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Impact of Covid-19 Outbreak on Turkey Electricity Generation

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ABSTRACT

With this study, it was aimed to analyze the change of electricity generation in Turkey depending on COVID-19 pandemic. For this purpose, analyzes of the changes in nine different electricity generation sectors besides total electricity generation were done. In addition, these analyzes were also carried out on a monthly basis in order to better understand the change in total electricity generation. Trend, naive, exponential smoothing and holt linear trend methods were used for the analysis. The results were obtained by taking into account the 2020 forecast values of the method belonging to the mean absolute percentage error (MAPE) values obtained from these methods. According to these results, it was concluded that the COVID-19 pandemic negatively affected electricity generation from total, dam, lignite, stream, imported coal and wind and did not adversely affect electricity generation from natural gas, wind, solar, geothermal and biomass in Turkey for 2020. From the results of the analysis done for the monthly change in total electricity generation in 2020, it was seen that there was a decrease in the total electricity generation compared to the expected in the months when there were restrictions.

Covid-19 Salgınının Türkiye Elektrik Üretimine Etkisi

Araştırma Makalesi

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ÖZ

Bu çalışma ile COVID-19 salgınına bağlı olarak Türkiye'de elektrik üretim değişiminin analiz edilmesi amaçlanmıştır. Bu amaçla toplam elektrik üretiminin yanı sıra dokuz farklı elektrik üretim sektöründeki değişimlerin analizleri yapılmıştır. Ayrıca toplam elektrik üretimindeki değişimi daha iyi anlayabilmek için bu analizler aylık olarak da yapılmıştır. Analizler için trend, naive, üstel düzeltme ve holt doğrusal eğilim yöntemleri kullanılmıştır. Bu yöntemlerden elde edilen ortalama mutlak yüzde hata (MAPE) ve değerlerine ait yöntemin 2020 tahmin değerleri dikkate alınarak sonuçlar elde edilmiştir. Bu sonuçlara göre 2020 yılında Türkiye'de COVID-19 salgınının toplam, baraj, linyit, akarsu, ithal kömür ve rüzgardan elektrik üretimini olumsuz etkilediği, doğalgaz, rüzgar, güneş, jeotermal ve biyokütleden elektrik üretimini olumsuz etkilemediği sonucuna varılmıştır. 2020 yılında toplam elektrik üretimindeki aylık değişim için yapılan analiz sonuçlarına göre ise kısıtlamaların olduğu aylarda toplam üretimde beklenene göre düşüş olduğu görülmüştür.

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1. Introduction

COVID-19 first appeared in Chinese province of Wuhan in December 2019 and was reported to be a pandemic in March 2020. This highly contagious acute respiratory disease can spread between people through small airborne droplets or contaminated surfaces (Wilder-Smith et al., 2020). The epidemic has significantly affected every aspect of life from the moment it first emerged. With the occurrence of the cases, the measures taken in the countries forced people to reorganize their lives. In this process, governments had taken various measures to manage the economic and social effects of the epidemic (Bulut, 2020; Norouzi et al., 2021; Baran 2019). Distance education in schools, flexible working in the public sector, daytime curfews and closure of workplaces were some of these measures. Those who remained outside of the compulsory working areas started to follow their work from their homes. The virus has affected many sectors such as health, education, environment and energy in all countries with cases. Energy is an important part of economic growth in every country. Due to the restrictions experienced on a global scale, electrical energy consumption has shifted from places such as industry, business and educational institutions, especially to homes and hospitals. These changes in demand have made it difficult to manage energy generation and distribution (İcel, 2013; Dincer, 2020; Baran, 2021; Ceylan, 2021). The first case in Turkey was announced on 11 March 2020. There has been a continuous increase in electricity demand due to both the increasing population structure of Turkey and COVID-19. Commercial and industrial electricity usage, on the other hand, experienced sharp declines. This situation also had an impact on electricity generation (Halbrügge et al., 2021).

Sahin et al. (2021) examined the effect of the COVID-19 quarantine on electricity generation in European countries. Linear regression, support vector machines and RF algorithms were used to estimate monthly electricity generation. According to the results, electricity generation from non-renewable sources for UK, Spain, Germany and France decreased by 21% -25% compared to the same period of 2019. For Turkey, this decrease had forecasted to be approximately 11%. In the study conducted by Ghenai et al. (2021), they concluded that the electricity generation from coal, natural gas and nuclear power plants in European countries decreased by 35%, 25% and 20% compared to the previous period during the COVID-19 process. They also forecasted that the share of renewable energy increased by up to 9%. In the study, digitalization and decentralization methods were used. Alhajeri et al. (2020) used regression analysis and genetic algorithm to forecast Kuwait's electricity generation during the COVID-19 period. In the study conducted by Ceylan (2021), the effect of COVID-19 on electricity demand in Turkey was examined. Gaussian process regression (GPR), sequential minimal optimization regression (SMOReg), correlated Nyström views (XNV), linear regression (LR), reduced error pruning tree (REPTree), and M5P model tree (M5P) were used.In the study conducted by Bulut (2020), it was determined that the electricity consumption in Turkey decreased in workplaces and increased in residences during the COVID-19 period. In the study conducted by Delgado et al. (2021), the decreases at electricity consumption in Brazil due to the COVID-19 epidemic were calculated as 14%, 15% and 19% by region. Data were analyzed by the

Joinpoint Regression Program. Monte Carlo Permutation method was employed to test the significance. Rayash et al. (2020) determined a 14% decrease in monthly electricity demand for the Canadian province of Ontario. Snow et al. (2020) conducted a study in Australia, which determined that there was an increase in electricity consumption caused by the usage of digital devices such as ovens, stoves, televisions and tablets during the quarantine period. Edomah et al. (2020) examined the impact of electricity consumption on industrial, residential and commercial sectors during the COVID-19 process in Lagos, Nigeria. In the study by Zhong et al. (2020), the changes in the load distribution during the Covid-19 process were examined. Apart from these studies, Elavarasan et al. (2020), Huang et al. (2021), Bahmanyar et al. (2020), Halbrügge et al. (2021), Kanitkar (2020), Cicala (2020) ve Janzen et al. (2020) also conducted studies on the effect of the quarantine period on electricity consumption.

The purpose of this article is to reveal the impact of the restrictions due to COVID-19 on Turkey's electricity generation. Based on this information, analyzes were done on the electricity generation data before and after the epidemic. Total and nine different electricity generation sectors were examined. In order to better understand the changes, the total electricity generation was also examined on a monthly basis. Trend, naive, exponential smoothing and holt linear trend methods were used for the analysis. The main contribution of this study is the analysis of the effect of the quarantine period on electricity generation in Turkey in ten different sectors. After this stage, the study consists of four sections. The materials used in the study are presented in the second section, and the method is presented in the third section. In the fourth section, the findings obtained in the study are given. Finally, in the fifth section, the results of the changes in electricity generation due to the COVID-19 epidemic in Turkey were presented.

2. Materials

The electricity generation data used in this study were taken from the publicly accessible Energy Exchange Istanbul (EXIST) (EXIST, 2021) website. There had been various restrictions since March 2020, when the first case was seen in Turkey. The timeline of these restrictions is as in Figure 1.

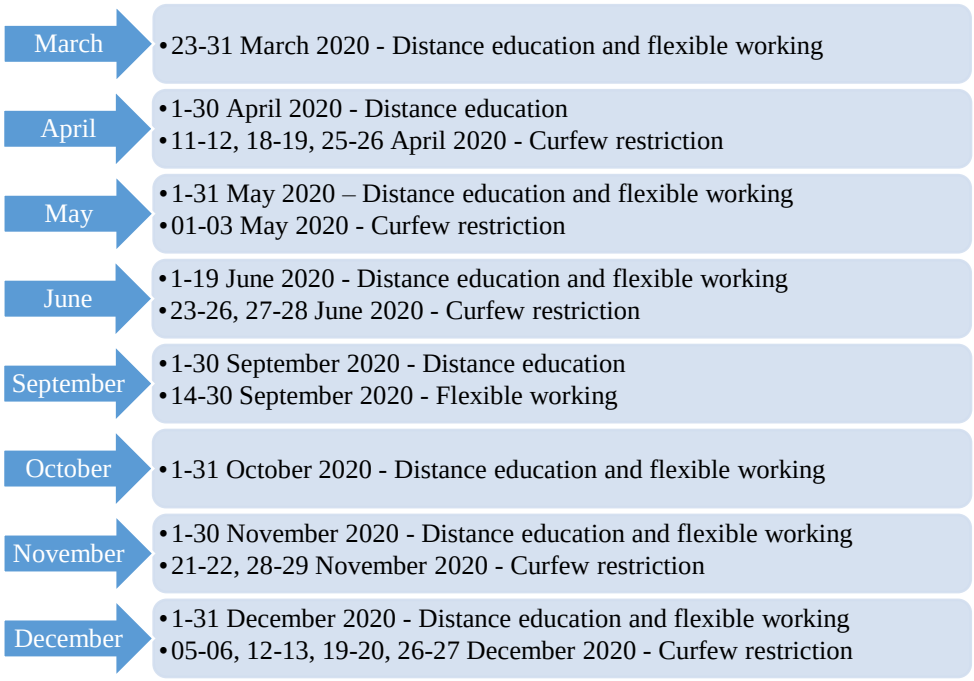

Figure 1. COVID-19 restrictions timeline in Turkey in 2020

The study was conducted for nine sectors and total generation used in electricity generation in Turkey. These nine sectors had been selected in this study because of their being the largest sectors playing a role in electricity generation in Turkey. Table 1 shows the electricity generation values between these sectors and the years 2014-2020.

Table 1. Electricity generation sectors and quantities in Turkey between 2014-2020 (EXIST, 2021)

Year	Total (MWh)	Natural Gas (MWh)	Dam (MWh)	Lignite (MWh)	Stream (MWh)	Imported Coal (MWh)	Wind (MWh)	Solar (MWh)	Geothermal (MWh)	Biomass (MWh)
2014	247842780,6	119169251,6	29250779	36035986	10547347	34877549	8484606	0,0	2102456	974720
2015	258415758,9	98533033,7	47517199	31105021	18876017	40038430	11657918	0,0	3060651	1158767
2016	269290507,2	88345823,8	48734170	37873357	18213324	47611089	15377383	1706,2	4213685	1498091
2017	289855258,3	109200983,1	41157951	39967138	16965265	50898234	17716692	21577,7	5287455	1871676
2018	291170736,3	90085199,9	40885859	44821132	18830892	62149282	19755914	57389,0	6905581	2305553
2019	289815303,1	54883429,2	65624215	46718392	22982596	60403122	21512281	187916,7	8229709	3148797
2020	290227386,4	68072555,1	57320772	37789515	20513348	62466466	24486679	421041,1	9316382	4065611

3. Modeling Methodology

To better evaluate modeling performance of trend naïve, naïve, exponential smoothing and holt linear methods, the generation data from EXIST (EXIST, 2021) was used. These methods can achieve successful results in time series forecasting. Figure 2 shows the flowchart of modeling and validation process used in this study.

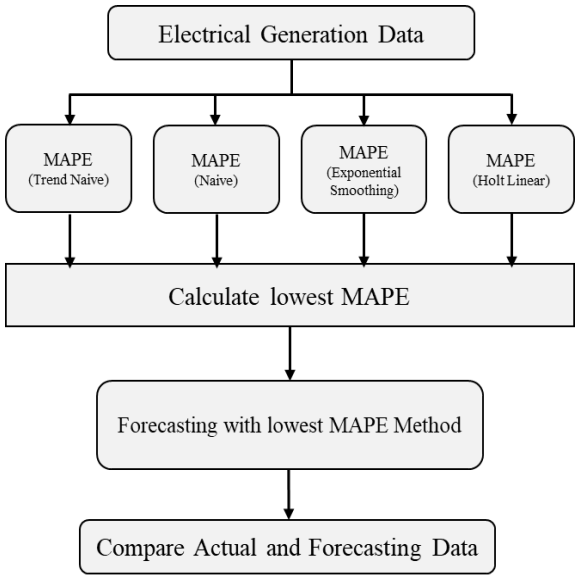

Figure 2. Flowchart of the modeling and validation process

There are many methods developed to evaluate the performance of the forecast models. Two of these methods are RMSE and MAPE. The results were obtained by considering the forecast values of the method giving the lowest RMSE and MAPE values for 2020. The RMSE value was calculated by using equation (1) and the MAPE value was calculated by using equation (2) (Ozkurt et al., 2020).

$$\mathrm{RMSE} = \sqrt{\frac{1}{n}\sum_{i=0}^{n-1}(y_a - y_p)^2} \quad (1)$$

$$\mathrm{MAPE} = \frac{100}{N}\sum_{i=1}^{n}\frac{|y_a - y_p|}{|y_a|} \quad (2)$$

Where the parameter N is the number of samples, the parameter y_a is the actual value, and the parameter y_p is the forecasted value. Trend, naive, exponential smoothing and holt linear trend methods are compared with LSTM because they have high performance in time series analysis forecastions.

3.1. Trend Method

It is a kind of linear regression method. It uses historical data on different variables, both dependent and independent, for forecasting. It examines the behavior of the factors behind past trends. It works on the assumption that this pattern of behavior will continue in the same way in the future. Its representation with the formula is as in equation (1) (Forecasting Methods, 2021):

$$Y = a + bX \quad (3)$$

a and b values in equation (3) are calculated by solving equation (4) and equation (5).

$$\sum Y = an + b\sum X \quad (4)$$

$$\sum XY = a\sum X + b\sum X^2 \quad (5)$$

The n value in equation (4) is equal to the total data items in a given series.

3.2. Naive Method

In this method, when forecasting the next period, the data in the previous period is used as the forecast data. This situation is represented by the formula in equation (6) (Forecasting Methods, 2021; Naïve Models, 2021):

$$Y'_{t+1} = Y_t \quad (6)$$

Y'_{t+1} represents forecasted and Y_t represents actual value. The advantage of this method is that it is inexpensive to develop, store and operate, while the disadvantage is that it does not consider possible causal relationships underlying the forecasted variable.

3.3. Exponential Smoothing Method

In this method, forecasts are determined by using weighted averages based on past observations. More importance is given to the last data in a given sequence. Also, the weights start to decrease exponentially with past observations. Each new forecast is calculated as in equation (7) (Forecasting Methods, 2021).

New forecast = Past forecast value + α (Actual demand value – Past forecast value) (7)

The value of α is considered a smoothing constant ranging from 0,01 to 0,50 (Exponential Smoothing, 2021; Holt's Linear Trend-1, 2021).

3.4. Holt Linear Trend Method

This method is a suitable method that can be used when the growth rate of the time series changes. Equations developed for the model are shown in equation (8-10) (Exponential Smoothing, 2021; Holt's Linear Trend-1, 2021).

$$F_{t+n} = L_t + nT_t \quad (8)$$

$$L_t = \alpha Y_t + (1-\alpha)(L_{t-1} + T_{t-1}) \quad (9)$$

$$T_t = \beta(L_t - L_{t-1}) + (1-\beta)T_{t-1} \quad (10)$$

L_t is the level forecast of the series at time t, and T_t is a forecast of the slope of the time series at time t. α is a correction parameter for level and takes a value between 0 and 1. β is a correction parameter for

the trend and takes a value between 0 and 1 (Benli et al., 2014). In this method, these processes are not applied for the first period while determining the level and trend values. When the studies in the literature are examined, it has been seen that values such as 0,3, 0,4, 0,5 and 0,2, 0,22 and 0,3 are usually given for the α and β coefficients. In this study, 0,5 (α) and 0,3 (β) values, which are close to the values in literature, were chosen.

4. Result and Discussion

4.1. Annual Analysis

In the annual analysis, generation data of 2019 (the year before COVID-19) and year 2020, (when the restrictions began) were taken into account. In addition to the total electricity generation, analyzes were made in nine different electricity generation sectors. The forecasting data of the lowest MAPE (%) value from the trend, naive, exponential smoothing and holt linear trend methods were used. The results that were obtained are shown in Table 2.

Table 2. Forecasting methods and obtained values (for ten sectors)

TOTAL GENERATION			IMPORTED COAL		
Model	RMSE	MAPE (%)	Model	MSE	MAPE (%)
Trend	$7{,}14\times10^{6}$	0,0207	Trend	$2{,}80\times10^{6}$	0,0393
Naïve	$1{,}05\times10^{7}$	0,0271	Naïve	$6{,}17\times10^{6}$	0,0993
Exponential Smoothing	$9{,}34\times10^{6}$	0,0248	Exponential Smoothing	$3{,}65\times10^{6}$	0,0579
Holt Linear	$1{,}35\times10^{7}$	0,0428	Holt Linear	$6{,}84\times10^{6}$	0,1135

NATURAL GAS			WIND		
Model	RMSE	MAPE (%)	Model	RMSE	MAPE (%)
Trend	$1{,}18\times10^{7}$	0,1267	Trend	$6{,}00\times10^{5}$	0,0372
Naïve	$2{,}14\times10^{7}$	0,2605	Naïve	$2{,}75\times10^{6}$	0,1587
Exponential Smoothing	$1{,}71\times10^{7}$	0,1834	Exponential Smoothing	$1{,}73\times10^{6}$	0,0926
Holt Linear	$1{,}97\times10^{7}$	0,2262	Holt Linear	$2{,}95\times10^{6}$	0,1627

DAM			SOLAR		
Model	RMSE	MAPE (%)	Model	RMSE	MAPE (%)
Trend	$7{,}47\times10^{6}$	0,1548	Trend	$8{,}06\times10^{4}$	5,4218
Naïve	$1{,}34\times10^{7}$	0,1870	Naïve	$1{,}10\times10^{5}$	0,7586
Exponential Smoothing	$1{,}29\times10^{7}$	0,1794	Exponential Smoothing	$5{,}00\times10^{4}$	0,4993
Holt Linear	$1{,}22\times10^{7}$	0,2079	Holt Linear	$1{,}27\times10^{5}$	0,8196

LIGNITE			GEOTHERMAL		
Model	RMSE	MAPE (%)	Model	RMSE	MAPE (%)
Trend	1437×10^{10}	0,0819	Trend	$3{,}79\times10^{6}$	0,0354
Naïve	3023×10^{10}	0,1291	Naïve	$5{,}50\times10^{6}$	0,2169
Exponential Smoothing	3659×10^{10}	0,1219	Exponential Smoothing	$6{,}05\times10^{6}$	0,1139
Holt Linear	3543×10^{10}	0,1455	Holt Linear	$5{,}95\times10^{6}$	0,2394

STREAM			BIOMASS		
Model	RMSE	MAPE (%)	Model	RMSE	MAPE (%)
Trend	$2{,}25\times10^{6}$	0,1249	Trend	$2{,}66\times10^{5}$	0,1219
Naïve	$4{,}04\times10^{6}$	0,1585	Naïve	$5{,}81\times10^{5}$	0,2111
Exponential Smoothing	$4{,}02\times10^{6}$	0,1506	Exponential Smoothing	$3{,}19\times10^{5}$	0,1046
Holt Linear	$3{,}93\times10^{6}$	0,1562	Holt Linear	$6{,}33\times10^{5}$	0,2379

While doing annual forecasting, different MAPE (%) values were obtained for different α values in the exponential smoothing method. For this reason, excel solver application was used to find the α value, which gives the low MAPE (%) value. Thus, the α values giving the minimum MAPE (%) value were calculated as 1,293 for total, 2,827 for imported coal, 2,112 for natural gas, 1,987 for wind, 0,658 for dam, 2,905 for solar, 0,078 for lignite, 2,181 for geothermal, 0,897 for stream and 2,328 for biomass. As can be seen from Table 2, the best estimation in eight of the ten sectors is realized by the trend method. In the remaining two sectors, the exponential smoothing method obtained the best predictive value. The RMSE and MAPE (%) values obtained for each sector by these methods are shown in Table 2. Graphs showing the forecasted electricity generation values and the actual generation values of the method providing the lowest MAPE (%) value for 2020, obtained from Table 2, are obtained as in Figure 3 and Figure 4.

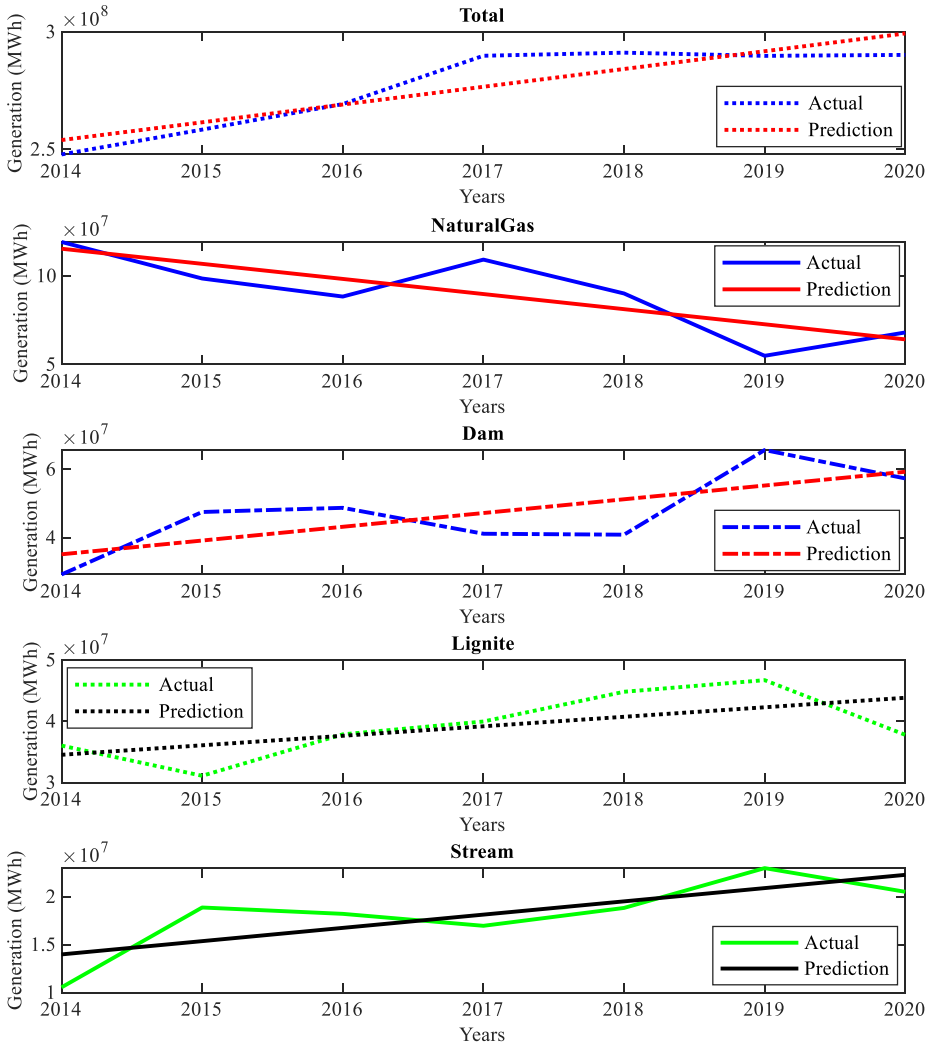

Figure 3. Comparison of the generation values obtained by the forecasting methods and the actual generation values (for five sectors-1)

Considering Table 2 and Figure 3, it was examined how the restrictions due to COVID-19 affect electricity generation in Turkey:

Total electricity generation was 289815303,06 MWh in 2019 and was 290227386,39 MWh in 2020 (EXIST, 2021). Total electricity generation increased by 0,14% compared to 2019 generation. The lowest MAPE (%) value for total generation is obtained from the trend method with 0,0207. The forecasted generation for 2020 obtained from this method was 299356083,11 MWh. That is, the actual generation is 9128696.72 MWh (3,05%) less than forecasted. In 2020, natural gas electricity generation increased by 24.03% compared to 2019. The forecasted natural gas electricity generation for 2020 is calculated as 64164690.68 MWh. According to this forecasted value, 6.09% more natural gas electricity is generated. Dam electricity generation decreased by 12.65% in 2020 compared to the previous year. In this study, it was forecasted that there would be 59274674.29 MWh of electricity generation in 2020. Actual generation was found to be 3,30% less than expected. Lignite electricity generation decreased by 19.11% compared to 2019. The forecasted electricity generation for 2020 was 43840981.29 MWh. 13,80% less lignite electricity was generated compared to the actual generation. Stream electricity generation in 2020 decreased by 10,74% compared to 2019. Forecasted stream electricity generation for 2020 was calculated as 22282190,82 MWh. 7,94% less stream electricity was generated than expected.

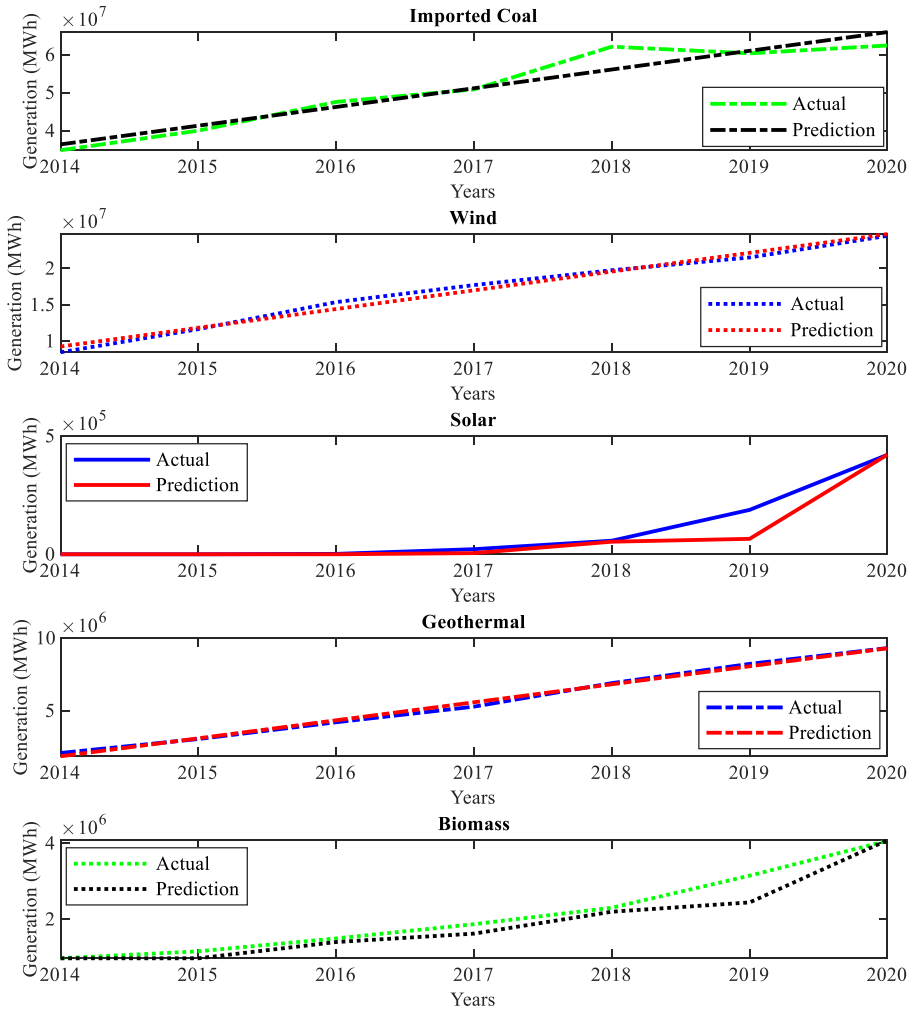

Figure 4. Comparison of the generation values obtained by the forecasting methods and the actual generation values (for five sectors-2)

According to Table 2 and Figure 4, it was examined how the restrictions caused by COVID-19 affect electricity generation in Turkey:

Imported coal electricity generation increased by 3,42% compared to 2019. The forecasted generation for 2020 was calculated as 65995702,57 MWh. Actual imported coal generation was 5,35% less than expected. Compared to 2019, 13,83% more wind electricity was generated in 2020. Wind electricity generation for 2020 was forecasted as 24723082,86 MWh. 0,96% less wind electricity was generated than expected. Solar electricity generation in 2020 has increased by 124,06% compared to 2019. The forecasted solar electricity generation for 2020 was calculated as 421527,47 MWh. Solar electricity generation was 0,17% less than expected. Geothermal electricity generation was increased by 13,2% compared to 2019. Geothermal electricity generation for 2020 was forecasted as 9302823,07 MWh. Geothermal electricity generation was 0,15% more than expected. Compared to 2019, 29,12% more

biomass electricity was generated in 2020. The forecasted biomass electricity generation for 2020 was calculated as 4083157,51 MWh. It can be concluded that 0.48% less biomass electricity generation was realized than the expected generation rate. According to these data, it was concluded that the COVID-19 epidemic experienced in 2020 adversely affected the total, dam, lignite, stream, imported coal, wind electricity generation in Turkey and did not adversely affect electricity generation from natural gas, wind, solar, geothermal and biomass electricity generation.

According to the data obtained from the General Directorate of Meteorology (MGM, 2021), the amount of rainfall in Turkey was measured as 580 mm in 2019 and 500 mm in 2020. This decrease in rainfall is thought to adversely affect the generation of electricity caused by dam and streams. In addition, the increases in the generation of electrical energy from the sun and wind are thought to be due to an increase in investment in renewable energy sources.

4.2. Monthly Total Electricity Generation Analysis

In the monthly analysis, the monthly total electricity generation data of 2019 (no COVID-19 epidemic) and 2020 (the restrictions began) were analyzed. As in the annual analysis, trend, naive, exponential smoothing and holt linear trend methods were used. The forecasting data of the method with the lowest MAPE (%) value obtained from these methods were used. Accordingly, the results obtained were depicted in Table 3.

Table 3. Forecasting methods and obtained values (for twelve months)

JANUARY			FEBRUARY		
Model	RMSE	MAPE (%)	Model	RMSE	MAPE (%)
Trend	$6{,}00\times10^{5}$	0,0214	Trend	$4{,}36\times10^{5}$	0,0152
Naïve	$1{,}11\times10^{6}$	0,0430	Naïve	$1{,}10\times10^{6}$	0,0424
Exponential Smoothing	$8{,}77\times10^{5}$	0,0289	Exponential Smoothing	$1{,}03\times10^{6}$	0,0374
Holt Linear	$1{,}33\times10^{6}$	0,0496	Holt Linear	$1{,}12\times10^{6}$	0,0462

MARCH			APRİL		
Model	RMSE	MAPE (%)	Model	RMSE	MAPE (%)
Trend	$5{,}92\times10^{5}$	0,0219	Trend	$1{,}31\times10^{6}$	0,0533
Naïve	$8{,}72\times10^{5}$	0,0309	Naïve	$1{,}57\times10^{6}$	0,0559
Exponential Smoothing	$7{,}75\times10^{5}$	0,0226	Exponential Smoothing	$1{,}43\times10^{6}$	0,0438
Holt Linear	$1{,}12\times10^{6}$	0,0449	Holt Linear	$1{,}89\times10^{6}$	0,0680

MAY			JUNE		
Model	RMSE	MAPE (%)	Model	RMSE	MAPE (%)
Trend	$1{,}43\times10^{6}$	0,0566	Trend	$6{,}32\times10^{5}$	0,0259
Naïve	$1{,}82\times10^{6}$	0,0635	Naïve	$9{,}59\times10^{5}$	0,0290
Exponential Smoothing	$1{,}82\times10^{6}$	0,0625	Exponential Smoothing	$9{,}64\times10^{5}$	0,0276
Holt Linear	$2{,}09\times10^{6}$	0,0715	Holt Linear	$1{,}06\times10^{6}$	0,0336

JULY			AUGUST		
Model	RMSE	MAPE (%)	Model	RMSE	MAPE (%)
Trend	$1{,}17\times10^{6}$	0,0379	Trend	$7{,}00\times10^{5}$	0,0203
Naïve	$1{,}67\times10^{6}$	0,0410	Naïve	$1{,}08\times10^{6}$	0,0370
Exponential Smoothing	$1{,}62\times10^{6}$	0,0364	Exponential Smoothing	$1{,}12\times10^{6}$	0,0374
Holt Linear	$2{,}01\times10^{6}$	0,0611	Holt Linear	$1{,}21\times10^{6}$	0,0387

SEPTEMBER			OCTOBER		
Model	RMSE	MAPE (%)	Model	RMSE	MAPE (%)
Trend	$7{,}14\times10^{5}$	0,0262	Trend	$6{,}48\times10^{5}$	0,0235
Naïve	$1{,}48\times10^{6}$	0,0433	Naïve	$1{,}20\times10^{6}$	0,0473
Exponential Smoothing	$1{,}50\times10^{6}$	0,0412	Exponential Smoothing	$1{,}19\times10^{6}$	0,0471
Holt Linear	$1{,}40\times10^{6}$	0,0441	Holt Linear	$1{,}29\times10^{6}$	0,0496

NOVEMBER			DECEMBER		
Model	RMSE	MAPE (%)	Model	RMSE	MAPE (%)
Trend	$6{,}56\times10^{5}$	0,0222	Trend	$6{,}16\times10^{5}$	0,0212
Naïve	$1{,}11\times10^{6}$	0,0422	Naïve	$1{,}03\times10^{6}$	0,0377
Exponential Smoothing	$1{,}14\times10^{6}$	0,0426	Exponential Smoothing	$9{,}70\times10^{5}$	0,0346
Holt Linear	$1{,}20\times10^{6}$	0,0428	Holt Linear	$1{,}20\times10^{6}$	0,0414

While doing monthly total electricity generating forecasting, different MAPE (%) values were obtained for different α values in the exponential smoothing method. For this reason, excel solver application was used to find α value, which provides the low MAPE (%) value. Thus, α values giving the minimum MAPE (%) value were calculated as 1,958 for January, 1,331 for February, 1,470 for March, 1,846 for April, 1,098 for May, 0,893 for June, 1,129 for July, 0,844 for August, 1,144 for September, 1,077 for October, 0,885 for November and 1,499 for December. As can be seen from Table 3, the best estimation was made by the trend method in ten of the twelve months. In April and July, it was realized with the exponential smoothing method. The RMSE and MAPE (%) values obtained for each sector by these methods are shown in Table 2. As can be seen, the obtained values are generally close to each other.

Graphs showing the forecasted electricity generation values and the actual generation values of the method that provides the lowest MAPE (%) value for 2020 (for twelve months), obtained from Table 3, are obtained as in Figure 5 and Figure 6.

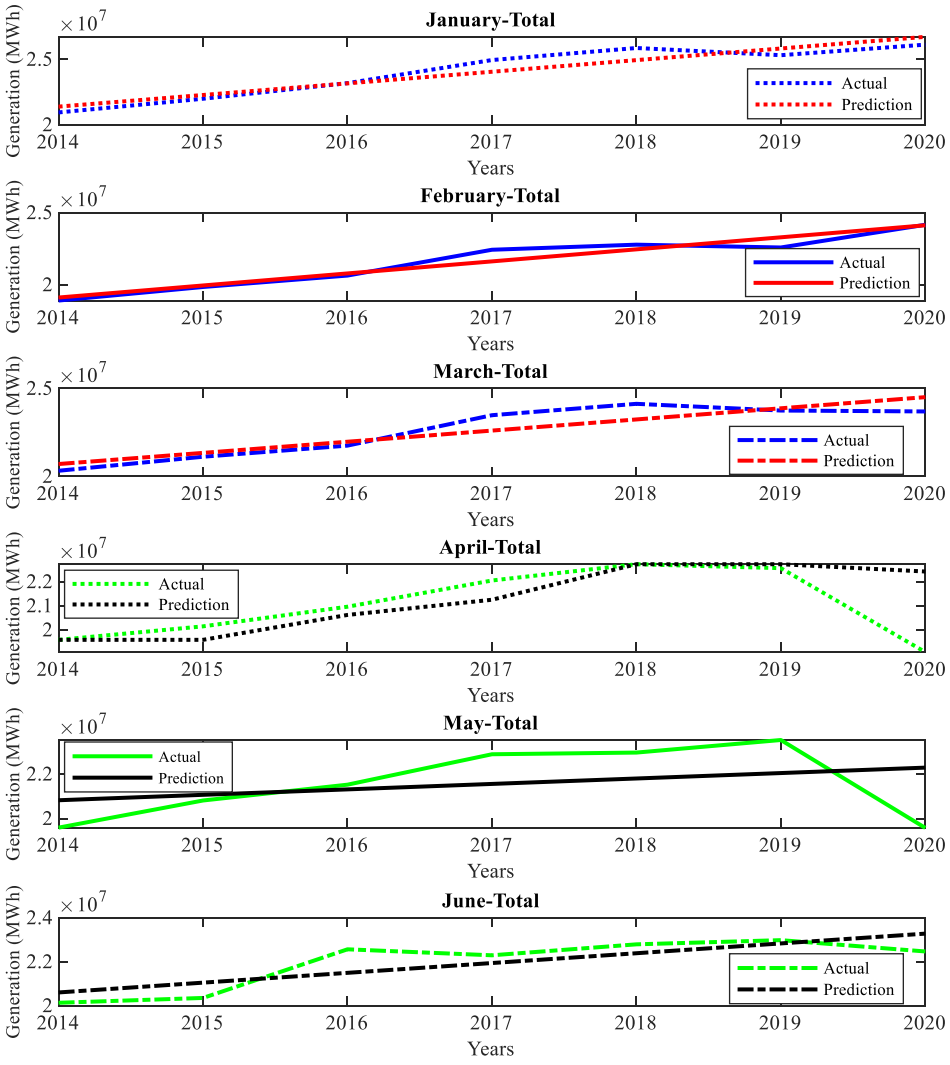

Figure 5. Comparison of the monthly generation values obtained by forecasting methods and the actual monthly generation values of 2020 (First six month)

Considering Table 3 and Figure 5, it was examined how the restrictions due to COVID-19 affect electricity generation in Turkey:

While the actual total electricity generation in January 2019 was 25316677,32 MWh, this value was 26124057,09 MWh in 2020 (EXIST, 2021). Compared to the actual generation in January 2019, it increased by 3,19%. In the analyzes done for the forecasted total electricity generation for January 2020, the lowest MAPE (%) value was obtained from the trend method with 0,0214. The forecasted total electricity generation obtained was 26719101,15 MWh. 595044,06 MWh (2,23%) less generation was realized than the expected total generation. Total electricity generation in February 2020 increased by 6,97% compared to the total electricity generation in February 2019. Total electricity generation for February 2020 was forecasted as 24125361,92 MWh. The total electricity generation is 0,14% higher

than expected. Total electricity generation for March 2020 decreased by 0,22% compared to 2019. Total electricity generation for March 2020 was forecasted as 24504174,07 MWh. Total electricity generation is 3,32% less than the expected total generation. Total electricity generation in April 2020 decreased by 15,43% compared to the total electricity generation in April 2019. The forecasted total electricity generation for April 2020 was calculated as 22422179,11 MWh. Total electricity generation was 14,91% less than expected. Total electricity generation in May 2020 decreased by 16,81% compared to the total electricity generation in May 2019. Total electricity generation for April 2020 was forecasted as 22290577,14 MWh. Total electricity generation was 12,17% less than the expected total generation. Total electricity generation in 2020 for June decreased by 2,24% compared to 2019. The forecasted total electricity generation for June 2020 was calculated as 23278997,37 MWh. Total electricity generation wasfound to be 3,49% less than expected.

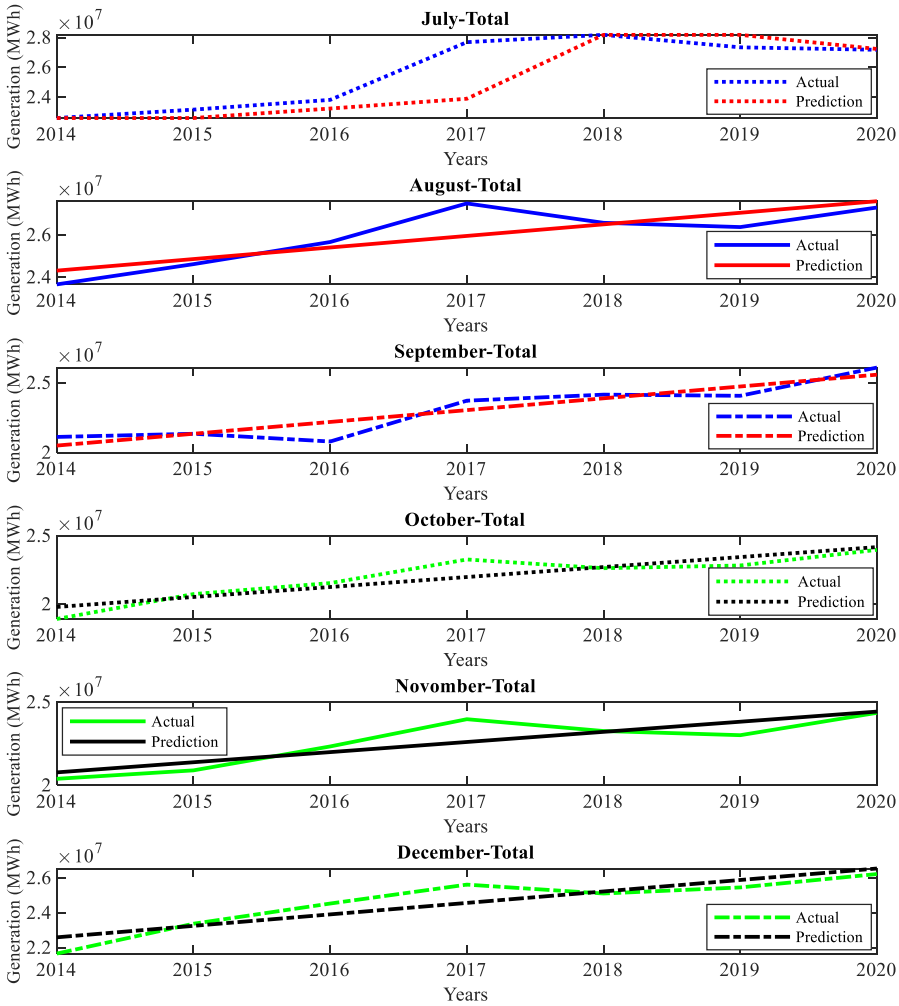

Figure 6. Comparison of the monthly generation values obtained by forecasting methods and the actual monthly generation values of 2020 (Second six month)

Considering Table 3 and Figure 6, it was examined how the restrictions due to COVID-19 affect electricity generation in Turkey:

Total electricity generation in July 2020 decreased by 0,60% compared to the total electricity generation in July 2019. Total electricity generation for July 2020was forecasted as 27237400,08 MWh. The total electricity generation was 0,20% less than the expected total generation. Total electricity generation in 2020 for August was increased by 3,50% compared to 2019. The forecasted total electricity generation for August 2020 was calculated as 27593481,13 MWh. Total electricity generation was 1,08% less than the expected total generation. Total electricity generation in September 2020 increased by 8,40% compared to the total electricity generation in September 2019. Total electricity generation for September 2020 was forecasted as 25584109,63 MWh. Total electricity generation was 1,99% less than expected. Total electricity generation in October 2020 increased by 5,00% compared to the total electricity generation in October 2019. Total electricity generation for October 2020 was forecasted as 24175562,06 MWh. Total electricity generation was 0,84% less than the expected total generation. For November, the total electricity generation in 2020 increased by 5,84% compared to 2019. The forecasted total electricity generation for November 2020 was calculated as 24433241,86 MWh. Total electricity generation was 0,31% less than expected. Total electricity generation in December 2020 increased by 3,02% compared to the total electricity generation in December 2019. Total electricity generation for December 2020 was forecasted as 26545324,18 MWh. The total electricity generation was 1,20% less than the expected total generation. According to these data, total electricity generation in 2020 didn't change in January and February (no restrictions), but decreased in the remaining ten months compared to what was expected. While the decrease rates in April and May were especially high, the decrease rates in the remaining months were below 4%.

When the studies in literature were examined, it was seen that the studies had been carried out to analyze the changes in electricity generation and consumption during COVID-19 epidemic. In this study, unlike other studies, both the total and nine different sectors were taken into account in the electricity generation forecasting. In addition, the monthly changes of total electricity generation was also examined. Trend, naive, exponential smoothing and holt linear trend methods were used as forecasting methods. In the study conducted by Sahin et al. (2021), it was forecasted that the electricity production from non-renewable sources in Turkey decreased by 11% in 2020 compared to 2019. In this study, lignite and imported coal, which are non-renewable energy sources, were analyzed. It was forecasted that the electricity generation expected from lignite in 2020 decreased by 13,80% compared to the actual lignite electricity generation of the same year. In addition, electricity generation from imported coal was forecasted to had decreased by 5,35%. When both were taken into account, it was forecasted that there was an average decrease of 9,58%. A value close to the study done by Sahin et al. was obtained. In the study by Ghenai et al. (2021), it was forecasted that electricity generation from coal and natural gas in European countries decreased by 35% and 25%

compared to the previous period during the COVID-19 quarantine period. According to the forecasting analyzes done in this study, it was forecasted that the real value of electricity generation from imported coal in 2020 decreased by 5,35% compared to the forecasted value expected to be generated in 2020, while electricity generation from natural gas increased by 6,09%. It is believed that this study will contribute to literature not only with the technical analysis, but also with the evaluations it contains.

5. Conclusions

In this study, changes in electrical energy generation in Turkey during COVID-19 period were analyzed annually and monthly. Trend, naive, exponential smoothing and holt linear trend methods were used for the analysis. The forecasted electricity generation values for 2020 were obtained from the method that gave the lowest MAPE (%) value. As a result of comparing these forecasted electricity generation values with the actual electricity generation values for 2020, it had been concluded that the actual total electricity was generated 3,05% less, electricity from natural gas was 6,09% more, electricity from dam was 3,30% less, electricity from lignite was 13,80% less, electricity from stream was 7,94% less, electricity from imported coal was 5,35% less, electricity from wind was 0,96% less, electricity from solar was 0,17% less, electricity from geothermal was 0,15% more and electricity from biomass was 0,48% less. Monthly changing analyzes of total electricity generation were done. According to these analyses, the actual generation of 2020 was 2,23% less in January, 0,14% more in February, 3,32% less in March, 14,91% less in April, 12,17% less in May, 3,49% in June, 0,20% less in July, 1,08% less in August, 1.99% less in September, 0,84% less in October, 0,31% less in November and 1,20% less in December than the forecasted electricity generation. This study determined the changings in electricity generation caused by the outbreak, and it is thought that it will guide government officials in terms of what kind of precautions can be taken in case of similar restrictions that may occur in the future.

Conflict of Interest

Authors have declared no conflict of interest.

Author's Contributions

The author declares that he has contributed 100% to the article.

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