Henrique Ajuz Holzmann
João Dallamuta
(Organizadores)

ENGENHARIAS: Pesquisa, desenvolvimento e inovação

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APRESENTAÇÃO

Um dos grandes desafios enfrentados atualmente nos mais diversos ramos do conhecimento, é o do saber multidisciplinar, aliando conceitos de diversas áreas. Hoje exige-se que os profissionais saibam transitar entres os conceitos e práticas, tendo um viés humano e técnico.

Neste sentido este livro traz capítulos ligados a teoria e prática em um caráter multidisciplinar, apresentando de maneira clara e lógica conceitos pertinentes aos profissionais das mais diversas áreas do saber.

Apresenta temas relacionados as áreas de engenharia, como civil, materiais, mecânica, química dentre outras, dando um viés onde se faz necessária a melhoria continua em processos, projetos e na gestão geral no setor fabril. Destaca-se ainda a busca da redução de custos, melhoria continua e automação de processos.

De abordagem objetiva, a obra se mostra de grande relevância para graduandos, alunos de pós-graduação, docentes e profissionais, apresentando temáticas e metodologias diversificadas, em situações reais.

Aos autores, agradeço pela confiança e espirito de parceria.

Boa leitura

Henrique Ajuz Holzmann
João Dallamuta

SUMÁRIO

CAPÍTULO 5

ENERGY AND COVID-19 – ANALYSIS OF THE IMPACT ON THE GLOBAL ENERGY MATRIX

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ABSTRACT: Ancient pandemics reverberated through their times, changing social and economic contexts, prompting and redirecting changes in social ties, business, and education, and restructuring the world that generated them. In this context, this study aims to assess the impact of the COVID-19 pandemic on the global energy matrix from January 2019 to June 2021. The energy balance showed variations in this period, with the incremental use of wind, solar and nuclear energies, which is positive for the environment. The participation of different sources in the final energy mix changed during the pandemic period evaluated, although these changes appear to not be lasting.
KEYWORDS: COVID-19, global energy matrix, nuclear energy.

1 I INTRODUCTION

The great pandemics that devastated humanity allowed the analysis of their historical impacts in the human, social, and economic fields. But one aspect, the impact on the area of consumption and generation of energy, was not specifically explained, which in a way it is understandable because, until the 18th century, thermal energy consumption was mainly coal – mineral and natural, and wood to firewood, another source was negligible. Between the 19th century and the middle of the 20th century, even though humanity used energy, its complexity and impact on human life was low, especially compared to what is seen from the second half of the 20th century until today.

This paper aims to answer the following question of whether the health and sanitation crisis affect or alter the use, demand, and consumption of present and/or future energy, and how so. To carry out a correlation, it is important to define the scope of the areas of analysis and the time of their application.

2 I METHODS

For the paper, there was a search for systematic literature review, bibliographic and documental survey [1,2]. The following electronic databases were selected as a source of scientific data: Web of Science, INIS, Google Scholar and databases from IEA, IFM and others. The query strategy consisted in the use of search tools for keywords related to the topic, with the main descriptors «pandemics and society», «Covid-19», «energy consumption and economy», «energy matrix» and «electricity ", as well as others to expand the themes. Other materials from different sources also served as support, such as the content expressed in books, interviews with scientists, and reports.

The research was carried out from December 2019 to July 2021, from the content analysis, and information in the bibliographic references. When the references presented the same objective approach of this study, they were systematized and correlated to obtain data about change in the world energy matrix.

3 I RESULTS AND DISCUSSION

Diseases, or rather the germs that cause them, are not prejudiced of any kind; they are indifferent to people and their well-being, and thus should be respected as skilful opponents and of great strength and resilience. They have been present in the world for a long time, before humanity even existed.

3.1 Pandemic

The germs cause individual diseases that afflict us, and in certain situations, those diseases are classified in regards to their proliferation [3,4]: a) endemic - an outbreak of disease that is consistently present but limited to a particular region; b) epidemic - an unexpected increase in the number of disease cases in a specific geographic area; and c) pandemic - when the growth of the disease is exponential; this means that the growth rate of cases soars and that a virus covers a wide area, affecting many countries and populations;

The difference between an epidemic and a pandemic is not the severity of the disease but the degree to which it has spread. A pandemic crosses international borders, as opposed to regional epidemics. The three biggest pandemics that ravaged the world, classified by their estimated mortality, are presented in Table 1.

Classification	Disease	Date	Deaths Global(1)	Affected Regions	Notes
1st	Justinian Plague	541 - 549	15 – 100	Europe and Asia	(c), (d)
2nd	Black Death	1346 – 1353	75 – 200	Europe, Asia, and North Africa	(a), (b), (c)
3rd	Spanish Flu	1918-1920	17 - 100	All World	(c), (e)

(1) Millions of individuals.

(a) Damen, 10; (b) Santamaria, 08. (c) Carpenter, 09. (d) Atkinsons, 02. (e) CDC, 19

Table 1: Biggest pandemics in the modern world.

The studies carried out on the effects of the mentioned pandemics on society highlight their negative effects at the time of their occurrence, foreseen for this type of event.

The Justinian's Plague contributed to the political and economic weakening of the Byzantine Empire by decimating its population, likely causing labor shortages and increasing the price of labor. Trade was disrupted, the agricultural sector was devastated, prices soared, and tax revenues fell, which contributed to reducing the ability to resist enemy invasions. Barbarian hordes invaded and divided northern Italy, and North Africa and the Near East were invaded by Arabs [5].

The Black Fever shook 14th-century European society, and caused the cessation of wars and a sudden drop in trade. There was a drastic reduction in the amount of cultivated land, due to the death of so many workers. The shortage of labor forced the aristocracy to replace labor services with wages or cash rents, helping to eradicate serfdom and the development of a new economic system. New social systems developed, as well as modern economic, religious, and scientific ideas [6,7]. On the other hand, outbreaks of violence occurred in communities, mainly aimed at some groups accused of being responsible for the spread of the disease [8].

The Spanish Flu pandemic took place during World War I and authorities discouraged social interaction, which fuelled rumors of enemies spreading the virus and created a climate of suspicion and mistrust that characterized the period and much later. Researchers estimate that, in a typical country, the pandemic reduced real GDP per capita by 6% and private consumption by 8%. The flu was particularly deadly for young adults without pre-existing conditions, which increased its economic and social impacts. The inefficiency of governments in managing the crisis provoked a wave of workers' strikes and anti-imperialism, a reaction to growing inequality, noting that in 1917 the Russian revolution had taken place [9,10].

COVID-19 is the disease of the Severe Acute Respiratory Syndrome Coronavirus 2 (SARS-CoV-2). The COVID-19 is the pandemic of the 21st century. It was first identified in Wuhan, Hubei province in December 2019, China. The main hypothesis of its transmission is regarded to the live animal market, where there is an interaction between humans, pigs, birds, and other animals, which favored the spread of this virus between species. It produced variables for which man has no immunity, and is transmissible in the incubation period, before the onset of symptoms, which is a critical condition. It started in December 2019 with atypical cases of pneumonia and quickly spread. The WHO identified the 2019 coronavirus on February 11, 2020, and declared the outbreak as a global pandemic on March 11 [11,12].

In just over a year and a half since the declaration of the COVID-19 pandemic, the disease, its consequences and sequelae remain mainly out of control, even with the beginning of vaccination. Its rapid evolution and expansion have drastically altered people's lives, with direct and severe impacts on the global and local economy, in the public and private sectors. Massive blockages, economic recession, tourism stoppage, reduced agricultural production, decline in the financial sector, intense reductions in the supply and demand aspects of the economy at the international level[11,13], significant expansion of home office activities, high demand for medical, hospital and funeral services, expansion of social inequality and poverty to extreme levels in a short period, are all aspects of the pandemic that have come to dominate the daily scene in global level.

After 14 months of the WHO declaration, the world accumulated 164 million cases, with 3.40 million lives lost to COVID-19, affecting 191 countries [14,15].

3.2 World Energy Demand and the Energy Matrix

Energy comes from a set of sources, and the combination of all these sources is the energy matrix. It represents the set of sources available in a country, state, or in the world, to supply the demand of energy. The energy matrix represents the set of energy sources available to move vehicles, planes and ships, to cook food, and generate electricity. The electrical matrix is formed by the set of sources available only for the generation of electrical energy, being a part of the energy matrix [16].

The composition of the energy matrix varies greatly from one country or region to another, and can change significantly depending on the period. Variables include the availability of usable resources in the domestic market or the possibility of importing them; the range and type of energy that needs to be met; and policy choices determined by historical, economic, social, demographic, environmental and geopolitical factors [17].

Energy is fundamental for human development, and its availability determines access to health, food, education, safety, and the well-being of the population [17]. This relation became evident after the British Industrial Revolution in 1760. It sourced energy from coal, which became an important production factor [18]. Figure 1 shows the inflection of the World Gross Domestic Product (GDP) curve, starting mid-18th century.

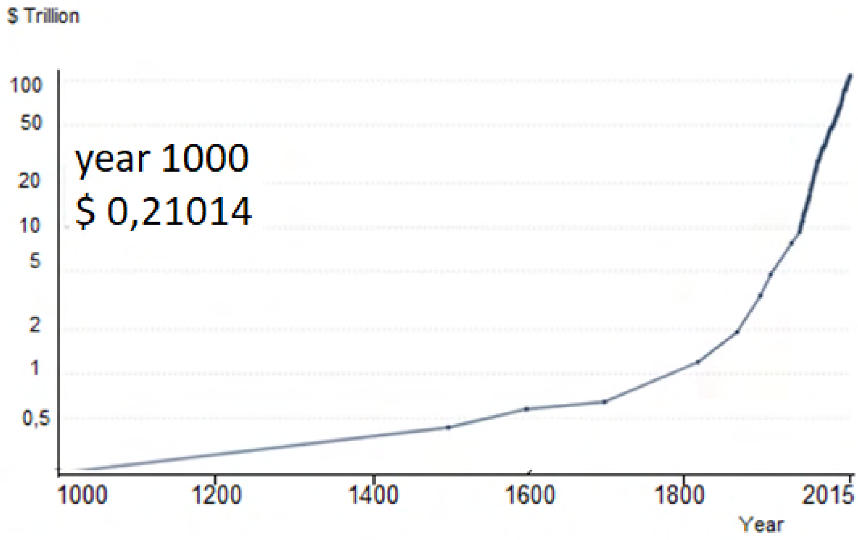


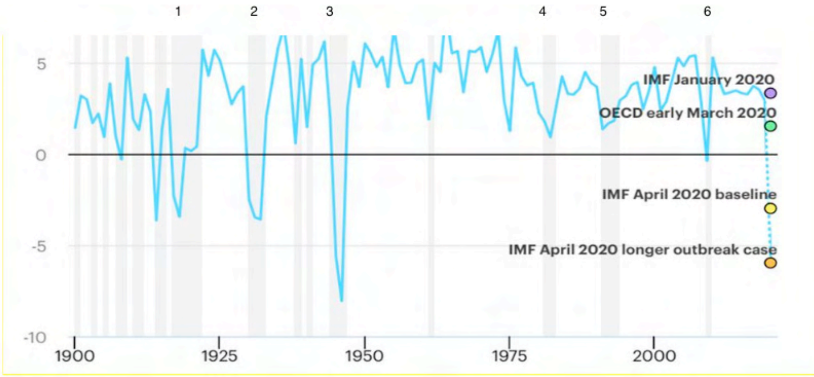
Figure 1: World GDP in the last millennium – (ROSER, 2013)

Sources: World GDP - Our world in data based on World Bank and MADDISON (2017); OurWorldInData.org/economic-growth.

Energy is identified as an economic commodity, and because it is poorly distributed, it is expensive and subject to price fluctuations that are often unpredictable. It is also an indicator of inequalities between countries, when analyzed by their relation with the Gross Domestic Product (GDP) of their economies, or by the per capita energy consumption of their inhabitants [19].

Energy drives economic productivity and industrial growth and is fundamental to the functioning of any economy [20]. Ensuring universal access to electricity, especially for billions of people in developing countries, who do not have access to services or whose consumption levels are far below industrialized countries, is a crucial goal that can spur growth and transformation in the world (UNDP, 2000).

Barney and Franzi argue that energy is responsible for at least half of the industrial growth in a modern economy, while representing less than a tenth of the cost of production [21]. To show the relation between the world economy and energy, Figure 2 shows the variation in the World GDP over the 20th and 21st century, and Figure 3 shows the variation in energy demand (global consumption) during the same period, where it is verified that positive or negative variations in GDP correspond to variations in the same module of demand.



1 – Spanish Flu, 2 – 29' Crush, 3 – II War, 4 – 1° Oil Chock, 5 – 2° Oil Chock, 6 – Financial Crises.

2020 values are predictions.

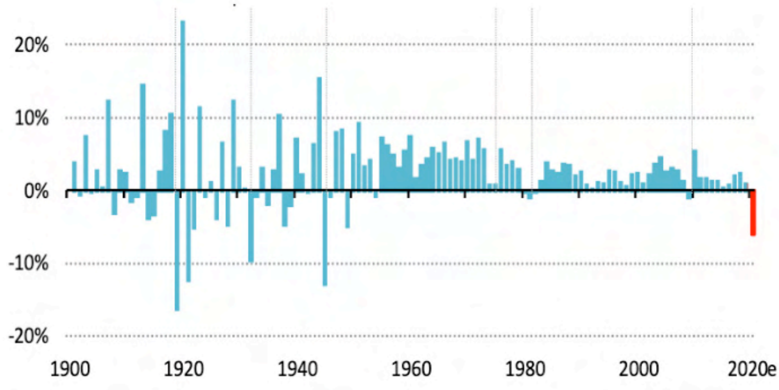
Sources: IEA based on IMF World Economic Outlook (January and April 2020), OECD Interim Economic Outlook Forecasts (March 2020) and MADDISON Project Database (2018).

Figure 2: Global annual change in real GDP - 1900-2020 – IEA Sustainable Recovery (2020)

Currently, as shown in Figure 4, fossil fuels dominate the energy matrix at a global level, accounting for more than 80% of the total needs. The total energy production (2018) was 583.9 EJ or 1621.9 x 103 TWh, and in the generation of electric energy, it accounts for the consumption of fossil sources in about 64% of the total needs. It is necessary to note that the format of the matrix shown is not static; it will necessarily undergo changes, seeking to meet extremely important priorities.

Most governments, faced with the pandemic, declared a national emergency and introduced in their countries measures of generalized physical distancing for the population, including confinement, with strong restrictions on transport systems and logistical services globally, and the mandatory use of masks, implementing efforts to flatten the curve of COVID-19 cases.

The effects of the new coronavirus pandemic go beyond health, economic, political, and environmental areas. Specifically, the energy, electrical and thermal supply sector, both for transport and production, or for services and related and for social use, suffered notable impacts [21].



1 – Spanish Flu, 2 – 29' Crush, 3 – II War, 4 – 1º Oil Chock, 5 – 2º Oil Chock, 6 – Financial Crises.

Notes: 2020e predicted fall due COVID-19

Figure 3: World Energy Demand – Base IEA Sustainable Recovery (2020)

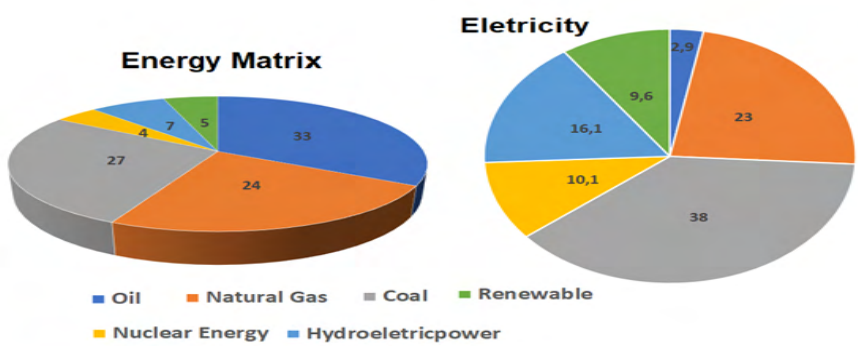


Figure 4: Global Energy Matrix (bp, 2020)

Source: bp. Plc – Statistical Review of World Energy 2020 I 69th edition

The measures of physically distancing the population and interrupting trade and travel can't stop the pandemic, only mitigate the mortality rates. It's important to note that several countries have passed or are going through the second and third waves of contamination. The solution, which was developed by science in historical time, is focused on the vaccine. Its offer is, however, currently limited to a few countries, although the World Health Organization expects that by the second half of 2022 the whole world will have access to vaccines [12].

3.3 Post-pandemic Energy Matrix

The economic crisis caused by COVID-19, mainly due to the quarantine applied by several countries, is comparable to that generated by World War II [22]. Due to its magnitude, it generated impacts on the daily lives of people all over the planet, which resulted, based on the analysis of the studies presented, in a significant reduction in the generation of greenhouse gasses, especially CO2 (Figure 5).

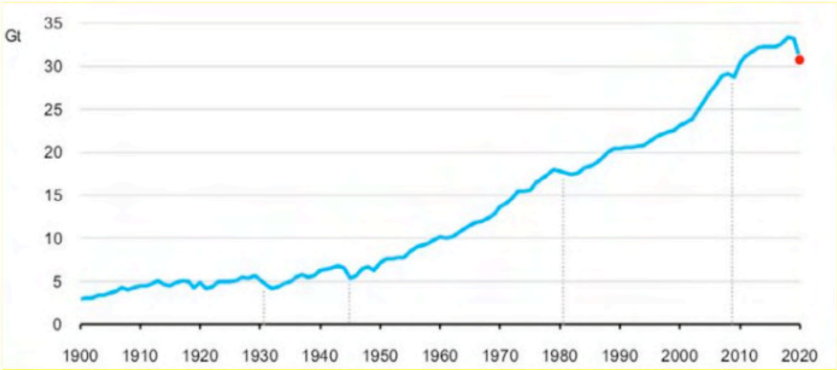


Figure 5: Global Energy-Related CO2 Emissions 1900 to 2020 (Gigatons CO_2)

Source: International Energy Agency (2020). Global Energy Review 2020.

To alleviate the socio-economic implications generated by the pandemic, the world's largest economies are taking unprecedented fiscal and monetary actions. According to the International Monetary Fund's analysis in 2021, the global economy is ready to start the most robust post-recession recovery in 80 years [23]. Governments hope that economically aggressive actions will result in rapid recovery for their countries, even though COVID-19 will cause permanent or at least long-term economic damage to poor or emerging countries [23,24].

The World Bank predicts that the global economy should recover by 5.6% in 2021, while 2020 brought a reduction of 3.5%. The recovery will occur mainly in a few important economies. The global GDP will grow by more than 2% from 2019 levels [25], and this will increase global energy demand by around 4.6% in 2021, offsetting the 2020 contraction and surpassing 2019 demand by 0.5% [26].

Even with the main environmental indicators worldwide showing that human activities must reduce the consumption of energy from fossil fuels [26], demand for all fossil fuels is expected to grow significantly in 2021, and the greatest increase in demand will occur in emerging markets and developing economies. The predictions for more advanced economies is a small reduction in demand due to policies of increasing energy efficiency and reducing emissions [27].

With the increased consumption of fossil fuels, there will be a reversal in the CO2 emissions drop that occurred in 2020 (which amounts to 20% less), with emissions in 2021 reaching values slightly below or at the same levels of emissions from 2019 [26]. Figure 6 shows the variation in CO2 emissions generated by the major financial crises that occurred in recent decades. The data indicates that during the crisis there is a reduction in CO2 emissions, but that just after the emissions curve returns to its growth trend [28].

The pandemic impacted the energy supply, something that extended the time for the return to regular conditions in the society, and generated an increase in inequality in the world. The pandemic has not been stopped, although most developed countries have been able to reduce its impact and return to almost normal living conditions. An energy crisis, however, has now set in and is also spreading across the world.

This spread is biasedly only correlated with the pandemic. Analyzing some of the causes, there is a confluence of several factors, whether related to the pandemic or the climate crisis [29-31]. Winter in much of the northern hemisphere, especially in Asia, was exceptionally cold in early 2021, followed by a cold spring in Europe, which increased demand for heating and impacted both the demand and supply for gas. The intense cold in Texas also hampered US gas production, resulting in lower US liquefied natural gas (LNG) exports to Asia and elsewhere during the beginning of the year.

Unusually severe summer heatwaves and droughts in China, Europe, and the United States, as well as in some other parts of the world have increased gas demand to produce electricity for cooling. Potential sources of electricity generation were harmed. Wind generation (Europe and China) has been far below averaged this year due to long periods with below-average wind speeds.

Demand for gas and coal increased to offset the reduction in renewable energy production, pushing up prices [32]. Drought conditions in China and South America have reduced hydropower production, attracting globally traded gas supplies to these markets.

The producers of gas, oil, and coal, in response to the record drop in prices and consumption at the height of the pandemic, have not increased, or are having trouble increasing, their production in the face of the growing demand.

The “green inflation” is due to governments restrictions on traditional energy sources to encourage renewable energy to meet global emissions targets [32]. China has promised an aggressive 65% reduction in its emissions by 2030 and cut coal mining sharply. The UK already relies on wind power to supply a quarter of its electricity needs, and Germany has pulled another three nuclear reactors off the grid this year. The push towards the adoption of renewable energy has led investors to divest into traditional energy sources. The amount of divestment from 2014 to 2021 reached US$14.5 trillion [33-35].

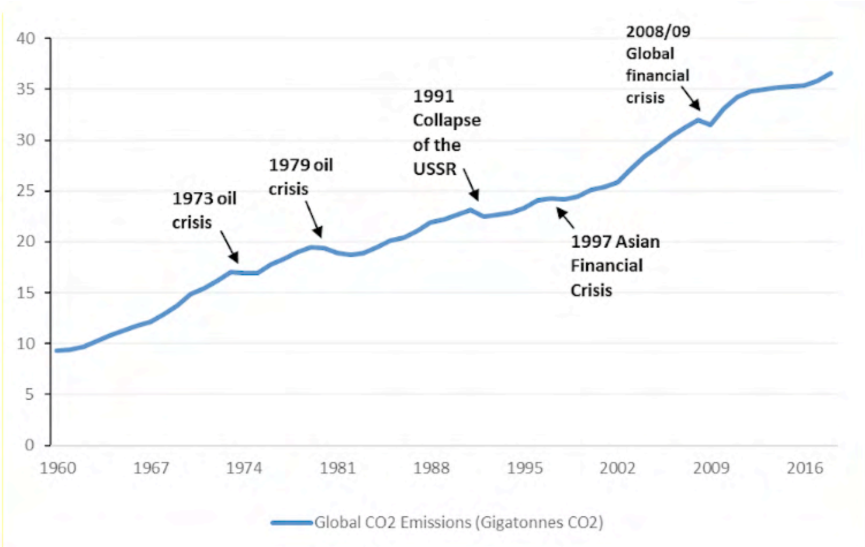
The situation demonstrated is not something foreign to the energy market; supply or demand crises are relatively frequent. Governments should avoid that in the future, as people have a perception that reaching the targets for emission of greenhouse gasses has a high economic cost. Renewable energy sources such as wind and solar can be unreliable, especially during winters, and countries are forced to depend on traditional fossil fuels. Hence the need for governments to rethink their energy policy.

There is no dispute, however, that climate change generated by greenhouse gasses is the reason for more extreme temperatures: hotter summers and polar cold waves. Climate change aggravates droughts and reduces hydroelectric energy, which is now prevalent in the generation of clean electricity.

Confusing or uncorrelated actions can lead to price volatility of carbon-based fuels, which, in turn, feeds energy price volatility, creating a feedback loop instead of pushing alternatives that can reduce the gap between energy generated by non-renewable and renewable sources.

The current situation and future prospects (see Figures 2, 3, and 6), whether originated from pandemics or social or political processes, highlights the urge to accelerate the pace of transition to clean energy. The transition process will demand unpredictable adjustments in the economy, society and policies, but also in individual decisions about what kind of car to buy, electricity to generate, housing to build, or production industry.

To supplement and maintain the reliability of a clean energy system, the maintenance, and even implementation of energy production from nuclear plants that guarantee against climate change and are not a source of CO2 emission, is essential.



(1) – 1st Oil Crisis; (2) – 2nd Oil Crisis; (3) – Collapse of the Soviet Union; (4) – Financial Crisis in Asia; (5) - Global Financial Crisis

Figure 6: CO_2 Emissions and Previous Economic Crises (OECD, 2020)

Source: Adapted from The Economist (2020), based on CO_2 emissions data from the Global Carbon Project. CO_2 emissions from the use of coal, oil, and gas (combustion and industrial processes).

Nuclear plants are compatible with the need for energy sources which are not based on fossil fuels. This reaffirms the importance of nuclear energy production, which has already been presented and defended in numerous studies, regarding its efficiency. It is enough to analyze that in the USA, more electricity is produced with zero carbon via nuclear power plants than with wind turbines and photovoltaic panels combined [36-42].

4 I CONCLUSION

The verification of the permanent growth of CO2 emissions, even after economic crises, confirms that the energy matrix will not present a permanent shift due to the COVID-19 pandemic. The changes lasted only during the economic slowdown brought by the acute phase of the pandemic, and were not a structural change in how the world fuels its cars or produces the electricity it consumes.

The current IPCC indicators demonstrate that consumption of energy based on fossil fuel will have to decrease and that this depends on a policy that develops new technologies and takes advantage of existing ones to bring the changes needed. Humanity must show efficiency mitigating impacts of the energy transition. Thus, nuclear energy has an important position in the portfolio of energy generation sources for the future of the world.

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