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Energy Saving by Double Electrochromic Glazing- A Case Study for Central Library MUET, Jamshoro, Pakistan

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Abstract: In this paper, Double Electrochromic Glazing technology for energy saving has been discussed. A case study of Central Library of Mehran University of Engineering Science and Technology Jamshoro, Sindh, Pakistan has been analyzed for the retrofitting of simple installed glass with Double Electrochromic glazing. Energy savings due to Double Electrochromic glazing has been critically analyzed. Moreover, the Floor to Window area ratio has been computed which is 2.43:1 for the retrofitting. The load calculations of cooling equipments for yearly basis have been comparatively analyzed before and after the use of glazing technology. Temperature at various intervals has been noted. After that eQUEST Software is used for energy simulation which resulted in saving of 8% of total Electrical Power (only air conditioning load). The study could help the investors in maximizing the profit by reducing the load of cooling equipments in building sector. Furthermore concern towards double electrochromic glazing minimizes the pollution by lowering the Electricity consumption.

Keywords: Electrochromic Glazing · Energy Savings ·Cost Analysis ·eQUEST

I. INTRODUCTION

Energy needs, specifically electrical energy, is increasing by time with the increase in population and increase of comfort in lifestyle. Currently, the energy consumption mostly dependant on fossil fuels have threatened the very structure of globe, energy use in buildings represents as much as 80% of total final energy use[1]. In this regard, for energy saving in building sector by replacement of simple glass with Double Electrochromic Glazing has been analyzed for indoor thermal comfort which results in saving of energy consumption. The Electrochromic glazings have reversible properties which changes through applied voltage [3, 4]. Among dynamic window technologies, Electrochromic (EC) glazings have emerged as a viable advancement over static technologies, with several manufactures bringing EC window products to the markets [5, 6]. In a building window application, Electrochromic materials can be actively modulated in order to control the transmittance of visible and near infrared solar energy (Heat) [7].

Double Electrochromic (EC) glazings are characterized by properties that can be tuned, steadily and reversibly, through the application of electrical current or voltage by changing their properties for reflection of solar heat(ultra violet rays and infrared rays). Double Electrochromic windows are capable of automatically altering their state to a shaded mode (bleached state) providing luminous indoor visual comfort. This state of double Electrochromic glazing reduces the heat gain which is generally experienced during the peak cooling demand times throughout the day in summer season. They are also manually controllable to shade the perimeter spaces according to the building occupant's desire; preventing the solar heat gain during hot summer months and transmitting solar radiation to occupied space during cold winter months when the heat is required for thermal comfort. In Double Electrochromic Glazing, Electrochromic coatings are used, by applying low voltages to those thin film coatings, the thermal and optical properties can be varied. This comprises of fours components i.e. conductors(outer layer), active and passive layers(electro chromic and counter electrode as middle layers) and electrolyte layer(center portion). Voltages applied to migrate the ions to opposite side turning the glass to shaded form and when voltages are dropped it causes the glass to turn into transparent.

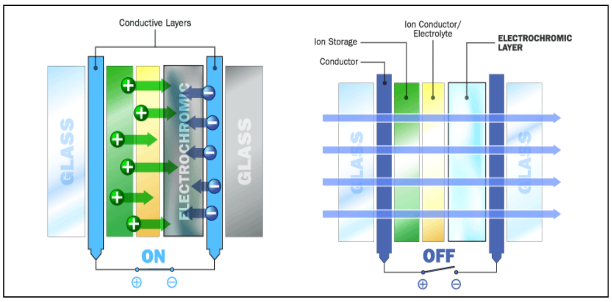

Fig. 1. Schematic of Electrochromic Glazing [11]

By doing so, Double Electrochromic glass demonstrates a wide range of visible transmittance. In terms of transparency, the transparency of this glazing may vary from 0.70 - 0.50 as upper range to 0.02 - 0.25 as lower range. But, for visual comfort, in the running state luminous transmittance have been noticed 81% for 54% glazing [8]. The greatest advantage for the use of

Double Electrochromic glazing compared to conventional window systems is the provision of unmitigated view inside the buildings throughout the day, which is the primary function of most commercial windows in modern days. A greater Visible Transmittance (Tv) in the luminous state bleached state (Tv-b) will decrease lighting energy use, increase interior luminance levels and room brightness resulting in visual comfort [8]. The consequences of Double Electrochromic Glazing on lighting energy use may be small but the energy saving for cooling loads is enormous. Double EC glazings can selectively block or transmit solar heat to optimize building energy use. Conventional Double Electrochromic glazing has the potential to be highly effective at blocking solar heat causing reduction in internal temperature and mitigating glare inside the buildings [9].

In this research work A case study of Central Library (CL) of Mehran University of Engineering Science and Technology (MUET), Jamshoro, Pakistan has been analyzed for the retrofitting of simple installed glass with Double EC glazing. Floor to window area ratio has been calculated for the purpose of standardized calculations. Total energy savings have been computed yearly basis after simulating the design after installation of glazing technology in eQUEST software. Savings resulted in 8% of total cooling loads.

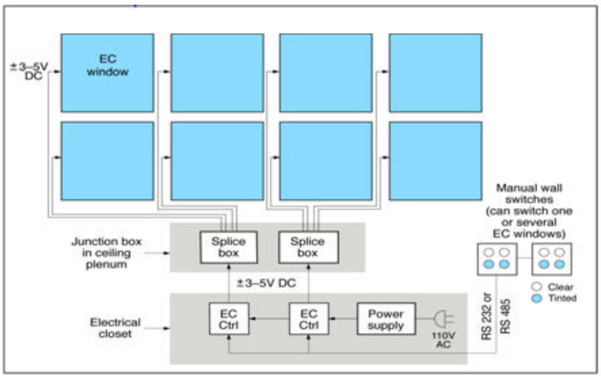

Fig. 2. Large Scale Double EC Glazing installation [11]

II. METHODOLGY AND DATA ACQUISITION

At first, the floor to window area ratio was computed with floor area of 9900 Sq. Ft and window area of 4080 Sq. Ft consisting 136 glass window sheets of 5x6 sq. ft each. As per ASHRAE 9.0 standards if the floor to window area ratio is 2:1 or above, double elctrochromic glazing may be used for maximum reduction in indoor temperature resulting in maximum energy savings.

Data related to cooling equipment in Central library was acquired for load calculations. Further, average electrical energy consumption for a year has been calculated comprising of estimated usage of energy for six months per year. The data acquisition is provided in the table below.

Table 1. Data for load calculation cooling equipment of CL, MUET, Jamshoro

No	Cooling Equipments	Quantit y	Avg Monthy Load(in kWH)	Consumption Cost
1	Air Conditioners (2 tonnes)	13(2500 wattage each)	9750	Rs.72,247.5
2	Air Conditioners (1.5 tonnes)	50(1900 wattage each)	28500	Rs. 211,185
		Total	**38250**	**Rs.283,432.5**

Temperature variations were recorded at various intervals on the basis of thermostats available in CL, MUET, Jamshoro. Average indoor temperature i.e. 24.5° Celsius was taken for simulation in eQUEST software.

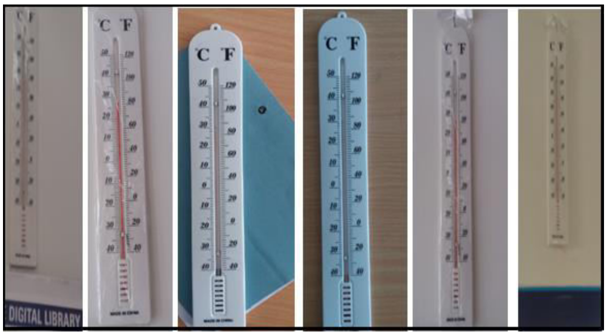

Fig.3. Temperature samples on various intervals

III. SIMULATION MODEL IN eQUEST WITH ENERGY SAVING RESULTS

The collected data was analyzed and computed using eQUEST modeling for possible energy savings with window area covered with Double Electrochromic glazing technology.

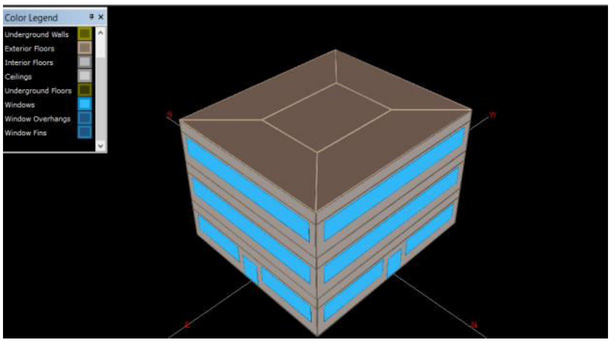

Fig. 4. eQUEST software generated model for the CL, MUET, Jamshoro

After simulating the CL, MUET, Jamshoro model in eQUEST with Double Electrochromic Glazing technology resulted in 8% energy savings for cooling loads. Actual average monthly load without glazing is computed in quantity of 38250 Units(kWh) amounting Rs.283,432.5 @ Rs.7.41 per Unit as per local electric power supply company. However, as per simulated model, after installation of Double EC Glazing technology results show reduced consumption to 35190 Units(kWh) amounting Rs.260,757.9. Results show an estimated energy savings of 3060 Units(kWh) with amount of Rs. 22674.6 per month.

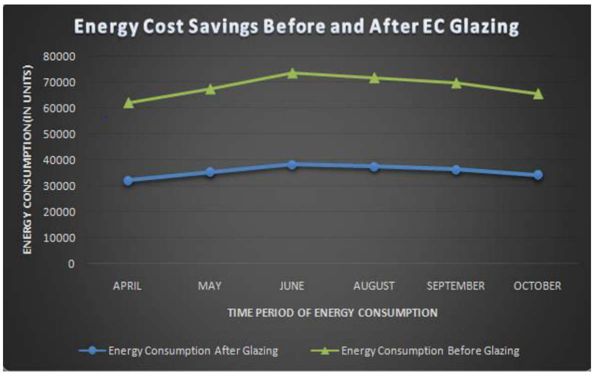

Fig. 5. Energy Savings after installation of Double EC Glazing

IV. COST ESTIMATION & PAYBACK PERIOD

Comparing costs of Double EC Glazing technology through various vendors, the most economic cost was obtained. Total cost was calculated including installation and labour costs, an estimated payback period is calculated on the basis of energy savings.

A. Total Installation Costs

Equipment cost was calculated for the window area of CL, MUET, Jamshoro . As per total area of 4080 sq. ft, 136 Double electrochromic glazing sheets of 5x6 sq. ft are required to be installed with each sheet amounting Rs.6319.8 approx (60 USD) and total amount of Rs. 859492.8, on the other hand an amount of Rs.68000 is estimated for labour and installation costs.

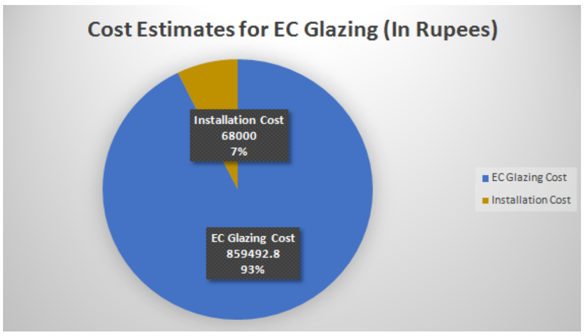

Fig. 4. Total Cost Estimates for Double EC Glazing

B. Payback Period

As the total cost is calculated Rs. 927492.8 and energy savings per month are calculated as Rs. 22674.6, after calculating payback period which results in 4.55 years is the period to recover all costs incurred in purchase and installation of Double EC Glazing.

V. CONCLUSION

In this paper, a case study of CL, MUET, Jamshoro for retrofitting of simple glass windows into Double EC Glazing has been analyzed having a 2.43:1 floor to window area ratio, it is recommended that Double Electrochromic Glazing would be the most energy saving glazing technology as the ratio exceeds 2:1. After the calculation using eQUEST energy simulation software, energy saving cost of air conditioning load for one month resulted in Rs.22674.6(8% of total air conditioning load consumption) Total cost Estimations for DOUBLE ELECTROCHROMIC GLAZING has been estimated which resulted in Rs. 927492.8 including EC glazing equipment and installation cost. Further it may be noted that use of Double EC Glazing may lead to reduction in environmental pollution and lightening and visual comfort may also be observed with the use of this technology.

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