Sustainable HVAC Systems in Commercial And Residential Buildings

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Abstract- Maintaining optimal temperature and air circulation are the basis of a comfortable indoor environment. This role is played by HVAC(Heating, Ventilation and Air conditioning) systems. All heating, ventilation and air conditioning system account for 60% of the World's total energy consumption this calls for a sustainable solutions for HVAC systems. We discuss many of such techniques used around the globe in this paper. The main objective is to minimise the energy consumption by shifting towards natural renewable sources while maintaining the required comfort level of a building.

Index Terms- HVAC, Radiant systems, Solar AC, Trombe wall.

I. INTRODUCTION

A modern building has a numerous requirements. Fresh air, Cooling and heating play an important role in designing and managing a building. An HVAC (Heat, Ventilation and Air conditioning) systems are provided so as to meet the requirements of comfort, cost, efficiency and aesthetic appeal. A sustainable system adds to the complexity of designing an HVAC system. The energy consumption by buildings must be reduced without compromising in the services provided by the building in a sustainable way, thus ensuring a comfortable indoor climate for the people. The major aspect of setting the energy goals should be HVAC system. The most efficient way of lowering the energy consumption is by improving the energy efficiency. The cooling needs in a building are increasing day by day to provide a comfortable indoor environment because of the extreme weather conditions and types. a favourable strategy for sustainable cooling is by using large surface at relatively high temperatures for radiant cooling system. This can be used for both heating and cooling the surfaces which provides a comfortable ambiance. Radiant cooling systems can be provided in spaces where the cooling load during day time is higher. Radiant cooling offers optimal operating conditions for integration of renewable energy and free cooling. Basically in a Sustainable HVAC system the main focus is on management of waste and pollutants which can extend up to the material of the equipments and the well being of the staff. The installation cost of an HVAC system can be attained by 30% cutting down of yearly energy cost and can be regained within a few years when the building gains conventional comfort. By providing natural ventilation and air movements the savings can be improved.

II. DESIGNING OF HVAC SYSTEM

- Displacement ventilation is based on the basic principle of air that it rises upwards after being heated by the machines and people. The rising air is then moved outwards from the exhaust placed at a height. This process requires low energy consumption and provides effective air circulation- which is in term with its sustainability- but it needs an inlet of pre-conditioned air from outside. Combining air distribution systems with floor access could be an added advantage.
- Outdoor air pre-heating integrating systems bank on collaborative solutions, co-ordination to get maximum advantages. A perforated metal plate is used to make a non-languishing Trombe wall which is used to preheat the air from outside or to make an outside wall shaded. Exposure to the southern direction is optimal for this product. It is cost effective as most of the heat produced is reusable using plain gas-fuelled systems rather than boiler or reheating coils which means lower cost and better performance.
- Heat pumps: Geothermal heat utilizes the contained heat of earth or water body to enhance the performance a normal heat pump mechanism by narrowing the range of loop temperature. Structure of this field loop and selection of the water body depends upon the site characteristics.
- Photovoltaic systems are more cost effective today. The chief cost generates in conversion and in providing connection to its utility grid.
- Solar thermal systems are the best forms of renewable energy. Its heat can be useful in industrial as well as domestic needs for hot water and could also be used to hasten the air conditioning plant. Liquid desiccant conditioners and absorbent chillers could be used to abstract latent heat for air supply of a building.
- Integrated photovoltaic system is composed of roofing materials like metal panels and tiles pr glazing materials like skylights acting like substrates for solar cells it hence ends the need of the usual framing systems which in turn reduces its cost. Cooling of solar cell puts the cell in order such that it utilizes natural convection of the building or its conditioned relief, reducing the cell's temperature, hence contributing to its conversion efficiency.

A sustainable method of heating and cooling as well is to use temp of water solution on radiant large surfaces applying high temperature for cooling and low for heating. Less energy is needed when an average temperature is maintained of water (18-28°C) closer to the surroundings comfortable temperature. These systems are integrated in the building's structure, leaving a smooth facade for the building and flexile interior architecture.

III. RADIANT HEATING AND COOLING SYSTEMS

A radiant system has water channelled pipes interspersed in the floors, walls or ceilings (in the concrete slabs) since more than 60% of energy commutation is by radiation.. Heating in low temperatures and cooling in high temperatures makes a building energy efficient and makes it a high performance building. The floor and ceiling system can acquire and output of up to 100 W/m² and cooling output of 60 W/m² and up to 75 W/m² cooling can be achieved with comfort panels for suspended ceilings. In case of a radiant heating system that uses low-temperature the performance of energy source will be noticeably more when compared to the usual techniques. This reduces the primary energy consumption. The radiant system is different from a typical HVAC system because it heats or cools the surface rather than air. Radiant systems save a large amount of energy and provides comfort depending on the climate. Spaces like docks and warehouses are suitable
for radiant floor heating. This system cannot be used for humidity control, it is best for dry climates.

IV. INTEGRATION OF RENEWABLE ENERGY SOURCE

Large surfaces can be used as reflectors and it allows cooling and heating at temperatures close to the surroundings. The renewable energy can be combined and utilized with ease. Ground-source heating can be amalgamated into the system via ground heat pumps. Mixing a radiant system with free cooling source can lower down the energy consumption by 90%, since only electricity for circulation pumps is required. Ground water's temperature is apt for Radiant system. This system can be powered by cooling with solar energy or sea water.

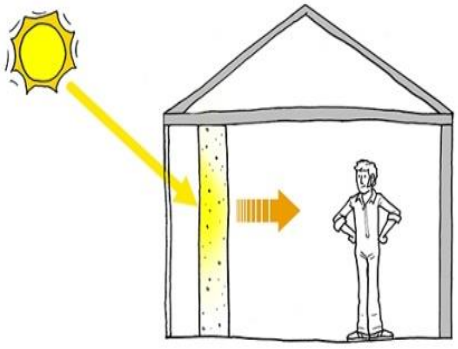
V. NEED FOR SUSTAINABLE COOLING

Some proclivities show that the cooling requirements in the whole building mass will elevate in the future. This is caused due to the extreme weather conditions with warmer summers and also due to the increasing comfort needs of people. The building codes should be amended according to the changing needs for the tightness of building envelopes thus introducing convincing cooling demands in summer. It is applicable in offices and industrial buildings. The heating and cooling needs of the building are satisfied with minimum usage of energy via free cooling with a ground-coupled heat pump. Water can be utilized for cooling in the form of cooling panels and beams. the thermo-active constructions are known for their energy performance and cooling effect. It follows a principle of pipes interspersed in the floors, walls or ceilings whereby the building mass is activated. This is best suitable for thermal indoor climate and also the peak load reduces considerably. The cooling is more required in office buildings due to the heat released by people and equipments. Radiant cooling systems are more beneficial because of the free cooling sources available like ground water, lakes or seas etc. By using radiant cooling the need for traditional chillers can be put to an end, and only a minimum amount of energy would be required for circulation pumps. When combine with the conventional cooling such as roof top chillers it(radiant system) would save a lot of energy. Radiant systems have a low energy consumption and a low operation cost.

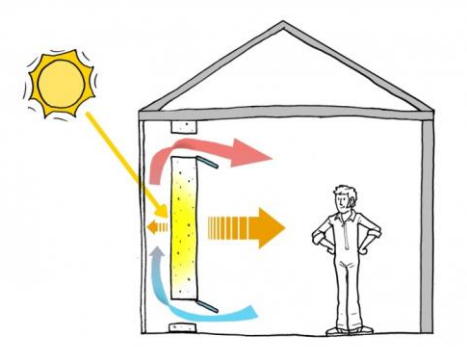
VI. SOLAR POWERED AIR CONDITIONERS

We are talking about absorption chillers which are urged by heat. Gas boilers and by-
products of heat from machineries have been sources of this heat for many years. Using solar energy for hot water production is also a known and tested form of efficient energy. So, the absorption chillers combine efficiently with solar thermal plants.
Thermal energy is captured from the sun via equipments like evacuated tube solar panels and is transferred to chillers having solutions that contain heat- i.e., there is no heat loss-through a system of tubes, pumps and control panels etc.
Chiller component of an air conditioner makes up for almost 41% of its ton consumption and if solar energy replaces the energy source for chillers, it makes up for a far sustainable solution. The only parts of this assembly that need electricity are very small components like fans pumps etc. The micro-inverters incorporated in the system convert DC power into AC power. A pump is requires to communicate the fluids carrying thermal energy, from collection unit to solar chiller and then back. Another pump is required to circulate refrigerant. The biggest energy consuming unit of an AC, its compressor, is no longer a necessity in this solar powered conditioner and the rest of energy consumption can be easily met by solar photo voltaic panels.

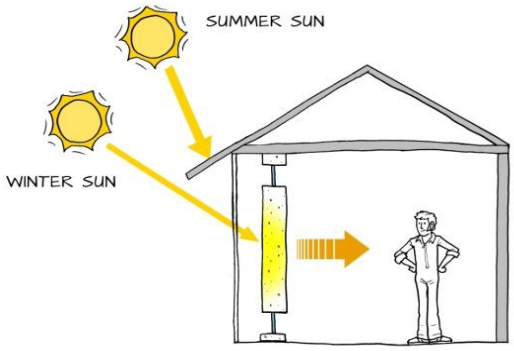
VII. TROMBE WALL



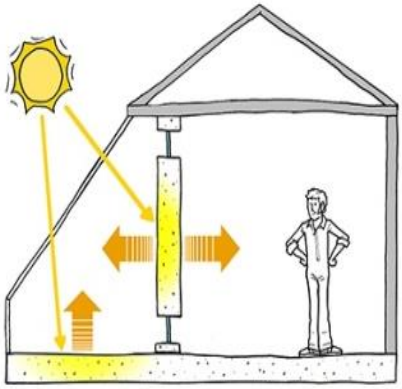
A trombe wall is system to trap heat from the sun and maintain apt temperatures and conditions for human comfort. This system contains a high wall of preferably dark colour and a glass panel a bit apart from the wall,



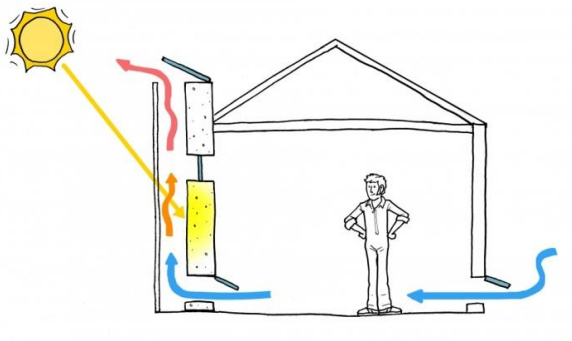
leaving air space in between. It acts like a green house and traps the sun's heat. It is an effective passive technique to heat a space by optimizing the gain and controls heat loss at night. The configuration of a trombe wall is such that, for a dark 19-38cm thick masonry wall, there could be 1 glass or a double layer at a distance of 2-15 cm, maintaining the air space. The glass plays the role of absorbing and retaining the heat whereas the heat is radiated to the space via the masonry wall. The heated air is trapped between the wall and glass and would take approximately 8-10 hours to transfer to the space behind the wall (for a thick wall of 38cm) which leaves the space of comfortable temperature in day time and radiates the heat of the trapped air at night time. Also, if vents are added at the top and bottom of the wall, a circulation can be created to let the warm air in the space besides the wall and the used up air from the space moves into the space between the wall and glass and gets heated up. This provides a slow and even heating throughout the day and night.
Glazing on the interior of the glass can stop the heat from re-radiating outwards. A trombe wall shall be combined with appropriate overhangs etc to maintain balance in the heat gain process according to the season.



Sunspace beside the Trombe wall acts like a vented wall, heating the space through radiation as well as convection. Only the space between the wall and glass is big enough to move around in. These are basically used for direct gain of heat and would contain extra glazing in comparison to floor area. But loss of heat during night is not an issue as this room may be shut down during night.
A variation of this system can be done by replacing the masonry wall by water as the heat containing space for sunspace or the trombe wall. Heat is transferred more quickly via convection currents in the water instead of convection as in masonry which



proves more appropriate when time of heat delay is lesser. Also this system also brings in more light into the room.
A solar chimney is used to create a current of air flow to let fresh cool air in from outside. The space between the wall and glass is heated and the air moves upward to get out of the vent above the glass and in turn makes the used air from the room to move towards the glass, forcing the air from outside to move inside the room.



VIII. CONCLUSION

A commercial building can be made energy-efficient by using a radiant system for heating and cooling when paired up with traditional HVAC system. Radiant system utilizes water temperatures for heating and cooling surfaces available from natural sources like lakes, seas or rivers. It works at temperature close to the surrounding temperature and results in reduction in energy consumption. For sustainable HVAC system the main aim is to gain thermal comfort by the utilization of minimum amount of energy and proper conditioning of the indoor air along with the radiant heating and cooling systems. Heating can be supported by the usage of large emitters with temperature close to the surroundings. The air is mostly cooled or heated more than the required temperature by after mixing with the indoor air it comes at the target temperature. Puncture in ducts can lead to drop in the heating or cooling capacity by 38%. The radiating systems and passive systems should work together to achieve the peak performance.

REFERENCES

[1] Lars sonderby nielsen,"Building integrated system design for sustainable heating and cooling", *REHVA Journal Feb-2012*

[2] Netgreen Development, "A few thoughts on sustainable HVAC", net source.

[3] P. Torcellini and S. Pless, " Trombe Walls in Low-Energy Buildings", World Renewable Energy Congress VIII and Expo Denver, Colorado, 2004

[4] Autodesk, "Trombe Wall and Attached Sunspace", net source.

[5] Otto H. Königsberger, "Manual of tropical housing & building", Book.

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