Cooling and Heating Energy Savings Using Airius Air Pear Destratification and Air Circulation Fans in an HVAC Environment in Temperate and Sub Tropical zones.
HAP Software Analysis.
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12.1.15 V1/11

Executive Summary

Thermal Equalisation and air circulation has been proven worldwide to be effective in saving energy in most types of conditioned buildings, primarily in the heating and cooling climate of the northern hemisphere.
The application of destratification and air circulation as a simple, cost effective, energy saving solution for air conditioned buildings in the southern hemisphere where the climate is temperate or sub-tropical has not been considered or understood until the last couple of years.

However, the recent use of thermal equalisation in conditioned buildings such as retail precincts, schools, manufacturing plants, cold stores, warehouses and offices using products such as the Airius Air Pear Thermal Equalizer® fans in Sydney, Melbourne, Brisbane and Auckland has provided some significant energy saving outcomes (Major retailer achieves 22% average saving in Melbourne) during the very hot summer of 2012-2013. Energy Savings and short 'Returns on Investment' in cooling and heating mode from the use of Airius Air Pear destratification fans can be extrapolated to all summer periods in a range of locations in Australasia.

This report has been commissioned by Airius Oceania P/L to help mechanical engineers and our other customers understand the efficacy of thermal destratification and air circulation in conditioned spaces (in the temperate and sub-tropical climate) as an acceptable and proven simple technology to significantly reduce HVAC energy usage in the cooling and heating months across a year. In addition user comfort is significantly improved due to the gentle air movement from Airius Air Pear units across the skin creating evaporative cooling. It is this gentle air movement capability in summer that facilitates the increase in cooling set point temperatures in air conditioned buildings.

Outcomes of the software Hourly Analysis Protocol (HAP) (HAP 4.8 software by Carrier) modelling in this report in sub-tropical and temperate climates for a 2000 sq. metre 4 metre high retail space using a water cooled HVAC system indicate cooling energy savings of a minimum of 6.3% (Darwin) across the year, for a 2 Deg. C Delta T between floor and ceiling, up to 26.4% cooling energy savings (Melbourne) where the Delta T is 6 Deg. C.

Returns on Investment as low as 15 months in summer cooling applications in Oceania can be achieved.

Heating savings of a minimum of 5.4% in Hobart for a 2 Deg C. Delta T to a maximum of 29% in Sydney with 6 Deg C Delta T have been shown in this analysis.

Real world savings in both cooling and heating have often been shown to be higher than those achieved in the software outcomes here in Oceania as well as overseas.

Research from BSRIA[C] in the UK indicates that One Deg. C temperature increase per metre in height is common inside buildings. In Australia temperature differences of 3 Deg. C every metre in height has been recorded in buildings prior to Air Pear installations that have rectified that issue.

It is important to note that different types of HVAC systems such as air cooled units may show even higher or varied energy savings dependent on climatic location, internal floor to ceiling Delta T as well as the Delta T between dry and wet bulb ambient temperature. Increased Delta T for both internal and ambient external temperatures will result in higher energy savings using destratification in summer.

Nonetheless, even buildings with a Low Delta T floor to ceiling of 0.5 Degrees C will still achieve significant HVAC energy savings.

Further energy savings, above the predicted savings achieved in this software process, can be realised via the use of thermal destratification creating other energy saving opportunities but those are outside the scope of this report.

These include;

- The use of Airius Air Pears to provide thermal comfort during load shedding opportunities in both cooling and heating environments resulting in significant energy savings across a year.
- Accelerated reuse of the chilled air captured by thermal buoyancy up under the ceiling post discharge.
- Increase or decrease of thermal set points as a result of destratification and a range of other energy saving opportunities.
- Use of soft type low velocity ductwork in combination with Airius Air Pears resulting in reduced AHU sizing and energy consumption.

It is important to note that in some cases energy savings of HVAC in summer can reach 35% but the overall yearly average cooling and heating savings have been considered in this report. The outcomes of this analysis are as follows:-

AIRIUS®
saving you energy

Cooling mode:

Note:- The Degrees noted below in the crimson boxes represent the floor to ceiling 'Delta T' .

City	Energy Saving(%)for 2C	Energy Saving(%)for 4C	Energy Saving(%)for 6C
Sydney	8.8	15.6	21.5
Melbourne	14.2	20.2	26.4
Brisbane	9.7	13.0	19.8
Auckland	12.1	19.1	22.3
Adelaide	11.4	16.8	23.2
Canberra	9.4	17.9	22.8
Darwin	6.3	8.8	16.6
Denver	8.9	15.4	22.3
Hobart	12.9	24.5	29.8
London	7.5	12.1	18.6
Perth	6.4	13.7	23.8

Heating Mode:

City	Energy Saving(%)for 2C	Energy Saving(%)for 4C	Energy Saving (%)for 6C
Sydney	7.8	19.0	29.0
Melbourne	8.4	17.1	27.8
Brisbane	9.8	20.8	25.6
Adelaide	7.8	11.8	18.7
Canberra	11.2	17.0	21.2
Hobart	5.4	8.9	13.4
London	8.9	13.6	19.7
Perth	7.3	12.4	18.9

Introduction

The worldwide use of Airius Air Pear destratification fans has been proven to significantly reduce equipment energy consumption in heating environments where the hot air rises to the ceiling and causes the heating system to over deliver on a continual basis in winter. (Carbon Trust UK, BSRIA) Energy savings of 35% of the HVAC system energy have been regularly achieved in heating environments through the use of Airius Air Pear Thermal Equalizer® air turbines. While this use of destratification is also applicable to southern hemisphere locales the impact and value of destratification and optimised air circulation on the HVAC energy use in warm to hot summer conditions and cold conditions in a temperate or subtropical climate has had minimal consideration or review to date.

The intent of this report is to validate the premise that destratification and optimised air circulation will significantly reduce cooling energy in HVAC systems using a fixed internal temperature set point of 23 Deg. C in summer and 20 Deg. C in winter via the use of the latest HVAC design and energy modelling software known as Hourly Analysis Protocol (HAP) 4.8 (By Carrier).

The outcomes of this report provide an average yearly energy saving prediction for both cooling and heating energy in water cooled VAV air conditioned facility. Further energy savings above those identified in this software analysis can be achieved by the inclusion of a range of additional energy savings outcomes achieved by the use of Airius Air Pears such as load shedding opportunities for the HVAC System while maintaining thermal comfort, adjustment of the set points to reflect improved cooling in summer due to increased air flow (Arens et al, 2010; Aynsley, 2009.) and other initiatives linked to the use of thermal destratification and air circulation. That work is outside the scope of this report.

Strategy

In this study, transient (an hourly-based steady state) simulations have been carried out using the Hourly Analysis Program (HAP)[2] Version 4.8, a powerful HVAC and energy analysis software programme designed by Carrier and used worldwide to undertake HVAC system design and related energy consumption analysis of the building and the HVAC system which is installed in that building. In this application it has been used to identify and verify the energy saving potential of the AIRIUS Air Pear Thermal Equalizer® destratification and air circulation fans in a nominated building type across a twelve month period. These simulations have been established for the following southern hemisphere cities using specific dynamic climate data- Sydney, Adelaide, Perth, Darwin, Canberra, Hobart, Melbourne, Brisbane and Auckland, New Zealand.

Methodology

The use of software modelling has limitations and in this application it is utilised to mimic the impact of destratification and optimised air circulation on the HVAC system in a medium sized (2000 sq. mts.) retail store. A range of assumptions are made around the store building fabric, internal loads etc. Please note that while changing the fabric loads etc. will improve the building's heating and cooling loads the impact of those types of changes on the value of destratification are minimal. The energy saving potential in this study has been considered as a function of cooling/heating plant duty cycling. Building cooling/heating loads as a result of increased or decreased insulation levels, glazing performance etc. are important only for sizing the cooling/heating equipment capacity and have a very limited impact on the value of destratification.
A range of data around building fabric and internal heat loads were input into the model to provide the data used for analysis so as to assure the reader that the modelled building complies with the latest Australian NCC building code requirements around energy efficiency.
Dynamic climate data utilised in the Carrier 'HAP' software provides the climatic information needed to provide modelling accuracy and relevance.

The building is initially modelled using the nominated HVAC system (see below) then the software is rerun in the relevant climatic zone but with the destratification temperature differences reduced to zero to show the energy savings achievable.

Airius Air Pear fans

Airius Air Pears are an American designed and manufactured patented Thermal Equalizer® air turbine fan that uses a unique rotor, stator and venturi throat design to propel large volumes of air gently in a non-turbulent manner over long distances using low amounts of energy. Their exclusive design allows them to propel the air in a narrow focused column, minimising air dispersion and turbulence. The narrow column air enables the units to effectively move air from floor to ceiling or wall to wall with minimal disturbance and maximum control over locations and efficacy of air flow. This is achieved with very low amounts of energy. The Airius Air Pear model 15 utilised in this study uses 13 watts of power at 240 volts. Working in concert together the units quickly destratify or circulate air in a space.

Case Study

The case study is a commercial shopping space with a 4 metre high ceiling and a 2,000 square metre floor area. The number and size of Airius Air Pear units has been selected based upon calculations provided by Airius Oceania P/L.
20 off Model 15 Airius Air Pear units have been considered as the destratification source. Each unit consumes 13 watts of power at 240 Volts/50 HZ.

The selected HVAC system for this building is a water-cooled chiller type which provides chilled water of 6 Deg. C for an air-handling (AHU) unit. The AHU fan is a Variable Air Volume (VAV) unit. An occupancy load of 200 people has been considered inside the building. (For more info please refer to the whole report)

All building fabric, lighting loads and HVAC systems for the different locations have been modeled under the 2013 NCC Section 'J' energy efficiency protocols.

Relevant and detailed climatic data for each location has been input into the facility and the examination is based on cooling and heating periods–when cooling or heating is required inside the building.

Temperature Differences

Three temperature differences (floor to ceiling) of 2 Deg. C, 4 Deg. C and 6 Deg. C have been considered for each city in the nominated space.

Occupation levels

Occupation levels are considered as 200 persons in the space. One person per 10 sq.metres.

How Destratification Saves Energy in Warm Climates

The energy saving potential using the destratification strategy is primarily due to reducing the duty cycling of the cooling plant. By destratifying the space the return air temperature to the cooling system in summer is cooler and the preset internal temperatures are held constant for a longer period of time. This causes the chiller

and compressors to shut down for a longer period during the occupied period of the day, start later and turn off earlier resulting in reduced energy consumption. In a conditioned facility the higher the temperature difference between floor and ceiling the greater the energy savings using destratification.
Different systems such as air cooled designs in different climates may result in larger or varied energy savings. Additionally, the greater the difference between ambient dry and wet bulb temperatures results in larger energy savings in hotter and drier climates.

How Destratification Saves Energy in Cold Climates

The energy saving potential using the destratification strategy is primarily due to the duty cycling of the heating plant. By destratifying the space in winter the warm air floating at the roof is bought down to the floor where it is needed. The thermostat is satisfied quicker turning the boiler off for longer. This causes the boiler and AHU to shut down for a longer period during the occupied period of the day, start later and turn off earlier resulting in reduced energy consumption. In a conditioned or heated facility the higher the temperature difference between floor and ceiling the greater the energy savings using destratification.

Limitations

The software doesn’t examine other areas of energy savings or thermal comfort achieved with the use of Airius Air Pear fans such as:-

- Load shedding during high demand charge usage in very hot or cold periods. Using the Air Pears to provide thermal comfort during those periods enables the HVAC System to be turned off for periods of time during the day adding significantly to the energy saving opportunities.
- Reduction and subsequent accelerated use of cold air captured at ceiling discharge level due to thermal buoyancy and heating of the chilled air. Air circulation using the Airius Air Pear fans optimises this energy discharge ensuring the chilled air is bought to the floor more quickly. This stops the over delivery of conditioned air.
- Removal of hot and cold spots in the space.
- Increased summer thermostat setting and decreased winter thermostat setting creating even more energy savings than shown in this report.
- Reduced AHU and fan loads due to the air movement being provided by the Airius Air Pear units.
- Reduced HVAC AHU energy and smaller duct design (less backpressure) if the Airius Air Pears are connected to the HVAC ducts and installed as a substitute powered ceiling register.
- Use of Airius Air Pears in conjunction with low velocity ‘soft ducts’ or SOX enables lower AHU size and velocity requirements.
- Provision of air circulation creating comfort based evaporative cooling.

1- **Outcomes**

The cooling and heating energy saving potentials for these cities using this approach is as follows:

Cooling mode:

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Hobart	5.4	8.9	13.4
London	8.9	13.6	19.7
Perth	7.3	12.4	18.9

A. The Author

Vahid Vakiloroaya.

Vahid has modeled for energy savings and air conditioning design over 150 buildings worldwide using this HAP software. He is an experienced mechanical HVAC engineer designing a range of air conditioning systems.

EDUCATION

2010/Present; PhD

School of Electrical, Mechanical and Mechatronic Systems,

University of Technology, Sydney, Australia

1998-2003 Bachelor of Science in Mechanical Engineering Hons. (1st Class), Iran

EMPLOYMENT

2013-Present Chief Executive Officer -Green HVAC Solution
Sydney, Australia
2010 – 2013 HVAC Designer (Part Time)
A1 Best Air Conditioning Services Pty Ltd
Sydney, Australia
2009 – 2010 Managing Director ASA; Tehran, Iran
2006 – 2009 HVAC Design Manager Sabalan; Tehran, Iran
2004 – 2006 HVAC Design Engineer HITACHI; Tehran, Iran

Awards

Winner of NASSCOM Australia Innovation Student Awards 2013,

"Innovative Hybrid Design of an Energy-Efficient Air-Conditioner Using Supervisory Programmable Logic Controller."

- Winner of UTS Annual Green Hero Award; 2013
- Winner of UTS Research Showcase Innovation Award; 2013
- Highly-Commended Consensus Innovation Awards 2013, "Ultra Cooler."
- Engineer Australia Excellence Awards, 2013 Finalist, IEAust, "Development of a New Eco-Friendly and Energy-Efficient Solar-Powered Single-Effect Hot Water Absorption Air Conditioning System."
- TRAILBLAZER 2012 Finalist, UTS, Uniquest, Davies Collision Cave, Fisher Adams Kelly.
- Winner of the Australian Postgraduate Award (APA) by the Department of Innovation,
- Industry Science and Research in conjunction with Australian Universities, 2010.
- Best Practical HVAC Engineer Award; 2005, Hitachi Co.

Book Chapters

V. Vakiloroaya, J. Madadnia, Cooling Coil Design Improvement for HVAC Energy

Savings and Comfort Enhancement, Sustainability in Energy and Buildings, Springer Berlin Heidelberg, Chapter 85, 965-974, 2013.

Journal Publications

- Author of highly-ranked international journal papers.

Conference Publications

- Author of 20 international conference papers

Book Publications

- Author of 10 books in field of HVAC&R.

Patents

- Name of Invention:
  "Solar Coolant System with the use of Adsorption Process,"
  Invention Registry book No.: 31370, Declaration Registry book No.: 38310227
  Date of Registration: April 05, 2005.

- Name of Invention: "Intelligent Deodorize with the Use of Forward Filtration," Invention Registry book No.: 35848, Declaration Registry book No: 38412068,
  Date of Registration: February 22, 2006.

2. Carrier HAP 4.8 Software

Carrier's Hourly Analysis Program is two powerful tools in one package. HAP provides versatile features for designing HVAC systems for commercial buildings. It also offers powerful energy analysis capabilities for comparing energy consumption and operating costs of design alternatives. By combining both tools in one package significant time savings are achieved. Input data and results from system design calculations can be used directly in energy studies.
http://www.commercial.carrier.com/commercial/hvac/general/1,,CLI1_DIV12_ETI496,00.html

Carrier web site, Accessed 2.12.2013

3. References

A. Arens et al. 2009: 'Moving Air for Comfort' ASHRAE, 2009.
B. Aynsley, R; 2007: 'How Air Movement Saves Energy in Indoor Environments'; Ecolibrium, 2007; AIRAH.
C. BSRIA; https://www.bsria.co.uk/

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