Journal of Engineering for Sustainable Buildings and Cities

Editorial

Reflecting on Impacts of COVID19 on Sustainable Buildings and Cities

The pandemic of Coronavirus Disease or COVID19 has disrupted all aspects of our lives in many ways since it was first detected in the early part of the year 2020; personal and professional lives were impacted including workplaces, learning environments, businesses, commerce, and industry. The global toll of impacted people has been higher than many anticipated, with more than 100 M confirmed infections as of this issue and more than 2.5 M of confirmed casualties [1]. To a large degree, buildings are at the center of the pandemic in terms of spread and its control. The severe acute respiratory syndrome coronavirus 2 (SARS CoV-2) virus spreads rapidly from person to person as the main contamination source presenting major challenges for human socializations and interactions, which occur mostly in indoor environments. Thus, indoor environments are a potential opportunity to reduce infection or to increase risk, if not properly ventilated. At the center of indoor environments are mechanical systems that control temperature and humidity levels, and ventilation rates, all requiring electrical energy to operate. The sudden shift from normal life to lockdowns and the associated reduced economic activities across the world have had unintended consequences to the use of buildings, where people tended to spend longer periods to conduct their daily personal and professional routines. This complex situation that places buildings at the center of human activities raises many questions about our state of knowledge and technology to face these extraordinary challenges presented by global pandemics; what should be the preparedness to properly manage indoor environments? How the energy infrastructure is coping with these challenges, how energy should be used to maintain proper indoor environments, and prolonged lockdown states? What are the impacts of extended stays in indoor environments on human health? What are the impacts on social equity and demographics? How pandemics may influence our future buildings' science and design practices?

These are some of the many questions that may need to be answered by buildings scientists and engineers. To reflect on these complex questions and to forge a forward agenda for our scientific and engineering community, a group of colleagues organized an initial open conversation at the ASME 2020 Energy Sustainability Conference, held virtually for the first time, this past month of June 2020. Prof. Max Zhang of Cornell University, and Dr. Kishor Khankari, ASHRAE Fellow President and Owner at AnSight LLC, joined the JESBC's Chief Editors, to reflect on specific and broad topics that included the following: (a) impacts of COVID19 on mechanical systems for indoor environments, (b) the role of COVID19 in outdoor environments, (c) how COVID19 has impacted energy demands in buildings with a global perspective, and (d) what maybe the role of COVID19 in social equity. Short summaries of these reflections are given in the following sections.

COVID19 and Indoor Environments

This topic has been, likely, one of the most debated aspects of the crisis, particularly as it refers to learning environments and workplaces. Standards for ventilation and filtration have been well established by several organizations such as the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) [2,3] and ASME. ASHRAE recommends filtration rates higher than Minimum Efficiency Reporting Value (MERV13), which may control particulate matter smaller than 1.0 μm at efficiencies higher than 85%, while high efficiency particulate air (HEPA) filters have an efficiency of more than 99% to control particulate matter higher than 0.3 μm as tested by ASME standards. Virus particles, including SARS CoV2, have an average aerodynamic diameter between 0.3 and 3.0 μm. The key challenge in implementing these types of filtration systems is the fact that most existing HVAC systems are not designed for the pressure levels these filtration systems may require. Extensive retrofits may be required in most existing buildings to meet these filtration standards including modifications to fans, which also lead to higher levels of energy consumptions. This topic has been a source of debate at institutional levels; New York City Public school system was under extreme pressure during the fall of 2020 to upgrade the mechanical systems to comply with these requirements as part of the possible solution to return students to the classroom [4]. The current infrastructure of buildings presents additional challenges to control the spread of the virus as most buildings have been designed to provide minimum ventilation rates during the heating season. The US on average is a cold climate environment, and most energy from buildings is used for space heating rather than cooling. Most buildings are equipped with radiant heating systems, far more efficient than ventilated heat pumps, however, providing poor ventilation. High ventilation rates are required for proper indoor air quality control, particularly under health risk conditions such as during global pandemics. This scenario suggests a rethinking of our approach to control indoor air quality, for new and existing building stocks. Under extreme conditions, the need for more demanding cleaner environments such as health centers and patient care points may require personalized indoor controls at the room levels and patient scales. These solutions and others are currently explored by some groups including AnSight LLC [5] to design personalized indoor environments with the aid of computational fluid dynamics (CFD) analyses.

COVID19, Outdoor Air Quality, and Climate Change

Outdoor air quality has seen significant improvements during the pandemic mainly due to the substantial reductions in economic and industrial activities, including transportation services. However, the risks of unhealthy outdoor conditions remain, particularly in very dense urban environments. Climate change remains a concern that COVID19 will likely not dissipate. Extreme heat events remain a threat to the urban environments [6,7], and our knowledge of this excessive heat event in air quality is increasing. Figure 1 shows recent observations by City College of New York researchers of an extreme heat event and its interaction with ozone as the result of photochemical reactions. Surface ozone is deadly to human

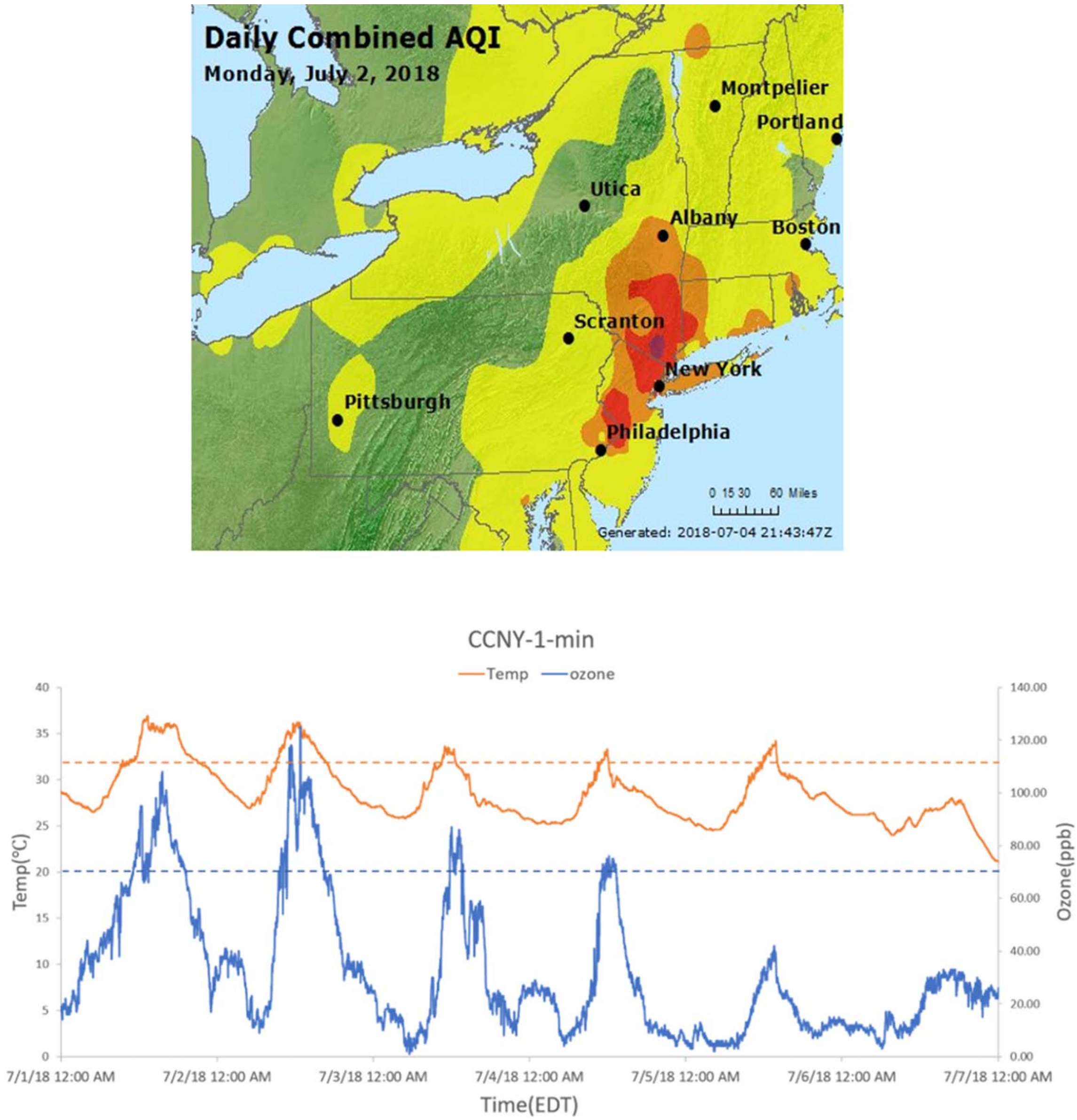

Fig. 1 Observations of surface temperature and ozone levels during a heatwave in July 2018 in New York City. Top—spatial distribution of air quality (red—unhealthy) and bottom—time series of surface temperature and ozone levels in Manhattan (City College of New York Station).

health, impacting those more vulnerable to respiratory illnesses. One wonders about the possible impacts of these harsh outdoor conditions in populations with minimum resources to remain indoor, due to lack of HVAC systems during the pandemics, or the level of technology to manage these conditions as part of the mechanical ventilation and infiltration systems.

COVID19 and Energy Demands

How the energy demands were impacted by the lockdowns, and in particular, the shifts in energy demands for the building sector is an issue of major practical and planning concerns. This question has been evaluated by a team from the University of Colorado Boulder led by Prof. Krarti, by analyzing energy demands changes pre and post-COVID19 with the limited available data, providing interesting insights into the impacts of the lockdowns for various sectors worldwide. Figure 2 shows total electricity demand reductions by more than 25% in some countries [8], consistent with more recent reports by the International Energy Agency [9]. Table 1 provides more specific data on the impact of lockdowns on the energy demand of the building sector for three countries, with a clear indication that an increase in energy demand of the residential building sector occurred due to the lockdowns while a slowdown of the commercial activities led to a decrease in their energy needs [10]. This type of information suggests the need for continuous monitoring of energy demands at large scales and to use these new data streams to adapt our designs of the built environment to accommodate occupant behaviors including where they are spending most of their time conducting multiple activities, under healthy conditions. How can our future buildings be multi-functional and healthy?

COVID19 and Social Equity

The key issue of social equity as it relates to indoor environments has been exacerbated by the COVID19 crisis. People are being forced to spend more time indoors, where conditions may not be healthy due to the lack of adequate HVAC systems. This question

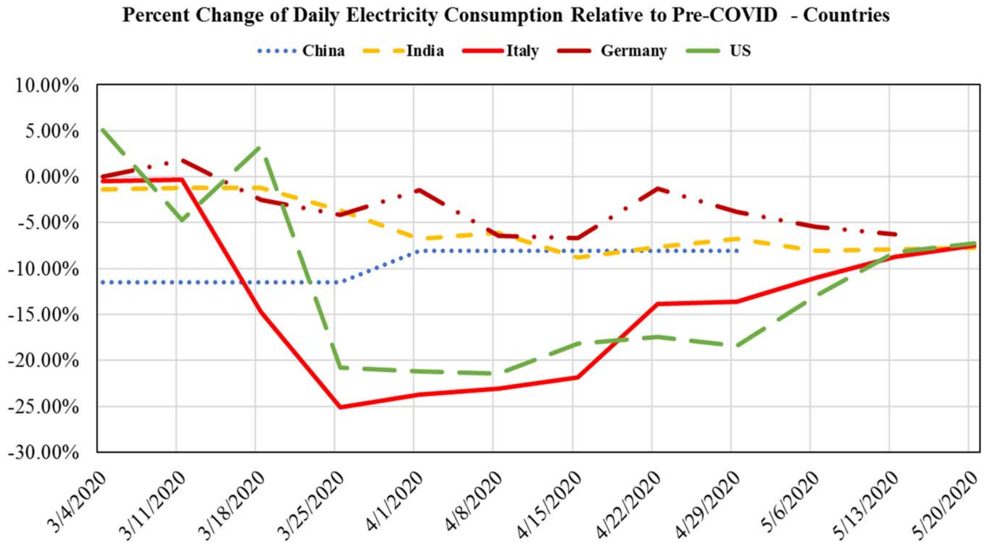

Fig. 2 Impacts of daily electricity demand reduction (pre-/post-COVIDD19) for selected countries

Table 1 Impact of COVID19 lockdowns on the energy demand of the building sector for selected countries

	Impact of electricity demand by sector (+ is increase and −decrease)				
Country/State	All	Residential	Commercial	Industry	Period of analysis
Argentina	−20%	NA	−18.2%	−32.4%	One week before and after lockdown
Australia	+1%	+14%	−7%	−1%	One week before and after lockdown
UK	−15%	+17%	NA	NA	Same periods for 2020 and the previous year

has been started to be addressed by a few research teams including those from the City College of New York. A recent article suggested the role of socio-economics in the use of HVAC systems for New York City [11]. Figure 3 illustrates a synthesis of this study where the percentage of residents with HVAC ownership is geospatially presented, along with the economic burden that using HVAC systems during the summer season may represent to the residents. This analysis blends geospatial demographic data and socio-economic information along with building energy modeling. As we consider extended stay home periods due to COVID, these social discrepancies will be further reflected, demanding socio-technical analysis and solutions to mitigate against the compounding challenges of climate change, low-income vulnerable communities, and global pandemics.

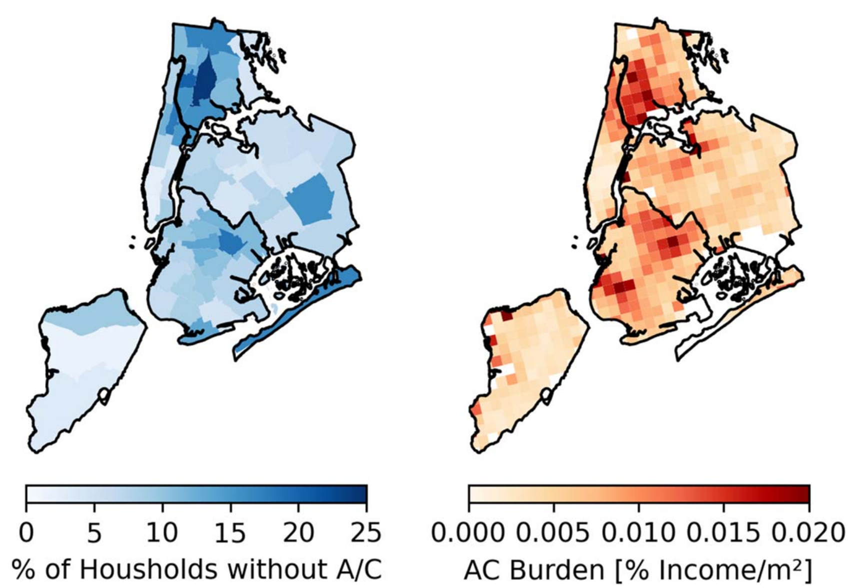

Fig. 3 Percentage of households with HVAC in New York City and projected associated cost of using HVAC systems as a function of income (source: Gamarro et al. [11])

Closure

In summary, it is too early to anticipate a complete end to the pandemic caused by COVID19; however, there is much to be learned from this experience to cope with its effects during present times, and certainly for future events. It is more likely that COVID19 and its impacts will be present in our lives for a long time and we need to adapt to this new norm. Thus, the crisis has shaken all aspects of societies and communities, including our conception of buildings, occupancy, buildings systems, and related energy demands. We are hopeful this wakeup call is serving to inspire new research concepts and approaches that will lead to buildings systems, which result in healthy and safe indoor environments as well as in resilient sustainable buildings and cities. We look forward to this dialog, hoping our Journal is a primary forum for these much-needed discussions and dissemination of novel and practical solutions to tackle some of the challenges created by COVID19 for the built environment.

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