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The impact of COVID-19 pandemic on the electricity production in Northern Cyprus under increasing installed photovoltaic capacity

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ABSTRACT

The Covid-19 pandemic has been affective throughout every sector globally. Northern Cyprus economy depends on mostly tourism and the education sectors which announced closure after the hit of Covid-19. On the other hand, the island is highly dependent on unsustainable fossil fuels, but there is gradual increase in the installation of Photovoltaic systems in last years which support sustainable power capacity. The aim of the paper is to study changes in electricity production and load profiles before and during the pandemic under the influence of increasing Photovoltaic systems in small islands with isolated grids. Real-time data was used to conduct year-on-year analysis in order to show the impact of COVID-19 in Northern Cyprus. Results showed that the closure of hotels and education affected the electricity production by a decrease of 21.44% in April 2020. Reduction in the power sector remained above 20% until the end of June 2020 and 10% for the remaining months. Compared to 2019 the total annual production dropped to 1.5 TWh which was equivalent to a drop of 9.6%. Weekly YOY analysis suggested that on the day with the lowest production, during the day, the hourly productions drop as much as 51.28% under complete lockdown conditions. During noon time, where the production via photovoltaic systems are at peak, prior the last two years before Covid-19, conventional power productions were around 132 MW. Between 2019 and April 2021, an addition of 60 MW PV capacity and the loss of half of the power productions resulting from Covid showed that the grid would go under complete blackout. These findings show, due to the high reliability on tourism and higher education sector the recovery periods of electricity in islands tend to be longer than developed countries. Another finding is the decrease in electricity consumption in the service sector, an important consumer and locomotive on the island, where the average decrease is 8.5% above the world average.

1. Introduction

The global epidemic of Corona Virus (COVID-19), which has effected the whole World, has had an immense effect on lifestyles and economy but electricity consumption and production. Governments have faced many issues concerning the high spread and death rate of the virus [1]. Restrictions such as quarantine, social distancing and lockdown measures have been carried out in order to take precautions against the deadly virus. Emerging as a health catastrophe, the pandemic has resulted in abject consequences for many sectors such as; industries, companies, tourism, education, energy and economy. It has made a huge change in people’s daily lives and activities of commercial companies which has altered the patterns of energy demand.

The first country in the world that was hit by the virus was Wuhan, China. On the 31st December 2019 the Wuhan Municipal Health Commission identified and announced the novel coronavirus in the region [2]. While spreading throughout the world, Cyprus was clean from the illness until a specific time. On the 9th of March 2020, the ROC (Republic of Cyprus) announced the first cases of Covid-19 [3]. Followed by this, Northern Cyprus declared their first covid case one day later [4]. With the statement of the first corona virus case, the TRNC announced restrictions for the community. As shown in Fig. 1, starting from the 14th March until the 4th May, a full lock down on the island was proclaimed. As the cases decreased, measures were lifted again until the 9th September. However, the government announced that all entrances to the island were suspended through air and marine on this date due to increasing cases. On New Year’s eve 2020, the government released other measurements during partial lockdown, stating that unless of urgent situations there was street curfew from 22:00 pm until 05:00 am. Due to celebrations and other events, starting from 28th January a full

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lockdown was announced again. More details about the partial curfews and dates can be observed in Fig. 1.

Owing to the responsive measures taken place globally, the collapsing economy also hit the energy sector. According to IRENA Post covid, 2020, for countries during partial and complete lockdown, weekly energy demand decreased 18% and 25%, respectively [5]. In addition to this, the World average electricity consumption decreased by 1.1% [6].

In connection with this, IEA (International Energy Agency) energy forecast stated that, the global energy demand will return to its pre-pandemic level in 2025. Negative effects persist longer in countries or islands with lower income. Declaring that governments have less capable of softening the impact from the COVID-19 pandemic [5].

Even though the pandemic has had huge hits for energy demand, it has had a positive influence on the CO$_2$ (Carbon dioxide) emission. Daily CO$_2$ have decreased 17% in April 2020 compared to 2019 [7]. Considering both energy demand and emissions, the importance of Green Deal, energy efficiency and Electrification can be understood better. This period is a good sample for leaders to bring forward initiatives in energy system integration, clean energy projects, energy efficiency measures and energy infrastructure in order to mitigate emissions. At this point it is very clear that electrification is the crucial point in unraveling green transition. Electrification of sectors is mainly based on important amount of renewable energy and carbon-neutral energy growth [8,9].

In Q2 (quartile two) of 2020, where covid-19 was at its peak, the electricity consumption in Europe decreased 11% compared to 2019 Q2 [10]. According to [11], in more than 50 years the greatest deterioration of electricity demand was seen in 2020. Peak reduction of electricity consumption during lockdown in Germany, Italy, India, France, UK (United Kingdom), China and Spain rose more than 10%. Weekly comparisons between limited restrictions, partial lockdown and full lockdown showed that the energy demand was to be roughly cut by 9%, 17% and 24%, respectively. In general, in 2020, there was 626 Mtoe of energy demand drop in the total of eight regions (USA (United States of America, EU (Europe), China, India, Japan, Africa, SEA (South East Asia) and South Korea) [12].

Facts show that dependant to population, world consumption changes directly. Fig. 2, shows the world electricity consumption comparison between years. Starting from 1971 until 2018, the consumption increases enormously. World population in 1971 was 3.775 billion and total consumption equalled to 377.1 Mtoe. In relation to this the most consuming sector was evaluated as the industry and residential usage. In 2000, world population increased by 62.72% and electricity consumption increased to 1091.8 Mtoe. The industrial and residential sector still protected its rank as the highest consumers of electricity. Population in 2010 didn’t increase immensely compared 1971–2000, but still increased by 13%, increasing total consumption by 40.8%, which also shows that in addition to population, there are other factors influencing consumption increase, such as urbanization, technological developments, industrialization etc. Finally in the year 2018, where population increased by 9.69% and world total consumption reached to 1918.8 Mtoe.

In general, while, industrial, residential and commercial and public services sectors were the most consuming, it is known that the least consuming sector in terms of electricity was the transport sector [13].

Many studies have been carried out in order to understand the effect of the viral Corona virus in the world. By doing this, problems faced come to earth in order to prevent similar issues from taking place in case of another health pandemic. [14] carried out a study in order to define the effect of restrictions and the lockdown activities on the power system in Italy. Results of the analysis showed nearly ~37% of electricity consumption compared with previous years in the same period. However, the decrease in consumption didn’t affect the renewable energy
generation but affected the energy produced from conventional sources. When considering previous seasonal renewable energy penetration, there was 17% increase in the energy supplied daily. Differing from this, [15] used hourly electricity consumption data to implement a difference-in-predicted-differences strategy in the USA. In terms of consumption, in the third months of the pandemic the electricity decreased by 3.7%, 5.4% and 4.0%. On the other hand, the author stated that, in July and August 2020 the usage of electricity increased by 2.9% and 4.6%, respectively. Predictions were made for the percentage increase and decrease of electricity consumption. Here the data stated that the predictions for November were rather normal compared to December, where the result was 2.6% higher than the prediction. In general, USA monthly data in the commercial and industrial sector was below the expected values. In contrast with this, residential values were higher than predicted. Similarly, in Brazil, the industrial sector consumption reduction was 14% in the North subsystem, as the Brazilian geographic regions have different electricity profiles. The residential sector was affected less with 7% reduction due to most of the consumption belonging to the residential sector [16]. Finally, [17] conducted a study about Spain, where it was stated that in the period of the first confinement the consumption reduction in one and a half month was 13.49%. With 14.53%, weekdays experienced more reduction compared with weekends with 10.62% reduction. In general, it can be seen that there was generally a decline in electricity consumption during the Covid-19 period which also affects the production of the systems and environment.

With increasing population and other mentioned factors, the energy demand and production of Northern Cyprus is leading to a constantly increasing trend. Especially, Northern Cyprus being a developing country, its electricity consumption is expected to increase following the years to come. However, Northern Cyprus is an island dependent on fossil fuels exported externally. Also it is well known that the main energy consumed in the Northern Cyprus is electricity. Nearly 55% of the all energy sources exported to the island is converted to electricity, which is 10% more compared to 20101. To sustain and meet the growing demand for electricity, reliable and cheap resources such as solar energy is required.

The historic evolution and averaged annual increase in power generation in Northern Cyprus is recorded as 3.53% over 16 years period. The maximum annual increase in power generation is recorded as 0.2 TWh in 2017, 14.1% higher compared to the previous year while the maximum annual reduction in power generation is recorded as 0.16 TWh in 2020. Due to Covid-19, 2020 data was 9.6% lower compared to 2019 levels, the highest recorded reduction in 16 years period. The effect of covid resulted in electricity generation lower than 2017 levels 2.

This study aims to define and compare the changes of electricity production and load profiles before and during the pandemic. To the authors’ knowledge, no study has been carried out including both the effect of COVID-19 and the effect of PV (Photovoltaic) on power generation systems in island conditions. Real-time five year hourly data was used in order to show the impact of COVID-19 on the north part of the island and the change in electricity generation during this period. The following study will also include the effect of Photovoltaic generation on the electricity load profile, mentioned in Table 1.

2. Methodology

There are various factors that affect electricity consumption such as price of energy, GDP, population, weather conditions, integration of renewables, pandemics etc. For determining the impact of covid-19 pandemic on the electric consumption for the case of a small island, North Cyprus, the following methodology is used. For generating YOY (year-on-year) analysis; weather corrected electricity generation from additional installed PV capacities should be adjusted for presenting the true impact of Covid-19.

2.1. Status of Northern Cyprus

The renewable energy policy of the Northern Cyprus is only based on net metering. 75% of the total PV capacity (60 MW) is installed in the low voltage network, while 25% of the installed capacity is integrated to the medium voltage network. Cyprus Turkish Electricity Authority and the Ministry of Energy generated the design and installation principles for the integration of the renewables to the grid as follows;

The DC electricity generated from the PV’s run through the inverters. The inverter then converts the direct current to alternative current. This current runs towards the distribution board and supply the household needs. If excess occurs, the smart meter records exported electricity otherwise records consumed energy. The monthly bill is generated based on the difference between consumed and exported electricity. Due to the installation and metering procedure of PV’s stated above, households with PV installations have insufficient electricity consumption and generation data. Therefore, in order to account the PV effect, the conventional power production and PV production data will be combined together. The conventional power production data were obtained from the output of the medium voltage transformers via SCADA.

In Northern Cyprus, the first solar PV module was installed in 2014. Since then, the cumulative installed capacity gradually increased. By the end of 2018, the cumulative installed capacity had reached to 20 MW. Table 1 above2, represents the cumulative installed capacity from 2019 until now. Since 2019, the annual installation rate (Jan 19–Jan 20) can be approximated as 30 MWp and it has remained constant until the end of April 2021.

2.2. Estimation of PV production

Electricity production contribution from PV’s is not fully known due to the installation and metering procedure as mentioned above. PV simulation is an option to determine the photovoltaic production of additional capacity. However, due to various reasons such as inclination, orientation, soiling, shading, malfunctions etc. it is only an estimation and the real production data tends to vary from the predicted data. Therefore, the actual electricity generations from the additional PV capacities are projected based on the production of real data as follows;

- The net hourly electricity imported to the medium voltage network from a 5.2 MW PV system was obtained from SCADA.
- Imported electricity was then scaled to represent the total approximated value of an average 30 MW PV system annually, based on the deployment rate of PV as shown in Table 1.
- The total seasonal percentage output of a 5.2 MW PV system is given in Fig. 2, below. This Correlates with the previous findings of [18].

2.3. Degree day analysis

Energy consumption and weather conditions are highly correlated with each other. Electricity consumption is highest during the summer with 5.3 GWh/day, followed by winter with an average consumption of 4.65 GWh/day. On the other hand, in spring, when the average ambient temperature is between 18 °C and 22 °C the average electricity consumption reduces to 3.35 GWh/day. This demonstrates the relation

| Months       | 2019 | 2020 | 2021 |
|--------------|------|------|------|
| January      | 20,68| 49,19| 76,83|
| April        | 23,02| 53,53| 83,30|
| September    | 34,51| 68,64| –    |
| December     | 44,01| 73,04| –    |
between ambient air temperature and energy consumption due to heating and cooling necessity. One method to include variability in electric consumption due to the weather conditions is the degree day analysis. The degree day analysis was performed as follows;

1- Meteorological data was collected from a governmental station located in the industrial area of Nicosia. This data was obtained by the meteorological institute of Northern Cyprus.
2- Temperatures 18 °C and 22 °C was selected for calculating heating and cooling degree days, respectively [19].
3- Heating degree day and the cooling degree day are correlated with the electricity production for 2019.
4- Slopes from this correlation for 2019, were used to project the electric production with the degree days to generate electricity production in 2020.
5- The difference between projected and actual values for 2020 gives us the reduction in electric production due to Covid-19.
6- The consumptions are averaged for periods 2019 and 2020 then their differences are taken as a fixed value. These values are for non-heating and non-cooling periods divided into two periods, Spring and Autumn, respectively.

Following the necessary assumptions, year on year data analysis was carried out in terms of production. The effects of both COVID-19 and PV were analysed in all analyses carried out. Seasonal comparisons were also analysed by using five years real-time data. Power production comparisons between pre-lockdown, lockdown and post-lockdown were studied, including the effect of PV on production. In summary, the study was carried out broadly and then narrowed down. This means after carrying out seasonal comparisons, monthly, Weekday/ Weekend and finally the lowest daily productions were compared and discussed.

2.4. Avoided fuel consumption and social cost of carbon

In North Cyprus, diesel generators and steam turbines are used to generate electricity. In order to generate 1 kWh of electricity, the energy consumption of these systems is given as 210 gr and 285 gr, respectively [20]. According to [21], the generation percentages of diesel generators and steam turbines are given as 71.43% and 28.57%, respectively. The combined fuel oil usage of generators is evaluated in terms of grams to find the total reduction of fuel oil consumption for the year 2020.

The annual reduction in CO\textsubscript{2} emissions of HFO (heavy fuel oil) is determined by the following equation;

\begin{equation}
\text{Annual Reduction} = \text{Avoided Fuel oil x Specific CO}_2\text{ emissions of HFO}
\end{equation}

The specific CO\textsubscript{2} emissions of HFO is 3.114 \text{Kg CO}_2/\text{Kg} \text{HFO} [22]. To understand the amount of social cost of carbon avoided, the cost amount for 1 tonne of CO\textsubscript{2} emission is taken as $54 [23]. In order to calculate the fuel cost savings in 2020 compared to 2019, the amount paid was obtained 3.

3. Results and discussion

3.1. Annual comparison between 2019 and 2020

Fig. 3, below compares the productions in 2019 and 2020. In the first two months of 2020 electricity generation increased by 1% and 10% in January and February, respectively. On 14th March 2020, the country went through a full lockdown due to covid-19 as the first cases were recorded. The island remained under complete lockdown until 4th May 2020. Here, compared to 2019, the highest reduction in electricity generation was observed as 27% in April. In addition to this, reduction in power generation remained above 20% until the end of June and the power production remained within 10% through the rest of the year. The total annual production was 1.66 TWh and 1.5 TWh in 2019 and 2020, respectively which is equivalent to an annual drop of 9.6%.

3.2. Annual generation seasonal comparisons

The annual electricity generation data was further investigated seasonally, in terms of hourly average basis. Fig. 4, demonstrates the evolution of electricity generation through 5 years and suggests electricity generation was in an increasing trend until spring 2020 between 17:00 and 08:00. On the other hand, due to the increase in cumulative installed PV capacity between 08:00 and 17:00 there is a declining trend due to the increase in cumulative installed PV capacity. In Spring 2020, a distinct sharp decrease was observed due to Covid-19 and decreased electric production continued throughout the year. When the figures are evaluated seasonal base;

1 In Winter season, (Fig. 4a), it is seen that there is an decrease in the production during the day time due to increasing PV effect but also an increase at nights probably due to the increase in the installed electricity consuming equipments at PV installed spaces. Owing to the lifted lock-down measures, during this period, there is a slight influence of Covid-19.
2 In Spring season, (Fig. 4b), the effect of Covid-19 is clearly seen during both day and night time in 2020. Also, we could see the influence of PV installations when 2018 and 2019 lines are compared.
3 In Autumn season, (Fig. 4c), the effect of Covid-19 during both day and night time in 2020 could be seen but this influence is not as much

![Fig. 3. Electricity generation comparison in North Cyprus.](image-url)
as spring season due to the change from full lock-down to partial. We could observe the continuous effect of PV installations on the day time production after 2018 also.

4 In Summer season, (Fig. 4d), owing to the suspended entrance to the island, the tourism sector, which is the leading sector in the island and also the leading energy consumer, is nearly stopped and huge drop in production is witnessed.

Fig. 4, demonstrates seasonal averaged hourly production reductions between 2019 and 2020. The graphic suggests that, in winter, hourly power generation occasionally falls below 0 MWh during night times, implying an increase in power generation in 2020 due to the first two months being without any closure or restrictions due to Covid-19. From 7:00 am until 16:00 pm, there is significant reduction reaching as high as 10 MWh in power generation compared to the rest of the day. This difference in hourly power generation peaked in Spring. The average production in spring 2020 dropped 20.3% compared to 2019 levels. Daily average production profile suggested drops in power production reaching as high as 55 MWh equivalent to 32% drop followed by 13.3% power reduction in the Summer. As explained above, this reduction is

Fig. 4. Illustrating reductions in electricity generation in (a) Winter, (b) Spring, (c) Autumn and (d) Summer, 2020.

Fig. 5. Seasonal hourly reductions of electricity in 2020 compared to 2019 levels (a) and demonstrates reductions in electricity generation in 2020 compared to 2019 due to covid-19 only.
boosted up by the influence of both strict Covid-19 measures and PV production. Fig. 5a presented above, includes reductions in power generation due to both Covid-19 and the PV effect. Removing electricity production from 30 MW installed PV capacity results in power reduction solely caused by the Covid-19 as given in Fig. 5b. 

During the night times, the difference in electricity production was as low as 15 MWh, on the other hand, during the day time this reduction increased and reached as high as 36.5 MWh in Spring, when the full lockdown was realised. Seasonally, the second highest reduction was in Summer, the difference between maximum and minimum hourly productions during day and night was almost half of the spring season. This could be explained as nearly all the sectors are closed including Tourism sector and Universities, which are the two biggest sectors in the island [24]. In Autumn, the differences in hourly production recorded as low as 1.95 MWh. On the other hand, hourly averaged seasonal electricity generation occasionally turned negative in Winter. In other words, the electricity production increased in hourly basis and the difference between the maximum and minimum hourly production was within 5 MWh.

3.3. Monthly generation comparisons

Fig. 6, given below represents electric production profiles on hourly basis monthly average under full lockdown during April 2020 and February 2021. In April 2020 the reduction in electricity production is recorded as 27.10% of which 4% lower due to additional new PV capacity in April 2021, as shown in Fig. 6a. The figure also suggested that maximum reduction in power production was as high as 42.85%. On the other hand during the second lockdown in February 2021, reduction in electricity production was recorded as 23.70%, as can be seen in Fig. 6b. Additional PV capacity equated to 2.94% and 20.76% of the reduction was due to Covid-19. Maximum reduction in electricity production was recorded as 41.23%.

Monthly averaged hourly production profile comparison for weekdays and weekends for April and May are illustrated below in Fig. 7a, for April 2020 and April 2019. Morning and evening productions differ slightly in April 2020 under full lockdown due to people being at home during whole month and their behavior pattern shows no distinct difference between weekends and weekdays On the other hand, in April 2019 during weekdays, there was distinct difference; morning peaks were one hour earlier compared to the weekend morning peaks. Night peaks, were slightly higher than the weekday peaks and the rate of decrease in electricity consumption was much higher during the weekdays compared to the weekends in correlation with people tending to sleep earlier during weekdays compared to weekends.

As soon as measures lifted in May, it can be clearly seen in the figure (Fig. 7b), that electricity consumption rises significantly in weekdays compared to weekends. The difference in electricity generation at 1 pm between weekdays and weekends are almost identical with 27.02 MW in 2020 and 27.12 MW in 2019.

3.4. Weekly electricity generation comparison

Weekly reductions in electricity production are presented below for one year period of 2020, Fig. 8. The graph suggests after the first lockdown energy production dropped as low as 30%, followed by recovery after the measures are relaxed. Occasionally electric production came close to previous years levels. It could be seen that when this figure is compared to Fig. 1, the lockdown policies are directly proportional to the variation of production. As the tourism sector remained closed, restaurants were only allowed to provide take away and universities were shifted to online teaching consequently.

3.5. Daily electricity generation comparisons

Fig. 9 shows the daily profile with the lowest production for the past four years. The lowest production in the year 2018 and 2019 was recorded. At 06:00 a.m on 22.04.2018 and 04:00 a.m on 24.04.2019 the production readings showed 98.7 MWh and 116.6 MWh, respectively. With the effect of Covid-19, there was significant changes with the daily production profile in 2020. On 26.04.2020, the lowest power generation was recorded as 46.1 MWh at 2 p.m equivalent to 66.78% reduction compared to lowest production occured in 24.04.2019. A similar power profile was observed in 2021 under partial lockdown. The lowest production was recorded at 11 a.m as 74.96 MWh. This shows a 42.2% decrease in electricity production compared to 2020 levels.

When analysing the data in spring without the effect of PV the lowest electricity production in 2020 during full lockdown was at 14:00, 67.62 MWh, as can be seen in Fig. 10. A 43% decrease is observed compared to pre-pandemic 2019 values. Also, a 16.6% increase in 2021 under partial lockdown compared to full lock down in 2020. The lowest production in 2021 was registered at 7 am with 93.89 MWh electricity production, on this particular day the production increased throughout the day and peaked at 8 p.m. While in 2020, under full lockdown, electricity production constantly reduced after midnight and bottomed at 2 p.m. The lowest production was recorded as 67.61 MWh followed by a constant increase and peaked at 8 p.m.

3.6. Avoided heavy fuel oil and social cost of carbon

The combined fuel consumption of diesel generators and the steam turbines for generating unit kWh of electricity is evaluated to be 231.43 gr. Therefore due to Covid-19, in 2020, HFO usage in electric generation was seen to decrease by 37,029 tonnes compared to 2019, which is equivalent to 12.4%. In relation with the amount of fuel saved, the fuel cost savings is $15 million. Moreover, due to the corresponding CO₂, the amount avoided was calculated as 132,545 tonne. This results in a social
cost saving of $ 6.24 million. As a result the total savings during this period (2019–2020) is $ 21.24 million.

4. Conclusion

The Covid-19 pandemic has affected every aspect of humanity. Ultimately the energy usage has also been affected. The economy of North Cyprus heavily relies on tourism, education and the service sector. As soon as the first Covid-19 cases were recorded, the government announced complete closure in mid-march. Most of the hotels announced complete closure for a year, the one remained open turned into a quarantine hotel and most of the students evacuated the island within 20 days. As discussed above, the net reduced electricity generation was 21.44% in April 2020 under complete lockdown, when comparing to Italy and Spain, the reduction in electricity generation (during complete lockdown period) was recorded as 12.5% in Italy in a week and 17% reduction was recorded in Spain in a month.

In IEA reports for year on year, weekly electricity demand for six countries, namely France, Germany, Italy, Spain, Great Britain and India suggested that the highest drop was observed in Italy with 27% [25], while in North Cyprus the reduction is recorded as low as 30.71%. This is expected because the island is dependent on two sectors mainly,
Tourism and Universities, which are both affected from the pandemic measures enormously. When the measures were partially lifted in the beginning of May 2020, the electricity generations reduction was slightly better, which amounted to 15% compared to previous year levels.

The measures were completely lifted in June and the electricity generation was continuously increased and slightly suppressed the previous levels by the end of August. By the end of August, electric generation under went another declination trend and bottomed by 17% at the beginning of October. This was followed by a V shape recovery barely reaching the 2019 levels by mid December. This followed by 5% reductions due the hotels being shut down during the last two weeks of the year aiming to minimize the spread of virus. The same recovery patterns were observed in IEA reports. All of the previously mentioned countries suppressed electricity demand in 2019 during August except Great Britain and Germany. On the other hand, during the following months, drops in demand were within 10%, unlike North Cyprus, reaching as low as 17% by the end of September. In terms of seasonal hourly averaged reductions, electricity generations were 26.65 MWh, 22.61 MWh 5.28 MWh in Spring, Summer and Autumn, respectively, suggesting a recovery pattern.

With the pandemic and under full lockdown the results show a possibility of a drop in electricity production of 23.1%, 30.8% 59.7% on motbly, weekly and daily basis, respectively.

For North Cyprus, in April 2020, the electricity production reduced by 23.1% compared to the previous year. On the other hand, for the second lock down in February 2021, reductions were recorded as 20.76% compared to February 2020 productions. Therefore it can be concluded that electricity consumption is sensitive to lockdown periods. The weekly YOY (year-on-year) analysis graph suggested that people tend to avoid electricity usage as much as they can during autumn and spring, where the temperature values are closer to 18 °C and 22 °C. The highest reductions are seen during this periods. YOY analysis also suggested that on the day with the lowest power production, hourly productions during day time may drop as much as 51.28% under complete lockdown. During the solar noon, where PV generations are at peak, conventional power productions were around 132 MW in the last two years prior to Covid-19. From 2019 to April 2021, with an addition of 60 MW PV capacity, and losing half of the productions resulted by covid, suggests that the grid would go under complete blackout. As expected under full lockdown, weekdays and weekends electricity consumption showed no difference. In conclusion, recovery periods of electric consumption of islands tend to be longer than developed countries. This is due to lack of diversity in sectors in other words highly relying on the tourism sector and higher education. In the past, with the highest annual installing rate of 30 MWp solar PV, it was observed that electricity generation was increasing parallel with the solar PV installations. With the pandemic the unthought happened and the energy consumption decreased as much as 51.28% in a single day. This projected that policy makers should be more cautious and should take into account the experienced declines, considering the 51.28% drop for the isolated grid and grant the photovoltaic installation permits accordingly. A second point to consider is, due to the reduction in electric consumption, in low voltage networks, where the presence of PV installations are denser, the grid voltages increased to 260 V. This caused the electricity generation of the PV inverters to stop. Therefore, this is a good signal for the electricity authority to take some precautions and strengthen the infrastructure otherwise as PV installed capacity percentage increases, this problem will be faced during the days out of pandemic period also.

When considering positive aspects, during the pandemic there was a reduction of 12.4% of HFO in a calendar year drop compared to consumption in 2019. The reduction in HFO usage caused reduction in CO2 emissions equivalent to 132,545 tonne, reducing the social cost of carbon by $6.24 million. The combined savings of unused fuel and avoided social cost of carbon is calculated to be $ 21.24 million in 2020. Therefore, it can be concluded that less use of HFO not only helps to minimize the undesired impact of these fossil fuels on environment but also helps to decrease expenses. In conjuction to the reduction in consumption of heavy fuel oil, the renewable energy increased it’s share by 1.1% in the total electricity generation. Finally, from an economic point of view, people across the island were under full lockdown, thus having lower incomes, and were forced to save electricity, recieving the incoming electricity bills at a reduced price. Although this is not something that people like to do but it could be a good sample both for the policy makers and also public to understand the possibility of energy saving and see the results directly, which is one of the most important missing processes in the island energy picture.

CRediT authorship contribution statement

M. Hastunç: Conceptualization, Methodology, Formal analysis, Investigation, Resources, Writing – original draft, Writing – review & editing. T. Karahüseyin: Conceptualization, Methodology, Formal analysis, Investigation, Resources, Writing – original draft, Writing – review & editing, Visualization. S. Abbasoglu: Conceptualization, Resources, Supervision, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial
interests or personal relationships that could have appeared to influence the work reported in this paper.

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