Air Cleaner to Make Up Air in Adverse Thermal and Environmental Conditions

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ABSTRACT

Moisture with salt and small fine sand particle it's harmful when combined in tropical hot climate onto HVAC environment application sites. The concept to urban carbonic island, where carbon dioxide is the pollutant that performs as a chemical marker, responsible for decreasing productivity at air-conditioned environments with uncontrolled indoor gas rates, in addition typical contaminants in both climates indoor environment. The psychometric conditions establish high thermal loads especially from May to August, when temperatures fluctuates between 46°C (115°F) to 30°C (86°F) respectively, while high humidity varies throughout the day from 25% to 82%, a thermal conjuncture challenge. Characterizing pollutants as multimodal, it has particulate matter, marine mist and gas beyond the adverse enthalpic conditions.

Gathered 34 years "know-how" in industrial applications of air pollutants control, using multiventuri liquid centrifugation technology of hydrodynamic precipitator gives us safe ground to develop HVAC technology to make up air for outdoor air applications by the urban air suction for the comfort on HVAC systems or industrial plants, for electrical rooms pressurization, telecommunication centers, data centers and air taken for the turbine combustion processes or polymers pellets pneumatic transfer. Application to remove salt, hydrogen sulfide and decrease high levels of carbon dioxide, demonstrated the high performance of air cleaner based in multiventuri centrifugation technology.

The hydrodynamic precipitator is characterized by associated combination of centrifugal mixing power, the multiventuri effect, which results in gas mixture with mass and energy transfer between gas mixtures with pollutants and cooled liquid neutralization. It's the theory of breadth molecular convergence vibration reached by this concept, becoming compact due to instantaneous removal of contaminants, based on centrifugation technology of two fluids simultaneously.

The reduction of carbonic load through chemical alteration of carbon dioxide in a salt increases the life cycle of conditioned air allowing external air flow reduction, impacting significant decrease of 23% to 28% in energy consumption, as well as guaranteeing indoor air pollution control. The hydrodynamics precipitators are independent units that extract physicochemical pollutants, without the use of mechanical filters, lowering external thermal load for arid and hot climate application. The presence of submicron silica particles which TLV-ACGIH (2012) = 0,025 mg/m³ defines the BADCT (Best Available Demonstrated Control Technology) use ensures high performance for this particles avoiding generating saturation of mechanical filters. This technology is an innovation of external air taken because acts simultaneously in the removal of multimodal contaminants and reduction of thermal load.

INTRODUCTION

Air pollution in industrialized urban centers has experienced a significant increase over the years. The emissions of some of these greenhouse gases are responsible for global warming and destruction of the ozone layer, gaining global leadership. Mobilizations in international meetings like Kyoto, Stockholm, Equator Principles are intended to control emissions and reduce negative impacts on planet earth.

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However, local urban atmosphere also has an impact on selective air-conditioned buildings, considering the circulation cycle in indoor air in buildings which promotes an increase in the concentration of pollutants, particularly carbon dioxide in air conditioned environments that have decreasing oxygen content, liquid consumables by living aerobic and load increment carbonic exhaled by occupants. The location of the undertaking provides more evident the presence of specific contaminants in the region, since concentrations in indoor environments are directly related to the external concentrations, because these pollutants are easily spread from the outside of the buildings through ventilation systems.

Faced with episodes harmful to health, the United States established air quality standards, specifying five pollutants that would be controlled, as shown in Table 1 below:

Table 1. Air Quality Patterns For Principles Pollutants According to the Environmental Protection Agency (EPA) of the United States of America

Pollutants	Primary Standards	Average Time
Particle Matter (PM10)	50 µg/m3 150 µg/m3	Annual arithmetic mean Threshold level for 24 hours
Ozone (O3)	0,12 ppm (235 µg/m3)	Average daily 1 hour maximum
Sulphur Dioxide (SO2)	0,03 ppm (80 µg/m3) 0,14 ppm (365 µg/m3)	Annual arithmetic mean Maximum level in 24 hours
Carbon Monoxide (CO)	9 ppm (10 µg/m3) 35 ppm (40 µg/m3)	Average 8 hours maximum In 1 hour maximum
Nitrogen Dioxide (NO2)	0,053 ppm (100 µg/m3)	Annual arithmetic mean

Hot climates promote gas emissions by reducing vapor pressure of organic substances, and these have resemblances in large urban centers worldwide which have among themselves the same sources as thermoelectric generators, vehicles, power generation, increased by the effects of marine salt in coastal cities as silica dust in desert regions. The gradual increase in population in hot climates regions such as Qatar, is generating an increase of motor vehicles, which becomes visible based on the number of vehicles that has more than doubled in the last 10 years, and emissions from industries, as shown in Figure 1.

The fine particles decreased from 105 to 185 micrograms / m³ in the capital and its surroundings, which is higher than the allowable limit. The concern to keep the air free of these atmospheric pollutants associated with low power consumption for insufflation indoors becomes a challenge, it requires technology capable to capture and store these pollutants.

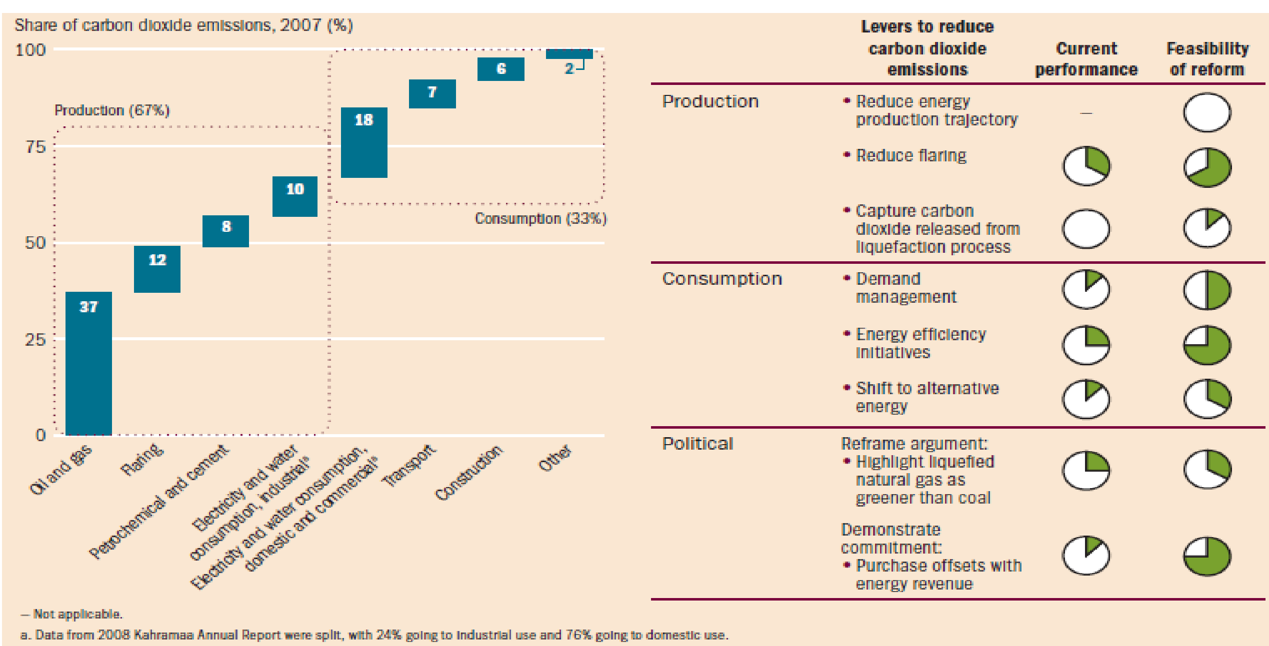

Figure 1 Share of Carbon Dioxide Emission in Qatar. 2007

Special attention should be taken in maximizing energy efficiency using LEED scores over quality air conditioned which is a matter of duty.

Air pollution causes breathing problems, such as asthma, however in indoor environments can cause other types of diseases such as sick building syndrome (SBS) that is when the individual is exposed to high concentrations of carbon dioxide in a given space of time. This syndrome affects rates of absence, performance and health when the concentration of carbon dioxide reaches value up to 2,500 ppm, recent studies have shown that concentrations between 1,000 and 2,500 ppm can also cause consequences in decision making.

High concentrations of carbon dioxide concentrations exceed environmental surroundings as ventilation rate decreases, this concentration difference increases. The typical concentration of CO2 in the air is 380 ppm and can reach values up to 540 ppm in urban centers. Concentration inside buildings can reach higher numbers. The effect of high concentrations of carbon dioxide on people's health is straightforward, but only at concentrations higher than normally found, as shown in Table 2

Table 2. Carbon Dioxide Health Effects

Concentration (ppm)	Effects
7000	Desmineralizaçao dos ossos
>20.000	Respiração profunda
40.000	Aumento do ritmo respiratório
100.000	Distúrbios visuais, tremores e perda de consciência
250.000	Pode causar a morte

The recommended limit for exposure of occupier for a period of 8 hours is 5.000ppm based on OSHA ACGIH 2012 and 2012.

The airshed region on the Arabian Peninsula consists of sodium chloride, sand and urban pollutants that vary depending on your location and environmental factors. The fine particles are small pieces of solid or liquid matter suspended in the atmosphere. Urban centers have as their primary source burning of fossil fuels in automobiles and industrial areas, while the lighter particles tend to remain airborne for weeks while the heavier settle by gravity. When the concentration of these particles reaches high levels it causes serious lung problems and property damage as troubleshooting of electrical operation trustworthiness, electronic telecommunications facilities, data centers, air intakes for HVAC systems, air intake of turbine generators and corrosion of electrical components of substations (electrical room).

The sandy part of the scenario is a local characteristic that is similar in Australia, with particles smaller than 20µm are able to stay in the air and seep easily into equipment and environments, causing respiratory and electromechanical problems. Figure 2 below shows the behavior of various sizes of sand particles.

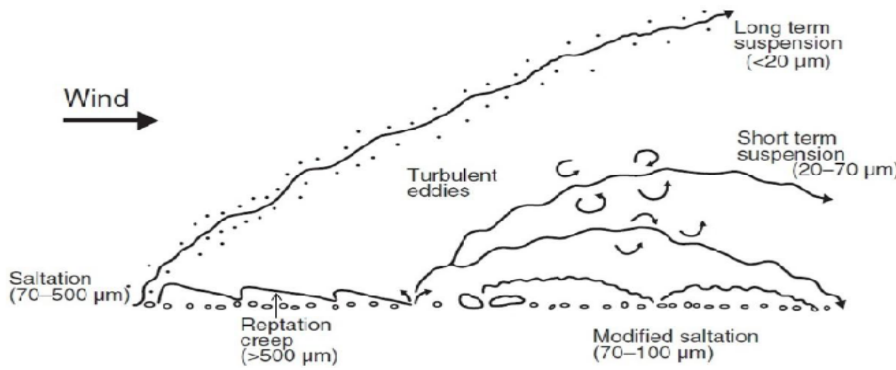

Figure 2. Schematic of the different modes of aeolian transport.

Locations near seas and oceans need special attention to the issue of salt in suspension. The salinity on the ocean surface water ranges from 32 to 37.5 ‰, this degree of variation is not enough to change corrosion rates, whereas the pH in the oceans varies between 7.5 and 8.3 with carbonate complexes tamponed, this pH variation does not affect the rate of corrosion for most alloys, except aluminum. In Table 3 we present large variation in the concentration of dissolved salts in isolated seas and oceans of the world, and this wide range of variation severely affects the corrosion rate, where the Atlantic Ocean and the Arabian Sea share greater wealth of dissolved ions.

Table 3. Total of Dissolved Solids in Isolated Seas and Oceans

Marine Body	Total of Dissolved Solids (ppm)
Baltic Sea	8000
Caspian Sea	13000
Black Sea	22000
Indian sea	32500
Atlantic Ocean	37000
Mediterranean Sea	41000
Arabian Sea (Kuwait)	39000 – 47000
Dead Sea	260000

The atmospheric corrosion in saline environments leads to reduction of operational reliability and most importantly, reduce the useful life of equipment and electrical components, responsible for a large portion of the costs arising from the deterioration of metallic materials by chemical oxidation.

Historically, the state of the art in the treatment of salt air intake is restricted to class G3 and F2 sequential filtering according to ASHRAE 62.1 (2007), with cumulative technology of residues collected by structures with means restricting the flow causing a retention of up to 95% particulate solids. This is followed by a coalescing filter of mist condensation, with the condensed residues trapped in mist eliminators. This arrangement is an air treatment unit that displays a gradual loss of pressure (60-190 mm.ca), with filter replacement becoming necessary every eight months (6.000 hours) on average for regions with a median presence of particulate matter. This period is reduced to a third of the cycle in an environment with a high load of pollutants in the atmosphere as found in siderurgies, refineries and mining. As a result, saturated disposable elements are generated that must be discharged as solid waste. Besides, the inefficiency of the technology of using sequential filters means that there will always be a percentage of pollutants (> 5%) continuously absorbed by the environment and responsible for the continued oxidation of the components, as shown by Capulli et al.(2009). These authors verified that the electrical substation of Pituba of COELBA-BA presented ordinary crashes as a result of the corrosion of silver and copper alloys in the contacts of controllers and circuit breakers. The adoption of multiventuri liquid centrifuging technology dispensed with the use of filters as well as the consequent generation of waste, eliminating these occurrences and increasing the reliability and operational availability of the substation. There were also performance gains since the air supply is cooled to the temperature conditions of the region's wet bulb, optimizing the performance of electric equipment that operate at temperatures below 30 ° C, even at full-load operation.

TECHNOLOGY OF AIR DEPURATION

The presence of pollutants agents in the air like salt ions, sand particles and combustion typical gases in urban environments, determine the necessity of air cleaning for buildings insufflation and for technical indoor environments like electrical stations ensuring air quality and functional reliability of equipment and devices. Therefore, it is necessary to use technology to remove physicochemical contaminants, and for that we will be demonstrating the use of precipitators of hydrodynamic spin liquid multiventuri technology, with a long tradition of use in the control of pollutants in outdoor air intakes.

The multiventuri liquid centrifuging technology was developed in Brazil by Giuseppe Capulli (1929-2008) as from 1967, aiming at providing effective and high performance tools in the control of air pollutants, materialized in the hydrodynamic precipitators which are self-priming. These precipitators bring together the centrifugal force with the multiventuri effect to achieve a high contact factor between two fluids in different physical states: gas and liquid.

This technology is founded on principles of fluid mechanics, mass and energy transfer as well as absorption and condensation phenomena, promoted by the centrifugal acceleration force of the liquid phase, with the multiventuri subdivision embodied in a piece of equipment capable of promoting biphasic chemical reactions that ensure mass transfer to the surrounding liquid, which behaves as a solvent, absorbing the contaminants contained in the flow of gaseous pollutants contained in the external atmosphere, such as flue gas or saline atmosphere. Thus, the process of biphasic centrifuging does not use filters, and the removal of solid material suspended in the air stream is achieved through hydraulic extraction and through chemical reaction, including the addition of gaseous contaminants in the liquid re-circulating fluid that consists of an aqueous solution capable of transforming gaseous pollutants by absorption through chemical reaction or condensation.

The core technology of hydrodynamic precipitators, operating through multiventuri liquid centrifuging is based on the theory of convergence of the amplitude of fluid molecular vibration as a result of their physical state and temperature, with the synergy of mechanical contact, as noted in Figure 3 where the rotor of simultaneous centrifugation of fluids in liquid and gaseous phases can be visualized, with the flow lines of the mixture of fluids in its hundreds of subdivisions as they cross the multiventuri perforations contained within the perimeter of the rotor.

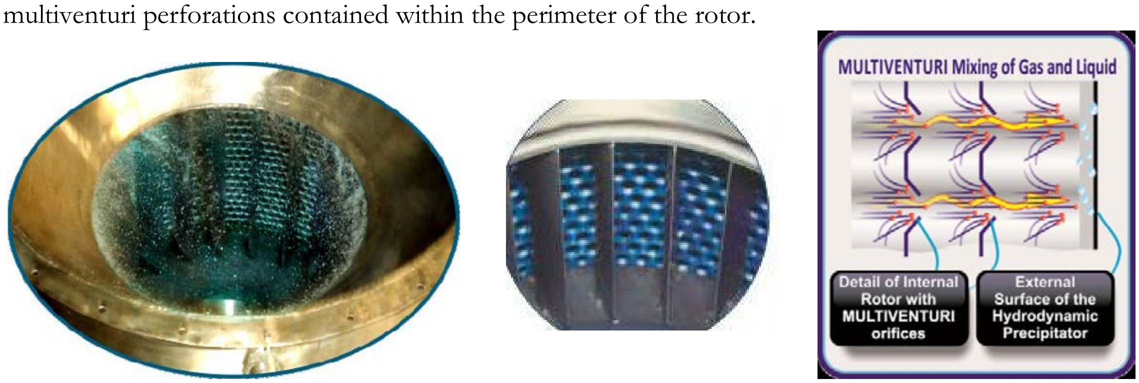

Figure 3. Detail of the core technology of multiventuri liquid centrifuging of hydrodynamic precipitators.

In the functional sequence of the technology, the fluids ejected by the rotor of centrifugation receive an additional liquid attack external to the rotor, which contributes to the carrying of contaminants. The resulting mixture is ejected to the opposite lobe which has the function of separating the phases though cyclonic acceleration and through the great difference in density (1:1000) between the air and the liquid, the latter returning to the tank of re-circulating liquid and the treated air is blowd into the ductwork supplying air conditioners, and from these to the ductwork of distribution to treated environments.

This is a reverse application when compared to those used historically, in other words, instead of receiving streams of contaminated gas from industrial processes for purification and discharge into a naturally balanced environment, we are capturing the external air and modulating its composition with the removal of aggressive pollutants to the infrastructure of equipments and instruments and/or harmful to the health of occupants of the confined environment. Typifying this application we have the atmospheres of pulp and paper plants with chloride ions, combustion gases and/or sulfurous and nitric atmospheres with the petrochemical and chemical plants, particulate matter in mining, siderurgy, coal and coke yard, hydrogen sulfide in units of effluent treatment or close of swamps, mangroves and salty sea air containing sodium chloride in all coastal areas of influence within a radius of up to 8 km, depending on winds and topography.

The maximization of condensation rates of vaporized substances contained in the process air depends on the difference in temperature, with direct connection to the molecular state of the fluids, and to the efficiency of contact between the gases and the condensation liquid and solubilization of contaminants.

CASE OF APLICATION

Between of hundred aplications of this pollutant agents control technology, we have as case the outside Petrobras base control building of air taken of natural gas re-gasification – LNG, Figure 5 where promotes the removal of salt ions and coke after processing in the hydrodynamic precipitator, cooling to the wet bulb (25.8 ° C), the treated air is distributed to three engine rooms that shelter the self-contained conditioners in the following way: (1) 2.870 m³/h for the VAC1 machine room containing two air-conditioners of 20TR and therefore meeting the needs of the first floor which shelters the electrical panels, transformers, battery room; (2) 650 m³/h for the VAC2 engine room containing two air-conditioners of 20TR that serve the second floor with the control room and TI/TCOM compartments; (3) 1.360 m³/h for the VAC3 engine room with one air-conditioner of 7,5TR thus meeting the needs of operational support offices and locker rooms. From the flow balance there is a 100% purge from the batteries room due to safety reasons given the risk of hydrogen liberation by these components. As a result, 84% of the air is re-circulated generating energy gains through a simple adjustment of temperature and humidity without generating cycles of adding salt ions to the air, as the extraction by liquid centrifugation achieves a 100% performance in the removal of salinity, due to the high solubility of sodium chloride in water, allowing the removal of up to 36g/l before starting the typical precipitation of supersaturated solution.

Figura 4. LNG terminal in Guanabara Bay, with detail of the pressurized and air conditioned control block.

In measurements of salinity in the coil trays, the salinity values were 0%. To sum up, we have got a synergistic technology of simultaneous extraction of contaminants from the air which presents a stable and non obstructive performance, with the automatic and cyclic purge of contaminants starting from the electrical conductivity measured in the liquid. In our field evaluation, we verified the presence of secondary pollution with typical carbonaceous residues from combustion gases probably generated by the operation of ships carrying LNG to berth and the re-gasification ship anchored as a terminal processing unit at the suction inlet of the hydrodynamic precipitator. This pollutant adheres to surfaces and if we did not have the debugging by the precipitator, it would be impregnating - in addition to salt corrosion -

sophisticated electrical and electronic equipment such as the Mooring panel of bathymetric and sea undulation monitoring, chromatographic panels, hydraulic arms panels, telecommunication racks as well as gas detection panels.

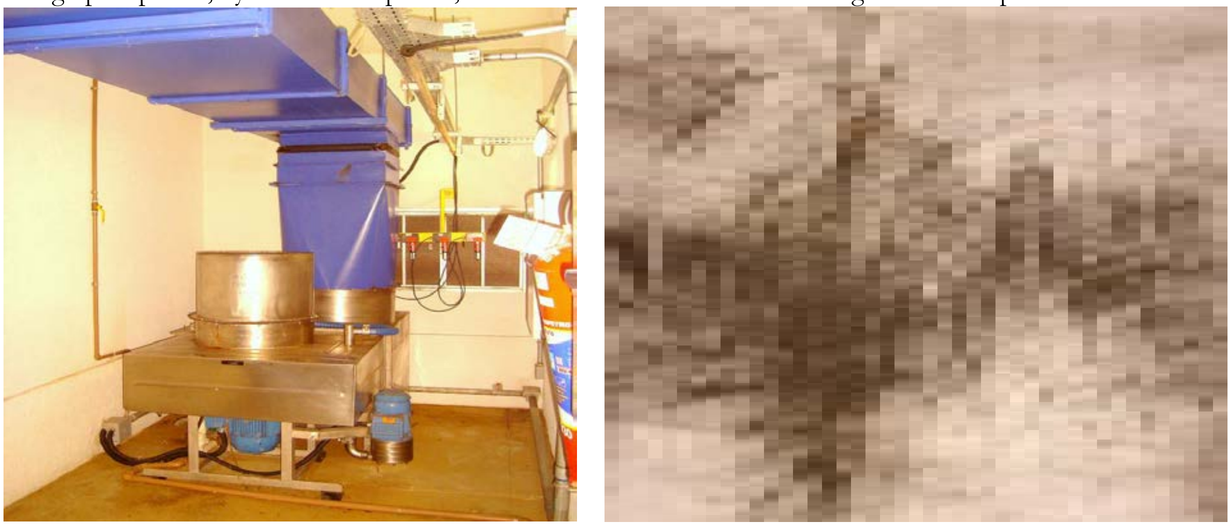

Figura 5. Hydrodynamic precipitator in the capture and desalination of sea air to be blowd into air conditioners, in detail: salt deposited on top of the precipitator and sooty residue of combustion gases from ships.

The reliability of air quality is guaranteed by the permanent extraction of contaminants, independently from the use of filters, from the intake of external air. The hydrodynamic precipitator operates autonomously, aspirating external air ("booster function"), extracting chloride and sodium ions by diffusion in the concentration gradient and blowing air into the two air conditioning rooms. The re-circulating liquid is pumped from the equipment internal tank into the multiventuri rotor where both fluids interact to achieve the transfer of mass and energy. This fluid runs until the electrical conductivity reaches a predetermined (set-up = 17600μS) value. At this point, a pump partially draining the saturated liquid operates.

Analyses of trays of fan coils over the last two operating demonstrate the absence of corrosion and lack of salinity in fluid collected according to the results table

Table 4. Results of the analysis of the liquid collected in the fan coils and Hydrodinamic Precipitator

TAG	Salinity %	Fungos(UFC/ml)	Total Heterotrofic (UFC/ml)
Fan coil VAC1	0,64	2,4 x 10^2	1,3x10^3
Fan coil VAC2	0,31	2,2 x10^2	8,1x10^2
Hydrodinamic Precipiador CA4-tank of circulating water	54,6	7,3x10^3	1,8x10^4

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CONCLUSION

The densification of urban society sustained on the basis of fossil fuels formatted carbonic islands that increase the effects of harmful or deleterious contaminants as natural marine atmosphere and particulate siliceous. The use of technology allows control via net simultaneously particulates, mists and gases instead of using traditional technologies of mechanical filtration dry. Under this umbrella we have conclusively that the synergy of contact between the fluids based on centrifuge technology multiventuri refrigerated liquid is recommended as a route through the efficient control of contaminants ensures heritage preservation and operational reliability of devices that remain protected from corrosive attack and / or typical of these abrasive contaminants.

Tests show that current through the cooling liquid circulating it becomes possible to solubilize and carbonation of carbon dioxide, a greenhouse gas which reduces the duty cycle of the air-conditioned this development will bring a new perspective in air conditioning systems of buildings .

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