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Analysis and Design of Energy Efficient Building

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Abstract: ***The building sector alone is responsible for 40% - 50% of total energy consumption. Fossil fuel reserve in India is depleting in a rapid way with development of the country. An increase in demand of new residential and commercial buildings is sign of economic development but with this comes an increased consumption of energy, raw materials and resources and becoming impossible to meet the demands of consumer with increasing population. The energy consumed by the buildings mainly affects the pollution, green house emission, environmental degradation. Green building and energy efficient buildings in general are growing and has become the preferred concept by engineers, government and financial bodies to meet all these issues regarding environment and health. Considering all these impacts this paper deals with the case study of BV'S Institute of Environment Education and Research Building and to analyze the annual and monthly energy consumption of the building by using popular energy simulation tool- eQuest to predict whether the building is Energy Efficient Building and if not various energy saving design alternatives will be recommended to reduce the energy consumption of the building.***

Keyword: Green Building, Energy Simulation, eQuest, Energy Consumption, Energy Performance Index (EPI)

I. INTRODUCTION

A. Green Building Concepts

The impact of energy consumption and climatic conditions surrounding the building is effective and has increased global attention on building efficiency. Increasing growth in population and uncontrolled development rate is burdening the non-renewable and finite resources that are available. Also the rapid increase in urbanization has shown its impact on environment and air pollution.
Hence a Green Building is required which uses less energy, water and natural resources, creates less waste and is healthier for people compared to a standard building. Green Building is the practice of creating structures and using processes that are environmentally responsible and resource efficient throughout a building's life cycle from siting to design, construction, operation, maintenance, renovation and demolition.

B. Benefits of Green Buildings

The benefits of a green design to a building owner, user, and the society as a whole are as follows:

1) Reduced energy consumption without sacrificing the comfort levels
2) Reduced destruction of natural areas, habitats and biodiversity and reduces soil loss from erosion etc.
3) Reduced air and water pollution
4) Reduced water consumption
5) Limited waste generation due to recycling and reuse.

C. Energy Simulation for Building Performance

Energy simulation tools predict the energy performance of a given building and thermal comfort for its occupants. With the increasing demand in energy efficient building design, whole building energy simulation programs are increasingly employed in the design process to help architects and engineers determine which design alternatives save energy and are cost effective. It can help in presenting analysis results in a highly visual format for easy comparison and interpretation. Also the tools can be used to quickly compare the energy consumption and lifecycle costs of design alternatives. An energy simulation tool models the thermal, visual, ventilation and other energy consuming processes taking place within a building to predict its energy and environmental performance.

D. eQuest (Quick Energy Simulation Tool)

eQUEST is a easy tool to calculate the building energy and it also provides professional-level results with an affordable level of effort. This software helps to perform the detailed analysis of any building design without having much experience in the art of building performance modeling. This is done by combining energy efficiency measure wizard (EEM), a building creation wizard and graphical displayed results. This wizard creation will help us in creating an effective building energy model. eQUEST calculates hourly building energy consumption. In this software heating/cooling loads are calculated using transfer function methodology.

II. AIM AND OBJECTIVES

The aim of the project is to analyze the energy consumption of Bharati Vidyapeeth (Deemed to be University), Institute of Environment and Research building using eQuest Energy Simulation Tool and to predict whether the building is Energy Efficient Building or not.

The objective for achieving the aim of the project-

A. Selection Of the Buildings and data collection of the building for the simulation in eQuest software.
B. Putting the collected information and Analyzing the energy consumption of opted buildings building in the eQuest software
C. To predict whether the building is an Energy Efficient Building on the basis of energy consumption of the building and if not, various energy savings design alternatives are recommended to reduce the energy consumption of the building.

III. METHODOLOGY

A. Energy Modelling Data Collection

TABLE 1Building Description

Building Name	BV'S Institute of Environment Education and Research
Location	Pune, India
Building Type	Institutional building
Climate Zone	Moderate
No. of floors	G+1

TABLE 2 AREA DETAILS

Total Built up Area	2397.762 SQ. M.
Ground Floor	1428.073 SQ. M.
First Floor	969.689 SQ. M.

Figure 1: Photograph of the building

TABLE 3
Building Envelope Details

Roof Construction		6 in. Concrete
Roof Finish		Roofing, shingle
Wall Construction		0.35m Thick U.C.R. Masonry
Interior Ceiling Finish		Plaster Finish
Flooring		Tandoor/Mosaic Finish (Vinyl Tile)
Doors		Wood 7/16 in.
Windows		Single clr/Tint
	U-Value	1.04
	SHGC	0.86

B. Modelling in eQuest

The information of the building is put in the Design Development Wizard (DD Wizard) of eQuest. The data of the building are put into 43 screens in the software. Each screen have different information required. On the basis of the details entered in the software a 3D model of the building is created.

1) Building Operation: The building is in operation 6 days a week from Monday through Saturday. The occupants generally begin to enter at around 8am and leave at 7pm. The building is closed on Sunday as well as on local holidays. However, the building is unconditioned throughout the year 24x7..

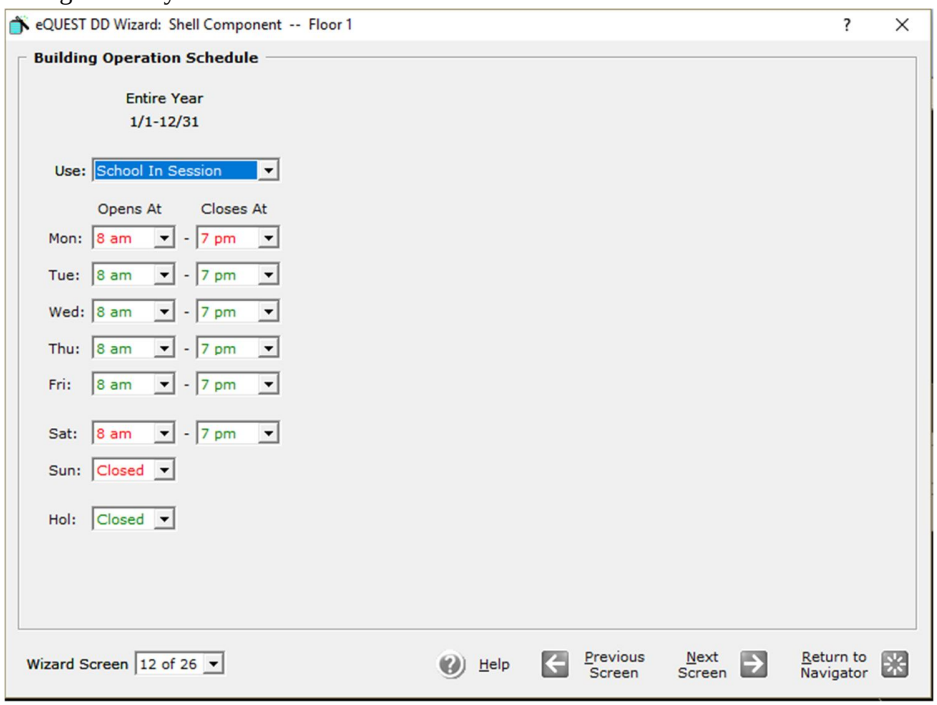


Figure 2: Screenshot of Occupancy schedule input screen in eQuest

2) Activity Areas

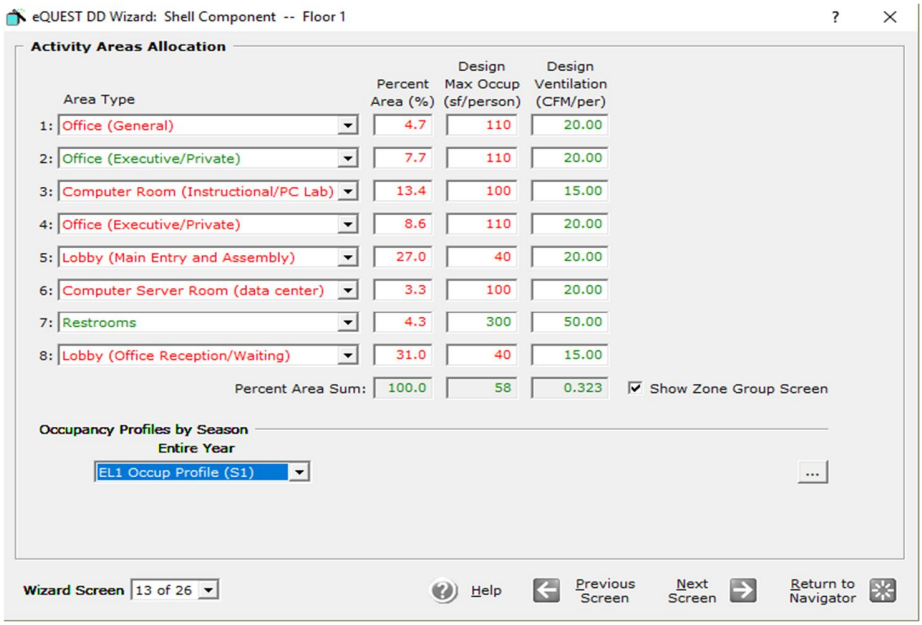


Figure 3: Screenshot of Activity Area input screen

3) Lighting Loads: Lighting loads in a building are often referred to in terms of a "Lighting Power Density" that is measured in watts per square foot or square meter.

Figure 4: Screenshot of Lighting Load input screen

3) Equipment Loads: Office Equipment Loads are the electricity used for other equipment, like computers and appliances. Office equipment loads are often referred in terms of "Equipment Power Density" that is measured in watts per square foot.

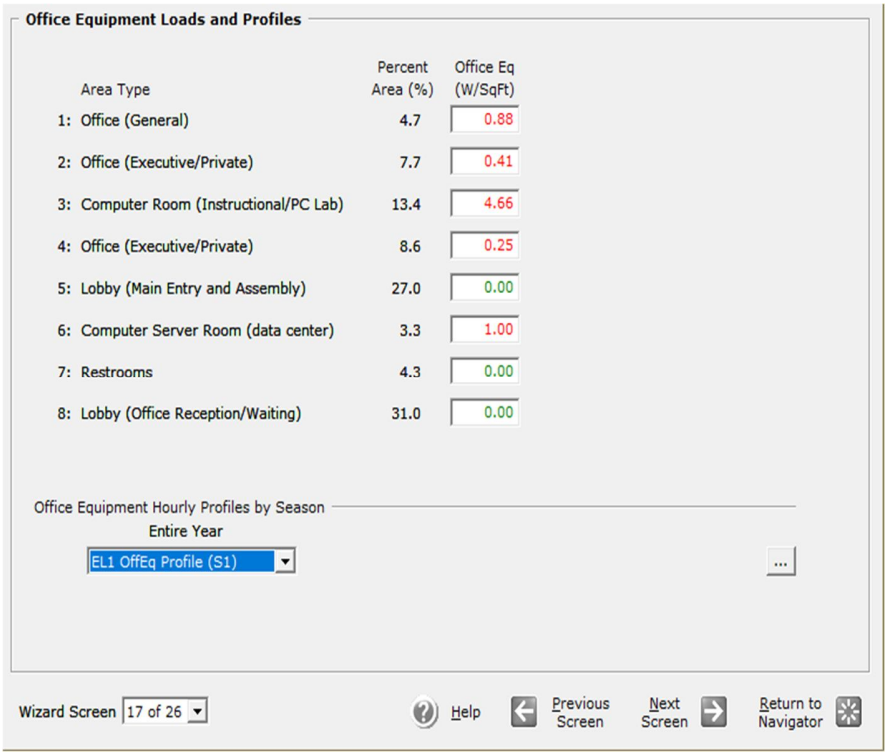


Figure 5: Screenshot of Equipment load input screen

4) *eQuest Model:* After the basic information of the building was inserted in the Design Development Wizard, eQuest's Detailed Interface (DI), eQuest 3D model of the building is created.

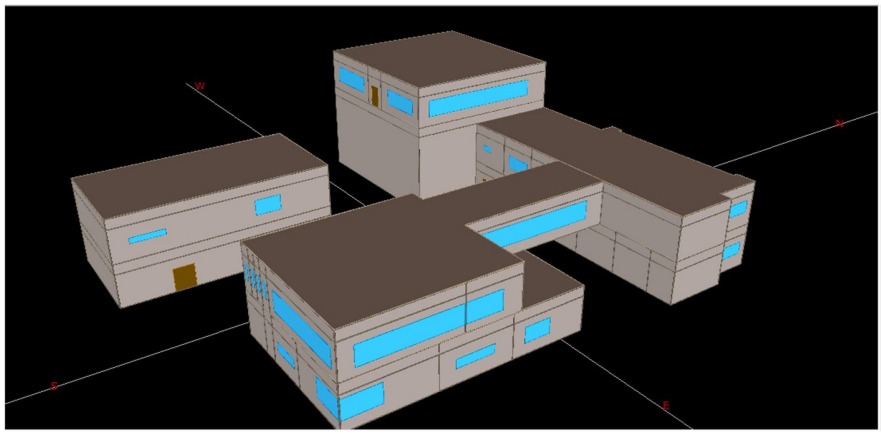
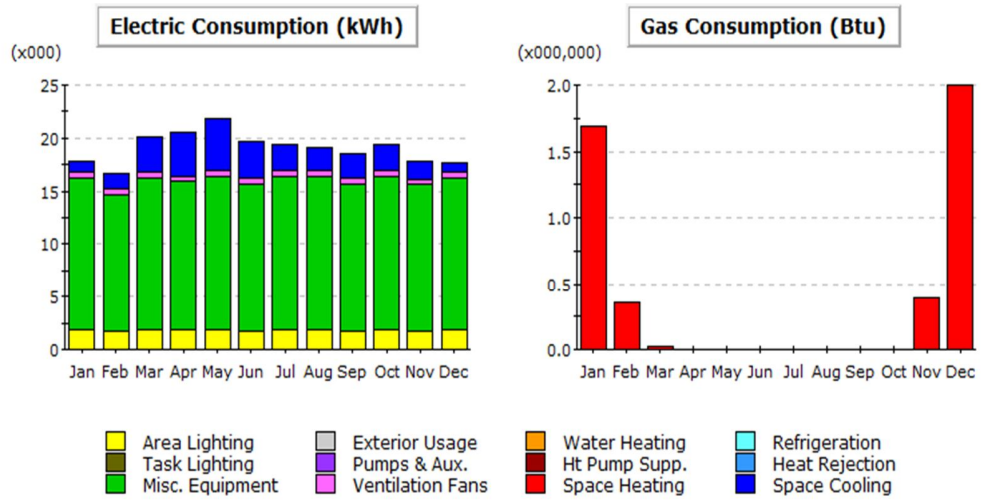


Figure 6: Screenshot of 3D Model of the building created by eQuest

IV. RESULTS

The simulation is performed and the results are shown in figure 7 . It shows the monthly total energy consumption of the building which adds up and gives the annual energy consumption of the building. The largest energy consumption is 21,790 KWh in the month of May and the minimum energy consumption is 16,720 KWh in the month of November. The total annual energy consumption is 2,28,640 kWh



Electric Consumption (kWh x000)

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Space Cool	1.09	1.55	3.35	4.16	4.90	3.46	2.47	2.14	2.33	2.56	1.70	0.85	30.56
Heat Reject.	-	-	-	-	-	-	-	-	-	-	-	-	-
Refrigeration	-	-	-	-	-	-	-	-	-	-	-	-	-
Space Heat	-	-	-	-	-	-	-	-	-	-	-	-	-
HP Supp.	-	-	-	-	-	-	-	-	-	-	-	-	-
Hot Water	-	-	-	-	-	-	-	-	-	-	-	-	-
Vent. Fans	0.53	0.49	0.55	0.55	0.55	0.53	0.55	0.57	0.51	0.55	0.51	0.53	6.42
Pumps & Aux.	0.00	0.00	-	-	-	-	-	-	-	-	0.00	0.00	0.01
Ext. Usage	-	-	-	-	-	-	-	-	-	-	-	-	-
Misc. Equip.	14.41	13.02	14.41	13.99	14.44	13.93	14.44	14.44	13.93	14.44	13.90	14.41	169.76
Task Lights	-	-	-	-	-	-	-	-	-	-	-	-	-
Area Lights	1.84	1.66	1.84	1.89	1.90	1.76	1.90	1.90	1.76	1.90	1.69	1.84	21.89
Total	17.87	16.72	20.15	20.59	21.79	19.68	19.36	19.05	18.53	19.46	17.81	17.63	228.64

Figure 7: eQuest output showing Annual Electric Consumption

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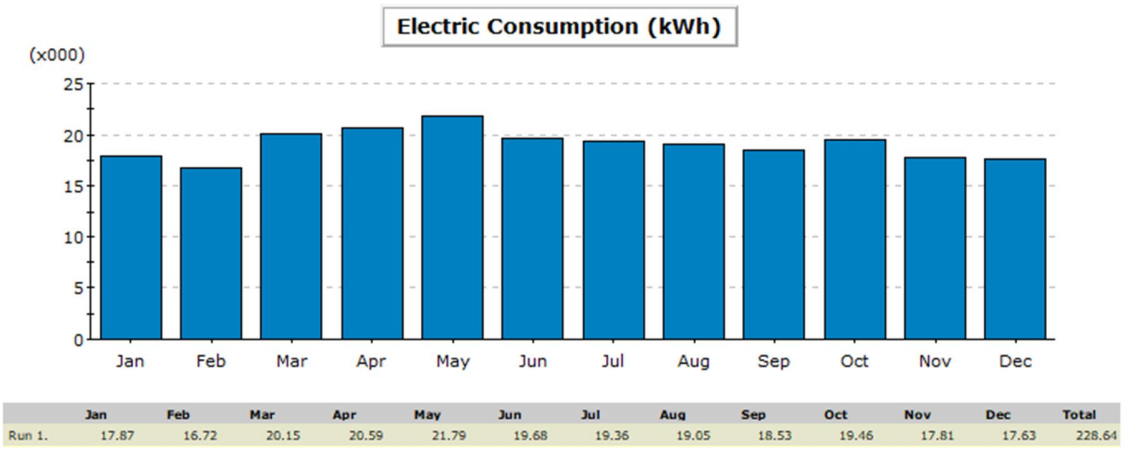

	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Total
Run 1.	17.87	16.72	20.15	20.59	21.79	19.68	19.36	19.05	18.53	19.46	17.81	17.63	228.64

Figure 8: General Bar Diagram of Annual Electric Consumption in eQuest

A. Energy Performance Index (EPI)

EPI is considered as the simplest and most relevant indicator for qualifying a building as energy efficient or not. Star rating programme of the Bureau of Energy Efficiency rates a building based on its EPI.

The Energy Performance Index (EPI) of a building is its annual energy consumption in kilowatt-hours per square meter of the building. The energy performance index is calculated by

$$EPI = \frac{annual\ energy\ consumption\ in\ kWh}{total\ builtup\ area\ (excluding\ unconditioned\ basements)}$$

Source: Energy Conservation Building Code 2017

Hence the EPI of the case study building is calculated by

EPI achieved (calculated though simulation) = (228640/2397.762) kwh/m^2/year

= 95.35 kwh/m^2/year

The benchmark of EPI for Energy Efficient Building is shown in figure 9

EPI benchmarks for Institutes

Climate Zone	EPI (kWh/m^2/yr)
Warm & Humid	150
Composite	117
Hot & Dry	106
Moderate	129

Figure 9: EPI Benchmark for Institutes
Source: Bureau of Energy Efficiency, India

V. CONCLUSION

The EPI benchmark for Institutes in moderate climate is 129 kwh/m^2/year as recommended by Bureau of Energy Efficiency, India .

EPI of our case study building comes out to be 95.35 kwh/m^2/year i.e it is less than 129 kwh/m^2/year.

Hence the case study building follows the EPI benchmark for energy efficiency and it is considered as an Energy Efficient Building.

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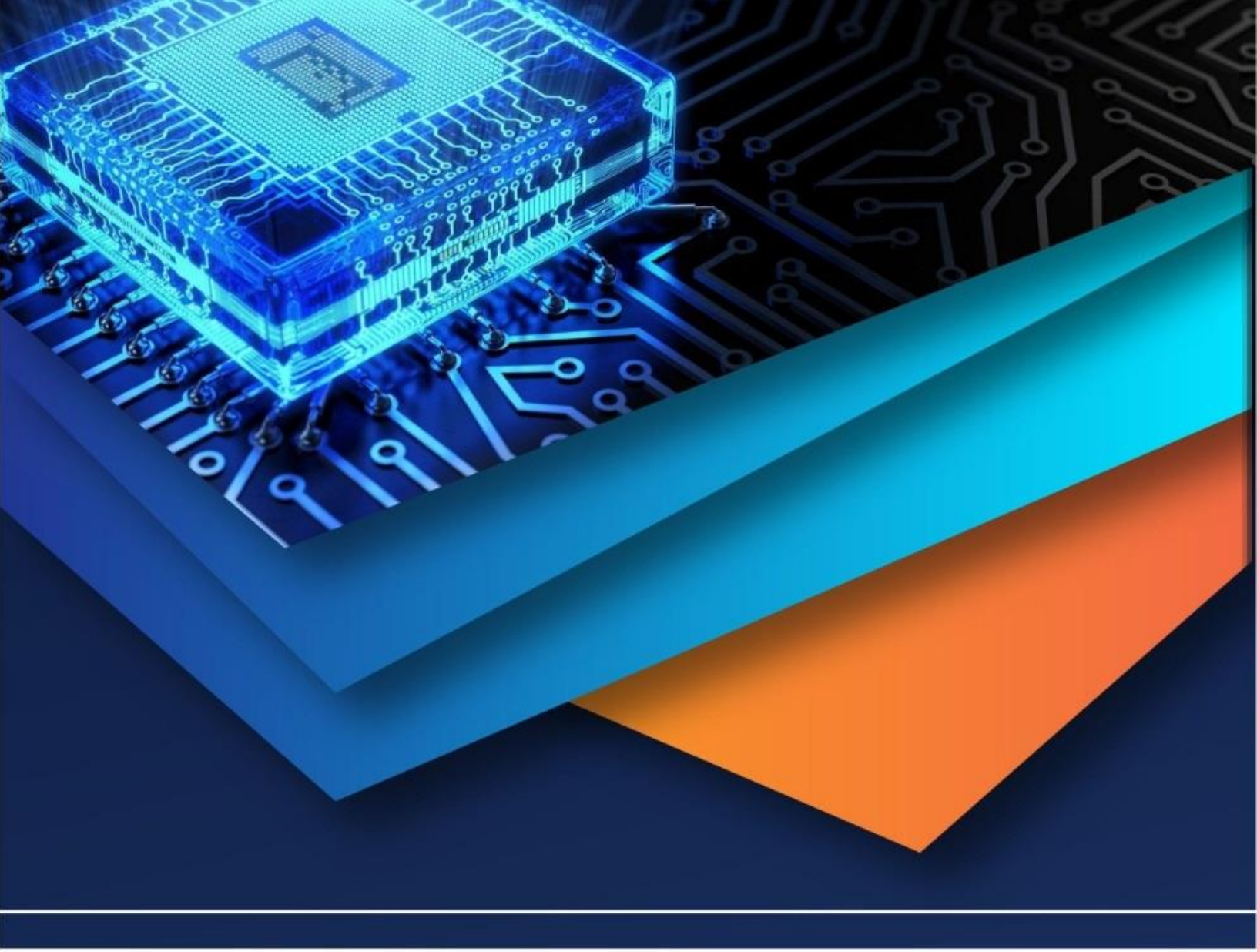

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