The impact of novel coronavirus (SARS-COV-2), on the electricity sector

O impacto do novo coronavírus (SARS-COV-2), no sector da electricidade

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ABSTRACT
The world is undergoing traumatic changes in 2020 caused by the novel coronavirus (SARS-COV-2. There have been profound changes in several sectors of the economy, including the electricity sector. This article aims to present an overview of the impact of the novel corona virus on the consumption of electricity in different regions of the world. Main socioeconomic factors that caused the impact on electricity consumption are analysed. In addition to consumption, the article also discusses the change in the energy matrix of some regions to generate electricity from fossil and renewable sources. Special emphasis is given to the study of electricity consumption in Brazil.

Keywords: Novel coronavirus, Electricity sector, Future trends for electricity demand, Renewable energy, Brazilian electricity sector.

RESUMO
O mundo está passando por mudanças traumáticas em 2020 causadas pelo novo coronavírus (SARS-COV-2). Houve profundas mudanças em vários setores da economia, incluindo o setor elétrico. Este artigo tem como objetivo apresentar uma visão geral do impacto do novo corona vírus sobre o consumo de eletricidade em diferentes regiões do mundo. Analisam-se os principais fatores sócio econômicos que causaram impacto no consumo de eletricidade. Além do consumo, o artigo discute também a mudança na matriz energética de algumas regiões para gerar eletricidade a partir de fontes fósseis e renováveis, com destaque para o estudo do consumo de energia elétrica no Brasil.

Palavras-chave: Novel coronavirus, Sector eléctrico, Tendências futuras para a procura de electricidade, Energias renováveis, sector eléctrico brasileiro.

1 INTRODUCTION

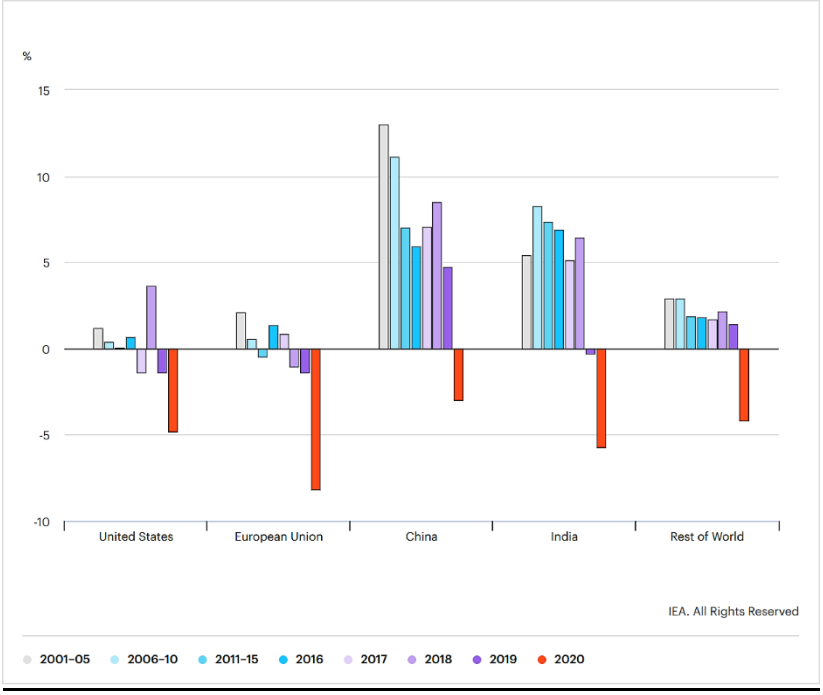
According to the International Energy Agency, global electricity demand is expected to fall by 5% in 2020, eight times the reduction in 2009 due to the global financial crisis. A faster recovery would reduce electricity demand by 2%, as all areas of economic activity resume. But wider spread of COVID-19 in Africa, Latin America and other areas of the developing world, and a second wave in winter in advanced economies, could lead to an even greater decline [1].

The World Bank Group simulated the potential impacts of COVID-19 on gross domestic product and trade. Under the global pandemic scenario, global exports may decline 4.6%. Several countries that experience larger than global average losses of exports are China (9.8%), Cambodia (7.4%), Singapore (8.5%), Laos (7.3%), and Thailand (6.8%). But also the Russian Federation and the Philippines may see losses up of 6.4%, while Canada, Europe, and the United States see declines of around 4.5% [2].

FIGURE 1 presents annual average rates of electricity demand in some global regions.

The purpose of this article is to present an overview of the impact of the novel coronavirus (SARS-COV-2) on the world electricity sector, based on the example of some world regions and countries, with emphasis in Brazil.

FIGURE 1 - ANNUAL AVERAGE GROWTH RATES OF ELECTRICITY DEMAND, 2001-2020 [1].



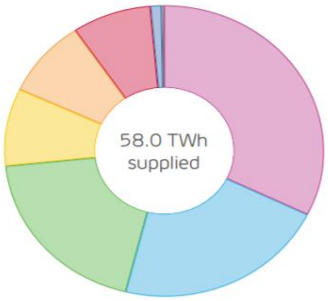
2 IMPACT IN EUROPE

According to the International Energy Agency, electricity demand dropped to Sunday levels under lockdown, with dramatic reductions in services and industry only partially offset by higher residential use. When confinement was eased in Italy and Germany in April, electricity demand showed the first signs of recovering. This trend was confirmed in May, as more countries (France, Spain, Great Britain) softened lockdown measures. In June, electricity demand stayed 10% below the 2019 level of the same month in most countries except India, where the recovery was more pronounced. This was still true in July, with electricity demand in most EU countries around 5% below 2019 levels, and India getting closer to July 2019 level. In Italy though, the electricity demand in July experienced a slower recovery, as the government enforced more stringent measures. In August, however, the sustained recovery in electricity demand growth for EU countries brings them close to their 2019 levels [3].

In France, the electricity sector has been heavily affected by the economic shutdown due to the COVID-19 pandemic. The first two weeks of confinement led to a reduction in electricity consumption in of around 15 to 20% compared to the consumption usually observed at the same year period under

equivalent weather conditions. Such a variation in electricity consumption over such a short period of time is unprecedented. The most recent significant drop in demand having been observed during the economic crisis of 2008-2009, when, in contrast, the contraction in demand spread over the long term, reaching a maximum of -5% from one year to the next. Concomitantly, electricity prices on the wholesale markets dropped from EUR50-55/MWh at the beginning of 2020 to around EUR20/MWh at the end of March. This distressed economic situation highly impacted the so-called "alternative" electricity suppliers in France, i.e., suppliers other than the incumbent operator, EDF, which entered the retail electricity market in France because of its opening up to competition. Several of these suppliers declared *force majeure* under the contracts entered into with EDF for buying nuclear electricity at a price which became too high compared to the wholesale market price [4]. In Great Britain, millions of people were furloughed or working from home, with shops shuttered up and down the country. This complete reworking of society continued to have unprecedented impacts on the power system. Lower electricity demand combined with exceptional weather to propel renewables to their greatest ever share of electricity, forced down prices, emissions, and the need for nuclear and fossil fuels. The spot-market value of Britain's electricity halved over the last 12 months, as demand remained depressed and wholesale prices hit their lowest in a decade. Britain's electricity over the last quarter of 2020 was also the cleanest it has ever been. Carbon emissions were one-third lower than this time in 2019. May was also the first ever month when absolutely no electricity was generated from coal. The longest zero-coal run was smashed, lasting for 67 days straight. For the first time, Britain's solar panels supplied more than 10% of Britain's electricity demand over a month during May. FIGURE 2 presents Britain's electricity supply mix in the second quarter of 2020 [5].

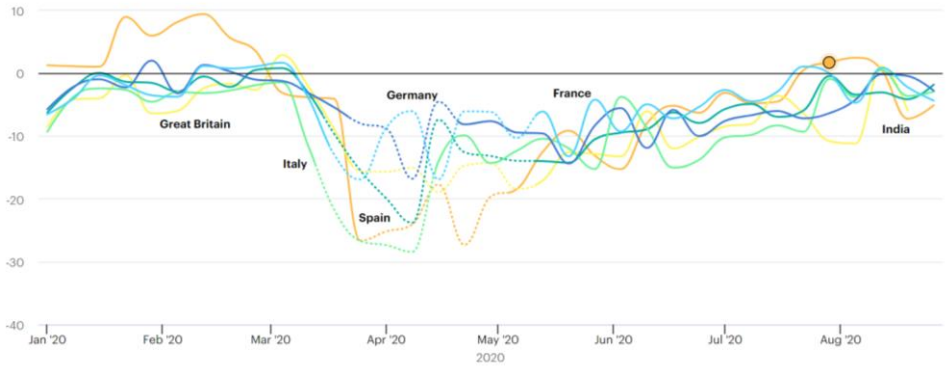
FIGURE 2 - BRITAIN'S ELECTRICITY SUPPLY MIX IN THE SECOND QUARTER OF 2020 [5].



	Share of the mix
Gas	32.5%
Wind	21.6%
Nuclear	19.3%
Solar	8.7%
Biomass	8.6%
Imports	7.8%
Hydro	1.2%
Coal	0.2%

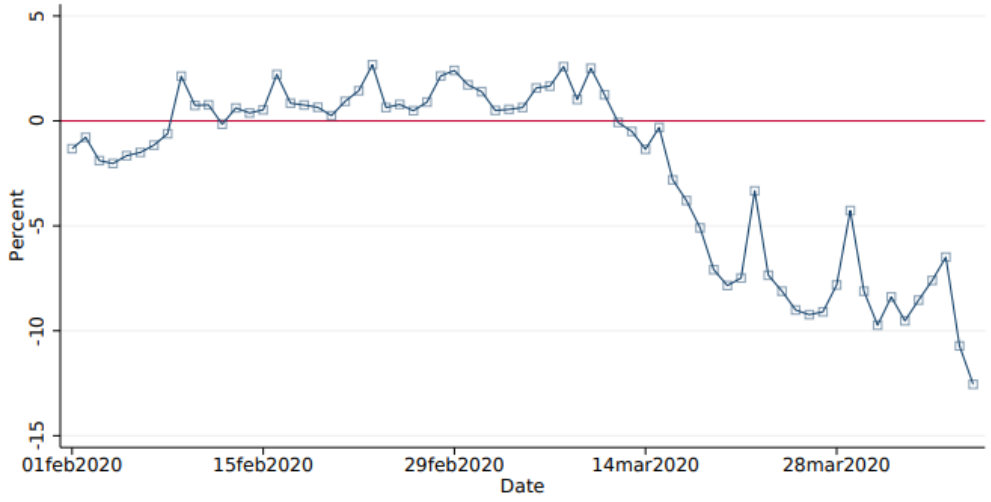
FIGURE 3 shows the reductions of electricity demand after implementing lockdown measures in selected countries, from 0 to 68 days since lockdown began. Dashed lines represent closures and partial lockdowns, and solid lines represent full lockdown. Italy was the European country more severely affected.

FIGURE 3 - YEAR-ON-YEAR CHANGE (%) IN WEEKLY ELECTRICITY DEMAND IN SELECTED COUNTRIES, 2020, COMPARED TO 2019 [3].



Regarding the whole Europe, FIGURE 4 presents the main results by calendar date for the European Union from February to April, 2020. It shows a sharp break in the second week of March as large-scale shutdowns and quarantines took effect, with most recent days indicating a roughly 10% decline in electricity consumption relative to baseline [6].

FIGURE 4 - CHANGES IN EU ELECTRICITY CONSUMPTION [4].



3 IMPACT IN THE USA

The novel coronavirus disease (COVID-19) has rapidly spread around the globe in 2020, with the U.S. becoming the epicenter of COVID-19 cases and deaths in March. In this context, there have been federal and state-level policy interventions aiming at mitigating the public health risks of this

pandemic. These social distancing and work-from-home policies, which vary widely across states, have impacted the US electricity sector, and economic productivity in general. As the US begins to gradually resume some economic and social activities, it is imperative for policy makers and electric power operators to take a data-driven scientific approach to understanding and predicting the change of electricity consumption in the shorter and longer term. According to GUANGCHUN et al., [7] there is a strong correlation between the rise in the number of COVID-19 cases and a reduction in the total load, especially in the Northeast and Coastal regions of the U.S., which contains the majority of the U.S. COVID-19 case load.

As the US recovers from the impact of the novel coronavirus disease (COVID-19) and the states re-open the economy, there is much uncertainty regarding the duration and severity of the impact on the electricity sector. Given the rapid spread of COVID-19 and the corresponding policy changes, there has been relatively little scholarly work on the impact of COVID-19 on the electricity sector. Several reports from non-peer-reviewed venues such as social media, consulting firms, government agencies, and professional communities, have shed some light on the adverse impact on the electricity sector, including operational reliability degradation, decrease in wholesale prices, and delayed investment activities. Electricity consumption analyses from regional transmission organizations (RTOs) also suggest an overall reduction in energy consumption, especially in zones with large commercial activity [7]. In FIGURE 5 it is possible to visualize the impact of COVID-19 on electricity consumption using NTL (National Transportation Library) data for New York city: (a) NTL imagery before the outbreak of COVID-19 (February 8, 2020), (b) NTL imagery during the outbreak (April 25, 2020).

FIGURE 5 - VISUALIZATION OF THE IMPACT OF COVID-IN NEW YORK [8].

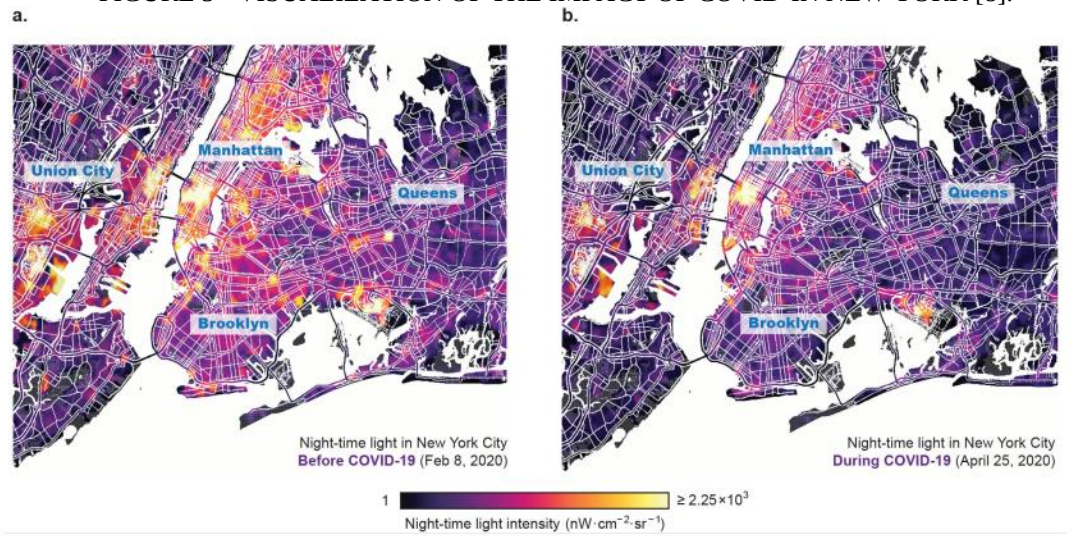
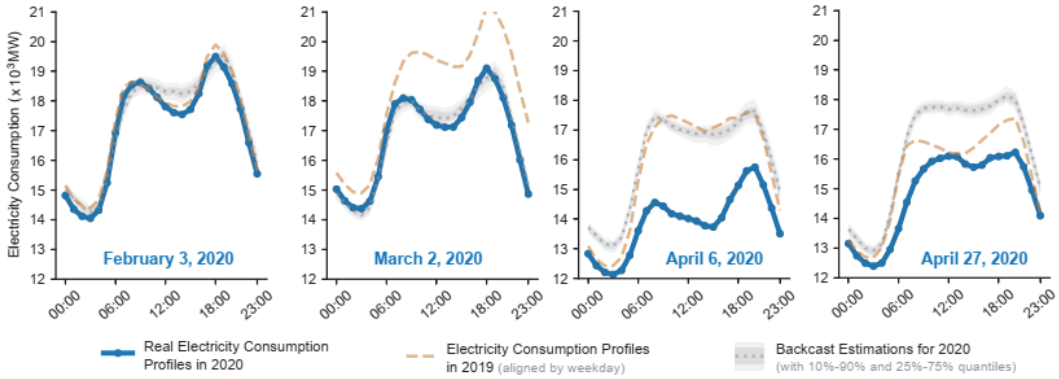


FIGURE6 presents the **e**lectricity consumption profile comparison in NYISO (*New York* Independent System Operator) between the backcast estimations, past profile, and real profile, from February to April 2020. Four typical Mondays were chosen for comparison during February to April. The past electricity consumption profiles in 2019 are aligned with the real profiles by the day of the week [8].

FIGURE6 - ELECTRICITY CONSUMPTION PROFILE COMPARISON IN NEW YORK [8].

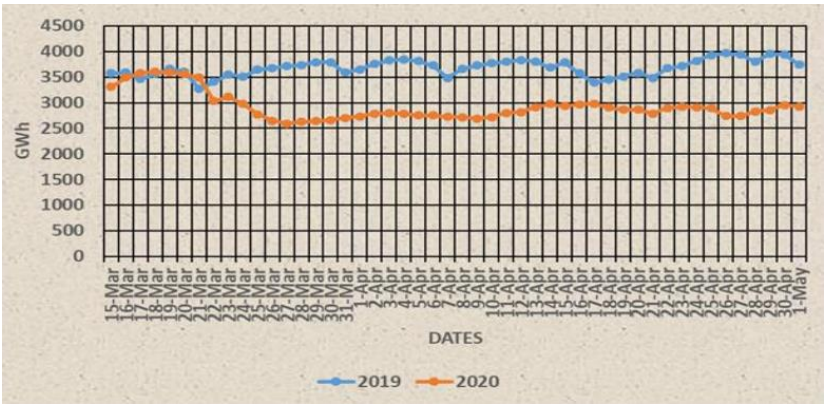


4 IMPACT IN INDIA

In India, from the preliminary analyses, it has been evident that commercial load demand dropped to maximum levels while residential load demand was increased to their maxima during the lockdown. Likewise, in other countries, the COVID-19 outbreak started in India and the government started acting from the middle of March 2020. In India, Janata Curfew was imposed on March 22nd, whereas nationwide lockdown started from March 25th and continued until May 17th. FIGURE7 shows that the average all India daily electricity consumption reduced by 1000 GWh compared to that of 2019 [9].

The recovery of electricity demand was confirmed during the first half of August/2020, with higher levels than in 2019. In the last two weeks of August, though, weather-corrected demand fell below 2019 levels again. This was driven by significant declines in industrialized states such as Gujarat and Maharashtra, with the latter having the most COVID-19 cases in the country. In contrast, the agricultural state of Uttar Pradesh remained at higher levels than in 2019 [3].

FIGURE7 - INDIA ELECTRICITY CONSUMPTION. COMPARISON 2019 – 2020 [9].



5 IMPACT IN AFRICA

The COVID-19 pandemic has created unprecedented challenges – but these are common challenges shared across the world, such as the importance of resilient health care systems and preparing recovery plans that will ensure that the millions of people who have lost their jobs can emerge from this crisis economically empowered.

Many African countries are particularly vulnerable, making support from other regions crucial. In April/2020, the World Bank forecast that Sub-Saharan Africa will in 2020 experience its first recession in 25 years, with the region's economy contracting between 2.1% and 5.1% because of the COVID-19 crisis. This will make key sustainable development goals, such as increasing access to electricity and clean cooking, much harder to achieve. Now, more than ever, the world needs groundbreaking initiatives that are focused on building a brighter future together [10].

In Lagos, Nigeria, initially it was observed a gradual increase in electricity consumption in all three (residential, commercial, and industrial) sectors in the three weeks preceding the lockdown as energy consumers envisaged that a lockdown was inevitable. The increase in electricity consumption was prompted by a certain fear of a possible lockdown based on the observations of many countries already implementing some form of lockdown to contain the spread of the new coronavirus. Businesses were ramping up services and industries were ramping up production in preparation for a possible lockdown. Residences were stocking up gradually. More refrigerators and deep freezers were in use as more items needed safe storage. After week 5 (total lockdown), the industrial sector experienced a drop in electricity consumption from 2.02 MW to 1.41 MW while the residential sector experienced an increase in electricity consumption from 3.72 MW to 3.87 MW [11].

6 IMPACT IN CANADA

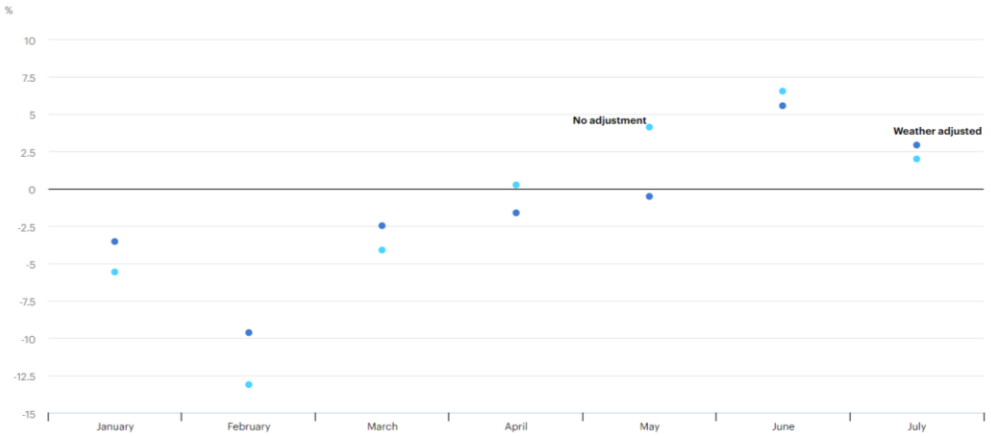
RAYACH, A. et al. published the impact of COVID-19 and the global pandemic on the electricity sector in Canada, specifically covering the province of Ontario. According to the authors, it is evident that health-related pandemics have a detrimental and direct influence on the concept of the smart city. This is manifested through various social, economic, environmental, technological, and energy-related changes. The overall electricity demand in the province for the month of April/2020 declined by 14%, totaling 1267 GW, compared to April/2019. The post-COVID-19 indicated higher energy demand in the earlier part of the week and a lower demand in the latter part of the week. Pre-pandemic, the days of highest electricity demand were in the latter part of the work week (Wed-Fri) in addition to the weekend. Post-pandemic, the highest electricity demand occurred in the earlier part of the week (Mon-Tue). GHG emissions were reduced by 40,000 tonnes of CO^2e and savings of $131,844 were realized for the month of April. These changes with significant energy savings are summarized as follows: Restricted international travel and limitation to the transportation sector; working remotely; self-sufficiency of manufacturing capabilities to avoid reliance on foreign goods, especially for basic needs and essential commodities [12].

7 IMPACT IN CHINA

Electricity demand in China dropped under lockdown in January, and more strongly in February (-13% compared to February 2019, leap year corrected) as can be observed in FIGURE 8. Part of the difference was also due to winter being significantly colder in 2019 than in 2020 in China. Weather corrected, the decrease in demand in February 2020 compared to February 2019 was still significant: -10%.

As confinement measures were eased, electricity demand showed the first signs of recovery while temperatures continued to be higher than in 2019. In May 2020, electricity demand in China was 4% higher than the level reached in May 2019. However, this seems mostly due to increasing cooling needs. Weather corrected electricity demand was 1% below the level reached in May 2019. In June 2020, electricity demand in China recovered completely and was even higher than last year's levels. Less weather correction was necessary in June and July as the difference in temperatures was smaller between the two years. Weather corrected, the demand for electricity in July 2020 is 3% higher than one year before [3].

FIGURE 8 - YEAR-ON-YEAR CHANGE IN MONTHLY ELECTRICITY DEMAND IN CHINA, 2020, COMPARED TO 2019 [3].



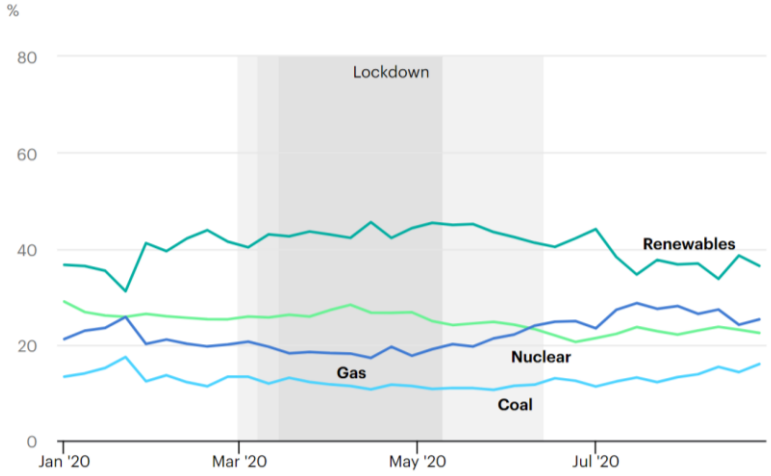
8 IMPACT ON RENEWABLE ENERGY MARKET

Renewables are also subject to the impact on the demand due to the COVID-19 crisis, but they are more resilient than other sources of energy. Existing renewable electricity plants are mostly sheltered from both lower electricity demand and declining prices. Many renewable electricity plants have fixed price contracts and are granted priority access to the grid, resulting in little or no output curtailment. COVID-19 lockdown measures have resulted in weekly electricity demand decreasing by 10%-35% across the affected regions of the world, increasing the overall share of variable renewables to meet this demand. A combination of low electricity demand and the additional capacity coming online in 2019 and in the first quarter of 2020, are leading to record high shares of infeed from variable renewables in electricity demand in some regions [3]. In the European Union renewable generation levels increased substantially compared to the first semester of 2019 due to ongoing deployment and favorable weather conditions over the first six months of 2020. The impact of lockdown measures and this higher renewable production drove demand for non-renewable generation down, particularly from coal and nuclear sources. From February to the first week of July, weekly renewable production has been higher than fossil fuel production. In June, as nuclear production remained low, partly due to programmed maintenance and to help with grid management, natural gas became the second source of electricity generation, behind renewables. Since then, natural gas has consolidated its position in the electricity mix and has also been compensated for the volatility of weekly wind production [3].

From the second week of July onwards, because of generally lower weekly wind production, fossil fuel production has been higher than renewable production. Since the last week of July,

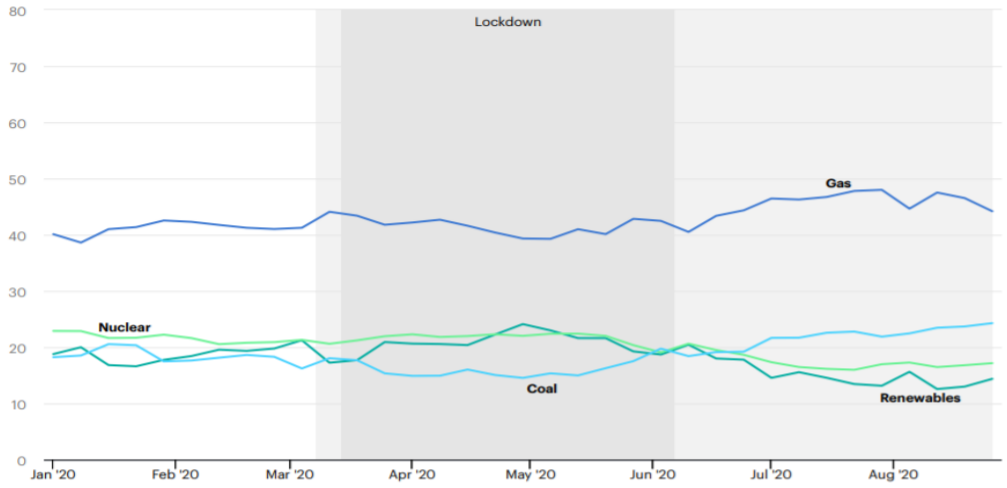
generation levels have been on par with 2019 levels. FIGURE 9 presents the electricity mix in the European Union, January-August 2020 [3].

FIGURE 9- ELECTRICITY MIX IN THE EUROPEAN UNION, JANUARY-AUGUST 2020. SOURCE: IEA [3]



In the USA, California and Texas experienced higher hourly participation of renewable shares before lockdown measures, showing that in some cases variability due to weather had stronger impacts than electricity demand reduction due to COVID-19 [13]. In July, the share of natural gas in the generation mix approached 50%, while coal and nuclear peaked up to respond to growing demand. They outpaced renewables generation, which decreased in the wake of the seasonal decline of wind and hydro. In August, the total electricity generation was much higher than in 2019 at the same period, as temperatures were higher, and this increase of demand was satisfied by increasing coal and higher wind generation [13].

FIGURE 10 - ELECTRICITY MIX IN THE UNITED STATES, JANUARY-AUGUST 2020. SOURCE: IEA [13].



In Asia, according to the International Renewable Energy Agency (IRENA) while coal reliance remains strong, reduced power demand due to COVID-19 have led to significant overcapacity, reflected in job reductions in the sector in China and India. India's government has explicitly prioritized solar energy over coal. IRENA published that during the shutdown, the share of renewables in the electricity mix grew in many countries, since renewable power plants have close to zero marginal costs and thus make economic sense to be dispatched first. However, there has been some problems for renewables as well. Those operating in liberalized markets, without a price hedge are sometimes (partially) exposed to wholesale market risk and therefore were confronted with lower electricity prices. In Mexico and South Africa, for example, reduction in demand was cited by authorities for curtailing variable renewable power producers [14].

9 IMPACT IN BRAZIL

Brazil's electricity sector felt the impacts of the demand shock caused by the reduction in consumption, especially in the industrial and services segment. Since the Senate approved the state of emergency on March 20th, a noticeable difference in load behavior has been observed in comparison to the equivalent period of the previous year [15].

In its monthly load bulletin (Boletim de Carga Mensal) for the month of July/2020, ONS (National System Operator) comments that since the month of June/2020 the energy load has been showing signs of increase, a behavior also observed during the month of July. This behavior is being sustained mainly by the broader return of economic activities after the relaxation of social isolation measures, which has caused a gradual recovery from the adverse effects of the 2019 new coronavirus pandemic (COVID-19), mainly regarding to the domestic demand. In addition to the factors mentioned above, the occurrence of temperatures higher than those observed in the same month of the previous year also contributed to the increase. In general, the results from the various indicators used in the load behavior analysis process showed positive signs in July/2020.

FIGURE 11 shows a comparison between the variation rates of the Verified Load and the Adjusted Load (*) of the National Interconnected System (SIN) in the 12-month period.

(*) Adjusted Load: The adjustments made in order to exclude the effect of random and non-economic factors on the load such as: atypical temperatures, calendar and losses in the basic network that result from the way the system is operated, and have no economical implication [16].

FIGURE 11 – COMPARISON BETWEEN VARIATION RATES OF THE VERIFIED LOAD AND THE ADJUSTED LOAD, 2019 2020 [16].

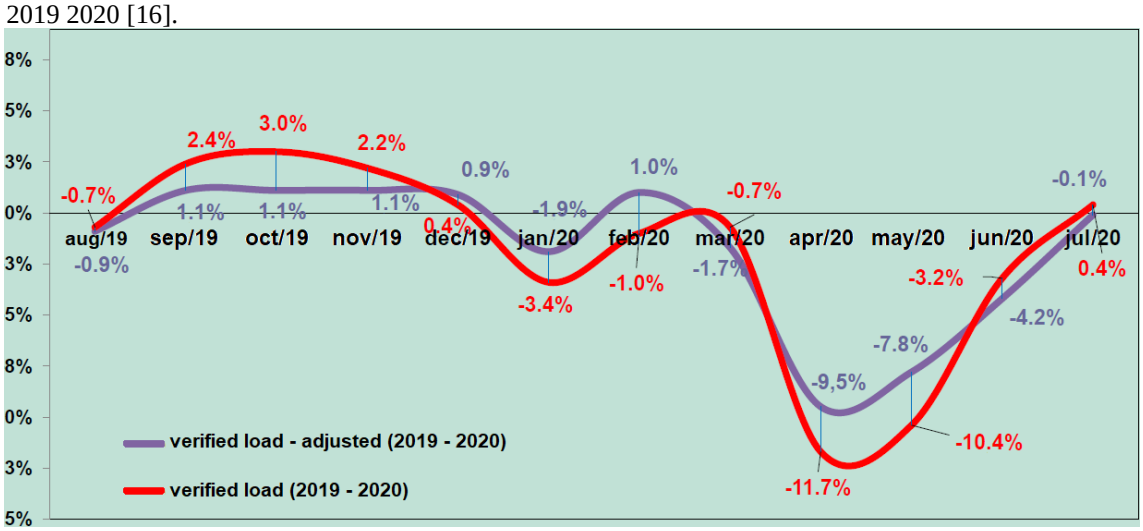
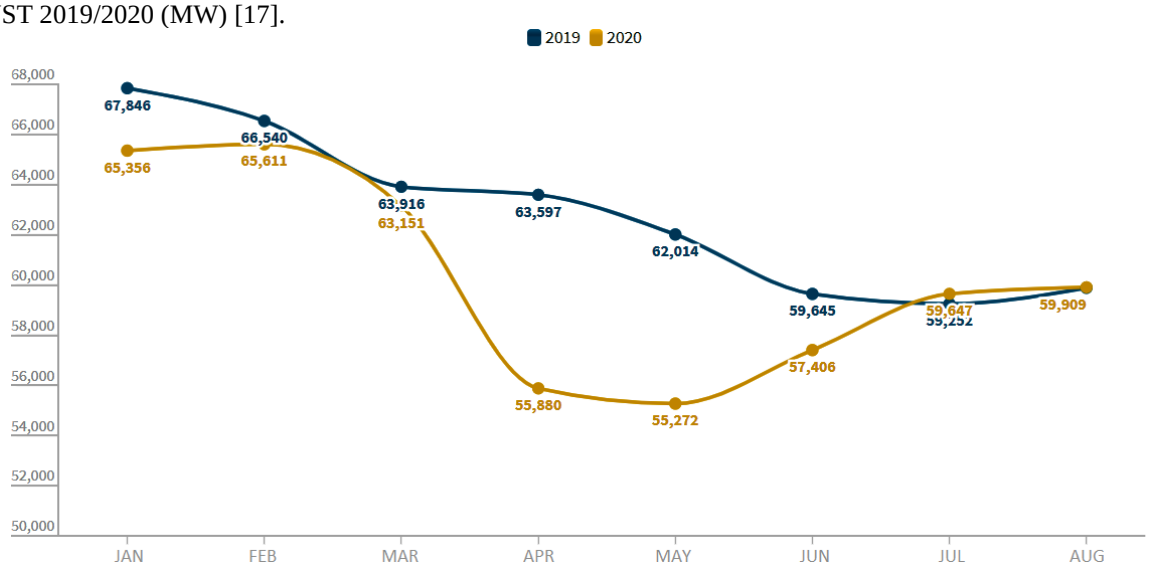


FIGURE 12 shows a monthly comparison of electricity consumption in Brazil between January and August 2019/2020. According to CCEE (Electric Energy Trading Chamber), electricity consumption in the National Interconnected System - SIN already shows stable signs of recovery after months of retraction caused by the intensification of measures to combat COVID-19. At the peak of the pandemic, in April, the electric sector reached a decrease of 12.1% in energy consumption, according CCEE. Since then, the result has gradually become more positive, falling to 10.9% in May, 3.8% in June and, finally, reaching a slight increase of 0.7% in July.

Preliminary data for August/2020 (until 29/08) pointed to a stable consumption compared to the same month of 2019. In FIGURE 12 it is possible to see this trajectory. The units on the ordinate axis refer to the energy load (consumption plus losses) for National Interconnected System (SIN) in average megawatts (MW)[17].

FIGURE 12 –COMPARISON OF ELECTRICITY CONSUMPTION IN BRAZIL BETWEEN JANUARY AND AUGUST 2019/2020 (MW) [17].



At the beginning of pandemic, the National Electrical System Operator (*ONS*) published that the energy load of the SIN (Integrated National Grid) verified in April/2020 presented a negative variation of 11.6%, in relation to the value verified in the same month of the previous year. Compared to March/2019, there was a negative variation of 11.7% [16].

The Energy Research Office (EPE in its Portuguese acronym) published that the consumption of electricity in April decreased by 6.6% in comparison to the same period of the previous year (37,116 GWh and 39,718 GWh), reflecting the impacts of the pandemic of COVID-19 for the different economic sectors, mainly in the commercial (-17.9%, from 7,782 GWh to 6,393 GWh) and industrial (-12.4%, from 13,899 GWh to 12,173 GWh). The commercial sector was more affected by the social isolation measures adopted to face the COVID-19 pandemic. The temporary closure of establishments and stores significantly impacted sales of retailers (retailer and wholesaler) and the hotel and restaurants activities were the most negatively affected. With the reduction of the economic activity for sector, all regions of the country presented a decrease in the consumption of electricity in the commercial class. The Northeast (-21.7%, from 1,266 GWh to 991 GWh) and the Southeast (-19.3%, from 4,116 GWh to 3,322 GWh) were the regions that had the biggest consumption contractions. The Southeastern region was also influenced by the milder climate compared to April 2019. Even with the longer billing cycles, compared to the equivalent period of the previous year, this effect on the consumption of the class was not enough to compensate for the drop caused by the partial interruption of economic activity [18].

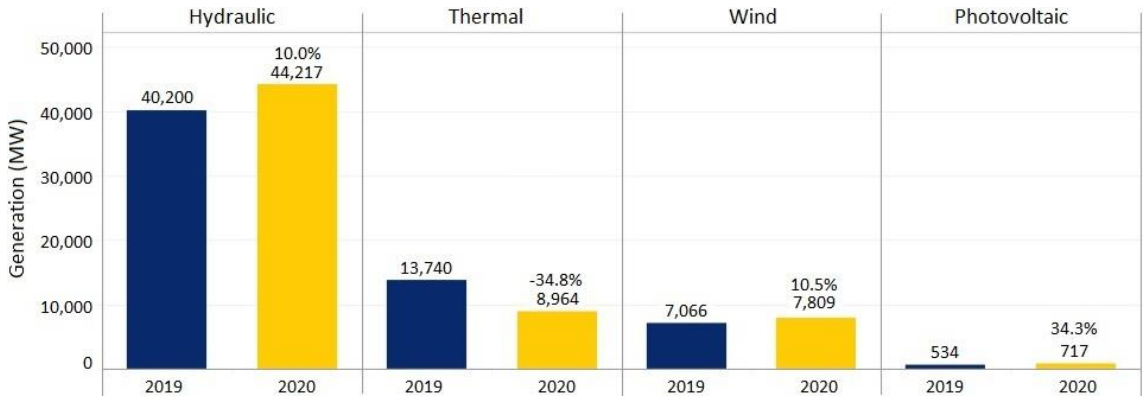
For the industrial sector, the decrease of 12.4% reflects the falls registered in practically all regions and all the consumption segments monitored by EPE, with some exceptions. Among the industrial segments, mining and quarrying increased 1.7%, showing less impact from the social isolation measures adopted in the cities, with emphasis on the Northern and Northeastern regions. In the latter, there was the influence of a non-ferrous metallic mineral extraction plant, which returned to its operation at the end of last year in the State of Bahia. In the Northern one, industrial consumption continued to be positively affected (+7.9%) by the low base statistical effect of non-ferrous metallurgy.

On the other hand, residential consumption was positively affected by measures of social isolation, presenting a 6% growth in April. This result was also influenced, to a large extent, by billing cycles with more days in relation to the equivalent period in the previous year at distributors with significant participation in the electricity distribution market. Disregarding this effect, the growth observed in the residential class in April was around 2%. For the Southeastern region, which corresponds to half of the consumption for the residential sector, the rate of +1.1% would pass to around -1.0% without the effect of the billing cycle, also reflecting the influence of the milder climate compared to April/2019 [18].

To assess the impacts of COVID-19 on electricity generation in Brazil, the following information was collected from the ONS database [19]: Electricity generation in May/2020 (44,736 GWh) was similar June/2015 (44,114 GWh). A one-year retrospective shows a reduction between May 2020 (44,736 GWh) and the same month of 2019 (49,795 GWh) by 11%.

More recently, it was observed that the electricity generation registered in the National Interconnected System - SIN advanced 3.4% in the first half of September/2020 compared to the same period in 2019, moving from 64,450 average MW to 66,621 average MW. The result was mainly due to the increase in the production of hydraulic (16.7%), wind (12.6%) and photovoltaic (24.2%) plants. Only thermal plants showed a drop in their generation (-36.8%), including biomass, which had been showing an increase in generation in the last months (FIGURE 13) [20].

FIGURE 13 – ELECTRICITY GENERATION BY SOURCE - COMPARISON 2019/2020 (MW) [20]



10 CONCLUSION

Global electricity demand was severely affected by the global pandemic scenario and the world electricity demand is expected to fall by 5% in 2020 compared to 2019.

It was observed that in many countries industrial and commercial load demand were dropped maximum while residential load demand was increased maximum during the lockdown and the stay-at-home policy.

Electricity prices on the wholesale markets in some regions dropped drastically with negative impact to conventional and renewable energy generation sector.

It has been observed a recovery of electricity demand from the third quarter of 2020 in many regions of the globe.

Even though we expect the markets should recover at least partially up to the end of 2020 from the impact of the novel coronavirus disease (COVID-19) and the countries start revitalizing their economies, there is still much uncertainty regarding the duration and severity of the impact on the electricity sector. Also, it may occur some changes in the pattern of the load as the health situation start to improve.

Renewables are more sheltered from both lower electricity demand and declining prices. During COVID-19 lockdown periods it was increased the overall share of renewables to meet electricity demand in many countries.

In Brazil, the electricity demand has increased from June to August/2020. The electricity market behavior presented similarities to other countries, with a significant drop in demand in the most severe period of the pandemic (March to June/2020). Sustainable growth is taking place and demand in August/2020 was like August 2019.

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