# Factors Affecting the Day lighting performance in the Residences

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***Abstract*: *Daylighting consideration improves the building efficiency in terms of energy. In residential buildings natural daylight provision enhance space quality and user well being. The design, construction, operation and maintenance of buildings have a significant impact on the environment. The challenge is to have buildings that minimize the usage of energy and its cost for operation with increase in occupants safety, comfort and health. Conventional building provides interrelationships between building occupants, components, surroundings, etc. In addition, majority of buildings consumes abundant amount of natura resources than required and frequently this leads to negative environmental impact. In this paper, the impact of daylighting in residential buildings was studied, and analyzed.***

***Index Terms*: *Residential building, delighting, illuminance, Energy saving.***

## I. INTRODUCTION

In recent years, India is subjected to rapid urbanization growth than expected rate. Building design with non-compliance and inefficiency emerges the building sector as higher energy demand. Energy requirement for building is growing at unexpected rate which acquires energy demand of around 8% among this residential sector alone contributes 25% of cummulative energy consumption rate (Yu et al., 2014). In residential building most of energy is consumed in the form of ventilation, cooling and artificial lighting. Energy efficient building adopts day lighting is considered as useful strategy (Debnath & Bardhan, 2016). Additionally, for improving energy efficiency of the building daylight is considered as an effective approach. Amount or quality or natural daylight in residential building could be considered as an effective approach for improving space quality and users well being. Daylight is more appropriate for desert location since it is endowed with the anundant amount of clearskies. But in other hand daylight supply in uncontrolled manner will result in uncomfortable glare in some times this will result in space overheating and due to direct solar admittance radiation in hot-arid climate of the desert (Sabry et al., 2014). In lighting industry daylighting is considered as an significant source of energy. Since it is necessary for obtaining certificate from Leadership in Energy and Environmental Design (LEED) (Newsham et al., 2009). Based on significant designing process and its implementation daylight is exhibits performance similar to adopt light which cope with environment else illumination required for space become inefficient (Sharp et al., 2014).

Significance: However, there is hardly any study that has made an attempt to assess the impact of building interior structure including window sizes with regards to daylighting. Hence, this study will review this issue thereby reflecting about a study gap in this regard.

Materials and methods : A review of literature was done to document and analyse the well-being in terms of user's daylight comfort in the residential buildings. The methodology includes a four stage cycle of identity, collect, classify and analyse. The first step was the identification of the key words. This research targeted to study and analyze the indoor environment quality impact on health and office occupant well-being. Keywords used for collecting relevant studies are indoor environment quality, well-being, occupant well-being, residential buildings and occupant comfort. Literatures are searched in Google scholar and science direct. After completion of articles based on keywords bibliographic are scrutinized for identification of relevant articles those are missed in results of first search. Final and third step adopts classification of articles based on three criteria in to consideration such as window system, daylight availability analysis and measuring the performance of light energy.

## II. RELATED WORK

In this section, studies related to impact of daylighting for residential buildings was discussed based on the availability and performance of light energy source through window system.

### A.Window system

Various relevant research studies were analysed to understand the admission of daylight into the interior spaces of the residence. Cheong et al. (2014) analysed the impact of double window system (DWS) on load reduction cooling rate and properties alteration occurs in daylight. This research considers residential building surface reflectivities shading based on highly glazed surface. Results demonstrated that DWS implementation in residential building reduces cooling load rate by 43%–61%. Further cooling period electricity cost reduced by the amount of 24%. However, settings of shading devices prioritize cooling load reduction effectively which highly reduces daylight factor and indoor space luminance level. On the whole this research concluded that implementation of DWS shading devices is most appropriate for high reflective surface which offers sufficient thermal and visual environment. Shading device with low reflectivity at the rear surface influence on additional load reduction cooling rate of 4%.

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Vanhoutteghem et al. (2015) evaluated the the properties of facade windows orientation, size and glazing properties related to geometries of different side-lit rooms located in Danish 'nearly zero-energy' houses. The upper limit for saving energy is higher for the rooms located in south-orientation. This leads to minimized space heating demand by designing large window for low U valued rooms located in north and south orientation. Moreover, it put forth the requirement that designing windows for rooms based on south-orientation for minimizing interior thermal heat..The best alternative is to opt solar control coating than dynamic solar shadings. However, there is a need to address the concerns relating to the narrow south facing rooms in getting daylight without overheating.

### B. Daylight Availability analysis

When Munoz et al. (2014)stated that daylight is based on climate and induced by the factors such as obstruction, orientation and location. During initial stage of building construction local climate, building surrounding and orientation are considered as significant factor. Daylight boundary conition assists the illumination of office space in open-plane for daylight factor attributes requisite, daylight autonomy and so on. Locationclimatic condition are decisive factors for ascertaining the features of the daylight source. However, consideration of adjacent buildings blocking daylight is more important as when compared to the orientation of glazed façades. Daylight availability is analysed by Mathew and Kini (2016)with consideration of building interior with fixed design and orientation. The selected building is evaluated for different climatic zones of India. The present research modeled the building through Ecotect daylight tool and simulation is performed using Radiance Beta V2.0. In this research illuminance is selected as performance indicator for analysis. Also in this research for all climatic zones of India daylight percentage is evaluated. Comparative analysis performed for daylit area under two scenario such as under illuminated and over illuminated and glare perceived area for various climatic zones are presented.

### C. Light energy

In a residence, energy is primarily consumed for different purposes such as heating, cooling, ventilation, lighting, etc. Buildings based on energy are considered throughout the life-cycle of building based on environmental analysis which focused on analysing the factors which affects the energy consumption. Energy consumption factors are glazing and fenestration, facades concepts/building envelope alternatives, thermal mass of building structure types, insulating material, natural ventilation, lighting and day-lighting control, natural ventilation and energy recovery opportunities for protecting air quality in indoor and outdoor environment. All factors mentioned above are having significant impact on energy efficiency of the buildings (Todorovic & Kim, 2012).

In most of the environment illuminance level in working plane is key determining factor for lighting acceptability and visual task performance (Goodman, 2009). Tzempelikos (2008) discussed about the impact of Venetian blind geometry and tilt angle on direct light transmission and illuminance in interior surface. This research presented a analytical method to calculate projected shades and fraction view equipped in windows with Venetian blinds of any shape was presented. Further this research evaluated the reflectance level on flat shape over window-blind system with estimation of effective reflectance. Analysis results demonstrated that effective reflectance in window is considered as significant factor for blind rotate specifically for curved slats. However, tilt angle are exhibits minimal impact in the component of inter-reflected when blind reflectance is considered as an less important factor(Tzempelikos, 2008). Although,factors are not related directly this provides intial concept with consideration of different considerations for solar screens by offering possible combination for changes in reflectance surface screen through automated tilting angle reflectance value.

Acosta et al. (2015) explored a study to assess autonomy of daylight with generation of illuminance in daylight inside the room with consideration of different window models. 28 simulations were carried out in the study. The daylight autonomy, the shape, size and position of windows were measured and found that in back of the room autonomy of daylight is directly proportional to glass surface. However, there is no relationship between energy and the window shape. Also it is concluded that the amount of luminance is high at room back side for upper position of windows than at the centred locations. In addition, reflectance value is decisive for inner surface in daylight autonomy measurement.

Debnath and Bardhan (2016) analysed two key parameters for incidences of daylight those are Useful Daylight Illuminance (UDI) and annual light exposure. Parameters intended for analysis is aimed to understand performance of daylight in case of high -rise buildings located in residential area. By varying UDI values reiterated the orientation (window-to-wall ratio). Day light usability is with consideration of illuminance level is considered as functional space and it is observed as more effective for energy management scenario. This is particularly significant in the cases where annual incident illuminance level alone considered as measurement metrics. However, in this research scheduling of lighting energy is not considered for simulation hence it is necessary to focus highly on calculation of energy saving from daylights. Further building with appropriate daylight inclusive factor abide by laws includes metrices like UDI which is foster for houses with significant energy efficiency in early designing stage.

Pattanasethanon et al. (2007) introduced a novel concept for irradiance over the horizontal plane and global and diffuse illuminance estimation. The developed model requires components such as sky quantities for retaining global and diffuse horizontal irradiance and illuminance for global horizontal is used for building energy saving is estimated. The analysis is performed with estimation of both empirical sinusoidal model and novel sinusoidal model with incorporation of exponential or polynomial function are validated. Analysis of results for past one year reveals that sky luminosity and energy on a horizontal plane for the area located around Mahasarakhamhigher impact than those Bangkok region. Model accuracy is validated and determined by consideration of terms such as mean bias deviation (MBD), the root means square deviation (RMSD) and the coefficient of correlation (R2) values. But their is still chance for higher error values for model application in consideration based on Perez's clearness index. Also

the developed model is considered as alternative model which is suitable for skylight quality estimation.

## III. FACTORS AFFECTING DAYLIGHT PERFORMANCE

### A.Building Orientation

Orientation of the building is considered as key factor which affects the performance of daylight specifically for interior spaces. Due to shifting or movement in Malaysia the building layout must be located in the east-west axis with location of major window facing either south or north direction for maximizing daylight penetration. Standards and Industrial Research Institute of Malaysia (2006) identified that easy transmission of direct sunlight results in energy consumption rate of building by 20% or higher while window faces either east or west direction (Husin & Harith, 2012).

### B. Types of Windows

Daylight penetration is determined by window type. In Malaysis Casement and louver windows are commonly used for residential building applications. To offers excellent ventilation casement type window is used and this windows able to seal tightly while closing but still this type of windows allows natural light penetration. These windows composites contains glass as main material. Louver windows have slats in horizontal or vertical direction with certain angle to permits air and light through the interior space. Slats angles in the louver windows can be adjusted . This type of windows are widely used in many houses since it improves the daylight penetration in indoor environment and limits the glare or redirect the light diffused.

### C.Type of Glass

Window glasses allows light and vision within the building. Different glasses exhibits distinct energy-performance characteristics which is ability to heat transfer resistance (U-value; UV), through glazing active controlling of solar heat gain (Solar Heat Gain Coefficient; SHGC) and light amount passing through the glazing material (visible transmittance; VT). Depending on the UV, SHGC and VT amount on the windows, users can able to select appropriate window for improving effectiveness of daylight at maximum level. In residential buildings typical glazing windows uses glass type such as tinted glass, obscure glass and clear glass. Among those glasses glazing with clear single glass daylights are transmitted at highest level and permits heat gain or heat loss depance on climatic condition (Husin & Harith, 2012).

### D.Position of the Sun

The position of sun in sky always subjected to certain changes throughout seasonally and affects the daylight availability. Based on identification of geographic location sun position is identified. Geometric location is calculated based on consideration of true altitude and azimuth angle. Usually, when sun is higher day will be more brighter. The significant orientation of buildings is identified through consideration of sun angle. Amount of daylight penetration within the building is affected by the movement of sun from east to west and its corresponding angle (Husin & Harith, 2012).

A summary of the literature review along with description, methodology, results and limitations are presented in the table 1:.

**Table 1 :Summary of the Factors**

| S.No | Description | Methodology | Result | Limitation |
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| 1 | Visual appraisal, Daylight Factor field measurements, lighting energy savings and discomfort glare were assessed in two GBI platinum rated office buildings in Malaysia.( Lim et al,2017) | Comparison of daylight design strategy. Visual appraisal survey. Daylight factor. Lighting circuit usage. Discomfort glare. | Lighting energy usage results show substantial savings of 53% and 41% occurred from daylighting. | For justification of daylight performance daylight factor alone doe not provides accurate results. |
| 2 | Performance of daylight distribution is analysed. (Sun et al,2017) | The annual daylight performance was investigated using RADIANCE. | The translucent slate of PS-TIMS exhibits significant performance than PS-TIMs through transparent slats in terms of uniformity ratio (UR), Daylight Glare Probability (DGP) and Useful Daylight Illuminance (UDI). | Behaviour of daylight does not considers the PS-TIM effect view. |
| 3 | A novel daylight assessment with consideration of predictive model us concern for examining health potential on non-visual impact, gaze bahaviour and visual interest within the immersive scene visuality (Amundadottir et al,2017) | Three different modes based on Human-centered approach were adopted. | Daylight performance from a human-centric perspective can provide designers with more information on an occupant's health, interest, and comfort, to move beyond analyses reliant on task-oriented illumination to address specific human needs of ocular light exposure. | When analysis method two or more factor is derived it is derived for illumination and fixed for glare prediction for field-of-view brought together for makign generalized assumption about performance of daylight. |
| 4 | In this paper techniques for metric analysis and visualization is presented which offers designer to examine non-viual effect of light with relative comparison of alternative design approach. (Konis,2017) | Baseituded on diffussion magnitudes on relative direct, stimulas frequency calculation and stimulas frequency of calculation and circadian effective area (CEA) calculation is performed through EML approach. | Daylight health benefits are evaluated under daylight performance objective with consideration of building design and evaluation. | Many parameters such as timing, spectrum, intensity, duration and past history of light exposure are assumed. |
| 5 | Analyzed the impact of DST applications in consideration of Chilean distribution networks. (Verdejo et al,2016) | A heuristic approach and a econometric method is used. | Results demonstrated that it offeres marginal reduction in electricity consumption rate of residential buildings. | Psychological impacts on traffic accidents, public transportation, biological subjects and social are considered based on government policies with consideration of daylight for application to save time and desire changes in the Chilean official time zone possibility. |
| 6 | Analysed the impact of light shelves on daylight luminance in commercial building in Toronto. (Berardi and Anaraki,2015) | Data collected based on building dimension, window size and sun light and simulated using The Perez All-Weather model. | The designed shading devices have minimal affects over the UDI in the middle of the room and full-height windows allow deep penetration of light, with UDI always above 50% in the back zone for all cases. | This research considers various orientation and obstruction scenario along with consideration of UDI parameters. |
| 7 | The performance of the daylight is evaluated for natural ventilated building to analyse the energy management. (Debnath and Bardhan,2016) | CAD Model developed, Daylight simulation is performed. Estimation of daylight for various design parameters | The amount of WWR is increased from 20% to 50% and it will be useful for increase in illuminance level by 63% within the room. | It is highly difficult to increase WWR level to 50% sicne it would leads to building structural infeasibility. |

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| 8 | Daylight illuminance determined for urban environments to comfort visual and estimate the energy performance. (Nasrollahi and Shokri 2016) | Literature survey from based on urban daylight 1993–2015. Daylight analysed using Daylight simulation software. | Factors are of high significance and their impact on the amount of daylight and energy consumption is undeniable. Based on the geometry of urban canyons by increasing the street width, the amount of radiation reaching urban canyons significantly increases whereas the energy consumption reduces. | A street orientation might cause an uneven distribution of the general radiation on surfaces of the urban canyons. |
| 9 | Through analysis of simulation tool daylight modeling is evaluated for reduction of computational load by means of optimum method Investigation of daylight modeling in energy simulation tools to find optimum method to reduces computational load. (Yi, 2016) | Kriging method. | It determines illuminance level for indoor environment is compared with daylight factor method at present with reduction of computation time in comparison of full advanced daylight performance analysis. | The research is limited for small indoor space with cosideration of test case. |
| 10 | A method is developed to design a guideline that includes day lighting at early design stages of affordable housing. (Bardhan and Debnath,2016) | The policy toolbox, using EMM is a simplified method and can easily be adopted for policy planning. | At south-east orientation, and at 20% WWR, the base-case building save up to 26% lighting energy | Assumptions are made for functional space for living room. |
| 11 | Daylight illuminance levels computed by ADSM and by Radiance correlated strongly under various sky conditions. (Yoon et al,2016) | Daylight coefficient approach and sun-matching method of ADSM. | Difference ranges between illuminance levels from measurements and simulations were effectively reduced when daylight coefficient approach of ADSM for sky was used with any other computational algorithms of ADSM for the sun. | The overall computation time, the daylight coefficient approach for the sky and the daylight coefficient approach with four sky patches for the Sun are to be considered for best performance. |
| 12 | The main objectives of this research it to find out if modern daylight assessment and design methods can be useful for urban residential planning in Poland. (Sokol and Martyniuk-Peczek,2016) | Pilot study | The large number of studies and research papers written in the field of daylight dynamic metrics suggests that those metrics may be seen as a set of new tools to create well day-lit spaces that satisfy occupants' health and comfort needs, and offer stimulating and energy-efficient architectural solutions. | To propagate the use of daylight design methods and techniques amongst professionals engaged in urban planning processes, a new method is to be created. |
| 13 | Building design or operation incorporates different methods for obtaining useful information related to daylight scheme for sutainable design of buildings (Yu and Su, 2015) | By means of simulation software metrices are not measured with consideration of daylight, performance assessment of indoor daylight with consideration of field measurement. Dt. | Findings of the research facilitates designer for adoption of application of effective assessment tools for daylight with consideration of indoor in terms of daylight availability and building energy conservation hence the scheme for daylight will be effective for the sustainable building design. | In this research sky is classified in to number of patches and each patch contributes based on illuminance level ans considered as assumption value. |
| 14 | the present model can be used to design building for optimum daylighting at a given point inside living space. (Sudan et al, 2015) | The predictive Daylight Illuminance Ratio (DIR) model developed in this research which shows the combined effect of both direct and diffuse components of the sunlight and skylight. | Higher ratio of rooftop window area to floor area, the energy saving potential is more, while it is less for higher perimeter to floor area ratio. | To propagate the use of daylight design methods and techniques amongst professionals engaged in urban planning processes, a new method is to be created. |

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| 15 | This paper focuses on daylight at the interior envelope of the building (the facades between atrium and adjoining spaces), rather than dealing with the urban façade. (Mohsenin and Hu ,2015) | Mechanical and Electrical Equipment for Buildings. | The relationship between the atrium depth and the daylight regardless of the atrium type and its location is provided | Future research will be carried out to address thermal loads in atrium buildings and cover different weather conditions. |
| 16 | An adaptive criterion to arrange the lighting system considering the presence of natural daylight and a "rule of thumb" to evaluate the prospected mean daylight availability in a room and the yearly energy consumption of the combined electric lighting systems with daylighting. (Parise and Martirano ,2013) | Daylight lumen method. | The evaluation is useful for designers to estimate the operational costs in reference to the initial costs and to plan an adequate management for an effective operation | Window Zone and Transition Zone heights are assumed. |

## IV. RESULTS AND DISCUSSION

Eventhough daylight factor is simple term for measurement but this factor is not important comprehensive factor for daylight measurement (Mardaljevic et al., 2009). Due to this for illuminance occurred in specific grid requires comprehensive monitoring during days with sunny sky occurred with equinox and the solstices also it is necessary to measure illuminance under electric lighting conditions (night, no daylight). For measurement of illuminance with electric lighting requires standards requires ratio with uniformity this is defined as ratio between ration of space minimum and average illuminance where task area value of 0.6 and area around the task and its value is 0.4. According to, (Slater & Boyce, 1990) and (Slater et

al., 1993) this criterion is not appropriate for building with side windows located interior lit since for electric lighting condition non-uniform illuminance tolerance is greater. Lim et al. (2017) stated that for green building design daylight is considered as important aspects for consideration. Major contribute of daylight was excellent energy efficiency and comfort for visualization. For analysis of design with daylight, factor of daylight factor (DF) is considered as major phenomenon. In two buildings daylight is compared with consideration of glazing transmittance, ceiling/wall/floor reflectance, workspace typology, blinds transmittance, orientation of openings, cubicle partition transmittance and office space. Based on analysis researcher concluded that DF is not accurate or effective parameter to measure the reflects of space performance of daylight. The DF justify the Discrepancy for application of space located in office as well as day-lit without any inappropriate noticeable relation for effective lighting energy saving mechanism of occupants for visual appraisal or discomfort glare.

Hence, DF is not considered as effective approach for analyzing daylight impact on the buildings. Sun et al. (2017) examined the double glazed window performance with consideration of daylight which is integrated with integrated parallel slat transparent insulation materials (PS-TIMs) for different site ranges and window orientation used for measuring radiance in combined with Bidirectional Scattering Distribution Functions (BSDFs) for representation of optimal performance of PS-TIMs. Further researcher concluded that translucent slats with PS-TIMs exhibits significant performance rather than PS-TIMs of transparent slats with consideration of uniformity ratio (UR), daylight glare probability (DGP) and daylight illuminance (UDI). But this research does not considers inner and outer effect over PS-TIM within the building.

Amundadottir et al. (2017)presented about requirement of multi-criteria analysis of daylight and moved the direction of research related to performance assessment on human-centric performance. By use of common workflow model, to predict response of human three models are adopted and compared with the other parallel workflow. The methodology of 'parallel comparison' is adopted in this paper to assess the performance of daylight through three predictive models such as visual interest, gaze behaviour and non-visual health potential model. This analysis of different models facilitates designer to obtain adaptive manner for space architectural program processing. By means of simulation approach in coordinated manner for predicting human response it is finalized by author. Konis et al (2016) proposed a building metric need to be considered for daylight design and evaluation. Designer is enable to adopts metric and visualization techniques for specific addressing of design with consideration of light with non-visual effect by applying adaptive comparison in relation to design alternatives. The derived metrics able to incorporate in workflow of simulation with incorporation of optimization with consideration of multi-objective simulation which seeks to balance objective of daylight for entire energy building and adopts other performance goals (Konis et al., 2016). As a result, daylight potential benefits begin to exhibits additional performance objectives for evaluating the building objectives. Workflow for assessment of daylight and differentiate the designing phase of the project or examines the existing space model. Developed workflow applicability is under two models in to consideration such as school classroom in portable size, and a generic open-plan commercial office floor plate.

Verdejo et al. (2016)examined the Daylight Saving Time (DST)impact under consideration of different number of approaches. Based on Daylight Saving Time policy impact is evaluated for analyzed with consideration of econometric model with heuristics approach is considered. For evaluation of DST different data were examined such as region economic activity prevalence, latitude, residential consumers percentage and so on. Results are obtained through proposed approach for application of model in in four regions of Chile. From analysis it is concluded that DST application impact on terms to minimize household electricity consumption rate was examined for econometric and heuristics model. Further small amount of marginal reduction in consumption of residential electricity utilization is observed but still in consideration of whole country these model is not homogeneous.

## V.CONCLUSION

Daylight plays a significant role to provide illumination in the residential building based on window opening sizes. The purpose of the daylighting is to minimize energy use and maximize human comfort. From the above review, a majority of the researches analysed the daylight using simulation software and concluded that the daylight depends on the factors such as location, windows size, weather condition, environmental built, building interior design, etc. Of them, factors such as location, weather condition and environmental built are directly dependent on the natural climatic and geographic conditions. Hence, the interior structure of residential building and window sizes are important for a daylight efficient design. Also, the building design, window openings and the surface finishes determine the interior daylighting. The following are suggested for a daylight efficient design: the choice of daylight methods or techniques should be specific to the building design. For overall computation of time, daylight coefficient with sky patches is to be estimated for best performance.

Parameters such as timing, spectrum, intensity, duration and past history of light exposure are to be taken into the account.

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