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# Significance of Energy Efficient Component in the Buildings Design Towards the Green Footprint

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## Abstract

*The energy efficient building or green building design and certifications was started in the starting of twenty-first century because of whole world's people wants warmth, peace and prosperous house. Low energy consumption or energy efficiency is the main component of the green building. In this communication the author's communicating the significance of the possible methods of energy saving in building design by these methods peoples can improve the 'aura' of the building. By the application of these methods' human can save lot of conventional energy and it say that it is sustainable approach for the building.*

## Keywords

*Green building, thermal conditioning, lighting systems and day lighting etc.*

## 1. Introduction

The highest conventional energy (39%) is consumed by the building sector and the important goal is to reduce the energy demand of this sector. The other energy consumption contributors are 28% transportation and 33% industrial sector. This conventional energy is consumed in the lighting, washing, comfort conditioning, cooking and other applications in the homes, offices, and the industries. Due to the largest energy consuming sector, small saving of conventional energy deals to save the environment [1-2].

The green building is having a better environmental quality and less energy consumption than a conventional building. The improved ecological condition means additional pleasing workplace which supports more productive workforce. The proof of this statement is not available, but differences were assessed by Paul and Taylor [3]. It was studied that the air condoning

retrofitted building given more thermal comfort and in addition to that the natural ventilated buildings are given better air quality. Apart from that Dai et al. [4] studied the solid adsorption cooling cavity integrated approaches with solar chimney for thermal comfort. Lal et al. also applied the integrated approaches of solar chimney (SC) with Earth air tunnel heat exchanger (EATHE) and borehole heat exchanger (BHE) for improving the thermal comfort ventilation of the conventional building [5,6]. Kanagaraj and Mahalingam [7] have included all micro and macro factors in integrated energy efficient building design process (IEBDP). Tavares and Martins [8] was used sensitivity analysis method for energy efficient design of buildings. Nilsson et al. [9] observed that the energy demand of conventional buildings which can be reduced by energy efficient retrofitting, for which suggested and implemented retrofitting are energy efficient HVAC, fans, lighting lamps, kitchen chimney which are discussing afterward.

Leadership in Energy and Environmental Design (LEED) provides the framework for identification, measurable and implementable in green building design, construction, operations and maintenance solution. In 2009 LEED have given 100 possible credit points for categorizing the buildings. LEED included the sustainable sites, water efficiency (WE), energy and environment (EE), materials & resources, and innovative design etc. in categorization of buildings [10]. Four types of certifications prescribed for green buildings according to the scoring points are: Certified (40-49), Silver (50-59), Gold (60-79), Platinum (80 and above).

This communication deals with the enhancement natural ventilation techniques, daylighting, air quality by reducing kitchen pollution for green building design. Some energy efficient lightings are also discussed in next topics.

## 2. Natural Ventilation and Thermal Comfort Enhancement through Solar Chimney

The ventilation and day lighting rate is depends on window sizing but it has some limit. The ventilation can be enhanced by providing solar chimney in building. The SC was used for centuries mainly in Europe (Romans, Middle East and northeast by Persians) [11]. The simple solar chimney and integrated approaches with EATHE is shown in figure 1. The "natural ventilation and space conditioning" enhancement techniques for common buildings have been proposed whereas used the SC & modified SC for wall mounted and rooftop with single pass and double pass configurations. It was observed that the recommended air change per hour (ACH) 5.7 to 7.7 can be maintained by single solar chimney and it can be improved by the retrofitting of the more numbers [12-17].

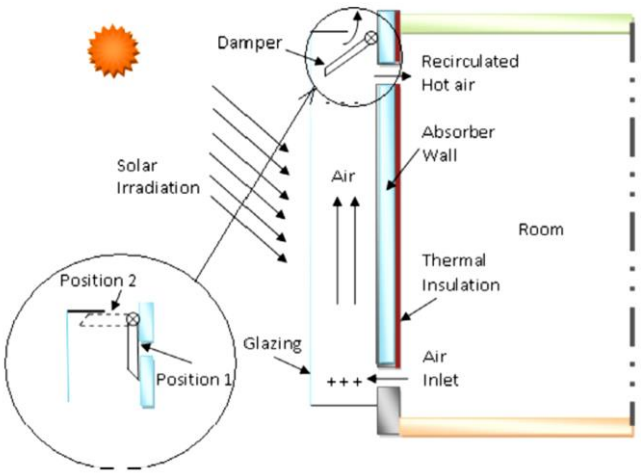



**Figure 1.** SC used to enhance the building ventilation and room heating [15].

The SC is working on the principle of buoyancy where air is heated by solar insolation or trapped solar heat. In the solar chimney, the hot air is lifted due to it reducing its density and that replaced room air is filled by ambient air. The SC mainly made of a black hollow rectangular thermal mass with two openings whereas one at the top for exit the hot air and another at bottom for entering the room air. The chimney is enhancing the ventilation or aeration by which room temperature will be reducing. SC can work to heating the room in cold region. The merits of SC are that there is no mechanical part, Low maintenance, no commercial energy Consumption, zero global warming, zero Pollution and it can be used for both cooling and heating. Only one drawback is to increases the cost of building.

The thermal comfort can be increased by applying SC both as tromba wall and roof top solar chimney. Rooftop solar chimney / Rooftop solar collector (RSC) means the solar collector situated at the top or roof. Dai et al. [4] suggested the design of single pass and double pass RSC for double mode operation such as for space heating and natural ventilation mode which are shown in figure 2 (i) & (ii). In this the dampers 1 & 2 are used to operate the arrangement in two different modes. It was estimated that the DPRSC found 10% higher efficiency than the SPRSC, where DP and SP are indicated the double pass and single pass.

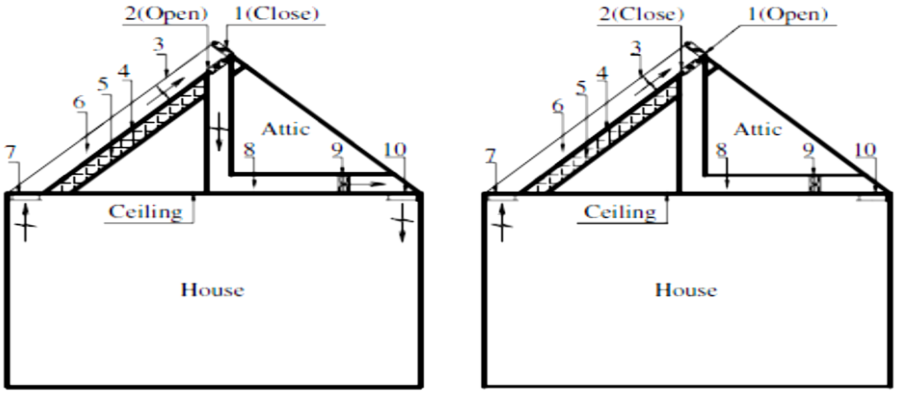



**Figure 2 (i).** Configuration of SPRSC (a) Room Space heating mode. (b) Natural ventilation enhancement mode. where 1—damper,2—damper, 3—glass cover, 4—absorber plate, 5—insulation plate, 6—-air channel, 7—tuyere, 8—air duct, 9—fan, 10—tuyere.[4]

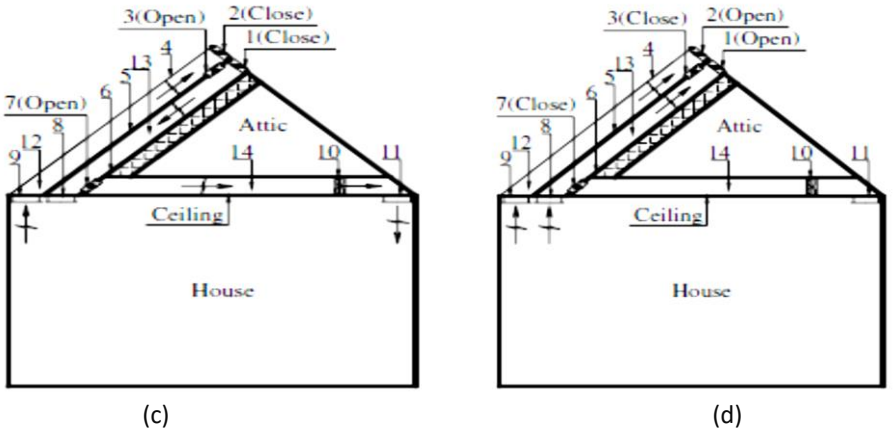


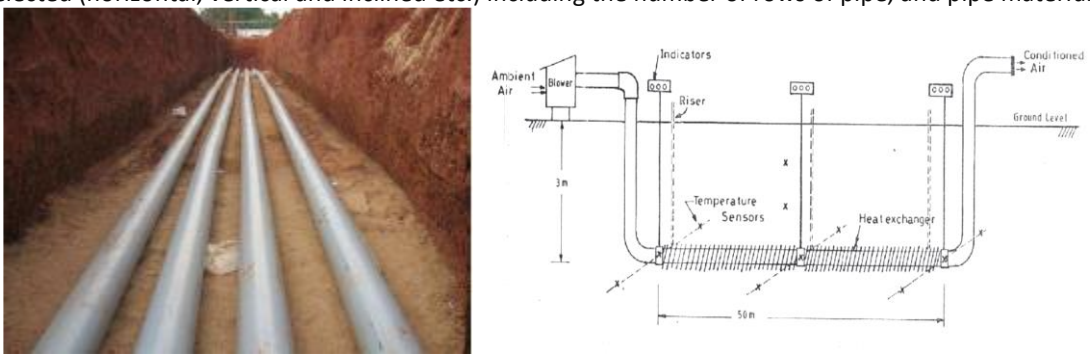

**Figure 2 (ii).** Configuration of DPRSC (a) Room space heating mode. (b) Natural ventilation enhancement mode. where 1—damper,2—damper, 3—damper, 4—glass cover, 5—absorber plate, 6—insulation plate, 7—damper, 8—tuyere, 9—tuyere, 10—fan, 11-tuyere, 12—air channel 1, 13—air channel 2, 14—air duct.[ 4].

## 3. Earth Air Tunnel and Integrated with Solar Chimney

The (EATHE) is a high potential option to reduce energy demand in comfort sir conditioning and adds a root of sustainable growth of the world which has obtained a major importance during the last three decades [19]. An EATHE system suitable to provides the reduction arrangement for heating and cooling conventional energy loads for buildings. Its working base is seasonally varying inlet temperature and tunnel-well temperature that depends on the undisturbed earth temperature. The soil temperature at a depth of about 3-4 meters or above is establish fairly constant, and it is called undisturbed earth temperature and it is almost equal to the average annual ambient air temperature. This undisturbed earth depth can be used for heating and cooling of buildings with the help of EATHE [20-21].

The performance of an EATHE system depends on temperature and moisture distribution in the ground as well as the earth surface conditions. Sodha et al. [22] designed ETHE system Mathura India for a hospital which having cooling capacity 512 kWh

and heating capacity 269 kWh at the observed air velocity of 4.89m/s. The Various simplified models of EATHE were presented by the researchers and experimentally investigated the performance [23-25]. The specific design of EATHE is depends on the condition of soil (Soil properties and water content in the soil at the depth of the EATHE pipe), undisturbed earth temperature, the design selected (horizontal, vertical and inclined etc.) including the number of rows of pipe, and pipe material.




(a) (b)

**Figure 3.** EATHE for comfort conditioning of conventional buildings [19].

The Singh [39] optimized the ETHE and evaluate the various parameters and constants which are required to design the system. Mathur and Bansal [27] integrated the desert air cooler to enhance the performance of ETHE. The main benefit of the ETHE system is to circulate 100% fresh air circulated in the building and conserve 1/3$^{rd}$ energy of conventional AC.

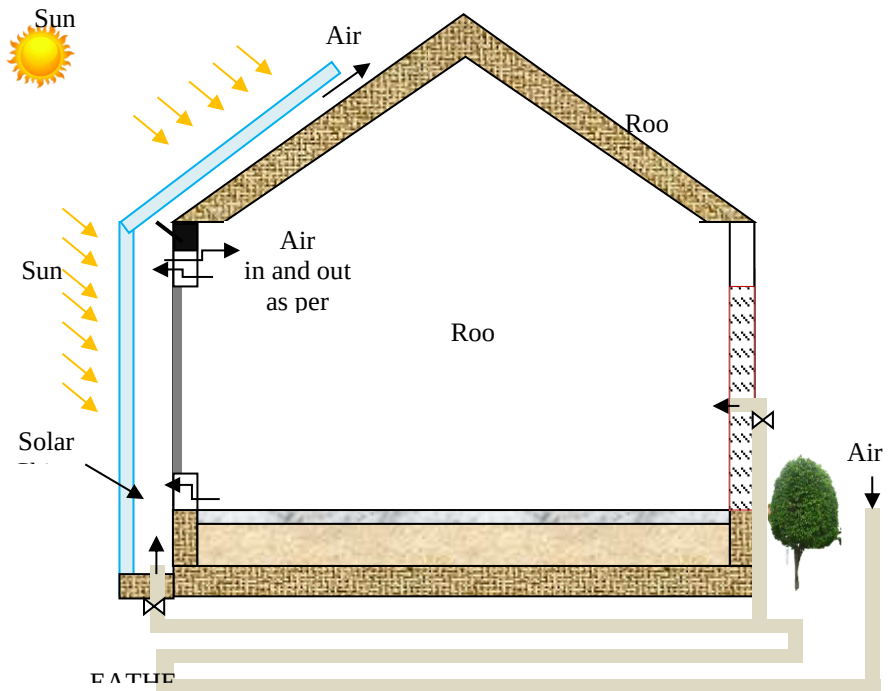
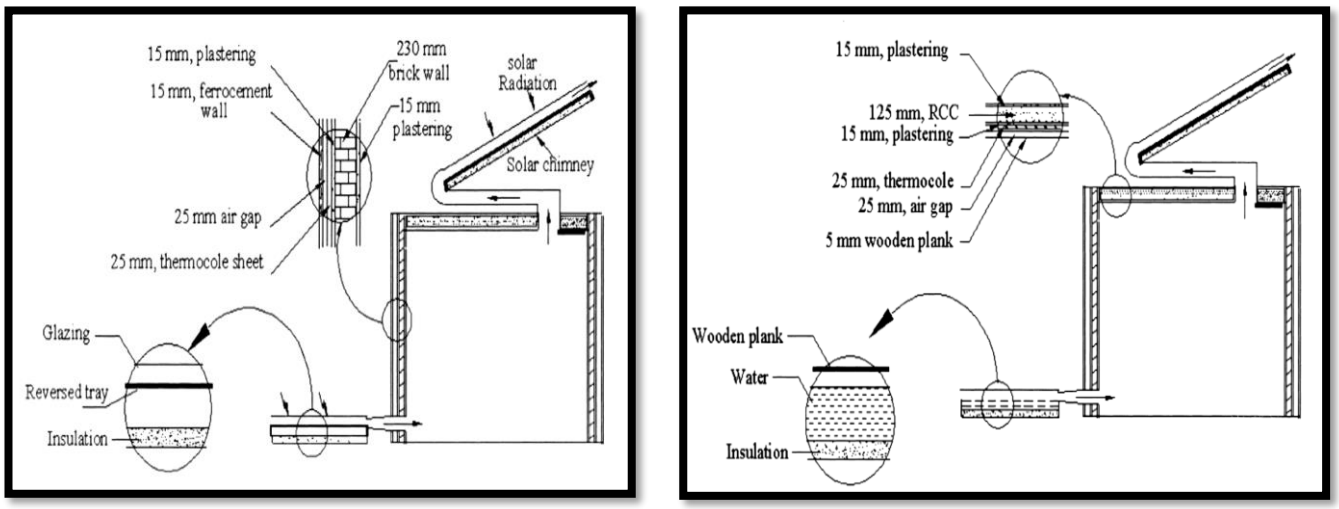



**Figure 4.** Integrated Solar chimney and EATHE.

## 4. Evaporative Cooling along with Chimney

Another important method for reducing indoor air temperature is conventional evaporative cooling. It can be used in composite climatic conditions. Chandra et al. [26] deliberate the thermal performance of passive solar air-conditioned building with

evaporative cooling. They used three different cases for evaporative cooling and found that maximum cooling is achieved by water spray over the roof. Kishore et al. [27] have given two passive heating and cooling models for winter and summer option as shown in figure 5. The cross section in the figure is shown that water will be used for summer cooling only. The roof was insulated by thermocol and wooden blocks (falls ceiling) to reduce the heat transfer. The combination of trombe wall and RSC can be used to increase the ACH (Air change per hour) and flow. The cost of building is increased up to 20% but this concept will reduce the power consumption and has good potential for thermal comfort.




(a) (b)

**Figure 5: (a).** Schematic diagram of passive model 1 system for winter operation. **(b)** Schematic diagram of passive model 1 system for summer operation [27].

## 5. Borehole Heat Exchanger and Integrated with Solar Chimney

A Borehole heat exchanger (BHE) uses the earth as a heat source and sinks to extract or reject the thermal energy from/into the ground. It is one of the examples of the geo-exchange and the hot/cold air made to be flow through BHE and produced air can be used in buildings space conditioning [28].

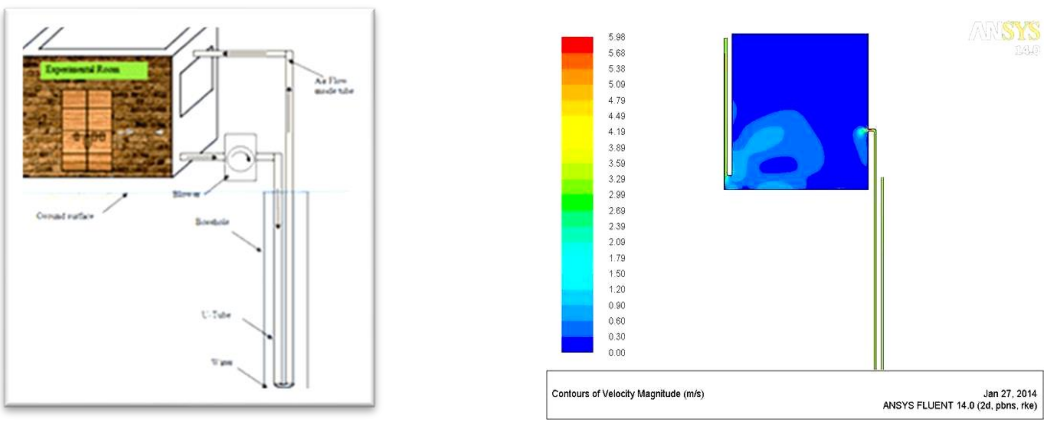



**Figure 6.** Borehole Heat Exchanger and Integrated with solar chimney [6].

Sanner [29] studied the shallow geothermal energy wells and found that geothermal temperature is reduced (up to annual mean ambient temperature) till 20 m depth and further temperature will be increasing on average 3°C for each 100m depth. A quasi three-dimensional model for heat transfer analysis of vertical ground heat exchangers was developed by Zeng et al.

[30]. Sharqawy et al. [31] suggested the dimensions of borehole heat exchanger for the purpose of building conditioning are 40-200 m depth and 75-150 mm diameter.

Lal etal [32] designed and experimentally analyzed the borehole heat exchanger which is situated at CBRI Roorkee is shown in figure 7. This design is based on the pre-study of underground water level and temperature. The 8-inch diameter borehole has been drilled and 60 feet long perforated PVC pipe is fitted to develop BHE. U-tube consisted of 2-inch diameter medium G.I. Pipe which having 3.6 mm wall thickness is used as double pass heat exchanger. A side channel blower (model YEBL-1-200, Make: Yash India) with rpm of 2880, power of 0.75kW and outlet pressure-150mbar and vacuum pressure of 140 mbar have been used for air circulation. A 2-inch Hose pipes is used to connect BHE to the experimental room. Lal [6] proposed an integrated approach of BHE and Solar chimney and evaluated the performance and observed that the integrated system performed better than the single alone BHE or solar chimney system in view of space conditioning of building.

## 6. Daylighting Enhancement

Light pipes are used to deliver or guide the sunlight to insufficient light area of building. The high reflectance materials are used as lined material in daylighting pipes. Anodized aluminum and coated plastic film (silverlux) having more than 95 reflectance [33]. The daylighting pipes are positioned in the roof with clear top dome. The top dome restricts harmful UV radiations and prevent from ingression of rainwater and dust. The Schematic diagram of light pipe in building is shown in figure 7. It was analyzed the performance of light pipe in sunny & cloudy days and found the percentage reduction in sunlight passed from outside to inside the building. The underground parking is a common feature in multi-story buildings or malls. Shin et al. [34] envisaged the energy performance of light pipe in underground parking and estimated energy saving was 27% through light pipe. The light pipes are commonly used in Korea. Hien and Chiarattananon [35] predicted the effect of heat gain by day light pipe for deep interior space of buildings. Muneer and Zhang's [36] predictive model is generally used to consider both configuration and climatic conditions for analyzing the light pipes.

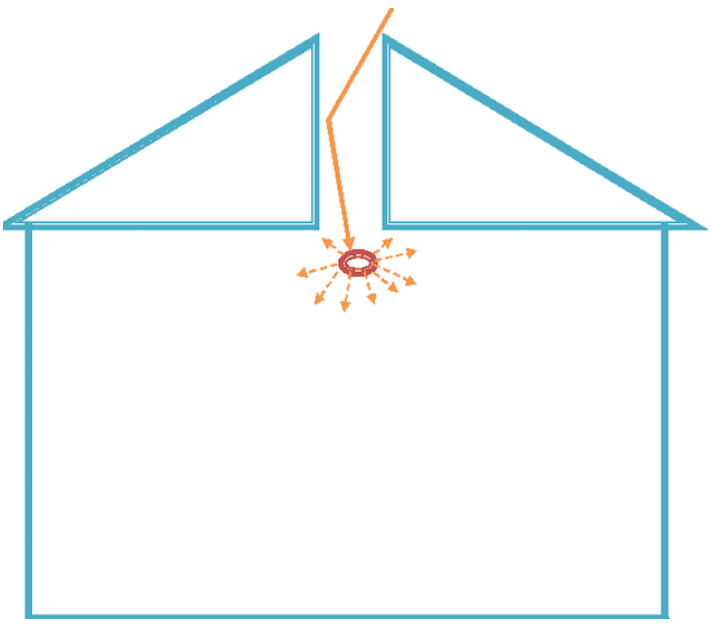
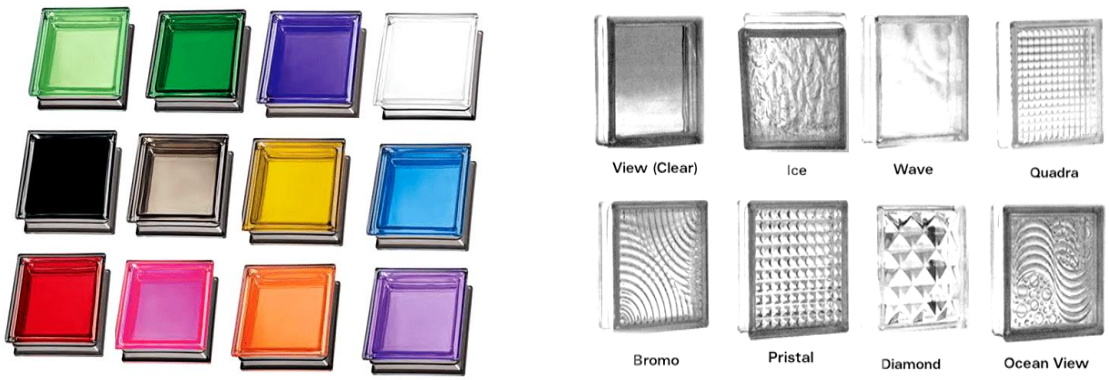


**Figure 7.** Light for daylighting of buildings.

The glass bricks are commonly used in building. It is the latest fashion of architectural design for modern buildings. The glass blocks can be used in front & side wall, and roof also for good looking and daylighting purpose. The application of glass block at various places is shown in figure 8.

**Figure 8.** Glass blocks used in buildings [37].

The glass block consists of two separate sections of pressed glass containing a partial vacuum and sealed together at high temperature. The glass block having excellent thermal conductivity, soundproof, moisture proof and fireproof characteristics and transmit light up to their transmitting limit. It is durable and allows for easy cleaning. It is available in various shape, sizes and affordable range of price. The glass blocks are also available in various colors and patterns as shown in figure 9.




(a) Colours of Glass Blocks

(b) Various patterns of Glass blocks

**Figure 9.** Glass blocks available in different colors and patterns [37].

## 7. Energy Efficient Lighting

The lighting affects the individual performance of human being. Insufficient light or poor lighting at workplace may cause of eye weakness [38].

The different level of lighting is mandatory according to work for example control room require 300 lux, corridor 50 lux and study & engineering drawing 750lux [39]. Higher illumination is the wastage of energy. We can conserve the energy by proper selection of lamp or lighting bulbs. It is essential to know the theory of lamps. The electrical lighting lamps are classified as per tree figure 10 and some lamps are shown in figure 12. The figure shows three basic types as incandescent, discharge and LEDs. Incandescent lamps are general purpose lamps available in 15, 25, 40, 60 100 and 200 watts. There is a tungsten wire or spring is used as filament in the bulb and bulb is filled by low pressure inert gas (argon, nitrogen, krypton and xenon). Its efficiency, cost and life is low. It emits light in all directions. The incandescent lamps are classified in A, R, ER, and PAR lamp named as standard, reflector, ellipsoidal reflector and paraboloidal reflector lamps respectively. Halogen lamp is having better performance and low efficacy reduction (6% efficacy is reduced of Halogen lamp and 20% efficacy reduced of incandescent lamp in whole life) than standard incandescent lamp. HID lamps are better energy efficient lamps. The types of lamps are used according to space requirement as indoor, outdoor, lobby, and study rooms etc.

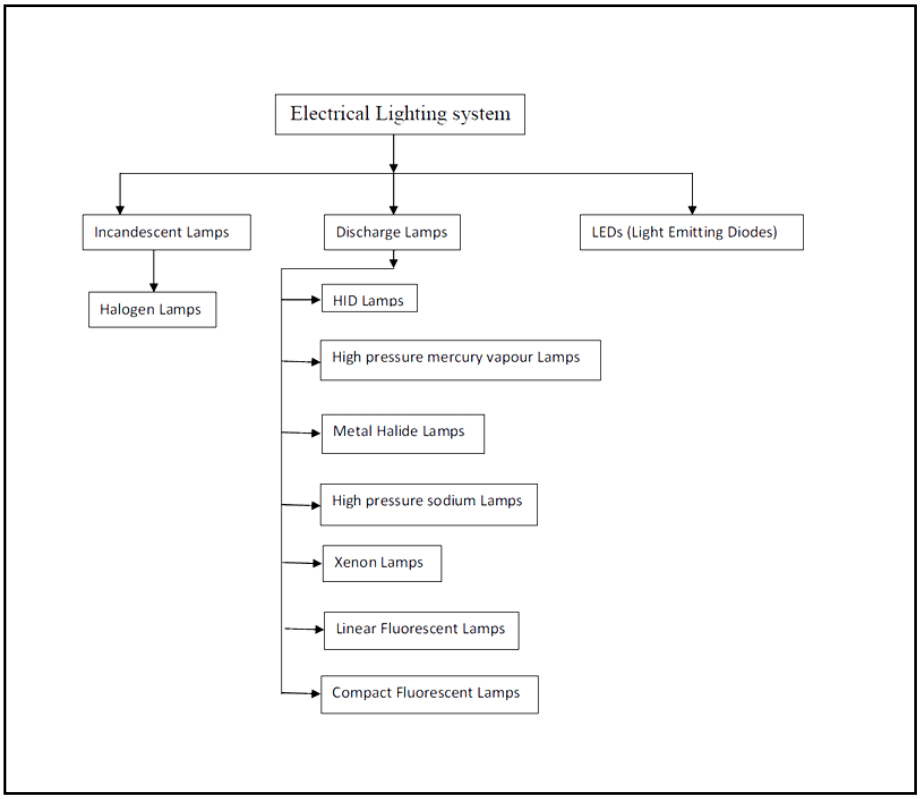



**Figure 10.** Classification of electrical lighting lamps [40].

The electrical lighting system should be designed by consideration of energy saving, economic analysis and payback period. The selection of bulb is depending on operating voltage, life, luminance and efficacy. Some of them are shown in table 1. The luminance and efficacy are the lighting parameters which depend on the watt, energy efficiency design and type of lighting source.

**Table 1.** Luminance and efficacy of some common light source [39-41, 44 etc.]

| | Types of Lamps | Average life In hours | Approximate average Luminance ($cd/m^2$) | Lamp Efficacy (Lm/watt) |
|---|---|---|---|---|
| 1 | 60-W inside frosted incandescent lamp | 750 | $1.2x10^5$ | 15 |
| 2 | 100-W incandescent lamp | 750 | $1.56x10^5$ | 17 |
| 3 | Tungsten-Halogen Lamp 300W | 2000 | $1.3x10^7$ | 20 |
| 4 | CFL-36W twin tube | 10000 | $1600\text{-}3x10^4$ | 100 |
| 5 | T-5 fluorescent Lamp 14-35W | 10000 | $2x10^4$ | 90 |
| 6 | T-8 fluorescent Lamp 36W | 10000 | $1x10^4$ | 70 |
| 7 | T-12 fluorescent Lamp cool white 800mA | 9000 | $1x10^4$ | 80 |
| 8 | High-pressure mercury Lamp 1000W | 18000 | $130000\text{-}2x10^8$ | 50 |
| 9 | Xenon short arc lamp 1000W | 2000 | $6x10^8$ | 30 |
| 10 | Metal- halide, low wattage 100W | 7000 | 8100lumen | 80 |
| 11 | Metal-halide, high wattage 400W | 10000 | 23000-36000 | 90 |
| 12 | High-pressure sodium, low wattage 70W | 18000 | 5950 | 90 |

| | | | | |
|---|---|---|---|---|
| 13 | High-pressure sodium, high wattage (diffuse) 250W | 24000 | 25000 lumens | 100 |
| 14 | Low-pressure sodium, U-type 180W | 16000 | 15000 | 180 |
| 15 | HID lamp 35-55W | 3000 | 3200 | 150 |

(a) LED Lamps

(b) Incandescent lamp

(c) High pressure sodium vapor lamp

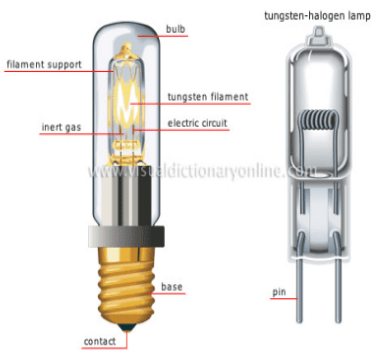
(d) Metal Halide lamp

(e) Induction Lamp

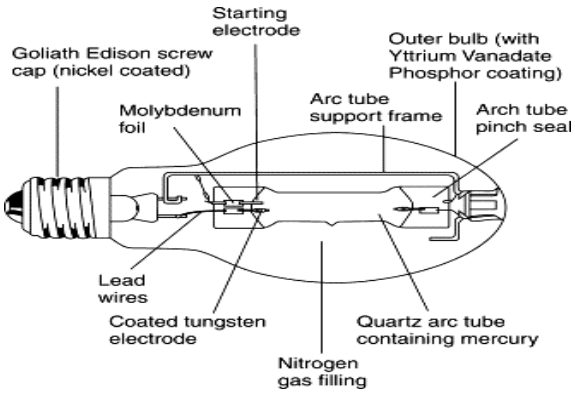
(f) various shapes of CFL

(g) Fluorescent tube

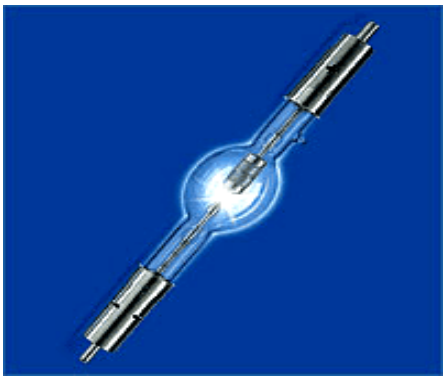
(h) HID Lamp




(i) Tungsten Halogen Lamp




(j) High pressure mercury Lamp



(k) Xenon short arc Lamp

**Figure 11.** Various types of electrical Lamps [41-45].

## 8. Kitchen Pollution Reduction

Kitchen exhaust is the main cause of indoor air pollution and increases serious health problems (respiratory illness, lung cancer and blindness). The solid, liquid and gaseous fuels are used in cookstove. Solid fuel (wood, animal dung cake and other biomass) is commonly used in rural areas of developing countries [46]. Liquid and LPG or LNG fuels are commonly used in urban cities. The liquid and gaseous fuels are clean burning as compared to solid fuel. But the kitchen has large number of pollutants caused by fuel burning or food preparation fumes. So, the chimney is the best solution of kitchen pollution. The chimney draught may be natural of force. The natural draught chimney work on the principle of buoyancy flow or stack effect and force draught chimney run by electrical energy (exhaust fan with filter). The exhaust fan is the important feature in electrical kitchen chimney; its energy consumption can be reduced by using star rating low energy consuming exhaust fan. The electrical and cement pipe chimney are shown in figure 12.


**Figure 12.** Electrical chimney for modern kitchen and Cemented pipe chimney for rural cook stove [46].

## 9. Improving Air Quality through Plants

Wolverton [47] has analyzed that the concentration of pollutants (formaldehyde, benzene, trichloroethylene, CO, NOx etc.) can be reduced by the plants. The root stems and leaves work together with micro-organism like air filtration system and creating an ecosystem [48, 49]. The small change in impurities of air may influence the health. So, the good air quality gives better feelings which increase the productivity. The plants affect psychologically and reduce the ambient temperature (area close to plant) because water will be evaporated from leaves, and it gives the cooling effect. The plantation would require in 60% area for green building as shown in figure 13 as below.

**Figure 13.** Green Building with plants, glass block and chimney

## 10. Conclusions

The green buildings are naturally ventilated with good quality air, thermally comfort energy efficient buildings. This review is presenting the major energy conservation criteria other than HVACs in buildings. The study has presented that the better environmental condition can be achieved by applying Chimney for ventilation, cooling and heating retrofitting, EATH, Light pipe, Glass block, energy efficient electrical lightings, kitchen chimney, location of building and plantation in buildings. Present scenario is demanding group housing and energy where all these aspects must be included in design for better living standard via energy conservation. The government should make rule for adoption of star rating to each building as a result of this energy demand of buildings can be reduced. The star rating on buildings is started by BEE just like as star rating on electrical appliances. The LEED ratings are global energy efficiency and environmental rating for buildings. There is need to research in the field given below to improve performance of buildings towards the side of energy conservation and comfort living etc.

- There is a need to study the solar chimney with new alternate materials for low-cost glazing, chimney structure and wall insulation for intended task.
- There is need to study of various thermal energy storage options so as to make solar chimney work continuously rather than daytime only.
- There is need to study the material selection, and underground workplace thermal data collection for EATH.
- There is need to study of illumination required to each task and implementation of light pipe, glass block and lamps accordingly.
- There is need to study of the site election and indoor air pollution reduction techniques.
- There is need to study on implementation of vastu in architectural design.

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