ASSESSMENT OF PASSIVE VS.ACTIVE STRATEGIES FOR A COMMERCIAL BUILDING DESIGN

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Abstract: This paper presents a simulation study to reduce heating and cooling energy demand of a Commercial building in **Ambegaon Pune Area, India**. The aim of this study is to estimate the impact of passive *vs.* active approaches on energy savings in buildings using Energy Plus simulation. By controlling lighting, the energy saving of the original Commercial building design was found most significant, and increased by 32% when the design is improved. It is noteworthy that energy saving potential of each room varies significantly depending on the rooms' thermal characteristics and orientation. Thus, the analysis of energy saving should be introduced at the individual space level, not at the whole building level. Additionally, the simulation studies should be involved for rational decision-making. Finally, it was concluded that priority should be given to passive building design strategies, such as building orientation, as well as control and utilization of solar radiation. These passive energy saving strategies are related to urban, architectural design, and engineering issues, and are more beneficial in terms of energy savings than active strategies.

Keywords: energy efficiency; passive; active; building design strategies; architectural engineering; energy simulation

1. INTRODUCTION

1.1 Introduction

In general, an active system refers to heating or cooling systems that use mechanical means to produce energy. In horticulture, the term active system is used in hydroponics to describe any system with moving parts. Passive design is a system or structure that directly uses natural energy such as sunlight, wind, temperature differences or gravity to achieve a result without electricity or fuel. Active design is a system or structure that uses or produces electricity. The term passive design is most often used with respect to architecture and infrastructure. For example, a building may have wide windows that automatically let in more light when the building needs heat and automatically shade when the building is too hot. Another common area of passive design is wet infrastructure such as drainage systems that generally often don't consume power but use gravity to move water. Most devices and infrastructure have an active design as they use electricity. The term is typically only used in comparison to passive designs. For example, solar panels that produce electricity are often referred to as active solar as a comparison to using solar passively for heat or to grow plants. The Difference Between Active & Passive Solar Heating. Active heating captures sunlight, either as heat or electricity, to augment heating systems, while passive heating captures heat from the sun as it comes into your home through windows, roofs and walls to heat objects in your home.

1.2 Passive Design vs Active Design Difference

Table 01 Passive Design vs Active Design Difference

Passive Design vs Active Design		
	Passive Design	Active Design
Definition	Infrastructure, architecture and devices that achieve a result by directly using natural forces without first converting it to electricity.	Infrastructure, architecture and devices that use or produce electricity to achieve a result.
Examples	Passive Heating Passive Cooling Green Roofs Rain Gardens	Solar Panels Wind Turbines District Heating Deep Water Cooling

1.3 Passive Benefits

Passive designs are often valued for their simplicity and aesthetic appeal. They also tend to have zero operational costs. As they often contain no moving parts, passive designs potentially last for centuries. Electrical components are valued for their accuracy and functionality but may need to be regularly maintained and replaced. They may also have a higher operational cost and environmental impact.

1.4 Buildings Using Passive Design Strategies for Energy Efficiency

Using passive design building form and thermal performance of building elements (including architectural, structural, envelope and passive mechanical) are carefully considered and optimized for interaction with the local microclimate. The ultimate vision of passive design is to fully eliminate requirements for active mechanical systems (and associated fossil fuel-based energy consumption) and to maintain occupant comfort at all times Even though we may not achieve the ultimate passive design vision on every building, implementing the passive design approach to the fullest extent possible will lower building energy use. Building shape, orientation and composition can improve occupant comfort by harnessing desirable site specific energy forms and offering protection from undesirable forms of energy. Through properly applied passive design principles, we can greatly reduce building energy requirements before we even consider mechanical systems.

A. Passive Design Strategies

With many passive strategies, there is a trade-off between heating performance and cooling performance. The building type and operation determine which strategies will have the best overall impact on energy performance.

1. Passive Heating: Using building design to harness solar radiation and capture the internal heat gains is the only passive way to add free thermal energy to a building. Passive solar heating combines a well-insulated envelope with other elements that minimize energy losses and harness and store solar gains to offset the energy requirements of the supplemental mechanical heating and ventilation systems.

Elements that contribute to passive solar heating include the following:

1. Orientation
2. Building shape
3. Buffer spaces and double facades
4. Space planning
5. High-performance windows (clear, low-e)
6. Mixed-mode heat recovery ventilation (HRV)
7. Low window to wall area ratio (N/E)
8. High window to wall area ratio (S/W)
9. Operable external shading
10. High-performance insulation
11. Thermal mass
12. Minimized infiltration

2. Passive ventilation

Passive ventilation strategies use naturally occurring air flow patterns around and in a building to introduce outdoor air into the space. Wind and buoyancy caused by air temperature differences create air pressure differences throughout occupied spaces. Buildings can be designed to enhance these natural air flows and take advantage of them rather than work against them.

The passive elements that contribute to natural ventilation include the following:

1. Operable windows
2. Buffer spaces and double facades
3. Building shape
4. Space planning
5. Orientation
6. Strategic architectural features

7. Openings to corridors and between otherwise separated spaces
8. Central atria and lobbies
9. Wind towers

3. Passive Cooling

Passive cooling strategies prevent the building from overheating by blocking solar gains and removing internal heat gains (e.g. using cooler outdoor air for ventilation, storing excess heat in thermal mass).

Elements that contribute to passive cooling include the following:

1. Fixed/operable external shading
2. Thermal mass
3. Low window to wall area ratio (S/W)
4. Passive ventilation
5. Nocturnal cooling
6. Stacked windows
7. Passive evaporative cooling
8. Earth-tempering ducts

Nocturnal cooling uses overnight natural ventilation to remove heat accumulated in the building mass during the day. The cooler nighttime air flushes and cools the warm building structure/mass.

4. Day lighting

Day lighting maximizes the use and distribution of natural diffused daylight throughout a building’s interior to reduce the need for artificial electric lighting.

The features which contribute to a day lighting strategy include:

1. Space planning
2. High ceilings paired with tall windows
3. Window size and placement (window to wall area ratio)
4. Interior surface colors and finishes
5. Strategic architectural features
6. Light shelves
7. Skylights and light tubes
8. Clerestories

5. Applying the Strategies: Commercial

Commercial buildings have different characteristics from residential buildings, such as reater internal heat gains from equipment and lighting, higher ventilation requirements, and different occupancy trends. Commercial buildings benefit from passive cooling, but in the Vancouver climate, design must strike a balance between heating and cooling performance.

Specific passive approaches that will improve the overall energy performance of commercial buildings in Vancouver include:

- Carefully detailed and constructed high-performance insulation in the envelope with minimal thermal bridging, including exterior walls and roofs.
- Solar gain control using either high-performance windows with low shading coefficient (tinted or reflective) or clear high-performance windows with a low-e coating in combination with operable external shading to block solar gains during summer and shoulder seasons and admit solar gains during winter.
- Window to wall area ratio limited to <50%.
- Double facades with operable shading elements and operable windows to act as thermal buffer spaces, preheat ventilation air in the winter, and block solar gains and provide natural ventilation in the summer.
- Building shape and massing that enhances natural ventilation and daylighting, ideally with central atria and ventilation towers.

- Thermal mass on the interior side of the insulation, located in the floors, external walls, and walls between adjoining units (i.e., party walls).
- Passive cooling strategies, such as nocturnal ventilation to pre-cool spaces during summer and ventilation air intakes located in cool areas and delivered to the building using earth tubes.
- Air- and moisture-tight envelope.

6. Applying the Strategies: Residential

In the Vancouver market, the vast majority of residential developments are medium- and high-rise towers. Residential spaces have night-time occupancy and relatively low internal heat gains (aside from intermittent cooking), which results in a heating-dominant residential energy profile in the Vancouver climate.

- Specific passive approaches that will improve the overall energy performance of residential buildings in Vancouver include:
- Carefully detailed and constructed high-performance insulation in the envelope with minimal thermal bridging, including exterior walls and roofs.
- Clear, low-e, high-performance windows in combination with operable external shading to block solar gains during summer and admit solar gains during shoulder seasons and winter

1.5 Passive building design

Designers tune the thermal characteristics of buildings so that they moderate external environmental conditions and maintain internal conditions using the minimum resources of materials and fuel. Passive design maximizes the use of 'natural' sources of heating, cooling and ventilation to create comfortable conditions inside buildings. It harness environmental conditions such as solar radiation, cool night air and air pressure differences to drive the internal environment. Passive measures do not involve mechanical or electrical systems. This is as opposed to 'active' design which makes use of active building services systems to create comfortable conditions, such as boilers and chillers, mechanical ventilation, electric lighting, and so on. Buildings will generally include both active and passive measures. Hybrid systems use active systems to assist passive measures, for example; heat recovery ventilation, solar thermal systems, ground source heat pumps, and so on. Very broadly, where it is possible to do so, designers will aim to maximize the potential of passive measures, before introducing hybrid systems or active systems. This can reduce capital costs and should reduce the energy consumed by the building. However, whilst passive design should create buildings that consume less energy, they do not always produce buildings that might be considered 'sustainable' as sustainability is dependent on a range of criteria, only one of which is energy usage.

Passive design can include:

- Passive cooling.
- Passive heating.
- Passive ventilation (or natural ventilation).

NB: Passive solar design is an aspect of passive building design that focusses on maximising the use of heat energy from solar radiation.

Passive design can include consideration of:

- Location.
- Landscape.
- Orientation.
- Massing.
- Shading.
- Material selection.
- Thermal mass.
- Insulation.
- Internal layout.
- The positioning of openings to allow the penetration of solar radiation, visible light and for ventilation.

2. LITERATURE SURVEY

AdebisiIlelabayo Ismail et al. The geometric increase in energy consumption in buildings due to high living standards, display of wealth and affluence and increase in population has resulted in energy crises and series of environmental problems such as sudden rise in temperature in urban areas, risk of global warming, climate change and co2 emissions. Architects and builders hence have a role in mitigating these effects through the reduction of energy consumption in buildings. This has informed various studies on climate responsive designs or what is referred to as passive Cooling of buildings. Passive cooling (designs) refers to design features or technology used in heating or cooling buildings naturally without energy consumption; it takes full advantage of the micro climate by using climate responsive design parameters. Passive cooling of buildings if properly imbibed is a significant way by which energy efficiency can be ensured in buildings.

M. S. Almatawa et al. The building sector is one of the highest consumers of energy in the world. This has led to high dependency on using fossil fuel to supply energy without due consideration to its environmental impact. Saudi Arabia has been through rapid development accompanied by population growth, which in turn has increased the demand for construction. However, this fast development has been met without considering sustainable building design. General design practices rely on using international design approaches and features without considering the local climate and aspects of traditional passive design.

Adrian Pitts et al. This paper describes research carried out to understand better the current and future emphases emerging from practice for the design and development of “Passive House” and low energy buildings. The paper initially discusses the extant position, particularly with regards to the UK and considers how regulation and assessment systems have changed in recent years, as well as projecting ideas forward taking account of contemporary political situations. Relevant previous research into Passive House and low energy design and construction is then reviewed.

JiEun Kang et al. This paper presents a simulation study to reduce heating and cooling energy demand of a school building in Seoul Metropolitan Area, Korea. The aim of this study was to estimate the impact of passive vs. active approaches on energy savings in buildings using Energy Plus simulation. By controlling lighting, the energy saving of the original school building design was found most significant, and increased by 32% when the design was improved. It is noteworthy that energy saving potential of each room varies significantly depending on the rooms’ thermal characteristics and orientation.

Raquel SO et al. Within this paper we describe the design and development of technological innovative modules to be applied in architecture cladding. They combine passive solar features like solar protection, solar thermal energy storage, ventilated and Trombe wall effects with active solar thermal collectors and photovoltaic systems. The proposed solar protection features can also include a biological element, proving support for vertical gardens and shelter for small birds.

By Michael C. Henry et al. In the past half century, expectations of thermal comfort in North America have been shaped by the increased availability of climate control technology and equipment and by the comparatively low cost of operating these systems. As conservation professionals, we have come to expect that climate control technology can alleviate the potential damage to museum collections from extremes and fluctuations in temperature and relative humidity (RH). Both expectation levels—comfort and conservation—have resulted in sophisticated energy-intensive climate management systems for old and new buildings.

3. RESEARCH METHODOLOGY

1. Passive Solar Design

In this project Passive Solar Design is Applied on Phase B at Viva Sarovar . Passive solar design refers to the use of the sun’s energy for the heating and cooling of living spaces by exposure to the sun. When sunlight strikes a building, the building materials can reflect, transmit, or absorb the solar radiation. In addition, the heat produced by the sun causes air movement that can be predictable in designed spaces. These basic responses to solar heat lead to design elements, material choices and placements that can provide heating and cooling effects in a home. Unlike active solar heating systems, passive systems are simple and do not involve substantial use of mechanical and electrical devices, such as pumps, fans, or electrical controls to move the solar energy.

Passive Solar Design Basics

A complete passive solar design has five elements:

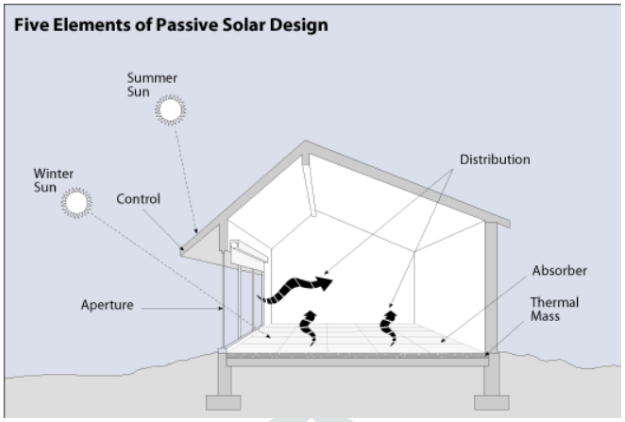


Fig. Elements of Passive Solar Design

- Aperture/Collector: The large glass area through which sunlight enters the building. The aperture(s) should face within 30 degrees of true south and should not be shaded by other buildings or trees from 9a.m. to 3p.m. daily during the heating season.
- Absorber: The hard, darkened surface of the storage element. The surface, which could be a masonry wall, floor, or water container, sits in the direct path of sunlight. Sunlight hitting the surface is absorbed as heat.
- Thermal mass: Materials that retain or store the heat produced by sunlight. While the absorber is an exposed surface, the thermal mass is the material below and behind this surface.
- Distribution: Method by which solar heat circulates from the collection and storage points to different areas of the house. A strictly passive design will use the three natural heat transfer modes- conduction, convection and radiation- exclusively. In some applications, fans, ducts and blowers may be used to distribute the heat through the house.
- Control: Roof overhangs can be used to shade the aperture area during summer months. Other elements that control under and/or overheating include electronic sensing devices, such as a differential thermostat that signals a fan to turn on; operable vents and dampers that allow or restrict heat flow; low-emissivity blinds; and awnings.

Passive Solar Heating

The goal of passive solar heating systems is to capture the sun’s heat within the building’s elements and to release that heat during periods when the sun is absent, while also maintaining a comfortable room temperature. The two primary elements of passive solar heating are south facing glass and thermal mass to absorb, store, and distribute heat. There are several different approaches to implementing those elements.

Direct Gain

The actual living space is a solar collector, heat absorber and distribution system. South facing glass admits solar energy into the house where it strikes masonry floors and walls, which absorb and store the solar heat, which is radiated back out into the room at night. These thermal mass materials are typically dark in color in order to absorb as much heat as possible. The thermal mass also tempers the intensity of the heat during the day by absorbing energy. Water containers inside the living space can be used to store heat. However, unlike masonry water requires carefully designed structural support, and thus it is more difficult to integrate into the design of the house. The direct gain system utilizes 60-75% of the sun’s energy striking the windows. For a direct gain system to work well, thermal mass must be insulated from the outside temperature to prevent collected solar heat from dissipating. Heat loss is especially likely when the thermal mass is in direct contact with the ground or with outside air that is at a lower temperature than the desired temperature of the mass.

Indirect Gain

Thermal mass is located between the sun and the living space. The thermal mass absorbs the sunlight that strikes it and transfers it to the living space by conduction. The indirect gain system will utilize 30-45% of the sun's energy striking the glass adjoining the thermal mass. The most common indirect gain systems is a Trombe wall. The thermal mass, a 6-18 inch thick masonry wall, is located immediately behind south facing glass of single or double layer, which is mounted about 1 inch or less in front of the wall's surface. Solar heat is absorbed by the wall's dark-colored outside surface and stored in the wall's mass, where it radiates into the living space. Solar heat migrates through the wall, reaching its rear surface in the late afternoon or early evening. When the indoor temperature falls below that of the wall's surface, heat is radiated into the room.

Operable vents at the top and bottom of a thermal storage wall permit heat to convect between the wall and the glass into the living space. When the vents are closed at night, radiant heat from the wall heats the living space.

Passive Solar Cooling

Passive solar cooling systems work by reducing unwanted heat gain during the day, producing non-mechanical ventilation, exchanging warm interior air for cooler exterior air when possible, and storing the coolness of the night to moderate warm daytime temperatures. At their simpliest, passive solar cooling systems include overhangs or shades on south facing windows, shade trees, thermal mass and cross ventilation.

Shading

Overhang design for shading. Diagram courtesy of the Arizona Solar Center. The steeper arrow shows the angle of the sun's rays during the summer, while the shallower arrow indicates the angle during the winter. To reduce unwanted heat gain in the summer, all windows should be shaded by an overhang or other devices such as awnings, shutters and trellises. If an awning on a south facing window protrudes to half of a window's height, the sun's rays will be blocked during the summer, yet will still penetrate into the house during the winter. The sun is low on the horizon during sunrise and sunset, so overhangs on east and west facing windows are not as effective. Try to minimize the number of east and west facing windows if cooling is a major concern. Vegetation can be used to shade such windows. Landscaping in general can be used to reduce unwanted heat gain during the summer.

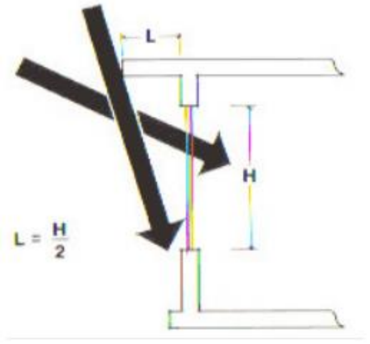


Fig Shading Mechanism in passive design.

Thermal Mass

Thermal mass is used in a passive cooling design to absorb heat and moderate internal temperature increases on hot days. During the night, thermal mass can be cooled using ventilation, allowing it to be ready the next day to absorb heat again. It is possible to use the same thermal mass for cooling during the hot season and heating during the cold season.

Ventilation

Natural ventilation maintains an indoor temperature that is close to the outdoor temperature, so it's only an effective cooling technique when the indoor temperature is equal to or higher than the outdoor one. The climate determines the best natural ventilation strategy. In areas where there are daytime breezes and a desire for ventilation during the day, open windows on the side of the building facing the breeze and the opposite one to create cross ventilation. When designing, place windows in the walls facing the prevailing breeze and opposite walls. Wing walls can also be used to create ventilation through windows in walls perpendicular to prevailing breezes. A solid vertical panel is placed perpendicular to the wall, between two windows. It accelerates natural wind speed due to pressure differences created by the wing wall. In a climate like New England where night time temperatures are generally lower than daytime ones, focus on bringing in cool nighttime air and then closing the house to hot outside air during the day. Mechanical ventilation is one way of bringing in cool air at night, but convective cooling is another option.

Convective cooling

The oldest and simplest form of convective cooling is designed to bring in cool night air from the outside and push out hot interior air. If there are prevailing nighttime breezes, then high vent or open on the leeward side (the side away from the wind) will let the hot air near the ceiling escape. Low vents on the opposite side (the side towards the wind) will let cool night air sweep in to replace the hot air. At sites where there aren’t prevailing breezes, it’s still possible to use convective cooling by creating thermal chimneys. Thermal chimneys are designed around the fact that warm air rises; they create a warm or hot zone of air (often through solar gain) and have a high exterior exhaust outlet. The hot air exits the building at the high vent, and cooler air is drawn in through a low vent.

There are many different approaches to creating the thermal chimney effect. One is an attached south facing sunroom that is vented at the top. Air is drawn from the living space through connecting lower vents to be exhausted through the sunroom upper vents (the upper vents from the sunroom to the living space and any operable windows must be closed and the thermal mass wall of the sunroom must be shaded).

2. Active Solar Energy Methodology

In Active Solar design is installed on Phase A at **Viva Sarovar Ambegaon Pune**. From solar pool heating systems to solar water heating systems, active solar energy is a cost effective way for homeowners to take advantage of solar energy. This solar energy technology is called "active" because you are "actively" gathering and using energy from the sun for your solar home heating needs. There are two major differences between active and passive solar energy...

- Active solar uses special boxes called solar collectors to capture the solar energy and convert it into heat. Passive solar uses the design of the home to capture solar energy.
- Active solar uses mechanical systems such as pumps or fans to distribute the solar thermal energy captured from the sun. Passive solar doesn't use mechanical systems.

Fig Active Solar Energy System Components

Active Solar Energy System Components

Active solar technology systems have three main components.

- Solar Energy Collection is done with a solar collector. The most common collector is the flat-plate collector, which is simply a glass covered, insulated box. Inside the box there are black absorber plates which absorb the solar energy and convert it into heat. The heat energy is then transferred to a fluid, usually water or air, that flows through the collector. This determines whether the system is liquid-based or air-based.
- Solar Energy Storage can be done with water tanks or thermal mass for liquid-based systems. For air-based systems, solar energy storage can be done with rock bins that hold the heated air.
- Solar Energy Distribution is based on the type of system used. Liquid-based systems will use pumps, radiant slabs, central forced air, or hot-water baseboards for distribution. Air-based systems will use fans and ducts to move the heated air.

Types of Active Solar Energy

There are three types of active solar applications that you can use in your home...

- Active Solar Space Heating
- Active Solar Water Heating
- Active Solar Pool Heating

2.1Active Solar Space Heating

To heat the air inside your home, active solar space heating uses mechanical equipment such as pumps, fans and blowers to help collect, store, and distribute the heat throughout your home.

These systems can be either liquid-based or air-based.

- Liquid-based systems will use large water tanks or thermal mass for heat storage. Distribution is handled with radiant slab systems, central forced air systems, or hot-water baseboards.
- Air-based systems will use thermal mass or rock bins to hold the heated air for storage. Using ducts and blowers, the hot air is then distributed throughout the home.

2.2 Active Solar Water Heating

To heat your home's water, active solar water heating uses pumps to circulate the water or heat-transfer fluid through the system.

There are two types of active solar water heating systems, indirect systems and direct systems.

- Indirect systems use a heat transfer fluid which is usually a water-antifreeze mixture. After the heat-transfer fluid is heated in the solar collectors, it is pumped to a storage tank where a heat-exchanger transfers the heat from the fluid to the household water. This type of system is also known as a "closed-loop" system.
- Direct systems heat the actual household water in the solar collectors. Once heated, the water is pumped to a storage tank and then piped to faucets for use in your home. Since this system uses regular household water in the collectors, it should only be used in areas that do not experience freezing conditions. This type of system is also known as an "open-loop" system.

2.3 Active Solar Pool Heating

To heat the water for your pool, active solar pool heating uses pumps to circulate your pool water through solar collectors for heating and then back to your pool. Your pool is used as the storage medium for the heated water so there isn't any need for water storage tanks.

4. CASE STUDY

Viva Sarovar Ambegaon Pun

4.1 Location details

Energy Efficient Design Features

Site Details-

Location	Ambegaon Pune
Geographical coordinates	18.4336° N, 73.8436° E
Occupancy Type	Residential
Typology	New Construction
Climate Type	Composite and Mix.
Project Area	14565 m^2
Grid Connectivity	Grid connected
EPI	43.75 $kWh/m^2/yr$

Introduction of the site

In this project we apply Active Feature on Phase A and Passive feature on Phase B at Viva Sarovar Ambegaon Pune, the new Residential building located at Ambegaon Pune. The project team put special emphasis. strategies for reducing energy demand by providing adequate natural light, shading, landscape to reduce ambient temperature, and energy efficient active building systems. Several energy conservation measures were adopted to reduce the energy loads of the building and the remaining demand was met by producing energy from on-site installed high efficiency solar panels to achieve net zero criteria. Viva Sarovar Ambegaon, uses 70% less energy compared a conventional building of Viva sarovar Phase 1. The project adopted green building concepts including conservation and optimization of water by recycling waste water from the site.

Viva Sarovar Ambegaon, is now India's highest green rated building. The project has received GRIHA 5 Sta.

4.2 Passive Design Strategies

- Orientation: Building is north south oriented, with separate blocks connected through corridors and a huge Water Lake. Orientation minimizes heat ingress. Optimal window to wall ratio.

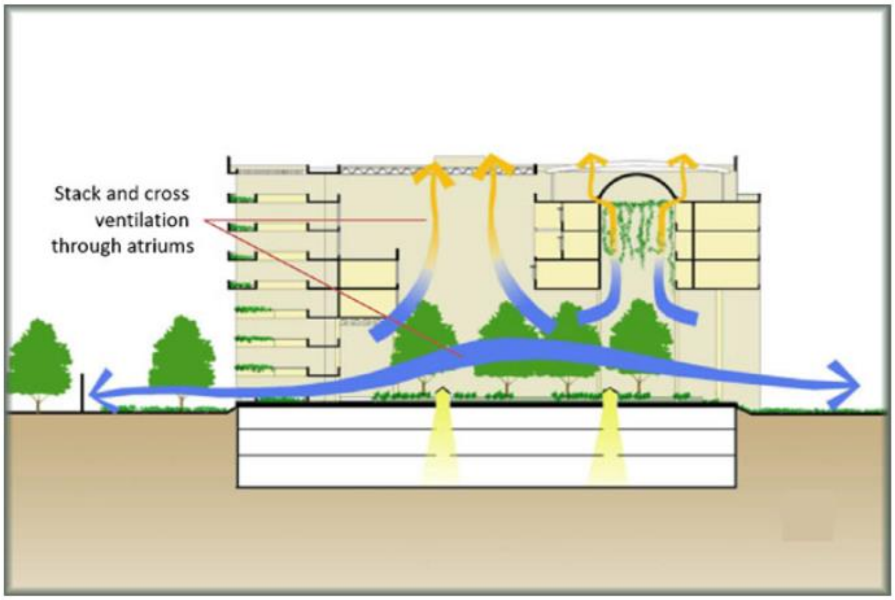
- Landscaping: More than 50% area outside the building is covered with plantation. Circulation roads and pathways are soft paved to enable ground water recharge.

- Daylighting: 75% of building floor space is day lit, thus reducing dependence on artificial sources for lighting. Inner courtyard serves as a light well.

- Ventilation: Water Lake helps in air movement as natural ventilation happens due to stack effect. Windows and jaalis add to cross ventilation.

- **Building Envelope and Fenestration:**
    - Optimized Building Envelope – Window assembly (U-Value 0.049 W/m^2K),VLT 0.59, SHGC 0.32
    - uPVC windows with hermetically sealed double glazed using low heat transmittance index glass
    - Rock wool insulation
    - High efficiency glass
    - Passive Solar paneling
    - Cool roofs: Use of high reflectance terrace tiles for heat ingress, high strength, hard wearing.

- **Materials and construction techniques Used :**
    - AAC blocks with fly ash
    - Fly ash based plaster & mortar
    - Stone and Ferro cement jaalis
    - Local stone flooring
    - Bamboo jute composite doors, frames and flooring
    - High efficiency glass, high VLT, low SHGC & Low U-value, optimized by appropriate shading
    - Light shelves for diffused sunlight



Passive Design View 1

Passive Design View 2

Passive Design View 3

4.3 Active Strategies

Lighting Design

1. Energy efficient lighting system (LPD = 5 W/m^2), nearly 50% more efficient than Energy Conservation Building Code 2007 requirements (LPD = 11 W/m^2) reduces energy demand further.
2. Remaining lighting load supplied by building integrated photovoltaic (BIPV).
3. Use of energy efficient lighting fixtures (T5 lamps).
4. Use of lux level sensor to optimize operation of artificial lighting.

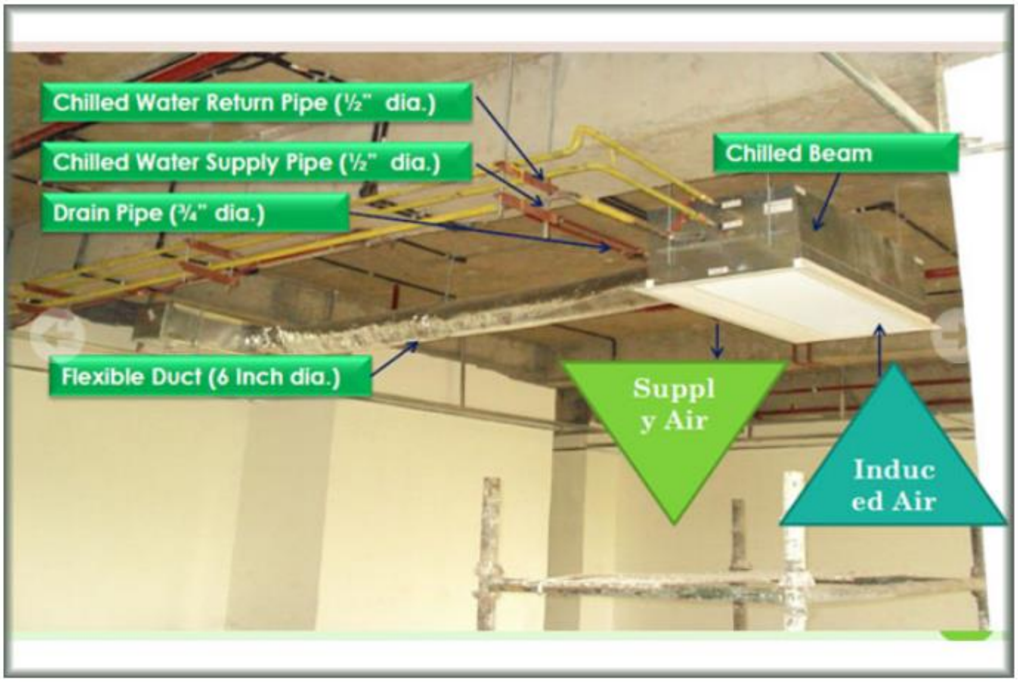
Optimized Energy Systems / HVAC system

Chilled beam system/ VFD/ Screw Chillers

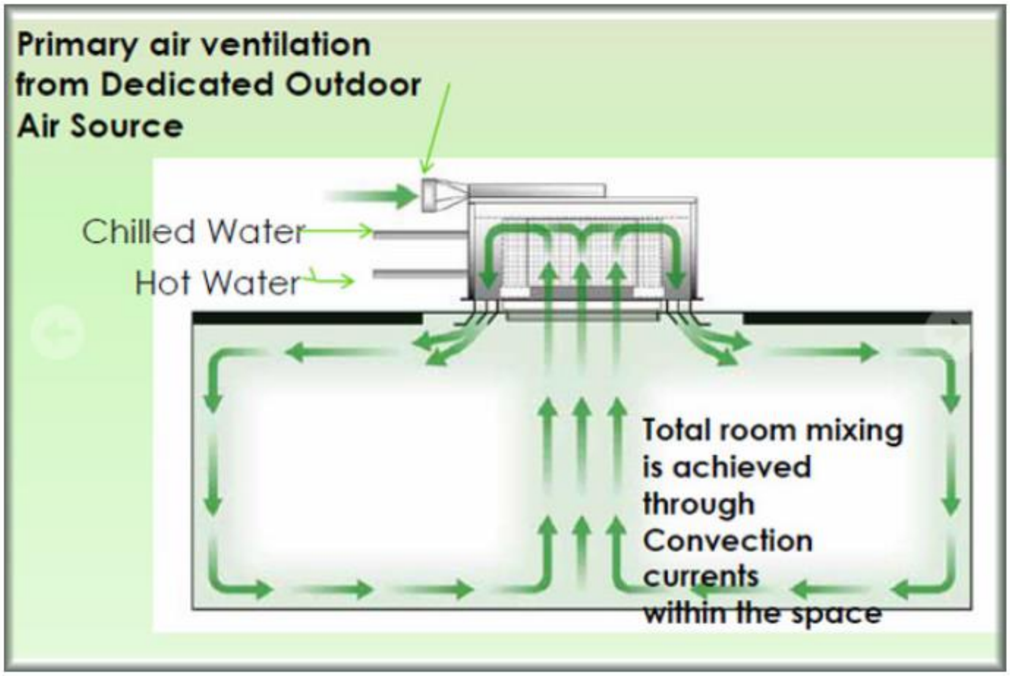
- 160 TR of air conditioning load of the building is met through Chilled beam system. Chilled beam are used from second to sixth floor. This reduces energy use by 50 % compared to a conventional system.
- HVAC load of the buildings is 40 m^2/TR, about 50% more efficient than ECBC requirements (20 m^2/TR)
- Chilled water is supplied at 16° C and return temperature is 20° C.
- Drain pans are provided with the chilled beams to drain out water droplets due to condensation during monsoon.
- Water cooled chillers, double skin air handling units with variable frequency drivers(VFD)
- Chilled beams save AHU/FCU fan power consumption by approximate 50 kW.
- VFDs provided in chilled water pumping system, cooling tower fans and AHUs.
- Fresh supply air is pre cooled from toilet exhaust air through sensible & latent heat energy recovery wheel.
- Control of HVAC equipment & monitoring of all systems through integrated building management system.
- Functional zoning to reduce air conditioning loads.
- Room temperature is maintained at 26 ±1 ° C

Geothermal heat exchange system

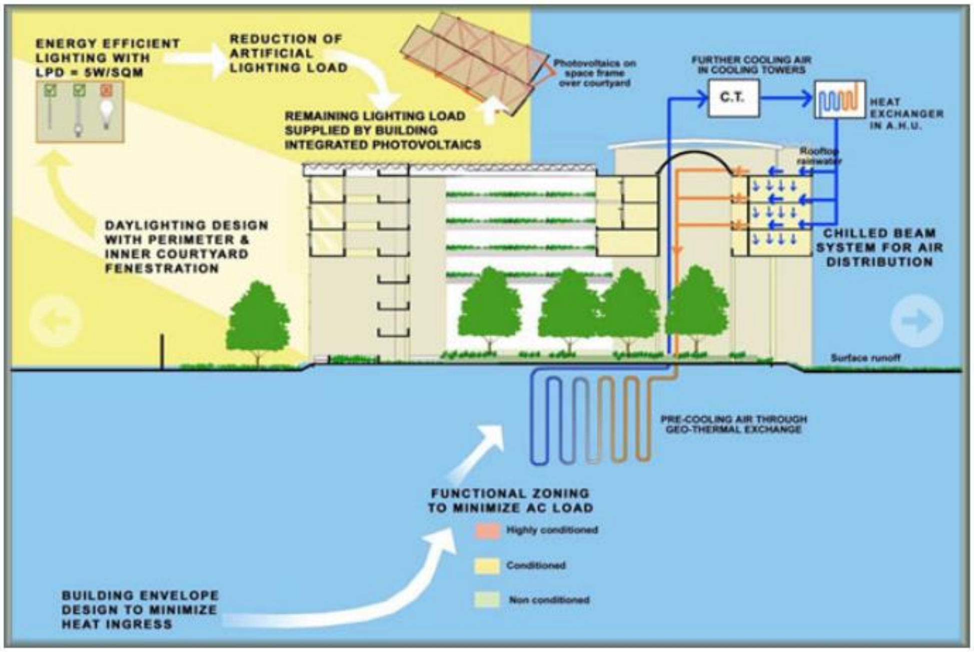
1. There are 180 vertical bores to the depth of 80 meter all along the building premises. Minimum 3 meter distance is maintained between any two bores.
2. Each bore has HDPE pipe U-loop (32mm outer diameter) and grouted with Bentonite Slurry. Each U-Loop is connected to the condenser water pipe system in the central air conditioning plant room.
3. One U-Loop has 0.9 TR heat rejection capacity. Combined together, 160 TR of heat rejection is obtained without using a cooling tower.



Active Design View 1



Active Design View 2



Active Design View 3

4.4 **Result and Discussion Energy Generation**

- Solar PV System of 930 kW capacity
- Total Area : 6000 m^2
- Total Area of panels : 4650 m^2
- No of panels : 2,844
- Annual Energy Generation : 14.3 lakh unit

Actual Generation on Site Phase A Using Active Design (As On 25.04.2019)

- Power supply to grid started on 19.11.2017
- Power generation achieved : 300 kWh per day
- Total generation : 2.0 kWh

Sr. no	**Parameter**	**Active design (Phase A)**	**Passive design (Phase B)**
1	Cost of Component	Rs 3,14,000	Rs 2,89,000
2	Energy Generation	300 kWh per day	342 kWh per day
3	Operating Procedure	Essay	Difficult
4	Maintenance	Every Year	One time
5	Moving Parts	Yes	No

Table No 1:

Sr. No	Parameter	Active design (Phase A)	Passive design (Phase B)
1	Cost of Component	Rs 3,14,000	Rs 2,89,000

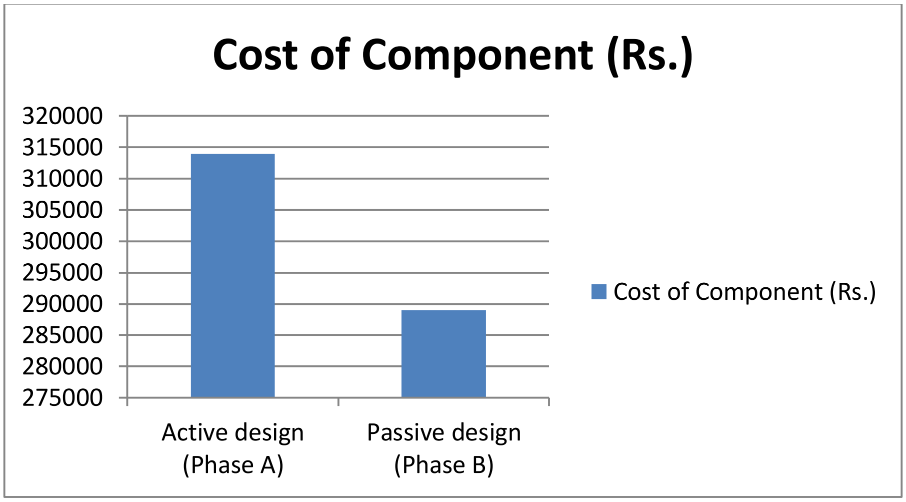


Figure : Cost of Component

Table No 2:

Sr. No	Parameter	Active design (Phase A)	Passive design (Phase B)
1	Energy Generation	300 kWh per day	342 kWh per day

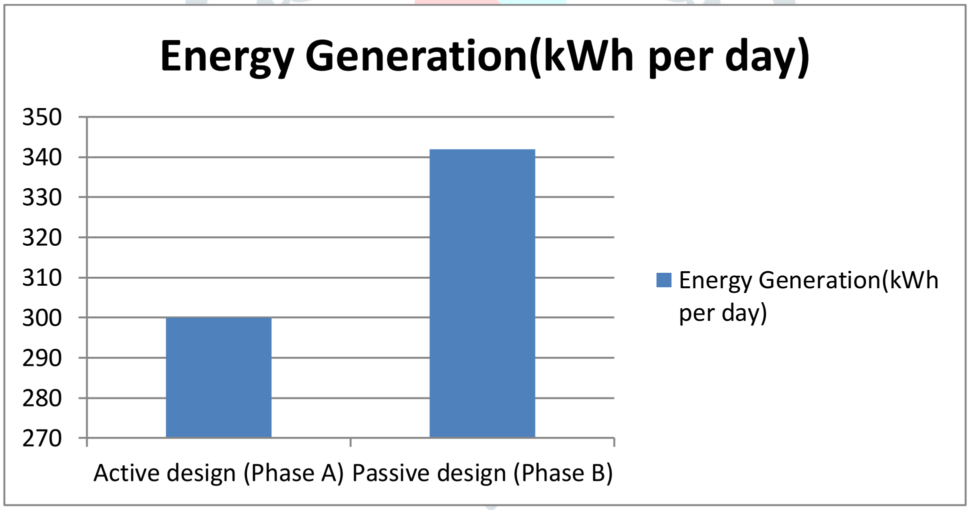


Figure : Energy Generation

Table No 3:

Sr. No	Parameter	Active design (Phase A)	Passive design (Phase B)
1	Operating Procedure Cost	35000 per year	24000 per year

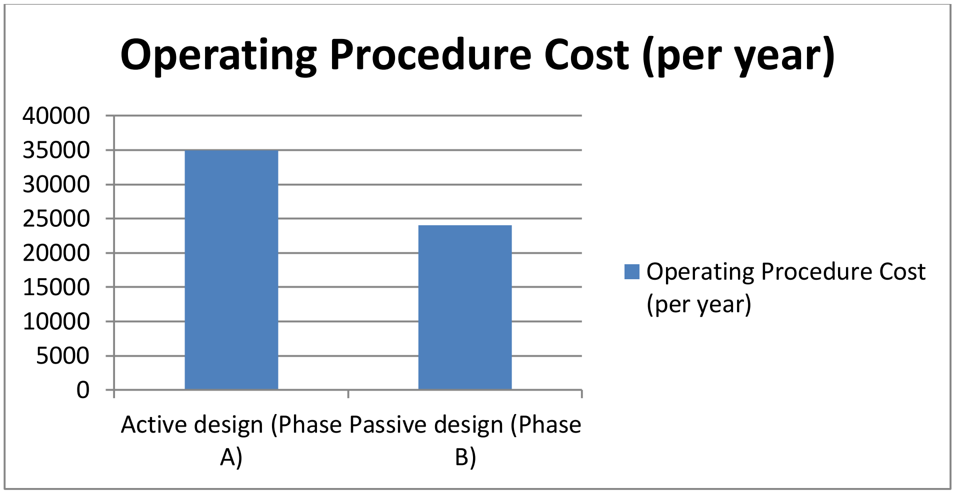


Figure : Operating Procedure Cost

Table No 4:

Sr. No	Parameter	Active design (Phase A)	Passive design (Phase B)
1	Maintenance Cost	24000 per year	19000 per year

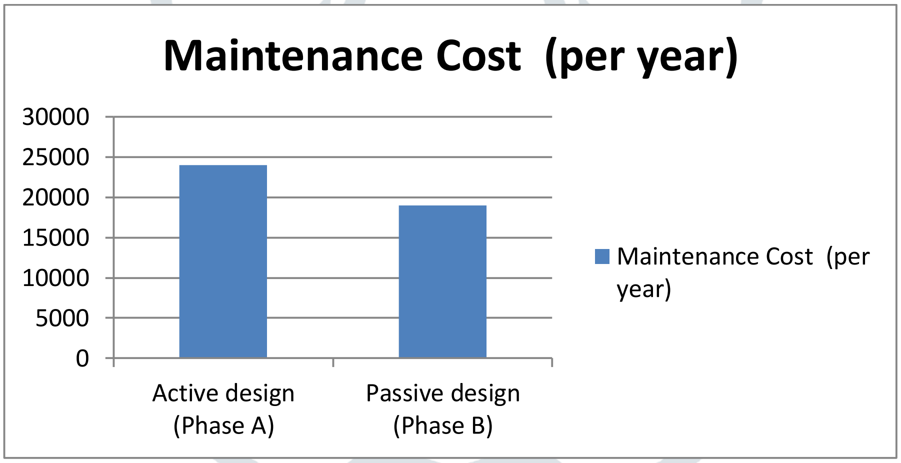


Figure : Maintenance Cost

Table No 5:

Sr. No	Parameter	Active design (Phase A)	Passive design (Phase B)
1	Moving Parts Operating Cost	27500 per year	22300 per year

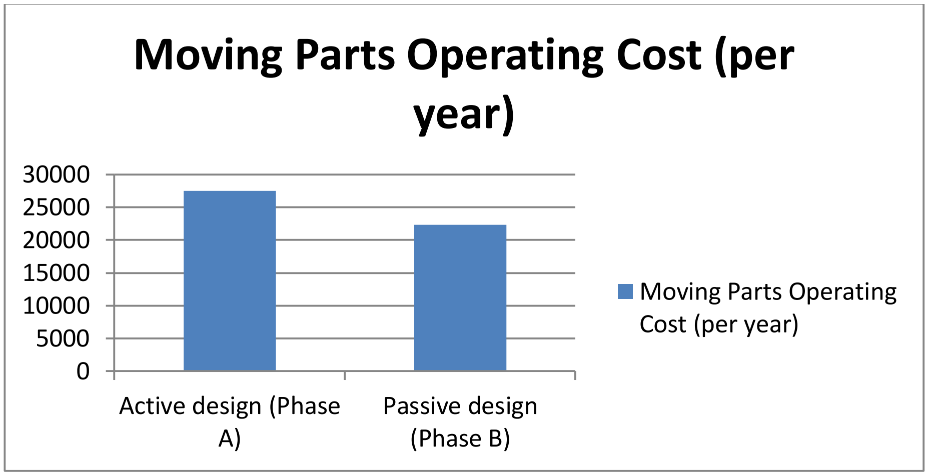


Figure : Moving part Operating Cost

After the analysis we compare that the, Passive vs Active. Passive design is a system or structure that directly uses natural energy such as sunlight, wind, temperature differences or gravity to achieve a result without electricity or fuel. Active design is a system or structure that uses or produces electricity. Passive design is better than active design.

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