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Statistical Analysis of Trends in Electricity Consumption with Reference to Uttarakhand

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Abstract: Electricity consumption indicates countries growth and development. The aim of the paper is to study the trend of per capita consumption of electricity in Uttarakhand during the years 2011 to 2019. The regression techniques with linear regression, quadratic regression and exponential regression were used to carry analysis and to examine trends between number of years and per capita consumption of electricity in kwh (kilowatt hours). The present study suggests the best fit model by comparing R square, adjusted R square and residual means square error (RMSE). The finding suggests that the quadratic regression model is the best fit model for per capita consumption of electricity with R square (coefficient of determination) of 0.95 for forecasting of electricity consumption per capita in Uttarakhand. This will support policy makers and related sectors in order to meet the growing demand of electricity consumption of Uttarakhand.

Keywords: Uttarakhand • Trend • Electricity Consumption • Linear • Quadratic • Exponential • Regression analysis

Introduction

Energy conservation have significant contribution for national development and economic growth. Energy in form of electricity plays key role for economic growth of that region. Therefore per capita electricity consumption is important factor to consider for an analysis. India stands at 3rd position in world as a largest electricity producer also it's stands at same position as largest consumer of electricity. The national electric grid in India has an installed capacity of 393.389 GW as of December 2021 (https://eu.m.wikipedia.org). India's per capita power consumption during 2019 to 2020 was 1208 kwh (Kilowatt per hour). Electricity consumption is consistently growing from the financial year 2012 - 13 (914 kwh) till the financial year 2019 to 2022(1208 kwh) which shows 32 percent of increase. Access to energy and in particular electricity is considered as a fundamental right of every household. The accessible source of electricity gets distributed to different electrical loads within family and the members are not aware of the individual consumption per load consumed by them, just because the overall cost is billed as a single number in electricity bill (Georgiou et al 2013). Due to lack of such awareness electricity consumption is not cost efficient. Saving electricity seems difficult due to insensitive attitude and ignorant behaviour of consumer, this can be achieved by spreading awareness about generation of electricity, its consumption and about its misuse. This will drive consumer to pay more attention to unnecessary use of electricity and most probably change their daily routine behaviour

(Thogersen and Gronhoj, (2010). As per capita electricity consumption is highly correlated with GDP in positive direction so per capita it can be thought as a grade for cost effective development of the country (Erdal et al,2008; Ikegami and Wang,2016; Zamani,2007). India is the fastest developing countries in the world, to sustain the country's growth, the electricity demand will increase every year in all the states

of India, as they are progressing. Electricity infrastructure and production are important to meet electricity consumption for developing economy in overall India (Tiewsoh et al, 2019).

The per capita power consumption is a kind of indicator to measure countries development. Electricity is consumed in different sectors in India viz: transport, agriculture, domestic purposes, and others to boost the Nation's economy. Electricity is the key component in National development, it provides access to communication across the world. It is the most essential form of energy for Industrial and Agricultural growth. (Anandan and Ramaswamy, 2013)

Indian government has made lot of efforts in achieving the target through thermal, hydel, solar, wind and green energies to fulfil the demand of electricity consumption in various sectors of economy in the country India.

Uttarakhand is the Northern state of India. The state is blessed with natural resources, flora, fauna and rivers like Gaga, Yamuna, Kosi etc. Uttarakhand has immense potential of hydro power due to its geographical location and water resources. The Government of Uttarakhand has taken various steps to improve the power supply in order to attain sustainable development which will ensure access to affordable energy for all by 2030.

Objectives of the Paper

To study the pattern of per capita consumption of electricity in Uttarakhand.

To study the rate of growth of electricity consumption in Uttarakhand with regression models viz; linear, quadratic and exponential regression for the time duration 2011 to 2019.

To select the model best fit for forecasting about the electricity consumption in Uttarakhand by comparing predictive analysis R square, adjusted R square and RMSE

Background of power sectors in Uttarakhand

Uttarakhand was formed on 9th November 2000 as a separate part from Uttar Pradesh. It has Dehradun as the capital of the state, being the separate state political and economic activities has increased. Thus, the demand of power and supply has also increased. The area of Uttarakhand is around 53483 km square.

Uttar Pradesh State Electricity Board (UPSEB) was founded on April 1, 1959. The function of UPSEB were distributed to three Corporation on 14 January 2000 register under Indian Companies Act 1956.

1.UPJ VNL [Uttar Pradesh Jal Vidyut Nigam Limited] owns and operates hydro power station of UPSEB, those are already existing and also those are under construction.

2. UPRVUNL [Uttar Pradesh Rajya Vidyut utpadan Nigam Limited] owns and operates thermal power station of UPSEB which are already existing.

3.UPPCL [Uttar Pradesh Power Corporation Limited] operates distribution of electricity in Uttar Pradesh and Transmission also. [https://www.electricalindia.in]

Uttarakhand was introduced with two companies as UPCL [Uttarakhand Power Corporation limited]and PTCUL [Power Transmission Corporation of Uttarakhand Limited] for Electricity Distribution and power transmission in the state. The company provides quality power supply to the consumer of 13 districts of Uttarakhand. The company introduced two new schemes for development of the state:

1. Power for all (PFA)Ministry of power for the state, the Dindayal Upadhyay gram Jyoti Yojana- DDUGJY with the aim for excess of electricity to rural residents.

2.The integrated power development scheme (IPDS), to provide reliable safe and Secure electricity to Urban, semi urban and rural household aiming to reduce transmission loss less than 14% in 2020 (https://www.electricalindia.in).

Research related work

Uttarakhand power potential Ranges from coal, gas, hydro and other renewable sources. The state has various hydro power plants. Numerous studies have been carried out in the area of electricity consumption across the countries of the world using various methodologies.

(Mohammad Jamii et al,2021) used A R I M A model for modelling the demand of electricity for forecasting in Morocco using Box and Jenkins approach of time series. Guorong Zhu et al (2021) proposed EMD- FB prophet LSTM method (empirical mode decomposition long short term memory model)for a short term electricity consumption prediction model for electricity which is based on time series (Mohamed and Bodger ,2005) utilized multiple linear regression analysis models and electricity consumption is fore casted using the effects of demographic and economic variables(Li and Li, 2017) used time dependent model ARIMA in combination of Grey Model for comparing forecasting energy consumption in Shandong (China)and the best so obtained was based on combined GM-ARIMA Models. Again (Li and Zang ,2018) has made an attempt for forecasting electricity consumption by improved grey prediction model. (Sahu S K, 2008) carried out studies on energy consumption patterns for India using trend analysis with regression technique.

By reviewing research related work, it is observed that various models and techniques were used to study patterns of electricity consumption across the countries. In this regard forecasting the electricity consumption plays vital role as it can support decision makers to keep with the pace of the growing demands of the economy and to reduce power disruption. The forecasting can be done by appropriate model, thus in this paper an attempt is made to select the best time dependent model. the study will focus on per capita consumption of electricity in Uttarakhand.

Data and methodology

A nine-year data from 2011 to 2019 related with consumption of electricity per capita in Kilowatt hours, in annual mode are collected from secondary sources in our study from Uttarakhand electricity consumption per capita [htts://khoema.com]. The study also shows Power capacity in megawatt from 2011to 2021 from the secondary source statisticia.com and electricity consumption in different sectors in Uttarakhand from secondary source Uttarakhand energy pedia. The data related with electricity consumption is analyzed with the help of statistical tools SPSS. The regression analysis is carried out and behavioral study of variables which vary according to time is done using linear regression analysis, quadratic regression analysis and exponential regression analysis for determining the trend. Here, to investigate the trend nature, about annual electricity consumption per capita in Uttarakhand, for the duration from 2011 to 2019 three types of models are used which are time dependent.

1. Linear $Y=p+q_1 t$
2. Quadratic $Y=p+q_1 t+q_2 t^2$
3. Exponential $Y= p e^{q t}$

Where, Y = per capita consumption of electricity in kwh
p = Intercept
q's = regression coefficients
t= number of years from 2011 to 2019
e= exponential constant

The validation of model is done by using R square (coefficient of determination), residual means square error (RMSE) and significant levels at p less than 0.05

Results and discussion

Results indicates that there were trends during the year 2011 to 2019 in the consumption of electricity in Uttarakhand. The finding showed that there were increase (+ 65.1) in consumption from 2011 to 2012 with the variation rate 5.28% while there was decrease (- 12.0) in the consumption from 2012 to 2013 by 0 .92%. The highest increase was observed (+72.5) from 2013 to 2014 by 5.64% whereas the huge decrease was observed (- 12.0) from 2012 to 2013 by 0.92%. The Uttarakhand flash flood due to cloud burst, a natural disaster in 2013, had impacted hydro power projects in Uttarakhand. This may be the reason for less consumption of electricity in this duration (www.circleofblue.org).

TABLE 1: Installed power capacity across Uttarakhand in India from financial years 2011 to 2021 in megawatts.

YEAR	POWER CAPICITY(MEGAWATTTS)
2011	2455.14
2012	2526.93
2013	2460.51
2014	2526.94
2015	2634.69
2016	2809.04
2017	3177.28
2018	3313.45
2019	3399.14
2020	3403.00
2021	3550.00

TABLE 2: Electricity Consumption in different sectors in Uttarakhand.

SECTORS	YEAR 2006-07
Domestic	29%
Commercial	15%
Industrial	40.4%
Agricultural	9.9%
others	5.7%

* Others covers railways, water works, streetlights etc.

TABLE 3: Summary Statistics for per capita consumption of electricity (PCCOE) in kilowatt hours.

YEAR	PCCOE (Kilowatt hours)	Differences	Variation rate
2011	1232.2		
2012	1297.3	+65.1	5.28%
2013	1285.3	-12.0	-0.92%
2014	1357.8	+72.5	5.64%
2015	1431.2	+73.4	5.41%
2016	1453.7	+22.5	1.57%
2017	1450.1	-3.6	-0.25%

YEAR	PCCOE (Kilowatt hours)	Differences	Variation rate
2018	1466.9	+16.8	1.16%
2019	1527.9	+61.0	4.16%

TABLE 4: Regression Analysis between electricity consumption per capita and numbers of year from 2011 to 2019.

S. No	model	equation	R^2	Adjusted R^2	RMSE	P VALUE
1	LINEAR	Y=1212.731+35.285t	0.936	0.927	725.990	.000
2	QUADRATIC	$Y=1179.586+53.364t-1.808t^2$	0.949	0.932	679.205	.000
3	EXPONENTIAL	$Y=1219.149e^{.026t}$	0.931	0.921	0.000	.000

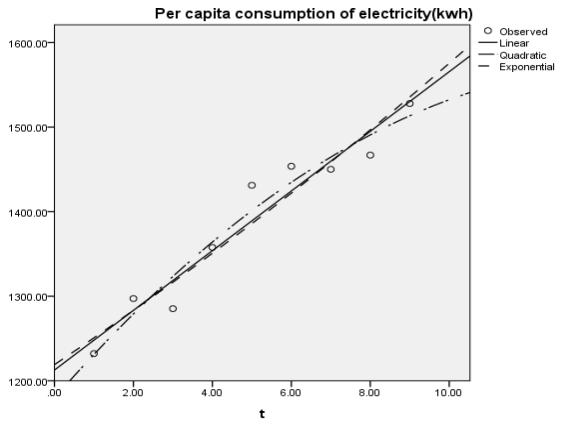

Fig. 1: Per capita consumption of electricity in kwh during 2011-2019 (t)

Regression analysis between consumption of electricity and number of years from 2011 to 2019 has been shown in the Table 4 and Figure 1. The results indicated that all the predicted regression models were statistically significant at p < =0.01. Results showed that linear (Table 4, s.no1, and Figure 1) quadratic (Table 4, s.no2, and Figure 1) and exponential (Table 4 s.no3 and Figure 1) regression had residual mean square [RMSE] error of 725.990,679.205and .000, respectively also coefficient of determination (R square) was 0.94, 0.95, 0.93, respectively. The linear regression analysis shows that the number of years explains about 94% of variation in consumption of electricity during 2011 to 2019. The quadratic regression analysis explains about 95% of variations in the consumption of electricity from 2011 to 2019 and the exponential regression analysis explains about 93% of variations in the consumption of electricity from 2011 to 2019. Table 1 explains Installed power capacity in annual mode across Uttarakhand in India from financial years 2011 to 2021 in megawatts. Table 2 explains the border sectors of electricity consumption in Uttarakhand.

The three regression models were used to examine the best fit model which express the variations of annual consumption of electricity per capita during the year 2011 to 2019. Regression finding suggest that quadratic regression model is the best model as it has the highest R Square value (0.949) to explain the variations of annual consumption of electricity during 2011 to 2019. The study will be helpful to recognize the trends and patterns of electricity consumption per capita in Uttarakhand there for the findings will be helpful for policy makers to have projections of electricity consumption in Uttarakhand.

We investigated three models of per capita consumption of electricity in Uttarakhand on the data of years 2011 to 2019 based on secondary source of data. The best regression model is quadratic regression model to recognize trends and patterns which can be helpful in forecasting so that future consumption (per capita) of electricity can be projected. Our objective was to select the best fit model for forecasting about the electricity consumption out of the three models viz linear, quadratic and exponential regression. The best model is selected by predictive performances of the model in terms of R square and adjusted R square. The highest value of R square is 0.949 for quadratic regression hence quadratic regression model is the best model to explain the variation in annual consumption of electricity between 2011 to 2019 and can be helpful for projections.

Therefore, the best model selected for per capita electricity consumption in Uttarakhand is a quadratic regression model given as below:

$Y=1179.586+53.364t-1.808t^2$

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References

Anandan M and Ramaswamy S (2013) Energy uses in India: A Case of electricity, IJRCM, VOL3,08, ISSN 2231-5756

Erdal G, Erdal H and Esengun K (2008) The causality between energy consumption and economic growth in Turkey.Energy Policy.Elsevier. Vol 36:3838–3842

Georgiou A, Ioannou P and Christodoulides P (2013) Domestic Electricity Consumption and the Public Awareness Factor, 4 th international conference on renewable energy sources and energy efficiency-new challenges Nicosia Cyprus (paper no 1342)

https://eu.m.wikipedia.org

https://www.circleofblue.org/2014/world/uttarakhand-flood-disaster-made-worse-existing-hydropower-projects-expert-commission-says/

Ikegami M and Wang Z (2016) The long-time causal relation between electricity consumption and real GDP: Evidence from Japan and Germany. Journal of Policy Modeling.Elsevier. Vol 38: 767–784

Installed power capacity in Uttarakhand from 2011 to 2021, https://www.statistia.com

Jamii M and Maaroufi M (2021) The Forecasting of Electrical Energy Consumption in Morocco with an Autoregressive Integrated Moving Average Approach, Mathematical Problems in Engineering. Article ID 6623570. https://doi.org/10.1155/2021/6623570

Li K and Zhang T (2018) Forecasting Electricity Consumption Using an Improved Grey Prediction Model. Information.9(8):204. https://doi.org/10.3390/info9080204

Li S and Li R (2017) Comparison of Forecasting Energy Consumption in Shandong, China using the ARIMA Model, GM Model and ARIMA-GM Model. Sustainability 9(7):1181. https://doi.org/10.3390/su9071181

Mohamed Z and Bodger P (2005) Forecasting electricity consumption in New Zealand using economic and demographic variables. Energy 30(10):1833-1843

Power Scenario of Uttarakhand--Electrical India, https://www.electricalindia.in

Sahu S.K. (2008) Trends and Patterns of Energy Consumption in India

Thogersen J and Gronhoj A (2010) Electricity saving in households- A social cognitive approach. Energy Policy.Elsevier. 38:7732-7743

Tiewsoh L, Jirásek J and Sivek M (2019) Electricity Generation in India: Present State, Future Outlook and Policy Implications, Energies. 12. 1361. 10.3390/en12071361

Uttarakhand electricity consumption per capita 2000-2021-khoema.com, httts://khoema.com

Uttarakhand energy pedia https://energypedia.infraenergysitutation

Zamani M (2007) Energy consumption and economic activities in Iran. Energy Econ.Elsevier. Vol 29:1135–1140

Zhu G, Peng S, Lao Y, Su Q and Sun Q (2021) Short-Term Electricity Consumption Forecasting Based on the EMD-Fbprophet-LSTM Method. Mathematical Problems in Engineering.Article ID 6613604. https://doi.org/10.1155/2021/6613604.