Residential Buildings Committee (RBC) Residential Issue Brief:

Wildfire Smoke Hazards for Dwelling Occupants

The Issue

Wildland fires are occurring with increased frequency and intensity throughout many areas of the world. This is due to accumulated fuels from forest management practices that suppressed fires over many decades, combined with extended periods of hot and dry conditions associated with climate change (Abatzoglou et al. 2016; Boer et al. 2009; Dennison et al. 2014; Rasker 2015; Schoennagel et al. 2017; Westerling et al. 2006).

The smoke from wildland fires contains fine particulate matter ($PM_{2.5}$) – as much as 90 percent of the particle mass emitted from a wildfire is made up of $PM_{2.5}$ or smaller particles (Groβ et al. 2013; Vicente et al. 2013). $PM_{2.5}$ consists of ultrafine particles, toxic particle-phase constituents, and many irritant gases including acrolein, formaldehyde, organic acids (O'Dell et al. 2020) and carbon monoxide. When fires reach and burn buildings, the human-produced materials add toxic constituents to the smoke, including polychlorinated biphenyls (PCBs) and polybrominated diphenyl ethers (PBDEs). Burning of buildings during wildfires is increasing due to many factors, including larger fires and the larger footprint of development at or near the wildland-urban interface (Radeloff et al. 2018; Schoennagel et al. 2017).

A single wildfire event can result in a large region experiencing levels of $PM_{2.5}$ that exceed the guideline-based daily average ambient air quality standards (Nazarenko et al. 2021) over many days (Ryan et al. 2021). While indoor concentrations of outdoor $PM_{2.5}$ can be decreased during infiltration and by removal through deposition indoors, these very high outdoor concentrations can lead to large portions of the population experiencing exposures in their dwellings that exceed the World Health Organization (WHO) exposure guideline of 25 μg m^3 over a 24-hour period (WHO 2006). Even as controls effectively reduce emissions of sources of $PM_{2.5}$ caused by human activities, wildfires are projected to become the predominant source for exceedances of ambient air quality standards (Ford, et al. 2018).

Some chronic health conditions contribute to greater susceptibility to wildfire smoke. These include respiratory compromises such as asthma, COPD, and bronchitis (U.S. EPA 2019). Diseases of the circulatory system, including high blood pressure and coronary artery disease, can be exacerbated by fine particles and other related air contaminants (U.S. EPA 2019). Exposure to elevated levels of wildfire smoke specifically has been linked to many adverse health outcomes (Arriagada et al. 2020; Black et al. 2017; Cascio 2018; Kunzli et al. 2006; Liu et al. 2015; Reid et al. 2019).

A recent study reported that $PM_{2.5}$ from wildfires appears to be substantially more harmful to respiratory health than non-wildfire $PM_{2.5}$, resulting in larger increases in respiratory hospitalization rates per 10 ug/m^3 increase in ambient concentration (Aguilera et al. 2021). This is consistent with a previous meta-analysis on smoke and respiratory outcomes (Arriagada et al. 2019).

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Segments of the population in various life stages are impacted differently by wildfire smoke. Children have respiratory systems that are still developing and thus more vulnerable, inhale more air per pound of body weight, and are often more active and spend more time outsides compared to adults (Sacks et al. 2011). During pregnancy women experience higher respiratory rates; this and other physiological changes may make them and their developing fetus' more vulnerable (Holstius et al. 2012; Li et al. 2017; Melody et al. 2019). Aging adults may also be more susceptible due to higher incidence of chronic disease and natural decline in lung function over time (U.S. EPA 2019).

The impacts of wildfire smoke are not equal across the socioeconomic spectrum. Some research has found that areas with the lowest socioeconomic status are at the greatest risk of adverse effects (Hanigan et al. 2008; Rappold et al. 2012), including indigenous populations. The reasons for this are complex, but include underlying heath conditions, leakier buildings allowing more smoke infiltration, and lack of air conditioning forcing occupants to open windows for ventilation and cooling. Renters are in a particularly challenging situation because they suffer from the hazards of wildfire smoke, but owners pay for improvements to the building.

What does this mean for ASHRAE?

Wildfire smoke exposure is becoming a seasonal event in many communities. Increases in property loss, Illness, and mortality are well documented (Burke et al. 2021; Fann et al. 2018; Matz et al. 2020). ASHRAE is uniquely qualified to provide guidance on building performance and the design, operation and maintenance of heating, ventilating, and air-conditioning systems to help protect occupants of diverse socioeconomic status, life stages, and health conditions from exposure to wildfire smoke.

The Role of ASHRAE

ASHRAE can provide evidence-based information and guidance to protect occupants from smoke exposure and help designers create residential buildings and systems to limit smoke entry and concentrations, thereby increasing building resiliency. As a recognized authority for developing standards and guidelines, ASHRAE has demonstrated the capability to evaluate the effectiveness of proposed protective measures. ASHRAE can help improve health outcomes during wildfire events.

Through its technical and educational committee structure, ASHRAE should consider the following actions:

1. Review and develop appropriate engineering interventions and operational recommendations to protect the building occupants from the impacts of wildfire smoke for
    - The building envelope
    - New construction practices
    - Existing HVAC systems
    - Existing structures in poor condition with high air infiltration rates
    - Enhanced filtration and filter maintenance
2. Support research to evaluate the effectiveness of proposed engineering interventions and operational recommendations focusing on smoke-resistant residential buildings and related resiliency. RBC should coordinate research proposals with appropriate ASHRAE committees and its residential partner organizations.

3. Evaluate and modify existing, or develop new, ASHRAE Standards and Guidelines to address occupant protection during wildfire smoke events, including possible new requirements in ASHRAE Standard 62.2.
4. Develop educational materials for engineering professionals, HVAC technicians, and the public. RBC should coordinate efforts with appropriate ASHRAE committees and its residential partner organizations.

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Contributors

Patricia Graef, Munters Corporation (Ret.), Residential Buildings Committee Chair
Rick Karg, Residential Energy Dynamics, LLC, Residential Buildings Committee Vice-Chair
Steven J. Emmerich, National Institute of Standards and Technology
Brett C. Singer, Lawrence Berkeley National Laboratory, Sustainable Energy & Environmental Systems Dept
Tom Javins, University of Montana (Ret.)
Eric D. Werling, U.S. Department of Energy, Building America Program