An economic analysis of electricity consumption in Kerala with special reference to Kalamassery Municipality

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ABSTRACT
A day without electricity is unimaginable for the populace of today. Electricity is the driving force of the thriving economic activities around us. The deficiency of electrical energy can open a Pandora's box of troubles for Kerala which is already lagging behind in industrial development in the country. The present study makes use of both cross sectional and time series data to analyse the generation and consumption of electricity in Kerala by calculating the compound annual growth rates and instability indices of various significant variables in electrical energy sector. The study also analyses the residential electricity consumption pattern of Kalamassery municipality by using Multiple regression estimation.

Key Words: Electrical energy, Growth, Instability, Consumption Pattern.

1.Introduction

Energy is an essential economic infrastructure required for a country or a region for accelerating its economic as well as its human growth. A reliable and sustainable energy supply is much needed for generation of income, employment and growth of any region. According to the Central Electricity Authority sources, India has an installed capacity of 329226 MW as on 31.08.2017. Kerala, the southernmost state of India with a population of 3.48 crores has an installed capacity of 2961.11 MW as on 31.03.2017. Kerala State Electricity Board Limited (KSEBL) has accumulated Rs.11035.88 crores as total revenue from the sale of power. Kerala has made the tremendous achievement of being the first state in India to have all its households electrified by May 2017. The total electrification of all the households in the state is a remarkable achievement when considering the fact that there are villages in India striving hard to get fully electrified.

Kerala State Electricity Board (KSEB) was a statutory body constituted in 1957 under section 5 of the Electricity Supply Act 1948 for the coordinated development of generation, transmission and distribution of electricity in the state. The assets, liabilities, rights and obligations of KSEB which was already vested into the state government, were re-vested to new successor entity Kerala State Electricity Board Limited (KSEBL) in 2008 [2].

The major source of power generation in Kerala are hydel, thermal, Wind and Solar. The total installed capacity of power in the state as on March 2017 was 2961.11 MW of which hydel contributed a major share of 2107.96 MW (71.19%); while 718.46 MW was contributed by thermal projects;75.42 MW from solar and 59.29 MW from Wind projects. Electrical energy consumption in Kerala has increased to 20453 MU in 2016-17 from 19325 MU in 2015-16. As per the 19th electric power survey by Central Electricity Authority, state is expected to have an increase of 60 per cent in domestic consumption of energy by 2026-27. [4]

Kerala had been an 'energy surplus state' till 1983 and used to export electricity to other states but since 1983 Kerala became an energy deficient state depending heavily on its hydro system for its electricity needs. KSEB had a past of restricting the internal demand by underinvesting in transmission and distribution networks as well as keeping the supply voltage low. Electricity generation in Kerala heavily depends on the availability on monsoons and the recurring power shortage is a major obstacle for the industrial growth and economic development of Kerala. [5]

2.Objectives of the study

1. To provide an overview of the generation and consumption of electricity in Kerala.
2. To estimate the growth and instability in the generation and consumption of electricity during 2006 to 2017.
3. To estimate residential consumption pattern of electricity in Kalamassery Municipality in Kerala
4. To suggest appropriate policy recommendations.

3.Methodology

The study made use of both cross sectional and time series data for analysis. Cross sectional Data is collected randomly from Kalamassery municipality of Kerala to analyse residential consumption pattern of electricity while time series data is collected from the budget estimates and Power Statistics of KSEBL. Regression analysis is worked out to find Compound Annual Growth Rate (CAGR) of various significant variables in the sector. Instability analysis is done with Coefficient of Variation (CV) and Cuddy Della Valle (CVD) index. The regression analysis in the study is done with the open source econometric software Gretl0 2019c.

3.1 Compound Annual Growth Rate (CAGR)

$$Y = a\, b^t\, e \quad (1)$$

$$\widehat{l\_y} = \hat{\beta}_1 + \hat{\beta}_2 t \quad (2)$$

$$CAGR = (\text{Antilog of } \hat{\beta}_2 - 1)100 \quad (3)$$

3.2 Instability Analysis

Instability analysis in this study is done in two ways.

Coefficient of Variation (CV) (4)

$$CV = \frac{STANDARD\ DEVIATION}{MEAN} * 100 \quad (5)$$

Cuddy-Della Valle (CDV) index

$$CDV = CV * \sqrt{1 - \bar{r}^2} \quad (6)$$

$\bar{r}^2$ is the adjusted R squared of Equation (2)

Cuddy Della Valle index was developed by John Cuddy and Della Valle for measuring instability in time series data. Coefficient of Variation is a good measure of instability but while analysing time series data involving trends, Cuddy Della Valle is a better indicator of instability as it is inherently adjusted for trend often observed in time series data [3]

4. Result analysis and Discussion of CAGR, CV and CVD of Variables.

The study made use of time series data of different variables significant to electricity consumption in Kerala during the period from 2006 and 2017 as shown in table 1 and figure 1 for the analysis of Compound Annual Growth Rate, Coefficient of Variation and Cuddy Della Valle indices.

Table 1. Data on various significant variables in electrical energy sector of Kerala

YEAR	Installed Capacity (MW)	Annual Energy Requirement (MU)	Own generation (MU)	Power Purchase (MU)	Total Sale (MU)	Per capita consumption (kWh)	Number of consumers (Lakh)	Total Revenue (Rs.in Crores)
2006	2650.41	13567.99	7554.1	6700.5	10905.7	314	82.95	3367.3
2007	2662.96	14695.17	7695.1	8149.84	12377.9	345	87.14	4009.71
2008	2676.66	15442.73	8647.7	8074.62	13396.6	366	90.34	4696.95
2009	2744.76	16357.16	6440.4	9628.87	12877.7	375	93.63	4893.02
2010	2752.96	17350.02	7189.5	10204.21	14025	420	97.43	4747.17
2011	2869.56	17807.77	7360	10512.27	14678.1	436	101.28	5198.52
2012	2878.36	19521.41	8289.9	11263.21	16181.6	478	104.58	5593.02
2013	2881.22	20736.19	5334.3	14908.82	16839.3	499	108.07	7223.39
2014	2891.72	21264.51	8163	14070.42	18885.5	516	111.93	9974.18
2015	2835.63	22040.04	7286.9	15031.71	18788.8	541	114.31	9879.34
2016	2880.18	22944.45	6739.3	16448.36	19513.8	569	116.68	10487.7
2017	2915.8	23849.54	4325.1	19734.93	20502.2	592.43	119.95	11035.9

Source: Power Statistics 2017 KSEBL

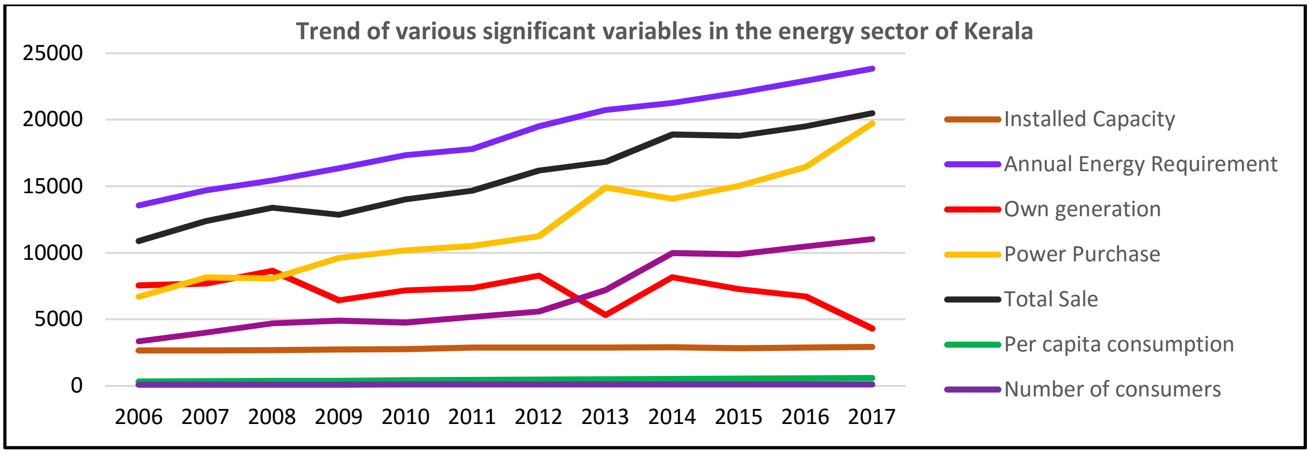

Figure 1. Trend of various significant variables in the energy sector of Kerala.

The growth and instability analysis of the above time series data produced interesting findings which are summarised in table 2.

Table 2. Comparative Analysis of CAGR, CV and CVD (2006-2017)

	CAGR(%)	CV(%)	CVD (%)
Installed Capacity	0.89	3.54	1.59
Annual Requirement	5.25	18.2	2.1
Own Generation	-2.79	17.5	15.7
Power Purchase	9.4	32.7	6.2
Total Sale	5.73	20.1	3.5
Per Capita Consumption	5.91	20.3	2.5
Number of Consumers	3.4	11.9	1.2
Total Revenue(crores)	11.76	41.6	10.75

SOURCE: Computed from data.

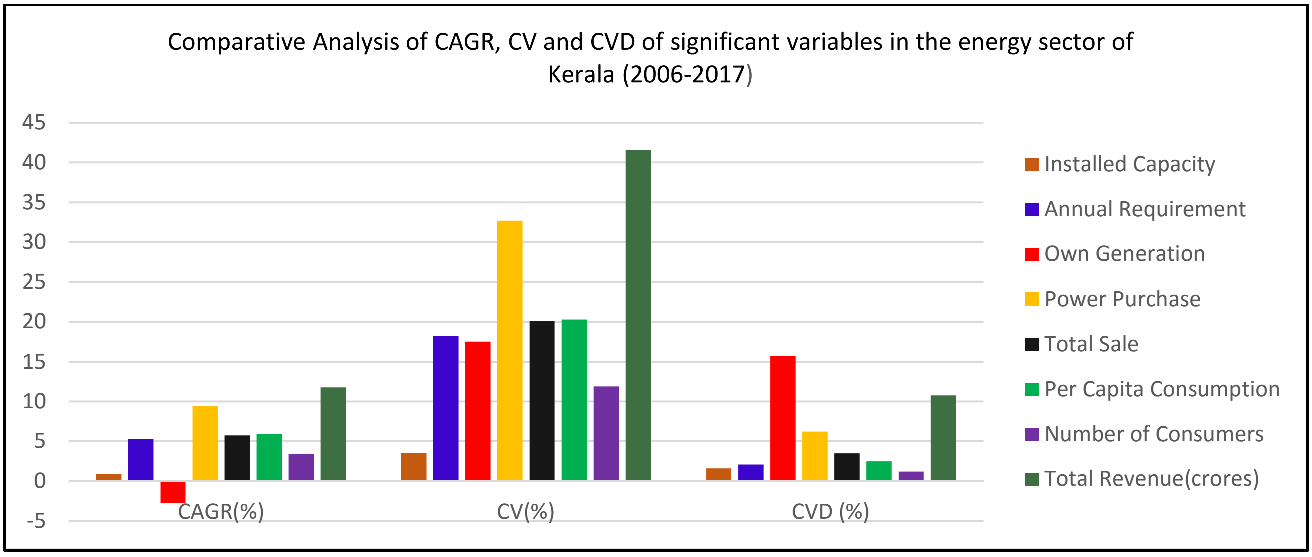

Figure 2. Comparative Analysis of CAGR, CV and CVD (2006-2017)

The comparative analysis of Compound Annual Growth Rates of various variables used under study sheds light on interesting findings. CAGR of the installed capacity of electricity generation in Kerala over the period from 2006 to 2017 registered 0.89% of growth. But at the same time the annual requirement of electrical energy grew at a rate of 5.25% for the same period. The per capita consumption and the number of consumers also grew at 5.91% and 3.40 % respectively. The total sale of electricity has increased at 5.73% but interestingly its own generation of electrical power registered a decline by 2.79%. KSEBL compensated this decline by increased purchase of power and the study reveals that power purchase grew at 9.4% during 2006 to 2017. The total revenue registered the highest growth rate of 11.9%. This remarkable increase in revenue may partly be attributed to the inflationary effect

While looking at the Coefficient of Variation (CV) and Cuddy Della Valle (CDV) Indices for measuring instability, the study finds that the greatest instability in terms of CV is in total revenue with 41.6% and the lowest in installed capacity with 3.5%. But considering the CVD indices, the study finds that the greatest instability is for own generation of power by KSEBL with the value of 15.7% and the lowest instability in terms of CVD index is for number of consumers with a value of 1.2%. It is to be noted that the greatest instability in terms of CV for total revenue may be because of considering the nominal values without discounting for the impacts of inflation.

5.Analysis and Discussion of Residential Consumption Pattern of Electricity in Kalamassery

Kalamassery municipality is an industrial hub of Ernakulam district of Kerala. Multiple regression analysis is done to analyse the impact of monthly income, number of electrical appliances at the household and number of inhabitants at the household on the residential electrical consumption pattern in Kalamassery municipality.

The dependent variable is electrical bill (ELECTR BL). It is used as a proxy to measure the household consumption of electrical energy. The significant independent variables are monthly income of the household(MONTHLY_INC), number of electrical appliances at the household (N_ELECAPLNS) and number of inhabitants in the household (N_INHABT).

The Regression Equation is

$$\widehat{ELECTRCBL} = \hat{\beta}_1 + \hat{\beta}_2 MONTHLY\_INC + \hat{\beta}_3 N\_ELECAPLNS + \hat{\beta}_4 N\_INHABT$$

$$\widehat{ELECTRCBL} = 1956.77 + 0.0322 MONTHLY\_INC + 147.68 N\_ELECTAPPLN + 260.38 N\_INHABT$$

Model: OLS, using observations 1-50

Dependent variable: *ELECTRCBL*

	Coefficient	*Std. Error*	*t-ratio*	*p-value*	
const	−1956.77	829.219	−2.360	0.0226	**
MONTHLY_INC	0.0321736	0.00340297	9.455	<0.0001	***
N_ELECTAPPLN	147.683	57.7117	2.559	0.0139	**
N_INHABTNTS	260.387	140.333	1.856	0.0699	*
R-squared	0.824296		Adjusted R-squared	0.812837	
F(3, 46)	71.93475		P-value(F)	2.14e-17	

From the multiple regression model, it is evident that all the three explanatory variables are statistically significant. The null hypothesis that monthly income, number of electrical appliances and number of inhabitants do not affect electrical bill which is a proxy for the electrical consumption is rejected.

H_0: $\beta 2 = \beta 3 = \beta 4 = 0$

H_1: $\beta 2 \neq \beta 3 \neq \beta 4 \neq 0$

The alternative hypothesis is not rejected which means that all the explanatory variables are statistically significant. The p values of all the independent variables are less than 0.05 implying the statistical significance of the explanatory variables. From the R squared it is clear that 82% of the variations in the dependent variable are explained by the independent variables. To be specific 82% of changes in electricity bill is caused by these three explanatory variables as per our sample estimates. The F value is 71.935 which is far greater than the critical value of F at (3,46 degree of freedom and 5% level of significance). The F value of 71.935> The critical F value of 2. 80684.The P-value (F) is far less than 0.05. Hence there is overall significance of the model. It again shows the statistical significance of the explanatory variables in the model

5.1 Analysis of Residual Plots to detect Heteroscedasticity

The analysis of the residual plots against various explanatory variables do not exhibit any patterns thereby concluding that there is no problem of heteroscedasticity.

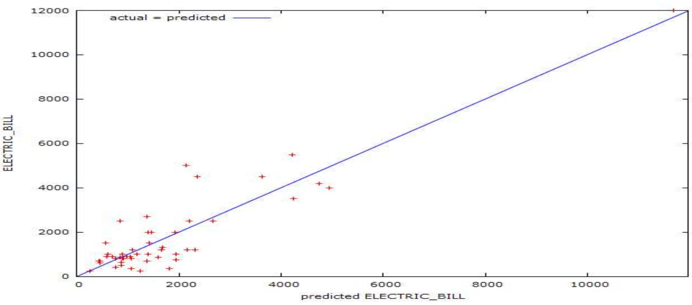

Figure 3. Actual vs Predicted electricity consumption

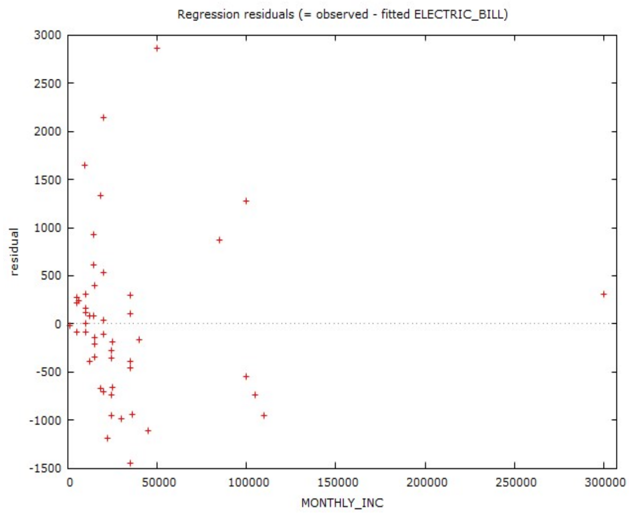

Figure 4. Residual vs Monthly Income

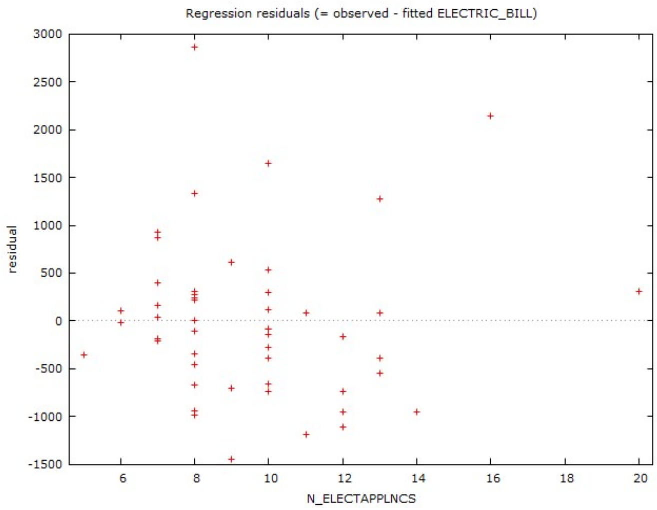

Figure 5. Residuals vs Electrical Appliances

Apart from analysing the residual plots to detect heteroscedasticity, Breusch-Pagan test and White test are conducted and their results are given below.

5.2 Interpretation of Breusch-Pagan Test

While applying Breusch-Pagan test, the null hypothesis is that there is no heteroscedasticity. Dependent variable uhat^2 is not explained by any of the independent variables. If test statistics LM is greater than critical chi square value, then null hypothesis of homoscedasticity is rejected. But in this case the test statistics LM is less than that of critical value of chi-square.
Test statistic LM=3.019
Critical value of chi square = 7.81473
3.019 is less than 7.81473 which indicates that null hypothesis is rejected and there is homoscedasticity.

5.3 Breusch-Pagan test for heteroscedasticity

OLS, using observations 1-50
Dependent variable: scaled uhat^2

	coefficient	std. error	t-ratio	p-value
const	−1.22282	1.97952	−0.6177	0.5398
MONTHLY_INC	−1.65709e-06	8.12362e-06	−0.2040	0.8393
N_ELECTAPPLNCS	0.113584	0.137770	0.8244	0.4139
N_INHABTNTS	0.251179	0.335004	0.7498	0.4572

Explained sum of squares = 6.03847
Test statistic: LM = 3.019236, with p-value = P (Chi-square (3) > 3.019236) = 0.388669

5.4 Interpretation of White's test for heteroscedasticity

While applying White test, the null hypothesis is that there is no heteroscedasticity. Dependent variable uhat^2 is not explained by any of the independent variables. If test statistics LM is greater than critical

chi square value, then null hypothesis of homoscedasticity is rejected. but in this case the test statistics LM is less than that of critical value of chi-square.
Test statistic TR^2 =11.87
Critical value = 16.919
11.87 is less than 16.919 which indicates that null hypothesis is rejected and there is homoscedasticity.

5.5 White's test for heteroscedasticity
OLS, using observations 1-50
Dependent variable: uhat^2

	coefficient	std. error	t-ratio	p-value
const	−1.35815e+07	9.98484e+06	−1.360	0.1814
MONTHLY_INC	119.333	69.8273	1.709	0.0952 *
N_ELECTAPPLNCS	−211882	789678	−0.2683	0.7898
N_INHABTNTS	5.52991e+06	3.22219e+06	1.716	0.0939 *
sq_MONTHLY_INC	0.000215454	0.000214355	1.005	0.3209
X2_X3	−9.51667	5.28844	−1.800	0.0795 *
X2_X4	−4.67986	8.93173	−0.5240	0.6032
sq_N_ELECTAPPLNCS	34997.9	29837.8	1.173	0.2478
X3_X4	−31158.4	127752	−0.2439	0.8086
sq_N_INHABTNTS	−521992	311135	−1.678	0.1012

Unadjusted R-squared = 0.237356
Test statistic: TR^2 = 11.867775, with p-value = P (Chi-square (9) > 11.867775) = 0.220867

5.6 Detection of Multicollinearty
Multicollinearty is tested by applying variance inflation factors (VIF) and it is found that values are significantly less than 10 indicating no multi collinearity.
Variance Inflation Factors
Minimum possible value = 1.0
Values > 10.0 may indicate a collinearity problem

MONTHLY_INC 1.673
N_ELECTAPPLNCS 1.673
N_INHABTNTS 1.000

5.7 Result Analysis of Regression Output

The Regression Equation is

$$\widehat{ELECTRCBL} = \hat{\beta}_1 + \hat{\beta}_2 MONTHLY\_INC + \hat{\beta}_3 N\_ELECAPLNS + \hat{\beta}_4 N\_INHABT$$

$$\widehat{ELECTRCBL} = 1956.77 + 0.0322 MONTHLY\_INC + 147.68 N\_ELECTAPPLN + 260.38 N\_INHABT$$

The above estimators of the regression equation are found to be Best Linear Unbiased Estimators (BLUE). The equation reveals that a hundred-rupee increase in monthly income of a consumer leads to Rs.3.22 increase in the electrical bill and an additional installation of an electrical appliance leads to an increase of Rs.147 to electrical bill and an addition of an inhabitant leads to an increase of Rs.260.38 to the electricity bill.

5.8 Confidence interval of estimated coefficients

Variable	Coefficient	95 confidence interval
const	-1956.77	(-3625.90, -287.641)
MONTHLY_INC	0.0321736	(0.0253238, 0.0390234)
N_ELECTAPPLNCS	147.683	(31.5150, 263.850)
N_INHABTNTS	260.387	(-22.0876, 542.862)

While analysing confidence interval of the coefficients, it is evident that coefficient of monthly income fares better than those of number of electrical appliances and number of inhabitants. By accumulating large samples, the confidence interval of coefficients can be improved and true estimates of coefficients can be calculated.

6. Recommendations of the study

The study analysed the major determinants of electrical consumption pattern in Kalamassery municipality. The analysis of the sample revealed interesting finding and based on these finding the study makes the following recommendations.

1) In the context of improvements in the Gross Domestic Product of the country and improvements in the per capita income of the people, it is inevitable that the electric energy consumption will get accentuated and the growing requirements of electrical energy has to be met and the priorities of the government should be aligned to these objectives of the nation.
2) The state government and KSEB must involve in awareness activities among the public to reduce the consumption of electrical energy as the current tariffs of electricity acts as a negligible deterrent on the consumption of electricity. Hence the government needs multi-pronged strategies to make reductions in electricity consumption which is getting scarcer day by day. As 71 per cent of electricity generation is from hydel projects, its generation is monsoon dependent. Water resource once was plenty in Kerala and now becoming a scarce resource is a worrying signs of imminent crisis in power sector.

3) It is high time that KSEBL makes a serious thinking on making substantial investments on other sustainable alternatives of electricity generation like solar and wind projects. Diversification can help in boosting dwindling own generation of electricity by KSEBL.

7. Acknowledgments

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