

Indoor Air Quality in Homes

*State Policies for Improving Health Now
and Addressing Future Risks
in a Changing Climate*

CHAPTER 2: WILDFIRE SMOKE



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CHAPTER 2

Wildfire Smoke

In recent decades, the incidence of large wildfires in the United States has risen dramatically, along with average annual acreage burned.⁴² In 2015, wildfires burned over 10 million acres in the country, the most on record.⁴³ In 2016, wildfires affected communities from California and the Pacific Northwest to the Mississippi Valley and Southeastern U.S.⁴⁴

Federal, state, and local agencies are grappling with a multitude of risks posed by wildfires, including injury to firefighters and residents, property destruction, and ecological damage. In addition, the risks from wildfire *smoke* have important consequences for public health and the economy. The health effects “range from eye and respiratory tract irritation to more serious disorders, including reduced lung function, bronchitis, exacerbation of asthma and heart failure, and premature death.”⁴⁵ Most vulnerable to these risks are older adults, children, those with preexisting health problems, and people who lack the financial and other resources needed to protect themselves.⁴⁶

The risks from wildfire smoke exposure are not limited to people living in communities directly affected by the fire. Smoke from wildfires can increase air pollution and respiratory impacts over a very large area.⁴⁷ Consider this contemporaneous account of the 2016 Santa Clarita fire in Southern California:

*Smoke from the fire, burning through parts of the Angeles National Forest just north of Los Angeles, is visible from the city and cast a pall over the entire region this weekend, prompting sinister scenes. Ash rained down on cars and beaches. The sun appeared as a smoky red ball in the sky in downtown Los Angeles on Saturday, and the fire was a trending topic on Twitter. Smoke from the fire has reached as far as Las Vegas.*⁴⁸

⁴² See A. Westerling, Increasing Western US Forest Wildfire Activity: Sensitivity to Changes in the Timing of Spring, *Phil. Trans. R. Soc.* 371, 4 (2016), http://ulmo.ucmerced.edu/pdf/files/16RSTB_Westerling.pdf; U.S. Env'tl. Protection Agency (EPA), Climate Change Indicators, Wildfires (Figs. 2, 4), <https://www3.epa.gov/climatechange/science/indicators/ecosystems/wildfires.html>.

⁴³ See NOAA, Nat'l. Centers for Env'tl. Information, Wildfires – Annual 2015, <https://www.ncdc.noaa.gov/sotc/fire/201513>; National Interagency Coordination Center, Wildland Fire Summary and Statistics Annual Report 2015 at 9, http://www.predictiveservices.nifc.gov/intelligence/2015_Statsumm/intro_summary15.pdf.

⁴⁴ As NASA recently noted, “The Mississippi Valley (and total Southeast U.S. including the Plains) actually sees more fires every fire season than the Western States which tend to receive a lot of national attention. The main difference is that the fires in the Southeast are smaller and less intense than the monster fires of the West.” NASA, Fires Overtake Landscape in the Mississippi Valley (Oct. 16), <https://www.nasa.gov/image-feature/goddard/2016/fires-overtake-landscape-in-the-mississippi-valley>.

⁴⁵ U.S. EPA, USFS, U.S. Centers for Disease Control and Prevention, Calif. ARB, Wildfire Smoke: A Guide for Public Health Officials (rev. 2016) at 13 [hereinafter Wildfire Smoke Guide], <http://bit.ly/2dXBcFG>.

⁴⁶ Wildfire Smoke Guide, *supra*, at 14-17.

⁴⁷ W. Fisk, Review of Some Effects of Climate Change on Indoor Environmental Quality and Health and Associated No-Regrets Mitigation Measures at 8 (2015), <http://bit.ly/2eb1pmy>.

⁴⁸ E. Holthaus, “The Sand Fire in Santa Clarita Offers Omens of a Fiery Future,” *Pacific Standard* (July 24, 2016), <https://psmag.com/the-sand-fire-in-santa-clarita-offers-omens-of-a-fiery-future-e142811ed90e#.e6l4oh8tf>.

This chapter provides background on the issue of indoor exposure to wildfire smoke and describes several key issues for consideration in developing state policies and programs to reduce exposure. These considerations are relevant not only for states that are currently most affected by wildfire smoke, but also for states that will be impacted as a result of increased wildfire activity in the future.

Background

Wildfires in the United States

The years ahead are expected to see more wildfires as a result of conditions associated with climate change.⁴⁹ In the wake of the record-setting 2015 wildfire season, a Forest Service report stated, “The U.S. burns twice as many acres as three decades ago and Forest Service scientists believe the acreage burned may double again by mid-century.”⁵⁰ At the same time, there has been a marked increase in the length of the average wildfire season – now eleven to twelve weeks longer than in the 1970s.⁵¹ As EPA has noted, “The extent of area burned by wildfires each year appears to have increased since the 1980s. According to National Interagency Fire Center data, of the 10 years with the largest acreage burned, nine have occurred since 2000, including the peak year in 2015....This period coincides with many of the warmest years on record nationwide...”⁵²

Wildfires have traditionally been associated with the West, and western states have been hardest-hit by the trends described above.⁵³ Nevertheless, federal data show that states in other regions of the country also have experienced increases in acres burned by wildfires in recent years.⁵⁴ A recent paper by U.S. Forest Service researchers projected that wildfire potential will increase not only in the Southwest, Rocky Mountains, and Pacific coast, but also in the northern Great Plains and the Southeast.⁵⁵

⁴⁹ See National Academy of Sciences – Institute of Medicine, *Climate Change, the Indoor Environment, and Health* at 104 (2011), <https://www.nap.edu/catalog/13115/climate-change-the-indoor-environment-and-health> (“Climate change is expected to increase the frequency of wildfires. Higher ambient temperatures combined with episodes of drought could lead to periods with a higher tendency for forests to burn.”). See also J. Abatzoglou & A. Williams, *Impact of Anthropogenic Climate Change on Wildfire across Western US Forests*, Proceedings of the National Academy of Sciences (2016), <http://www.pnas.org/content/early/2016/10/05/1607171113.abstract?tab=dsb>; J. Yoon, et al., *Extreme Fire Season in California: A Glimpse into the Future?* Bulletin of the Amer. Meteorological Society (2015), https://www.researchgate.net/publication/283425168_Extreme_Fire_Season_in_California_A_Glimpse_Into_the_Future.

⁵⁰ U.S. Forest Service (USFS), *The Rising Cost of Wildfire Operations: Effects on the Forest Service’s Non-Fire Work* at 2 (2015), <http://www.fs.fed.us/sites/default/files/2015-Rising-Cost-Wildfire-Operations.pdf>. “The six worst fire seasons since 1960 have all occurred since 2000. Moreover, since 2000, many western states have experienced the largest wildfires in their state’s history.” *Id.* at 6. See also Institute of Medicine, *Climate Change, the Indoor Environment, and Health*, *supra*, at 47, 104.

⁵¹ USFS, *The Rising Cost of Wildfire Operations*, *supra*, at 2. See also Westerling, *supra*, at 6-8.

⁵² U.S. EPA, *Climate Change Indicators: Wildfires (Key Points)*, <https://www.epa.gov/climate-indicators/climate-change-indicators-wildfires>.

⁵³ *Id.*

⁵⁴ See U.S. EPA, *Climate Change Indicators: Wildfires (Figure 5-Change in Annual Burned Acreage by State Between 1984-1999 and 2000-2014)*, <https://www.epa.gov/climate-indicators/climate-change-indicators-wildfires>.

⁵⁵ See Y. Liu, et al., *Future U.S. Wildfire Potential Trends Projected using a Dynamically Downscaled Climate Change Scenario*, *Forest Ecology and Management* 294, 131-133 (2013), https://www.firescience.gov/projects/08-1-6-06/project/08-1-6-06_08_1_6_06_Deliverable_01.pdf.

Wildfire smoke is already having a considerable impact on levels of particulate matter (PM) in ambient air.⁵⁶ The anticipated increase in future wildfire activity is expected to lead to an increase in the mean outdoor air levels of fine particles in the western U.S.⁵⁷ These air pollution impacts are not limited to the immediate area of a wildfire. As winds carry fine particulates and ozone precursor gases, smoke can affect people even far downwind from the fire itself.⁵⁸ Under certain conditions, wildfire smoke may have a pronounced effect on air quality hundreds of miles away, including over land not typically associated with wildfire smoke.⁵⁹

Health Impacts of Wildfire Smoke

Wildfire smoke is a complex mix of gases and fine particles; particulate matter is the main public health threat from short-term exposure.⁶⁰ Wildfire smoke “can trigger asthma attacks and severely restrict breathing for those with other respiratory ailments. [Ultra-fine] particles in the smoke can bypass the protective filtering mechanisms in our airways. More than an irritant, [these very tiny particles] can lodge deep in the lungs and enter the bloodstream, increasing the risk of heart attack among those with cardiovascular problems.”⁶¹

Studies of urban particulate matter have found that “short-term exposures (i.e., days to weeks) to fine particles...are linked with increased premature mortality and aggravation of preexisting respiratory and cardiovascular disease.”⁶² A recent review of several studies of the health effects of pollution from wildfires describes documented increases in hospital admissions, mortality, respiratory symptoms, eye and nose symptoms, and respiratory infections.⁶³ These health impacts can also translate into significant economic costs for individuals and communities.

In addition to increasing outdoor airborne particles during wildfire events, wildfires can cause temporary large increases in pollutants other than particulate matter – e.g., carbon monoxide, nitrogen oxides, and

⁵⁶ See Cal. Air Resources Bd. (ARB), Possible Wildfire Impacts on Air Quality, <https://www.arb.ca.gov/smp/wildfire/wildfire.htm>; J. Coco Liu et al., Particulate air pollution from wildfires in the Western US under climate change, *Climatic Change* 138 (2016) (finding that wildfire smoke is the component most responsible for the vast majority of days with fine particulate matter levels exceeding regulatory standards, especially in northern California, the Pacific Northwest, and the northern Rocky Mountains).

⁵⁷ Fisk, *supra*, at 8 (discussing findings that summertime mean outdoor-air levels of fine particles in the western U.S. will increase by 30% to 40%, and noting that percentage increases in urban areas with higher current particle concentrations are likely to be smaller); U.S. Global Change Research Program (USGCRP), The Impacts of Climate Change on Human Health in the United States: A Scientific Assessment at 77 (2016), <https://health2016.globalchange.gov/> [hereinafter Impacts of Climate Change on Health] (“By 2050, changes in wildfires in the western United States are projected to result in 40% increases of organic carbon and 20% increases in elemental carbon aerosol concentrations.”).

⁵⁸ Fisk, *supra*, at 8.

⁵⁹ J. Coco Liu et al., *supra*; L. DeBell et al., A major regional air pollution event in the northeastern United States caused by extensive forest fires in Quebec, Canada, *Journal of Geophysical Research* 109 (2004), <http://onlinelibrary.wiley.com/doi/10.1029/2004JD004840/full>; Natural Resources Defense Council, Where There’s Fire, There’s Smoke: Wildfire Smoke Affects Communities Distant from Deadly Flames (2013), <https://www.nrdc.org/sites/default/files/wildfire-smoke-IB.pdf>.

⁶⁰ Wildfire Smoke Guide, *supra*, at 13; Fisk, *supra*, at 8.

⁶¹ Cal. ARB, Protect Yourself from Wildfire Smoke, https://www.arb.ca.gov/videos/impacts_of_smoke.htm.

⁶² Wildfire Smoke Guide, *supra*, at 13.

⁶³ See Fisk, *supra*, at 9-10. See also USGCRP, Impacts of Climate Change on Health, *supra*, at 77 (finding that “PM2.5 from wildfires affects human health by increasing the risk of premature death and hospital and emergency department visits”).

volatile organic compounds (VOCs).⁶⁴ Two VOCs, formaldehyde and acrolein, are “two of the principal contributors to the cumulative irritant properties of smoke.”⁶⁵ VOCs and nitrogen oxides are also ozone precursors, and the increase in wildfires due to climate change can lead to increased ozone concentrations near the ground.⁶⁶ According to the U.S. Global Change Research Program, climate change is expected generally to increase ozone pollution in the future throughout much of the United States, in part due to higher temperatures and more frequent stagnant air conditions.⁶⁷

Indoor Exposure to Wildfire Smoke

Wildfire smoke is an important indoor, as well as outdoor, air quality issue. Indeed, “the adverse health effects expected from increased wildfires will substantially be the consequence of exposures to particles that penetrate to and persist indoors.”⁶⁸ This is due to the fact that, while indoor particulate levels may be only about 50 percent of outdoor levels, people spend nearly all of their time indoors and are likely to spend even more time indoors when outdoor air is impacted by wildfire smoke. Thus, most of the health effects from wildfire smoke may be the result of indoor exposures.⁶⁹

There are three main factors that determine the degree to which outdoor particles are present indoors: particle size, building ventilation rate, and filtration.⁷⁰ Residences do not generally provide significant protection from fine particles, the primary constituent of wood smoke.⁷¹ The building ventilation rate affects the amount of outdoor air brought inside; while a lower building ventilation rate tends to provide greater protection against some outdoor pollutants, a lower ventilation rate tends to *increase* concentrations of pollutants from indoor sources. Public health science research indicates that “increased ventilation rates are, on average, associated, with fewer adverse health effects and with superior work and school performance.”⁷² Thus, a critical element for reducing wildfire smoke exposure is *filtration* of outside air.⁷³ Mechanical ventilation systems that provide supply

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⁶⁴ Fisk, *supra*, at 8.

⁶⁵ Wildfire Smoke Guide, *supra*, at 13.

⁶⁶ USGCRP, Impacts of Climate Change on Health, *supra*, at 73. See also D. Jaffe and N. Wigder, Ozone production from wildfires: A critical review, *Atmospheric Environment* 51:1-10 (2012), https://www.researchgate.net/publication/235342520_Ozone_production_from_wildfires_A_critical_review (finding that wildfires have been shown to contribute to background ozone levels and to days that exceed air quality standards).

⁶⁷ See USGCRP, Impacts of Climate Change on Health, *supra*, at 80 (noting that around 45% to 75% of a person’s exposure to ozone will occur *indoors*, and thus “about half of the health effects resulting from any outdoor increases in ozone...will be due to indoor ozone exposures”). See also Fisk, *supra*, at 76 (noting that “the amount of ozone inhaled when people are indoors is typically 25%-60% of the total amount of ozone inhaled”).

⁶⁸ Fisk, *supra*, at 10.

⁶⁹ USGCRP, Impacts of Climate Change on Health, *supra*, at 79; Fisk, Effects of Climate Change, *supra*, at 11.

⁷⁰ Institute of Medicine, Climate Change, the Indoor Environment, and Health, *supra*, at 101.

⁷¹ Fisk, *supra*, at 10.

⁷² Lawrence Berkeley National Laboratory (LBNL), IAQ Scientific Findings Resource Bank: Building Ventilation, <https://iaqscience.lbl.gov/vent-summary>.

⁷³ Institute of Medicine, Climate Change, the Indoor Environment, and Health, *supra*, at 101 (“Absent active filtration, higher ventilation rates tend to produce higher indoor concentrations of outdoor particles.”); National Academies of Sciences, Engineering, and Medicine – Health and Medicine Division, Health Risks of Indoor Exposure to Particulate Matter: Workshop

air can be equipped with particle filters, and “good filtration efficiency is possible at a modest cost.”⁷⁴ Portable air cleaners are another option, and those devices are available in a wide range of prices.⁷⁵

Wildfire Smoke and Vulnerable Populations

Some people face greater health risks from exposure to wildfire smoke. The groups considered to be at higher risk from wildfire smoke exposure include:

- *Those with preexisting lung and heart disease*, because wildfire smoke impacts those health conditions in particular;
- *Older adults*, due to preexisting diseases, as well as the decline of “important physiologic processes, including defense mechanisms”;
- *Young children*, because they breathe more air relative to their size and because their organs are developing;
- *Pregnant women*, because “numerous physiologic changes occur during pregnancy increasing a woman’s vulnerability to environmental exposures,” and due to the risk of “adverse effects to their fetus, during a critical window of human development”;
- *Racial minorities*, who bear a disproportionate burden of asthma and other diseases; and
- *People of low socio-economic status*, who suffer disproportionately from diseases such as asthma and who also may lack the resources needed to obtain air conditioning and take other recommended actions to protect themselves from wildfire smoke exposure.⁷⁶

State Policies and Programs

Although states do not regulate indoor wildfire smoke directly, a variety of state and local policies and programs can be implemented to help reduce the risks of indoor smoke exposure generally and for vulnerable populations. This section describes several areas in which states and local governments have been active: monitoring air quality during wildfire events; developing guidance for reducing indoor exposures; providing information and technical assistance to local agencies and communities; providing direct material assistance to vulnerable populations; and incorporating minimum standards and best practices into regulations governing rental housing and new home construction. This chapter does not discuss the role of the Clean Air Act, smoke management programs, and other federal and state ambient air quality policies governing prescribed fires and agricultural or other outdoor/open burning.⁷⁷

Summary at ch. 5, p. 49 (2016), <https://www.nap.edu/download/23531> (summarizing comments of William Fisk, that “the filtration of incoming outdoor air and recirculated indoor air should be the first approach taken to mitigate individual exposure to PM”).

⁷⁴ Institute of Medicine, *Climate Change, the Indoor Environment, and Health*, *supra*, at 106.

⁷⁵ *Wildfire Smoke Guide*, *supra*, at 13.

⁷⁶ *Wildfire Smoke Guide*, *supra*, at 14-17. *See also* Institute of Medicine, *Climate Change, the Indoor Environment, and Health*, *supra*, at 102; Fisk, *supra*, at 74-75.

⁷⁷ For general information on smoke management policies, see National Interagency Fire Center, *Smoke Management*, <http://www.nifc.gov/smoke/>.

Monitoring Air Quality and Wildfire Smoke

Air quality monitoring is a central tool for determining when action is needed to reduce wildfire smoke exposure. Air quality data are used by government agencies to warn the public about potential risks of wildfire smoke and to prompt individuals to take action. Federal, state, and local government agencies collaborate to maintain a permanent network of air quality monitoring stations throughout the country and to deploy additional monitoring stations during wildfire smoke events.

Deploying Air Monitors During Wildfires. Air quality during wildfire smoke events can be gauged using both permanent and portable air monitors. Under the federal Clean Air Act, each state must establish air monitoring stations for “criteria” air pollutants (particulate matter, ozone, lead, nitrogen oxides, sulfur oxides, and carbon monoxide).⁷⁸ Nearly 300 state and local governments and tribal agencies own and operate these permanent air quality monitoring stations throughout the country, which can provide valuable data during wildfires.⁷⁹

The capacity to deploy temporary, portable monitors during wildfires is also important, especially for communities that are not represented in the permanent monitoring network. The U.S. Forest Service’s Wildland Fire Air Quality Response Program, which “was created to directly assess, communicate, and address risks posed by wildland fire smoke to the public as well as fire personnel,” maintains a cache of portable air particulate matter monitoring kits that are available upon request by firefighting agencies as part of the response to wildfires.⁸⁰ The program maintains a web page displaying the availability of portable monitors.⁸¹ In addition, the program offers Air Resource Advisors, trained personnel who can be dispatched to an incident to deploy temporary air monitors and to assist with understanding, predicting, and communicating smoke impacts to agency officials and the public.

States also have portable air monitors for supporting local jurisdictions during wildfire emergencies, though this capacity may vary from state to state due to funding and other constraints. In California, the Air Resources Board (ARB) has been able to expand resources in recent years to accommodate the increasing requests for wildfire smoke monitoring from rural communities.⁸² Some local air quality districts in California also make available portable air quality monitors to expand pollutant measurements during wildfires. For example, the South Coast Air Quality Monitoring District (SCAQMD) in California “can add up to four mobile air quality monitors to its 4-county network of 38 fixed monitoring stations....The information gathered from the extra monitors will assist SCAQMD to better inform the public of appropriate precautions as suggested in SCAQMD smoke advisories....SCAQMD

⁷⁸ See U.S. EPA, Air Quality Monitoring, <https://www3.epa.gov/airquality/montrng.html>.

⁷⁹ National Science and Technology Council, Air Quality Observation Systems in the United States (2013), <http://bit.ly/2d17kuB>.

⁸⁰ USFS, Wildland Fire Air Quality Response Program, <http://www.wildlandfiresmoke.net/>. The USFS’ AirFire Team operates the BlueSky smoke modeling system, which provides daily smoke impact modeling of active wildfires throughout the lower 48 states, as well as the Alaska BlueSky system.

⁸¹ See USFS, Wildland Fire Air Quality Response Program, Monitor Status, <http://www.wildlandfiresmoke.net/monitoring/smoke-monitor-status/>.

⁸² These deployments typically range from two to six weeks. Communications with California Air Resources Board, Office of Emergency Response (10/13/16) (on file with ELI).

incorporates the extra data from the mobile monitors into the online interactive air quality map on an hourly basis.”⁸³

Communicating Air Quality Monitoring Information to the Public. EPA runs the AirNow website (www.airnow.gov) to present monitoring information from permanent and temporary air particulate monitors across the country. The AirNow website includes maps showing the locations of and data from the monitors in use throughout the country, as well as maps showing current wildfire activity and associated monitors. Air quality information is presented using EPA’s Air Quality Index (AQI), which reports information about air pollution (including particulate matter and ozone) by converting ambient concentrations into general descriptors (ranging from “Good” to “Hazardous”) and numbers on a scale of 0-500. AirNow’s “current conditions” report uses a methodology that estimates the AQI for each hour in order to incorporate changing air quality conditions.⁸⁴

The AQI is the central tool used by most government agencies to communicate to the public information about air quality based on monitoring data. At least one state has developed its own framework for translating monitoring data. Washington State’s Air Quality Advisory (WAQA) is similar to the AQI, using color-coded categories to describe air quality, but it “shows the health effects of PM_{2.5} at lower levels than the AQI does. In other words, WAQA shows that air quality is unhealthy sooner – when there is less PM_{2.5} in the air.”⁸⁵

The EnviroFlash system, managed by EPA, sends state air quality forecasts and Action Day alerts to subscribers. States also play an important role in communicating air quality forecasts to the public by posting air quality monitoring data and the AQI directly on state agency web pages, as well as linking to the AirNow website. The California ARB’s Air Quality Data Query Tool, for example, affords access to a wealth of data: users can select for particular pollutants and time frames, and they can examine specific locations or broader regions. Aside from being able to obtain daily or hourly measurements from areas of interest, users can view “special reports” on the same range of pollutants that highlight the findings’ most significant implications (e.g., number of days above the national standard for PM_{2.5} levels).⁸⁶ In addition, some states have comprehensive smoke information websites – “blogspots” – that are maintained by volunteers and that include information posted by many city, county, tribal, state and federal agencies “to coordinate and aggregate information for....communities affected by wildfire smoke.”⁸⁷

Indoor Air Monitoring. While ambient air quality monitoring during wildfires is a central governmental function, there has been relatively little activity around monitoring *indoor* air quality. To the extent that government agencies have undertaken indoor air monitoring during wildfires, those

⁸³ South Coast Air Quality Monitoring District, Fire Monitoring Explained, <http://www.aqmd.gov/fire-monitoring-new>.

⁸⁴ See AirNOW, https://www.airnow.gov/index.cfm?action=topics.smoke_wildfires.

⁸⁵ Wa. Dept. of Ecology, Washington Air Quality Advisory (WAQA) http://www.ecy.wa.gov/programs/air/air_monitoring_data/waqa_intro_page.html.

⁸⁶ See Cal. ARB, Air Quality Data (PST) Query Tool, <https://www.arb.ca.gov/aqmis2/aqdselect.php>.

⁸⁷ See <http://wasmoke.blogspot.com/>, <http://oregonSmoke.blogspot.com/>, <http://californiasmokeinfo.blogspot.com/>, <http://idsmoke.blogspot.com/>.

activities seem to have focused on public facilities, rather than on homes. For example, the Colville Tribe has purchased a monitor to measure both outdoor particulate matter and indoor PM in tribal facilities.⁸⁸

The states of Oregon and California have developed guidance documents that address indoor monitoring. Oregon's wildfire response protocol includes as a desired outcome for state agencies, the "(a)bility to monitor indoor smoke levels in work environments and schools."⁸⁹ The protocol further states, "Indoor air quality may be poor in older dwellings. These may include schools, community centers with care centers, nursing homes, or group homes. When air quality is 'unhealthy' for an extended smoke duration, it may be worthwhile to assess indoor air quality for these and other types of facilities where people who are sensitive to smoke live or stay."⁹⁰ The protocol provides general information on monitoring equipment and indicates that the state Department of Environmental Quality (DEQ) is available to provide more specific information on the types, availability, and cost of monitoring equipment, but that the DEQ "is responsible for monitoring air quality outdoors, and does not have equipment for indoor air monitoring."⁹¹ Individuals with questions about employee health and possible indoor air monitoring in the workplace are directed to Oregon OSHA.

California's Wildfire Smoke Response Coordination best practices guidance includes similar information about indoor air monitors and directs local agencies to contact the California ARB or CalOSHA for more information, noting that "CARB...is responsible for monitoring air quality outdoors but does have the capability to conduct limited indoor monitoring in schools, evacuations centers, incident commend posts, or other public facilities."⁹²

In addition to monitoring air quality inside public buildings and workplaces, state agencies can consider how to support governmental or non-governmental efforts to conduct indoor air monitoring in the homes of sensitive individuals. In addition, as advances in sensor technology make accurate indoor air monitoring more cost-effective, state governments can play an important role in providing guidance to citizens on interpreting their own indoor monitoring data and on using that data to take appropriate action.⁹³

⁸⁸ Tribal Healthy Homes Network, Tribal Healthy Homes Network Partner Profile – Kris Ray, Colville Tribe (2016), <http://thhnw.org/colville-tribe/>.

⁸⁹ State of Oregon, Oregon Wildfire Response Protocol for Severe Smoke Episodes at 4 (rev. 2015), <http://www.deq.state.or.us/aaq/burning/docs/WFresponse.pdf>.

⁹⁰ *Id.* at 9.

⁹¹ *Id.* at 12.

⁹² Cal. Air Response Planning Alliance & Cal. ARB, Wildfire Smoke Response Coordination – Best Practices Being Implemented by Agencies in California (Working Draft, 2014), <https://www.arb.ca.gov/carpa/iascpresentations/2016/airemergencyresponsepreparednesspacket.pdf>.

⁹³ For information about EPA's program on sensor technology, including the agency's Air Sensor Toolbox for Citizen Scientists, Researchers and Developers, see <https://www.epa.gov/air-sensor-toolbox>.

Identifying Best Practices for Reducing Indoor Wildfire Smoke Exposure

Federal Guidance. Guidance documents can be an important policy tool for advancing best practices for reducing indoor exposures to wildfire smoke. Government wildfire smoke program activities rely largely on a federal/state guidance document that provides extensive background on wildfire smoke and best practices for reducing indoor exposure. *Wildfire Smoke: A Guide for Public Health Officials* was developed by federal and state officials in 2001 and revised in 2008, and it has been widely used since. In 2016, the U.S. EPA, the U.S. Forest Service, the Centers for Disease Control and Prevention (CDC) and the California ARB, issued a draft revision that builds on the Guide’s core set of best practices and incorporates new information in areas such as health effects and air quality monitoring resources.⁹⁴ EPA expects to finalize the Guide in 2017, following field testing during the 2016 wildfire season.

A central recommendation of the Guide is to stay indoors with windows and doors closed. The Guide also recommends taking the following actions – either in the home generally or in a “clean room” within the home:

- Reducing Other Indoor Sources of Pollution. According to the Guide, “Smoking cigarettes, using gas, propane and wood-burning stoves and furnaces, spraying aerosol products, frying or broiling meat, burning candles and incense, and vacuuming can all increase particle levels in a home and should be avoided when wildfire smoke is present.”⁹⁵
- Using Air Conditioners and Filters. As the Guide points out, “An important drawback of advising people to stay inside and close windows and doors of homes without air conditioning during smoke events is the increased risk of heat stress.”⁹⁶ Thus, in periods of very hot weather, those

Key actions for reducing smoke exposure include using medium- or high-efficiency particle filters and portable air cleaners.

without air conditioning are advised to seek shelter elsewhere during wildfire smoke events. For those with air conditioning, the Guide recommends setting air conditioners to “recirculate” mode or turning off the “fresh air” component of newer air conditioners, where possible. The use of filters is critical to exposure reduction: “If possible, one should replace the

central air handler filter with a pleated *medium- or high-efficiency particle filter*....If a filter upgrade has been performed, during a wildfire smoke event the central system’s circulating fan can be set to operate continuously...to obtain maximum particle removal....”⁹⁷ The Guide also notes that caution must be taken to make sure that the system can operate properly with a high efficiency filter, which increases air flow resistance.

⁹⁴ Wildfire Smoke Guide, *supra*.

⁹⁵ *Id.* at 19.

⁹⁶ *Id.* at 18.

⁹⁷ *Id.* at 19-20 (italics added).

- **Operating Properly-sized Air Cleaners.** According to the Guide, “High-efficiency particulate air (HEPA) filter air cleaners and ESPs [electro static precipitators] can help reduce indoor particle levels, provided the specific air cleaner is properly matched to the size of the indoor environment in which it is placed.”⁹⁸ Central air cleaners can be more effective than room air cleaners, but one or more portable air cleaners can be effective if placed where people spend most of their time. Air cleaners can be used in combination with air-handling system filters to further reduce indoor particles. The Guide provides information about how to select from among different types of air cleaners for particle removal and notes that new models are available that combine particle and gas removal. The Guide warns *against* the use of ozone generators that may be sold as air cleaners since low levels of ozone can cause respiratory symptoms and worsen asthma and other chronic respiratory diseases. Indeed, because of the potential health impacts, the state of California has taken regulatory action to limit the ozone emitted from indoor air cleaning devices. (See Text Box.)
- **Establishing Cleaner Air Shelters.** Because sensitive individuals may not be able to protect themselves adequately inside their homes, the Guide recommends that public health agencies make available cleaner air shelters and provides detailed information for doing so.
- **Using Respirators.** The Guide notes that filtering facepiece respirators (e.g., “N95” respirators) can provide some level of protection, but should only be used after implementing the above strategies, and provides extensive information on proper selection and use of respirators.

**LIMITING OZONE EMISSIONS FROM AIR CLEANING DEVICES:
California’s Testing, Certification, and Labeling Program**

Pursuant to a 2006 state law, the California Air Resources Board adopted a regulation making California the first state to limit ozone emissions from indoor air cleaning devices in order to protect public health. As of 2010, all air cleaning devices sold in the state were required to comply with the regulation, which set an ozone emission concentration standard for air cleaners and requires devices to be tested, certified, and labeled. The regulation applies to “any indoor air cleaning device for use or intended for use in occupied spaces,” but exempts specified industrial devices and certain in-duct systems.

The ARB maintains a Consumer’s Air Cleaner Portal web page, which includes a link to a list of ARB-certified indoor air cleaning devices, along with other background information for consumers: <https://www.arb.ca.gov/research/indoor/aircleaners/consumers.htm>. The ARB regulation (17 Cal. Code Regs. §§ 94800–94810) can be accessed through that page or at: <https://www.arb.ca.gov/research/indoor/aircleaners/air-cleaner-regulation.pdf>.

⁹⁸ *Id.* at 20.

State Guidance. States, along with tribal and local governments, have relied heavily on the recommendations in the Wildfire Smoke Guide, and the document has been disseminated extensively via state websites and other public outreach activities. Some states have created additional guidance on specific best practices described in the Guide. For example:

- The California ARB has developed guidance on air cleaning devices, including both central air system filters and portable air cleaners. The guidance explains how a filter's particle removal efficiency is rated and provides general information to help people select and use an appropriate filter or air cleaner.⁹⁹
- The Washington State Department of Health has developed guidance on how to address ventilation and indoor air quality during wildfire events in schools and other mechanically-ventilated buildings. The guidance describes how to manage a building's ventilation to improve indoor air quality when outside air is in a hazardous or unhealthy category and offers general information on filtration and air cleaning to improve indoor air quality.¹⁰⁰

A number of states have established formal guidance for coordinating their response to wildfire smoke emergencies. For example, the Oregon Wildfire Response Protocol for Severe Smoke Episodes was created by a multiagency task force established after the 2012 wildfire season and revised in 2015 to reflect the lessons learned from the 2013 and 2014 seasons. The Protocol sets forth the roles of several state agencies, detailing which entities are responsible for air monitoring, smoke forecasting and modeling, issuing health warnings, managing state websites, and recommending public actions such as canceling outdoor events or setting up shelters. The Protocol establishes a pre-season conference call, daily calls during major wildfire events, and other calls as needed among affected agencies, including public health officials.¹⁰¹ In California, a working document captures "the best practices and planning efforts of [multiple] agencies, to ensure continued coordination of resources and response efforts in order to best mitigate public health impacts," and describes agency responsibilities during wildfire incidents, examples of agency actions and resources, and recommended public health actions based on the particulate concentrations and the duration of smoke exposure."¹⁰²

Public Outreach on Indoor Wildfire Smoke Exposure

Outreach and education are vital elements of state, tribal, and local programs to reduce smoke exposure. It is especially important for information to reach households with young children, older adults, and others with preexisting medical conditions that leave them more vulnerable to health

⁹⁹ See Cal. ARB, *Air Cleaning Devices for the Home: Frequently Asked Questions* (rev. July 2014), <https://www.arb.ca.gov/research/indoor/aircleaners/consumers.htm>. See also U.S. EPA, *Guide to Air Cleaners in the Home*, <https://www.epa.gov/indoor-air-quality-iaq/guide-air-cleaners-home>.

¹⁰⁰ See Wa. Dept. of Health, *Improving Ventilation and Indoor Air Quality during Wildfire Smoke Events: Recommendations for Schools and Buildings with Mechanical Ventilation*, available on the WA DOH web page, *Smoke from Fires*: <http://www.doh.wa.gov/CommunityandEnvironment/AirQuality/SmokeFromFires>

¹⁰¹ See State of Oregon, *Oregon Wildfire Response Protocol for Severe Smoke Episodes* (rev. 2015), <http://www.deq.state.or.us/air/burning/docs/WFRresponse.pdf>.

¹⁰² See California Air Response Planning Alliance, *Wildfire Smoke Response Coordination – Best Practices Being Implemented by Agencies in California (Working Draft)* (Aug. 2014), <http://bit.ly/2dy7RC8>.

impacts. The Wildfire Smoke Guide includes information for public health agencies on communicating health risks and best practices through public advisories and other means.¹⁰³ Montana is an example of a state that has developed a communications toolkit addressing wildfire smoke.¹⁰⁴

As noted earlier, many of the states most affected by wildfires have established extensive web sites where residents can find out about current wildfire and air quality conditions and get information on how to protect themselves. In addition to disseminating the Wildfire Smoke Guide, some states have developed extensive web pages or independent fact sheets and other publications specific to wildfire smoke. Tribal and local agencies also communicate a broad range of information about wildfire smoke through their websites, social media platforms, and other advisories.¹⁰⁵

State Health Agency Information on Wildfire Smoke Exposure

State health and other agencies have created a variety of materials focused on communicating the health effects of wildfire smoke and the steps residents can take to protect themselves. Examples of state health department materials that offer extensive information, including links to other publications include:

- **Washington** - Smoke from Fires web page, <http://www.doh.wa.gov/CommunityandEnvironment/AirQuality/SmokeFromFires>.
- **Minnesota** - Health Hazards of Smoke from Wildfires, web page and 2-page fact sheet, <http://www.health.state.mn.us/divs/eh/emergency/natural/wildfire/smokehaz.html>.
- **Oregon** - Wildfire Smoke and Your Health, 6-page fact sheet, <http://bit.ly/2fUkAll>.

Along with creating materials and web pages devoted to wildfire smoke, states can ensure that information about reducing exposure is integrated into other state outreach efforts on wildfires, including state web pages, advisories, and social media messaging. Wildfire smoke information can also be provided as part of outreach and education on emergency preparedness. The Wildfire Smoke Guide recommends that states encourage people (at greater risk) to purchase higher efficiency filters or air cleaners *before* a wildfire event. Governmental emergency preparedness materials disseminated to the public could suggest that vulnerable populations consider purchasing HEPA filters to have on hand, along with other emergency supplies. The Arizona Public Health Emergency Preparedness Program recommends that when putting together a clean air kit, people should consider including a HEPA filter to help remove contaminants from the room where they are sheltering.¹⁰⁶

¹⁰³ See Wildfire Smoke Guide, *supra*, at 38-45.

¹⁰⁴ See Montana Dept. of Public Health and Human Services, Public Health Wildfire Communication Toolkit (rev. 2015), <http://bit.ly/2gJJbgh>.

¹⁰⁵ See, e.g., Spokane Regional Health District, Wildfires-Frequently Asked Questions, <http://www.srhd.org/feature.asp?id=72#Exposure>; Southern Nevada Health District, Wildfire Smoke and your Health, <https://southernnevadahealthdistrict.org/health-topics/wildfire-smoke.php>.

¹⁰⁶ See Az. Dept. of Health, Just in Case Arizona! Make a Kit – Clean Air, <http://azdhs.gov/preparedness/emergency-preparedness/just-in-case-az/index.php#kit-air>.

Direct Assistance for Reducing Residential Wildfire Smoke Exposure: Supplies and Equipment for Vulnerable Populations

The dissemination of clear information on steps that residents should take during wildfire smoke episodes is vital to reducing indoor wildfire smoke exposure. Yet for some residents, information alone will not be enough. Lower-income households that include sensitive individuals may require material assistance. State and local policies and programs can be brought to bear in implementing recommended best practices for reducing indoor smoke exposure in vulnerable households.

Cleaner Air Shelters. During wildfire episodes, some sensitive individuals must move temporarily to another location because they cannot adequately reduce exposure while in their home. The Wildfire Smoke Guide discusses how to set up cleaner air shelters and recommends that, prior to fire season, government officials identify and evaluate options for providing shelters. During recent wildfire smoke episodes, many local communities impacted by wildfire smoke have made cleaner air shelters available during some or all hours of the day.¹⁰⁷ In addition to technical and logistical challenges in establishing and maintaining the shelters, there may be practical challenges and limitations in residents' use of cleaner air shelters. For example, residents may have difficulty traveling to the shelters or remaining in the shelters for long periods of time, given work and other obligations.¹⁰⁸

Respirators. One form of direct assistance provided by some jurisdictions is the distribution of respirators. The Wildfire Smoke Guide includes detailed information on the use of respirators, which can be helpful for some people if worn properly. The N-95 masks described in the Guide are relatively inexpensive, and a number of state and local government agencies have provided these masks – along with instructions on how to use them – to community members during wildfire incidents.¹⁰⁹ Respirators have limitations, though. In addition to the need for a proper fit, residents with preexisting respiratory or other health problems – who are among those especially susceptible to the effects of smoke – may be unable to wear respirators. The Wildfire Smoke Guide advises, “Respirators should only be used after first implementing other, more effective methods of exposure reduction, including staying indoors, reducing activity, and using HEPA air cleaners to reduce overall smoke exposure.”¹¹⁰

Air Conditioners, Air Cleaners, and In-Duct Filters. An important consideration for policymaking in this area is the provision of equipment that can help reduce indoor smoke exposure, but that may be inaccessible to some vulnerable residents.

¹⁰⁷ For example, in June 2016, Navajo County (AZ) Public Health Services District set up shelters at two area public schools. Navajo County Public Health Services District, Facebook Post: Heavy Smoke Warning (6/22/16), <http://bit.ly/2dlgVYS>. In August 2015, Trinity County (CA) Health and Human Services agency set up 24-hour and part-time cleaner air shelters in a variety of locations. Trinity County Health and Human Services, Press Release: Air Quality Update for Trinity County (8/9/15), <https://lostcoastoutpost.com/2015/aug/9/air-quality-update-trinity-county/>.

¹⁰⁸ British Columbia Centre for Disease Control, Evidence Review: Home and community clean air shelters to protect public health during wildfire smoke events (2014), <http://bit.ly/2d8EN4w>.

¹⁰⁹ See, e.g., Chelan-Douglas Health District, Press Release (8/26/15)(respirator mask distribution in several county agencies in Washington State and the Colville Tribe), <http://bit.ly/2d3FwTD>; Amador County Public Health, Press Release (9/14/15), <http://bit.ly/2dwcajp> (several respirator mask distribution sites within Amador County, California, in response to the Butte Fire).

¹¹⁰ Wildfire Smoke Guide, *supra*, at 24.

- Air Conditioners. As noted earlier, a core recommendation for reducing exposure to wildfire smoke indoors is to keep doors and windows closed, yet this may not be feasible or advisable for those who lack air conditioning and who rely on open windows in hot weather. As the U.S. Energy Information Administration has pointed out, “access to air conditioning by low income households is much lower relative to other households.”¹¹¹
- High Efficiency Filters and Portable Air Cleaners. High efficiency filters for forced air ventilation systems can reduce exposure to particles during wildfires. The Wildfire Smoke Guide recommends that homes with susceptible occupants upgrade filters in advance and keep extra filters on hand, since filters must be replaced regularly. Nevertheless, many existing homes in the U.S. lack such systems, or have systems that are not equipped for higher efficiency filters.¹¹² Ensuring that homes have HVAC systems with the capacity for high efficiency particle filtration is an important consideration for residential building codes and other policies and programs addressing new home construction. A recommended alternative (or adjunct) to high-efficiency, in-duct filtration is the use of portable air cleaners. Though air cleaners are available in a range of prices, lower-income households may nonetheless be unable to purchase these items.

Public policies and programs can play a vital role in assisting households most vulnerable to wildfire smoke exposure.

Future policy and program development for offering direct assistance should focus especially on helping vulnerable households secure air conditioning, air cleaners, and/or high efficiency (in-duct) filters for forced air systems. This equipment can potentially benefit vulnerable residents not only during wildfire events, but also during other episodes of poor outdoor and/or indoor air quality and in times of extreme heat. While agencies have undertaken to distribute filters or portable air cleaners during wildfire events, this does not appear to be a common practice.¹¹³ Given the financial and logistical challenges of providing equipment, advance planning is important for identifying sustainable funding opportunities. Indeed, the Wildfire Smoke Guide notes, “Choosing to buy an air cleaner is a decision that ideally should be made *before* a smoke emergency occurs.”¹¹⁴

Federal funding programs administered by states, tribes, and local governments may offer flexibility to use funds to pay for equipment and supplies to protect vulnerable residents. For example, the Federal

¹¹¹ U.S. Energy Information Agency, Residential Energy Consumption Survey (RECS) 2009, <http://www.eia.gov/consumption/residential/reports/2009/air-conditioning.cfm>.

¹¹² Fisk, *supra*, at 75. See also Institute of Medicine, Climate Change, the Indoor Environment, and Health, *supra*, at 104 (“ordinary indoor environments, especially residences, do not provide much protection” from wood-smoke particles).

¹¹³ In August 2015, The Hoopa Valley Tribe of California declared a state of emergency due to “sustained unhealthy air quality conditions” resulting from several wildfires. The Tribal Council notified residents, “Those with a serious risk of respiratory problems may require a medical evaluation for an air filter. Air filter distribution from K’ima:w Medical Center will be decided on a case-by-case basis, depending on the severity of your medical condition.” Hoopa Valley Tribal Council, Hoopa Public Health Threat: 2015 Public Service Announcement (8/20/15), <http://bit.ly/2cVwvKT>.

¹¹⁴ Wildfire Smoke Guide, *supra*, at 20.

Emergency Management Agency (FEMA) operates a number of programs that provide assistance for wildfire emergencies and could potentially be used for home supplies that enable residents to remain in their homes and avoid hospitalizations or other medical emergencies. These programs include: the Pre-Disaster Mitigation Grant Program (PDM), whose goal is “to reduce overall risk to the population and structures from future hazard events, while also reducing reliance on Federal funding in future disasters”; the Hazard Mitigation Grant Program (HMGP) program, which “may be used to fund projects that will reduce or eliminate the losses from future disasters”; and the Assistance to Individuals and Households Program (IHP), which provides funding directly to households following a disaster and explicitly covers items such as air cleaners.¹¹⁵

Communities can also identify in advance federal and state funding programs that are *not* specific to wildfires but that may be available to assist residents in purchasing the air conditioners or air filters that will be vital during future wildfire smoke emergencies. For example, in recent years, some state, tribal, and local governments have pursued Medicaid policy changes and other innovative health care financing approaches to paying for medically necessary environmental control equipment, such as air cleaners and air conditioning, for patients with asthma or other medical conditions.¹¹⁶ State programs that subsidize home repairs are another potential source of funding for such equipment.¹¹⁷

Addressing Wildfire Smoke Exposure in Rental Housing

Tenants make up nearly 60 percent of households in the U.S. living at or below the poverty line, and many will lack the resources to address an indoor wildfire smoke problem or to find alternate housing.¹¹⁸ Some states and many local governments have adopted housing or property maintenance codes that establish minimum standards for health and safety that are enforced through local housing agencies. These codes include general requirements for providing natural or mechanical ventilation, but do not typically include more specific ventilation standards that are independent of state building or mechanical codes.

Although housing and property maintenance codes generally do not require air conditioning or include specific provisions governing filtration, they often include requirements for maintaining equipment in

¹¹⁵ U.S. Federal Emergency Mgmt. Agency (FEMA), Pre-Disaster Mitigation Grant Program, Hazard Mitigation Grant Program, <https://www.fema.gov/pre-disaster-mitigation-grant-program>; FEMA, Hazard Mitigation Grant Program, <https://www.fema.gov/hazard-mitigation-grant-program> (noting, “Projects must provide a long-term solution to a problem....In addition, a project's potential savings must be more than the cost of implementing the project.”); FEMA, Assistance to Individuals and Households Program, <https://www.fema.gov/recovery-directorate/assistance-individuals-and-households> .

¹¹⁶ For information and case studies on state financing initiatives, see Nat’l. Center for Healthy Housing, Healthcare Financing of Healthy Homes, <http://www.nchh.org/resources/healthcarefinancing.aspx>; Green and Healthy Homes Initiative, Sustainable Funding and Business Case for GHHI Home Interventions for Asthma Patients (2015), <http://bit.ly/2dGlorG>.

¹¹⁷ Examples of federal programs that fund home repairs and rehabilitation include HUD’s Community Development Block Grant program and 203k Rehab Mortgage Insurance Program, and the Department of Agriculture’s Section 504 Home Repair program. Minnesota’s Rehabilitation Loan/Emergency and Accessibility Loan Program is an example of a state program that aims to “assist low income homeowners in financing basic home improvements that directly affect the safety, habitability, energy efficiency or accessibility of their homes.”

¹¹⁸ See American Housing Survey, Table Creator (Poverty, Tenure), http://sasweb.ssd.census.gov/ahs/ahstablecreator.html#?s_areas=a0000&s_year=n2013&s_tableName=Table1&s_byGroup1=a10&s_byGroup2=a2&s_filterGroup1=t1&s_filterGroup2=g1.

good repair. For example, the Massachusetts Sanitary Code requires that owners “maintain free from leaks, obstructions or other defects...all heating and ventilating equipment and appurtenances thereto....and all owner-installed optional equipment.”¹¹⁹ In the District of Columbia, if mechanical ventilation is provided, the owner must maintain the system in safe and good working condition and, if the system is not under control of the occupant, the owner must keep the equipment in constant and continuous operation.¹²⁰ Further, owners who provide air conditioning units or a central air conditioning system must maintain them in safe and good working condition and must have them inspected each year by a licensed professional.¹²¹

During wildfire smoke events, housing officials can prioritize inspections and use provisions such as these to ensure that air conditioning systems are functioning properly and that filters are replaced as appropriate. State and local officials can also consider strengthening their housing codes. A recently-developed model housing code incorporates filtration provisions that go beyond current housing codes. The National Healthy Housing Standard includes the following measure: “Any dwelling with a forced air system....shall have a clean air filter installed in accordance with manufacturer specifications at each change in tenancy and at least annually. This filter shall have a minimum efficiency reporting value of eight (MERV 8) unless the system is not equipped to use a MERV-8 filter.” The standard includes as a “stretch” provision, the requirement that air filters be replaced at least every three months.¹²²

Jurisdictions that experience the highest impacts from wildfire smoke could consider stronger policies, such as requiring landlords to provide portable air filters during wildfire smoke events, if in-duct filtration is not feasible or adequate to protect occupants. These provisions could be incorporated into housing and property maintenance codes or into landlord-tenant laws, which govern the rights and responsibilities of landlords and tenants and are enforced privately by the parties.

Addressing Ventilation and IAQ in New Residential Construction

State policies and programs addressing wildfire smoke focus primarily on how community residents can protect themselves during wildfire emergencies in their existing homes. Nevertheless, state and local policies governing new home construction affect how the future housing stock will protect residents from wildfire smoke and from other air pollutants and allergens that impact residents now and are expected to increase due to climate change.

In developing these policies, states can draw on a variety of guidance documents that advance current best practices. For example, EPA’s Indoor airPLUS is a voluntary labeling program that builds on EPA’s ENERGY STAR program criteria for new homes. Indoor airPLUS provides additional construction specifications on a wide range of IAQ issues to minimize exposure to airborne pollutants, “to help improve IAQ in new homes compared with homes built to minimum code.” Ventilation elements include

¹¹⁹ 105 Code. Mass. Regs. 410.351.

¹²⁰ D.C. Mun. Regs. 14-508.

¹²¹ D.C. Mun. Regs. 14-510.

¹²² See Nat’l. Center for Healthy Housing, Amer. Public Health Assoc., National Healthy Housing Standard (2014), <http://www.nchh.org/policy/nationalhealthyhousingstandard.aspx>.

requiring mechanical whole-house ventilation and local mechanical exhaust ventilation in bathrooms and kitchens in accordance with American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE) Standard 62.2, requiring whole-house dehumidification to maintain indoor relative humidity at or below 60 percent in “warm-humid” climates, and requiring central forced-air HVAC systems to have a minimum MERV 8 filter and no ozone generators in the home.¹²³

It is beyond the scope of this chapter to describe in detail the broad range of ventilation, filtration, and other building design and construction measures that influence indoor exposure to outdoor pollutants. Following is a brief description of two key policy vehicles for addressing ventilation and IAQ in new homes: building codes and government funding programs.

Building Codes. Building codes are the central state (and local) policymaking tool for establishing residential design and construction requirements. In its report on climate change and the indoor environment, the Institute of Medicine concluded, “Promoting research on and development and adoption of regionally appropriate building codes that account for the possibility of future climatic conditions not only will protect the well-being of occupants but could produce economic benefits in the form of longer building lives, lower building insurance fees, and avoided retrofitting costs.”¹²⁴

The International Residential Code (IRC) (one- and two-family low rise), along with the International Building Code (IBC) and International Mechanical Code (IMC) (larger multifamily), are model building codes that are widely used by states and local governments. According to the International Code Council, the large majority of states have adopted the IRC, with or without modifications and limitations, as a mandatory minimum statewide. In some states without a statewide code, localities have adopted the IRC.¹²⁵ Most, but not all, of these states have adopted the 2012 or later version of the IRC, which includes requirements for local exhaust ventilation in bathrooms and kitchens, as well as whole-house mechanical ventilation, and establishes minimum ventilation rates.¹²⁶ The IRC requirement for whole-house mechanical ventilation allows an exhaust-only, supply-only, or balanced system. While mechanical systems that provide supply air can be equipped with filters to remove particles, “exhaust only systems, such as continuous bathroom exhaust fans, do not provide the opportunity to deliberately filter supply air as a means of protecting occupants from outdoor particles.”¹²⁷

States can adopt the most current version of a model building code and modify the code to incorporate additional best practices for ventilation and IAQ appropriate to the state’s climate. Prior to the IRC’s adoption of mechanical whole-house ventilation requirements, a number of states, including Minnesota, Washington, and Vermont, incorporated such requirements in their own residential codes. California’s current Building Standards Code, which also requires mechanical whole-house ventilation in all new

¹²³ See Indoor airPLUS Verification Checklist at 1, 7, 10 (rev. Oct. 2015), www.epa.gov/indoorairplus.

¹²⁴ Institute of Medicine, *Climate Change, the Indoor Environment, and Health*, *supra*, at 11.

¹²⁵ Int’l Code Council (ICC), U.S. Usage of the I-Codes, <http://www.iccsafe.org/about-icc/overview/international-code-adoptions/>.

¹²⁶ See *Id.*; Int’l Code Council (ICC), Int’l. Res. Code, R303.4, M1507, <http://codes.iccsafe.org/app/book/toc/2015/I-Codes/2015%20IRC%20HTML/index.html>.

¹²⁷ Institute of Medicine, *Climate Change, the Indoor Environment, and Health*, *supra*, at 104. Higher efficiency filters for central heating and air systems and/or portable air cleaners can be considered in homes that utilize continuous bathroom exhaust fans.

homes, includes standards from the national model codes, along with standards that have been adapted from the model codes and “extensive additions not covered by the model codes that have been adopted to address particular California concerns.”¹²⁸

One area for consideration in strengthening state building codes is minimum filter efficiency rating. The current ASHRAE standard requires a MERV 6 (low-medium) filter rating, except in areas of the country that are in non-attainment status for federal particulate matter standards.¹²⁹ However, recent research suggests that higher efficiency filters are required in order to be effective at removing particles from wildfires and in filtering outdoor air pollutants generally.¹³⁰ The Wildfire Smoke Guide underscores the importance of using medium- or high-efficiency filters during wildfire smoke events.¹³¹

Requirements for Projects Receiving State Housing Construction Funds and Incentives. A number of states administer programs to help finance affordable housing construction and rehabilitation. These may be state-specific programs or federal programs (such as the Low Income Housing Tax Credit or HOME Investment Partnership) that are administered by the states. Increasingly, states are establishing laws, regulations, program guidelines, and other policies requiring that these publicly-funded projects meet design and construction criteria that go beyond minimum building codes.¹³² State financing programs can ensure that affordable housing built with public funds incorporates best practices for ventilation and filtration consistent with building science research.¹³³ These considerations apply as well to federal and state disaster recovery programs, to the extent that those programs fund housing rehabilitation and construction.¹³⁴

¹²⁸ Cal. Building Standards Commission, California Building Standards Code (Title 24, Calif. Code of Regulations), <http://www.bsc.ca.gov/Codes.aspx>.

¹²⁹ See ANSI/ASHRAE Standard 62.2-2013, Ventilation and Acceptable Indoor Air Quality in Low-Rise Residential Buildings, § 6.7. California is one state that has adopted ASHRAE 62.2 and its minimum filtration requirement into the state building energy efficiency code. See Cal. Energy Commission, 2013 Residential Compliance Manual at 4-83 (2014), http://www.energy.ca.gov/title24/2013standards/residential_manual.html. In 2016, ASHRAE combined Standards 62.1 and 62.2 into one standard for residential buildings. See ANSI/ASHRAE Standard 62.2-2016, Ventilation and Acceptable Indoor Air Quality in Residential Buildings, <https://www.ashrae.org/news/2016/2016-residential-iaq-standard-published-by-ashrae>.

¹³⁰ See B. Singer, et al. (LBNL), Reducing In-home Exposure to Air Pollution (2016), https://www.arb.ca.gov/research/single-project.php?row_id=65080 (study evaluating a variety of ventilation and air cleaning systems for pollutant removal and energy use). See also National Academy of Sciences, Health Risks of Indoor Exposure to Particulate Matter: Workshop Summary at 61 (2016), <http://www.nationalacademies.org/hmd/Activities/PublicHealth/Health-Risks-Indoor-Exposure-ParticulateMatter.aspx> (summarizing remarks by William Fisk, noting that MERV 6 filters remove less than 20 percent of the particles of most sizes).

¹³¹ See Wildfire Smoke Guide, *supra*, at 19-20. See also Institute of Medicine, Climate Change, the Indoor Environment, and Health, *supra*, at 104-106.

¹³² See generally U.S. Dept. of Housing and Urban Devt. (HUD), Sustainable Housing Initiative, http://portal.hud.gov/hudportal/HUD?src=/program_offices/economic_resilience/sustainable_housing_initiative; HUD, Energy-efficient and Green HOME Housing, http://portal.hud.gov/hudportal/HUD?src=/program_offices/comm_planning/affordablehousing/programs/home/greenhome; Amer. Planning Assoc., Green Goes Mainstream in Low-Income Housing (2013), <http://bit.ly/2e4tRCJ>.

¹³³ In Connecticut, e.g., the state Housing Finance Authority has developed Standards of Design and Construction for multi-family housing financed through the agency, requiring “MERV 8 high-efficiency particulate air (HEPA) filters in the return air stream at the air handler, located so that return and ventilation air pass through prior to conditioning,” and requiring that air handlers are sized “to accommodate the reduced air pressure caused by the filter.” Conn. Housing Auth., 2015 Multifamily Design, Construction and Sustainability Standards at 45, <http://bit.ly/2aMa8Jk>. New Jersey requires projects participating in certain federal/state funding programs to incorporate a number of IAQ practices, including MERV 8 filtration. See New Jersey Housing and Mortgage Finance Agency, Green Future Guidelines 2014/15, <http://bit.ly/2fSNgHK>.

¹³⁴ See generally FEMA, National Disaster Recovery Framework: Housing Recovery Support Function, <http://bit.ly/2fUFuRU>.

Some states also offer financial and other incentives for privately-funded buildings to incorporate green building criteria. Such policies typically refer to third-party green building rating systems such as Leadership in Energy and Environmental Design (LEED), Enterprise Green Communities, or the National Green Building Standard (ICC/ASHRAE 700-2015). While third-party rating systems include an IAQ component, they vary in the extent to which they require specific IAQ measures in an individual project. States and municipalities can advance ventilation and other IAQ best practices in their housing policies by requiring specific IAQ measures as part of a referenced green building standard or by requiring compliance with an IAQ-focused set of criteria such as EPA's Indoor airPLUS program.

Summary

Climate change has led to larger wildfires and longer wildfire seasons, and this trend is expected to continue. As a result, wildfire smoke has become an increasingly prominent public health challenge for communities across the country. States have an important role to play in helping reduce indoor exposure to wildfire smoke in home, and this chapter has highlighted a number of areas for further policy and program development.

- **Air Quality Monitoring.** States have stationary and portable monitors that provide air quality data during wildfires, but increased capacity for portable monitoring equipment may become necessary to meet local demand in areas of increasing wildfire activity. States may also be called on to monitor indoor air quality in public facilities and to assist residents in interpreting their home indoor air quality measurements, especially as low-cost sensor technology becomes more widely available.
- **Guidance on Best Practices.** The Wildfire Smoke Guide has helped advance a common set of best practices for reducing indoor residential exposure to wildfire smoke. Further research will help refine and enhance some of these practices. For example, research on exposure to wildfire smoke constituents other than particles can help ensure the effectiveness of public health measures. Further research can also refine understanding of how well filters perform in real-world conditions and how filter technology can address smoke constituents other than particles. States can work together with federal agencies to revise the Wildfire Smoke Guide and/or develop supplemental materials in the future to reflect new research.
- **Outreach and Education.** States impacted by wildfires have developed numerous mechanisms for communicating information about wildfire smoke conditions, the health impacts of exposure, and practices for reducing exposure indoors. States can assist local agencies in ensuring that this information is disseminated broadly and to a diverse audience, including those who are most vulnerable. Information provided before and during wildfire episodes can also be designed to communicate information about reducing exposure from other sources of outdoor and indoor air pollutants, especially particulate matter.

- **Direct Assistance.** Implementation of best practices guidance is generally carried out by tribal and local governments, who work directly with community residents to reduce risks from wildfire smoke. States have an important role to play in providing information and technical assistance to tribal and local agencies, and in establishing policies that authorize, prioritize, or facilitate material assistance for households. Such policies can focus particularly on those households that include children and sensitive adults and that lack sufficient resources to follow recommended best practices such as using air conditioning for ventilation instead of windows, using higher efficiency filters, and using air cleaning devices. Research on the opportunities for leveraging existing federal and state funding programs toward this end can help facilitate efforts to protect vulnerable residents from future wildfire emergencies.
- **New Construction and Rental Housing Codes and Policies.** Building and housing codes represent policy opportunities for states and localities to institutionalize the use of residential mechanical ventilation and filtration systems that are effective at protecting people from outdoor particulate matter and other pollutants. States can also integrate these best practices into their programs that provide funding and incentives for housing construction and renovation.

Wildfire emergencies require agencies to respond quickly to changing situations, and the response requires close coordination among a number of state and other agencies with responsibilities for addressing wildfires. Thus, advance planning is necessary for establishing a state's capacity to address wildfire smoke effectively, and it is vital to incorporate public health and indoor air quality expertise into planning processes. States have developed a variety of planning documents to facilitate this coordination, some focused specifically on wildfire response, and others related more broadly to emergencies. State climate action plans and other climate planning initiatives are another mechanism that can help in prioritizing and facilitating action to address wildfire smoke indoors.

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