The Relationship Between Climate Emergency, Pandemics and Buildings: COVID-19 Has A Vaccine Now But Climate Emergency Has Not

Kılkış, Birol

The Relationship Between Climate Emergency, Pandemics and Buildings:

COVID-19 Has A Vaccine Now But Climate Emergency Has Not

BİROL KILKIŞ
OSTIM Technical University, Ankara, Turkey

Prof. Dr. Kilkis was born in 1949 in Ankara. He received his Ph.D. degree in Mechanical Engineering with high honors from Middle East Technical University. He graduated in 1972 with an honors degree from von Karman Institute for Fluid Dynamics in Belgium- a NATO Research Center. He completed his master degree in 1973 and PhD degree in 1979. Dr.Kilkis who received the Science Encouragement Award from TUBİTAK in 1981 retired from the METU Mechanical Engineering Department as a professor in 1999. Currently, Dr. Kilkis is the member of ASHRAE Building Performance Metrics Steering Committee and the member of ASHRAE Research Journal Sub-Committee. ASHRAE has elevated him to Fellow Grade in 2003 due to his outstanding services and has been named distinguished lecturer. In 2008, he received Distinguished Service and Exceptional Service awards from ASHRAE. He is the author of more than 500 papers in several journals and proceedings on a large variety of topics, and has several patents pending on green buildings, solar trigeneration, heat pump coupled cogeneration, and low-exergy HVAC systems. Dr. Kilkis has been appointed to the Executive Committee membership of the European Union Solar Thermal Technologies Platform in 2015. Since his commencement of this duty in 2018, he became the Vice Chair of Renewable Heating and Cooling Committee (RHC). He also served Turkish Society of HVAC and Plumbing Engineers at a capacity of President between 2017 and 2019.

E-mail: birolkilkis@hotmail.com
https://orcid.org/0000-0003-2580-3910

How to cite: Kılkış, B. (2021). The relationship between climate emergency, pandemics, and buildings: COVID-19 has a vaccine now but climate emergency has not. *Belt & Road Initiative Quarterly,* 2(3). 61-68.

ABSTRACT

This paper identifies two types of carbon dioxide gas emissions. The first type concerns direct emissions, emanating from sources that involve fossil fuels, such as industrial process, power generation, transportation, and farm waste. The second type, which has not been accounted for so far, is concerned with exergy mismatches between the supply and demand in any given process, even if no fossil fuels are directly involved. Exergy is the useful work potential of any given amount or flow of energy. This paper presents a direct link between the climate emergency and carbon dioxide emissions due to quality (Exergy) mismatches between the energy supply and energy demand, which may be minimized by proper design, control, and system selection in the built environment. It is shown that these nearly avoidable exergy mismatches are as pressing as direct emissions from fossil fuel usage and such destructions also take place in green energy systems, including solar and wind energy systems. The paper further explains that these emissions are responsible for the climate emergency (Global warming) as direct emissions are. An example is given about a wind power-heated house, and it is shown that it is responsible for emissions despite no fossil fuel being involved on the site. The paper then establishes a direct link between emission exceedances and the additional pandemic risk to conclude that buildings are responsible for most of these additional pandemic risks.

Keywords: Climate emergency, CO_2 emissions, COVID-19, global warming, pandemic-resistant building

Introduction

Climate Emergency

UN SECRETARY-GENERAL ANTONIO GUTERRES urged all countries to declare climate emergencies in his speech at the Climate Ambition Summit and asserted that more must be done to hit net-zero emissions (Reuters, 2020). He explained that global warming has already become an emergency issue, and all nations must take action. This is indeed an urgent issue, but will the wish of the UN Secretary-General come true? The answer is no, not with today`s measures, theory, and understanding being without a holistic view of the mechanism of global warming. Figure 1 shows that decarbonization measures developed so far will not be sufficient, even with carbon capture and storage (CCS). This data means a missing part in the big puzzle of sustainable decarbonization, which the Secretary-General alludes to. Current global warming data has a complete picture of the level of CO_2 content in the atmosphere (Figure 1), but overall potential solutions are not wholly recognized due to today`s limited understanding of the root causes of CO_2 emissions. Figure 1 is sad proof that the wish of net-zero carbon will never come true unless a holistic picture of the root causes is drawn.

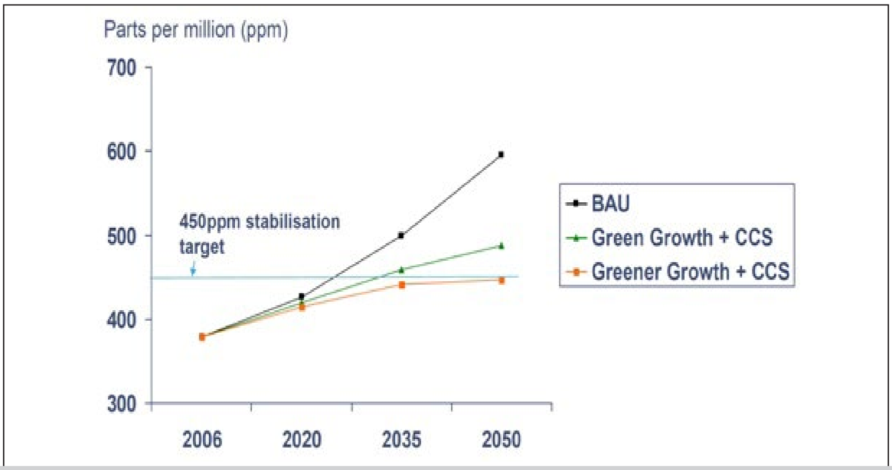

Figure 1. CO_2 concentration can hardly stabilize but will not decrease (Hawksworth, 2006)

CO_2 Emissions, Humidity, and Ozone

According to the Author, Figure 2 shows the direct relationships between the climate, atmosphere, global warming, humidity, comfort, and ozone depletion. Consider a green energy system like a wind turbine or PV. Once the electricity is generated, it is important to trace downstream how it is utilized from an exergy point of view. For example, if this "green" electric power is used in an electric radiator for indoor comfort heating at 20°C (293 K), the unit quality (exergy) of useful work demand, ε_{dem}, for heating may be calculated according to the ideal Carnot cycle:

$$\varepsilon_{dem} = \left(1-\frac{273\ K}{293\ K}\right) = 0.068\ kW/kW$$

Here, 273 K (0°C) is the reference environment condition. On the other hand, electricity is a very high-quality energy source with a unit supply exergy, ε_{sup} of 0.95 kW/kW. This means that most of the useful work potential of the generated electric power is destroyed:

$$\varepsilon_{des} = (0.95\ kW\text{-}h/kW\text{-}h) - (0.068\ kW\text{-}h/kW\text{-}h) = 0.88\ kW\text{-}h/kW\text{-}h$$

The exergy rationality of using wind or solar energy in comfort heating will be only 0.07 (0.068/0.95).

This amount of irreversibly destroyed exergy (lost opportunities for useful work) must be offset by someone, somewhere, and most likely by fossil fuels. This causes more "unseen" CO_2 emission from "green power":

$$\Delta CO_2 = [0.27\ kg\ CO_2/kW\text{-}h] \times \varepsilon_{des} = 0.24\ kg\ CO_2/kW\text{-}h$$

This result shows that although there is not a direct CO_2 emission source in this example (except in manufacturing, installation, etc.), exergy destructions are responsible for large amounts of additional emissions, which are almost equal to the emissions from a natural gas condensing boiler that we can directly measure and see.

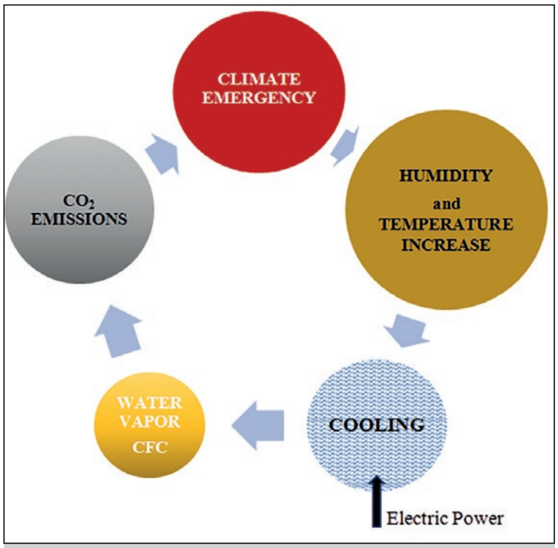

Figure 2. Climate loop with humidity and temperature increase. Drawing belongs to the author, ©2020, B. Kilkis

These additional emissions due to exergy destructions are unseen and are only revealed in the global warming temperatures. In other words, these emissions are observed in the global warming context but remain unexplained and unsolvable unless the exergy concept is recognized by scientists and engineers.

According to another research study by the Author, which mathematically relates nearly avoidable CO_2 emissions to exergy destructions (Kilkis, 2021a), for every destroyed exergy, the global temperature is estimated to increase by a rate of 0.256 x 10^{-13}K/kW-h. If, for example, 2 x 10^{13} kW-h/year is a stable number of annual electric power generation using fossil fuels, it is estimated that exergy utilization rationality in the energy sector will rise to 0.8 in the coming decades;

$\Delta CO_2 = 0.256 \times 10^{-13}$K/kW-h x 2 x 10^{13} x (1-0.8) = 0.1 K/year

As this estimation shows, the unseen part of emissions is responsible for about 0.1 K global temperature rise, and all decarbonization measures must be revised accordingly by taking into account the exergy destructions.

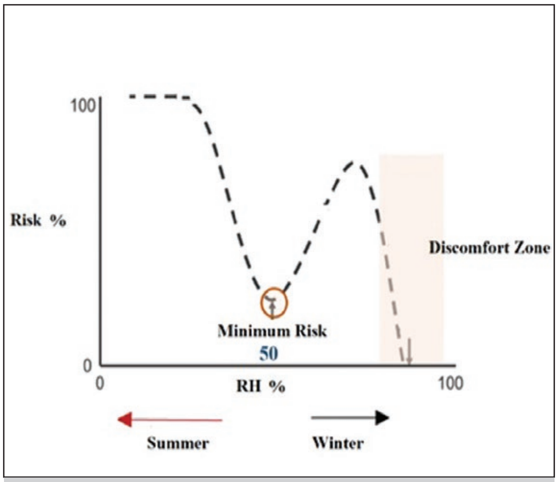

Figure 3. COVID-19 is related to CO_2 and relative humidity. Safest Relative Humidity is 50% (Lowen, et al., 2007).

Figure 4 shows that most of the world is too humid while some parts are too dry. There are almost no places with ideal RH values. For example, Turkey and other countries on the Belt and Road are in the humid zone, whereas China is not. These figures may partly account for the regions where the pandemic is strongest. Humidity is related to global temperature and CO_2 emissions.

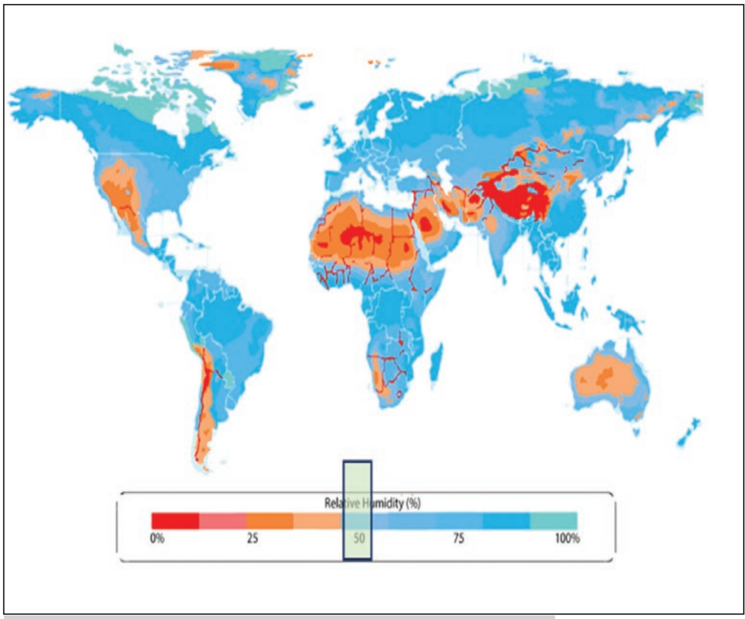

Figure 4. Worldwide relative humidity atlas (H2O, 2021)

Climate Emergency and Virus Infections

There are already qualitatively established correlations between the air temperature, humidity, and other adverse weather conditions in addition to the well-known, well-observed air pollution on the anthropogenic side of the equation. Unfortunately, there has been little quantitative modeling about virus infections and the climate emergency elements so far. That is the main reason to develop a mathematical model, which is expected to guide scientists towards further understanding the mathematics of such a direct link.

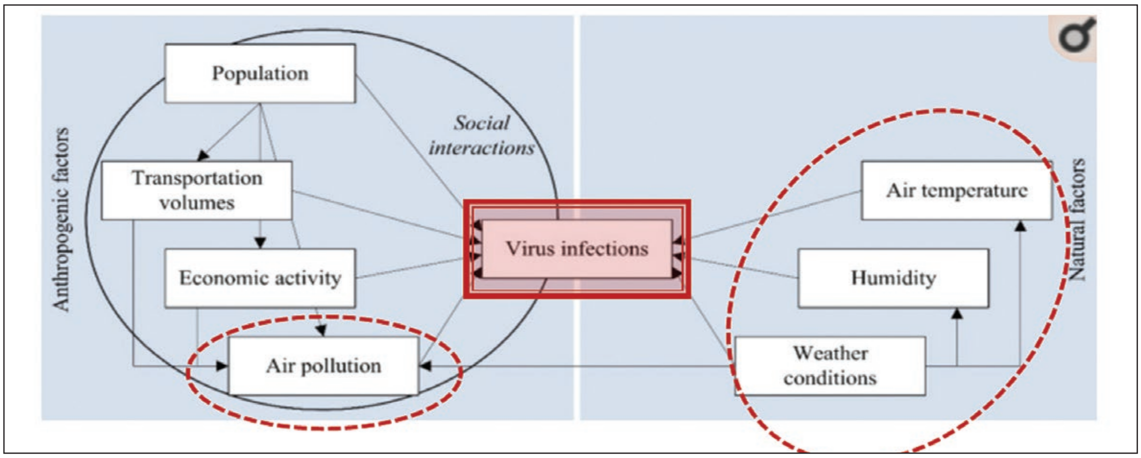

Figure 5. Anthropogenic and natural factors on virus infections adopted from: (Copiello & Grillenzoni, 2020)

A Green Building May Not Be COVID-19 Safe

Buildings are both energy-intensive and corona-virus-intensive. We spend about 90%, even more with pandemic isolation measures, of our time indoors. Buildings, especially with 100% fresh air requirements against COVID-19 spread, are responsible for approximately 45% of total energy consumption (Cao, Xilei, & Liu, 2016; Tokazhanov, et al., 2020).

Such a high level of energy consumption means exceptionally high CO_2 emission responsibilities, and the green energy they may use may not be green, depending upon the energy usage. For example, the Chinese government considers reducing CO_2 emissions in cold rural areas by replacing local coal and lignite stoves and boilers with local wind turbines. A preliminary study (Kilkis, 2021b) revealed that the direct use of wind energy for heating, even with heat pumps, is not rational as claimed by the 1st Law. The refrigerant leakage from a heat pump also has a ΔCO_2 -equivalent ozone depletion effect. For each kW-h of wind electricity supply, the emission responsibility based on R32 refrigerant with a global warming potential (GWP) of 677 and an assumed leakage rate, L of 1.7×10^{-4} kg/h, is calculated as follows:

$$\sum CO_2 = 0.63 \times 1\ \text{kW-h} \times \left(1 - \frac{\varepsilon_{dem}}{\varepsilon_{des}}\right) + \left(\frac{L}{1\ \text{kW-h}}\right) GWP = 0.65\ \text{kg}\ CO_2/\text{kW-h}$$

On the other hand, for a lignite stove with ε_{sup} = 0.8 kW/kW for lignite and an efficiency of 0.35 without any ozone depletion potential (no refrigerants), ΣCO_2 is only 0.26 kg CO_2/kW-h of heat supply. Therefore, although the 1st Law indicates almost zero CO_2 responsibility with COP =3, the 2nd Law shows that the nearly avoidable emissions responsibility is 2.5 times.

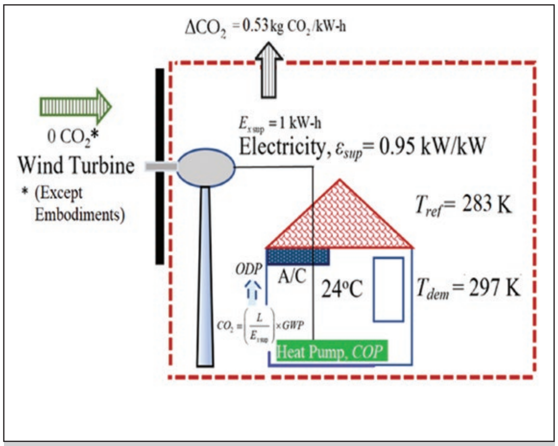

Figure 6. Wind-to-Heating in Chinese Projects. Drawing belongs to the Author, ©2020, B. Kilkis (Kılkış, 2021b)

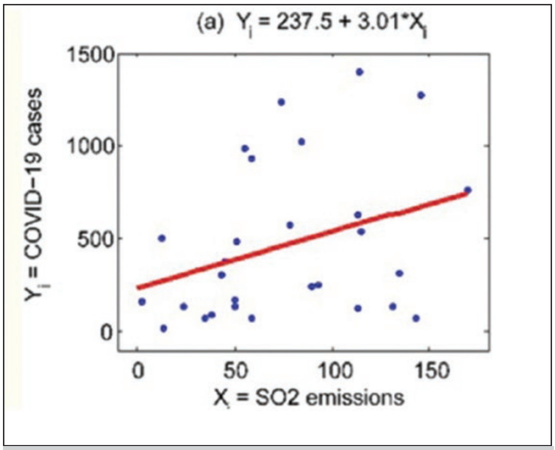

Figure 7. March 2020 preliminary data for Italy (Setti, et al., 2020)

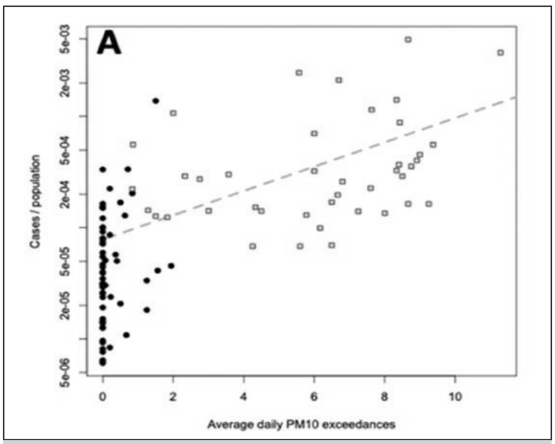

Figure 8. Cases per population correlation with daily PM_{10} exceedance (Setti et al., 2020)

The Need for the Present Study

The importance of such preliminary data is that in many countries, including Turkey, exceedances are high. PM_{10} means the amount of particulate matter with diameters less than or equal to 10 micrometers (0.01 mm) in the air (EPA Victoria, 2021). It needs to be officially monitored hourly, year-round. A good air quality corresponds to less than 40 PM_{10} μg/m^3 averaged over 1 hour. WHO limits this value to 20 PM_{10} μg/m^3. Any exceedance over this limit has several health risks depending on the amount recorded; if PM_{10} μg/m^3 averaged over 1 hour is above 300, then the air quality is extremely poor. For example, in Ankara PM_{10} limits were exceeded 287 days out of 365 days in a year. This value is a clear indication of the severity and urgency of the case.

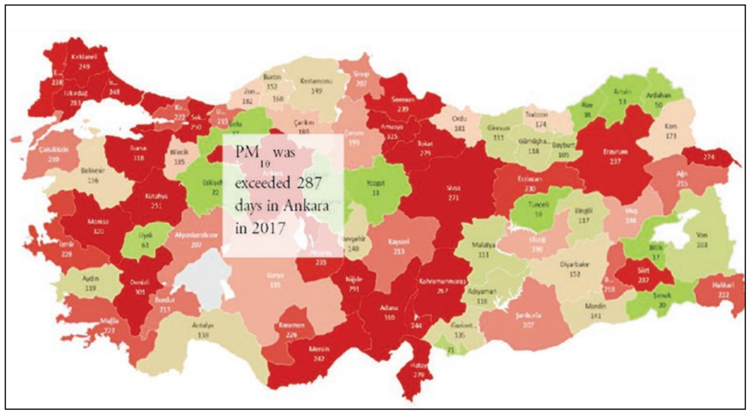

Figure 9. PM_{10} exceedance days in one year in Turkey (Nur, 2018)

Figure 10. 50 PM_{10} μg/m^3 exceedances for 2019 (UCTEA Chamber of Enviromental Engineers, 2019).

According to Figure 10, only the province of Hakkari does not exceed 50 PM_{10} μg/m^3 more than 35 times a year. All other provinces exceed this limit annually, and the limit of 50 PM_{10} μg/m^3 is a quite high value, already corresponding to short-term unhealthy conditions, especially during the pandemic period. Grey areas are provinces where measurements are not available for more than 75% of the year.

The Correlation Model

A model was developed based on initial data from Italy about daily COVID-19 cases per thousand people as a function of PM_{10} and $PM_{2.5}$. The difficulty in adopting their correlations to CO_2 versus COVID-19 cases was their unavailability. Therefore, it was necessary first to establish a relationship between PM values and CO_2 emission values. This is the first step in determining all the interrelations among four conflicting factors (Quadrilemma) and six vectors. The rest of the interrelationships are already available, known, or more easily determinable. Recently, the COVID-19 pandemic became a bilateral relative with all of them (See Figure 11). Therefore, it is time to include the concept of "Pandemic Resistant Buildings" to the green metrics under a broadened title of safe buildings.

PM is related to CO_2 emissions now, which is shown in Figure 12 and the following linear relationship in terms of the average conversion mapping factor, f. For example, for marine diesel engines, the proportion of $PM_{2.5}$ to CO_2, namely the f factor, is 0.002 by weight. In coal or lignite-fired power plants, this ratio is about 0.1. Therefore, as long as fossil fuels will be kept in diminishing use in several sectors, ΔCO_2, which has remained unaccounted for so far, is an important factor in pandemic risk.

An estimate for the factor f may be approximated to be 0.06 by weight. This means that 1 kg ΔCO_2 is responsible for an increase of 0.06 kg $PM_{2.5}$ increase. Depending on the limits of the local maximum number of daily exceedances, the potential COVID-19 case increase per population in that locality may be estimated. For such an endeavor, current medical reports, which are shown in Figures 8 and 9, were used.

$$PM_{2.5} = fCO_2$$

$$CP = \left(0.000006 \times CO_{2exceedance} + 0.0001\right)$$

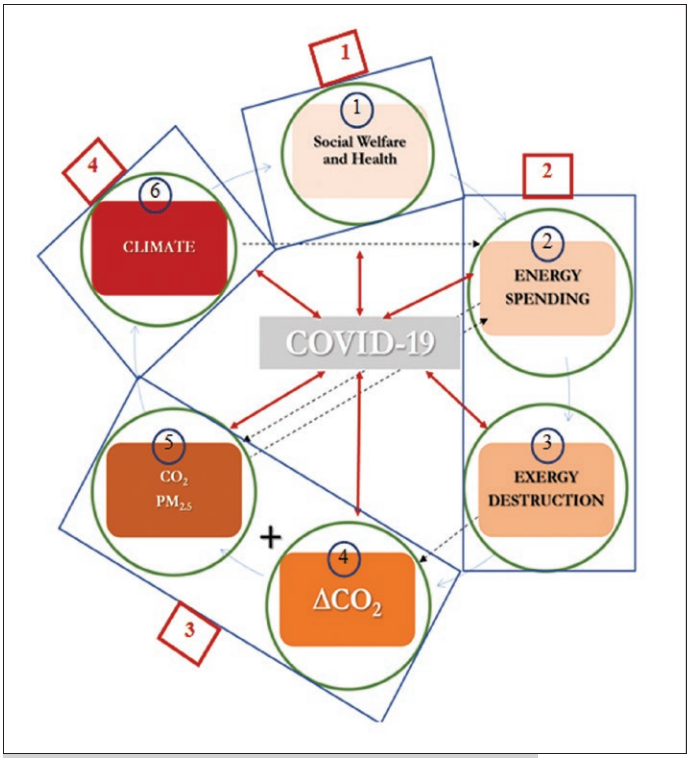

Figure 11. Quadrilemma of pandemic-resistance concept against climate emergency (Erten & Kilkis, 2021).
Drawing belongs to the author, ©2020, B. Kilkis.

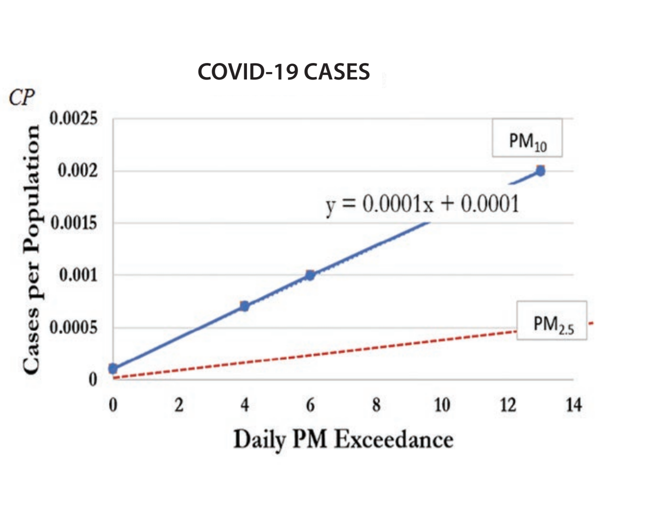

Figure 12. NO_X emissions exceedance and COVID-19 cases per population, *CP*. Prepared by the author from figures 7 and 8, ©2020, B. Kilkis

Daily exceedance of CO_2 from local air quality measures may be determined. The exceedance limit may be established by local and national authorities. For example, if the exceedance limit is 300 ppm in a given district and CO_2 concentration exceeds this limit 22 times, then *CP* is 0.0002, meaning two more cases in a population of 10,000 due to CO_2 exceedance. This is an additional number of cases over the particulate matter exceedances. If the CO_2 level is always above the 300-ppm limit, then the upper case of an additional 25 cases per ten thousand population may be estimated. However, more data is needed to project the current exceedance correlation further.

Results and Discussions

It is known that changing climatic conditions will also have significant effects on human health, even increasing the death rate. Deaths and diseases associated with weather conditions may increase due to more frequent extreme climatic events. The increase in the number of consecutive very hot days will directly affect acute health problems, especially in the elderly and those with chronic cardiovascular or respiratory disease. The increased risk of flood will also change landscapes and the spread risks of communicable diseases due to infectious and/or new disease-causing microorganisms or vectors entering new environments. Also, due to climate change, there is an increased possibility of the spread of serious infectious diseases carried by insects such as zoonoses.

This research has developed an initial correlation between additional COVID-19 cases and local CO_2 concentrations. This correlation may now be linked to buildings and their emission responsibilities because, currently, they are responsible for more than 45% of emissions due to the 100% fresh air requirement and increased time spent indoors. The work presented here is the first step of the ambitious research plan to complete the puzzle shown in Figure 11. This is paramount work that needs to be done by all nations, as the UN Secretary-General urged in the Paris agreement. If this goal is achieved in time, it will also reduce the risk of current and future pandemics.

References

Cao, X., Xilei, D. & Liu, J. (2016). Building energy-consumption status worldwide and the state-of-the-art technologies for zero-energy buildings during the past decade. Energy and Buildings. 128. 10.1016/j.enbuild.2016.06.089. Retrieved from https://www.researchgate.net/publication/304712030_Building_energy-consumption_status_worldwide_and_the_state-of-the-art_technologies_for_zero-energy_buildings_during_the_past_decade

Copiello, S. & Grillenzoni, C. (2020). The spread of 2019-Ncov. in China was primarily driven by population density. Comment On "Association between short-term exposure to air pollution and COVID-19 infection: Evidence from China" By Zhu Et Al., Elsevier Public Health emergency Collection. Retrieved fromhttps://www.ncbi.nlm.nih.gov/pmc/articles/PMC7365069/

EPA Victoria. (2021, March 16). PM10 particles in the air. Retrieved from https://www.epa.vic.gov.au/for-community/environmental-information/air-quality/pm10-particles-in-the-air

Erten, D., & Kilkis, B. (2021). How can green building certification systems cope with the era of climate emergency and pandemics? Manuscript submitted for publication.

H2O. (2021). Atmospheric water collector production. Retrieved from https://h2omachine.com/humidity-maps/

Hawksworth, J. C. (2006). The world in 2050: Can rapid global growth be reconciled with moving to a low carbon economy? Retrieved from https://www.pwc.com/gx/en/psrc/pdf/world_in_2050_carbon_emissions_psrc.pdf

Kilkis, B. (2021a). Is exergy destruction minimization the same thing as energy efficiency maximization? Journal of Energy Systems, DOI: 10.30521/jes.

Kilkis, B. (2021b). (In Print). An exergy-based minimum carbon footprint model for optimum equipment oversizing and temperature peaking in low-temperature district heating systems, Energy.

Lowen, A. C., Mubsreka, A. S., Steel, S., & Palese, P. (2007). Influenza virus transmission is dependent on relative humidity and temperature. PLos Pathog, 3(10), 1470-1476. PMC2034399.

Nur, O. K. (2018). Air pollution in Istanbul. Netherlands Enterprise Agency.

Reuters. (2020). U.N. chief urges leaders of every country to declare "climate emergency". Retrieved from https://www.reuters.com/article/uk-climate-change-un-summit-idUSKBN28M0IR

Setti, L., Passarini, F., De Gennaro, G., Barbieri, P., Licen, S., Perrone, M. G., Piazzalunga, A., Borelli, M., Palmisani, J., Di Gilio, A., Rizzo, E., Colao, A., Piscitelli, P., & Miani, A. (2020). Potential role of particulate matter in the spreading of COVID-19 in northern Italy: First observational study based on initial epidemic diffusion. BMJ Open. Retrieved from https://bmjopen.bmj.com/content/bmjopen/10/9/e039338.full.pdf

Tokazhanov, G., Tleuken, A., Guney, M., Turkyilmaz, A., Karaca, F. (2020). How is COVID-19 experience transforming sustainability requirements of residential buildings? Sustainability, 12, 8732. https://doi.org/10.3390/su12208732. Retrieved from https://www.mdpi.com/2071-1050/12/20/8732/htm

UECTA Chamber Of Enviromental Engineers. (2019). Air Pollution Report 2019. Retrieved from https://www.tmmob.org.tr/sites/default/files/2019.pdf