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ARIMA Forecasting for commercial Electricity Bills for Small scale Industry in Pre -COVID and COVID scenario in India

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ABSTRACT- ElectricalEnergy is one of the major forms of energy in the world today. All developed and developing nations majorly use electrical energy to undertake their day to day industrial activities. The consumption pattern of electrical energy differs in various small scale industries as per seasonal demand of manufacturing of products. However, COVID pandemic has changed the consumption pattern of electrical energy due to lock-down, labour shortage and other restrictions in India. The forecasting of electricity or energy used in small-scale industries is important to achieve energy conservation by improving their energy performance and also helps in reducing environmental hazards. The current study aims, to understand the temporary impact of COVID-19 pandemic on *electronic kits producing* small-scale industry, which is related to educational institutions of Central India. High energy consumption is directly correlated to high production capacity of any particular industry in the peak demand season. ARIMA forecasting method can be used to get the best forecasted model as per different data types. This forecasting could be helpful to understand the future trend of demand for *electronic kits producing* small-scale industry and to manage the resources in the best possible manner. Results and analysis reveal that in normal time, around the year there are 2 cyclic hikes in demand, followed by two cyclic dips in Bills. First hike in the demand of electronic kits is observed in the months of May-July every year due to the start of new academic sessions. After July, the first cycle of dip in orders was observed from August to September. Then the second cycle of high demand starts after October which continues till December due to the commencement of semester exams where electronic kits are required by all the technical institutions for conducting the practical experiments. Data was forecasted at 95% confidence interval; hence it can be considered a highly reliable prediction.

Keywords: Commercial Electricity Bills,ARIMA, Forecasting, TVS Lab Physiotronics,Electronic kits

Introduction

Electric Energy is considered to be very essential for functioning of all the small-scale industries in developed and developing nations. The forecasting of electricity or energy used in small-scale industries is important to achieve

energy conservation by improving their energy performance and it would also help in reducing environmental challenges or its impacts. The electricity consumption in these small-scale industries is affected by various factors like weather conditions, use of sub level components like air conditioner, heaters etc. Load forecasting for small-scale industries plays an important role in the smart — network paradigm, since precise forecasting helps in effective energy management by adding peak- load sharing, load scheduling and various effective demand response programs. It also estimates the values of power consumption and its consumption in a building. Major electricity loads in small-scale industries are affected by various factors such as temperature, humidity, holidays etc., [1]. Electricity forecasting is an essential process to increase proficiency and revenues for electricity generation and distribution to medium and small-scale industries. It helps to regulate essential resources like fuels to operatethe generating plants.While forecasting load it face variouschallengeslikethe weatheris somethingunpredictableandtheloadcomplexmayvarydependinguponchange in season and the total consumption [2].

Conventional forecasting models: Forecasting models generally used in different fields like in finance to forecast stock exchange, in commerce to plan staff performance, bring about inventory and predicting demand, in medicine to display disease spread and in meteorology for weather predictions. Forecasting plays an important role in control of energy or power plants. It also helps energy planners for accepting the impact of various variables on energy consumption and helps in assessment. It can be done in two terms period like in short term forecasting period it helps in assessing the supply of electricity and in long term forecasting it includes capacity expansion, capital investment and revenue analysis. Earlier various forecasting models have been used to predict electricity consumption and power supply by using various models like ANN, SVM, time series analysis includes ARIMA and ARMA. Out of these forecasting models ARIMA is the best model used for predicting the electricity consumption as it works on small data efficiently.

ARIMA model is an overview of ARMA model as these two are the basics of time series analysis to predict future forecasting. It is applied on non – stationery dataset. In ARIMA the AR(denoted by p) specifies that the developing interest is reverted on previous values and the regression error is recognized as MA (denoted by q)part which is a linear combination of error positions.The "I" or "Integrated" (denoted by d) indicates the time-series differencing.[3].

There are many difficulties that are associated with monthly electricity forecasting as its consumption of energy change after every few years due to macroeconomic conditions and social development and also monthly consumption is complex because of peoples' living habits, weather conditions etc. Electricity consumption for a commercial small scale industry even shows their manufacturing status also, high consumption also reflect more manufacturing.

COVID-19 Pandemic: Under the pandemic COVID–19, a serious virus spread has enforced governments to execute tough restrictions on daily life activities of the people to stop the spread of the disease. Due to strict restrictions buses, roads, airports, railway stations, shops, restaurants were shut down and all the industrial activities were affected globally, due to this there was a decline in the demand of electric power nearly by 20% to 40% in small scale industries [4, 5,6]. The Economic Times [7], highlights that demand for energy was recovered from government for implementing the relaxations for economic activities by allowing people to go at their work and also consumption of ventilation system increased as the temperature climbed beyond 45^0Celsius in May. The International Energy Agency (IEA), [8] states that after the lockdown there was decrease in energy demands of small-scale industries due to closures of the manufacturing units but the energy consumption in the house holds has risen due to the hot weather [9, 10,11]. Economic activity and the energy demand were effective due to the present pandemic and it was compared with earlier financial year or crises in 2008-2009 [12,13]. A recent study about the impact of current pandemic on household energy consumption demonstrated that 25% participants in the study has paid higher amount for the primary fuel during the locked down[14]. Another study shows that closure of all modes of travel has result in a decrease in the crude oil price [15]. Government also faced issues during the locked down period in generating electricity bills and revenue collection due to lack of mobility and electric meter reading [16]. Thus, COVID-19 pandemic has adversely affected the energy sector of India. The results show the decrease in energy demand by 26% within 10 days from lockdown. [17, 18].

Government has introduced many reforms and relaxation even for small scale industries during lockdown, to help them to stand again.So, from 1stJune 2020, many industries started working again, labors and skilled persons started coming to their workplace.

India is world's third biggest producer and consumer of hydraulic electricity [19, 20] with capacity of 372.693 GW (till 31st August 2020). During the

gross Fiscal year 2018-2019 report states that the gross electricity generated during this year was 1,372 TWh and 1,547 TWh was the total energy generated in the country. [21,22]. The per capita of electricity consumption 2018-2019 was 1,181 kWh.However, there is lack of adequate infrastructure [23], for providing essential set-up to ensure the supply of electricity to all households, industries, and small-scale industries [24-30].

The energy consumption has increased in Post-COVID times, across the world, especially in developing nations. Increased energy consumption has been observed due to the restart of all the industries and manufacturing units in nations like India, China, South-east Asia and Africa. To predict the effects of Locked-down and COVID pandemic, researchers have used hybrid ARIMA forecasting method to deal with limitation of small data-set [31].The present condition of COVID-19 pandemic had made incredible impact on socio-economic sector, health sector, and environment owing to the worldwide restrictions [32-41].

The present study is to examine how electricity consumption has adversely affected electronic kits manufacturing unit of Central India and other similar industries at large. ARIMA forecasting technique closely predicts the electric unit consumption and its cost for coming 6 months by the researchers. This study will be helpful in understanding the impact of COVID-19 pandemic on small scale industries of India and delay in manufacturing of goods due to the locked down.

Methodology

Source of data: Primary data was manually collected from commercial electricity bills of electronic kits manufacturing (for physics and engineering experiments in schools and colleges) producing company in Indore, MP (India) by name "**TVS Lab Psychotronics".**Data was considered for past 18 months (Jan'19-Aug'20)to do forecasting of upcoming 6 months (Sep'20-Feb'21). Electronic kits are a combination of electronic and small electrical components, assembled on a printed circuit board and box packed to deliver required functionality. It has a circuit diagram, schematic and instructions on the front panel. Patch cords, connecting cords etc., are there. Training kits customers are mostly technical and science colleges. All data set in the study was taken from utility Monthly Bill. Complete building is managed by one utility bill.

*Site Description:*The Site of Commercial Electronic Industry used, consist of a building with three floors. Constructed area was 1530 Square meter, out of which ground floor had 468 square meter, first floor and Second floor were of 510 square meters each. Workshops, Cafeteria, Stock room and Parking were on

ground floor. Assembling Units, Packaging Units, Office and Sales and Marketing Section were on the first and second floor.

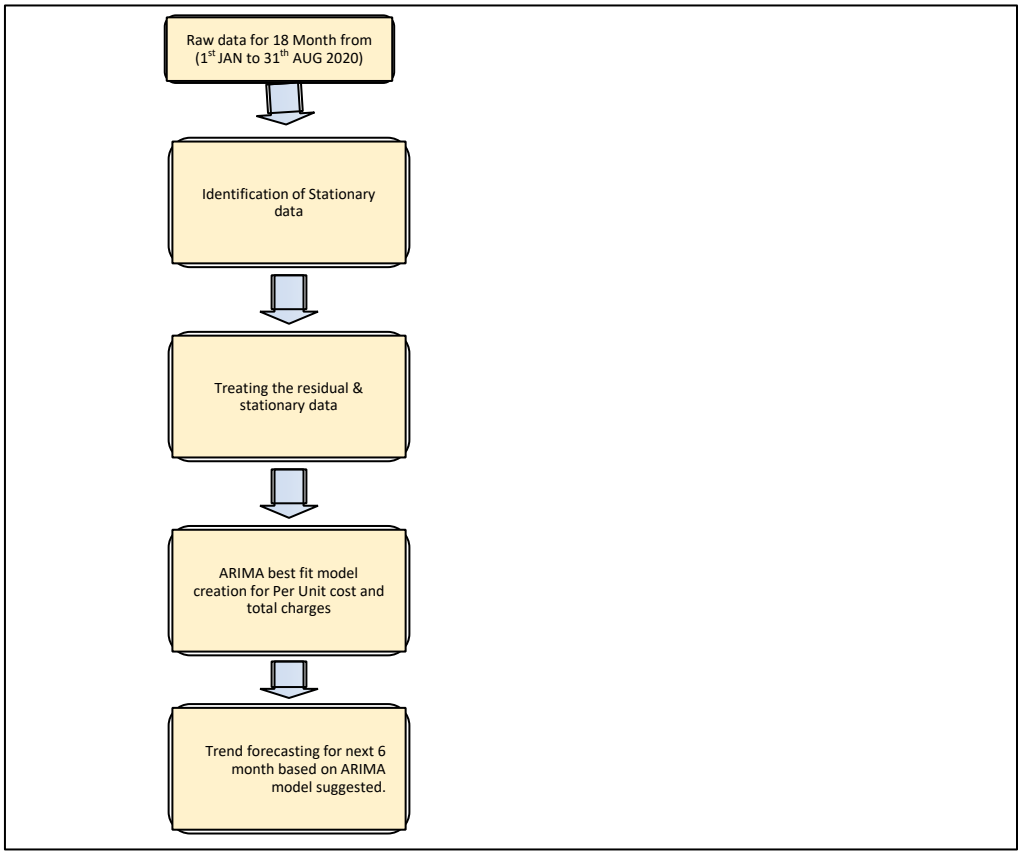
ARIMA forecasting:ARIMA forecasting method was deployed in this study to predict the followers for coming 6 months (Sep'20-Feb'21) for the company to see the impact of COVID-19 over the bill. ARIMA models are mainly used for non-stationary and short datasets. ARIMA stands for Autoregressive Integrated Moving Average. In ARIMA, AR indicates the lagged values, MA indicates regression error and I(for "integrated") represents the data values, which is difference of current and previous values.

The formula for ARIMA models as given by Box–Jenkins approach is mentioned below:

$$X_t - \alpha_1 X_{t-1} - \cdots - \alpha_{p'} X_{t-p'} = \varepsilon_t + \theta_1 \varepsilon_{t-1} + \cdots + \theta_q \varepsilon_{t-q}$$

Where, t=integer index and the Xt = real numbers, L= lag operator (autoregressive parameters of the model).Error terms are usually considered to be independent(see Figure 1 for more details).

Figure 1: Flow Chart of ARIMA modelling.



Results and Analysis

Table 1a: Details of actual data

Month	Units Consumed	Energy consumed Cost	Fixed Cost	Non-Government Tax	Other Tax	Total Final Charges
Jan-19	196	1482	460	172	25	2139
Feb-19	186	1406	460	159	25	2050
Mar-19	229	1733	460	237	25	2455
Apr-19	282	2137	460	298	25	2920
May-19	546	4139	460	598	25	5222
Jun-19	521	3949	460	570	25	5004
Jul-19	513	3924	460	566	25	4890
Aug-19	335	2562	460	361	25	3322
Sep-19	363	2829	506	401	25	3675
Oct-19	491	3904	540	562	25	5031
Nov-19	392	3116	540	444	25	4125
Dec-19	622	4944	540	718	25	6227
Jan-20	51	396	540	36	25	996
Feb-20	69	534	540	57	25	1156
Mar-20	80	612	540	0	25	1177
Apr-20	80	612	540	0	25	1177
May-20	80	612	8	74	25	718
Jun-20	592	4222	540	707	25	5767
Jul-20	393	3007	540	435	25	4286
Aug-20	278	2126	540	301	25	3256

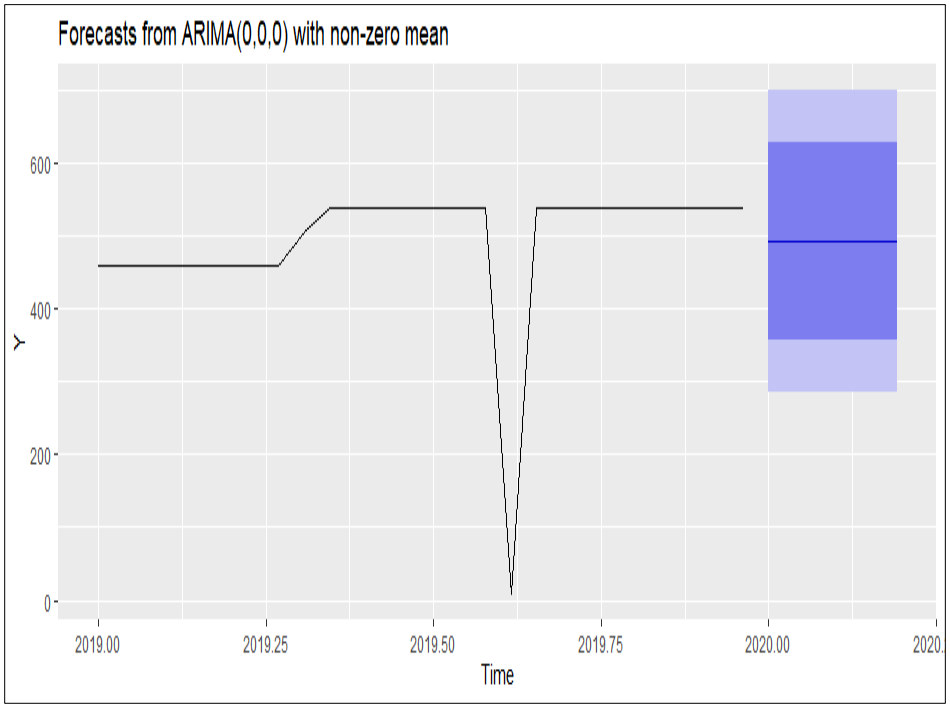
Table 1b: Details of Forecasted data

Month	Units Consumed	Energy consumed Cost	Fixed Cost	Non-Government Tax	Other Tax	Total Final Charges
Sep-20 (P)	**314.95**	**2277.47**	**540**	**401**	**25**	**3558.42**
Oct-20 (P)	**558.855**	**4221.096**	**540**	**562**	**25**	**5906.9514**
Nov-20 (P)	**558.855**	**4263.73**	**540**	**444**	**25**	**5831.5854**
Dec-20 (P)	**687.971**	**5285.041**	**540**	**718**	**25**	**7256.0121**
Jan-21 (P)	**314.95**	**2373.04**	**540**	**36**	**25**	**3288.99**
Feb-21 (P)	**314.95**	**2374.452**	**540**	**57**	**25**	**3311.402**

Table 1a provides actual values of utility bill and table 1b provides predicted or forecasted data for next 6 months. In table 1b, P stands for predicted values for the electricity consumption and cost of **TVS LabPhysiotronics.** Commands for forecasting are mentioned below, where fpp2 library was used along with Auto-Arima function in R studio.

```
> library(fpp2)
> library(fpp2)
> # LOAD THE DATASET,
> #Give the command
> Y=ts(AE[,4],start=c(2019,1),frequency=26)
>autoplot(Y)+ggtitle("Time plot:Energy Consumed Units")+ylab("Total Energy Consumed")
>fit_arima<-auto.arima(Y)
> print(summary(fit_arima))
```

Figure 1a: ARIMA Plot (0,0,0,) for Total Energy Units Consumed from Jan'19-Feb'21 (forecasted data for Sep'20-Feb'21) generated using Auto-Arima forecast library in R studio

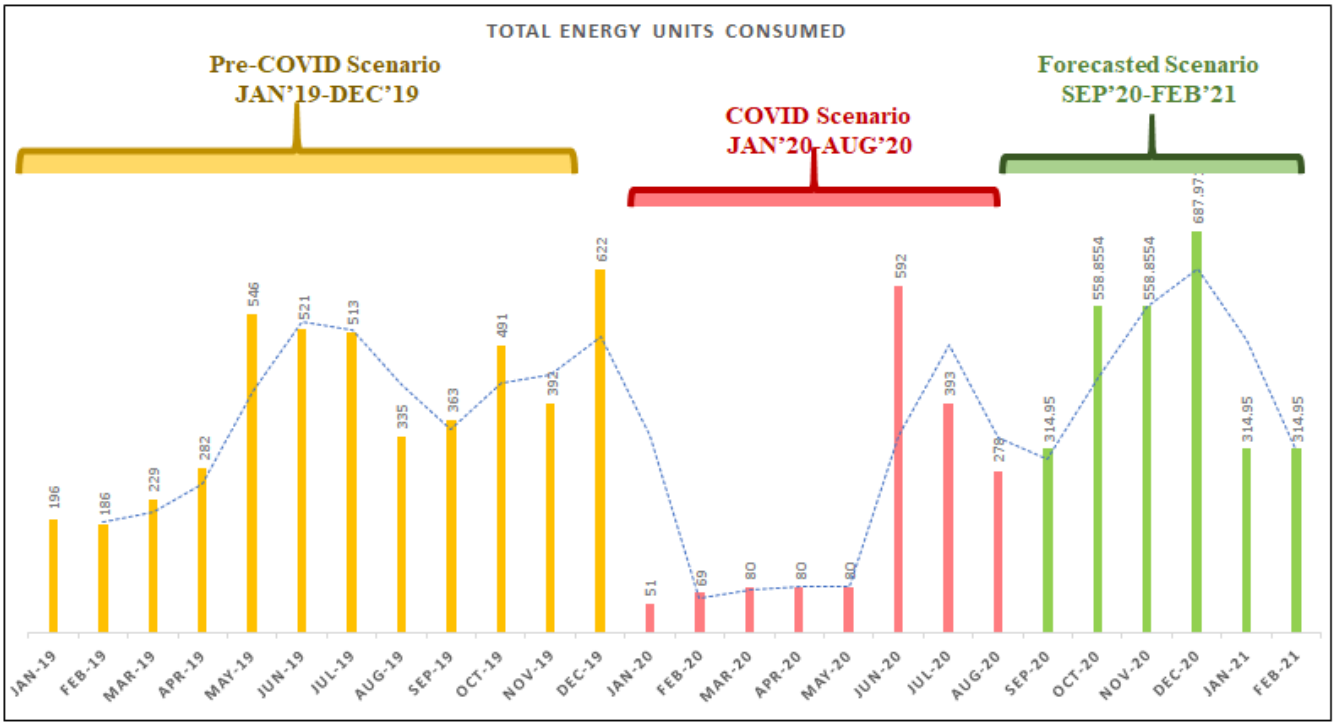


- ARIMA (0,0,0) with non-zero mean

• Coefficients: ar1=493.6154, s. e. =20.3316, sigma^2 estimated as 11178: log likelihood=-157.56
, AIC=319.13, AIC c=319.65, BIC=321.64

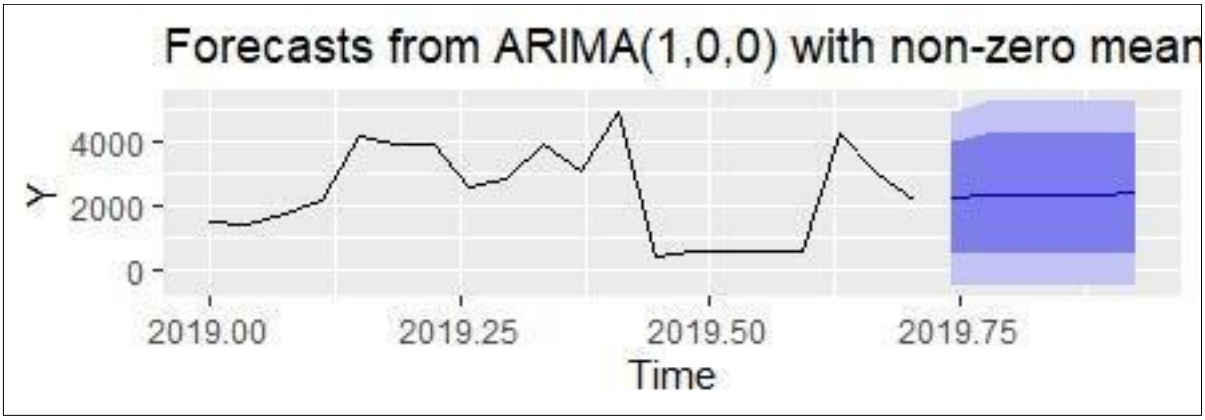
• Training Set Error Measures: ME=-2.7674e-10, RMSE =103.6711, MAE=58.04142, MPE=-230.3373, MAPE=94.08227, MASE=NaN, ACF1=-0.02455127

Figure 1b: Plot for Total Energy Units Consumed from Jan'19-Feb'21 (forecasted data for Sep'20-Feb'21)



Above Figure 1a and 1b displays the cyclic pattern of total energy units consumed by the manufacturing unit from the months of Jan'19-Aug'19.The forecasted data is displayed in green coloured bars. It was observed that even the forecasted values predicted hike in total energy consumption for the months of Oct-Dec'20, following a trail similar to year 2019. Dip due to COVID is shown in Pink, March 2020 to June 2020

Figure 2a: ARIMA Plot (1,0,0,) for Energy Consumed Cost (without taxes) from Jan'19-Feb'21 (forecasted data for Sep'20-Feb'21) generated using Auto-Arima forecast library in R studio



• ARIMA (1,0,0) with non-zero mean

• Coefficients: ar1=2375.3648, s. e. =464.1203, sigma^2 estimated as 1872900: log likelihood=-171.84, AIC=349.68, AIC c=351.18, BIC=352.66
• Training Set Error Measures: ME=21.12653, RMSE =1298.31, MAE=1016.01, MPE=-69.05093, MAPE=94.08227, MASE=NaN, ACF1=0.01236167
Figure 2b: Plot for Cost of Energy Units Consumed (without taxes) from Jan'19-Feb'21 (forecasted data for Sep'20-Feb'21)

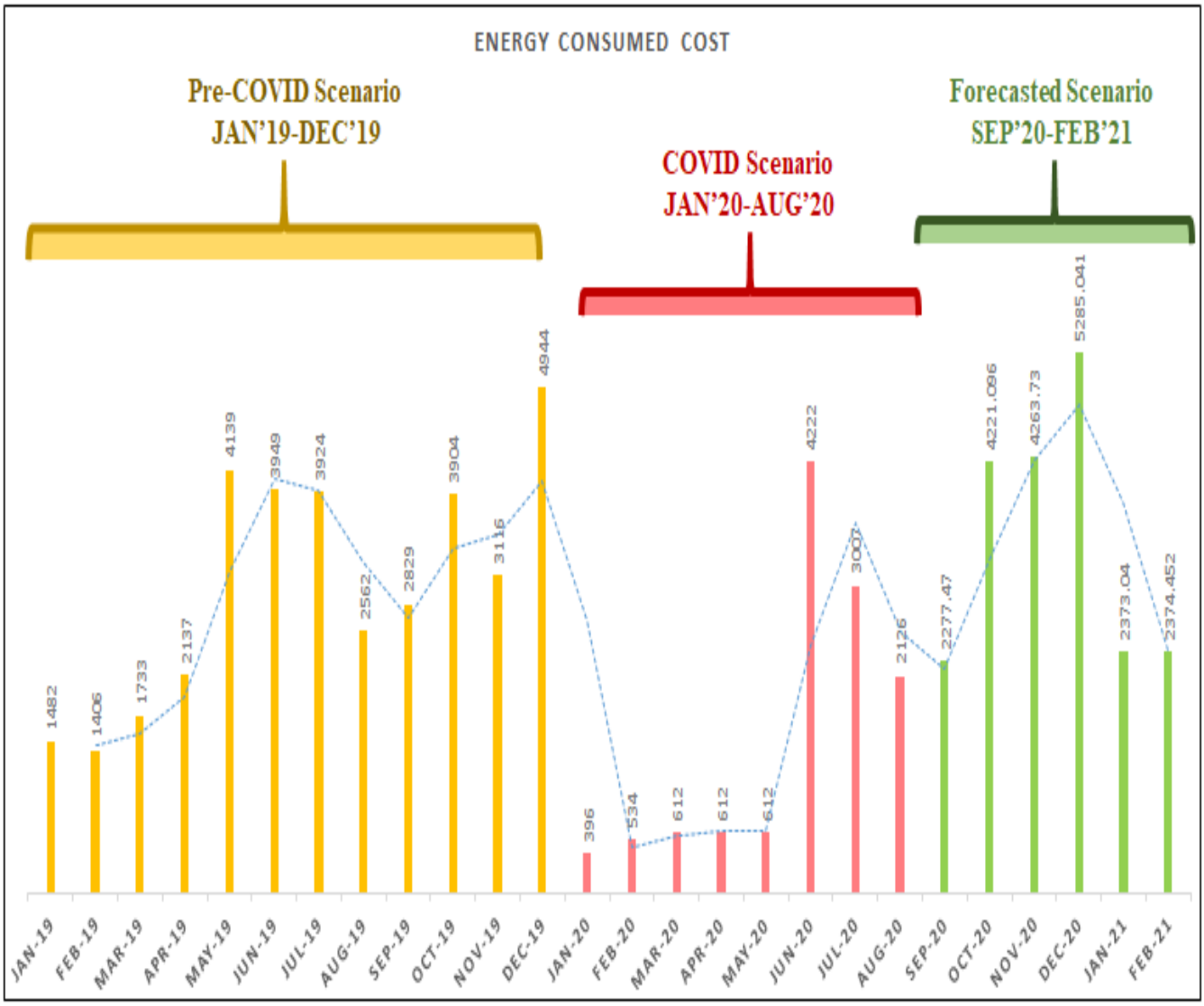
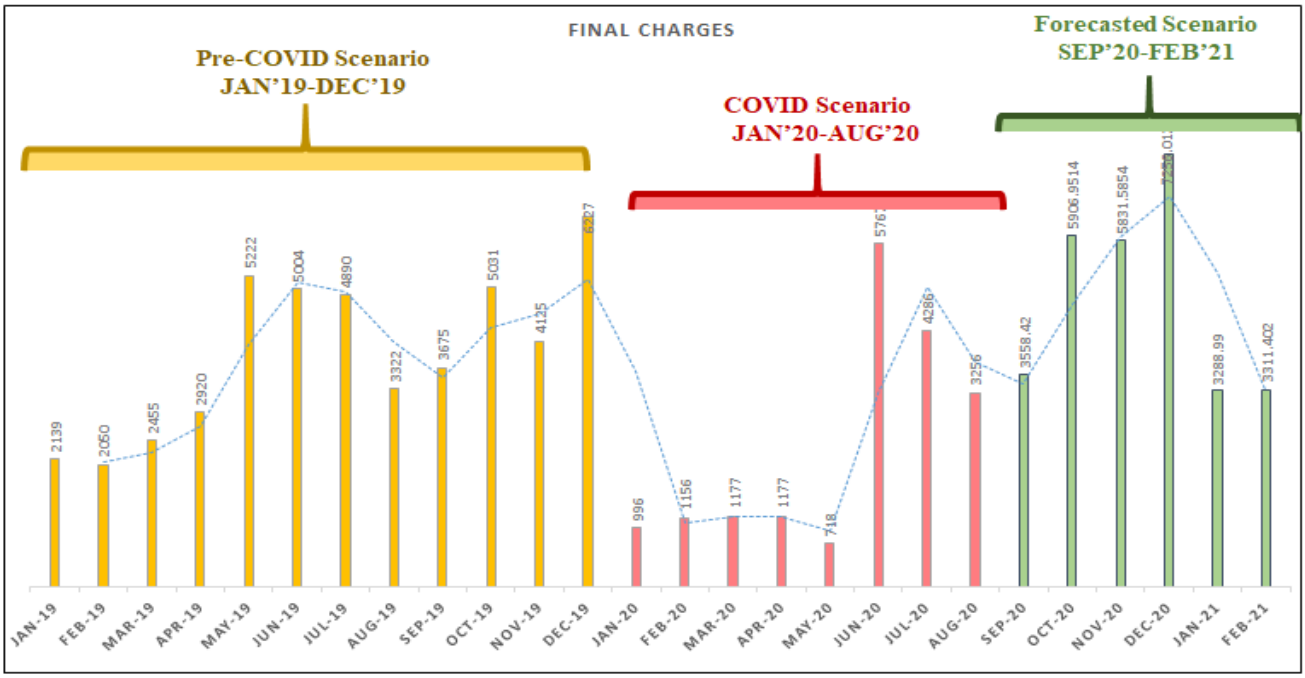


Figure 2c: Plot for Final Charges of Energy Units Consumed (including taxes) from Jan'19-Feb'21 (forecasted data for Sep'20-Feb'21)



Above Figure 2a-2c displays the cyclic pattern of cost (without taxes) and final charges (with taxes) for total energy units consumed by the manufacturing unit from the months of Jan'19-Aug'19. The forecasted data is displayed in green coloured bars. It was observed that even the forecasted values hiked up the months of November and December' 2020 the most followed by a forecasted slowdown for the months of January and February, 2021. Forecasted plots were created using ARIMA best fit model (1,0,0) using Auto-Arima forecast library in R studio.

Discussion

The commercial Electricity bill was taken from Jan'19-Aug'20 (18 months) in order to forecast the consumption of energy units and its cost for coming 6 months. Cost was first given without government taxes, to reduce seasonality in the data. Later government taxes were included to estimate the final cost for the upcoming 6 months from Sep'20-Feb'21. The main causes of variation in the monthly Electricity bill was the fluctuation in academic demand of electronic kits by the academic institutions.

Fig 1a of results and analysis, reveal that around the year there are 2 cyclic hikes in demand, followed by two cyclic dips. First hike in the demand of electronic kits is observed in months of May-July every year due to start of new academic session, where academic institutions like schools, colleges and university give orders for bulk manufacturing of electronic kits for new upcoming batch of students. After July, first cycle of dip in orders was observed from August to September. Then second cycle of high demand starts after October which continues till December due to the commencement of semester exams where electronic kits are required by all the technical institutions for conducting the practical experiments. The consumption of electricity units and its cost for the **TVS Lab Physiotronics**(Small

scale manufacturing industry) was observed higher in the months of May and Julys, followed by a second hike in months of October to December and this is valid for 2019 as seen from fig. 1b. As the Pandemic hit India from Jan 2020, followed by lockdown in March, April and May 2020. Electronic Industry has to shut down, also workers were not available for the manufacturing unit, in March, April and May2020. Low Electricity Bills of above 3 months reflects the story as can be seen from fig 2b, as there was no manufacturing.All small-scale industrieswere badly affected in these 3 months.On June 1st, 2020 the Lockdown rules loosened, and manufacturing started following COVID new norms and started gearing up, which can be seen by the hike in Electricity consumption from fig. 2c.

Using ARIMA best-fit forecasting technique, it has been predicted that in year 2020-2021, manufacturing company could observe a hike in manufacturing, leading to hike in consumption of electricity units and its cost for the month of November to December, 2020, as colleges might reopen after October, Diwali. It was also forecasted that in the months of January and February, 2021, the demand for electronic kits would fall, thus the overall electricity consumption and its cost would also reduce. Consumption of Light load, tubelight, LED Bulb are almost constant throughout the year. Fan and Cooling loads are season dependent in Central India, as September and October are considered warmer months, so we find an increase in consumption of electric units. November and December are peak manufacturing seasons, so consumption of electricity is higher. Same trend is shown in the ARIMA prediction, which is quite accurate. Semester system is followed in the Technical and Science institute, so their purchase request is also affected in Semester break (15 Dec to 15 Jan) and so the manufacturing also get affected and electricity consumption reduced.

Conclusion

Electricity forecasting for small-scale industries have been done previously by different methods, but this study speciallyfocuses on Pre-COVID and COVID duration in Central India with respect to Small scale Commercial Industry**.** In this study electricity demand for the electronic kits small scale manufacturing company was estimated, based on utility bill. ARIMA best-fit model has been used in this study to predict the electricity unit consumptions and estimated cost (both without and with government tax)**.**

The study shows how electricity consumption has adversely affected electronic kits manufacturing unit of Central India and other similar industries at large. ARIMA forecasting technique closely predicts the electric unit consumption and its cost for coming 6 months. This study will be helpful in understanding the impact of COVID-19 pandemic on small scale industries of India and delayed in consumptions of goods due to the locked down.We have chosen ARIMA forecasting, as it is best for small data points and gives accurate results.It gives accuracy near to 95%, which is very good comparing other regression analysis.Forecasted figures 1a, 2a, follow the similar cyclic high-low pattern as displayed by the data of past 18 months. Data was forecasted at 95% confidence interval; hence it can be considered a highly reliable prediction. ARIMA best-fit

forecasted method can be used to get the best forecasted model as per different data types. This forecasting could be helpful to understand the future trend of demand for electronic kits and to manage the resources in the best possible manner.COVID19 has impacted industries adversely, after May, manufacturing and industries started gearing up due to new policies and reforms brought by the Government.

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