comprehensive approach needs to be applied to reduce the use of energy..."*

Innovative product recognised by ISHRAE

The Indian HVAC&R industry is expected to grow by 30% to over Rs 30,000 crore over the next two years. Thus, in this developing sub-continent also, huge importance is being attached to innovation in the HVAC&R segment. This year, ACREX India 2015, the Indian Society of Heating, Refrigeration and Air Conditioning Engineers's (ISHRAE's) exhibition, which was produced by NuernbergMesse India, was conducted at India's only LEED Certified Green Exhibition Center – Bangalore International Exhibition Center (BIEC) with over 40,000 sq mt of fully covered and air conditioned space. Around 28,000 business visitors were present in the exhibition. This figure also shows the interest of the business community – mainly from India and other Asian countries.

Global warming and climate change is the result of excessive use of energy. The global warming has brought in loss of human lives, loss of forest cover, extinction of certain flora and fauna. There is a strong need to reduce the level of energy usage. A comprehensive approach needs to be applied to reduce the use of energy like: replacement of fossil fuel energy with clean energy, conserving energy, using of energy efficient systems, processes and equipments. Hence, the theme of ACREX India 2015 was 'LESS ENERGY = MORE LIFE.' Four hundred exhibitors representing over 25 countries, including Canada, China, Czech Republic, France, Germany, Hong Kong, Italy, Japan, Korea, Netherlands, South Korea, Taiwan, Thailand, Turkey, Ukraine, UAE, United Kingdom, USA, displayed their latest products in ACREX India 2015.

Emerson Climate Technologies, a business segment of Emerson, won the 'Green Product' Award at ACREX India 2015 for its Copeland R410A Large Commercial Scroll Compressors. The Copeland Scroll Residential Variable Speed Compressor was also recognised at the awards in the 'Energy Savings' category for its outstanding performance. According to the manufacturer, the new Copeland R410A Larger Commercial Scroll compressor opens the door to a widespread use of R410A for air-cooled as well as water-cooled chiller systems. This large commercial scroll compressor can be assembled in a wide range of Copeland qualified combinations, which is ideal for

Copeland Scroll ZPV038 and ZPV063 variable speed compressors and Emerson drives...

manufacturers who gain from increased flexibility in system design as well as inventory optimisation.

ASE recognises an innovative and patent pending technology

Danfoss has been named the 2015 recipient of the Alliance to Save Energy's (ASE's) Innovative Star of Energy Efficiency award, recognising the innovative success and potential of Danfoss Turbocor oil-free, magnetic bearing, variable speed centrifugal compressors on the commercial HVAC

AQUAIR PREMIUM...

market. With a compact footprint and oil-free design that reduces maintenance needs and noise, Danfoss Turbocor compressors can improve chiller efficiency by up to 40% compared to a similarly sized fixed-speed screw chiller.

The Star of Energy Efficiency awards recognise outstanding and/or unique contributions to energy efficiency with demonstrated, quantifiable, cost-effective energy savings. According to an ASE report, Danfoss Turbocor Compressors has been transforming the commercial HVAC market with innovative technology that redefines lifetime operating costs for mid-range chiller and rooftop applications. Known as the pioneer and world leader in the oil-free centrifugal compressor product category, Danfoss' Turbocor compressor has received numerous awards and international recognition with the introduction of the world's first oil-free centrifugal in the TT Series. VTT (Variable Twin Turbo) is the model group name of the latest compressor innovation from Danfoss Turbocor Compressors. The VTT series of compressors will be available with nominal capacity ranges from 200 to 350 Tons for voltage applications between 380 to 460Volts as well as 575Volts and operates with R134a. These models are intended for water-cooled or evaporative cooled chiller applications reaching up to 1,000 Tons or more.

They are intended for commercial air conditioning or process cooling applications, which require a high efficiency solution. The compressors enable chiller manufacturers to meet the new ASHRAE 90.1-2015 efficiency standards by Path A and Path B. Based on proven TT series compressor technology, the VTT models are oil-free, variable-speed, magnetic bearing centrifugal compressors. They extend the stable operating envelope while simultaneously improving both full- and part-load efficiency. The VTT series of compressors is the first to introduce IntraFlow technology, an innovative and *patent pending* technology for improving compressor efficiency – and providing an extended stable operating range while simplifying capacity control. The new drive technology, which will be exclusive to the VTT series of compressors, is the result of integrated R&D efforts blending Danfoss' extensive expertise and capabilities in high efficiency compressors and variable frequency drives for the HVAC industry. The VTT drive will have the superior reliability and performance that has come to be expected from Danfoss – in a small frame size made achievable only with refrigerant controlled heat removal.

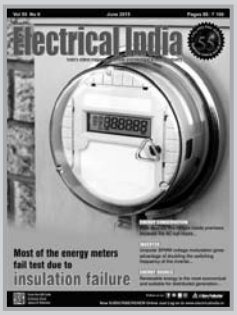
The VTT compressors will also include newly developed control electronics capable of communicating via USB, Ethernet, and wireless. Other new features include USB drive data recording, shaft speed detection, motor & drive cooling and condensation protection.

These compressors will also have the capability to download firmware and configuration updates remotely – without requiring any hardware exchanges. Up to 35% energy savings (annually) is possible with use of oil-free variable speed compressors compared to equivalent fixed speed screw chiller.

Conclusion

With development of technology, environmental complications have grown manifold. However, it is pleasing to note that globally, all stake holders are continuously working to mitigate the menace of global environmental change. Although, the pace of innovations is supposed to accelerate, at this moment it's more important to disseminate the new innovations and their benefits – so that the global user community can embrace the new technologies ASAP – and save our environment from further deterioration. ■

P K Chatterjee (PK)
Editor
Cooling India



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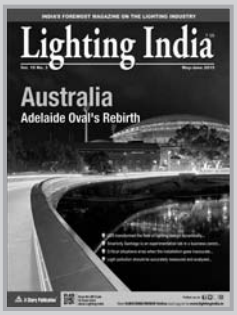

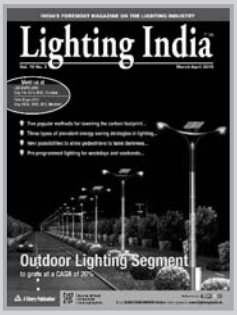

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"An integrated approach should be followed by all the stake holders…"

***UL** certifies, validates, tests, inspects, audits, advises and trains people from the industry to raise the quality standard of their products and services – to meet the global standards and expand their market potential. In an exclusive interview with **Cooling India**, **Peeyush Gupta**, **Director, Sales and Marketing, UL**, talks to **P. K. Chatterjee**, on UL's contribution to raise the standard of Indian HVAC&R industry. Excerpts…*

Q How is the demand for HVAC&R services growing in India?

A The HVAC&R market in India is poised for rapid growth due to a number of changes in the Indian economy and society, as well as easier availability of A/C products, which constitutes the bulk of the HVAC segment in the market. The Indian central AC market is expected to reach $2.3Billion by 2015. This growth will be driven by various internal facets of the industry.

Newer energy-efficient chillers, such as centrifugal and scroll types, are expected to outpace reciprocating and screw chillers, which are less energy-efficient. Tighter regulations and stricter enforcement of building codes as well as energy-efficiency standards and practices will also drive growth and attract more foreign players to the market.

Q What are the prominent stumbling blocks that are hindering the growth of this industry, in India?

A The key stumbling blocks that we see hindering the growth in India are: (no. 1) slowdown in the economy over the last three years, particularly in the infrastructure area, (no. 2) insufficient mega initiatives – like cold chain facilities or large infra projects like metro rail or airport – have materialised and (no. 3) intense competition in the consumer HVAC market coupled with low quality imports.

Q How can you help the industry grow as long as India remains a power-starved country?

A It is extremely important to have energy efficient products so that the overall consumption is reduced. We at UL are helping the industry by setting up laboratories / testing infrastructure to ensure compliance, we are also working with industry bodies / regulators in writing standards.

UL works with regulatory bodies like the Bureau of Energy Efficiency (BEE), BIS – in not only understanding the regulatory framework – but also is closely developing the implementation mechanism for those regulations.

Q How can we use more sunlight to run our HVAC&R systems efficiently?

A A commercial solar energy system generates electricity from the sun's rays to power a building's HVAC system. Made up of PhotoVoltaic (PV) cells, the system's solar modules harvest the sun's energy and convert it into electricity that can be used to power HVAC units, lights, computers and other electrical

devices. In many states across India, this may allow business owners to take advantage of incentives to lower operating costs. The solar modules feed electricity directly to the solar-ready rooftop unit (HVAC) at a single point of connection, using the converted power to run the building's central heating and cooling system.

When the rooftop unit is not operating, excess solar energy is supplied to other devices that use electricity, such as lighting, fans, computers and more. If the system generates more power than the building needs, it is sent back to local electric grid. To further increase efficiency, a communication module provides real-time online monitoring of system status, energy production and environmental benefits. The monitoring system provides data to offer a true picture of the environmental impact and savings achieved.

UL plays an important role in these kinds of energy saving systems; we understand that if even one of the products fails, the whole BMS will come to a standstill. Hence, we ensure the energy saving systems in places is not only cost effective but also compliant to the standard requirements.

Q What are the areas that urgently need to be revamped to enhance efficiency of the sector?

A The key areas that need to be addressed are: Life cycle cost (which is installed cost, operation and maintenance cost) and manufacturing energy efficiency products. Importance to the quality and specifications during manufacturing of the HVAC&R products ensures lesser failure rates. An integrated approach should be followed by all the stake holders, from developers, architects, project managers, manufacturers, contractors, facility managers to make the products energy efficient.

Q How can we improve product and operating personnel's safety through following compliance regulations?

A As global energy consumption continues to increase, the race to build more energy-efficient products intensifies. HVAC/R equipment manufacturers, in particular, are innovating to meet stricter, mandatory efficiency regulations around the world. Product and consumer safety is the need of the hour – and compliance to the standards and regulations by the manufacturers will ensure in enhancing the same. By following the product safety standards, the manufacturers can ensure that their products are safe to be used by their customers – and also conduct stricter design reviews in order to solve problems with previous products.

UL'S GLOBAL NETWORK OF LABORATORIES INCLUDES FIVE FACILITIES DEDICATED TO MEETING THE NEEDS OF THE APPLIANCE AND HVAC INDUSTRIES. OUR APPLIANCE AND HVAC&R TEAM HAS UNPARALLELED EXPERTISE IN DESIGN REVIEW PROCESS...

Q How can UL help in the process?

A UL offers a portfolio of performance or efficiency testing services and safety conformity assessment solutions – and certification services for manufacturers of household appliances, HVAC and refrigeration equipment. Our laboratory in Chennai offers testing to the complete range air conditioners and the components that go inside them. For the commercial and household refrigerators our Centre of Excellence in Manesar offers complete performance and safety testing.

UL identifies the critical standards and requirements for a manufacturer's product and also seamlessly delivers multiple international marks or the specific mark that a manufacturer requires to enable access to target markets.

The UL Energy Efficiency facility also assists customers in obtaining Global Product Certifications such as cULus, CE, ENEC, ENERGY STAR, IEC CB Scheme etc. The facility is NABL Accredited, assessed under the standard ISO/IEC 17025:2005 for General Requirements for the Competence of Testing and Calibration Laboratories. From appliances to HVAC/R, lighting to roofing, televisions to servers, UL has the technical expertise to deliver outstanding service to help manufacturers meet the market's demand for proven energy efficient products.

Q What are the most essential steps that we need to take to raise our HVAC/R systems to the global standard? How will it help in growing our global business?

A Industry bodies, such as BIS and BEE, have been working on measures developing frameworks to raise the HVAC&R systems to global standards. Initiatives such as launch Star Labelling Program, Indian green building movement promoted by IGBC are few campaigns that mark the commitment of Indian government to elevate the HVAC&R industry. We at UL have services that are designed to help our customers cut through compliance complexity and fasten the process of bringing safer products to the global market.

UL's global network of laboratories includes five facilities dedicated to meeting the needs of the appliance and HVAC industries. Our appliance and HVAC&R team has unparalleled expertise in the design review process. We work closely with our customers to help them plan for and meet compliance demands for energy efficiency programmes, including ENERGY STAR.

Q What would you like to communicate to the decision makers of the Indian industry?

A As India has shown signs of more proactive engagement on climate change issues both internationally and at home, these are major steps that we can implement within the country where we can ensure basic regulatory requirements for quality products entering our market. Also, if we see... countries like U.A.E. and Saudi Arabia are far ahead in implementing these standards of EE & Safety with greater importance and focus to safeguard energy requirement for their countries. ■

Managing AC Systems Efficiently

By having demand controlled ventilation, the fresh air is taken only based on demand. Thus, energy is saved as frequent cooling of fresh air to the room (inside) temperature needs a good amount of energy ...

The key component of air conditioning is air distribution – as the air picks up the heat to keep the area /space cool by circulating the air within the room after passing over the evaporator coil – where it gets cooled. Fresh air from outside is added to the system. We will see each component of the air distribution that affects energy consumption.

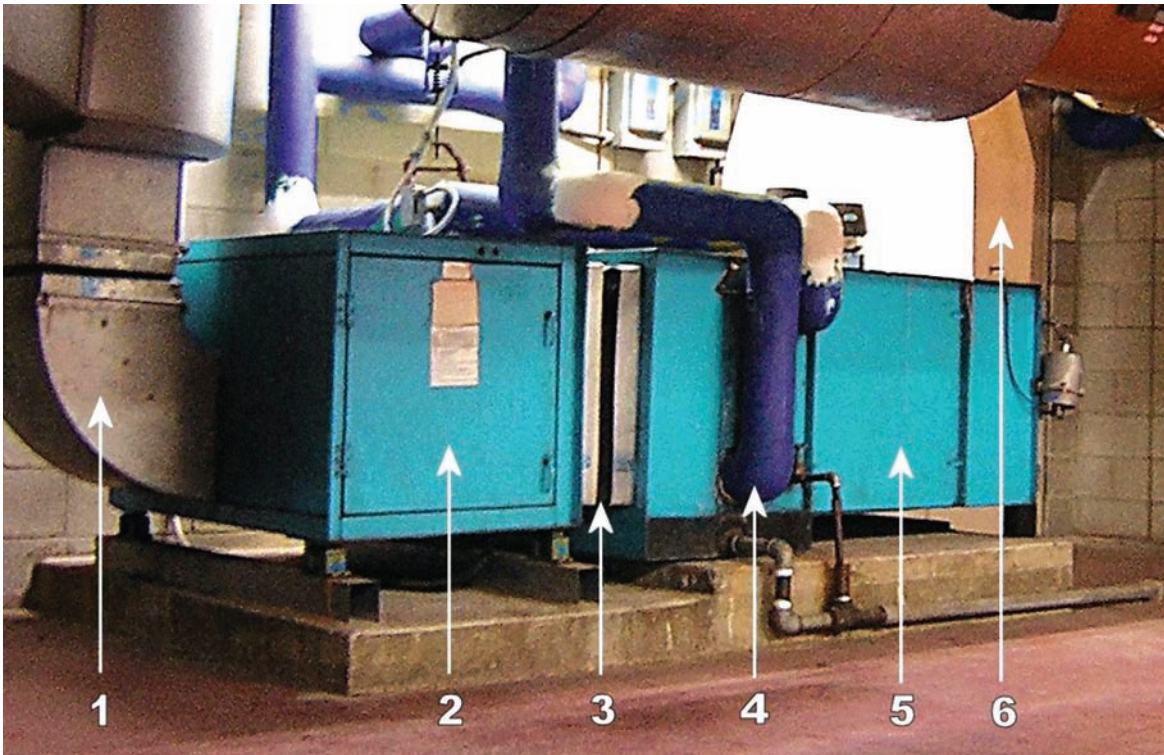
Purpose of fresh air

The fresh air needs to be regularly added in to the room or space through the air handling unit or indoor unit in small systems. The purpose of the fresh air is to dilute the carbon dioxide build up within the room / space. This aspect is very important for comfort of people in the air conditioned zone.

The carbon dioxide level within the room / space has to be less than 1000 ppm. Desirable level is at less than 800 ppm of carbon dioxide or 500 ppm plus what is in fresh air. In most of the green buildings designed, they have demand controlled ventilation i.e., taking fresh air through filter based on sensing through carbon dioxide sensors – and the damper will open the moment the carbon dioxide level is more than 500 ppm. By having demand controlled ventilation, the fresh air is taken only based on demand. Thus, energy is saved as frequent cooling of fresh air to the room (inside) temperature needs a good amount of energy.

There is no provision of fresh air in the modern day window air conditioners or split air conditioners, and hence lots of people complain of headache, which is due to build-up of carbon dioxide level. It may not be out of place to bring

1. Return air duct
2. Return air plenum
3. Filter section
4. Cooling coil Section
5. Supply air fan
6. Supply air duct



A typical air handling unit room...

it to your notice – that the research carried out at Singapore University says that two adults and a child gets in to the bedroom at 10 pm with 500 ppm carbon dioxide level and the level of carbon dioxide at 6 am morning is 3000 ppm. The above experiment is with a window air conditioner.

Air handling unit room space

The air handling unit /indoor unit have to be a free space all around for maintenance and connecting the refrigerant /chilled water piping with valves and also for cleaning the pre filters at regular intervals.

The air haling unit room /indoor unit is part of the air conditioned space and has to be kept clean. We have seen at many places, the air handling unit rooms are dumped with all sorts of materials blocking the filters. Even cleaning the filters become almost impossible.

Filter maintenance

Filters in the indoor units of smaller units are of synthetic materials, and they are mostly used for preventing the cooling coil getting choked.

When the filters are choked, the air quantity across the cooling coil is less – consequently consuming more energy. Hence, the filters need to be removed once a month and cleaned with detergent or water jet.

In air handling units of central plants, the filter can be cleaned regularly (say) every fifteen days, and when the pressure drop across the filter is high, it requires replacement.

If replacement is not done, the pressure across the filter is more – consequently increasing energy consumed as the static pressure increases and the fan will consume more energy.

> *"There's no provision of fresh air in the modern day window or split air conditioners, and hence lots of people complain of headache...*

Evaporator cooling coil /cooling coil in indoor /air handling units

As already discussed above, the filters protect the cooling coil, and sometimes for lack of manpower the cleaning is sub-contracted. Obviously, if it is not done properly, then the fine dust particles pass through filters and get stuck to the cooling coil – as there is moisture on the coil. Due to the above process, the air handling units are blocked consuming more energy.

To overcome the above problem, the indoor units or smaller units need to be completely cleaned with water jet annually – preferably before the summer sets in.

For the air handling units, it is suggested that the cooling coil cleaning is done at least twice annually or more times depending on the cooling coil's condition.

Fans

Fans shall be cleaned for both indoor unit and air handling unit at least once in a year. As the fans are struck with dusts, they will be making noise both in indoor unit of splits as well as the duct cable units and also in air handling units. Power across the fan motor should be measured, when it is new and kept in record. If you can compare it with power measured before cleaning the filters, you will find the amount of extra energy being consumed.

Air distribution system

Air from fan outlets is taken into the room or space to be air conditioned – and taken back to the air handling room for the process of cooling and dehumidifying the air. The entire air is distributed to the space through ducts with ceiling or wall outlets depending on the type of arrangement. We have observed in many five star hotel lobbies – they have white air distribution terminal – (say) continuous grill completely coated with black soot. This is mainly because of not cleaning the filters. Air distribution is important for any AC system through the ceiling /wall terminal outlets – as it is the only visible component to the occupants / visitors. The occupants only will tell if it is not cooling enough or over cooling. It may not be possible to satisfy all the occupants. Hence, ASHRAE standard says as long as 80% of occupants are satisfied the comfort level is good.

Duct cleaning frequency

The frequency of duct cleaning shall be at least once in five years for hospitals, hotels etc., elsewhere once the dust accumulates or once in every 10 years. Nowadays, lots of modern gadgets are available for duct cleaning. The dusts in the ducts is carried to conditioned space, hence, we have pre filters in the air handling units as well as indoor units although they are very much parts of the air conditioned area /space. ■

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Founder
Enervac Engineering Consultants

Energy Efficient Systems

The make-up fresh air into the air handling system, predominantly designed for constant volume make-up, adds dust and heat load. This can be modulated and controlled with demand control ventilation standards using a CO_2 sensor through a motorised damper...

The effective operation of year round working air handling system above 5000 CMH connected to cooling or heating cycle, mostly neglected once the system is in operation for ensuring only the performance. But each and every part of the system requires careful attention in order to achieve the same performance the unit has been installed and commissioned. A detailed study as below provides some of the key points one should consider while the system is in use.

OPERATION AND MAINTENANCE CHECKLIST common to all air handling units

Verify proper operation of air dampers

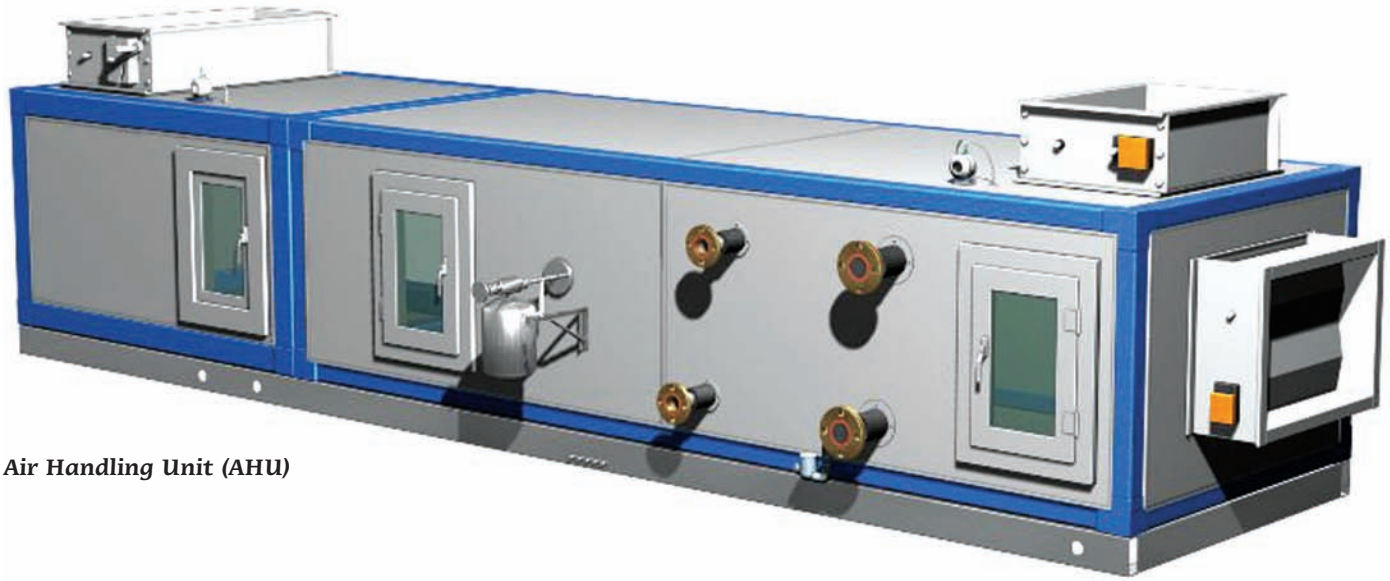
Confirm that all AHU dampers are operating correctly. Have an operator to send a control signal to open and close all dampers – and visually confirm that they are fully opening and closing. Also, have the operator open the dampers to about 50% to make sure they are modulating correctly. Repair any actuators or damper banks that are not functioning correctly. In some cases, modulating damper actuators will need to be installed to allow for changes in outside airflow rates if the current dampers are open/closed.

Dust control for ensured air quantity

The entire air system must be periodically cleaned for removal of air borne dust particles and specifically the filters, so that the required quality and quantity of air can be rest assured for maintaining indoor comfort conditions.

Regulate the untreated fresh air

The makeup fresh air into the air handling system, predominantly designed for constant volume make up, which adds dust and heat load. This can be modulated and controlled with demand control ventilation standards using a CO_2 sensor through a motorised damper.



Air Handling Unit (AHU)

Verify proper operation of air-side economiser

Check the DDC system control sequence to see if the current control system is using an air-side economiser. Make sure the economiser is working correctly by viewing damper positions and outside airflow rates at different outside air temperatures. If no air-side economiser function is currently used, determine the applicability of enabling one. Outside air temperature sensors are required for dry bulb–based economisers and an additional outside air relative humidity sensor is needed for enthalpy-based economisers. Both of these sensors need to be working correctly for the system to operate as designed.

Eliminate duct leakage

Periodically trace the main heating, ventilating, and air conditioning (HVAC) duct runs and listen for air leaks in the duct system. Confirm that the duct static pressure set point is within the pressure class of the installed ductwork before repairing any leaks. If the distribution system is really leaky, consider replacing the ductwork or using a duct sealant system to seal the leaks.

Verify proper operation of heating and cooling valves

Check all heating and cooling valves for proper operation. Check the heating valve in the winter by shutting off the valve and checking the air handler mixed air and discharge temperatures. If the valve is closed and supply is still heated by the coil, the valve isn't seating correctly – and it is causing unnecessary simultaneous heating and cooling. The same procedure should be followed for cooling coil analysis.

Check the condition of heating and cooling coils and AHU filters

Visually inspect the condition of the heating and cooling coils and the AHU (Air handling Units) filters. If the coils are dirty or the filters are clogged, change out the filters and clean the coils. If the current maintenance schedule isn't sufficient, revise the schedule accordingly.

If static pressure sensors are used to determine filter dirt loading, make sure the sensors are working correctly. Dirty filters and coils will increase the static pressure across the coil, increasing fan system energy use in addition to reducing the heat transfer coefficient ofthe coil, forcing the system to move more air over the coil for the same heating / cooling effects.

> *"When the air flow is higher than 70%, increased air flow has a significant impact on fan power..."*

Eliminate 100% of outside air systems if practicable

One of the largest energy-wasting systems is 100% outside air ventilation in areas that don't require it. Common areas that require 100% outside air are Operating Rooms (ORs) and labs. If 100% outside air AHUs are being used for differing space types that don't require outside air, modulating outside air dampers and return air systems should be installed to reduce outside air.

Constant Volume Air Handling Unit

Adjust total airflow and head

Airflow rates are often significantly higher than required in buildings, primarily due to system oversizing. In some large systems, an oversized fan causes over-pressurisation in terminal boxes. The excessive airflow can often cause excessive fan energy consumption, excessive heating and cooling energy consumption, humidity control problems, and excessive noise in terminal boxes. Calculate the required airflow rate in heating and cooling mode to determine the correct flow rates. Replace match pulley sizes based on actual airflow. If the rate can be reduced, install a VFD and slow the fan down to the required flow rate. The VFD can also be used to slow down the fan during unoccupied hours, if the AHU has to stay on at night. In addition, make sure outside air is reduced accordingly.

Convert the constant volume system to a VAV system

A VAV system can significantly reduce HVAC system energy use. All constant volume AHUs should be identified and considered for retrofit to a VAV system.

Implement a supply air temperature reset schedule

The goal of a supply air temperature reset schedule is to minimise combined fan power and thermal energy consumption or cost. For single duct constant volume systems, maintain the supply air temperature not higher than 57°F if the outside air humidity ratio is higher than 0.009 or the dew point is higher than 55°F. When the outside air humidity ratio is lower than 0.009, the supply air temperature can be reset to a higher temperature over the temperature range of 55 to 65°F.

Variable Air Volume Air Handling Unit

Investigate duct static pressure

For VAV systems, review your duct static pressure set points – and adjust them as low as possible while keeping all VAV dampers below 90% open. If VAV dampers are 100% open during periods, identify the reasons the space is calling for additional air flow – and adjust system loads (i.e., relocate certain internal loads).

Reset the supply air temperature

Maintain the air temperature not higher than 57°F, if the outside air humidity ratio is higher or the dew point is higher than 55°F. Both humidity ratio and dew point can be determined using dry bulb temperature – and relative humidity data. Maintain the supply air temperature no higher than 57°F if the fan air flow is higher than 70% of the air flow under the maximum load conditions. This is often significantly smaller than 70% of the design air flow. When the air flow is higher than 70%, increased air flow has a significant impact on fan power. For example, resetting the supply air temperature from 55°F to 57°F can potentially increase the air flow by 10%. This will increase fan power from 34% to 51% of the maximum value. When the outside air humidity ratio is lower and the air flow is lower than 50%, the supply air temperature can be modulated to maintain total airflow at 50% or lower.

If the air flow is lower than 50%, the supply air temperature can be increased. However, the supply air temperature must be lower than a high limit, which can be set to 65°F. The old air handling units once down for major repair or replacement, one should go in for energy efficient systems with all best options now available should be considered for reduced repairs and maintenance cost as well as energy efficient system with more power savings. ■

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Solar Air Handing & Distribution Systems

Fortunately, we are rich in natural solar energy incident on our rural places. If it is properly collected and utilised with the help of the latest available technology, it can definitely improve the scenario prevailing in rural India...

Solar ventilation systems, for both cooling and heating applications, are used mainly for Indian rural market.

Solar cooling or heating for poultry farm in rural India

The temperature in Indian rural areas varies from 6 to 52^{0}C throughout the year depending on the seasons. Maintaining 25 to 30^{0}C temperature during night-time in winter-season, when the ambient temperature is to the tune of 6^{0}C – and maintaining the same temperature range during daytime in summer-season, when the ambient temp. is ~ 48 to 50^{0}C – is a challenging but essential task.

In addition to this, availability of continuous and steady conventional electric-supply is an impossible and distant dream. Fortunately, we are rich in natural solar energy incident on our rural places. If it is properly collected and utilised with the help of the latest available technology, it can definitely improve the scenario prevailing in rural India.

Technology involved: A high-efficiency solar-panel mounted on poultry roof-top converts solar energy into electrical energy. The electrical energy thus generated drives the solar equipments in poultry including the cooling or heating fans during daytime directly online – and the balance energy is stored in the battery-bank, which is used for lighting, cooling and heating applications.

The technology is foolproof as the solar-panels used have a proven-life of 25 years and more. The solar-powered farm or poultry equipments are BLDC-based, hence they have a very long-life span of minimum 15 years. The Solar Torr Tubular

Model No- SLR/100/ BLDC/DC48: Solar-powered poultry farm or silkworm farming equipment from Solar Electronics, India...

batteries used have an average life span of 10 years or more. Hence, the overall system efficiency becomes good with excellent reliability. This is the future for healthy rural economy. This shall definitely help in cutting down the suicide rate in rural India.

Solar-cooling for rural milk centre

Refrigeration of milk-centres in rural India is very difficult as the rural part of the country is always power-starved. Majority of our agricultural products, which are perishable, are lost mainly because of poor power-supply.

Model No- COLDSOLAR/100 (Make Solar Electronics, India)...

Rural agricultural products are lost either due to natural irregularities or non-availability of proper refrigeration facilities.

100% solar powered cold storage

Cold storage is vital for preserving perishable products like grapes, milk etc., and consumes lot of power. However, continuous failure-free electric power supply is very crucial throughout the year, especially during summer. Model COLDSOLAR/100 is a typical model from Solar Electronics, India, which is 100% powered by solar input of 100 sq.ft. area. The model consists cold storage roof top of solar panel, cold storage walls made up of sandwiched panels and solar powered compressor systems. The model varies from 100 to 1000 sq.ft. with cascading effect.

New evaporative solar cooling system

Introduction: There's a world of difference between old-style swamp coolers and modern evaporative cooling systems. The latter can provide years of trouble-free service and cool, clean, comfortable, fresh air at a lower energy cost than conventional air conditioners – and initial costs are competitive as well. In addition, the latest evaporative cooler designs are a lot easier. In addition to improved performance, modern evaporative coolers include options

> *"There's a world of difference between old-style swamp coolers and modern evaporative cooling systems...*

for thermostatic control and automated flushing of reservoir water to reduce buildup of impurities. Accordingly, wide-spread use of evaporative coolers can help delay in adding expensive new power plants to the electric grid – and the controversial transmission lines that often accompany them. That's the reason a number of utility companies in areas with hot, dry summers and substantial population growth have programmes to promote efficient evaporative coolers.

Evaporative cooling function

When air blows through a wet medium – a tee shirt, aspen fibers (excelsior), or treated cellulose, fiberglass, or plastic – some of the water is transferred to the air and its dry bulb temperature is lowered. The cooling effect depends on the temperature difference between dry and wet bulb temperatures, the pathway and velocity of the air, and the quality and condition of the medium.

Solar powered evaporative cooler

'Direct' evaporative coolers use a fan to pull outside air through media (pads) that are kept thoroughly wet by water that is sprayed or dripped on them (Figures 2 and 3). This filters the air and cools it. The water is typically

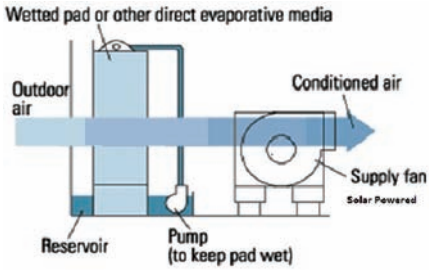

Fig – 2: Direct evaporative cooler...

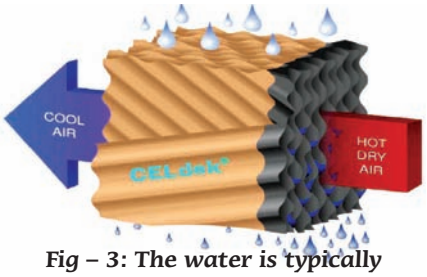

Fig – 3: The water is typically delivered via tubes...

delivered via tubes from a small pump, which draws from a reservoir below. The reservoir is replenished with tap water whose level is controlled by a float valve. The resulting fresh, cool, humidified air is blown into buildings – where the pattern of flow (and cool air delivered) is determined by the location and extent of openings in the conditioned envelope – such as windows or special dedicated ducts.

A typical Solar-Powered Evaporative Cooler From Solar Electronics, India, uses 100W/12V Solar-Panel & 12V/60AH battery (Model-SolaCool-SLR60). The total power – consumption of solar fan & water-pump is less than 60W. During daytime the cooler is directly powered online and during night powered by battery-bank. Additional LED bulb (12V DC/5W) also can be used on the same battery for minimum eight hours' backup.

Modern evaporative coolers couple high-performance media with low-velocity air flow. They maximise moisture transfer as the air traverses the media to enhance 'direct saturation effectiveness,' which is analogous to cooling efficiency. Direct evaporative cooler performance is measured relative to the wet bulb 'depression.' Well-designed systems with thick (10 to 12 inches or more) media operating properly can achieve 93% effectiveness. ■

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Best Practices In Maintenance Of AHUs

In practice, it is often seen that the AHUs are not given priority when maintenance plans are developed. The basic maintenance activity of regular cleaning of AHU filters is often missed or not undertaken as per the manufactures guidelines...

The modern high rise, high density buildings one sees in the large metros are able to house the teeming work force thanks to air conditioning systems, which provide thermal comfort to the occupants – and allows them to work at high productivity levels. A key component of the air conditioning system is the Air Handling Unit (AHU), which is the most common equipment used to remove the heat load from the work space and transfer conditioned air into the floors. The AHU is an important element of the Heating, Ventilation and Air Conditioning (HVAC) system in a building as it enables large spaces to be cooled simultaneously – and also aids in maintaining the Indoor Air Quality (IAQ).

While there are usually one or a few chillers in buildings, there are multiple AHUs supporting the chillers. This requires a higher quantum of maintenance as each AHU is required to be monitored, maintained and repaired in case of a break down. While this fact is known to building operators, in practice, it is often seen that the AHUs are not given priority when maintenance plans are developed. The basic maintenance activity of regular cleaning of AHU filters is often missed or not undertaken as per the manufactures' guidelines. An improperly maintained AHU not only leads to poor IAQ, but also increases operating costs. There is thus a business case to have an effective AHU maintenance plan, which is in turn derived from an understanding of AHU functioning and design.

An overview of AHU

The basic function and components of a typical room AHU is shown in figure 1. The layout

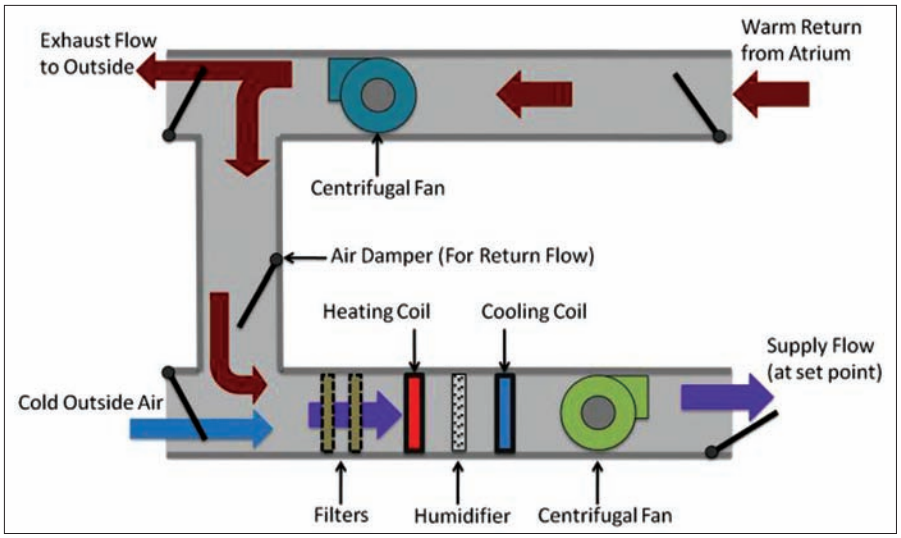

Fig. 1: Typical AHU layout...

represents an AHU, where a portion of the room air is recirculated and some amount of fresh air is introduced in each cycle. Room air is drawn in by the suction of the AHU fan and passed through filters and a heat exchanger – after which air is reintroduced into the room. The heat exchanger has chilled water flowing and reduces the warm air temperatures and causes cool air to go back into the work spaces, when the temperature is increased by gaining sensible heat of the space.

AHU design basics

The quantity of air that needs to be circulated to remove the sensible heat is given in Cubic Feet per Minute (CFM) and can be calculated by the formula

$Q = 1.1 \times CFM \times \Delta T$ where Q is the sensible load, ΔT is the temperature difference between the return and supply air and CFM the volume of air to be supplied for maintaining a desired temperature. 1.1 is conversion factor catering to the atmospheric pressure the AHU operate, 1.1 being the value for sea level operations.

AHU classification is based on the above formula – for a given space load Q, either the volume (CFM) can be varied or the ΔT is varied to cater to any change in load conditions. When the CFM is constant, the AHU is classified as a Constant Volume (CV) AHU – and if the CFM is varied to maintain load, it is called a Variable Air Volume (VAV) system. The cooling coil of an AHU is also a critical component and its design directly affects the performance of the system. The key parameter to be considered in the cooling coil design is the velocity of the air across the heat exchange surfaces. The higher the velocity, smaller will be the coil and pressure drop is higher, which therefore requires higher powered fans. Conversely, with a lower coil velocity, the size of the coil increases but the pressure drop is lower and energy required for the fan is lower.

The filters in an AHU ensure that the air entering the work space is fee of dust and other contaminants. The type of filters to be used in an AHU is based on the quality of air required in the work space. Contaminants such as dust, smoke, mites etc. are termed as aerosols and their size measured in microns (micrometer). The ASHRAE standard 52.1 and 52.2 is the commonly used standard to rate performance of filters and the term MERV is used for classifying filtration capacity. Higher the MERV rating (starting from 1, going up to 16), smaller the particles that the filter can capture. Control of cooling capacity in AHUs is achieved by the following approaches:

- Changing the amount of chilled water that is flowing across the heat exchanger by use of a bypass line between the chilled water inlet and out lines. Based on the return air or room temperature, the value on the bypass line is regulated to allow more (when room temp is high) or less (when room temp is low) water to the heat exchanger. The volume of air flow is fixed. This is the most commonly used AHU design due to its simplicity and low initial cost.
- Changing the volume of the air entering the room by use of damper allows the temperature of chilled water to be constant. The damper opens or closes based on the return air temperature.
- BY using a Variable Frequency Drive (VFD) on the fan motor, the CFM is varied based on room temperature. This is the most efficient way to vary capacity as the power consumption varies as a cube of the motor speed.

Functions of AHU

- Air Mixing
- Volume Control
- Filteration
- Cooling/Heating
- Space Presurisation

AHU maintenance challenges

Since the AHU is a relatively simple system, it is often assumed that nothing can go wrong in the AHU and one need only to clean the filters and the maintenance is complete. There is however a number of other areas that needs maintenance which is equally critical and important. Table 1 lists the key maintenance requirements of AHUs.

AHU Maintenance areas	
Filter cleaning	Motor vibration levels
Filter damage inspection	Belt tension checks
Filter pressure differential	Noise levels
CFM measurement	Air leakages
Damper functioning	By pass value functioning
Sensor calibration	General hygiene and upkeep

Table 1: AHU Maintenance...

While the maintenance plan in a building will cover most of these areas, based on the authors practical experience in operating and maintaining a large and wide variety of AHUs, the situation however is not so simple. The key challenges or reasons why effective AHU maintenance is not undertaken is as follows:

- No space for maintenance: AHUs are usually housed in AHU rooms on the floor.

Since floor space is always at a premium (more the work space, more the rent!), many AHU installations are so poorly designed that there is no space for the maintenance staff to access the filters or the motor belts for maintenance.

- Provision for filter cleaning: Filter cleaning is a labour intensive task and requires space as well as water for effective cleaning. A good AHU room will have earmarked space for cleaning with a water point provided. Most AHU rooms however do not have such arrangement, and the technicians have to take the filters to a designated space for cleaning. If the technicians do not perform this task due to the physical effort required to take the filters, cleaning takes a back seat and maintenance suffers.
- Faulty sensors, manual operations: It is common to see AHUs are running at the full capacity irrespective of the load as the sensors have failed, the damper is not operational or the bypass valve is malfunctioning. Since these sub systems are complex, repairs are costly and often postponed by the maintenance team as the system still functions. This results in the AHU running at off design point leading to system deterioration.
- Untrained staff: One of the most important reasons for poor AHU maintenance is the lack of knowledge of the staff undertaking the maintenance as well as the maintenance planning staff. The focus is on filter cleaning and other aspects are often neglected, leading to poorly performing AHUs.

AHU Maintenance Best Practices

Considering the thumb rules of 400 CFM per ton air conditioning or 20 CFM per person a 100,000 sq ft, 5 floor building can have anywhere between 10 – 20 AHUs.

> *"Many AHU installations are so poorly designed that there is no space for the maintenance staff to access the filters or the motor belts…*

Effectively maintaining these AHUs is critical for managing the IAQ, providing air at the desired temperature and keeping operating costs down as the AHUs are on the full duration of the time the workforce is in the office. A few best practices in AHU maintenance that can enhance the overall utilisation of the AHU are as follows:

- Clean AHU drains at regular frequency. This helps in preventing microbiological growth.
- Provide a water point in the AHU room to enable cleaning of AHU filters. If this cannot be provided, then a space in the closest wash room should be ear marked for AHU cleaning.
- Balancing of the System should be undertaken whenever there is a change in the office layout. Proper balancing can save up to 5 to 10% of energy.
- CFM measurements must be conducted once a year as part of the pre annual shutdown activities of the HVAC system. This allows any defects in the system such as improper balancing, motor conditions, filter conditions etc. to be identified in advance and can be rectified during the shut down.
- Record of the filter pressure differential should be maintained and regularly analyses to predict filter clogging before it becomes chocked.
- Identify leakages in the ducting and AHU casing to minimise losses and reduce power consumption.
- Install a VFD drive to older AHU motors to improver energy usage of the AHU.
- Calibrate the AHU linked sensors annually
- Measure static pressure developed by the AHU annually – this will help identify faults in the motor and AHU system.
- Monitor AHU Motor current on a weekly basis to check for defective motor bearings or impeller imbalance, which can lead to higher power consumptions.

Conclusion

AHUs are an important part of the HVAC system in a building, and hence require a high level maintenance and upkeep. A poorly maintained AHU leads to higher energy costs, higher pollutant levels in the work space and inadequate thermal comfort for the occupants.

Although the importance AHUs is understood by the designers and maintainers, AHUs are often neglected as the system is relatively simple and delivers cooled air, even if the system is degraded. Basic aspects such as space for maintenance is often neglected when designing AHU installations, leading to poor maintenance.

The cost of neglecting AHUs is substantial, and building maintenance planners and staff need to give a higher focus on AHU maintenance – and operation than is currently being delivered. This will not only ensure better air quality for the occupants, it will also lower the owners operating costs due to the lower use of energy in the AHU operations. ■

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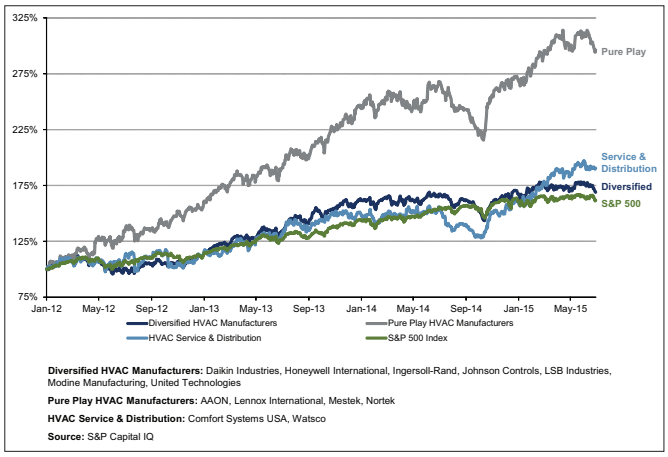
Identifying Growing Markets

Within the U.S. HVAC universe, pure play manufacturers, which include AAON, Lennox, Mestek and Nortek, have led the market since January 2012 with a cumulative return of 196%. HVAC service and distribution and Diversified HVAC manufacturers' stocks have also performed well, gaining 90% and 69%, respectively, outperforming the S&P 500 with a gain of 62% over the same period. We are not experts in the growing markets of India; however trends in the U.S. and Europe show that foreign HVAC markets such as India, show great opportunity. Going forward, we expect to see HVAC manufacturers looking toward India and Asia and capitalise on these faster growing and large markets. Key market trends that have become apparent throughout this year in India are: (1) rapid pace of population growth, (2) continued and increased government regulations and (3) the shortage of cooling distribution and storage products.



Disclosure: Inclusion of these indexes is for illustrative purposes only. Keep in mind that individuals cannot invest directly in any index...

India: A Growing Market

As India realises the benefits from the fall of oil prices, the International Monetary Fund predicts that the country's economy will grow by 6.5% in 2016 (China is only expected to expand at 6.3%). According to a report issued by CEBR World Economic League Table, India will be the 3rd largest economy in the world by 2024 only behind the US and China. By 2050, India's population is expected to be 1.69 billion while China's is anticipated to be 1.31 bn. Although India's economy is rapidly growing, the overall country's standard of living remains relatively low. As policymakers and officials in India fight to improve the quality of living for all, main HVAC players are poised to take advantage of the opportunity of significantly increasing demand. Through the sheer growth in population and need to improve the standard of living, India is positioned to represent a large portion of the $175 billion global HVAC market. Within the next few years, we expect India to be a manufacturing hub for HVAC appliances.

A Necessary Evil: Government Regulations

Governments around the world are issuing new regulations that necessitate the reducing of the amount of chlorofluorocarbon refrigerants produced from HVAC appliances. These regulations are costly to consumers but are necessary in order to prevent further damage to the Earth's ozone layer. The new, more efficient and required appliances have an initial cost that is significantly higher than their predecessors; however the systems will eventually pay for themselves through energy expense savings in the long haul. Contractors are also concerned with the new guidelines, fearing that they will limit their ability to compete in the extremely competitive industry. In summary, more stringent government regulations have left HVAC contractors uniquely positioned to reap the rewards of a growing replacement market.

Perishable Goods Crisis

India is the world's largest producer of fruits and milk, second largest producer of vegetables and third largest producer in the fishing industry. Agriculture is a main staple of India's GDP, and according to the report titled "Prospering Rural India" written by Veena Sinha and Alok Tripathi, "Cold storage facilities for India's agricultural produce are short by more than 10 million tons." The expensive cost of energy and an unreliable power grid leads to the loss of perishable goods. However, new efficient cooling equipment could be a key factor in solving the predicament of distribution and storage of perishable goods. These new appliances have the ability to reduce the stress on the unpredictable power grids and slash commercial energy costs. While the country's population continues to explode, it will be a necessity to stop the deterioration of these goods en-route to India's massive and growing urban areas.

Seeking Growth across the Pacific

HVAC manufacturing companies are seeking global growth as the United States and European markets continue to mature. Manufacturers realise that there is not a "one size fits all" formula to expand from the U.S. and Europe into Asian markets. In India, a growing commercial real estate sector, rapid urbanisation and new government regulations are all stimulating tremendous growth in the HVAC market. The main players plan on leveraging their technology through Research and Development in order to reach across the globe. For example, ductless systems are growing in demand due to such advantages as: heating and cooling in one appliance; easy, low-cost installation; cleaner, healthier air; and energy efficiency, with incentive opportunities available. Manufacturers do not have the ability to 'ship air' in the form of large frames of HVAC units, but they do have the ability to manufacturer necessary components and perform final assembly of parts closer to their end markets. ■

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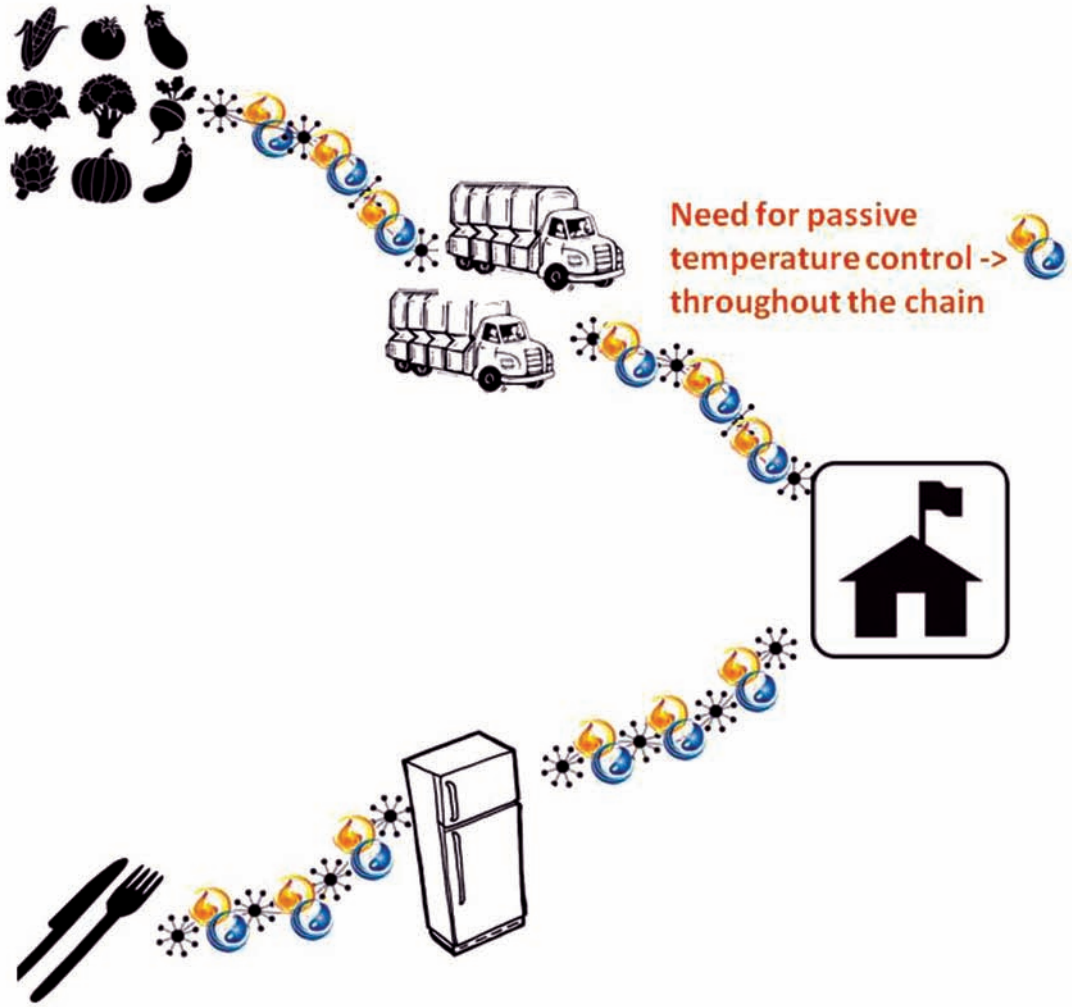
Meeting Food Inflation With Passive Cooling Technology

Phase Change Materials (PCMs) are passive cooling materials, which have the potential to reduce 80% and more of the operating cost incurred due to diesel consumption. PCMs fall under the sub category of energy exchanging smart materials...

An average Indian is spending much more on buying fruits, vegetables and milk products than cereals and pulses. The latest National Sample Survey Office (NSSO) data shows that spending of an Indian has more than doubled on buying fruit, vegetables and milk products in the last five years whereas expenditure on cereals and pulses has increased by only between 33 to 75% (Chauhan, 2013). Today's food inflation is less about food grain, more about fruit and vegetables, eggs, fish, meat and dairy products. This article focuses mainly on these commodities presenting different challenges and inefficiencies in the present value chain, highlighting the role of phase change materials in improving the situation.

The largest consumer segment to focus is the urban areas. This segment is crucial in virtue of its high population growth rate that has increased many-folds from 79 million in 1961 to 377.1 million in 2011. This has led to putting an increasing pressure on the agriculture sector to produce more. However, more than the productivity increment, the development of effective food supply chain is of utmost importance to satisfy the hunger of the growing population. The agriculture value chain is of



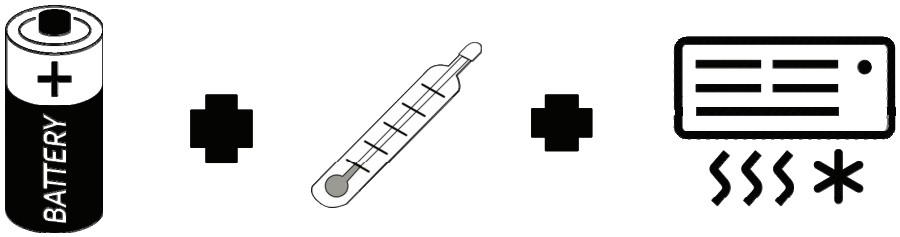
central substance to all the farmers, processors, logistics partners, wholesalers and retailers. The supply-side constraints are influencing the food prices largely both at local, national and global level. Market imperfections, like lack of proper infrastructure in rural areas, shortage of storage and transportation facilities further add to food inflation (Ministry of Agriculture, 2012). All of these points converge to the point, that there is urgent need to deal with the inefficiencies in the whole agriculture value chain.

Need to optimise consumption of fuel

An increase in fuel prices has both obvious and more subtle impacts on inflation. One type of impact is straightforward - fuel prices (along with lighting) have a share of about a tenth in the overall basket of goods used by the government to calculate consumer inflation. So, any increase in petrol or diesel or LPG prices will automatically result in the inflation rate inching higher (Celestine, 2013). In 2011, the RBI, in a study, assessed that a 10% increase in domestic fuel prices could raise overall wholesale prices by about one percentage point in the short run. In the longer-run though, that 10% impact, would cause inflation to rise by about two percentage points.

Need to counter the effects of long transportation time

The farmers incur labour costs for loading and off-loading of agriculture produce and weighing costs also, which increases their total cost of selling their agricultural produce, reducing their income.

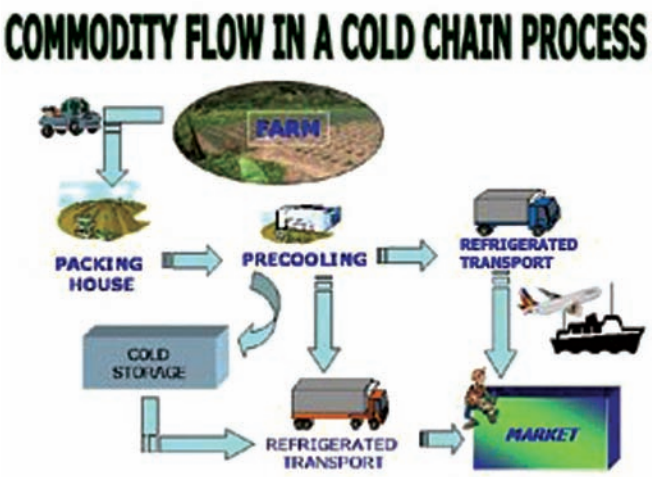


Value addition - Three functions in one product...

It is estimated that the total cost of transportation of the agriculture produce from farms to the wholesale markets accounts for nearly 10% of the total value of agriculture produce in many cases.

The total time taken by the farmer to transport the produce sometimes takes 3 to 4 hours, which is a big pain. Many times, farmers don't even negotiate the price of their agriculture produce with the broker before going to wholesale market. As a result, they are bound to sell at the given price at that particular time – in order to save the costs of transporting the agriculture produce back to their farms.

The situation gets worse when these commodities are transported from one state to other through the network of middlemen – and wholesalers again causing high loss in terms of both quality and quantity of the horticulture commodities. The degradation of the horticulture commodities caused due to longer transportation time attracts adulteration in the horticulture commodities. Various types of harmful chemicals and injections are used to improve the visibility of the commodity so that it seems to be fresh to local consumers. As most of the wholesale and retail markets don't have any effective mechanism to check the quality and artificial freshness of the horticulture commodities, it has severe harmful consequences on health and environment.



Passive cooling technology

With the above backdrop to the problem areas resulting in high cost of fruits & vegetables, one solution that can positively impact the cost of storage and transportation of temperature sensitive commodities is Phase Change Materials (PCM) technology. PCMs are passive cooling materials which have the potential to reduce 80% and more of the operating cost incurred due to diesel consumption. Phase Change Materials fall under the sub category of energy exchanging smart materials.

Energy exchanging smart materials is defined as those materials that are able to store latent and sensible energy in the form of light, heat, electricity or hydrogen and exhibit reversibility. A PCM has the ability to store and release large amounts of heat/ energy while maintaining a constant temperature.

PCMs are engineered to change their phase (solid to liquid or vice versa) at a specific temperature and one should look at the following three factors to qualify a PCM;

- High thermal storage capacity in the form of latent heat (200KJ/Kg or above)
- Constant temperature maintenance during the release of stored energy.
- Guaranteed repeatability in performance for over 3000 times.

The benefits of the above features are;

- Precise temperature control allowing not more than +/- 1°C of error.
- Longer duration of retention period – upto 18 hours due to high latent heat.
- Reduction in the overall weight of the freezer due to high energy storage to weight ratio of the PCMs.

Value addition - three functions in one product

PCMs have tremendous potential to fulfill the growing need of energy for cooling and heating applications across various industries. The PCM based transportation application market offers a large potential in developing countries as these account for

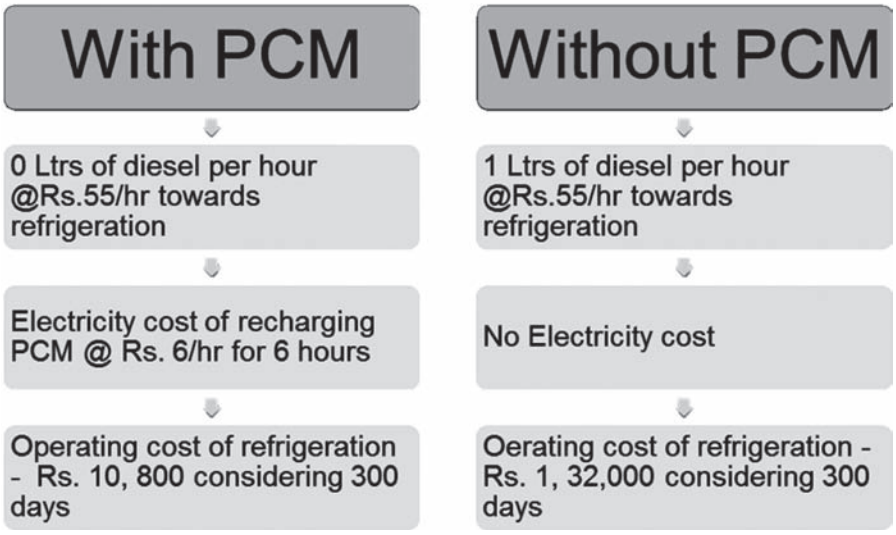


Fig - 1

60% of the global exports. India, though accounts for just 1.5% of the total export, the demand is growing at a CAGR of 20.61% and 7.21% for fruits and vegetables respectively (Trade, 2013).

The total production of fruits and vegetable accounts for 14% of the world's production (Trade, 2013). Passive cooling technologies can drastically reduce the price to the consumer while reducing the cost of wastage and transportation at the upstream of the supply chain.

In temperature control transportation 80 to 90% of operating costs can be reduce by reducing the dependability on diesel. PCM based trucks once charged for 8 to10 hours using electricity can provide refrigeration for about 12 hours during the journey.

This puts lesser pressure on the farmers or sellers to sell the commodity on the same day there by enabling them negotiate. PCM helps in using the energy when it is cheap and store it for use during operation.

The concept can be used even for cold stores similarly to save on the diesel cost during power outages by keeping energy stored in PCM for backup.

In the (above) figure 1 shows a comparison of the savings in operating cost between a conventional reefer truck and a truck using phase change materials. This is achieved at a little or no difference in the capital cost which is paid back within a year.

> ***"One solution that can positively impact the cost of storage and transportation of temp. sensitive commodities is PCM technology...***

The phase change material market is estimated to grow from $460 million in 2013 to $1,150 million by 2018, growing with a CAGR of 20.1% during the same period (Markets, 2013).

Factors such as government policies, unpredictable climatic changes and lack of infrastructures will continue to contribute to rising inflation. It is the need of the hour to adopt and implement innovative technologies such as phase change materials to prevent further losses. ■

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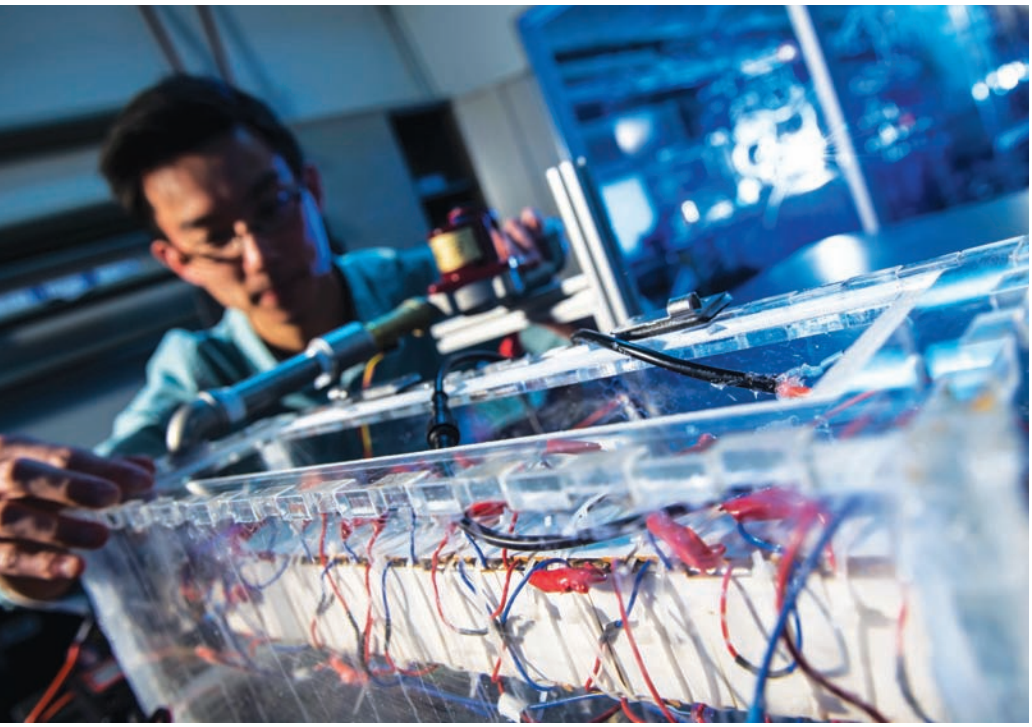


Shota Mikino shows the Space Ring, a heat-exchange device invented by Rice University students that turns waste heat into electricity through thermoelectric generators... (Credit: Jeff Fitlow/Rice University)

Thermoelectric Heat Exchanger

The incentive for using thermoelectrics, lies in their compact size, light-weight, high reliability, and near/sub-ambient heating and cooling application...

Heat exchange plays an important role in many industrial applications to mankind and may refer to: heat transfer, an area of engineering concerned with the transfer of thermal energy (heat). Heat exchange is accomplished with the help of a heat exchanger, a device built for heat transfer from one medium to another (in various viz. air to air, air to liquid, liquid to air, liquid to liquid, surface to air, air to surface, liquid to surface and surface to liquid etc.). The media may be separated by a solid wall, so that they never mix, or they may be in direct contact. Heat exchangers are widely used in space heating, refrigeration, air conditioning, power plants, chemical plants, petrochemical plants, petroleum refineries, natural gas processing, and sewage treatment. The classic example of a heat exchanger is found in an internal combustion engine, in which a circulating fluid known as engine coolant flows through radiator coils and air flows past the coils, which cools the coolant and heats the incoming air.

Thermoelectric technology offers the highest quality thermoelectric heat exchangers for all of our heating and cooling needs. We can design and manufacture thermoelectric heat exchangers for heating and cooling applications that demand extremely high reliability. The incentive for using thermoelectrics, lies in their compact size, light-weight, high reliability, and near/sub-ambient heating and cooling application. All thermoelectric heat exchangers are similar in concept: thermoelectric modules are sandwiched between two surfaces. When DC current is applied, the thermoelectric modules 'pump' heat from one surface to the other. The 'cold side' of the heat exchanger is designed to maximise cooling within the customer's equipment. The 'hot side' of the heat exchanger is designed to efficiently move heat into another medium. The total heat rejected from the heat exchanger is the sum of the heat removed from the customer's equipment plus the power supplied to the modules themselves. Working of different modes of thermoelectric heat exchangers is summarised as:

Liquid to liquid: Liquid on cold side of the thermoelectric modules is cooled while the heat is rejected into another liquid on the other side. Liquid chillers provide an example of liquid to liquid heat exchangers. The chiller circulates temperature-controlled coolant to equipment and rejects the heat into a facility's 'house water.'

Liquid to air: In liquid to air heat exchangers, liquid is cooled on one side of the thermoelectric modules, while heat is rejected into a finned heat sink with a fan to rapidly dissipate the heat into air. Liquid to air heat exchangers are commonly used for cooling machine tools, lasers, liquid chillers or any type of equipment with a coolant loop where the heat is rejected into air.

Surface to air: In surface to air cooling (one type of point-of use cooling) thermoelectric modules are located at the point requiring cooling. The heat is rejected into a finned heat sink with a fan to rapidly dissipate the heat into air. Two examples of surface to air heat exchangers are air-cooled cold plates and air-cooled containers. The cold plate could be in contact with electrical components or a container of fluid.

Surface to liquid: In surface to liquid cooling (point-of-use cooling) thermoelectric modules are located at the required cooling point. The heat is rejected into a liquid heat sink cooled by a facility's 'house water.' Direct cooling can be a cost effective and elegant replacement for a remote chiller.

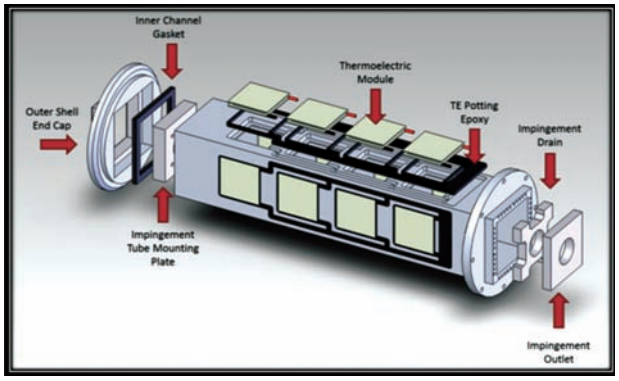
Air to air: A fan circulates cool air from a finned heat sink inside the area to be cooled. The heat is pumped through the metal wall of the enclosure and rejected to the outside air, again via heat sink and fan. Examples: a common AC, an electronics enclosure cooler.

> *Thermoelectric integrated heat exchanger may be used in various applications, where heat exchange against the thermal gradient is needed...*

Air to liquid: In this, air is chilled on the cold side of the thermoelectric modules, while the heat is rejected into a fluid. A typical air to liquid heat exchanger is an air conditioner where the heat is rejected into water. Another example is an air dehumidifier.

The thermoelectric integrated heat exchanger could be used in various applications – where heat exchange against the thermal gradient is required. Specifically, applications requiring compact solutions, long term reliability, and essentially no maintenance will be the best suited for the use of thermoelectric heat exchanger technology. Additionally, innovations in integration, e.g., allowing direct convection heat removal from the hot side, provide system level efficiencies that are currently unattainable with large scale thermoelectric solutions. Further, the technology is easily scalable increasing the flexibility of potential application. The system includes a thermoelectric heat exchanger having a thermoelectric device configured to pump heat. Heat exchangers are provided for transferring heat to and from the thermoelectric device, and for generating a fluid flow across the device. The conditioned fluid may be placed in thermal communication with a variety of objects, such as a vehicle seat, or anywhere localized heating and cooling are desired. Thermal isolation may also be provided in the direction of flow to enhance efficiency.

An Automotive Thermoelectric Generator (ATEG) is a device that converts waste heat in an Internal Combustion (IC) engine into electricity using the Seebeck Effect. A typical ATEG consists of four main elements: A hot-side heat exchanger, a cold-side heat exchanger, thermoelectric materials, and a compression assembly system. ATEGs can be classified into two categories depending on their hot-side heat exchanger: exhaust-based and coolant-based. The exhaust-based ATEGs convert the waste heat from the exhaust in an IC engine into electricity. Alternately, coolant-based ATEGs use the engine coolant's waste heat to generate electricity. In ATEGs, thermoelectric materials are packed between the hot-side and the cold-side heat exchangers. The thermoelectric materials are made up of p-type and n-type semiconductors, while the heat exchangers are metal plates with high thermal conductivity. The temperature difference between the two surfaces of the thermoelectric module(s) generates electricity using the Seebeck Effect. When hot exhaust from the engine passes through an exhaust ATEG, the charge carriers of the semiconductors within the generator diffuse from the hot-side heat exchanger to the cold-side exchanger. The build-up of charge carriers results in a net charge, producing an electrostatic potential while the heat transfer drives a current. With exhaust temperatures of 700°C (~1300°F) or more, the temperature difference between exhaust gas on the hot side and coolant on the cold side is several hundred degrees. This temperature difference is capable of generating 500-750 W of electricity.



Schematic design of a thermoelectric heat exchanger...

A subscale thermoelectric heat exchanger designed, fabricated and optimised for performance through testing and simulation. A thermoelectric heat exchanger concept that integrates solid-state coolers to provide active cooling in a compact, modular package. Specifically, direct fluid contact and jet-impingement were used to improve heat transfer at both hot and cold junctions of the thermoelectric. A schematic of the design concept can be seen in the figure (above). This approach resulted in a five-fold increase in the cooling coefficient-of-performance.

Experimentally validated predictions also demonstrated that a 100-kW heat exchanger is both lighter per unit-power than comparable vapour-compression systems. This feasibility study raises the outlook of reducing thermoelectric technology to practice in large heat load applications. Thermoelectric cooling uses the Peltier effect to create a heat flux between the junction of two different types of materials. A Peltier cooler, heater, or thermoelectric heat pump is a solid-state active heat pump which transfers heat from one side of the device to the other, with consumption of electrical energy, depending on the direction of the current. Such an instrument is also called a Peltier device, Peltier heat pump, solid state refrigerator, or thermoelectric cooler (TEC). The Peltier device is a heat pump: when direct current runs through it, heat is moved from one side to the other. Therefore, it can be used either for heating or for cooling (refrigeration), although in practice the main application is cooling. It can also be used as a temperature controller that either heats or cools. This technology is far less commonly applied to refrigeration than vapour-compression refrigeration is.

The main advantages of a Peltier cooler (compared to a vapour-compression refrigerator) are its lack of moving parts or circulating liquid, and its small size and flexible shape (form factor). Its main disadvantage is that it cannot simultaneously have low cost and high power efficiency. Many researchers and companies are trying to develop Peltier coolers that are both cheap and efficient. A Peltier cooler can also be used as a thermoelectric generator. When operated as a cooler, a voltage is applied across the device, and as a result, a difference in temperature will build up between the two sides. When operated as a generator, one side of the device is heated to a temperature greater than the other side, and as a result, a difference in voltage will build up between the two sides (the Seebeck effect). However, a well-designed Peltier cooler will be a mediocre thermoelectric generator and vice-versa, due to different design and packaging requirements. ■

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Cooling & Heating with Ground Source Energy

Air conditioning systems are an example of an air-to-air heat pump. They are becoming increasingly prevalent, particularly because new cars are often fitted with air conditioning systems and people are beginning to ask for more controlled internal environments...

Renewable energy sources have one thing in common; they all existed before man appeared on this planet. Wind, wave, hydro, solar, geothermal and tidal power are all forces of nature and are mostly intermittent energy sources, geothermal is the only consistent phenomenon. Geothermal renewable energy sources were probably the first to be fully utilised by man. Early civilisations tapped this heat to cook, fire clay pottery, create baths and spas and even heat their homes. Roman villas had under floor heating from natural hot springs over 2000 years ago.

Shallow geothermal resources (<400 m depth by governmental definition in several countries) are omnipresent. Below 15 to 20 m depth, everything is geothermal. Figure 1 show a summary of the soil thermal properties. The temperature difference between determine the ground temperature. The ground and the fluid in the ground heat exchanger drive the heat transfer, so it is important that the temperature field is governed by terrestrial heat flow and the local ground thermal conductivity structure (groundwater flow). In some countries, all energy stored in form of heat beneath the earth surface is as per definition perceived as geothermal energy (VDI, 1998). The same approach is used in North America. The ubiquitous heat content of shallow resources can be made accessible either by extraction of groundwater or, more frequently by artificial circulation like the Borehole Heat Exchanger (BHE) system (Knoblich, Sanner, and Klugescheid, 1993). This means, the heat

extraction occurs – in most cases – by pure conduction; there is no formation fluids required. The most popular BHE heating system with one or more boreholes typically 50 to 200 m deep is a closed circuit, heat pump coupled system, ideally suited to supply heat to smaller, de-centralised objects like single family or multifamily dwellings (Figure 2). The heat exchangers (mostly double U-tube plastic pipes in grouted boreholes) work efficiently in nearly all kinds of geologic media (except in material with low thermal conductivity like dry sand or dry gravel). This means to tap the ground as a shallow heat source comprise:

- Groundwater wells ('open' systems)
- Borehole Heat Exchangers (BHEs),
- Horizontal heat exchanger pipes (including compact systems with trenches, spirals, etc.)
- 'Geo-structures' (foundation piles equipped with heat exchangers).

A common feature of these ground-coupled systems is a heat pump, attached to a low-temperature heating system like floor panels/slab heating. They are all termed 'Ground-Source Heat Pumps' (GSHP) systems. In general, these systems can be tailored in a highly flexible way to meet locally varying demands. Experimental and theoretical investigations (field measurement campaigns and numerical model simulations) have been conducted over several years to elaborate a solid base for the design and for performance evaluation of BHE systems (NASA, 2009; and Rybach, and Eugster, 1997). While in the 80s, theoretical thermal analysis of BHE systems prevailed in Sweden (Claesson, and Eskilson, 1988; and Eskilson, and Claesson, 1998) monitoring and simulation was done in Switzerland (Gilby, and Hopkirk, 1985; and Hopkirk, Eugster, and Rybach, 1988), and measurements of heat transport in the ground were made on a test site in Germany (Sanner, 1986).

> ***"Shallow geothermal resources (<400 m depth by governmental definition) are omnipresent. Below 15 to 20 m depth, everything is geothermal..."***

In the German test system at Schöffengrund-Schwalbach near Frankfurt/Main, a 50-m BHE was surrounded by a total of 9 monitoring boreholes at 2.5, 5 and 10 m distance, also 50 m deep. Temperatures in each hole and at the BHE itself were measured with 24 sensors at 2 m vertical distance, resulting in a total of 240 observation locations in the underground. This layout allowed investigating the temperature distribution in the vicinity of the BHE. The influence from the surface is visible in the uppermost approximately 10 m (Figure 1), as well as the temperature decrease around the BHE at the end of the heating season. Measurements from this system were used to validate a numerical model for convective and conductive heat transport in the ground (Bourna, and Koppenol, 1984; and Sanner, Klugescheid, and Knoblich, 1996). Starting in 1986, an extensive measurement campaign has been performed at a commercially delivered BHE installation in Elgg near Zurich. The object of the campaigns is a single, coaxial, 10 m long BHE in use since its installation in a single-family house. The BHE supplies a peak thermal power of about 70 W per m of length.

The ground temperature results are highly informative with respect to the long-term performance (Hellstrom, Sanner, Klugescheid, Gonka, and Martensson, 1997). Atmospheric influences are clearly visible in the depth range 0 to15 m, and below 15 m, the geothermal heat flux dominates. The results show that in the near field around the BHE, the ground coils down in the first 2 to 3 years of operation. However, the temperature deficit decreases from year to year until a new stable thermal equilibrium is established between BHE and ground, at temperatures that are some 1 to 2 K lower than originally. Thus, a 'thermal collapse' (i.e., sudden drop of heat extraction efficiency) will not happen. After calibration of a numerical model with the data from the Elgg system, the extrapolation for an operation over a 30-year period as well as the thermal recovery for 25 years following the end of the operation period has been simulated. Temperature close to the BHE in winter drops quickly in the first years, only to stay more or less stable over the next years. In summertime, initial temperatures are not achieved again, but the temperature drop is decreasing from year to year (Knoblich, Sanner, and Klugescheid, 1993). After termination of the operation, a rapid thermal recovery can be seen in the first spring, followed by a slowing down of the recovery process due to the decreasing temperature gradients. In the numerical simulation, a complete recovery will occur only after an indefinitely long time period; nevertheless, the remaining

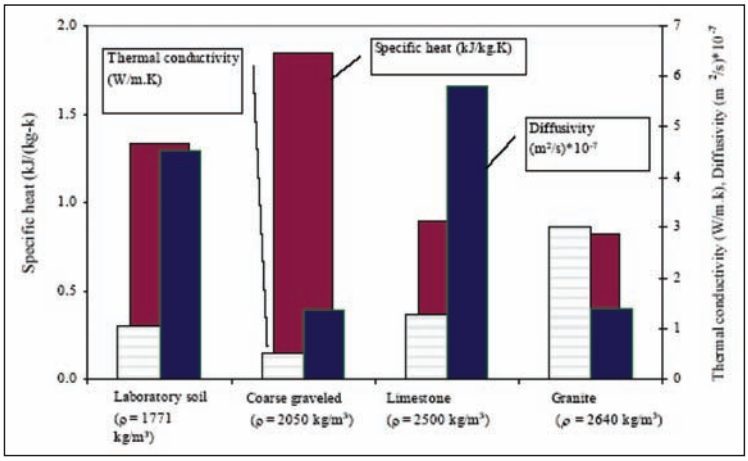

Fig. 1: Measured thermal properties for different soils...

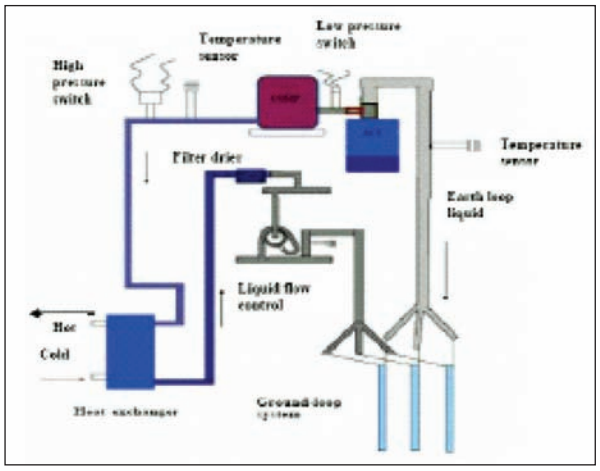

Fig. 2: Typical application of a Borehole Heat Exchanger (BHE) heat pump system in a central European home, typical BHE length = 100 m...

temperature deficit 25 years after the operation is stopped, is only in the order of 0.1 K. The long-term reliability of BHE-equipped heat pump systems, along with economic and ecological incentives, led to rapid market penetration. This was accomplished by the development of design standards (e.g., VDI, 1998), and easy-to-use design tools (Hellstrom, Sanner, Klugescheid, Gonka, and Martensson, 1997).

Heat Pumps

Heat pumps work on a similar principle to domestic refrigerators, extracting heat from one source and transferring it to another. A key ingredient in the heat pump is the refrigerant in its coils, usually a substance called Freon, which vaporises into a gas at a boiling point far lower than the 100ºC that water requires to boil. When the refrigerant boils, it changes from a liquid to a gas, absorbing heat from its surroundings. As the refrigerant changes back into liquid form it gives up its heat to the surrounding atmosphere. An expansion valve and an electric compressor control this process of transformation from liquid to gas and back again. An Earth Energy (EE) heat pump is one of the most efficient means available to provide space heating/cooling for homes and offices (Figure 3). It transfers the heat located immediately under the earth's surface (or in a body of water) into a building in winter, using the same principle as a refrigerator that extracts heat from food and rejects into a kitchen. A heat pump takes heat from its source at low temperature and discharges it at a higher temperature, allowing the unit to supply more heat than the equivalent energy supplied to the heat pump. An Earth Energy system relies on the 51% of solar energy that is absorbed by the land and water (NASA, 2009).

Terminology

Due to the large demand for EE as cooling devices, the earth energy industry uses the term 'ton' to describe a unit that will provide approximately 12,000 Btu of cooling capacity. On average, a typical 2,000 square-feet new residence would require a 4-ton unit for sufficient heat. Within the full swing of heat pump applications in Europe, ground-coupled heat pumps play a significant role. The development started around 1980 when the first BHE coupled heat pump systems were built in Germany and Switzerland. Following a larger number of new units installed during the oil price crises and a subsequent low (except for Switzerland), the number of new installations is again increasing in the 90s.

Air Flow

EE units work efficiently because they provide a small temperature rise, but this means that the air coming through the register on the floor is not as hot as the air from a gas or oil furnace. A unit must heat more air to supply the same amount of heat to the houses, and duct sizes must be larger than those used for combustion furnaces to accommodate the higher CFM (Cbic Feet Per Minute) air flow. The major advantage of an EE system is that the heat obtained from the ground (via the condenser) is much greater than the electrical energy that is required to drive the various components of the system. The efficiency of a unit is the ratio of heat energy provided versus the electrical energy consumed to obtain that heat, and it is called its Coefficient Of Performance (COP). EE units must exceed 3.0 (i.e., for every kilowatt of electricity needed to operate the system, the heat pump provides three kilowatts of heat energy).

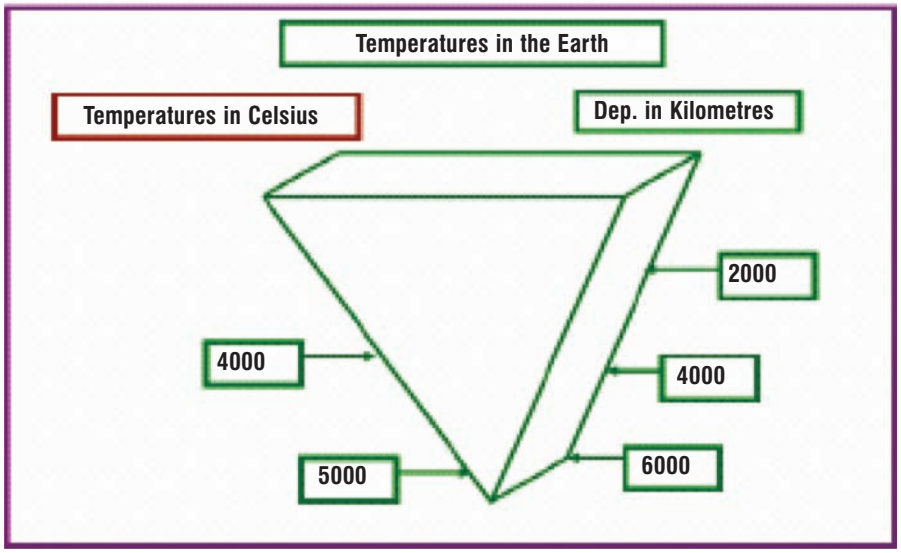

Fig. 3: Earth energy budget...

Soil Type

Loose dry soil traps air and is less effective for the heat transfer required in EE technology than moist packed soil. Each manufacturer provides specifications on the relative merits of soil type; low-conductive soil may require as much as 50% more loop than a quality high-conductive soil.

Auxiliary Heat

When the outdoor air temperature drops below the design balance point, the EE unit cannot meet the full heating demand inside the house (for units sized to 100% of heat loss, this is not an issue). The difference in heat demand is provided by the supplementary or auxiliary heat source, usually an electric resistance element positioned in the unit's plenum. Like a baseboard heater, the COP of this auxiliary heater is 1.0; so excessive use of backup heat decreases the overall efficiency of the system and increases operating costs for the homeowner.

Balance Point

The outdoor temperature at which an EE system can fully satisfy the indoor heating requirement is referred to as the balance point, and is usually -10ºC in most regions of North Europe. At outdoor air temperatures above this balance point, the unit cycles on and off to satisfy the demand for heat indoors. At temperatures below this point, the unit runs almost continuously, and also turns on the auxiliary heater (called second stage heat) to meet the demand.

Heat Transfer Fluids

Closed-loop units can circulate any approved fluid inside the pipe, depending on the performance characteristics desired. Each manufacturer must specify which fluids

are acceptable to any particular unit, with the most common being denatured ethanol or methanol (the latter is not approved for use).

Loop Depth

EE technology relies on stable underground (or underwater) temperature to function efficiently. In most cases, the deeper the loop is buried, the more efficient it will be. A vertical borehole is the most efficient configuration, but this type of digging can be very expensive.

Loop Length

The longer the amount of piping used in an outdoor loop, the more heat that can be extracted from the ground (or water) for transfer to the house. Installing fewer loops than specified by the manufacturer will result in lower indoor temperature, and more strain on the system as it operates longer to compensate for the demand. However, excessive piping can also create a different set of problems, as well as additional cost. Each manufacturer provides specifications for the amount of pipe required. As a broad rule of thumb, an EE system requires 400 feet of horizontal loop or 300 feet of vertical loop to provide heat for each ton of unit size.

Loop Spacing

The greater the distance between buried loops, the higher the efficiency. Industry guidelines suggest that there should be 3 m (10 feet) between sections of buried loop, in order to allow the pipe to collect heat from the surrounding earth without interference from the neighbouring loop. This spacing can be reduced under certain conditions.

Loop Configuration

Closed loops generally are installed either in a vertical or in a horizontal configuration, depending on the land available and a number of other factors. Earth Energy ground pipe comes in two common diameters: 0.75" and 1.25". Two coiled loops (commonly called the Svec Spiral and the Slinky) require less trenching than conventional straight pipe. As a result, the lower trenching costs and the savings in property disruption offset the higher cost of the coiled pipe.

Varieties of Heat Pumps

Air conditioning systems are an example of an air-to-air heat pump. They are becoming increasingly prevalent, particularly because new cars are often fitted with air conditioning systems and people are beginning to ask for more controlled internal environments. However in the UK, the need for air conditioning is often a result of overheating because of unsatisfactory shading and poor natural ventilation. Every attempt should be made to design buildings, which do not require air conditioning, because of the additional energy load required.

In addition to air-to-air heat pumps there are air to water heat pumps and water to air systems. These can draw water from a well or pond and expel the used water to a discharge well. Because the source of heat is fairly constant (about 10ºC) the heat pumps are more efficient than air-to-air systems. Water to water heat pumps are even more efficient, taking the energy from geothermal supplies which are at a constant year round temperature and transferring heat to about 53ºC. Because heat pumps do not produce very high temperatures, they work best when heating well insulated houses, which are designed to be heated by low temperature systems. Traditional radiators, which are oversized, will give a larger area to dissipate heat and so work at lower surface temperatures. Underfloor water based heating systems are ideal as they work on the radiant heating principle, which create a comfortable environment at a lower temperature.

The heating loads for a house will vary considerably over the year. At the coldest time of the year, the energy requirements will be the greatest. If the design to these levels of maximum load, the heat pumps size can get very big, and as a result costly. It is thought best to design the heat pumps to only cover about 50 to 70% of the annual heating demand, and where demand peaks over a smaller period, to provide supplementary direct electrical heating (or alternatives) to meet this demand.

Types of Geothermal Systems

There are a number of different methods to heat a building using geothermal energy:

- Groundwater GSHP, of which there are two variations, open loop and closed loop. An open loop groundwater GSHP supplies ground water directly to each heat pump and then returns the well water to the source. This system is normally not recommended because of fouling and corrosion concerns. The closed loop uses an isolation plate and frame heat exchanger between the ground water and the building water loop.
- Surface-water GSHP, which uses multiple heat exchangers made from spooled plastic pipe submerged in a body of surface water and connected to the building heat pumps.
- Ground heat exchanger GSHP, which relies on a ground-coupled heat exchanger installed either horizontally in trenches or as “U” tubes in vertical bores.

The heat exchangers are connected together in parallel, and run-outs are tied to the building’s water loop. The selection of a particular design depends on the available land area. Table 1 provides the guidelines on the surface-area requirements for horizontal/ vertical configurations. The decision to use any of the above systems depends on the results of geotechnical / hydrogeological investigations.

Design	Horizontal	Vertical
2 pipes per trench	2000	3500
4 pipes per trench	1400	2400
6 pipes per trench	1400	2400

Table 1: Surface area requirements GSHP (sq metres)...

Water Discharge Quality

There are environmental regulations, which govern how the water used in an open-loop system can be returned to the ground. A return well is acceptable, as long as the water is returned to the same aquifer or level of water table. A discharge pit is also acceptable, as long as certain conditions are followed.

Open water systems depend on a source of water that is adequate in temperature, flow rate and mineral content. EE units are rated under the nation performance standard (CSA C446) based on their efficiency when the entering water temperature is 10ºC (0ºC for closed loop units), but this efficiency drops considerably if the temperature of water is lower when it comes from the lake or well. Each model has a specified flow rate of water that is required, and its efficiency drops if this rate is reduced. The CSA installation standard

demands an official water well log to quantify a sustainable water yield. Water for open-loop systems must be free of many contaminants such as chlorides and metals, which can damage the heat exchanger of a unit.

Selecting A GSHP

GSHPs are very similar to conventional heat pumps. Their specifications differ from conventional water-source heat pumps (WSHP) only in the following areas:

- GSHPs operate over a very wide range of entering water temperatures from source (ground), typically, 20^{O}F to 110^{O}F, whereas the conventional WSHP operates over a very narrow range (60 to 90^{O}F). This requires the use of an extended-range heat pump to preserve the ability of the system to operate at low ground-water temperatures. Table 2 gives the typical temperature ranges for the water loop of GSHPs.
- GSHPs with the ground as a heat exchanger must be rated under ARI 330 or CSA 446 closed-loop conditions. GSHPs are to be rated under ARI 325 or CSA 446 open-loop conditions. Conventional heat pumps are rated under ARI 325 or CSA 656 conditions.
- GSHPs usually use a thermal-expansion valve as opposed to the capillary expansion device used in WSHPs.
- GSHPs typically encounter low suction temperatures and, therefore, need to be specified with low-temperature/pressure controls for freeze protection.
- GSHPs usually employ larger liquid side and airside heat exchangers and insulated internal components to prevent internal condensation.
- In conventional WSHPs, the insulation on the loop piping is not required because the loop temperatures are always maintained above 45^{O}F. GSHP system piping will require insulation, and, in some cases, antifreeze solutions will be required to prevent freeze up.
- Specify copper heat exchangers for heat pumps on closed-loop ground source, groundwater, or surface-water applications. Use only cupronickel heat exchangers for open ground-water systems.
- While calculating the loads for the ground-source heat pumps, it is necessary to perform the calculations with an hour-by-hour and month-by-month simulation program because these calculations will be required to design the well field.

Horizontal design	Heating	Cooling
Ground heat exchanger	30-55	90-105
Surface water heat exchanger	30-45	80-95
Closed loop ground water	40-50	75-85
Open loop ground water	50-60	55-65

Table 2: Entering liquid temperatures for different system types (^{O}F)...

Selection and Pre-Installation Considerations

The Ground Source Heat Pump (GSHP) system represents the natural evolution of a traditional water loop heat pump (WLHP) system. The GSHP system offers all the advantages of the WLHP system, combined with considerable reductions in building operating costs. The beauty of this system is that it can perform both heating and cooling without the use of separate boilers/furnaces and A/C systems. A GSHP system does not create heat; it moves heat from one area to another. GSHP systems use the ground (earth, ground water, or surface water) as heat sink in the summer and a heat source in the winter. This system is considered the most energy-efficient, environmentally safe, and cost-effective system available. Among the many components of a GSHP system, the most important is the heat pump itself.

Heat Pump Accessories and Controls

Considerations for heat pump:

- Heat pumps, whether water or ground source, should not be used to handle large outdoor air loads. These outdoor air loads should be handled through separate A/C units, preferably with heat-recovery capabilities and conditioned outdoor air ducted to each heat pump.
- Heat-pump sizing is very critical. It doesn't need to oversize heat pumps. In general, size at no less than 95 percent for adequate latent-heat capacity. Do not size greater than 125% of the zone peak sensible-cooling load unless the heat pump has multi-speed fan/compressor and automatic means of adjusting flow.
- Pay special attention to the specifications for the on/off automatic valve in the source water-supply connection to the heat pump, which is interlocked with the compressor to permit compressor operation only after it is fully open. Though seemingly a small component in the overall system, this is prone to frequent failures if it is not of good quality. Its failure will lead to expensive compressor failures.
- Heat-pump schedules must include the minimum acceptable coefficient of performance for heating performance and energy efficiency ratio for the cooling performance to take advantage of the most efficient heat pumps available on the market.

Geothermal Heating Systems

Geothermal energy is a natural resource, which can be used in conjunction with heat pumps to provide energy for heating and hot water. CO_2 emissions are much lower than gas fired boilers or electric heating systems. Geothermal heating is more expensive to install initially, than electrical or gas fired heating systems. However it is cheaper to run, has lower maintenance costs, and is cleaner in use than other sources of heating.

The temperature of the earth under 2 metres of the surface is a fairly constant 10^{o}C throughout the year. At a depth of about a 100 metres, the temperature of any water or rock is at about 12^{o}C throughout the year. The heat stored at this depth comes largely from the sun, the earth acting as a large solar collector. For very deep wells, in excess of about 170 metres, there is an added component of heat from the core of the earth. As an approximation, one can add 3^{o}C of heat gain for every 100 metres of depth drilled into the earth.

A closed loop system takes the heat gained from the bedrock itself. In a vertical system a borehole of a diameter of about 150mm is drilled, depth varies between 32 and 180 metres but will depend on the energy requirements. Multiple boreholes can be drilled. A pair of pipes with a special U-bend assembly at the bottom is inserted into the borehole and the void between pipe and hole backfilled with a special grout solution so that the pipe is in close contact with the rock strata or earth. Fluid (referred to as 'brine' is then circulated through this loop and is heated up by the bedrock. Different rock

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types will give different results. In some cases a number of boreholes will be made (for example, over a car park) to provide sufficient energy for the heat pump supply. If the ground is not suitable, horizontal loops can be laid or even trench filled 'slinky' loops, which are very simple to install. However trench filled systems and horizontal systems require much more ground than vertical systems. If one has a pond or lake nearby then can lay a closed loop at the base of the pond (it needs to be about 2 metres deep), or simply extract the water directly out of the lake at low level and re-distribute it elsewhere in the lake.

Heat pumps can be cheaper to operate than other heating systems because, by tapping into free heat in the outdoor air, ground or water supply, they give back more energy-in the form of heat-than the equivalent amount of electrical energy they consume. For example, in heating mode, a highly efficient heat pump could extract energy from the earth and transfer it into a building. For every 1 KWh of electrical energy used to drive the heat pump, around 3 to 4 kWh of thermal energy will be produced. In cooling mode, the heat pump works in reverse and heat can be extracted from a building and dissipated into the earth. Heat pumps which work in a heating mode are given a 'coefficient of performance' or 'COP' calculated by dividing the input kWh into the output kWh. This will give a COP figure, which varies with the input temperature and is the ratio of energy in to energy out. In cooling mode, the ratio is called the 'energy efficiency ratio' or 'EER'. When the EER and COP ratios higher, the more efficient the unit. Geothermal/ GSHPs are self-contained systems. The heat pump unit is housed entirely within the building and connected to the outside-buried ground loop.

Thermal Storage

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

The key to the diffusion of any innovation is the ability to reduce the uncertainty or risk associated with the innovation. There are several diffusion attributes of a technology that help us identify the technology's ability to overcome uncertainty and achieve potential adoption. The key attributes have been divided into five categories, presented below with our assessment of the status of GSHP relative to these attributes (Table 3).

Applications for Earth Energy

The decision to use geothermal heat pumps should be based on the results of geotechnical/ hydrogeological investigations. Sites may be encountered that are inappropriate for geothermal heat pumps. The geothermal heat-pump system is an all-electric system. A life-cycle analysis, using gas and electric rates, initial costs, maintenance costs, and replacement costs, must be conducted before selecting these systems. These systems may not be cost effective in locations with high electric rates and inexpensive gas. The geothermal heat-pump concept is not a good candidate for buildings that are not expected to have heating loads. EE units can be used for the dehumidification of indoor swimming pool areas, where the unit can dehumidify the air and provide condensation control with a minimum of ventilation air. The heat recovered from the condensed moisture is then used for heating domestic/pool water or for space heating. EE systems are also used as heat recovery devices to recover heat from building exhaust air or from the wastewater of an industrial process. The recovered heat is then supplied at a higher temperature at which it can be more readily used for heating air or water. Efficient heating performance makes EE a good choice for the heating and cooling of commercial and institutional buildings, such as offices, stores, hospitals, hotels, apartment buildings, schools, restaurants and penitentiaries. EE systems can heat water or heat/cool the interior space by transferring heat from the ground outside, but they can also transfer heat within buildings with a heat-producing central core. The technology can move heat from the core to perimeter zones where it is required, thereby simultaneously cooling the core and heating the perimeter.

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

Table 3: Key attributes have been divided into five categories, presented with assessment of the status of GSHP relative to these attributes...

Heating and Cooling

A GSHP extracts solar heat stored in the upper layers of the earth; the heat is then delivered to a building. A re-circulating piping system connects the heat pump. The piping system adds or removes heat to the circulating water. GSHPs can reduce the energy required for space heating, cooling and service water- heating in commercial/ institutional buildings by as much as 50% (Figure 4). GSHPs replace the need for a boiler in winter by utilizing heat stored in the ground; this heat is upgraded by a vapour-compressor refrigeration cycle. In summer, heat from a building is rejected to the ground. This eliminates the need for a cooling tower or heat rejecter, and also lowers operating costs because the ground is cooler than the outdoor air. Water-to-air heat pumps are typically installed throughout a building with

ductwork serving only the immediate zone; a two-pipe water distribution system conveys water to and from the ground-source heat exchanger.

The heat exchanger field consists of a grid of vertical boreholes with plastic u-tube heat exchangers connected in parallel. Simultaneous heating and cooling can occur throughout the building, as individual heat pumps, controlled by zone thermostats, can operate in heating or cooling mode as required. Unlike conventional boiler/cooling tower type water loop heat pumps, the heat pumps used in GSHP applications are generally designed to operate at lower inlet-water temperature.

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

Typically, single packaged heat pump units have no field refrigerant connections and thus have significantly lower refrigerant leakage compared to central chiller systems. GSHP units have life spans of 20 years or more. The two-pipe water-loop system typically used allows for unit placement changes to accommodate new tenants or changes in building use. The plastic piping used in the heat exchanger should last as long as the building itself. When the system is disassembled, attention must be given to the removal and recycling of the HCFC or HFC refrigerants used in the heat pumps themselves and the anti-freeze solution typically used in the ground heat exchanger.

Radiant Heating and Cooling

There is an alternative source of heat beneath our feet. GSHPs are 380% efficient, 75% renewable, and 100% reliable. The land absorbs radiant energy from sun, even on the darkest days (Figure 5). This is stored, every day, and all for free. Solar energy from above and geothermal heat from below maintains the subsurface UK ground temperature within a range of approximately 10^{O}C – even in winter. GSHPs tap this low-grade energy and turn it into usable heat through the simple principle refrigeration- an idea recognised as long ago.

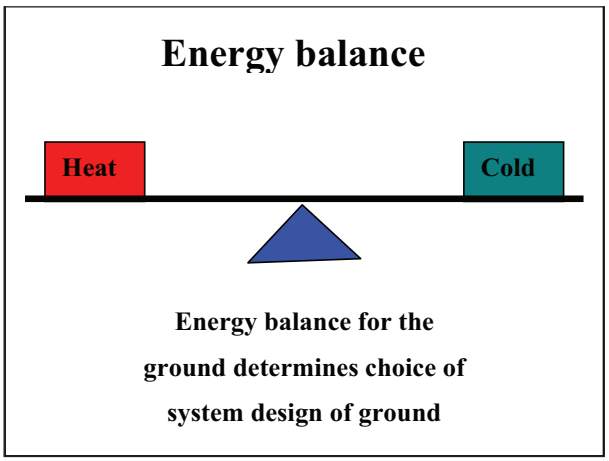

Fig. 5: Energy balance for ground...

Conventional radiators have been used for many years to heat buildings. The radiators are located around the building perimeter. Because of the small surface area of the radiators, they must be operated at a high temperature to deliver sufficient heat. Modern systems are different in that they cover a large area of floor or ceiling and operate at temperatures much closer to room air temperature, approximately 15^{O}C in cooling mode and 35 to 50^{O}C in heating mode. The system cannot be operated at lower temperatures in cooling mode without the risk of condensation (Figure 6). The small temperature difference means that about 30 to 50% of the ceiling or almost the entire floor area must be available as heat transfer surface. Ventilation air is provided by a small-dedicated ductwork system and works particularly well with displacement ventilation concepts. Several companies have developed metal radiant panels that can be ceiling mounted, either attached directly to the ceiling or as part of a T-bar suspended ceiling. For floor systems, flexible plastic piping is embedded in the concrete floor or in gypsum topping on a wooden sub-floor. Ceiling mounted systems are usually best for combined heating and cooling systems.

Floor systems are best for heating-only systems (provided the floor isn't covered with heavy carpets). The amount of heat transfer depends on the direction of heat flow. Air in contact with a cooled ceiling panel will

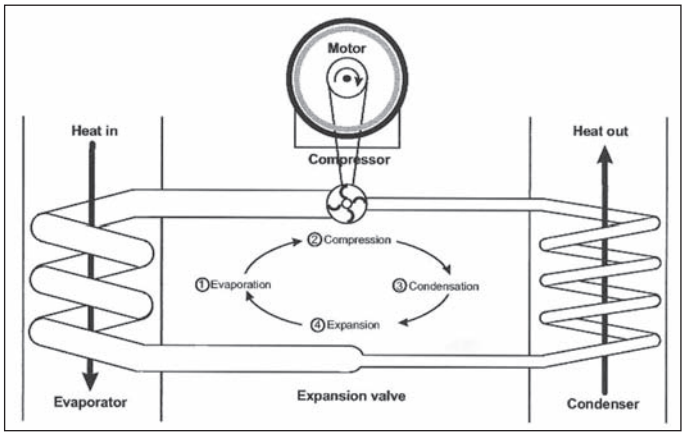

Fig. 4: Ground source heat pumps...

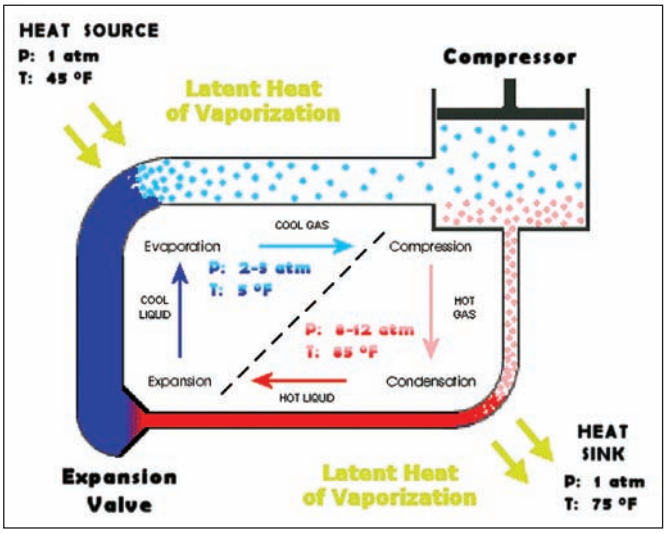

Fig. 6: Heat pump works by promoting the evaporation and condensation of a refrigerant...

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

Table 4: Design load and criteria...

naturally fall as it is cooled increasing the movement of air over the panel. Conversely, air in contact with a warm ceiling will stratify at the ceiling and have low convective heat transfer. As a guide to system sizing, the total heat transfer rate (combined radiation and convection) is about 11 W/m^2/^{0}C temperature difference for cooled ceilings and heated bare floors. This value drops to 6 W/m2/^{0}C for heated ceilings and cooled floors. Floor coverings such as carpeting reduce the output of heated floors. Radiant systems are more energy-efficient than air-based systems. They require less parasitic energy (pump and fan energy) to deliver heat. The low operating temperatures mean that boilers can operate more efficiently. Finally, because the walls are radiantly heated, the air temperature can be cooler to achieve the same level of comfort. These lower air temperatures result in lower heat losses to the outdoors (Table 4).

Heat Distribution System

The heat pump works by promoting the evaporation and condensation of a refrigerant to move heat from one place to another (Figure 6). A heat exchanger transfers heat from the water/antifreeze mixture in the ground loop to heat and evaporate refrigerants, changing them to a gaseous state. A compressor is then used to increase the pressure and raise the temperature at which the refrigerant condenses. This temperature is increased to approximately 40^{0}C. A condenser gives up heat to a hot water tank, which then feeds the distribution system. Features include: Lower utility bills, less maintenance, no visible outdoor plant, reduction in emissions, and versatility of system.

Because GSHPs raise the temperature to approximately 40oC they are most suitable for under floor heating systems, which require temperatures of 30 to 35^{0}C, as opposed to conventional boiler systems, which require higher temperatures of 60 to 80^{0}C. GSHPs can also be combined with radiator space heating systems and with domestic hot water systems. However top-up heating would be required in both cases in order to achieve temperatures high enough for these systems. Some systems can also be used for cooling in the summer. Geothermal heat pumps are the most energy efficient, environmentally clean, and cost effective space conditioning systems available according to the Environmental Protection Agency in the United States of America. Ground Source Geothermal heating and cooling is a renewable resource, using the earth's energy storage capability. The earth absorbs 47% of the suns energy amounting to 500 times more energy than mankind needs every year.

The closed loop portion of a ground source heat pump system consists of polyethylene pipe buried in the ground and charged with a water/antifreeze solution. Thermal energy is transferred from the earth to the fluid in the pipe, and is upgraded by passing to a water source heat pump. One 100 metres vertical closed loop borehole will typically deliver 14000 KWh of useful heating energy and 11000 KWh of useful cooling energy every year for life. For typical commercial building early trials indicate annual HVAC energy consumption in the order of 75 kWh/m^2 compared with 156 kWh/m^2 'good practice target', and 316 kWh/m^2 typical consumptions published by the Department of the Environment in Energy Consumption Guide No.19 (DOE, 1998). Low energy consumption means associated lower CO_2 emissions than from conventional systems.

Energy savings of 40% compared with air source heat pumps and by over 70% compared to electric resistance heating are being achieved, and CO2 emissions are reduced to 40 kg/m^2, less than half that associated with DOE typical HVAC design (EPA, 1993). With the heat source buried in the ground, the system is both invisible and silent. There is no need for boiler, flue, cooling tower, water treatment or associated plant rooms, and the total building resource content is reduced. At a depth of 7 to 7.5 metres the earths temperature will be constant at a temperature equal to the average mean ambient temperature throughout the year in any location meaning temperature in winter higher than the air temperature, and in summer lower than air temperature thereby providing higher efficiencies in both heating and cooling modes and ensuring a lower peak load throughout the year (Figure 7).

This invention relates to a cooling and heating system, which operates on the absorption and phase change heat exchange principle. More particularly it relates to a continuous heat actuated, air cooled, double effect generator cycle, absorption system. In further aspects, this invention relates to a system constructed for use with an absorption refrigeration solution pair consisting of a nonvolatile absorbent and a highly volatile refrigerant, which is highly soluble in the absorbent. A disclosed refrigerant pair is ammonia as the refrigerant and sodium thiocyanate as the absorbent. An absorption cycle is disclosed using the thermo physical properties of sodium thiocyanate/ammonia,

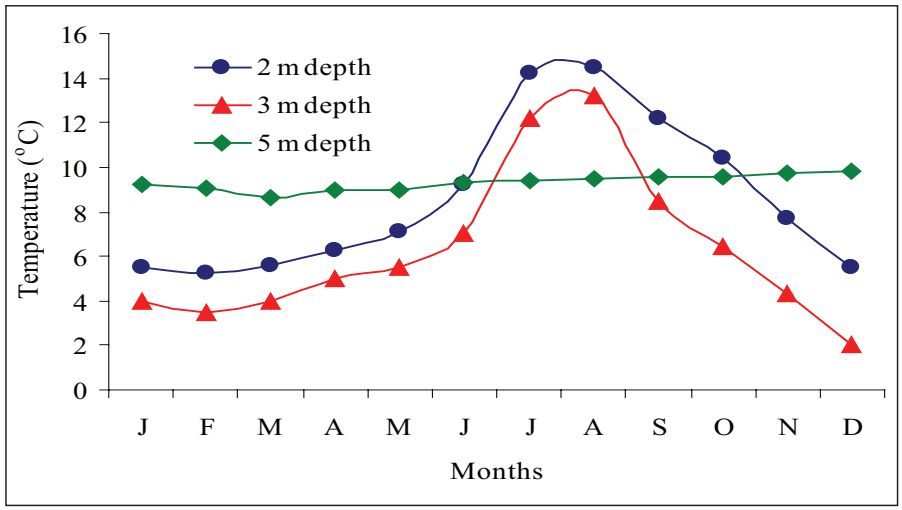

Fig. 7: Ground temperatures throughout the year...

absorption/refrigerant pair. Also disclosed is the construction and configuration of a reverse cycle air cooled double effect generator absorption refrigeration system for use with the sodium thiocyanate/ammonia refrigeration pair, as well as sub-compositions, subsystems and components that improve the system efficiency and reduce cost (SHTA, 1996; GEFF, 2009; and Malin, Nadav, and Alex, 2000).

There is unlikely to be a potentially larger mitigating effect on greenhouse gas emissions and the resulting global warming impact of buildings from any other current, market-available single technology, than from ground-source heat pumps. Over its first year of operation, the ground source heat pump system has provided 91.7% of the total heating requirement of the building and 55.3% of the domestic water-heating requirement, although only sized to meet half the design-heating load. The heat pump has operated reliably and its performance appears to be at least as good as its specification (Breembroek, 1998; Breembroek, and Lazáro, 1998; Van De Venn, 1999; Sanner, 1999; Rybach, and Wilhelm, 1999; Anderson, 1998; and Eklöf, and Gehlin, 1996).

The system has a measured annual performance factor of 3.16. The occupants are pleased with the comfort levels achieved and find the system quiet and unobtrusive. The heat pump is mounted in a cupboard under the stairs and does not reduce the useful space in the house, and there are no visible signs of the installation externally (no flue, vents, etc.). The ground source heat pump system is responsible for lower CO_2 emissions than alternative heating systems (the emission figures for an all-electric system and oil- or gas-fired boilers are given in table 4). For example, compared with a gas-condensing boiler, the heat pump system resulted in 15% lower CO_2 emissions (assuming a CO_2 emission factor for electricity of 0.46 kg/kWh). When compared with a new oil-fired boiler system or an all-electric system, the emissions of CO_2 are cut by over 40% and nearly 60% respectively. Annual fuel costs, based on the fuel prices and are about 10% higher than those for a gas condensing boiler and about 20% higher than for a new regular oil boiler, but servicing costs are likely to be lower. Running costs are substantially cheaper than for an all-electric heating system.

At present, suitable products are not readily available in the UK, so the heat pump had to be imported. This had some drawbacks, e.g., limited documentation in English and possible difficulty in obtaining spare parts. The controller supplied with the heat pump was not designed for use with an Economy 7 type tariff structure. There is however potential to improve the operation of the system by scheduling more of the space and water heating duty during the reduced tariff period. The performance of the heat pump system could also be improved by eliminating unnecessary running of the integral distribution pump. It is estimated that reducing the running time of this pump, which currently runs virtually continuously, would increase the overall performance factor to 3.43. This would improve both the economics and the environmental performance of the system.

More generally, there is still potential for improvement in the performance of heat pumps, and seasonal efficiencies for ground source heat pumps of 4.0 are already being achieved. It is also likely that unit costs will fall as production volumes increase (Sanner, 1995; Rybach, and Hopkirk, 1995; Omer, 2008a; Omer, 2008b; Omer, 2008c; and Omer, 2009). By comparison, there is little scope to further improve the efficiency of gas- or oil-fired boilers.

Conclusions

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

The results of soil properties investigation have also demonstrated that the moisture content of the soil has a significant effect on its thermal properties. When water replaces the air between particles it reduces the contact resistance. Consequently, the thermal conductivity varied from 0.25 W/m/K for dry soil to 2.5 W/m/K for wet soil. However, the thermal conductivity was relatively constant above a specific moisture threshold. In fact, where the water table is high and cooling loads are moderate, the moisture content is unlikely to drop below the critical level. In Nottingham, where the present study was conducted, soils are likely to be damp for much of the time.

Hence, thermal instability is unlikely to be a problem. Nevertheless, when heat is extracted, there will be a migration of moisture by diffusion towards the heat exchanger and hence the thermal conductivity will increase. ■

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Welcome To
Dairy Tech India 2015

A new study reports that the demand for milk in India will rise by a compound annual growth rate of about 4% over the next few years…

Dairy is a vital part of the global food system, providing economic, nutritional and social benefits to a large proportion of the world`s population. The Indian dairy sector is estimated to be worth Rs.3.6 lakh crore, according to the Department of Animal Husbandry, Dairy & Fisheries, Ministry of Agriculture, Govt. of India. Indian Dairy sector has grown substantially over the years. As a result India ranks first among the world`s milk producing nations, achieving an annual output of 132.4 millions of milk during 2012-13. The production during 2013-14 was 139 million tons over the previous year. Demand of the dairy products in India has increased dramatically in both rural and urban sectors. Also, as a larger population is migrating from rural areas to cities, the demand for milk –based product in cities is showing an ever-growing trend.

Indian policy makers and planners always believed that the Indian dairy industry has huge untapped potential – as it has the largest animal herd in the world. India produces around 17% of world`s total milk production from more than 300 million cattle. The 14 major milk producing States of Andhra Pradesh, Bihar, Gujarat, Haryana, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh and West Bengal accounted for over 90% of country`s milk production, having 87% of breedable cattle and buffalo population with 98% of the fodder resources.

Organized retail selling of value-added dairy products and the food service management has helped the sector grow. Thus, the growth of food and coffee chains such as Café coffee Day, Pizza Hut, Dominos, KFC and McDonald`s are expected to help increase the consumption of value-added dairy products. In the short run, India`s dairy sector is well positioned to accommodate the rapid growth in dairy product consumption. An increasingly urbanized population with a greater income will drive demand.

Government of India's initiatives

The Government of India gave an administrative approval to the plan (National Dairy Plan) on March 16, 2012. The National Dairy plan phase I (2011-12 to 2016-17 is a World Bank assisted Central Sector Scheme of Government of India with an outlay of Rs. 2242 crore implemented by the National Dairy Development Board through End Implementing Agencies (EIA). It is a scientifically planned multi state initiative to increase the productivity of milch animals and thereby, increase milk production to meet rapidly growing demand of milk. The objects are to increase the productivity of milch animals and thereby increase milk production, provide rural milk producers with greater access to the organized milk processing sector by strengthening and expanding milk procurement system at the village level.

The exhibition will be an opportunity for stake holders of Animal Farming, Dairy Industry & Allied activities who want to expand and/or diversify their business activities...

Ministry of Food Processing Industries also has its own programmes targeting to increase the dairy processing and value added products in the country. In the fast changing world scenario and increasing competition, there is need to exploit the available resources to the maximum level and to use the best technologies, to cope up with the rising domestic demand for dairy products and to target export markets to become "A Food Factory to the World."

DairyTech India 2015

DairyTech India 2015 exhibition will, therefore, be an opportunity for stake holders of every segment of Animal Farming, Dairy Industry & Allied activities who want to expand and/or diversify their business activities. The Netherlands, Turkey, Germany, Taiwan, Bulgaria and China will be the FOCUS Countries of the exhibition.

Concurrently 4th Edition of "International Poultry & Livestock Expo 2015", an International exhibition on Poultry, Livestock and Technologies along with 2nd edition of MeatTech Asia 2015, 7th edition of India Foodex 2015 and AgriTech India 2015 will also be held for the benefit of all visitors. ■

Indoor Air Quality

Indoor air pollution in developing nations is the most deadly risk globally. Estimates indicate approximately 2.2 to 2.5 million deaths occurring annually is a result of high levels of exposure to particulate matters. The majority of deaths occur in the developing nations…

Indoor Air Quality (IAQ) or Indoor Air Pollution refers to the Air Quality within and around buildings and premises used for residential, commercial or factory premises and its surroundings – especially as it relates to the health and comfort of its occupants. IAQ can be affected by gases (including carbon monoxide, carbon dioxide, radon, volatile organic compounds that include but are not limited from sources such as smoke, toxic gases, kerosene fumes, unvented and malfunctioning furnaces & stoves, building materials such as paint, furnishings, pollen, varnish etc. personal care products), particulates, microbial contaminants (mold formed due to humidity, bacteria), or any mass or energy stressor that can induce adverse health conditions. Ventilation, filtration and control of source are the primary ways to dilute contaminants for improvement of Indoor Air Quality in most occupied premises. Residential units can further improve indoor air quality by routine cleaning of carpets and area rugs. Cleaning based on traffic, number of household members, pets, children and smokers usually help create a framework guidance for IAQ improvement. Carpets and rugs act like an air filter and must be cleaned.

Determination of IAQ involves the collection of air samples, monitoring human exposure to pollutants, collection of samples on building surfaces, and computer modelling of air flow inside buildings.

IAQ is part of Indoor Environmental Quality (IEQ), which includes IAQ as well as other psychological and physical aspects of life indoors (e.g., lighting, visual quality, acoustics, and thermal comfort).

Fig. 2: A common air filter, being cleaned with a vacuum cleaner...

(Picture courtesy: environmentmasters.com)

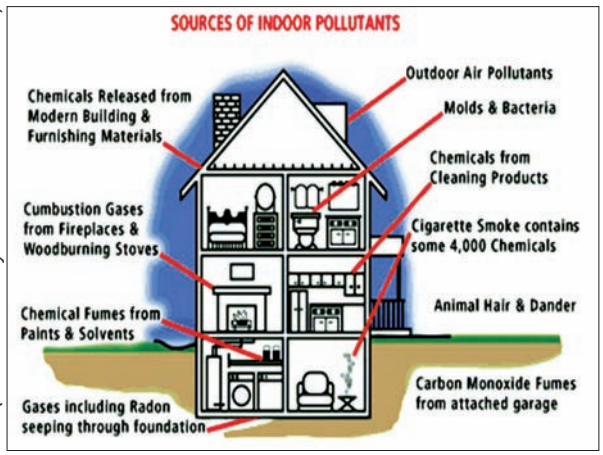

Fig. 1: shows sources of Indoor Air Pollution...

Indoor air pollution in developing nations is the most deadly risk globally. A major source of indoor air pollution in developing countries is the burning of wood, charcoal, dung, or crop residue for heating and cooking. Estimates indicate approximately 2.2 – 2.5 million deaths occurring annually as a resultant to such high levels of exposure to particulate matter. The majority of deaths occur in the developing nations.

A way of quantitatively ensuring the IAQ is by the frequency of effective turnover of inside air by replacing it with outside air. In the UK, for example, classrooms are required to have 2.5 outdoor air changes per hour. In gymnasiums, physiotherapy spaces and restaurants & dining areas, the ventilation should be sufficient to limit carbon dioxide to 1,500 ppm. In the US, and according to ASHRAE Standards, ventilation in classrooms is based on the amount of outdoor air per occupant plus the amount of outdoor air per unit of floor area, not air changes per hour. Since carbon dioxide indoors comes from occupants and outdoor air, the adequacy of ventilation per occupant is indicated by the concentration indoors minus the concentration outdoors. The value of 615 ppm above the outdoor concentration indicates approximately 15 cubic feet per minute of outdoor air per adult occupant doing sedentary office work where outdoor air contains 385 ppm, the current global average atmospheric CO_2 concentration.

In classrooms, the requirements in the ASHRAE standard 62.1, Ventilation for Acceptable IAQ, would typically result in about 3 air changes per hour, depending on the occupant density. Here as we now know the occupants aren't the only source of pollutants, so outdoor air ventilation may need to be higher when unusual or strong sources of pollution exist indoors.

When outdoor air is polluted, then bringing in more outdoor air can actually worsen the overall quality of the indoor air and exacerbate some occupant symptoms related to outdoor air pollution. Generally, outdoor country air is better than indoor city air. Exhaust gas leakages can occur from furnace metal exhaust pipes that lead to the chimney – when there are leaks in the pipe and the pipe gas flow area diameter has been reduced.

Fig. 3A: shows an Indoor Air Quality Sensor (VOC)...

Courtesy: Telaire

Fig. 3B: Shows CO_2 RH Temperature...

Moisture management and humidity control requires operating HVAC systems as designed. Moisture management and humidity control may conflict with efforts to try to optimise the operation to conserve energy. For example, Moisture management and humidity control requires systems to be set to supply Make Up Air at lower temperatures (design levels), instead of the higher temperatures sometimes used to conserve energy in cooling-dominated climate conditions. However, for most of the places where during the majority of hours of the year, outdoor air temperatures are cool enough that the air does not need further cooling to provide thermal comfort indoors. However, high humidity outdoors create the need for careful attention to humidity levels indoors. High humidities give rise to mold growth and moisture indoors is associated with a higher prevalence of occupant respiratory problems.

The 'dew point temperature' is an absolute measure of the moisture in air. Some facilities are being designed with the design dew points in the lower 10's °C, and some in the upper and lower 4,5's °C. Some facilities are being designed using desiccant wheels with gas fired heater to dry out the wheel enough to get the required dew points. On those systems, after the moisture is removed from the make

Courtesy: Telaire NDIR DEW point sensor

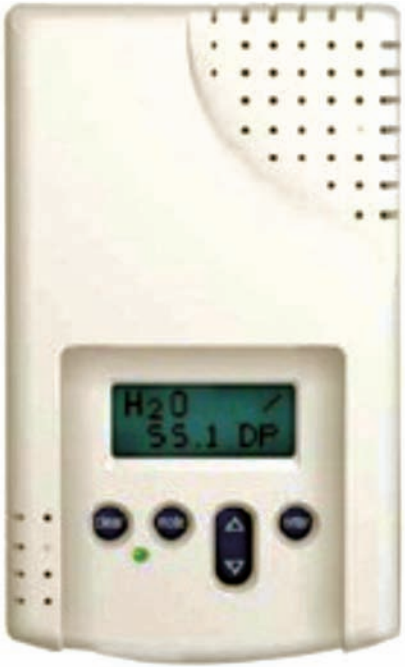

Fig. 4: Shows a Dewpoint Sensor used for moisture removal/ prevention of mold formation...

up air, a cooling coil is used to lower the temperature to the desired level.

Commercial buildings, and sometimes residential, are often kept under slightly positive air pressure relative to the outdoors to reduce infiltration. Limiting infiltration helps with moisture management and humidity control.

Dilution of indoor pollutants with outdoor air is effective to the extent that outdoor air is free of harmful pollutants. Ozone in outdoor air occurs indoors at reduced concentrations because ozone is highly reactive with many chemicals found indoors. The products of the reactions between ozone and many common indoor pollutants include organic compounds that may be more odorous, irritating, or toxic than those from which they are formed. Recent research has shown that mortality and morbidity increase in the general population during periods of higher outdoor ozone and that the threshold for this effect is around 20 parts per billion (ppb).

Institutional program

A variety of scientists work in the field of indoor air quality including chemists, physicists, mechanical engineers, biologists, bacteriologists and computer scientists. Some of these professionals are certified by organisations such as the American Industrial Hygiene Association, the American Indoor Air Quality Council and the Indoor Environmental Air Quality Council.

On the international level, the International Society of Indoor Air Quality and Climate (ISIAQ), formed in 1991, organises two major conferences, the Indoor Air and the Healthy Buildings series. ISIAQ's journal Indoor Air is published 6 times a year and contains peer-reviewed scientific papers with an emphasis on interdisciplinary studies including exposure measurements, modeling, & health outcomes.

In our country, the IAQ awareness is not as high as is in the developed world nevertheless it is not very less as agencies like ISHRAE, ASHRAE, certain NGOs. We are also aware that IAQ is also related to cleanliness with the advent of our Prime Minister's Clean India Campaign (Swachh Bharat Abhiyan) I am sure the awareness for cleanliness and in turn IAQ will be more high and widespread. ■

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Old Versus New – Whether To Repair or Replace

- Pruthvi Dhamdhere

In today's economic scenario, with growing inflation and with the prices of almost everything rising with the tide, managing expenses is more important than having time to enjoy your life. Even with the job that one has, managing a house is not easy. But the situation is such that in major metros like Mumbai, one cannot live without an air conditioning system or cooler.

The rising temperatures (even during winters) and abrupt climatic changes cause various health problems. The HVAC systems use coolants which release green house gases into the atmosphere. Green house gases lead to global warming, which is something that cannot be ignored. So the major question that one has to consider is whether to repair their Air Conditioning units or whether to replace them.

If the unit is older than 7-8 years, it's time to buy a new one. The physical life of a HVAC system is longer than the economic life. Like many other commodities like television or computers, they also long. After the end of its economic life, these units if maintained properly, might still function properly. But there are many factors which come into play here:

- Even if they are working, their output is reduced
- They may not be as energy efficient as they used to be
- The cost of maintenance over the entire period becomes relatively large
- All the added benefits at the time of purchase are long gone.

One of the major things that need to be considered is 'The Rising Cost of Fuel', which leads to rising cost of per unit of electricity that you consume. With more money being paid due to the low output of old HVAC system, is it really viable to continue using them?

On the other hand, the new units would be energy efficient, compact, will provide better output, longer life period and have higher star ratings. The new units would also reduce your costs and provide your better returns in the payback period. This will happen because of the technological trend which provides with better drivers and chips for the internal systems. ■

Ice chamber for testing anti-icing coatings © Fraunhofer IFAM

Anti-Icing Tests To Be Done At Fraunhofer IFAM

The opening of the 90 cubic meter ice laboratory with integrated icing wind tunnel at Fraunhofer IFAM in Bremen was held in presence of a scientific colloquium. Fraunhofer Institute for Manufacturing Technology and Advanced Materials IFAM's Paint/Lacquer Technology Department has reached a huge milestone for testing anti-icing coatings and innovative deicing technologies. Fraunhofer IFAM researchers and their project partners from industry and R&D organizations will now be able to test anti-icing systems under realistic conditions at temperatures down to minus 30^{0}Celsius and at wind speeds of up to 350 kilometers per hour.

Preventing ice forming on surfaces is a major challenge. For aircraft, ships, rail vehicles, cars, air-conditioning systems, refrigeration units, and wind turbines – ice formation often endangers safety and also incurs high costs. Intensive R&D is underway to develop ever more effective technologies for preventing the formation and adhesive of ice on technical surfaces. Fraunhofer IFAM is investigating a variety of solution-oriented approaches and for minimizing ice formation. These include, for example, heatable coatings and their integration into a total coating concept. The heatable coatings are suitable for all uses and can be applied using conventional spraying methods, meaning that even components with very complex geometry can be rapidly and efficiently coated. Highly promising results have also been obtained for hydrophobic, namely water-repelling, coatings that make ice adhesion more difficult. Nanostructured surfaces and the direct integration of freezing point depressors into the coatings themselves are other anti-icing strategies that are being pursued.

All these anti-icing concepts are undergoing thorough testing. The icing wind tunnel is equipped with special control and monitoring equipment: To get defined ice formation the water injection and air humidity can be precisely controlled. An infrared camera simultaneously records the icing process and the heat distribution on the surfaces. The new test laboratory with icing wind tunnel will facilitate ongoing and future R&D projects and will be used for fundamental research work, ice adhesion tests, and the investigation of surface icing by snow, rain, and super cooled water droplets. ■

Why To Spend More On Energy Costs Of Refrigeration Systems?

In order to achieve or realise an effective cost reduction, a concerted, properly planned effort is required on the part of an organization. It is generally noted that a new project undergoes an intensive scrutiny as far as the capital cost is concerned – but a little attention is paid to the future cost of running the plant.....

The ever increasing energy cost has indeed been pushing the industry to look for energy saving methods. Refrigeration system owners too are keen to use appropriate methods to save energy – since it constitutes a major running cost. As a commitment, the refrigeration system users too are committed to a smaller carbon foot print, which has assumed a greater significance. The energy cost of refrigeration system of a typical super market, for example, constitutes about 60 to 70% of total running cost. And therefore in such a case, the energy cost saving can add to the bottom line of the owner.

In order to achieve or realise an effective cost reduction, a concerted, properly planned effort is required on the part of an organization. It is generally noted that a new project undergoes an intensive scrutiny as far as the capital cost is concerned – but a little attention is paid to the future cost of running the plant.

In a scenario like this, at times the buyer ends up with old technology products that are not very energy efficient. Besides, the auxiliary system equipment like cooling tower, condenser water pumps, piping installation need careful attention, and so does the post commissioning maintenance to realize the benefits of energy efficiency. All in all, a careful equipment selection, its proper installation and maintenance are the hallmarks of a good system.

There is a great scope for improving the energy efficiency of refrigeration systems. In addition to the reduction of energy costs, it has the added benefit of increasing the reliability and reducing service and downtime costs throughout the plant`s life. The energy saving steps will vary from application to application, however, an attempt is made here to generalize steps, which would lead to energy cost reduction in refrigeration systems.

Key points are summarised for better understanding. These are as under :

Evaporator performance is governed by

- the temperature difference between the medium being cooled & suction saturation temperature (refrigerant temperature) in evaporator. The higher the temp difference, greater will be the heat transfer
- size & design of evaporator.

> *"The energy cost of refrigeration system of a typical super market, for example, constitutes about 60 to 70% of total running cost...*

Condenser capacity is affected by

- Cooling medium
- Size and design of condenser

Compressor capacity is affected due to

- Compressor size or simply displacement in metre cube per hour.
- Compression ratio
- Temperature of vapour entering the compressor
- Refrigerant characteristics.

Thumb rules

- An increase in evaporator temperature by 1 deg C results in an increase of compressor COP by about 2 to 4%
- A decrease in condensing temperature by 1 deg C also has a positive effect on COP which improves by 2 to 4%

Evaporator efficiency issues

In order to maintain higher evaporator efficiency, evaporator temperature should be as high as possible. Use of a larger evaporator can achieve this but in addition

- keep away dirt & slime on evaporator coil surface.
- Clean regularly (in shell & tube evaporators), scale, corrosion & deposits of dust/foreign particles.
- Carry out regular maintenance of equipment (water circulating pumps/ blowers) which circulate cooling medium.
- Always keep oil out of evaporator, it lowers efficiency & COP of system
- Abnormal superheat.

Compressor efficiency issues

Operation on an in-built capacity control should be avoided or minimised wherever possible. Methods to achieve this are:

- Avoid single large capacity compressor
- Select compressors in such a combination that it avoids a need to operate one or more compressors on capacity control
- On multiple compressor applications, attempt to minimise the use of compressors on capacity control. Example, do not design a system whereby two compressors operate on 50% capacity simultaneously. Rather operate one compressor on 100% load.

Condenser efficiency issues

Three different types of condensers are used in refrigeration system; each of these have been associated with energy consumption. The energy should be accounted.

- Air-cooled: Fan consumes the energy
- Water-cooled: Condenser water pump, cooling tower
- Evaporative condenser: Fan and water pump.

Larger surface area of condenser contributes to lowering the condensing temperature closer to the temperature of cooling medium. This results in lower energy consumption.

Heat transfer of all condenser types reduces, if these are contaminated/ fouled

- Air-cooled condenser space between fins should be free of debris, dirt and be in a clean condition always
- in water-cooled condensers, tubes should be free of fouling by dirt, scale, corrosion etc.
- non-condensable gas, air in system increase the condensing pressures and lower the efficiency.
- Condensing pressure should be allowed to float with ambient temperature to take advantage of the lower ambient temperature at night and in winter time. However, this results in drastic drop in pressure ratio, which can cause system problems with commonly used expansion valves. Under such a condition, an electronic expansion valve or balanced port types are suggested. Or alternatively, raise the condensing pressure to maintain a healthy pressure ratio to operate effectively the selected expansion valve.

Expansion devices efficiency issues

- Capillary tube / orifice plates : In refrigeration systems , refrigerant quantity circulated in an evaporator is critical for system capacity & efficiency. If a capillary tube is damaged or partly blocked, it will control the system correctly and the efficiency will reduce.

- TEX Valve: Superheat setting has a significant effect on efficiency and system reliability
- Low super heat will return liquid refrigerant to compressor leading to compressor breakdown
- High super heat will reduce the system efficiency
- TEX Valves do not control well over a wide range of pressure difference across it.

Issues related to refrigerant

- Types of refrigerant can affect the efficiency of a system by about 10%
- The relative performance & efficiency of a refrigerant is affected by the type of compressor and operating conditions
- Charge of refrigerant should be optimum
- Systems should be free of leaks
- Contamination of refrigerant with air,N_2 will result in lower system efficiency.

Common efficiency issues

The following golden rules apply for all systems:

- The design & selection of condensers: These should be sized to maintain practically lowest discharge pressures
- Evaporators: Should be sized such as to maintain practically highest effective evaporation temperatures
- Suction line should be insulated
- System should be charged with optimum quantity of refrigerant and system should be leak free
- Defrost evaporator as & when necessary.

Over and above, a few simple things as mentioned below will contribute to saving the energy cost substantially.

- Replace redundant old technology power consuming compressors, inefficient condensers and evaporators
- Electrical power wiring too is a culprit example; loose wire connections, partly burnt- out cable/loose lugs, un-balanced voltage, switch gear contacts with a carbon layer, dust in the switch gear box, undersized cables etc. These issues contribute to the power leakage and entail extra energy consumption and results in additional energy cost.
- Avoid frequent start stops of the plant since locked-rotor current would weaken motor windings.
- Implement preventive plant maintenance practices
- Replace/rebuild old cooling water treatment units & in-efficient cooling towers
- Only trained manpower should operate the plant machinery
- Limit outsourcing of technical manpower to only non-essential items
- Install variable frequency drive units preferably on refrigeration compressors since it typically consumes about 50 to 60% of the total refrigeration system power
- Carryout regular leak check of system & correct it, if found
- Maintain cooling tower, condenser since condenser is a major source of energy leak. The compressor energy consumption rises rapidly concurrently with increase in head pressure
- Monitor de-frost cycles in case of low temp cold storage
- Avoid frequent door openings and monitor insulation of refrigeration piping for any damages/leakage
- In AC plants, control infiltration load, if that is resulting in energy consumption, look for gasket leaks on ducting, slipping belts of AHU fan, check for cooling tower nozzles and fan for proper function, maintain tower hygiene.

The above suggestions are indicative, and individual system will need appropriate maintenance checks and schedule. ■

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(formerly Bock India Pvt Ltd)

Expansion valves introduced by Danfoss

At the 2015 AHR Expo in Chicago, Danfoss introduced its new ETS Colibri electronic expansion valves. Thanks to its compact and in-line design, ETS Colibri easily fits almost anywhere in the system. The hermetic body incorporates less complexity with fewer parts, which guarantees uncompromised integrity of internal components and fewer potential leak points in the system. The valves' capsule design includes a balanced cage and slider assembly driven by stepper motor technology. This ensures solenoid tight shut-off in both flow directions, thus helping to achieve smooth operation of the system.

Features and Benefits

- Linear opening and closing characteristic
- Fast open/close time
- Direct drive motor technology
- Stainless steel valve body and balanced cage design
- Solenoid tight seal
- Sight glass with moisture indicator. ■

Website: www.danfoss.com

Gas Cooler Valves Released by Parker Sporlan

A new range of gas cooler valves has been released by Sporlan division of Parker Hannifin Corporation. These valves are rated 140 bar for transcritical CO_2 (R-744) high pressure systems. The product range is designed to satisfy equipment manufacturers' control needs in the field of CO_2 transcritical systems using a high pressure flash tank. The line features five Gas Cooler valves (GC-10,-20, -30, -40, and -50) for system capacities from 7 to 200 Ton (25 to 700 kW). The gas cooler valves allow for fine pressure tuning in transcritical operation. The gas cooler valves can also be applied in heat reclaim applications to modulate the flow to subsequent reclaim coils. Systems will benefit from the high resolution actuators — and rapid full stroke actuation, in addition to excellent full range flow control. Synthetic seats are utilized for tight seating capability. ■

Website: www.parker.com

Automated ball valve package – Series 22

A-T Controls' Triac Series 22, 2-Piece Direct Mount Automated Ball Valves feature a high quality investment cast body and end. They are available in sizes from 1/4" to 3". Superior leak protection is accomplished by using "Pyramidal" stem seal system. This advanced system protects against wear and leakage experienced by other ball valves.

Features

- Available 1/4" – 3"
- Full Port Valve
- Direct Actuator Mount
- 800-1000 psi WOG
- NACE MR-0175
- 2-Piece High Cycle Design
- 316SS Body, Ball and Stem
- Pyramidal Stem Seal Packing System
- Blowout Proof Stem
- ISO 5211 Mounting
- Locking Handle Standard. ■

Website: www.a-tcontrols.com

Wi-Stat IIIe - New Generation Wireless/Standalone Thermostat

Wi-Stat IIIe is the 3rd generation wireless/standalone electric thermostat released by Millennial Net. Wi-Stat IIIe replaces existing manual, analog or programmable thermostats and can support most single or dual-stage conventional heating and cooling as well as heat pump systems. It is designed for easy retrofit to existing HVAC infrastructures without disruptive and expensive rewiring.

"The Wi-Stat IIIe truly stands out in a slew of networked thermostats. It is not another Wi-Fi thermostat - Wi-Stat IIIe communicates via extremely robust and already proven Meshscape wireless mesh technology and can be easily deployed in large, multi-story buildings or can be used as your regular programmable thermostat," said Sheng Liu, President and CEO of Millennial Net. ■

Website: www.millennialnet.com

Hansen hot oil temperature valve

The Hansen Oil Temperature Valve is a 3 -way mixing valve used to accurately control the oil temperature of screw compressors or other oil-cooling circuits within appropriate design parameters. The internal thermostatic element modulates to maintain a near constant temperature at the outlet of the valve. As oil and refrigerant are circulated through the screw compressor, the oil is heated. The hot oil is fed to the valve and it is also fed to a heat exchanger, which provides cold oil to the opposite side of the valve. The thermostatic element modulates the flow of oil from the cold oil port and the hot oil port to maintain the nominal temperature setting at the outlet.

Advantages and Key Features

- Easy to service-the valve can stay inline Durable Teflon sliding seal is compatible with most refrigerants, oils, and temperatures
- Suitable for mixing or diverting applications
- Low pressure drop
- Thermostatic element is stainless steel with a plated sensing bulb
- Suitable for oils operating with ammonia, R22, R134a
- Rugged, all-steel construction, weld ends and other compatible refrigerants. ■

Website: www.hantech.com

Tighter control of residential energy consumption

EcoNet, a smart technology that will efficiently manage 65 percent of a home's energy consumption has been introduced by Rheem. EcoNet is a system to connect a home's heating, cooling, and water heating systems through a central hub, making it easy for homeowners to conveniently manage energy usage and monitor diagnostics and maintenance schedules. The system uses a home's existing WiFi connection to locate and link all compatible Rheem air and water products. Homeowners can then securely control these products through the free EcoNet mobile app on smartphones or tablets or a control center mounted in their home. The EcoNet smart thermostat is a wall-mounted 4.7" touch screen that has many of the same features of a traditional programmable thermostat - allowing homeowners to regulate temperature, change settings, program schedules – as well as smart features such as automated service alerts and reminders. ■

Website: www.rheem.com

4-Way Reversing Valves

The RANCO brand of Eliwell offers Type LDK and LDL solenoid coils for use with the entire range of RANCO Heat Pump Reversing Valves. These colour coded epoxy encapsulated, continuous duty, moisture resistant magnetic coils are designed to operate the pilot valve controlling the RANCO Reversing Valves. The 4-way Reversing Valve is the key component to provide Heating and Cooling from the system to the air conditioned space by reversing the flow direction of refrigerant.

Advantages

- It is used at room air conditioners, packaged and central air conditioners
- The reversing Valves are designed for Heat Pump Systems with capacity from 3kW to 580kW
- They are suitable for most refrigerants as R407C - R410A - R134A. ■

Website: www.eliwell.it

Infinity remote access touch control

The Infinity Touch control is the key to unlocking comfort potential. It's also the brains behind a Greenspeed intelligence system. As part of a complete Infinity, communicating system, this one control can manage temperatures, humidity, ventilation, airflow, indoor air quality and up to eight zones. It offers features that fit your lifestyle like easy, touch screen settings, filter replacement reminders and system diagnostics that make it our most user-friendly control. Energy-conscious features like advanced smart setback, Touch-N-Go program adjustments, energy-use tracking capability and Greenspeed intelligence system management also make it most energy-wise control ever.

Standard Features

- Real-time energy use tracking
- Ideal Humidity System management capable for exacting comfort
- Hybrid Heat system management capable
- Intelligent, heating- and cooling-comfort staging capable
- Auto changeover between heating and cooling
- Monitors indoor air quality products
- ComfortFan technology capable with four levels of "constant ON" fan speeds
- Ventilation management capable. ■

Website: www.carrier.com

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Sustainability leads to super hospitals

Sustainability is increasingly playing a greater role in both new builds and renovations...

Denmark-based Grontmij is a company that has a considerable track record in delivering sustainable buildings, both in Europe and across the globe. Søren Larsen, Country Managing Director in Denmark says, 'Sustainability is increasingly playing a greater role in both new builds and renovations. Hospitals, such as Rigshospitalet and other hospital projects that we are working on – within Europe, represent a very specific challenge. These are complex, high-energy consumption buildings with a wide range of technical requirements. The environment requires high-tech solutions for ventilation, light, energy, handling of highly contaminated waste and logistics. Moreover, they must provide a comfortable and pleasant environment for people to recover in, to work in and to visit. All these requirements must be integrated and fully compatible. The fact that this is the second 'super' hospital in Denmark that will be using Grontmij's expertise is a clear recognition of our skills in designing smart buildings.' ■

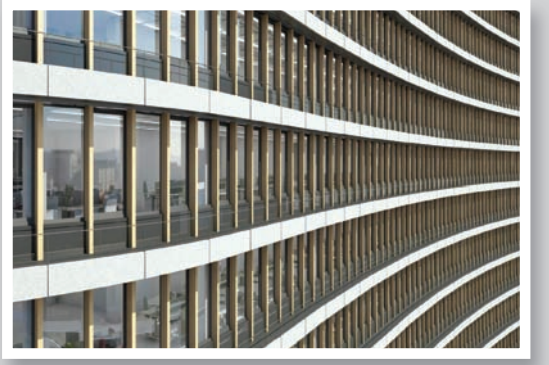
CO_2 emissions reduced in Denmark

SuperBrugsen is making a difference for the environment by sending surplus heat to the district heating networks. This is significant because heat recovery reduces the impact of CO_2 emissions on the environment.

SuperBrugsen in Høruphav already saves more than DKK 200,000 annually on gas and reduces CO_2 emissions by 34% by utilising the surplus heat from the refrigeration system to heat tap water for cleaning, among other things, and with the new district heating connection, SuperBrugsen has one more source of income, namely by selling district heating to the Sønderborg District Heating consumers. "SuperBrugsen has an environment-friendly solution, which matches their green profile very well, with heat recovery and solar cells on the roof, and on top of this, the investment is paid for within 12 months only," says Danfoss engineer Torben Green, who is part of the project team behind the development of the solution in Høruphav. ■

SuperBrugsen has an environment-friendly solution, which matches their green profile very well...

Enterprise office center is environment friendly



Up to a 1/4 th of the cost of cooling will be saved by the external blinds installed on all windows...

At 50 meters above ground, the modern Enterprise Office Center in Prague 4 - Pankrác has reached its highest point, the top of the roof. The project is expected to complete in the last quater of this year. The building, like other Immorent buildings, has been designed with a view to sustainability, the development of a pleasant work environment, respect for the area, and energy savings. It has been pre-certified and received the prestigious BREEAM Excellent certificate.

Up to a quarter of the cost of cooling will be saved by the external blinds installed on all windows, allowing for individual regulation of shading and direct sunshine, that prevent heat from entering the building. The large glass areas also cut lighting costs by 15%. Heat pumps located on the roof of the building improve the efficiency of heating and save up to a fifth of heating costs. Energy consumption is monitored by an electronic building management system that makes it possible to optimise the building's operating costs. Aggregate savings on energy costs compared to other buildings of a comparable size are up to 25%.

"There is lots of light everywhere, and the roof of the western wing offers a shady garden and terraces that lend themselves to other uses," said architect Vladimír Krátký, who worked both on the architectural and design aspects of the building. ■

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MACHINE-TO-MACHINE SOLUTIONS
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