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Seasonal Variations in Electricity Consumption: A Trend Analysis

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Abstract: ***Electricity has allayed darkness and has illuminated every realm of human activity. It adds to the comfort and convenience of people, resulting in huge electricity consumption in residential sector. Data from Cochin City on bimonthly electricity consumption is analyzed in this study. The time series analysis indicates the presence of seasonal variations and also an increasing trend in the consumption pattern over the years. The paper also studies the association between the electricity consumption and the atmospheric temperature during the last three years and shows that the peak electricity consumption is during the summer season.***

Key words: Electricity consumption, Climate change, Seasonal variation, Forecast of consumption, Time series analysis

I. INTRODUCTION

Electricity is a great boon that modern science has given to mankind. It has revolutionized modern living and in present day, one cannot imagine a life without it. Electricity has allayed darkness and has illuminated every realm of human activity. Energy has a tremendous impact on quality of living in the modern day world [1]. It adds to the comfort and convenience of people through its various uses. Use of labour saving equipment and equipment that provides for comfort is increasing day by day, resulting in huge electricity consumption.

Increase in electricity consumption has also led to large energy wastage. Due to affordable energy cost by an average urban consumer more energy is wasted. Even though, the cost of production of electricity is on the rise, demand is also increasing exponentially. Disproportionate demand supply is one of the major reasons for rising energy cost. The primary source of energy for electricity production in Kerala is hydel due to abundant hydel resources [2]. But global warming resulting in decline in rainfall has limited the tapping potential of hydroelectricity. Other options like thermal and nuclear power comes with its hazards and disadvantages. The cost of electricity from thermal power plants is high due to non-availability of coal and fossil fuels. Similarly Kerala is yet to have a nuclear power plant as the health and safety hazards it poses outweighs the option of setting up one.

Today climate change is becoming a bigger scare which calls for immediate attention [3] [4]. Various positive and negative fores, which are natural and anthropogenic causes fluctuation in climate [5]. Impact of these anthropogenic activity resulted in global warming which again gave rise to increased temperature [6]. To mitigate this, people started using indoor comfort equipment such as fans, air conditioners and air coolers, which further aggravate the problem [7]. Unprecedented temperature rise in the pre-monsoon season resulted in an over use of electrical devices to provide cooler indoor climate which ultimately resulted in the surge in electricity consumption. Thus, there should be a shift in the attitude and practice of people to reduce energy consumption [8]. This paper analyses electricity consumption pattern for thirty six months among 500 households from Ernakulam city based on data collected from Kerala State Electricity Board, Ernakulam Central section.

II. METHODOLOGY

Ernakulam Central Division of Kerala State Electricity Board was the selected area of study. It consists of ten sub divisions which comprises of 131799 electrified houses. The sample was randomly selected from the area. As majority of houses does not have the habit of keeping the electricity bill for longer periods, their consumer number was collected and with this consumer number the consumption details for 36 months were collected for the study. This data was obtained directly from various sub sections of KSEB from the consumption data base available with them.

Based on the bimonthly bills, the data is classified into pre-monsoon (February, March, April and May), monsoon (June, July, August and September) and post monsoon (October, November, December and January) seasons. As the temperature differs in all these seasons, electricity consumption was also seen to vary.

III. RESULTS AND DISCUSSION

Table 1 shows the mean energy consumption units of the study sample for 36 months. The data of the households was analyzed to examine the seasonal variations in electricity consumption in the domestic sector.

Table I: Seasonal variation in electricity consumption pattern

Year	Mean Bimonthly Electricity consumption in units/consumer*						Average consumption per year
	Pre Monsoon		Monsoon		Post monsoon		
	Feb-Mar	April-May	June-July	Aug-Sept	Oct-Nov	Dec-Jan	
2015	358	391	342	356	340	354	357
2016	393	418	351	356	355	362	373
2017	388	421	366	380	375	383	384

*Source KSEB, Central Division, Kochi

Average electricity consumption for various months from Feb 2015 to Jan 2018 is presented in the following figure.

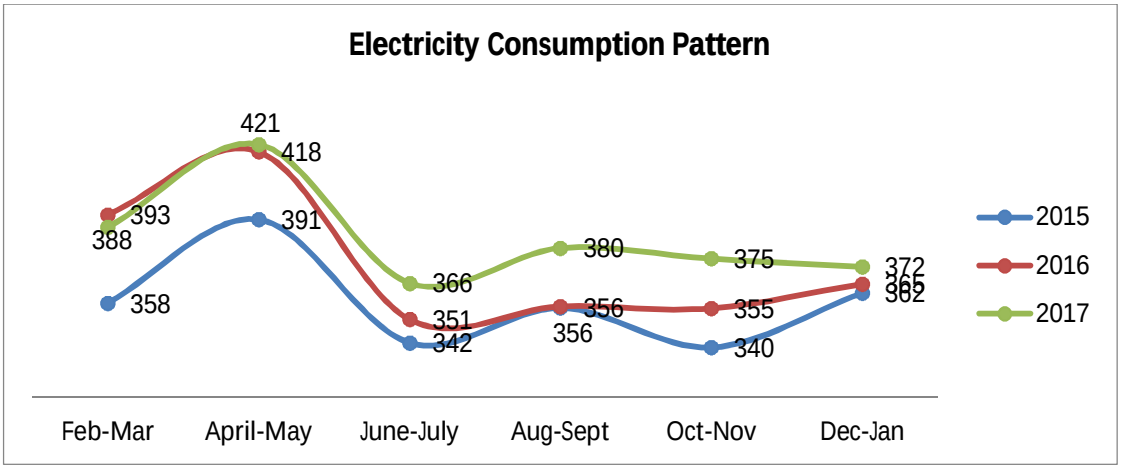

Figure 1: Average electricity consumption during Feb 2015 – Jan 2018

From the graph it is obvious that the consumption is very high during April – May months (hottest months of the year) and also that the consumption is increasing over the years. It can also be observed that there is a significant increase in electricity consumption during the pre-monsoon period of the year 2016 and 2017 when compared to that of 2015 and also there is a significant increase in the monsoon period of the year 2017.

Based on the pattern observed from the graph, a paired t test is carried out to check the increase in electricity consumption over the years during pre-monsoon, monsoon and post monsoon seasons. Table below shows the result of paired t test and the mean and standard deviation of the units consumed during the three seasons . The comparison is made at 5% level of significance.

Table II : Paired t test for Average Electricity Consumption

Season	N	Mean	Std. Deviation	t	p value
pre-monsoon 2015-'16	500	374.23	351.60	5.48*	0.000 (< .05)
pre-monsoon 2016-'17	500	405.42	387.63		
pre-monsoon 2016-'17	500	405.42	387.63	0.343	0.366
pre-monsoon 2017-'18	500	404.33	401.10		
monsoon 2015-'16	500	348.70	364.15	0.75	0.230
monsoon 2016-'17	500	353.67	347.72		
monsoon 2016-'17	500	353.67	347.72	5.01*	0.000(< .05)

monsoon 2017-'18	500	372.55	397.68		
post monsoon 2015-'16	500	350.14	326.85	2.32*	0.01 (< .05)
post monsoon 2016-'17	500	358.49	379.47		
post monsoon 2016-'17	500	358.49	379.47	3.47 *	0.000 (< .05)
post monsoon 2017-'18	500	373.82	406.56		

*Significant at 5% level

It can be observed from table 2 that the consumption has increased significantly in all seasons compared to the previous year except for the pre monsoon season of 2017with respect to 2016 and with a marginal increase for the monsoon season of 2016 when compared to 2015. But in general it can be inferred that average consumption of urban households is showing an increasing trend over the years.

The hike in consumption may be due to global warming. As the temperature increases household electricity consumption also increases. The reason might be the increased usage of AC, cooler, fan and other electrical equipment to control the room temperature during summer. Energy demand for space cooling is growing at a rapid pace in India driven by increasing disposable income [9] and global warming. It added that air conditioners are among the most prevalent purchases for the growing Indian middle class, with air conditioner sales increasing by twenty percent annually in recent years. This can be even vied as a change in spending pattern of an average consumer with a shift towards more electricity spends through the use of appliances to mitigate the indoor temperature.

To analyze the correlation between temperature and electricity consumption, secondary data on temperature of Kochi during the period from February, 2015 to January, 2018 is collected from the internet source "World Weather Online" [10] and is given in table 3.

Table III: Electricity Consumption Vs Temperature in Kochi

Period	Electricity Consumption	Temperature
Feb-Mar, 2015	358	30.5
April-May, 2015	391	31.5
June-July, 2015	342	29.5
Aug-Sept, 2015	356	29.5
Oct-Nov, 2015	340	30
Dec-Jan, 2016	354	30
Feb-Mar, 2016	393	31.5
April-May, 2016	418	32
June-July, 2016	351	29
Aug-Sept, 2016	356	28.5
Oct-Nov, 2016	355	29.5
Dec-Jan, 2017	365	29
Feb-Mar, 2017	388	30.5
April-May, 2017	421	32
June-July, 2017	366	28
Aug-Sept, 2017	380	30.5
Oct-Nov, 2017	375	31.5
Dec-Jan, 2018	372	30

*Source "World Weather Online"

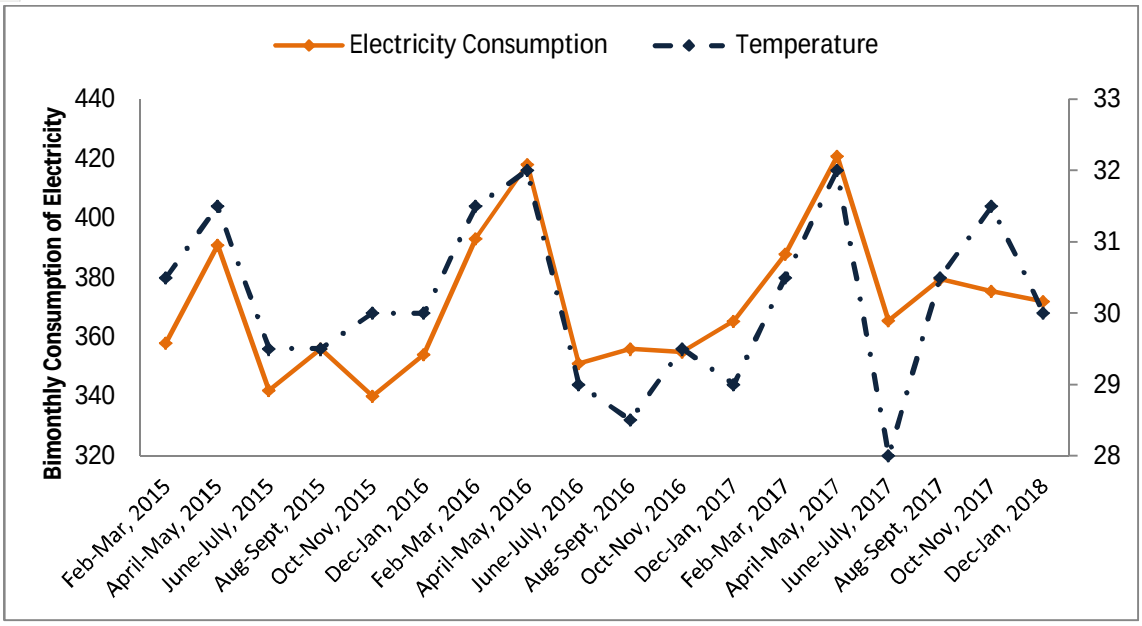

Figure 2 : Electricity Consumption & Atmospheric Temperature

From figure 2, it can be observed that the electricity consumption is showing a regular seasonal change similar to that of temperature. In summer, there is a peak in electricity use due to high cooling demand. Further, a relatively lower peak in electricity use is found during the months of August- September also.

The time series of the bi monthly consumption of electricity in cochin city shown in figure 3 can be described using an additive model since the seasonal and random fluctuations seem to be roughly constant in size over time. The original time series data is decomposed into seasonal, trend and random causes. The plot below shows the original time series (top), the estimated trend component (second from top), the estimated seasonal component (third from top), and the estimated irregular component (bottom) decomposed using R software.

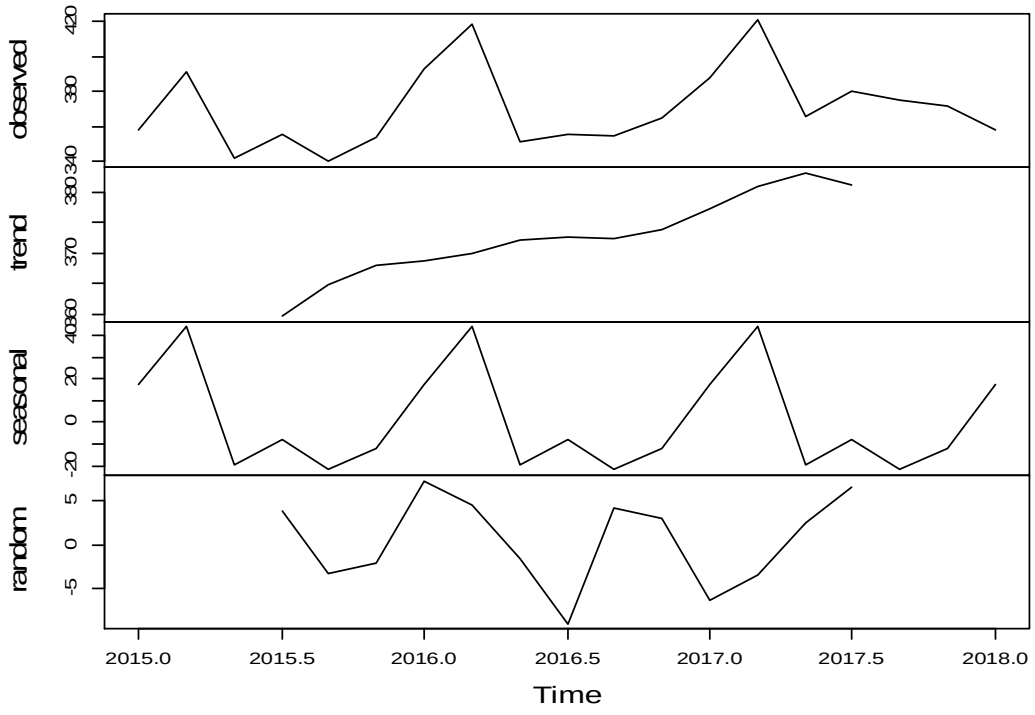

Figure 3: Decomposition of Additive Time Series

The seasonal factors are eliminated and the trend values are obtained. A linear trend equation ($Y= a+ bt$) is fitted and the Y intercept, a is obtained as 352.30 and the slop ***b*** is obtained as 2.17. The fitted linear trend equation is

$$Y= 352.3 +2.17t$$

Forecast for the consumption during next year (2018) at six different time points is obtained using the fitted trend equation and are shown in table IV.

Table IV: Forecast for the consumption during Feb 2018- Jan 2019

Period	Seasonal Index	Trend	Forecast
Feb-Mar, 2015	1.02	350.02	358
April-May,2015	1.10	353.97	391
June-July, 2015	0.95	359.72	342
Aug-Sept,2015	0.98	363.12	356
Oct-Nov,2015	0.96	353.68	340
Dec-Jan,2016	0.98	361.18	354
Feb-Mar,2016	1.02	384.24	393
April-May, 2016	1.10	378.41	418
June-July,2016	0.95	369.19	351
Aug-Sept, 2016	0.98	363.12	356
Oct-Nov, 2016	0.96	369.28	355
Dec-Jan, 2017	0.98	372.66	365
Feb-Mar,2017	1.02	379.14	388
April-May, 2017	1.10	381.01	421
June-July,2017	0.95	384.48	366
Aug-Sept, 2017	0.98	387.15	380
Oct-Nov, 2017	0.96	390.44	375
Dec-Jan, 2018	0.98	379.55	372
Feb-Mar,2018	1.02	393.50	402
April-May, 2018	1.10	395.67	437
June-July,2018	0.95	397.84	378
Aug-Sept, 2018	0.98	400.00	392
Oct-Nov, 2018	0.96	402.17	387
Dec-Jan, 2019	0.98	404.34	396

The largest seasonal index of 1.10 is for the period April – May which means that there is a 10 percentage increase in consumption during these months and the lowest index 0.95 is for June - July which indicates that there is a 5 % decrease in consumption during this period. This indicates that there is a peak in consumption during April- May and a trough in consumption during June- July each year.

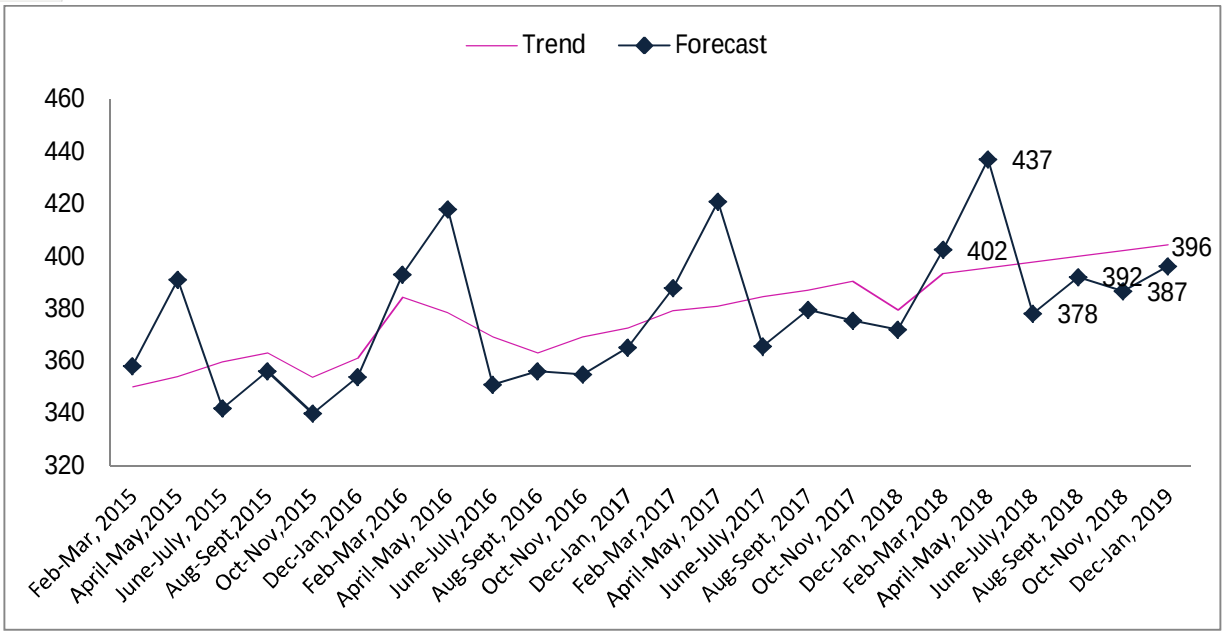

Figure 4: Electricity Consumption Trend & Forecast

The above figure shows the estimated trend and the time series forecast for the six time points during the year 2018. The predicted values show that the mean consumption may increase from 358 to 399 during next year.

IV. CONCLUSION

The study points out the fact that there is strong correlation between weather and electricity consumption. Electricity consumption varies during different seasons such as pre-monsoon, monsoon and post monsoon. There is also an increasing trend in electricity consumption year on year, which poses a challenge for making available new and sustainable sources of energy to meet this increasing demand. This emphasizes the need for exploiting the immense potential of solar and other sustainable/renewable source of energy.

V. AKNOWLEDGEMENT

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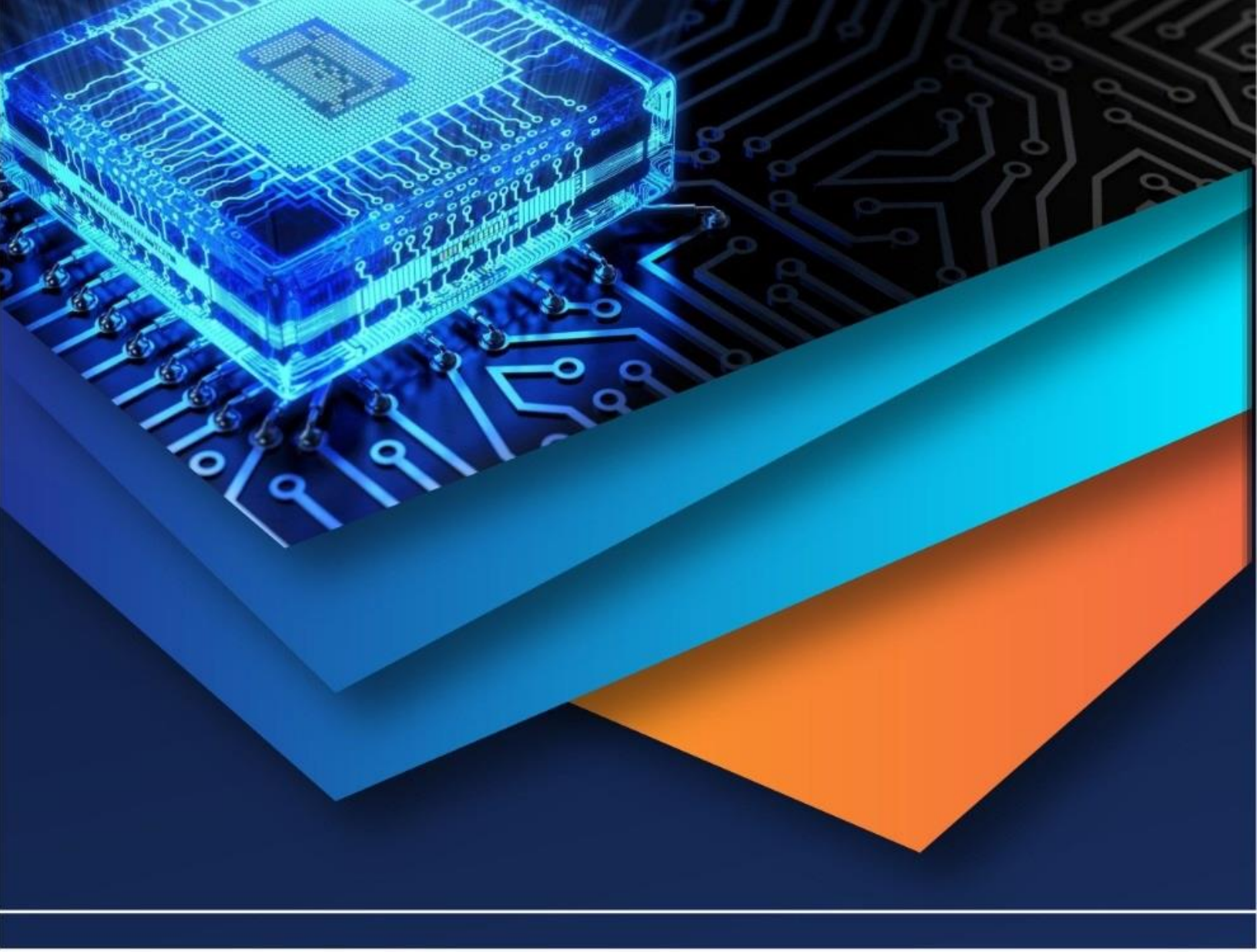

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