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Sustainable Design as a Tool for Healthy Indoor Environment

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Abstract:- This research on indoor environment would not have been possible unless it can be proven that indoor environment without design criteria by designers and occupants will affect building occupants health and well-being. This research presenting the Indoor Environment Quality (IEQ) and how it affect occupants health, comfort and satisfaction. This research will investigate relationship between elements of indoor environment in building such as heat, lighting, sound, materials, etc. and their impact on indoor health. It is believed that poor indoor air quality (IAQ) is associated with Sick Building Syndrome (SBS), which, of course, have major effects on occupants health. symptoms as a result of poor indoor environment like sickness, asthma, itching, allergy etc. as shown in **Fig.1**. This paper consists of a collection of available information about indoor sustainable design and occupant health. In addition, it reviewed different literature which relates to indoor building health. Finally, its main aim is reach healthy indoor environment which can be adversely affects neither health of its occupants nor larger environment.

Keywords:- Sustainable building, Indoor Environment Quality (IEQ), Human health, Active system, Passive System

Fig. 1- Source of indoor contaminants cause sick building syndrome.

I. INTRODUCTION

The indoor environment is considered to be healthy for its occupants if they are not threatened by any kind of risk, illness or injuries [1]. Meanwhile, poor indoor environment as a result of improper ventilation, wrong materials used in interior space and construction and lack of maintenance threatened the occupants safety, comfort and productivity [2]. In general people spend a high percentage of their time in indoor spaces (

homes, work, schools, etc.) therefore they are influenced with different types of pollution more than outdoor spaces as a result of their daily activities. Moreover, human health and well-being inside buildings is affected by the indoor air quality (IAQ) as a result of different pollutants carried by the indoor air such as biological contaminants, chemicals and particles [3]. Also, ventilation minimize sick building syndrome (SBS) symptoms and other diseases [2]. Therefore, providing clean and natural ventilation (passive system) will eliminate or reduce the amount of pollutants from indoor air reducing hazards affecting occupants health. On the contrary, natural ventilation (passive system) can elevate the level of pollutants as a result of gasses emission from vehicle outdoor and factories or even dusty wind. Meanwhile, increasing natural lighting from windows or skylight can be improved by increasing the size of openings or redistribute them or even create new ones, but this will increase heat gain. On the other hand, using mechanical ventilation (active system) has different disadvantages such as increasing energy expenses, need regular maintenance and it affect the interior spaces because of the piping, ducting and drainage. On the other hand, other symptoms influence occupant comfort and health as a result of thermal, noise, inadequate lighting, air quality, etc. [4]. Therefore, unhealthy indoor environment has an economic impact on the occupants as it increases expenditure on health different diseases such as itchy eyes, allergy and asthma, headache, and so on [5]. In addition, 3% of diseases are as a result of poor indoor environment [6]. Therefore, to provide a healthy indoor environment became the main priority among architects, designers and planner. Consequently, designing a new building that reduce hazards on occupant health is a sustainable design. Nowadays, the challenge is to accomplish sustainability and healthy and comfortable indoor environment. Therefore, the main aim of this research is to provide buildings occupants with a healthy, pleasant and comfortable indoor environment. Besides new buildings should provided with proper indoor hygiene and air quality, while proper remedies would be applied in dealing with existing buildings.

A. Research Hypothesis

The research main hypothesis is" *Creating an integration between a natural(passive)system and a mechanical (active) system will produce a sustainable design which will provide an indoor healthy environment for occupants"*.

B. Research Problem

Recently, modern buildings were designed and constructed disregarding sustainable principles. Therefore, incompatible designs affect indoor environment quality (IEQ) and influence occupants health. In addition, the lack of experience designers in the field of sustainable design influence our buildings performance in relation to health and comfort.

C. Research Aims

This research aims to provide people with a fundamental knowledge of building-related illnesses, their causes and effects. Also, this research will address the issues of sustainable design in an indoor environment and check whether the new emphasis on sustainability is helping to improve our indoor environment and affect occupant health positively.

D. Methods

The following methods were adapted to reach the research aims and objectives. These include:

1. Review of the relevant literature made by other researchers in order to provide a suggestion for improvement, in addition to searching key relevant journals and conference proceedings in the field.
2. Define the term sustainable design and its benefits.
3. Present guidelines for designers, contractors, and owners to turn their existing buildings into sustainable and healthy one.

E. Green and Sustainable Architecture Relationships

Green design is part of sustainable architecture that integrate climate, landscape, and materials to create healthy indoor environment. Moreover, materials used in green design do not negatively affect the environment during manufacture, construction, and deconstruction. In addition, sustainable architecture is integrating the principles of green design and make a balance between a passive and active system [7].

F. Benefits of Sustainable Architecture

Benefits to Nature Environment.

- Reduction of generated gasses that contribute to global warming such as carbon dioxide, methane, etc.
- Minimizing pollutions and other negative impacts for ecosystems.
- Reduction of the heat islands effect on local microclimates.

Benefits to Economic Environment

- Reducing raw materials consumption.
- Improving reusing and recycling systems.

Benefits to Social Environment

- Enhancing people life quality, health, performance and satisfaction.

II. LIKELY SOURCES FOR INDOOR POLLUTION

It is important to identify threats affecting occupants health in indoor environment in order to put criteria to mitigate these threats as shown in **Fig.1**.

- Exterior environment pollution such as traffic and industry chimneys.
- People behavior such as smoking, cooking, working with different electrical machines such as laser printers, etc.
- Products and materials used such as cleaning materials, paint, etc.
- Construction and finishing materials such as paint, floor and wall covering, furniture, etc.
- Climate change: the rise in outdoor temperature affect indoor temperature and leads to increase the number of air conditioning system.

III. SUSTAINABLE BUILDING

Over the past decade our environment suffer from a vast degradation as a result of urbanization, air pollution, climate change, etc. as a result sustainability has been proposed to mitigate environmental hazards [8]. The energy used in building sector reach roughly 40% as a result of Population growth and increasing urbanization fuel building and construction activities [9]. Meanwhile, as architecture has a major role in economic activity which represent in the mass construction activates and a new demand of more residential, commercial, factories building it is imperative to provide environmental sustainability in these newly constructions. In addition, the target should be focused on architecture schools in order to foster a greater understanding of sustainable design with an awareness of the environment.

A. Assessment for sustainable building

The criteria of sustainable design in order to improve indoor environment differ from region to region. Therefore, in order to achieve an integrated sustainable design needs it is essential to develop a guidelines for implementation during each stage of a project. These guidelines need a rating system of all aspects of indoor environment to measure its performance. Different international sustainable design assessment methods around the world:

- **BREEAM, UK**
- **LEED, US**
- **CASBEE, Japan**
- **GREEN STAR, Australia "NABERS"**
- **ASHRAE**

Their main role is to check to what extent sustainable design were applied in project to improve an indoor environment. Also, guiding architects, contractors, and occupants to applying sustainability in a successfully way. In this research BREEM and LEED will be discussed.

BREEAM, UK, 1990

It is a method used around the world for building environmental assessment method to check IEQ using rating scale Pass – Good – Very Good – Excellent – Outstanding [10].

LEED, US, 1998

It is a green building system aiming to promote a high building performance, healthful and comfortable environment. LEED basic category to assess buildings.

Scheme	BREEAM UK	LEED US
Introduced Date	1990	1998
Developed By	Building Research Establishment, UK (BRE, UK)	US, Green Building Council (USGBC)
Scope	Offices, Retail, Industrial Education, residential	residential, commercial, indoor environment, schools, retail
Category	health & wellbeing, pollution	energy & atmosphere, indoor air quality

Table 1- Comparison between BREEM & LEED building rating systems

Table 1shows both the schemes BREEM and LEED sharing health & well-being and indoor air quality (IAQ).

IV. INDOOR ENVIRONMENT

An indoor environment which affect the health and well-being includes indoor air quality (IAQ), thermal, acoustical and lighting.

All these factors are very important in designing a building through environmental design. "*The interaction of light and air and sound with the form and materiality of architectural space is of the very essence of the architectural imagination.*" [2] [11].

Indoor Air Quality (IAQ) is responsible about occupants' health. Most of the symptoms of illness are as a result of air pollutants [3]. Different studies of indoor environments show indoor materials used in finishing and furniture are responsible of unhealthy indoor environment [8] as shown in **Fig.1.**

Despite all buildings nowadays are equipped with heating, ventilation and air-conditioning (HVAC) systems to control climate, occupants still exposed to risk [3]. Part of indoor environment is thermal comfort that include feeling warm, cold, draught etc. Nevertheless, unwanted thermal effects is as a result of poor air quality, poor ventilation. Another aspect of indoor environment is sun (light) have different benefits on both human health and architecture, which was acknowledged previously by different civilization. In addition, people experience architectural spaces through vision as it is a medium revealing spaces, texture, color. Therefore, the challenge here is the balance in use between natural and artificial lighting as natural light is important for health purposes as visual discomfort can lead to eyestrain and headaches. On the other hand using artificial lighting has a relationship with the increase in energy consumption and visual discomfort. With regard to sound it is part of an indoor environment quality (IEQ), disturbing sound is called noise which considered an environmental pollution. Despite these problems in indoor environment making indoor environment a healthy place can be by using sustainable building design which use cleaner materials, less toxic compounds and a proper ventilation. Therefore, using sustainable design will have an excellent IEQ.

V. INDOOR ENVIRONMENT CONTROL

The integrated indoor environment is one of the sustainable architecture important issues to achieve a high quality of the indoor environment to occupants without losing more energy and more pollution. The following part present improving IEQ:

A. Indoor Solar Control

In order to improve indoor building environment, it is essential to control heat gain from solar radiations which will conserve energy and reducing fuel consumption used in lighting, ventilation, cooling, decreasing glare, etc. However, natural daylight, ventilation, exterior views should be considered in controlling solar gain. To achieve the benefit of solar control the following elements should be considered:

[2] Hawkes, D. (2008) The environmental imagination, technics and poetics of the architectural environment, p: XVI.

Windows

It is very important in building design connecting occupants with outside, providing cheapest ventilation and reducing the need for cooling system. Placement of windows is very important in climate control. Advantages window design provides whether (single, double or triple pane) or flush, recess or projected in reducing unwanted solar heat gain and noise and improving natural daylight and outside view as shown in **Fig. 2**. In addition using overhang system above windows and louvered shading systems contribute in reducing heat gain and improving both natural daylight and passive cooling system as shown in **Fig.3.**

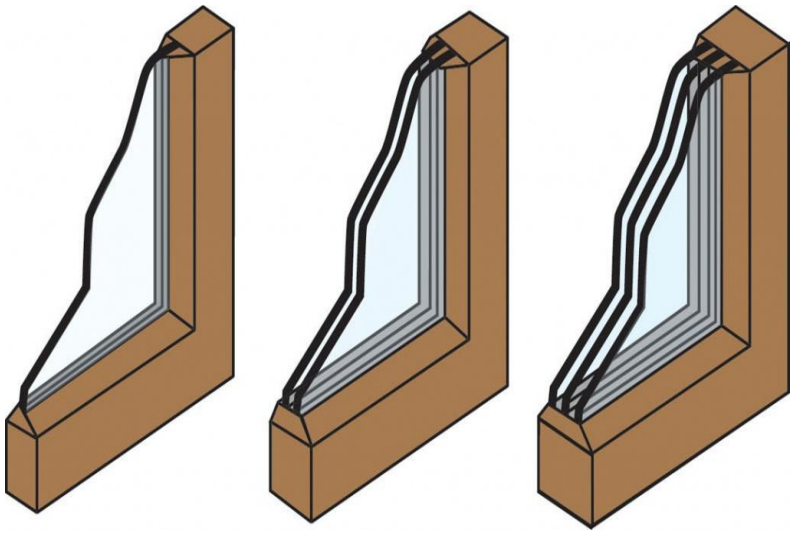
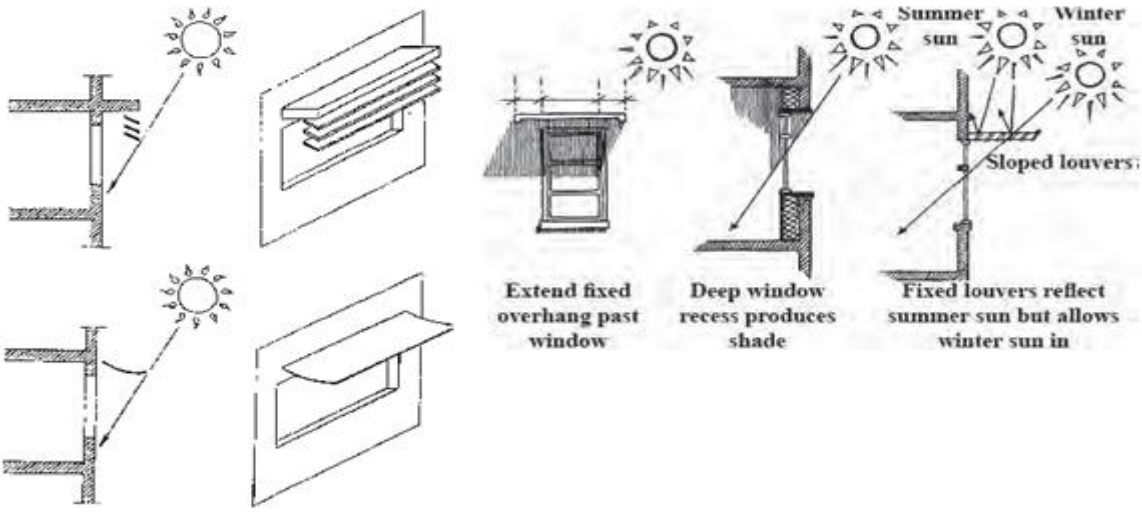


Figure 2: Single, double and triple window pane [3].



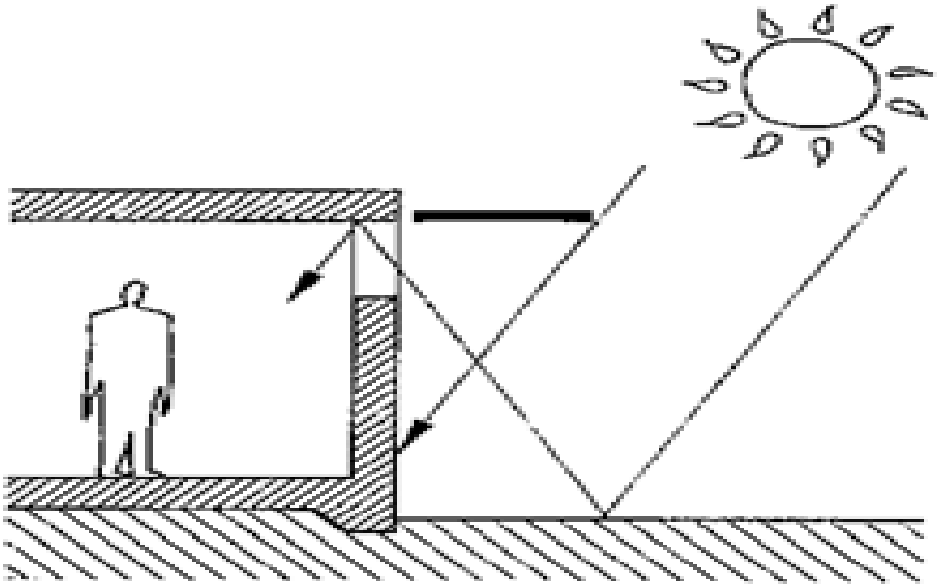


Figure 3: Using overhang, louvers and recess window to control solar heat gain (Moraekip, 2013, p: 73).

[3] http://hubpages.com/living/Difference-Between-Single-Pane-Double-Pane-Glass-Windows

Roof shape & Materials

To reduced heat gain it important to notice the shape of the roof (flat, pitch or vaulted) affecting heat gain as inclined and vaulted roofs give more shade therefore reduce heat emission to interior spaces as shown in **Fig. 4**. In addition using light colors reflect sun rays and reduce solar heat gain. Selections of good materials with good acoustic properties help reducing noise.

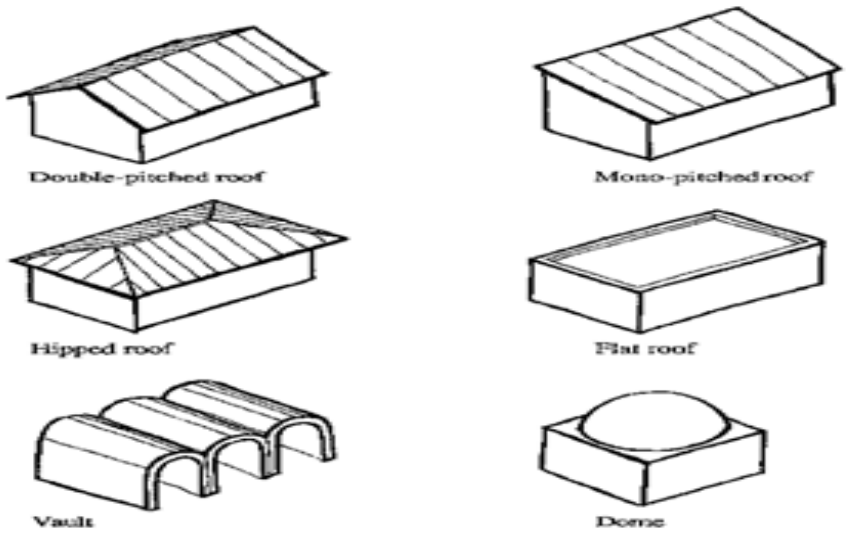


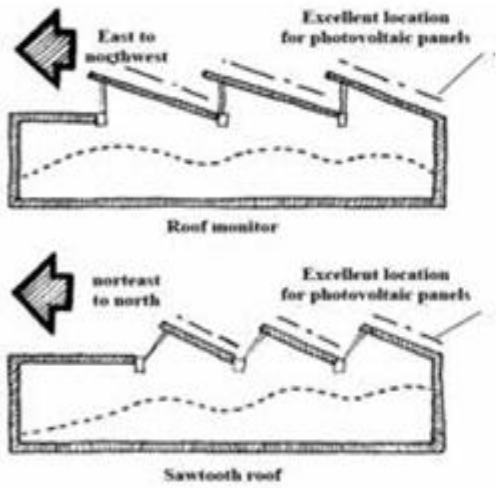
Figure 4: Different roof type shape (Stulz, 1993).

Green Roof

Green roofs with a thin layer of soil and light weight on building's structure can improve building performance by reducing heat gain and improve the outdoor environment which reflect on the indoor one by taking up CO2 and producing O2 the same happened of using indoor plants.

B. Indoor Natural Daylight

It is much healthy for human vision to depend as possible in his daily activities on natural sunlight rather than artificial light. Another benefit of natural light is reducing artificial light which depend on energy which add another value for healthy indoor environment. The way natural daylight enter building's interior spaces is through windows, roof (skylight) and saw tooth roofs as shown in **Fig. 5**. Therefore, windows which provide natural daylight and reducing heat gain it is essential to increase window glazing in north and north east elevations and limited in south and southwest elevations. Moreover, using light shelves will increase the natural daylight as it collect sunlight and reflect and distribute it to interior spaces and conserving energy as shown in **Fig. 6**. On the other hand using artificial lighting should be designed based on reducing growling energy by sensors and economizing lighting fixtures can saving up to 75% of lighting energy [7].



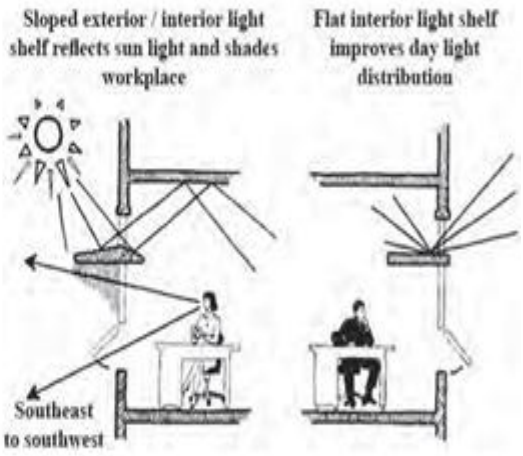


Figure 5: Roof shapes (Moraekip, 2013, p: 62)... Figure 6: Using light shelves (Moraekip, 2013, p: 75)

Indoor Natural Ventilation

The main function of natural ventilation is to change the polluted indoor air with a fresh air. Ventilation also get rid of odor, water vapor and reduce energy required to operate artificial HVAC system. There are many methods improving natural ventilation (passive cooling) such as placement of windows facing breeze, and creating open plan layout, and building orientation. Natural ventilation happened as a result of pressure difference that drive the air to move, therefore windows has to be in lower level while others at higher levels as shown in **Fig. 7**.

On the other hand, HVAC system is an artificial way of providing a building with ventilation to improve indoor air quality. Therefore, HVAC systems should achieve a balance between indoor temperature and humidity and maintaining indoor air to improve indoor air quality and produce comfortable indoor environment.

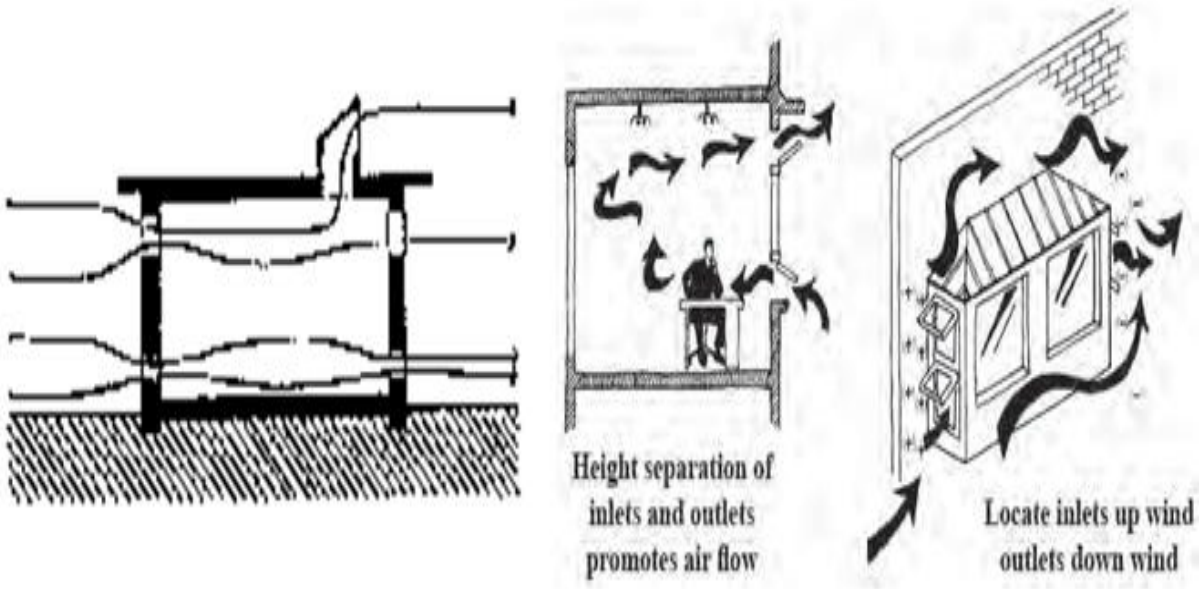


Figure 7: Creating pressure differences to improving air flowing Using light shelves (Moraekip, 2013, p: 76).

Materials

All materials used in buildings in general and in an indoor environment may contribute to unhealthy air quality as a result of releasing toxic gas, supporting a growth of molds and bacteria. The most common unhealthy building materials are plastic and rubber flooring, paint and glues uses for building's interior spaces finishing. Therefore, selection of healthy building materials which has minimal or no toxic properties to create healthy building's interior spaces to occupants is very important. However, green building materials are selected for: low consumption of energy, low pollution and negative impacts on human health as follows:

- Reduce the consumption of building materials embodied energy by using renewable types of energy.
- Recycle all waste of building materials and reuse it to reduce the consumption of new and raw materials.
- Reuse old building materials comes from buildings demolition processes in suitable usages.

VI. CONCLUSION

Various aspects affecting occupant's health and well-being in an indoor environment. These aspects include daylight, air quality, temperature, noise, odor which constitute the indoor environment quality (IEQ). Once the hypothesis has been confirmed, then it is essential to develop reasonable mitigation measures with the assistance of the information provided from literature and other references. As people spend much of their time indoors IEQ has an impact on them. The application of green building design which maintain IEQ to provide a healthier environment. To serve such a purpose, many regulations were reviewed. Architects, designers, contractor, and owners have a vital role in protecting the health and reduce indoor hazards. However, provision of guidelines still needs more efforts in providing a balance between natural and artificial system.

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