Reducing Exposure to Cooking Pollutants

Policies and Practices to Improve Air Quality in Homes

ENVIRONMENTAL LAW • INSTITUTE®

APRIL 2021

The Environmental Law Institute (ELI) is grateful to those who shared their expertise in providing information for this report and in reviewing drafts.

Funding for the report was provided by the U.S. Environmental Protection Agency (EPA). The contents of the report are the responsibility of ELI. The views expressed herein should not be attributed to EPA, nor should any official endorsement be inferred.

The Environmental Law Institute makes law work for people, places, and the planet. Since 1969, ELI has played a pivotal role in shaping the fields of environmental law, policy, and management, domestically and abroad. Today, in our sixth decade, we are an internationally recognized, nonpartisan research and education center working to strengthen environmental protection by improving law and governance worldwide.

Reducing Exposure to Cooking Pollutants: Policies and Practices to Improve Air Quality in Homes

Cover Photos: CheapStockImage_com/pixabay.com; Joshua Resnick/shutterstock.com, LightField Studios, Shawn Hempel/shutterstock.com.

CONTENTS

Executive Summary i

Part One: Introduction 1

Cooking Pollutants, Indoor Air, and Health 2

Reducing Indoor Exposure to Cooking Pollutants 9

Scope and Purpose of Report 11

Part Two: Kitchen Ventilation Best Practices for Reducing Exposure in Homes 12

Installation of a Vented Range Hood 12

Minimum Ventilation Performance Standards for Effective Pollutant Removal 13

Proper Use of Kitchen Ventilation Systems and Low-Emission Cooking Practices 18

Part Three: Policy Strategies for Improving Kitchen Ventilation in New Homes 21

Building Codes: Strengthening Minimum Residential Construction Requirements 21

Model Building Codes and Standards 22

Kitchen Ventilation in State and Local Building Codes 28

Kitchen Ventilation in the Manufactured Housing Code 36

Green Building Requirements 41

Third-Party Green Building Standards 41

State and Local Green Building Requirements 44

Discussion 47

Part Four: Policies and Programs for Improving Kitchen Ventilation in Existing Homes 51

Policies Addressing Kitchen Ventilation in Existing Homes 51

Housing Codes 51

Landlord-Tenant Laws 53

Financial Assistance for Improving Kitchen Ventilation in Existing Homes 54

The Weatherization Assistance Program 54

Healthy Homes/Asthma Programs 58

Housing Repair/Improvement Grant Programs 59

Discussion 61

EXECUTIVE SUMMARY

This report discusses policies needed to reduce indoor air pollution from a common household activity: cooking. The report provides information to assist states, local governments, and tribes in taking action to protect people from exposure to particulate matter and other harmful cooking pollutants inside their homes.

The focus of the report is on ensuring that new homes are equipped to reduce exposure to cooking pollutants by strengthening building codes and other policies that set standards for residential construction and renovation. The report also notes opportunities to address cooking pollutants in existing homes, by improving housing codes and leveraging funding programs to assist families least able to afford the changes needed to reduce their exposure.

The primary strategy discussed here is *ventilation* of cooking-related pollutants at or near their source. Recent years have seen increased interest in a related strategy – "electrification" of new buildings, which prohibits or discourages natural gas appliances (including stoves) in order to decrease fossil fuel burning and improve indoor air quality. However, ventilation remains important not only for gas appliances in existing homes unaffected by electrification policies, but for electric cooking appliances as well.

Cooking Emissions Contain Harmful Air Pollutants
Depending on the stove type, cooking-related emissions can contain many different pollutants, including particulate matter, nitrogen dioxide, carbon monoxide, and toxic chemicals such as formaldehyde and polycyclic aromatic hydrocarbons. Regardless of the type of stove used, any type of cooking – from boiling water to frying food – will generate some amount of cooking pollution. Decades of research have demonstrated the harms associated with these pollutants – most prominently particulate matter, which can cause cardiovascular disease, respiratory disease, cancer, and other systemic health effects. Nitrogen dioxide, which is produced by gas appliances, can irritate airways and aggravate respiratory disease and has been linked to increased risk of asthma in children. Some people are at greater risk of harm from exposure to cooking pollutants, including: children, older adults, people with lung disease or heart disease, and people who have been economically or socially disadvantaged.

Kitchen Ventilation Can Effectively Remove Cooking Pollutants from Indoor Air
Ventilation practices for reducing indoor exposure to particles and cooking-related pollutants are well established and readily available. Local exhaust ventilation systems for kitchens provide "spot ventilation" for particulate matter and other pollutants generated by igniting burners, heating oil, and cooking food. There is consensus among indoor air quality experts that kitchen ventilation systems, in particular vented range hoods, can be effective at removing these pollutants before they mix with the rest of the indoor air and can be inhaled by occupants.

The Time is Now: New and Strengthened Policies are Needed to Reduce Exposure
This report provides information for policymakers considering steps to protect people from exposure to particulate matter and other cooking pollutants in new and existing residential buildings. In typical years, home is where people spend most of their time and are exposed to a variety of pollutants. In 2020-2021,

anything but a typical period, the pandemic has required many people to spend even more time at home. Concerns about virus transmission and underlying health conditions related to air pollution have led to increased awareness of the importance of ventilation and indoor air quality in homes, schools, workplaces, and other buildings. For policymakers, this is an opportune time to improve public health and fill a glaring hole that persists in most jurisdictions – by requiring the installation of kitchen exhaust systems in all new and renovated homes.

Building Codes Can Mandate Kitchen Ventilation in All New Residential Construction

In many jurisdictions, the most straightforward way to ensure that kitchen exhaust systems are installed in all newly constructed (or renovated) dwellings is to update the residential building code. Because the model residential building code on which most building codes are based does not affirmatively require kitchen ventilation systems, jurisdictions must amend the model code to establish such a requirement.

New Research Highlights a Need to Strengthen Minimum Kitchen Ventilation Performance Standards

In addition to requiring kitchen ventilation, it is important to establish minimum ventilation performance standards to ensure that the exhaust system can remove a sufficient share of the pollutants emitted during cooking immediately after they are emitted. New research from Lawrence Berkeley National Laboratory has identified minimum performance standards to prevent unhealthy concentrations of two key pollutants, nitrogen dioxide and fine particles, in all dwellings. The studies identify separate ventilation performance standards for kitchens with gas stoves and for kitchens with electric stoves; they also differentiate the standards based on dwelling size, with more stringent standards for smaller units.

Kitchen Ventilation Best Practices Can Also be Integrated into Green Building Requirements

Reducing greenhouse gas emissions from buildings is an important climate mitigation strategy, and jurisdictions will likely continue to establish green building standards as building code overlays, as separate requirements for specific types of construction, or as voluntary criteria. In particular, jurisdictions increasingly require publicly funded construction – including affordable housing development – to comply with third-party green building criteria. These green building policies present an important opportunity to protect health at the same time they are promoting energy and other resource conservation strategies. Policymakers can make sure that the green building criteria they adopt incorporate kitchen ventilation best practices to protect residents from unhealthy levels of pollutants.

Policy Tools are Available to Reduce Exposure in Existing Buildings

Reducing cooking pollutant exposure in existing homes is no less important than in new construction. Housing codes (and to a lesser extent, landlord-tenant laws) are a common policy tool for establishing minimum property maintenance standards. These policies typically have general ventilation requirements that could potentially be applied to ensure adequate kitchen ventilation. They may also require maintenance of equipment, which could be used to address malfunctioning kitchen ventilation. Jurisdictions can strengthen their housing codes to include more specific kitchen ventilation requirements, and they can incorporate kitchen ventilation provisions into inspection forms and other code enforcement practice documents.

Funding Programs Can be Leveraged to Help Repair or Retrofit Existing Dwellings

A variety of financial and material assistance programs have been established to help households retrofit or repair existing homes. These programs can help accelerate kitchen ventilation improvements in affordable rental properties and for homeowners with limited incomes. Weatherization and energy retrofits will continue to play a prominent role in climate policies, and thus represent an important opportunity for improving kitchen ventilation for lower-income families. Healthy homes and asthma programs that provide in-home assessments, education about behavior change, and/or modifications to the home are another potential source of funding to reduce exposures. Integrating these and other funding programs can help maximize resources to improve health in affordable housing and can help ensure that energy-focused projects incorporate health goals as well.

Information and Outreach are Vital to Reducing Exposure to Cooking Pollutants

Noise is often cited as a key obstacle to proper use of kitchen exhaust systems and can be addressed in policies requiring maximum sound ratings. Perhaps even more important is the need to increase public awareness – of both the health risks from cooking pollutants and the solutions that are available. Many people are not aware of these risks or of the ventilation practices and cooking practices that can significantly reduce exposure.

Policymakers can require builders or landlords to provide information about ventilation systems or label appliances. Government agencies (and non-government groups) also have an important role in developing education programs. Culturally relevant educational materials and ad campaigns can help the public better understand the importance of ventilation and other key practices to mitigate cooking emissions, such as cooking on the back burners instead of the front burners; cooking at lower temperatures when possible; using cooking oils with high smoke temperatures; and covering pots and pans to reduce particle emissions from oil and food. Campaigns might also incorporate low-cost air quality sensors (e.g., loaned out or used in citizen science projects), which can be a powerful tool for residents to assess the effectiveness of their kitchen ventilation systems, as well as to increase awareness of the problem.

PART ONE: INTRODUCTION

Cooking produces indoor air pollutants that can be harmful to human health.[1] While some of these pollutants are perceptible to occupants in the form of odors or smoke, others (e.g., combustion gases and ultrafine particles) are not as obvious. Without sensing these pollutants in the air around them, many people do not know pollutants are there at all, much less realize that they may be present in harmful concentrations.[2] Until recently, domestic cooking pollutants and their health impacts have not been a topic of mainstream conversation.

In recent years, however, researchers, public health advocates, and the media have begun to focus greater public attention on cooking pollutant levels in typical homes and the health risks posed by exposure. New research is indicating that "cooking-related pollutants have a greater impact on health, safety and indoor air quality than had previously been recognized," while also demonstrating that many people remain unaware of the problem.[3] As of late, the issue has gained some momentum in the news media, with a particular focus on the pollutants generated by gas stoves.[4] The coronavirus pandemic also has helped to raise awareness about indoor air pollution generally, as most people have been forced to spend more time at home. The pandemic has brought the health effects of particulate matter – a major component of cooking emissions – under more scrutiny. Evidence has mounted that the chronic health effects caused by air pollution – which disproportionately affects communities of color and lower-income communities – exacerbate the impact of COVID-19.[5]

Fortunately, there are ways to address this widespread problem, starting with source reduction. This does not require people to stop cooking indoors, but it does require attention to factors like stove type, cooking methods, and local ventilation, all of which can significantly reduce the amount of cooking pollutants that end up mixing with indoor air. To some extent, these factors are determined by individual choices and behaviors, but they also are driven by governments that adopt policies around how homes are designed, constructed, and maintained.

This report discusses how state, local, and tribal policies and programs can reduce exposure to pollutants from cooking, an activity that occurs regularly in many U.S. homes. The focus of the report is on ensuring that new homes are adequately equipped to reduce occupant exposures by strengthening building codes and

---

[1] J.C. Stratton & B.C. Singer (Lawrence Berkeley Natl. Laboratories (LBNL)), ADDRESSING KITCHEN CONTAMINANTS FOR HEALTHY, LOW-ENERGY HOMES at 2 (Jan. 2014) [hereinafter LBNL Report 2014], *available at:* https://www.osti.gov/servlets/purl/1129518.

[2] *See* remarks by P. Strait, Building Standards Development Supervisor, California Energy Commission at p. 20-21 of Transcript from California Energy Commission Hearing on Indoor Cooking, Ventilation, and Indoor Air Quality (Sept. 30, 2020), *available at:* https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=19-BSTD-03.

[3] *See* LBNL Report 2014, *supra*, at 2.

[4] *See, e.g.,* J. Mingle, Why Gas Stoves Are More Harmful than We've Been Led to Believe (Dec. 3, 2020), https://slate.com/technology/2020/12/gas-stoves-hazardous-asthma.html.

[5] *See* Harvard T.H. Chan School of Public Health, Coronavirus and Air Pollution, https://www.hsph.harvard.edu/c-change/subtopics/coronavirus-and-pollution/.

other policies that establish standards for construction and renovation. The report closes by noting the potential for housing codes to address cooking exposure in existing rental housing and highlights key funding programs that could assist families least able to afford the changes needed to reduce exposure in their homes.

Cooking Pollutants, Indoor Air, and Health

Indoor Air Pollutants Generated by Cooking. Cooking on a domestic stove (or in an oven or toaster) can generate odors as well as combustion pollutants including gases, chemicals, and particles. Cooking-related pollutants that adversely affect health include, but are not limited to:

- fine particulate matter ($PM_{2.5}$);
- ultrafine particles (UFP);
- nitrogen dioxide (NO_2);
- carbon monoxide (CO);
- volatile organic compounds (VOCs), such as formaldehyde and acetaldehyde; and
- semivolatile organic compounds, such as polycyclic aromatic hydrocarbons (PAHs) and heterocyclic amines (HCAs).[6]

Cooking also generates moisture that can lead to the growth of mold, bacteria, and other allergens. [7]

Regardless of the type of stove used, any type of cooking – from boiling water to frying food – will generate some amount of cooking pollution.[8] While more frequent and higher-temperature cooking results in greater emissions and higher pollutant concentrations,[9] studies have shown that a single cooking event can cause elevated short-term concentrations of $PM_{2.5}$ and UFP in homes.[10]

---

[6] *See, e.g.,* World Health Organization (WHO), Common pollutants from household heating, cooking and lighting, https://www.who.int/airpollution/household/pollutants/combustion/en/; K. Kang et al., *Characteristics of cooking-generated PM_{10} and $PM_{2.5}$ in residential buildings with different cooking and ventilation types*, SCI. TOTAL. ENV. 668:56-66 (June 2019), *available at*: https://pubmed.ncbi.nlm.nih.gov/30852226/; Dennekamp et al., *Ultrafine particles and nitrogen oxides generated by gas and electric cooking*, OCCUPATIONAL AND ENVIRONMENTAL MEDICINE 58(8), 511-516 (Aug. 2001), *available at*: https://oem.bmj.com/content/58/8/511.long; H. Jung et al., *Changes in acetaldehyde and formaldehyde contents in foods depending on the typical home cooking methods*, J. HAZARDOUS MATERIALS vol. 414 (July 15, 2021), *available at:* https://www.sciencedirect.com/science/article/abs/pii/S0304389421004386?via%3Dihub#ab0010; NIH National Cancer Institute, Chemicals in Meat Cooked at High Temperatures and Cancer Risk, https://www.cancer.gov/about-cancer/causes-prevention/risk/diet/cooked-meats-fact-sheet.

[7] *See, e.g.,* U.S. Environmental Protection Agency (EPA), MOISTURE CONTROL GUIDANCE FOR BUILDING DESIGN, CONSTRUCTION AND MAINTENANCE at 16 (Dec. 2013), *available at*: https://www.epa.gov/sites/production/files/2014-08/documents/moisture-control.pdf.

[8] *See* LBNL Report 2014, *supra*, at 2; *see also* remarks by B.C. Singer in Transcript from California Energy Commission Hearing on Indoor Cooking, Ventilation, and Indoor Air Quality, *supra*, at 54.

[9] *See* ASHRAE Guideline 24-2015 (Ventilation and Indoor Air Quality in Low-Rise Residential Buildings) at Sec. 10.3.4 (2015), *available at*: https://webstore.ansi.org/preview-pages/ASHRAE/preview_ASHRAE+Guideline+24-2015.pdf; *see also* J. Huber, Use your range hood for a healthier home, advises indoor air quality researcher, *Scope Stanford Medicine Blog* (Mar. 6, 2018) (quoting B. Singer), https://scopeblog.stanford.edu/2018/03/06/use-your-range-hood-for-a-healthier-home-advises-indoor-air-quality-researcher/.

[10] *See* K.L. Abdullahi, J. Maria Delgado-Saborit & R.M. Harrison, *Emissions and indoor concentrations of particulate matter and its specific chemical components from cooking: A review*, ATMOSPHERIC ENVT. 71:260-294 (2013), *available at*: https://www.kau.edu.sa/files/188/researches/64469_35626.pdf; Q. Zhang et al., *Measurement of Ultrafine Particles and*

Different stove types vary in the type and quantities of pollutants emitted. Electric induction stovetops are the least polluting.[11] Electric burner elements can produce ultrafine particles, but for electric stoves generally, the PM resulting from the cooking itself is the key pollutant of concern.[12]

Unlike electric stoves, gas stoves (like all natural gas appliances) emit nitrogen dioxide (NO_2) as a combustion byproduct, even when functioning properly.[13] Another relatively well-known component of gas stove emissions is carbon monoxide: especially when poor tuning or equipment malfunction results in incomplete combustion, CO produced by gas stoves and other indoor sources (e.g., gas furnaces, fireplaces) can build to dangerous levels if not vented to the outdoors or sufficiently diluted with fresh air.[14] In addition to these commonly cited combustion gases, research has shown that under some conditions, gas burners can emit "substantial quantities" of UFP, as can electric burner elements.[15]

Health Impacts of Cooking Pollutants. Depending on the frequency and intensity of the pollutant concentrations, exposure to cooking pollutants can increase the risk of both short- and long-term health impacts. In U.S. homes, "indoor pollutant levels from cooking can exceed health guidelines for particulate matter (PM), nitrogen dioxide," and other pollutants.[16] This section focuses on PM and NO_2, two cooking pollutants with well documented health impacts, but the health risks posed by other pollutants (e.g., formaldehyde) should not be minimized. Additionally, while the health effects of pollutant mixtures are not well studied, combinations of cooking-related pollutants and other indoor pollutants may increase health risks.[17]

Particulate Matter. Particulate matter, also referred to as particles or particle pollution, is a complex mixture of small, solid particles and liquid droplets found in air. Particles may be emitted from a source directly, though most form in the atmosphere as a result of complex reactions of other chemicals emitted into the air. Thus, particulate matter may be composed of many different individual substances, including

---

Other Air Pollutants emitted by Cooking Activities, J. ENV. RES. PUBLIC HEALTH 7(4):1744-1759 (2010), *available at*: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2872333/.

[11] *See* remarks by B.C. Singer in Transcript from California Energy Commission Hearing on Indoor Cooking, Ventilation, and Indoor Air Quality, *supra*, at 54.

[12] *See* B.C. Singer (LBNL), KITCHEN VENTILATION SOLUTIONS TO INDOOR AIR POLLUTION HAZARDS FROM COOKING (California Air Resources Board Research Seminar Presentation) (Oct. 10, 2013) [hereinafter LBNL Presentation 2013], *available at:* https://ww3.arb.ca.gov/research/seminars/singer2/singer2.htm. Electric stoves produce no carbon monoxide and only small amounts of NO_2. *See* Huber, Use your range hood for a healthier home, *supra*.

[13] *See, e.g.,* L.M. Paulin et al., *Home interventions are effective at decreasing indoor nitrogen dioxide concentrations*, INDOOR AIR 24(4): 416-424 (Aug. 2014), *available at*: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC4909253/.

[14] *See generally* Centers for Disease Control and Prevention (CDC), Carbon Monoxide (CO) Poisoning Prevention, https://www.cdc.gov/nceh/features/copoisoning/index.html.

[15] *See, e.g.,* L. Wallace et al*., Contribution of Gas and Electric Stoves to Residential Ultrafine Particle Concentrations between 2 and 64 nm: Size distributions and Emission and Coagulation Rates*, ENV. SCI. TECH. 42(23): 8641-8647 (Oct. 2008), *available at*: https://tsapps.nist.gov/publication/get_pdf.cfm?pub_id=861579; Zhang et al., *supra*.

[16] T. Phillips (ROCIS Initiative), DUCTED RANGE HOODS: RECOMMENDATIONS FOR NEW AND EXISTING HOMES at 5 (updated Dec. 2019) [hereinafter ROCIS Issue Brief], *available at*: http://rocis.org/sites/default/files/user-files/ROCIS-Ducted-Range-Recommendations-Dec-2019-Update.pdf.

[17] *See* Y. Ma et al., *In vivo respiratory toxicology of cooking oil fumes: Evidence, mechanisms and prevention*, JOURNAL OF HAZARDOUS MATERIALS 402:123455 (2021), *available at*: https://www.sciencedirect.com/science/article/abs/pii/S0304389420314448; *see also* Y. Wei et al., *Assessing additive effects of air pollutants on mortality rate in Massachusetts*, ENVTL. HEALTH 20:19 (2021), *available at*: https://www.researchgate.net/publication/349543146_Assessing_additive_effects_of_air_pollutants_on_mortality_rate_in_Massachusetts/link/6035e5364585158939c5b146/download.

acids (e.g., nitrates and sulfates), organic chemicals, metals, soil or dust particles, and allergens (e.g., mold spores or pollen).[18]

We are exposed to many different pollutants indoors, but PM is one of the most significant in terms of health risks. A large body of scientific research conducted over decades has illuminated these impacts.

Most research in this area has focused on the size of particles as an important factor in how they affect health. Particle size (mass median aerodynamic diameter) is measured in microns; one micron (µm) equals one millionth of a meter. Particles under 10 µm are of special concern and are broken down into three categories:

- PM10 – "coarse" particles equal to or less than 10 µm;
- PM2.5 – "fine" particles equal to or less than 2.5 µm; and
- Ultrafine particles, or UFP – particles less than 0.1 µm, or 100 nanometers.

When inhaled, these particles can pass the nasal defenses and penetrate deep into the lungs, and some can even enter the bloodstream. We know the most about the risks of inhaling particles less than 2.5 µm (30 times smaller than the diameter of the average human hair), which have been the focus of much of the public health research.[19]

Breathing particles not only causes illness, but shortens lives as well.[20] Recent estimates of premature deaths in the U.S. associated with particulate matter range from tens to hundreds of thousands each year.[21] A study by scientists at Lawrence Berkeley National Laboratory (LBNL) modeled the health impacts of non-biological air pollutants in U.S. homes and found that fine particulate matter was responsible for the largest number of lost years of productive life.[22]

---

[18] U.S. EPA, PARTICLE POLLUTION AND YOUR HEALTH (2003), *available at*: https://nepis.epa.gov/Exe/ZyPDF.cgi/P100RQ5N.PDF?Dockey=P100RQ5N.PDF.

[19] *See generally* U.S. EPA, Particulate Matter Basics, https://www.epa.gov/pm-pollution/particulate-matter-pm-basics; CDC, Particle Pollution, https://www.cdc.gov/air/particulate_matter.html; U.S. EPA, Integrated Science Assessment for Particulate Matter (2019), *available at*: https://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=347534.

[20] *See generally*, WHO, Air Pollution, https://bit.ly/2pxYITb ("There is a close, quantitative relationship between exposure to high concentrations of [PM] and increased mortality or morbidity, both daily and over time.").

[21] *See, e.g.,* A. Goodkind, et al., FINE-SCALE DAMAGE ESTIMATES OF PARTICULATE MATTER AIR POLLUTION REVEAL OPPORTUNITIES FOR LOCATION-SPECIFIC MITIGATION OF EMISSIONS, *Proceedings of the Natl. Acad. of Sciences,* 116(18) 8775-8780 (2019), *available at*: https://www.pnas.org/content/116/18/8775 (estimating that in the U.S. "anthropogenic PM2.5 was responsible for 107,000 premature deaths in 2011, at a cost to society of $886 billion"); P. Azimi & B. Stephens, *A Framework for Estimating the U.S. Mortality Burden of Fine Particulate Matter Exposure Attributable to Indoor and Outdoor Microenvironments*, J. EXPO. SCI. ENVIRON. EPIDEMIOL. at 1, *available at:* https://www.nature.com/articles/s41370-018-0103-4; A. Cohen, et al., *Estimates and 25-year Trends of the Global Burden of Disease Attributable to Ambient Air Pollution: An Analysis of Data from the Global Burden of Disease Study: 2015*, THE LANCET, vol. 389, no. 10082 at 1907-1918 (May 13, 2017) (estimating over 88,000 deaths in the U.S. attributable to ambient PM pollution in 2015); N. Fann, et al., *Estimating the National Public Health Burden Associated with Exposure to Ambient PM2.5 and Ozone*, RISK ANAL. V 32(1):81-95 (2012), *available at*: https://www.ncbi.nlm.nih.gov/pubmed/21627672 (estimating 130,000 PM2.5-related deaths in 2005).

[22] J. Logue, et al., *A Method to Estimate the Chronic Health Impact of Air Pollutants in U.S. Residences*, ENVTL. HEALTH PERSP., vol. 120, no. 2 at 216 (2012), https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3279453/.

Although many people think of respiratory problems as the main health effects from air pollution, there is broad consensus that exposure to particle pollution affects not only the respiratory system, but the cardiovascular system as well.[23]

The American Lung Association summarized the scientific literature that linked exposure to particulate matter with a variety of health effects, including:

- Short-term exposure: premature death from respiratory and cardiovascular causes, including strokes; increased hospitalization for cardiovascular and respiratory problems; increased hospitalization for asthma and increased severity of asthma attacks among children; increased mortality in infants.

- Long-term exposure: increased risk of death from cardiovascular disease; increased risk of heart attacks and stroke; increased risk of lung cancer; worsening of chronic obstructive pulmonary disease in adults; slowed lung function growth in children and teenagers; development of asthma in children; significant damage to the small airways of the lungs; and increased risk of lower birth weight and infant mortality.[24]

Studies have also examined the impacts of particulate matter on neurological and psychiatric disorders, finding evidence linking $PM_{2.5}$ exposure to, e.g., dementia, Parkinson's disease, and Alzheimer's disease.[25] In its 2019 Integrated Science Assessment for Particulate Matter, the U.S. Environmental Protection Agency (EPA) concluded that the evidence supports a "likely to be causal relationship" between long-term $PM_{2.5}$ exposure and both cancer and nervous system effects.[26] A study of 95 million Medicare hospitalization claims, published in 2020, confirmed these associations and also found links between $PM_{2.5}$ exposure and other diseases, including kidney failure, urinary tract and blood infections, and fluid and electrolyte disorders.[27] This and other studies found that even short-term exposure to $PM_{2.5}$ can be harmful.[28]

Under the federal Clean Air Act, which establishes the nation's principal legal framework for protecting air quality, EPA sets primary (public health) and secondary (public welfare) national ambient air quality standards (NAAQS) for certain pollutants, including particulate matter. The primary standards must be set at levels which, "allowing an adequate margin of safety, are requisite to protect the public health." [29]

---

[23] *See generally*, CDC, Health Impacts of Fine Particles in Air, https://ephtracking.cdc.gov/showAirHIA.action; Cal. Air Resources Board, Reduce Your Exposure to Particle Pollution, https://ww2.arb.ca.gov/resources/fact-sheets/reduce-your-exposureparticle-pollution; U.S. EPA, Indoor Particulate Matter, https://www.epa.gov/indoor-air-quality-iaq/indoor-particulate-matter. *See also* R. Allen, *Indoor Particulate Matter Pollution and Cardiovascular Health*, from Natl. Acad. of Sciences, HEALTH RISKS OF INDOOR EXPOSURE TO PARTICULATE MATTER: WORKSHOP SUMMARY (2016) at p. 81, *available at:* https://www.nap.edu/read/23531/chapter/2 (noting that the "global public health burden of PM is primarily due to its cardiovascular effects.")

[24] Amer. Lung Assoc., Particle Pollution (citations omitted), https://www.lung.org/clean-air/outdoors/what-makes-air-unhealthy/particle-pollution.

[25] See Natl. Acad. of Sciences, HEALTH RISKS OF INDOOR EXPOSURE TO PARTICULATE MATTER: WORKSHOP SUMMARY, *supra*, at 87 (summarizing remarks of Marc Weisskopf); Amer. Lung Assoc., Particle Pollution, *supra*.

[26] U.S. EPA, INTEGRATED SCIENCE ASSESSMENT FOR PARTICULATE MATTER, *supra*, at ES-15.

[27] Y. Wei, et al., *Short-term Exposure to Fine Particulate Matter and Hospital Admission Risks and Costs in the Medicare Population: Time Stratified, Case Crossover Study*, BMJ, 367:6258 (2019), *available at:* https://www.bmj.com/content/367/bmj.l6258.

[28] *See id*.; U.S. EPA, INTEGRATED SCIENCE ASSESSMENT FOR PARTICULATE MATTER, *supra*.

[29] 42 U.S.C. §7409. The EPA has set NAAQS for $PM_{2.5}$ and PM_{10}, along with five other "criteria" pollutants (carbon monoxide, nitrogen dioxide, lead, ozone, and sulfur dioxide) that cause adverse health effects.

Although NAAQS are established for outdoor air, the primary standards can be instructive as to unhealthy pollutant levels indoors. The current 24-hour average primary standard for $PM_{2.5}$ is 35 µg/m^3 (the annual mean standard is 12 µg/m^3); the 24-hour standard for PM_{10} is 150 µg/m^3.[30] The World Health Organization (WHO), whose air quality guidelines were last updated in 2005, has adopted lower guideline values for both $PM_{2.5}$ (25 µg/m^3 24-hour mean and 10 µg/m^3 annual mean) and PM_{10} (50 µg/ m^3 24-hour mean).[31] However, exposure to particulate matter at levels equal to or below current NAAQS or WHO guidelines may also be harmful to health, and research has not identified a threshold value below which $PM_{2.5}$ does not affect health.[32]

Nitrogen Dioxide. Nitrogen dioxide (NO_2) is a member of a group of highly reactive gases broadly referred to as nitrogen oxides (NOx). NO_2 is a natural result of oxygen and nitrogen combining during the combustion process.[33] At room temperature, NO_2 is an odorless gas.[34] NO_2 is also "the main source of nitrate aerosols, which form an important fraction of $PM_{2.5}$," and is a major contributor to ozone, a key constituent of outdoor "smog" that forms in the presence of ultraviolet light.[35]

Appliances that burn gas (or other fuels) for cooking or heating are important sources of NO_2 in homes.[36] Most combustion appliance types (e.g., water heaters, furnaces, gas dryers) are regulated in building codes, and are required to be vented so that NO_2 and other combustion byproducts will not enter the living spaces in the home. Gas stoves, however, are *not* uniformly required to be vented to the outdoors. According to researchers, "Nitrogen dioxide from gas cooking burners may commonly reach indoor concentrations that exceed the threshold of 100 parts per billion (ppb) over one hour that is used in the United States ambient air quality standard."[37]

Health impacts most commonly associated with NO_2 exposure are respiratory, because "[b]reathing air with a high concentration of NO_2 can irritate airways in the human respiratory system."[38] Short-term exposures can

---

[30] *See* U.S. EPA, NAAQS Table, https://www.epa.gov/criteria-air-pollutants/naaqs-table. In late 2020, as part of its required review, EPA decided not to change the PM standard. EPA, Natl. Ambient Air Quality Standards (NAAQS) for PM, https://www.epa.gov/pm-pollution/national-ambient-air-quality-standards-naaqs-pm.

[31] WHO, WHO Air quality guidelines for particulate matter, ozone, nitrogen dioxide and sulfur dioxide at 10 (2005), *available at*: https://apps.who.int/iris/bitstream/handle/10665/69477/WHO_SDE_PHE_OEH_06.02_eng.pdf?sequence=1.

[32] *See, e.g.,* U.S. EPA, Integrated Science Assessment for Particulate Matter, *supra*, at ES-23; F. Dominici, et al., (Health Effects Inst.), Assessing Adverse Health Effects of Long-Term Exposure to Low Levels of Ambient Air Pollution: Phase 1 at 24 (Nov. 2019), *available at:* https://www.healtheffects.org/system/files/dominici-rr-200-report.pdf; WHO, Air Pollution, https://bit.ly/2pxYITb; Natl. Acad. of Sciences, Health Risks of Indoor Exposure to Particulate Matter: Workshop Summary at 78 (2016), *available at:* http://nationalacademies.org/hmd/Activities/PublicHealth/Health-Risks-IndoorExposure-ParticulateMatter/2016-FEB-10.aspx. (summarizing remarks of R. Allen); Amer. Lung Assoc., Year-Round Particle Pollution, https://www.lung.org/our-initiatives/healthy-air/sota/key-findings/year-round-particle-pollution.html.

[33] *See* WHO Regional Office for Europe, WHO Guidelines for Indoor Air Quality: Selected Pollutants at 201 (2010), *available at*: https://www.euro.who.int/__data/assets/pdf_file/0009/128169/e94535.pdf?ua=1.

[34] U.S. EPA, Asthma Triggers: Gain Control (July 13, 2020), https://www.epa.gov/asthma/asthma-triggers-gain-control.

[35] WHO, Ambient (outdoor) air pollution (May 2, 2018), https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health.

[37] *See* WHO Regional Office for Europe, WHO Guidelines for Indoor Air Quality: Selected Pollutants, *supra*, at 202 (noting that in addition to appliances tobacco smoke is another important source of indoor NO_2.)

[37] B.C. Singer et al. (LBNL), Effective Kitchen Ventilation for Healthy Zero Net Energy Homes with Natural Gas at 1 (Jan. 2021), *available at*: https://ww2.energy.ca.gov/2021publications/CEC-500-2021-005/CEC-500-2021-005.pdf. *See also* Dr. Y. Zhu et al. (UCLA Fielding School of Public Health), Effects of Residential Gas Appliances on Indoor and Outdoor Air Quality and Public Health in California at 12 (Apr. 2020) [hereinafter UCLA Report 2020], *available at*: https://ucla.app.box.com/s/xyzt8jc1ixnetiv0269qe704wu0ihif7.

[38] U.S. EPA, Nitrogen Dioxide (NO2) Pollution, https://www.epa.gov/no2-pollution/basic-information-about-no2#Effects.

"aggravate" existing respiratory disease – e.g., asthma – leading to symptoms such as wheezing, coughing, chest tightness, and difficulty breathing, as well as increased emergency room visits and hospital stays for respiratory problems.[39] Long-term exposure has been linked to increased risk of chronic bronchitis and chronic obstructive pulmonary disease.[40] According to EPA, "strong" evidence links long-term NO_2 exposure and development of asthma in children.[41]

Like particle pollution, NO_2 is a criteria pollutant under the Clean Air Act for which EPA has established primary standards to protect public health, including the health of "sensitive" populations such as children, the elderly, and people with asthma.[42] EPA's one-hour standard is 100 parts per billion (ppb); the annual standard is 53 ppb. The WHO 2005 Air Quality Guidelines establish guideline values of 200 $\mu g/m^3$ (one-hour) and 40 $\mu g/m^3$ (annual) for nitrogen dioxide; in 2010, the WHO Regional Office for Europe published indoor air quality guidelines for certain pollutants, adopting the values for NO_2 that apply outdoors.[43] While these standards are useful reference points in efforts to reduce cooking pollutant exposure, it is important to note that "a threshold for safe levels of NO_2 has not been determined," and a recent literature review published by the Rocky Mountain Institute found that "studies indicate that the EPA outdoor air standards are not protective of sensitive populations."[44]

Populations at Higher Risk of Health Impacts. Some people face greater health risks from exposure to cooking pollutants. Many people in the U.S. fall into these groups, which include:

- Children;
- Older adults;
- People with lung disease or chronic respiratory conditions;
- People with heart disease; and
- People who have been disadvantaged economically and socially.[45]

---

[39] *Id*.; U.S. EPA, Asthma Triggers: Gain Control, https://www.epa.gov/asthma/asthma-triggers-gain-control.

[40] *See, e.g.,* Zhang Z. et al., *Exposure to nitrogen dioxide and chronic obstructive pulmonary disease (COPD) in adults: a systematic review and meta-analysis*, ENV. SCI POLLUT. RES. INT. 25(15):15133-15145 (2018), *available at*: https://pubmed.ncbi.nlm.nih.gov/29558787/.

[41] U.S. EPA, INTEGRATED SCIENCE ASSESSMENT FOR OXIDES OF NITROGEN – HEALTH CRITERIA at 1-16, 1-32 (Jan. 2016), *available at*: https://cfpub.epa.gov/ncea/isa/recordisplay.cfm?deid=310879 (noting that enough evidence links NO_2 exposures at or near children's homes or schools with asthma development to provide a "strong basis for relating long-term NO_2 exposure to asthma development"). *See also* B. Seals & A. Krasner (Rocky Mountain Institute et al.), GAS STOVES: HEALTH AND AIR QUALITY IMPACTS AND SOLUTIONS at 12 (2020) [hereinafter Rocky Mountain Institute et al. 2020], *available at:* https://rmi.org/insight/gas-stoves-pollution-health/.

[42] U.S. EPA, NAAQS Table, https://www.epa.gov/criteria-air-pollutants/naaqs-table.

[43] WHO, AIR QUALITY GUIDELINES – GLOBAL UPDATE 2005, *available at:* https://www.who.int/airpollution/publications/aqg2005/en/; WHO Regional Office for Europe, WHO GUIDELINES FOR INDOOR AIR QUALITY: SELECTED POLLUTANTS, *supra*, at 246-47. The NAAQS one-hour standard of 100 ppb is roughly equivalent to the WHO guideline of 200 $\mu g/m^3$ (one-hour). However, the NAAQS annual standard of 53 ppb is over twice as high as the WHO guideline of 40 $\mu g/m^3$. *See generally* Air Pollution Information System, Unit Conversion, http://www.apis.ac.uk/unit-conversion.

[44] Rocky Mountain Institute et al. 2020, *supra*, at 12. The report explains, "Documented health effects occur at levels well below the EPA outdoor air standard of 53 ppb for long-term exposure." *Id.* (internal citation omitted).

[45] *See, e.g.,* U.S. EPA, Indoor Particulate Matter, https://www.epa.gov/indoor-air-quality-iaq/indoor-particulate-matter; Rocky Mountain Institute et al. 2020, *supra*, at 12; CDC, Outdoor Air: Particulate Matter, https://ephtracking.cdc.gov/showAirHealth.action#ParticulateMatter; U.S. EPA, Indoor Particulate Matter, https://www.epa.gov/indoor-air-quality-iaq/indoor-particulate-matter; U.S. EPA, WILDFIRE SMOKE: A GUIDE FOR PUBLIC

Disproportionate Impacts. Some communities are disproportionately affected by exposure to cooking pollutants. Because chronic respiratory conditions like asthma increase susceptibility to the impacts of PM and NO_2, populations with higher prevalence rates of those underlying conditions bear a disproportionate risk. According to a report published in 2020 by the Asthma and Allergy Foundation of America, "Nearly 25 million people in the United States are living with asthma, but prevalence rates differ significantly by race and ethnicity" and "the burden of asthma falls disproportionately on Black, Hispanic and American Indian and Alaska Native populations."[46] As the report also notes, "Research shows that asthma disparities are highly driven by socioenvironmental and economic conditions, and that structural injustices over time have led to accumulated disadvantage for specific racial and ethnic populations in the U.S."[47]

These higher prevalence rates for asthma are attributable in part to increased exposure to air pollution generated outdoors. While there are areas in all parts of the U.S. with elevated levels of outdoor PM, racial/ethnic disparities in air pollution exposure are well documented. According to a 2011 Centers for Disease Control (CDC) analysis, "Minority groups, including Asians and Hispanics, were more likely to reside in [counties where outdoor PM levels exceed NAAQS] in comparison with non-Hispanic whites."[48]

Socio-economic status, which encompasses a variety of individual and community-level indicators such as education and income, may increase exposure to outdoor particulate matter.[49] Socio-economic factors may also come into play in exposure to cooking pollutants, which can reach unhealthy concentrations faster in smaller dwellings such as apartments and manufactured housing; thus, cooking pollutants can "present[] an additional risk for renters, who are often lower income than homeowners."[50] Lower-income communities and communities of color are also more likely to be located near busy roadways, where concentrations of traffic-related air pollutants are frequently elevated and people who live near those roads are more highly exposed to particulate matter and other pollutants.[51]

HEALTH OFFICIALS at 9 (rev. 2019), https://www3.epa.gov/airnow/wildfire-smoke/wildfire-smoke-guide-revised-2019.pdf. ("Epidemiologic studies of fine particulate matter using indicators of SES provide initial evidence that individuals of low SES may be at increased risk of mortality due to short-term exposures.").

[46] Asthma and Allergy Foundation of Amer., ASTHMA DISPARITIES IN AMERICA: A ROADMAP TO REDUCING BURDEN ON RACIAL AND ETHNIC MINORITIES at 11-12 (2020), *available at*: www.aafa.org/asthmadisparities. The report notes, "Decades of extensive research and public health data identified disparities in asthma prevalence, mortality and health care utilization along racial and ethnic lines." *Id*. at 11. As of the 2020 report, "Puerto Ricans have the highest rate of asthma prevalence. Black Americans are also disproportionally diagnosed with asthma compared to white Americans." *Id*. at 12. *See also* CDC, HEALTH DISPARITIES AND INEQUALITIES REPORT – UNITED STATES, 2011 at 84 (Jan. 14, 2011), *available at*: https://www.cdc.gov/mmwr/pdf/other/su6001.pdf (noting that based on data from 2006-2008, asthma prevalence was higher among multiracial people; Puerto Rican Hispanics; and non-Hispanic blacks than non-Hispanic whites).

[47] Asthma and Allergy Foundation of Amer., ASTHMA DISPARITIES IN AMERICA: A ROADMAP TO REDUCING BURDEN ON RACIAL AND ETHNIC MINORITIES, *supra*, at 14.

[48] CDC, FACT SHEET: HEALTH DISPARITIES IN UNHEALTHY AIR QUALITY (2011), *available at:* https://www.cdc.gov/minorityhealth/chdir/2011/factsheets/AirQuality.pdf. *See also* U.S. EPA, WILDFIRE SMOKE: A GUIDE FOR PUBLIC HEALTH OFFICIALS, *supra*, at 9 (noting that people of color and low-income children and adults "bear a disproportionate burden of asthma and other respiratory diseases and therefore they may be at increased risk of health effects due to exposure to particle pollution").

[49] U.S. EPA, WILDFIRE SMOKE: A GUIDE FOR PUBLIC HEALTH OFFICIALS, *supra*, at 9. *See also* CDC, Outdoor Air: Health Impacts of Fine Particles in Air, https://ephtracking.cdc.gov/showAirHIA; Rocky Mountain Institute et al. 2020, *supra*, at 15.

[50] UCLA Report 2020, *supra*, at 41.

[51] *See* T. Boehmer et al., *Residential Proximity to Major Highways – United States 2010*, CENTERS FOR DISEASE CONTROL AND PREVENTION MORBIDITY AND MORTALITY WEEKLY REPORT SUPPLEMENT, vol. 62, no. 3 at 46 (2013), *available at*: https://www.cdc.gov/mmwr/pdf/other/su6203.pdf; Health Effects Inst., TRAFFIC-RELATED AIR POLLUTION: A CRITICAL REVIEW OF THE LITERATURE ON EMISSIONS, EXPOSURE, AND HEALTH EFFECTS at 3-35 (2010), https://www.healtheffects.org/publication/traffic-related-air-pollution-critical-review-literature-emissions-exposure-and-health.

Addressing the Risk of Carbon Monoxide Poisoning in Homes With Gas Stoves

Carbon monoxide (CO) is an odorless, colorless gas produced from the incomplete burning of fuels such as natural gas, oil, kerosene, wood, and charcoal. Early symptoms of CO poisoning may mimic the flu. Long-term breathing of carbon monoxide can affect memory, brain function, behavior, and cognition; at high concentrations, acute CO exposure can cause loss of consciousness and death.

When gas-fired cooking equipment functions properly, CO concentrations in the home do not typically exceed safe levels. But malfunctioning fuel-burning appliances are a potential source of CO poisoning. In addition, using fuel-burning appliances improperly – e.g., using a gas stove as a heating source, or using a diesel generator indoors – pose risks for CO poisoning.

Regular inspections of gas stoves and other indoor fuel-burning equipment can thus help prevent the buildup of CO indoors by ensuring that the appliance is operating properly and is vented to the outside. It is also important to address CO as part of home energy retrofits, where air sealing can alter the internal air pressure of a home, leading to back drafting of carbon monoxide and other combustion gases.

Since a person cannot see or smell carbon monoxide, another key measure for preventing CO poisoning is the use of indoor CO alarms, which measure the concentration of carbon monoxide in the indoor air and alert occupants to elevated CO levels within a building. Use of CO alarms increases the likelihood that evacuation or other preventive measures can be taken before CO concentrations reach dangerous levels.

Most states in the U.S. have some type of requirement for CO alarms in new and/or existing homes. In many states, CO alarm requirements are found in the statewide fire code.

Sources: U.S. Consumer Product Safety Comm., Protect Your Family from Carbon Monoxide Poisoning, https://www.cpsc.gov/safety-education/safety-education-centers/carbon-monoxide-information-center/protect-your-family-from-carbon-monoxide-poisoning--; U.S. EPA, Carbon Monoxide's Impact on Indoor Air Quality, https://www.epa.gov/indoor-air-quality-iaq/carbon-monoxides-impact-indoor-air-quality; Institute of Medicine, Climate Change, the Indoor Environment, and Health, *supra*, at 224-6; U.S. EPA, Energy, Weatherization, and Indoor Air Quality, https://www.epa.gov/indoor-air-quality-iaq/energy-weatherization-and-indoor-air-quality; U.S. EPA, Preventing Carbon Monoxide Poisoning: Information for Older Adults and Their Caregivers at 3 (2009), *available at*: https://www.epa.gov/sites/production/files/2015-08/documents/pcmp_english_100-f-09-001.pdf.

Reducing Indoor Exposure to Cooking Pollutants

This report discusses a key strategy for reducing indoor exposure to cooking pollutants: ventilation.

A related approach is "electrification" of new buildings – i.e., prohibiting natural gas appliances, including stoves and ovens, in new construction. Led by environmental and public health advocates, there is a growing movement to ban natural gas appliances with dual goals of decreasing fossil fuel use and reducing indoor pollutant exposure.[52] Where adopted, these bans can considerably reduce exposure to pollutants generated by gas combustion, but they will not eliminate all risk from gas stoves, as there are many such appliances

[52] *See, e.g.*, Sierra Club CA Comments on 2022 Energy Code Workshop on November 3, 2020 (docketed Nov. 18, 2020), *available at*: https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=19-BSTD-03.

already installed in existing homes. Moreover, electric cooking appliances also produce pollutants; burner elements generate ultrafine particles, and cooking itself produces $PM_{2.5}$ and other indoor air contaminants.

Therefore, whether cooking appliances are fueled by gas or fully electric, ventilation of cooking-related emissions is important for protecting health and improving indoor air quality (IAQ).[53] Fortunately, ventilation practices for reducing indoor exposure to particles and other pollutants generated by cooking are well established and readily available.

Adequate ventilation is a key component of good indoor air quality. Whole-house mechanical ventilation (or "dwelling unit ventilation") provides an important baseline, but it is local exhaust ventilation that reduces indoor pollution at or near its source. Local exhaust systems for kitchens – also referred to here as "kitchen exhaust" or "kitchen ventilation" – provide "spot ventilation" for PM and other pollutants generated by cooking. There is consensus among IAQ experts that local exhaust ventilation systems, in particular vented range hoods, can be effective at removing these pollutants.[54]

"Many homes have been built and are being built today without any kitchen ventilation."

Yet even as the body of research into the problem and available solutions grows, the incorporation of best practices into mandatory building codes and standards remains "extremely limited."[55] In fact, as this report will discuss, most state and local residential building codes do not include a baseline requirement to install local exhaust ventilation in kitchens, and "[a]s a result, many homes have been built and are being built today without any kitchen ventilation."[56] Moreover, even in homes that do have kitchen ventilation, the existing system as designed and installed may not be adequate for removing pollutants to maintain IAQ and protect occupant health.[57] Thus, strengthening building standards to incorporate best practices for kitchen ventilation is an important and largely untapped policy opportunity for reducing risk and advancing public health.

However, integrating these technical solutions into policies is only part of the challenge. One obstacle to reducing exposures is that even where range hoods are installed, many people do not use them routinely.[58] Most residential range hoods on the market are designed to operate on demand, relying on the user to

---

[53] *See, e.g.,* UCLA Report 2020, *supra*, at 30 (stating "[t]here are indoor air quality issues associated with the use of gas cooking appliances that will remain despite the implementation of electrification…. Some PM emissions are associated with cooking oils and foods, and there are no mitigation methods for this, other than the use of ventilation devices such as range hoods. We do not claim that the transition to electric appliances would make a substantial difference in terms of emissions from cooking oils and food").

[54] *See, e.g.,* ROCIS Issue Brief, *supra*, at 5 ("Using a range hood can help reduce pollutant exposures and health impacts from cooking, by keeping emissions from spreading into and lingering in a home") (internal citations omitted); ASHRAE Guideline 24-2015, *supra*, at Sec. 10.3.4; U.S. Dep't of Energy (DOE), Development of the Industry's First Smart Range Hood, https://www.energy.gov/eere/buildings/downloads/development-industry-s-first-smart-range-hood.

[55] LBNL Report 2014, *supra*, at 2.

[56] *Id*.

[57] LBNL Report 2014, *supra*, at 2. ("Even in homes that have kitchen ventilation, the systems may not be very effective owing to a variety of factors."); *see also* UCLA Report 2020, *supra*, at 16 (internal citations omitted).

[58] *See, e.g.,* V.L. Klug, A.B. Lobscheid & B.C. Singer (LBNL), COOKING APPLIANCE USE IN CALIFORNIA HOMES—DATA COLLECTED FROM A WEB-BASED SURVEY at 27 (Aug. 2011) [hereinafter LBNL Survey Data 2011], *available at*: https://homes.lbl.gov/sites/all/files/lbnl-5028e-cooking-appliance.pdf. ("This analysis shows that 40-60% of the respondents did not use their range hood even though they didn't have windows open.") *See also* T.J. Phillips et al., ACTIVITY PATTERNS OF CALIFORNIA ADULTS AND ADOLESCENTS: APPLIANCE USE, VENTILATION PRACTICES, AND BUILDING OCCUPANCY at 4.193 (1990), *available at*: https://www.aceee.org/files/proceedings/1990/data/papers/SS90_Panel4_Paper20.pdf (finding "a very small percentage of the population used exhaust fans").

activate the system as needed.[59] While national data on range hood use are not available, surveys conducted in California, for example, have shown "low rates of range hood use" in homes.[60] A key factor that discourages routine use of kitchen exhaust is noise.[61] Another factor is a general lack of awareness about the risks associated with cooking pollution and the importance of activating the system routinely, rather than only when food is burning or cooking produces a lot of smoke.[62]

Another challenge is ensuring that the benefits of public policies reach those who are most susceptible to the impacts of air pollution and who cannot afford the cost associated with the measures needed to reduce their exposure. Financial assistance programs, including those described in Part Four, are needed to help underserved communities that are heavily impacted by pollution and at greater risk from exposure to cooking pollutants.

Scope and Purpose of Report

States, localities, and tribes can revise their building codes and other new construction policies to help ensure that future homes and retrofits incorporate effective kitchen ventilation systems. Jurisdictions can also strengthen their housing codes, funding programs, and other policies that address health and safety in existing homes to help protect residents from unhealthy levels of cooking pollution. The purpose of this report is to support those efforts by:

- ***Reviewing technical practices*** that can be integrated into policies governing new residential construction (and some renovations and retrofits);
- ***Describing current model building codes and standards***, as well as existing state building code provisions;
- ***Highlighting potential code changes in the state of California*** that offer a model for strengthening kitchen ventilation requirements;
- ***Describing third-party green building standards***, and summarizing green building policies that apply to affordable housing and certain other types of new residential construction; and
- ***Describing policies and programs that address conditions in existing buildings*** — for example, housing codes and financial assistance mechanisms such as healthy homes and weatherization assistance programs.

Most of the policies discussed in this report can be adopted by states, local governments, and tribes; in most cases, references to "states" are intended to encompass adopting jurisdictions generally. The report does not review policies outside the United States.

---

[59] See California Energy Commission (CEC), CASE REPORT MULTIFAMILY INDOOR AIR QUALITY at 49 (docketed Oct. 19, 2020) [hereinafter Final CASE Report 2020], *available at:* https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=19-BSTD-03. ("Range hoods are also typically demand controlled (user-operated).")
[60] UCLA Report 2020, *supra*, at 43 (citing LBNL Survey Data 2011).
[61] *See* CEC, PRESENTATION – NOVEMBER 3, 2020 ENERGY CODE PRE-RULE MAKING WORKSHOP at 100 (docketed Nov. 4, 2020) [hereinafter CEC November 2020 Workshop], https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=19-BSTD-03; UCLA Report 2020, *supra*, at 16 (noting "studies have shown that the excessive noise produced by many range hoods and fans is a primary reason for the lack of range hood use").
[62] *See* LBNL Report 2014, *supra*, at 2 (noting that due to lack of public awareness of the potential health impacts, "use of kitchen ventilation is inconsistent even when it is available").

Part Two: Kitchen Ventilation Best Practices for Reducing Exposure in Homes

Researchers have identified ventilation and cooking practices that can significantly mitigate the problem of cooking-related pollution. While cooking practices relate to personal behavior or consumer preference and are outside the purview of government policies, ventilation measures can be incorporated into building codes and other state, local, and tribal laws, as discussed in Part Three. The technology to implement these ventilation practices already exists, and many range hoods currently on the market have the capacity to meet the recommended standards.[63]

Installation of a Vented Range Hood

The simplest form of kitchen ventilation is natural: opening a window.[64] However, windows often do not provide sufficient ventilation to protect occupant health due to lack of airflow. Mechanical ventilation in the form of a local exhaust system is needed to provide reliable, effective kitchen ventilation. Such types of mechanical kitchen ventilation include[65]:

- *Range hoods:* Located above the stovetop; mounted along a wall or over an island range; typically run on-demand with manual controls.
- *Downdraft exhaust systems*: Located next to or at the surface of the stovetop; typically run on-demand with manual controls; typically run at higher speeds.[66]
- *Wall- or ceiling-mounted exhaust fans:* Located anywhere on a kitchen wall or ceiling; may run on-demand or continuously.

Research has shown that **range hoods** are generally much more effective than the other kitchen exhaust system types in removing cooking pollutants as they are emitted, before they have time to mix with the indoor air.[67]

---

[63] *See* M. Nakajima, M. Goebes & E. McCollum, MEMO RE: MARKET ANALYSIS IN SUPPORT OF SINGLE-FAMILY AND UPDATED MULTIFAMILY RANGE-HOOD REQUIREMENTS (docketed Dec. 21, 2020) [hereinafter "Market Analysis Memo"], *available at*: https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=19-BSTD-03.

[64] *See* LBNL Presentation 2013, *supra*, at 17:50.

[65] *See, e.g., id*. at 17:20.

[66] According to the Home Ventilating Institute, "Downdraft kitchen exhausters require a higher volume and velocity of air to adequately capture contaminants. They are an alternative when canopy style hoods are not desired due to location of the cooking surface and kitchen aesthetics; however, their performance cannot equal that of hoods that capture the rising column of air above the cooking surface." Home Ventilating Inst. (HVI), HVI's Fresh Ideas Home Ventilation & Indoor Air Quality Guide Articles: How Much Ventilation Do I Need?, https://www.hvi.org/resources/publications/home-ventilation-guide-articles/how-much-ventilation-do-i-need/.

[67] *See, e.g.,* LBNL Report 2014, *supra*, at 2. ("An exhaust fan at another location in the kitchen is inherently not as efficient at capturing pollutants before they mix into the breathing space.")

Types of range hoods include under-cabinet range hoods; microwave range hoods (where the fan is combined with a microwave and mounted above the stove); and chimney hoods.[68] The physical design of the hood and its surrounding surfaces are important because cooking-related emissions coming off the stove are first captured within the hood, then sucked out through the exhaust duct. Hoods should extend over the entire cooking surface (i.e., cover all burners), and a system with a deeper collection hood (also known as the "sump") is more effective than a shallow or flat hood.[69] Laboratory simulations have shown that hoods located against a wall or in a corner are more effective at capturing pollutants than hoods mounted on the ceiling above an island or mounted without adjoining cabinets.[70]

A key element of effective range hood design is venting to the outdoors through a duct.

One of the most critical elements of an effective range hood design is that it be properly **vented to the outdoors** through a duct. There is general agreement among building scientists that "ductless" or "recirculating" range hoods – which may employ a carbon filter before the air is blown back into the room – do not effectively remove many of the pollutants that are emitted during cooking.[71] In addition, filters must be periodically replaced, resulting in ongoing costs.[72] Duct sizing, material, and design also factor into a system's ultimate efficiency, because the more resistance the air meets in the duct, the lower the system's airflow "as installed."[73]

Minimum Ventilation Performance Standards for Effective Pollutant Removal

Minimum performance standards for kitchen exhaust systems are important for ensuring that the system can remove a sufficient share of the particle pollution, NO_2, and other cooking pollutants immediately after they are emitted – and before they mix with the rest of the home's indoor air and can be inhaled by occupants.

There are two main types of performance standards for range hoods: capture efficiency and air flow. A growing body of building science research has helped technical experts identify performance standards of

---

[68] ROCIS Issue Brief, *supra*, at 7.

[69] *See* B.C. Singer et al. (LBNL), PERFORMANCE OF INSTALLED COOKING EXHAUST DEVICES (Nov. 2011) at 10, *available at*: https://ses.lbl.gov/sites/all/files/lbnl-5265e-r13.pdf.

[70] *See, e.g.,* ROCIS Issue Brief, *supra*, at 7, 12, 18. The ROCIS Issue Brief suggests that if CE ratings are not available, consumers should "pick a deep, wide hood that has an open bottom and that covers all the burners," citing Singer et al., PERFORMANCE OF INSTALLED COOKING EXHAUST DEVICES, *supra*. *See also* LBNL Presentation 2013, *supra*.

[71] *See, e.g.,* ROCIS Issue Brief, *supra*, at 5 (noting that "ductless (or recirculating) range hoods lack a vent to the outside and do not effectively remove cooking emissions, even if the hood has grease, particle, or charcoal filters"); ASHRAE Guideline 24-2015, *supra*, at 10.5.1 (noting that recirculating range hoods "do not improve most pollutants created by a cooking event and should be avoided"); *see also* G. Rojas, I.S. Walker & B.C. Singer (LBNL), COMPARING EXTRACTING AND RECIRCULATING RESIDENTIAL KITCHEN RANGE HOODS FOR THE USE IN HIGH ENERGY EFFICIENT HOUSING (2017), *available at*: https://indoor.lbl.gov/publications/comparing-extracting-and (noting that "[n]o scientific study investigating the performance of recirculating range hoods was found. Tests for consumer magazines as well as surveys indicate notably lower performance compared to extracting hoods"); LBNL Report 2014, *supra*, at 9 (finding no recirculating range hood products that claim to remove CO or water vapor).

[72] *See, e.g.,* Consumer Reports, Range Hood Buying Guide, https://www.consumerreports.org/cro/range-hoods/buying-guide/index.htm.

[73] *See* LBNL Presentation 2013, *supra*. Duct-related recommendations from the ROCIS Initiative include, among others: "Use 8-inch round smooth metal ducts (NOT FLEX DUCT)"; "Minimize bends in the duct layout and avoid 90 degree to reduce improve air flow"; and "Mechanically fasten all duct joints." ROCIS Issue Brief, *supra*, at 18.

both types that will keep indoor pollutant concentrations below unhealthy levels when systems are used properly.

Capture Efficiency. In the ventilation industry, the effectiveness of a kitchen exhaust system in removing cooking pollutants is referred to as "capture efficiency" (CE).[74] Expressed as a percent, the capture efficiency of a range hood or other kitchen exhaust system is the fraction of the total pollutants emitted at the cooktop that are removed by the exhaust system (and are "thus not available for inhalation").[75] For example, a range hood with a capture efficiency of 50% would capture half of the pollutants generated during cooking but allow the other half to "escape" and mix with the indoor air. In the real world, the capture efficiency of a particular kitchen exhaust system depends on several factors, including airflow rate, design of the exhaust hood (size, shape/depth, and distance from cooktop), whether front or back burners are used, and the type and amount of cooking activity.[76]

Given the many factors that can influence capture efficiency during cooking, it is important to have a standardized testing method upon which product certifications can be based. Until recently, there were no standardized testing methods to measure and certify the capture efficiency of kitchen exhaust systems. However, in 2018, the American Society for Testing and Materials (ASTM) published S*tandard E3087: Standard Test Method for Measuring Capture Efficiency of Domestic Range Hoods*, which sets out a test method for rating capture efficiency for wall-mounted range hoods up to 36 inches in width.[77] The Home Ventilating Institute (HVI) is in the process of developing a testing and rating procedure based on the ASTM test, which, once finalized, will be used by HVI to certify products based on capture efficiency.[78]

Capture efficiency as a performance measure is beginning to gain momentum among policymakers. California plans to include CE standards in the next edition of its Energy Code, which will take effect in 2022.[79] In the pre-rulemaking process, the agency developing the standards noted that it expects CE ratings to be available from HVI by 2022, but that it plans to allow alternative compliance pathways in the form of airflow ratings "[b]ecause manufacturers are still finalizing test conditions for the capture efficiency test and are not yet publishing the capture efficiency of their equipment…."[80]

---

[74] *See, e.g.,* B.C. Singer, W.W. Delp & M.G. Apte (LBNL), EXPERIMENTAL EVALUATION OF INSTALLED COOKING EXHAUST FAN PERFORMANCE at ii (Nov. 2010), *available at:* https://indoor.lbl.gov/publications/experimental-evaluation-installed.
[75] *Id*. at 2.
[76] *See* W.R. Chan, I.S. Walker & B.C. Singer, TECHNICAL MEMO ON UPDATED ANALYSIS FROM NO2 AND PM2.5 COOKING SIMULATIONS TO INFORM CAPTURE EFFICIENCY STANDARDS at 1 (docketed Nov. 2, 2020) [hereinafter LBNL Technical Memo 2020], *available at*: https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=19-BSTD-03; *see also* CEC November 2020 Workshop, *supra*, at 88.
[77] According to ASTM, "This test method measures the capture efficiency of wall-mounted domestic range hoods under controlled conditions in a test chamber." It "applies to range hoods that exhaust air to outside and does not apply to recirculating range hood" and "only applies to range hood air flows up to 200 L/s and widths up to 0.91 m (36 in.)." The "test method is intended to quantify the capture efficiency of range hoods under controlled laboratory conditions suitable for rating." ASTM International, ASTM E3087-18, STANDARD TEST METHOD FOR MEASURING CAPTURE EFFICIENCY OF DOMESTIC RANGE HOODS at 1.1 et seq. (2018), *available at*: https://www.astm.org/Standards/E3087.htm.
[78] *See* HVI, HOME VENTILATING INSTITUTE COMMENTS – RESPONSE TO CEC'S NOV 3 PROPOSAL TO ESTABLISH MINIMUM CAPTURE EFFICIENCY FOR RANGE HOODS (docketed Nov. 17, 2020), *available at*:
https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=19-BSTD-03.
[79] *See* CEC, DRAFT 2022 ENERGY CODE EXPRESS TERMS (docketed Feb. 22, 2021), *available at:*
https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=19-BSTD-03.
[80] Final CASE Report 2020, *supra*, at 55, 91. ("HVI 917 [for rating CE] has been published but, as of August 2020, has not been publicly released. However, HVI plans to begin listing capture efficiencies in late 2020 and to make the listing

Minimum Airflow Rates as a Proxy for Capture Efficiency. Because testing and rating products for CE is a recent and developing practice, current versions of popular model building codes and standards – and the state and local codes based on them – do not currently express performance requirements in terms of capture efficiency. Instead, building codes rely mainly on *airflow rates* (expressed in cubic feet per minute, or cfm) to measure the performance of kitchen ventilation systems (though some codes and standards also measure local ventilation performance in air changes per hour, or ach).

While the relationship between CE and airflow depends in part on a variety of factors, as noted above, researchers at LBNL have used laboratory simulations to approximate how certain range hoods' airflow rates correspond to CE, concluding that "higher airflow generally translates to higher CE."[81] Until CE-based testing and certification become available for more products, airflow remains a widely used proxy for measuring the performance efficiency of a kitchen ventilation system.

To that end, best practice guidance from the ROCIS (Reducing Outdoor Contaminants in Indoor Spaces) initiative and HVI include recommendations for airflow. The 2019 ROCIS recommendations state that while airflow needs vary by home and depend on a number of factors, "[a]irflow rates for typical homes should be 200-350 cubic feet per minute (cfm)."[82] HVI has published its recommended ventilation rates for kitchen range hoods based on the width of the range: 100 cfm per linear foot when located against a wall (for island ranges, the rate is multiplied by 1.5). For a standard 30-inch range located against a wall, this translates to an HVI-recommended rate of 250 cfm.[83] However, as described below, recent research by LBNL has shed new light on airflow needed to maintain pollutants below unhealthy levels depending on home size and stove type.

Research on Capture Efficiency and Airflow Standards for Protecting Occupant Health. Recent research conducted by a team from LBNL has provided important data about the connection between range hood capture efficiency and healthy indoor air.[84] To determine a minimum performance level needed to protect occupant health, researchers performed simulations to measure levels of two key pollutants – $PM_{2.5}$ and NO_2 – emitted during heavy but not atypical cooking activities.[85] Using both gas and electric stoves, the researchers ran simulations that allowed them to calculate the minimum capture efficiency needed to keep unhealthy levels of $PM_{2.5}$ (gas and electric stoves) and NO_2 (gas stoves only) from accumulating inside homes of different sizes. The research was designed to account for "emissions from cooking, pollutants from outdoor air, removal of emissions and pollutants by kitchen ventilation, continuous dwelling unit ventilation,

---

mandatory in October 2021. Thus, capture efficiency data will be available when the 2022 Title 24, Part 6 code goes into effect.")

[81] LBNL Technical Memo 2020, *supra*, at 3. Following the Technical Memo, a final project report on the study and its findings was released in January 2021. *See* B.C. Singer et al. (LBNL), EFFECTIVE KITCHEN VENTILATION FOR HEALTHY ZERO NET ENERGY HOMES WITH NATURAL GAS, *supra*.

[82] ROCIS Issue Brief, *supra*, at 6. The ROCIS guidance notes that "[i]sland installations will require higher flows than wall installations," and that "[f]or frequent high emitting cooking activities your hood should have a rated airflow rate of at least 300-400 cfm." *Id*. at 6, 13.

[83] HVI, HVI's Fresh Ideas Home Ventilation & Indoor Air Quality Guide Articles: How Much Ventilation Do I Need?, https://www.hvi.org/resources/publications/home-ventilation-guide-articles/how-much-ventilation-do-i-need/.

[84] See LBNL Technical Memo 2020, *supra*.

[85] W. Chan et al. (LBNL), SIMULATIONS OF SHORT-TERM EXPOSURE TO NO2 AND PM2.5 TO INFORM CAPTURE EFFICIENCY STANDARDS (March 2020), *available at*: https://eta.lbl.gov/publications/simulations-short-term-exposure-no2; LBNL Technical Memo 2020, *supra*. *See also* CEC November 2020 Workshop, *supra*, at 96.

and deposition to surfaces" and took into consideration higher short-term exposure for the person who is in the kitchen doing the cooking.[86] Overall, the researchers found that:

- Higher CE was needed for range hoods in kitchens using *gas stoves*, whose burners emit NO_2 in addition to $PM_{2.5}$, and
- Range hoods must have higher CE in *smaller dwelling units* (such as multifamily units and manufactured homes), where pollutants become more concentrated due to lower total air volume.

The study's findings, summarized in Table A below, suggest minimum performance standards based on airflow for all stoves to meet the WHO 24-hour $PM_{2.5}$ guideline and the EPA 1-hour NO_2 standard. The findings also illustrate the potential for establishing different performance standards based on stove type and/or home size, rather than the "one-size-fits-all" approach taken by many residential codes.[87]

TABLE A: SUMMARY OF LBNL STUDY FINDINGS ON CAPTURE EFFICIENCY/RANGE HOOD AIRFLOWS TO PROTECT HEALTH

Cooking Pollutant (Health-Based Threshold)	Floor Area of Dwelling	Capture Efficiency	Airflow as Installed (cubic feet/minute, cfm)
$PM_{2.5}$ (25 micrograms/m^3 per 24-hours, WHO Guideline) *Electric and gas stoves*	>1500 ft^2	50%	110 cfm
	1000 – 1500 ft^2	50%	110 cfm
	750 – 1000 ft^2	55%	130 cfm
	< 750 ft^2	65%	160 cfm
NO_2 (100 parts per billion per 1-hour, EPA NAAQS) *Gas stoves*	>1500 ft^2	70%	180 cfm
	1000 – 1500 ft^2	80%	250 cfm
	750 – 1000 ft^2	85%	280 cfm
	< 750 ft^2	85%	280 cfm

Source: Reproduced with minor formatting changes from W. Chan, B. Singer & I. Walker, *Technical Memo on Updated Analysis from NO2 and PM2.5 Cooking Simulations to Inform Capture Efficiency Standards* at Table 3, page 6 (Oct. 26, 2020), *available at*: https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=19-BSTD-03.

TABLE B: PRACTICAL APPLICATION OF LBNL STUDY FINDINGS BY DWELLING SIZE

Floor Area of Dwelling	Uses Electric Stove		Uses Gas Stove	
>1500 ft^2	50% CE	110 cfm	70% CE	180 cfm
1000 – 1500 ft^2	50% CE	110 cfm	80% CE	250 cfm
750 – 1000 ft^2	55% CE	130 cfm	85% CE	280 cfm
<750 ft^2	65% CE	160 cfm	85% CE	280 cfm

Source: Derived from W. Chan, B. Singer & I. Walker, *Technical Memo on Updated Analysis from NO2 and PM2.5 Cooking Simulations to Inform Capture Efficiency Standards* at Table 3, page 6 (Oct. 26, 2020), *available at*: https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=19-BSTD-03.

[86] *See* Market Analysis Memo, *supra*, at 3.
[87] The International Mechanical Code (IMC), which in many adopting jurisdictions applies to certain types of residential dwelling units, includes a requirement based on square footage of the kitchen floor area. *See* 2021 IMC at 403.3.

Analysts for California's Statewide Codes and Standards Enhancement (CASE) Team reviewed products that are currently available on the market and concluded that the standards in Tables A and B would be "feasible for all or most island and chimney range hood products, and for the majority of undercabinet range hoods."[88]

For microwave range hoods, "all products could meet the minimum airflow requirement up to 160 cfm," i.e. the most stringent requirement for electric stoves; for gas stoves, 92% of microwave range hoods could meet the 180 cfm requirement, but only "[a]bout half the products" could meet the 250 cfm requirement, and fewer than a quarter of the products (17%) could meet the 280 cfm requirement.[89]

This recent research provides important insight into how kitchen ventilation standards can be strengthened to provide greater protection against cooking pollutant exposure. Indeed, based on these findings and prior research, the California Energy Commission recently issued for public review and comment a preliminary proposal to adopt significant amendments to kitchen ventilation standards in the state's residential building code. California's effort to strengthen kitchen ventilation requirements in residential buildings is described in Part Three.

Verifying Performance. As with other consumer products, performance verification requirements for kitchen exhaust systems – e.g., certification, rating, testing – help ensure that such systems perform as expected. Research has shown that for cooking exhaust fans, "airflows of installed devices are often below advertised values."[90] Manufacturers' claims regarding a product's performance capabilities (e.g., airflow settings) can be verified by requiring that kitchen exhaust systems undergo independent, standardized performance testing. The American National Standards Institute (ANSI) and ASHRAE have developed a standardized method for testing fans in laboratories: ANSI/ASHRAE Standard 51 (also known as ANSI/AMCA Standard 210): *Laboratory Methods of Testing Fans for Aerodynamic Performance Rating.*

One recommended approach is that kitchen exhaust equipment be tested for airflow after installation in the home, since in practice "[m]any installed hoods…do not perform nearly as well as rated or designed."[91] Building standards can establish requirements to test ventilating equipment "as installed" using industry-standard devices and methods.[92]

Another approach is to require certification from a trusted third-party organization in advance of installation indicating that the product has been tested according to standard test methods that were conducted properly. The Home Ventilating Institute (HVI), through its Certified Ratings Program (CRP), is a leading third-party certification provider for kitchen exhaust fans and range hoods. HVI ratings are intended to assure customers that the airflow (and sound) ratings advertised by a product's manufacturer are independently verifiable.[93]

---

[88] Market Analysis Memo, *supra*, at 8. The CASE Team is a group charged with "present[ing] recommendations to support the California Energy Commission's…efforts to update the California Energy Code (Title 24, Part 6) to include new requirements or to upgrade existing requirements for various technologies." Final CASE Report, *supra*, at 11.
[89] Market Analysis Memo, *supra*, at 8.
[90] B.C. Singer et al., PERFORMANCE OF INSTALLED COOKING EXHAUST DEVICES*, supra,* at Abstract.
[91] ROCIS Issue Brief, *supra*, at 19.
[92] *See, e.g*., *id*. at 19. ("Building performance contractors and energy auditors can test using devices such as flow hoods or blower doors and pressure gauges.")
[93] HVI, HVI-Certified Ratings Programs - Overview, https://www.hvi.org/hvi-certified-ratings-programs/hvi-certified-ratings-programs-overview/.

When relying on third-party certification and rating rather than on-site testing, it is important that the system, including ductwork, is designed and installed so as to minimize resistance that can result in lower airflows.[94] The Home Ventilating Institute also has developed a new rating method it refers to as "nominal installed airflow" (NIA), which, at the recommendation of an ASHRAE 62.2 range hood work group, was developed to "provide[] the closest approximation of a range hood's 'as installed' airflow."[95]

Other IAQ Considerations: Avoiding Depressurization and Backdraft. It is not always the case that "the higher the airflow, the better the IAQ." High exhaust air flows – e.g., above 300-400 cfm – "can cause imbalances in airflows in and out of the home."[96] As explained in a ROCIS report,

> "When insufficient air is brought into the home to balance exhaust flows from exhaust fans and other appliances, depressurization (negative air pressure, or suction) of the home occurs. This can cause combustion equipment to backdraft carbon monoxide and other combustion pollutants into the home. It can also pull unwanted pollutants from adjoining spaces and the outdoors."[97]

Especially in homes with downdraft exhaust systems and/or professional-style gas stoves with large burners, which typically require higher airflow rates, it is important to ensure that "makeup air" is provided to prevent depressurization.[98] Technical experts recommend that "dedicated, automated make-up air – e.g., via pressure relief damper, or inter-locked supply fan – is always installed with high airflow (>400 cfm) range hoods, as required by manufacturers' instructions and building and mechanical code."[99] Where naturally-vented combustion appliances (e.g., fireplaces) are also present in the home, a combustion appliance safety test should be conducted.[100] Backdraft prevention is especially important in multifamily dwellings, where one unit's ventilation practices and air pressure changes may indirectly affect other units.[101]

Proper Use of Kitchen Ventilation Systems and Low-Emission Cooking Practices

Kitchen ventilation systems can only effectively remove cooking pollutants if they are used properly by occupants. Best practices for using kitchen exhaust fans include:

- Operating the system whenever cooking on the stove or in the oven (and leaving the fan running for 10-20 minutes afterward);
- Cooking on the back burners instead of the front burners if the range hood is mounted under a cabinet or against a wall (and using lower temperatures when possible);
- Using cooking oils with high smoke temperatures (e.g., sunflower oil); and
- Covering pots and pans to reduce particle emissions from oil and food.[102]

---

[94] *See* LBNL Presentation 2013, *supra*.
[95] HOME VENTILATING INSTITUTE COMMENTS – RESPONSE TO CEC'S NOV 3 PROPOSAL TO ESTABLISH MINIMUM CAPTURE EFFICIENCY FOR RANGE HOODS, *supra*, at 4.
[96] ROCIS Issue Brief, *supra*, at 14.
[97] *Id*.
[98] *Id*. at 14-15.
[99] LBNL Report 2014, *supra*, at 22 (internal citation omitted).
[100] ROCIS Issue Brief, *supra*, at 14.
[101] *See generally* K. Ueno, J. Lstiburek & D. Bergey, MULTIFAMILY VENTILATION RETROFIT STRATEGIES (Dec. 2012), *available at:* https://www.nrel.gov/docs/fy13osti/56253.pdf.
[102] *See* ROCIS Issue Brief, *supra*, at 6; LBNL Presentation 2013, *supra*; T. Phillips, KEEP A LID ON IT: BEST PRACTICE FOR REDUCING COOKING POLLUTION IN HOMES at 26, *available at*: http://rocis.org/sites/default/files/user-files/2020_Keep_a_lid_on_it.pdf

While many of these practices involve personal behaviors, there are two important issues that can be addressed by policies in order to help overcome key obstacles to proper use of kitchen ventilation systems: *noise* and *consumer awareness*.

Sound. According to experts, "Acoustic noise that is generated by operation of the range hood is an important attribute that determines the device's acceptability and usability. Excessive noise reduces the likelihood that the ventilation system will be operated."[103] The most important way to encourage use of kitchen fans is to ensure they do not operate too loudly for occupants' comfort or convenience.

> *An important way to encourage use of kitchen exhaust fans is to ensure they do not operate too loudly.*

Sound ratings, expressed in units of measurement called sones, indicate how loudly an exhaust fan operates at a given speed. (The sound of a refrigerator running is around 1.0 sone; a face-to-face conversation is around 3.0 sones.[104]) Including a maximum sound rating as part of kitchen exhaust system requirements can help overcome occupants' reluctance to activate an installed fan because it is too loud.

As described in Part Three, many of the current codes and model standards have adopted a maximum sound rating requirement of 3.0 sones at 100 cfm, but other sources suggest that more stringent standards may be needed. For example, based on the consensus recommendation of expert advisors to the ROCIS initiative, the ROCIS guidance recommends selecting a system with an HVI sound rating of less than 3.0 sones for airflow rates of 200 cfm or more.[105] Energy Star, a joint program of the U.S. Department of Energy and EPA, has adopted certification criteria including a maximum sound rating of 2.0 sones for range hoods.[106]

Independent sound rating and certification is available through HVI (HVI 915, *Loudness Testing and Rating Procedure 2015*), and ANSI/AMCA have developed a standard method for sound testing (ANSI/AMCA Standard 300, *Reverberant Room Method for Sound Testing of Fans*).[107] Sound ratings are available for many kitchen exhaust fan products on the market (though "few microwave range hoods currently have sound or airflow ratings certified by HVI."[108]) However, many manufacturers do not provide sound ratings for all settings/speeds, meaning that a product rated at 3.0 sones at 100 cfm may be considerably louder at higher settings.[109] One study found that "[f]or many devices, achieving capture efficiencies that approach or exceed 75% requires operation at settings that produce prohibitive noise levels….[R]esults suggest the need for improvements in hood designs to achieve high pollutant capture efficiencies at acceptable noise levels."[110]

---

[103] *E.g.*, Singer et al., PERFORMANCE OF INSTALLED COOKING EXHAUST DEVICES, *supra*, at 9.
[104] P. Schrader (Broan NuTone), What are Sones?, https://www.broan-nutone.com/en-us/home/learn/what-are-sones.
[105] ROCIS Issue Brief, *supra*, at 7. The issue brief also recommends selecting "a multispeed fan that can be used at lower flow rates and sound levels when cooking with low emissions or on small burners." *Id.*
[106] Energy Star, Ventilation Fans Key Product Criteria, https://www.energystar.gov/products/heating_cooling/fans_ventilating/key_product_criteria.
[107] *Id.*
[108] ROCIS Issue Brief, *supra*, at 13.
[109] LBNL Presentation 2013, *supra*; *see also* Market Analysis Memo, *supra*, at 20.
[110] Singer et al., PERFORMANCE OF INSTALLED COOKING EXHAUST DEVICES, *supra*, at 2.

Information and Education to Increase Public Awareness. Beyond ensuring that kitchen exhaust systems are not prohibitively loud, information and education that increase public awareness of the need for kitchen ventilation are practical strategies to encourage people to use them.[111]

As a first step, *clear labeling* of range hoods and other kitchen exhaust systems (and their controls) can help ensure that occupants will know what the system is for and how it can be activated. Builders and landlords can provide *informational materials* directly to occupants about the importance of cooking ventilation for protecting health, as well as instructions on the operating, cleaning and maintenance measures that may be necessary for continued effectiveness of the equipment.[112]

There is also an important role for public health and building agencies in developing public education and outreach programs (e.g., public ad campaigns) to raise awareness of the importance of reducing cooking pollutant exposure and to provide tips on how to do so.

[111] Investigators conducting market research in connection with California's current energy code update found, based on a survey, that lack of awareness was the most common reason why respondents do not use the range hood for all cooking: "consumer selected 'not needed' most often, followed by 'too noisy.'" Final CASE Report 2020, *supra*, at 57.

[112] For example, HVI recommends that for range hoods, "The aluminum mesh grease filters should be washed in your dishwasher approximately every month depending on the amount of usage." HVI, Resources: FAQs, https://www.hvi.org/resources/faqs/. The ROCIS Issue Brief recommends that users "[c]lean the hood's grease mesh filters: To prevent cooking fumes from backing up and spilling outside the hood, clean the grease filters about four times a year to maximize airflow through the ducting." ROCIS Issue Brief, *supra*, at 10.

PART THREE: POLICY STRATEGIES FOR IMPROVING KITCHEN VENTILATION IN NEW HOMES

In order to protect occupants from the risk of exposure to unhealthy levels of fine particles and other cooking pollutants and to maintain indoor air quality, policies that regulate the design and construction of new residential buildings should include mandatory provisions requiring installation of kitchen exhaust ventilation systems that vent to the outdoors. This Part describes how states, localities, and tribes can use building codes that establish minimum standards for building design and construction, as well as green building standards that go beyond minimum requirements, to help ensure future homes are equipped with the kitchen ventilation they need.

<u>Building Codes: Strengthening Minimum Residential Construction Requirements</u>

Building codes are the central policymaking tool for establishing building design and construction requirements. Most states have adopted a mandatory statewide building code that sets minimum requirements throughout the state for new residential and/or commercial construction and renovation.[113] A minority of these states have adopted a statewide building code for commercial and/or public buildings, but not a separate code for low-rise residences. State building codes are generally enforced at the local level, and state law may give localities authority to amend the state code; typically, local amendments must be at least as stringent as the state requirements.[114]

Building codes in the United States have expanded greatly since their early adoption as a means of preventing loss of life and property. Current building codes cover a wide scope of design and construction practices, addressing evolving societal priorities ranging from accessibility and resilience to energy efficiency and indoor air quality. Because of the technical and financial resources required to develop buildings codes, state and local codes draw largely on model codes and standards developed by third-party organizations.

This section therefore begins with a short description of widely referenced model codes and standards. As noted earlier, the primary purpose of range hoods and other kitchen ventilation systems is to capture cooking pollutants at or near their source and exhaust them to the outdoors. Thus, while whole-house ventilation and filtration of recirculated air have a role to play in diluting and filtering cooking pollutants that do end up mixing with the indoor air, the focus here is on provisions in the model codes related directly to exhaust ventilation in kitchens. It also is beyond the scope of this report to discuss the variety of technical

---

[113] The information about current building code provisions presented in this section is based primarily on an ELI review of state building codes in mid-2020.

[114] *See generally* U.S. Dept. of Energy (DOE), How are Building Codes Adopted, https://www.energy.gov/eere/buildings/articles/how-are-building-codes-adopted; International Code Council (ICC), Code Adoption Process by State, https://www.iccsafe.org/wp-content/uploads/Code-Adoption-Process-by-State-June-2019.pdf.

issues relevant to determining more broadly how best to ensure adequate ventilation while achieving energy efficiency goals.[115]

As discussed below, the model residential construction codes and standards most commonly incorporated into state and local policies either do not mandate kitchen ventilation in new construction and/or establish minimum performance standards that are not sufficient to protect occupant health and maintain good IAQ in all dwellings. A recent study sponsored by the California Energy Commission indicated that the minimum airflow rate found in popular building codes and standards (100 cfm intermittent) is "too low to maintain IAQ at acceptable levels" in small dwellings.[116]

While most state and local building codes follow the model codes and standards described below, this section ends by highlighting California's efforts to strengthen kitchen ventilation standards as part of its current building code update. These proposed changes may serve as a useful model for other states and municipalities considering amending their building codes to strengthen protections for occupants from the health risks posed by exposure to cooking pollutants.

Model Building Codes and Standards

This section describes kitchen ventilation requirements found in widely accepted model codes and standards: the International Code Council's model building codes, and the ASHRAE model standard for residential ventilation.

ASHRAE Standard 62.2. ASHRAE, a professional organization representing building system design and industrial process professionals, undertakes research, standards writing, publishing, and continuing education.[117] ASHRAE 62.2, *Ventilation and Acceptable Indoor Air Quality in Residential Buildings*, is a consensus standard of practice for dwelling units in non-transient residential occupancies. This section describes the most recent update, ASHRAE 62.2-2019.[118] (Prior to 2016, residential units in buildings four stories or higher were covered by a separate standard, ASHRAE 62.1, *Ventilation for Acceptable Indoor Air Quality*; that standard now applies only to commercial buildings and to common areas and spaces other than dwelling units in high-rise residential buildings.[119])

ASHRAE 62.2 provisions are framed as enforceable requirements that can be incorporated into building codes. ASHRAE 62.2 has been incorporated into some state and local building codes, as well as certain

---

[115] *See generally* U.S. DOE, Whole House Ventilation, https://www.energy.gov/energysaver/weatherize/ventilation/whole-house-ventilation; ASHRAE, INDOOR AIR QUALITY GUIDE: BEST PRACTICES FOR DESIGN, CONSTRUCTION AND COMMISSIONING at 117-137, *available at*: https://www.ashrae.org/technical-resources/bookstore/indoor-air-quality-guide.
[116] *See* LBNL Technical Memo 2020, *supra*, at 1-3.
[117] ASHRAE, ASHRAE's Mission and Vision, https://www.ashrae.org/about/mission-and-vision. ASHRAE is a member of the American National Standards Institute (ANSI), which approved Standard 62.2 as an American National Standard. *See* ASHRAE Standard 62.2, *infra*, at Special Note (front matter). The organization was formerly known by both its acronym and the longer name, the American Society of Heating, Refrigerating and Air-Conditioning Engineers.
[118] *See* ANSI/ASHRAE Standard 62.2-2019, VENTILATION AND ACCEPTABLE INDOOR AIR QUALITY IN RESIDENTIAL BUILDINGS, *available at*: https://www.ashrae.org/technical-resources/standards-and-guidelines/read-only-versions-of-ashrae-standards. The 2019 version incorporates 16 addenda to the 2016 edition.
[119] *Id.*

governmental and non-governmental high performance building programs.[120] California's Energy Code, for example, incorporates elements of ASHRAE 62.2, including provisions for kitchen ventilation.[121] According to researchers at LBNL, "[i]n the U.S., ASHRAE Standard 62.2 is the most important standard with kitchen ventilation requirements."[122] ASHRAE 62.2 does not, however, encompass all best practices for kitchen ventilation; rather, it purports to set a "minimum standard" for ventilation.[123] A separate publication, ASHRAE Guideline 24-2015: *Ventilation and Indoor Air Quality in Low-Rise Residential Buildings*, "provides information on achieving indoor air quality (IAQ) that may go beyond minimum requirements, i.e., better IAQ"; though still available, the document was withdrawn in 2020 and will not be updated.[124]

*ASHRAE 62.2 - Mandatory Kitchen Exhaust in New Construction***.** ASHRAE 62.2, Section 5.1, requires that "[a] local mechanical exhaust system be installed in each kitchen…."[125] An exhaust system is defined in the standard as "one or more fans that remove air from the building…."[126] Standard 62.2 does not require or prefer vented range hoods over other exhaust fan types, nor does it specify where a range hood or other fan should be installed in the room or how it should be sized in relation to the cooktop.

*ASHRAE 62.2 - Minimum Kitchen Exhaust Performance Standards***.** ASHRAE 62.2 includes performance requirements expressed in minimum airflow (cfm). The standards are intended to ensure systems installed in kitchens can perform at a level that will achieve minimum acceptable air quality. The ASHRAE 62.2 committee is considering amending the standard to incorporate performance standards based on capture efficiency in future versions.[127]

The minimum exhaust airflow rates for demand-controlled systems are indicated in Table 5-1, which sets out varying requirements based on the system's design and the home's layout. For *vented range hoods* (including appliance-range hood combinations), the required rate is 100 cfm, whether the kitchen is enclosed or non-enclosed. For "[o]ther kitchen exhaust fans, including downdraft," the required airflow rate is 300 cfm in non-enclosed kitchens; in enclosed kitchens, other systems must be capable of either 300 cfm or 5 ach.[128] Per

---

[120] *See, e.g.,* Wa. Admin. Code 51-51-1507 (adopting the 2018 IRC but allowing ASHRAE 62.2 as a compliance path for meeting whole-house mechanical ventilation system design requirements); VT. RESIDENTIAL BUILDING ENERGY CODE HANDBOOK at 33 (2020), *available at*: https://publicservice.vermont.gov/sites/dps/files/documents/2020-VT_Residential_Energy_Code_Handbook_v8.pdf (ASHRAE Standard 62.2 allowed as alternative method to meet mechanical ventilation requirements).

[121] Ca. Code Regs. Title 24, Part 6, Secs. 120.1(b)(2), 150.0(o).

[122] LBNL Report 2014, *supra*, at 11.

[123] *See* LBNL, ASHRAE Standard 62.2, https://homes.lbl.gov/ventilate-right/ashrae-standard-622. ("ASHRAE 62.2 is a standard that national experts could agree upon that sets a minimum standard for ventilation — not best practice, which would further customize ventilation rates based on factors such as number of occupants in a dwelling and strength of pollutant sources.")

[124] ANSI Webstore, ASHRAE Guideline 24-2015, https://webstore.ansi.org/standards/ashrae/ashraeguideline242015. According to the foreword, the guideline was published because "the 62.2 project committee felt that the new standard by itself did not adequately address the need to provide information on achieving better IAQ in low-rise residential buildings." *Id*.

[125] ASHRAE 62.2-2019, Sec. 5.1. A kitchen is defined as "any room containing cooking appliances." *Id*. at Sec. 3.

[126] *Id*. at Sec. 3.

[127] *See* Final CASE Report 2020, *supra*, at 54 ("Given the health impacts associated with kitchen pollution, several industry groups are working to incorporate a capture efficiency rating or requirement, including the ASHRAE Standard 62.2 committee. This committee established a working group in 2019 to develop recommendations for a capture efficiency requirement for future versions of the ASHRAE 62.2 Standard."); *see also* ASHRAE, Measuring Range Hood Capture Efficiency Values, https://www.ashrae.org/news/ashraejournal/measuring-range-hood-capture-efficiency-values.

[128] ASHRAE 62.2-2019 at Table 5-1.

Table 5-2, in an enclosed kitchen with a continuous mechanical exhaust system, the minimum airflow rate is 5 ach based on kitchen volume.[129] There are no differences in minimum airflow rate requirements based on the size of the home or stove/fuel type (e.g., gas vs. electric).

As noted previously, high exhaust airflow rates without sufficient makeup air can lead to air pressure changes that may create or exacerbate risk of other IAQ problems, including backdraft of combustion products and infiltration of outside pollutants. ASHRAE 62.2 addresses some of these issues.[130]

ASHRAE 62.2 - Verifying Performance. ASHRAE 62.2 provides two ways to demonstrate compliance with minimum airflow requirements: testing the kitchen exhaust airflow "as installed"; or conforming to a "prescriptive" requirement based on airflow rating and duct specifications.[131] All "[v]entilation devices and equipment serving individual dwellings" must be tested according to ANSI/ASHRAE Standard 51 and rated for airflow in accordance with the "rating procedures of the Home Ventilating Institute."[132]

*ASHRAE 62.2 - Proper Use of Kitchen Ventilation: Sound Ratings and Information/Education***.** As noted above, requiring sound rating limits for fans can help ensure that systems will not be turned off due to noise concerns.[133] Section 7.2 of ASHRAE 62.2 sets maximum sound ratings for ventilation fans (except HVAC air handlers and remote mounted fans): a 1.0 sone maximum for continuous local exhaust fans; and a 3.0 sone maximum for on-demand exhaust fans at an airflow setting of 100 cfm (except fans with a minimum airflow setting above 400 cfm.)[134]

Like airflow rates, a product's sound levels can be verified through rating and testing. The standard requires all "[v]entilation devices and equipment serving individual dwellings" be tested according to ANSI/AMCA Standard 300 (Reverberant Room Method for Sound Testing of Fans) and rated for sound in accordance with

---

[129] *Id*. at Table 5-2.

[130] *See* ASHRAE 62.2-2019, Sec. 6.4.2. Guideline 24-2015 explains that "[m]echanical local exhaust normally is balanced by transfer air from other parts of the dwelling" and the fan sizes specified in ASHRAE 62.2 "do not usually induce significant depressurization of the entire building and thus have little impact on space conditioning costs. However, in tight dwellings or in dwellings with large exhaust flows, local exhaust can induce or cause unacceptable depressurization." ASHRAE Guideline 24-2015, *supra*, at Sec. 10.5.1.

[131] Section 5.4 states: "The airflow required by this section is the quantity of indoor air exhausted by the ventilation system as installed and shall be measured according to the ventilation equipment manufacturing instructions, or by using a flow hood, flow grid, or other airflow measuring device at the mechanical ventilation fan's inlet terminals, outlet terminals, or in the connected ventilation ducts." An exception provides that in place of an airflow measurement, use of "[m]anufacturer design criteria or the prescriptive [duct sizing] requirements of Table 3," which identifies minimum duct diameter sizes based on duct type and fan airflow rating at a minimum static pressure of 0.25 in. of water (L/s at minimum 62.5 Pa), is permitted. Note the prescriptive pathway is *not* available to duct systems that are over 25 ft. long; have four or more elbows; or fail to meet certain hydraulic diameter specifications. *See* ASHRAE 62.2-2019, Sec. 5.4.

[132] ASHRAE 62.2-2019, Sec. 7.1. ASHRAE 51 is *Laboratory Methods of Testing Fans for Aerodynamic Performance Rating*. Relevant HVI ratings include HVI 916: *Air Flow Test Procedure* and HVI 920: *Product Performance Certification Procedure Including Verification and Challenge*.

[133] ASHRAE Guideline 24-2015, Section 10.5.1, notes "noise can be an inhibiting factor in [kitchen fans'] use, but quieter, lower-sone systems are available."

[134] ASHRAE 62.2-2019, Sec. 7.2. There is an exception for "remote mounted fans" that are "mounted outside the habitable spaces…and there must be at least 4 ft (1 m) of ductwork between the fan and intake grille." All air-moving equipment used to comply with the ventilation requirements must be "rated in accordance with the airflow and sound rating procedures of the Home Ventilating Institute (HVI 915 [2015, Loudness Testing and Rating Procedure], 916 [2013, Air Flow Test Procedure], and 920 [2015, Product Performance Certification Procedure Including Verification and Challenge])." ASHRAE 62.2-2019, Sec. 7.1.

the "rating procedures of the Home Ventilating Institute" (HVI 915-2015, Loudness Testing and Rating Procedure.)[135]

Under ASHRAE 62.2, information about the ventilation systems installed, instructions on their proper operation, and instructions detailing any required maintenance must be provided to the owner and the occupant of the dwelling unit, and controls must be labeled as to their function.[136]

International Code Council Model Codes. Most jurisdictions with mandatory building codes have adopted one or more of the model codes of the International Code Council (ICC), with amendments. Most, but not all, of these states have adopted the ICC codes for both low-rise residential and large residential buildings.

The ICC publishes 15 different model codes intended to be adopted by states and other jurisdictions. The International Residential Code (IRC), which covers one- and two-family dwellings and townhouses three stories or less, is a comprehensive code that covers most construction requirements. The International Building Code (IBC) applies to all other building types, including larger multi-unit residential buildings, and is used in conjunction with a series of specialized codes, including the International Mechanical Code (IMC), which governs ventilation systems. In 2018, ICC and ASHRAE jointly produced the International Green Construction Code (IgCC), a model code designed to be fully compatible with the ICC family of codes and applicable to all occupancies except single-family homes, multifamily structures up to three stories, and other low-rise occupancies.[137]

The purpose of the ICC codes is to establish minimum standards for protecting public health and safety.[138] Following is a short summary of how the IRC and IBC/IMC incorporate kitchen ventilation strategies for reducing indoor pollutant exposure from cooking. The ICC updates its codes every three years; the citations below are to the 2021 IRC and the 2021 IMC unless otherwise noted.

*ICC Codes - Providing Kitchen Exhaust Systems***.** In buildings/areas covered by the International Mechanical Code (e.g., larger multi-unit residential), local exhaust ventilation systems must be provided in kitchens.[139]

Under the IRC, however, the code *does not* affirmatively require the installation of local exhaust systems in all kitchens.[140] Rather, the IRC includes specifications that apply *if and when* local kitchen exhaust systems are installed. There are general requirements that all mechanical exhaust systems be vented to the outdoors,[141]

---

[135] ASHRAE 62.2-2019, Sec. 7.1.

[136] *See* ASHRAE 62.2, Sec. 6.2. More information on instructions and labeling can be found in ASHRAE Guideline 24, Section 13.

[137] ICC et al., INTERNATIONAL GREEN CONSTRUCTION CODE (2018), *available at*: https://www.iccsafe.org/products-and-services/i-codes/2018-i-codes/igcc/. The IgCC is the product of a partnership between the ICC and ASHRAE, as well as the U.S. Green Building Council, the American Institute of Architects, and the Illuminating Engineering Society.

[138] *See* ICC, 2021 INTERNATIONAL MECHANICAL CODE [hereinafter IMC] at 101.3; ICC, 2021 INTERNATIONAL RESIDENTIAL CODE [hereinafter IRC] at R101.3.

[139] *See* IMC at 403.3. The IMC also includes a more general requirement that "[s]tationary local sources producing air-borne particulates…in such quantities as to be irritating or injurious to health shall be provided with an exhaust system in accordance with Chapter 5 or a means of collection and removal of the contaminants. Such exhaust shall discharge directly to an approved location at the exterior of the building." *Id*. at 401.6.

[140] Only open-top broiler units, which are not typically found in residential kitchens, must be provided with exhaust hoods under the IRC. IRC at M1503.2.1. Note that while most combustion appliances must be vented under the IRC, gas-fired ranges are explicitly exempted from the venting requirement. *See id*. at G2425.8.

[141] IRC at M1501.1.

and that domestic cooking exhaust equipment "discharge to the outdoors through a duct";[142] however, an exception to that requirement – for "properly installed ductless range hoods where mechanical or natural ventilation is otherwise provided" – effectively allows the use of recirculating range hoods, provided there is another ventilation source (e.g., an operable window in the kitchen).[143]

Like ASHRAE 62.2, the ICC codes do not require or prefer range hoods over other exhaust system designs (except in the special case of open-top broilers, for which metal range hoods are required). Neither the IRC nor IMC address the installation location for kitchen fans specifically, though the IMC includes a general provision requiring inlets to exhaust systems to "be located in the area of heaviest concentration of contaminants."[144]

*ICC Codes - Minimum Performance Standards***.** The current ICC codes do not incorporate the concept of capture efficiency for domestic kitchen equipment. Both the IRC and IMC include performance standards using minimum airflow rates.[145]

Under the IRC, if and when a local kitchen exhaust system is installed in a one- or two-family dwelling, it must have a minimum airflow of 100 cfm for intermittent (on-demand) fans, or 25 cfm for continuous fans.[146] In buildings covered by the IMC, where kitchen exhaust systems are required, minimum airflow rates depend on both building type and floor area.

- For *most building types*, including apartment buildings (occupancy Group R-2) that are higher than three stories, the 2018 IMC (Sec. 403.3.1.1) requires minimum airflow rates of 25 cfm per 100 square feet of floor area; for the 2021 IMC, the minimum rate was increased to 50 cfm per 100 square feet of floor area.
- For *apartment buildings three stories and less* in height, the IMC (Sec. 403.3.2.3) requires a minimum rate of 100 cfm for intermittent systems or 25 cfm for continuous systems.

Like ASHRAE 62.2, the IRC and IMC include provisions addressing depressurization and backdraft, which may result from high airflow rates in tight dwellings where makeup air is not provided.[147]

ICC Codes - Verifying Performance. The IRC specifies in Chapter 15 that "[w]here domestic cooking exhaust equipment is provided," it must be listed and labeled in accordance with the Underwriters Laboratories (UL) or ANSI standard applicable to the type of system.[148] Under the IMC 2021, "Fans providing

[142] *Id*. at M1503.3.
[143] IRC at M1503.3.
[144] IMC at 502.1.1.
[145] While not using CE as a metric, the IMC's specifications for *commercial* kitchen hoods do address the concept, requiring that exhaust outlets be located within the hood "to optimize capture of particulate matter," and specifying that each exhaust outlet not serve more than a 12-ft. section of the hood. IMC at 507.1.5.
[146] IRC at Table 1505.4.4.
[147] *See* IRC at M1503.3, M1503.6.
[148] UL 507 (Standard for Electric Fans) for "the fan for overhead range hoods and downdraft exhaust equipment not integral with the cooking appliance" and "overhead range hoods and downdraft exhaust equipment with integral fans"; UL 858 (Standard for Household Electric Ranges) or ANSI Z21.2 (Household Cooking Gas Appliances) for "domestic cooking appliances with integral downdraft exhaust equipment"; UL 923 (Standard for Microwave Cooking Appliances) for "[m]icrowave ovens with integral exhaust for installation over the cooking surface." IRC at M1503.2. The IRC also includes a general requirement that "[a]ppliances regulated by this code shall be listed and labeled for the application in which they are installed and used…" IRC at M1302.1.

exhaust or outdoor air shall be listed and labeled to provide the minimum required air flow in accordance with ANSI/AMCA 210-ANSI/ASHRAE 51."[149]

ICC Codes - Proper Use of Kitchen Ventilation: Sound Ratings and Information/Education. In contrast to ASHRAE 62.2, the ICC codes do not establish maximum sound ratings for local exhaust fans.

The IRC does not include requirements related to labeling/instructions for kitchen ventilation systems. Since the 2018 edition, the IMC has included a minimal requirement that, for apartment (Group R-2) buildings three stories or less, "Where provided within a dwelling unit, controls for outdoor air ventilation systems shall include text or a symbol indicating the system's function."[150]

TABLE C: KITCHEN VENTILATION REQUIREMENTS IN ICC AND ASHRAE MODEL CODES AND STANDARDS

	Exhaust Ventilation Required in Domestic Kitchens?	Minimum Airflow Rate	Maximum Sound Rating
International Residential Code **2021**	No (*except open-top broiler units*)	If provided, must be rated: 100 cfm (intermittent) or 25 cfm (continuous)	N/A
International Mechanical Code **2018**	Yes	Group R-2 (three stories or less) and certain other buildings: 100 cfm (intermittent) or 25 cfm (continuous) Group R-2 (four stories or more) and certain other buildings: 25 cfm per 100 ft^2 of floor area	N/A
International Mechanical Code **2021**	Yes	Group R-2 (three stories or less) and certain other buildings: 100 cfm (intermittent) or 25 cfm (continuous) Group R-2 (four stories or more) and certain other buildings: 50 cfm per 100 ft^2 of floor area	N/A
ASHRAE 62.2-**2019**	Yes (Section 5.1) *Non-enclosed kitchens: demand-controlled* *Enclosed kitchens: demand-controlled or continuous*	Vented range hood (demand-controlled): 100 cfm Other fan types (demand-controlled): 300 cfm (300 cfm or 5 ach if in an enclosed kitchen) Other fan types (continuous): 5 ach	Continuous fan: 1.0 sone Demand-controlled system (rated at a setting of at least 100 cfm): 3.0 sones

[149] IMC at 403.2.5. This reflects a minor change from the 2018 edition of the IMC, which read: "Exhaust equipment serving single dwelling units shall be listed and labeled to provide the minimum required air flow in accordance with ANSI/AMCA 210-ANSI/ASHRAE 51." 2018 IMC at 403.3.2.5.
[150] IMC at 403.3.2.4.

Kitchen Ventilation in State and Local Building Codes

While the ICC codes promote uniformity and consistency, it is common for states to amend the model codes to address their own circumstances and priorities. The same is true for states incorporating ASHRAE 62.2 into their codes. A number of states have made minor changes to the IRC/IMC ventilation requirements, but the building codes in most states incorporate the kitchen exhaust provisions in the IRC and IMC as described above. Only a few states have enacted provisions for reducing exposure to cooking pollutants that are more stringent than those in the ICC model codes.

Thus, opportunities exist in most states to strengthen kitchen ventilation provisions in their statewide building codes. A potential model is currently under development in California, where the current building code incorporates kitchen ventilation requirements consistent with ASHRAE 62.2. The state is considering code amendments that would strengthen this requirement, moving the building code beyond the model codes and consensus standards and closer to the best practices described in Part Two.

Opportunities exist in most jurisdictions to strengthen kitchen ventilation provisions in building codes.

Overview of Current State and Local Building Codes. This section describes examples of other states and localities with kitchen exhaust provisions that exceed current model codes; however, this review does *not* represent an exhaustive list of jurisdictions that have amended the IRC, IMC, or both with respect to kitchen ventilation.

Requiring Kitchen Exhaust in All New Residential Construction. An important step states can take to strengthen their building codes is to amend the IRC to affirmatively require installation of kitchen exhaust systems in all newly constructed dwellings. **Washington** and **Oregon** are states that have amended the IRC to include such a requirement.[151] **St**. **Louis County, Missouri** is an example of a local government that has amended the IRC, providing, "All kitchens shall be equipped with means of mechanical exhaust directly over, or adjacent to, a range or a cook top."[152] In the **District of Columbia**, the IRC is amended to require "range hoods or down-draft exhaust systems…above ranges and cook tops."[153] In **Maryland**, the model codes are amended so that all residential buildings are covered by the IMC, which requires kitchen ventilation in dwellings covered by its provisions.[154] In **Maine**, the Maine Uniform Building and Energy Code is based on the 2015 IRC but also – by specific mandate of the state legislature in 2019 – includes ASHRAE 62.2-2013 as a mandatory standard.[155]

States can also amend and strengthen the ICC specifications for kitchen exhaust systems. One such change would be to require range hoods, rather than allow less-efficient fan types to be installed.[156] **Oregon** has

---

[151] *See* WASH. IRC 2018 at M1505.4.4.1, *available at*: https://sbcc.wa.gov/sites/default/files/2020-11/2018_IRC_Insert%20Pages_3rdpr.pdf; 2017 OREGON RESIDENTIAL SPECIALTY CODE (based on 2015 IRC) at 1503.4, *available at:* https://www.oregon.gov/bcd/codes-stand/Pages/residential-structures.aspx.
[152] St. Louis County, MO Code of Ordinances, Title XI, 1116.115 (amending IRC M1503.1).
[153] 12 DCMR M-1503B.
[154] Md. Code Regs. 09.15.05.01. *See also* CURRENT ADOPTED BUILDING CODES IN THE STATE OF MD., *available at:* http://www.dllr.maryland.gov/labor/build/buildcodematrix.pdf.
[155] *See* Maine House Paper No. 1101, 129th Maine Legislature (June 19, 2019); *see also* State of Maine Office of State Fire Marshal, Building Codes, https://www.maine.gov/dps/fmo/building-codes.
[156] Policies could also establish more stringent performance standards for fan types known to be less effective with lower airflows (e.g., downdraft systems), as in ASHRAE 62.2.

amended the IRC to require that domestic kitchen cooking appliances be equipped with ducted range hoods or downdraft exhaust systems.[157] Policymakers can also require all range hoods to be ducted, eliminating the exception for recirculating range hoods. For example, **Oregon**'s code specifies that range hoods are required to discharge to the outdoors through a duct, and **California's** building code (which adopts ASHRAE 62.2, rather than the ICC provisions for kitchen ventilation) similarly does not allow recirculating range hoods in new construction.[158] Short of prohibiting all recirculating hoods, jurisdictions might prohibit their use in conjunction with gas stoves, for which a vented exhaust system is especially important to extract NO_2.[159] States also might consider amending their codes to specify that the range hood width must not be less than the width of the stovetop.[160]

Jurisdictions can also include stronger kitchen ventilation provisions in supplemental, mandatory green building codes, where such codes exist. At the state level, only **California** has adopted a mandatory green building code that applies to all residential construction, but it does not include kitchen ventilation requirements beyond those found in the California Energy Code.[161] At least one other state has taken steps toward a mandatory statewide green building code that could lead to enhanced kitchen ventilation provisions: in **Oregon**, Executive Order 17-20 (Accelerating Efficiency in Oregon's Built Environment to Reduce Greenhouse Gas Emissions and Address Climate Change) directs the state building codes agency to "conduct code amendment of the state building code to require newly constructed residential buildings to achieve at least equivalent performance levels with the 2017 U.S. Department of Energy Zero Energy Ready Standard by October 1, 2023." Though the Oregon Executive Order is focused on energy, the referenced federal standard incorporates EPA's Indoor airPLUS criteria and thus provides a ready model for integrating IAQ goals as the state upgrades its building code. (Additional information about Indoor airPLUS is provided later in this Part, in the "Green Building Requirements" section.)

Strengthening Kitchen Exhaust Minimum Performance Requirements. By amending the model codes to raise minimum performance requirements, states can help lower the chances that certain homes – including small dwelling units with gas stoves – will exceed health-based pollutant thresholds during and after cooking.

As the ventilation industry moves toward capture efficiency as the best measure of kitchen ventilation performance, states can consider adopting minimum performance requirements, or alternative compliance

[157] 2017 Oregon Residential Specialty Code (based on 2015 IRC) at 1503.4.

[158] *Id*. at 1503.1; CEC, 2019 RESIDENTIAL COMPLIANCE MANUAL FOR THE 2019 BUILDING EFFICIENCY ENERGY STANDARDS, *supra*, at p. 4-100. ("Recirculating range hoods that do not exhaust pollutants to the outside cannot be used to meet the requirements of ASHRAE 62.2 unless paired with an exhaust system that can provide at least five air changes of the kitchen volume per hour.")

[159] *See* Final CASE Report 2020, *supra*, at 53.

[160] Range hoods are generally more effective when they cover the entire cooking surface. *See* ROCIS Issue Brief, *supra*, at 12. The 2015 IRC included this type of specification for open-top broilers. That requirement reads in part: "…The hood shall be not less than the width of the broiler unit, extend over the entire unit, discharge to the outdoors and be equipped with a backdraft damper or other means to control infiltration/exfiltration when not in operation..." 2015 IRC at M1505.1.

[161] Ca. Code of Regs., Title 24, Part 11 (CALGreen 2013), *available at*: https://ladbs.org/docs/default-source/publications/code-amendments/2013-california-green-building-standards-code.pdf?sfvrsn=7a02fc53_7. As California works to strengthen its building code standards on kitchen ventilation (see following section of this report, "Future Directions"), there also may be opportunities to strengthen CALGreen by including residential kitchen exhaust measures.

pathways, based on this measure.[162] Regardless of how performance is measured in the code, states can strengthen the IRC/IMC and ASHRAE 62.2 by increasing minimum performance standards.

- One option is to establish a minimum performance requirement that is stringent enough for *all home sizes and all fuel types* (see standards summarized in Part Two, Table A).
- Alternatively, requirements could *differentiate by fuel type*, but set the CE for each type at the high end of the square footage range. As the Home Ventilating Institute explains, "Selecting a value towards the upper end of each of these ranges will promote equivalent protection for individuals located within the immediate vicinity of the cooktop during cooking events (e.g., cooks, guests, children doing homework, etc.), regardless of the size of the home that they are located in."[163]
- Another option is to establish *tiered requirements based on fuel type and home size*, with higher capture efficiency and/or airflow rates for dwellings that need them, rather than adopt the IRC's one-size-fits-all approach to minimum airflow rates. In November 2020, the California Energy Commission (CEC) proposed residential code amendments using this approach, as described below.

Short of these measures, states can make their adopted building codes somewhat stronger by even modestly increasing the minimum airflow rate requirement for kitchen exhaust systems. At least one state has amended the model building codes to slightly increase the minimum airflow ratings required for continuous kitchen exhaust systems: in **Washington**, dwelling units in all residential buildings must have kitchen systems capable of exhausting at a rate of 100 cfm intermittent or *30 cfm* continuous (compared to 25 cfm in the model codes).[164]

States can also amend the model codes to include stronger performance verification requirements. **Washington** has added a provision to its local exhaust section requiring HVI ratings for kitchen exhaust fans (though range hoods and downdraft fans are exempted from the ratings requirement).[165] In **California**, where the Energy Code has incorporated ASHRAE 62.2's rating specifications since 2008, the 2019 edition introduced additional verification requirements to help ensure proper functioning of kitchen range hoods: in high-rise residential buildings, HVI ratings for kitchen range hoods must be verified in accordance with California's Home Energy Rating System (HERS) program,[166] which "tests and rates the energy performance of

---

[162] In comments provided in response to a CE-based standard proposed by California, manufacturers argued that the ASTM test method for CE is not yet proven reliable and should not be the basis for a regulatory standard. *See, e.g.,* GE Appliances, GE APPLIANCES COMMENTS IN RESPONSE TO STAFF WORKSHOP PRESENTATION ON RANGE HOODS at 2 (docketed Nov. 17, 2020), *available at*: https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=19-BSTD-03. ("Unfortunately, the result of GEA's work has been to show that the ASTM E-3087-18 test procedure, as implemented in HVI 917, lacks reproducibility and repeatability.") A 2020 ASHRAE newsletter described recent efforts to address the reproducibility issues, summarizing researchers' goal of "build[ing] a test chamber that can be used to determine the capture efficiency (CE) of residential, wall-mounted range hoods in accordance with a newly developed ASTM standard, ASTM E3087-18, and ultimately integrate CE into a new ASHRAE/HVI certification program for residential range hoods." ASHRAE, Measuring Range Hood Capture Efficiency Values (Nov. 10, 2020), https://www.ashrae.org/news/ashraejournal/measuring-range-hood-capture-efficiency-values.

[163] HVI, HOME VENTILATING INSTITUTE COMMENTS - RESPONSE TO CEC'S NOV 3 PROPOSAL TO ESTABLISH MINIMUM CAPTURE EFFICIENCY FOR RANGE HOODS, *supra*, at 2.

[164] WASH. IRC 2018, *supra*, at M1505.4.4.1.

[165] *Id*. at Sec. M1505.4.4.2.

[166] CEC, 2019 RESIDENTIAL COMPLIANCE MANUAL FOR THE 2019 BUILDING EFFICIENCY ENERGY STANDARDS, *supra*, at 4-177.

a home" using independent raters to "address[] construction defects and poor equipment installation."[167]

In connection with the 2019 code update, the CEC explained the reasons for this change:

> "This HERS verification intends to ensure compliance with the HVI ratings requirement in ASHRAE 62.2 which has generally been not well enforced. Indoor pollutants from cooking that [are] not adequately exhausted from a dwelling because of inadequate range hood performance have been identified by research as a significant danger to human health. These changes are necessary to ensure compliance with [code] requirements relating to residential range hoods, and for consistency with ASHRAE 62.2."[168]

*Promoting Use of Kitchen Exhaust Fans by Occupants***.** The ICC model codes do not address one of the most significant barriers to consumers' proper use of kitchen exhaust systems: noise. To help overcome users' concerns that required fans are prohibitively loud, states can amend the model codes to include maximum sound limits. One option is to incorporate ASHRAE 62.2, which includes a sound rating requirement for kitchen fans (3.0 sones at a setting of 100 cfm for an on-demand fan). **California's** 2019 Energy Code, which incorporates ASHRAE 62.2's requirement that a vented mechanical exhaust system be installed in each kitchen, requires range hoods to comply with ASHRAE 62.2 sound rating requirements.[169] As sound ratings become available for products operating at higher airflows (or products with capture efficiency ratings), states can consider establishing their maximum sound rating requirements to correspond with operation at the higher speeds that may be needed for effective pollutant removal.[170]

The IRC does not include labeling/instructional requirements for kitchen ventilation systems, and the IMC requires only that controls for ventilation systems have text or a symbol indicating the system's function. Jurisdictions can incorporate ASHRAE 62.2's additional requirement that information and instructions be provided to the owner and occupant. **California's** proposed updates for its 2022 code include "a requirement for the builder to provide instructions for proper operation and maintenance of local exhaust systems, including instructions for when any user-controlled systems should be used," further specifying that "for systems in buildings or tenant spaces that are not individually owned and operated, the instructions shall state that the building's owner or their representative shall provide copies of instructions for these systems to all tenants at the start of their occupancy."[171] Another approach – which was considered but ultimately

---

[167] CEC, Home Energy Rating System – HERS, https://www.energy.ca.gov/programs-and-topics/programs/home-energy-rating-system-hers-program.The requirement that HERS raters be independent of the builder or installer is found in 20 Ca. Code Regs., Div. 2, Ch. 4, Art. 8, Sec. 1673(j)(2). Field verification requirements for airflow and sound rating are found in reference appendices to the 2019 Energy Code. In high-rise residential buildings, range hoods are to "be field verified in accordance with Reference Nonresidential Appendix NA7.18.1…" which requires both construction inspection and functional testing. Ca. Energy Code at 120.1(b)2Bii. The Appendix includes both construction inspection and functional testing requirements. In low-rise residential buildings, "[t]he installed kitchen range hood shall be field verified in accordance with the procedures in Reference Residential Appendix RA3.7.4.3 to confirm the model is rated by HVI to comply with [airflow and sound rating requirements.]" *Id*. at 150.0(o)2B. Per that Appendix, verification includes "visual inspection of the installed kitchen range hood." Ca. Energy Code 2019 Residential Appendices, RA3-93, at RA3.7.4.3.

[168] CEC, 2019 STANDARDS INITIAL STATEMENT OF REASONS at 79 (docketed Jan. 18, 2018), *available at*: https://efiling.energy.ca.gov/getdocument.aspx?tn=222218.

[169] 24 Ca. Code Regs. Pt. 6, Secs. 120.1(b)2, 150.0(o).

[170] In California, a group of analysts recommending 2022 amendments to the residential code have suggested that "[f]uture code cycles should consider a sound requirement at a higher airflow." Final CASE Report 2020, *supra*, at 59.

[171] *Id*. at 61-62.

deferred by California for a future update – is to require a "consumer facing label" on exhaust systems "to educate the resident of when the hood should operate and health consequences if this is not followed."[172]

Increasing Kitchen Ventilation Use with Automated Range Hoods

As discussed in Part One, even in households where range hoods are installed, they may not be used routinely. Most range hood and downdraft exhaust products are user-controlled systems that operate on demand, depending on the user to activate the on-off switch. While labeling and other information/education strategies can help increase consumers' knowledge of proper use, another approach to ensuring systems are used routinely is the incorporation of automated controls. Unlike a manual on-off switch, an automated range hood does not rely on users remembering or choosing to turn the system on. Instead, the ventilation system activates automatically, either because the appliance is in use or based on sensors that detect pollutants. Thus, according to HVI, "range hood auto operation could be useful in reducing occupants' exposure to pollution generated during cooking events."

The ASHRAE 62.2-2019 standard does not preclude automated system controls, providing that an on-demand system must have either a "readily accessible occupant-controlled ON-OFF control" *or* an "automatic control that does not impede occupant ON control." The IRC does not include specifications for on-off controls, but states can amend the model language to expressly address automatic controls. In **Washington**, e.g., the residential code requires kitchen exhaust systems to "be provided with controls that enable manual override or automatic occupancy sensor, humidity sensor or pollutant sensor controls."

The team developing proposed kitchen ventilation changes to the California Energy Code noted in a 2020 report that there is stakeholder interest in automated range hoods, describing them as "an exciting idea that should be explored in future code cycles as a means of increasing the IAQ benefits to occupants." The team declined to include automated range hoods as part of the 2022 code update, "in part because there were almost no off-the-shelf products available with these automated features. In addition, energy impacts and user acceptability of automated kitchen ventilation should be investigated before an automatic function is required." Experts at Lawrence Berkeley National Lab have noted the particular importance of low sound ratings, explaining that "[a]utomated range hoods that are noisy have the potential to incite public backlash, especially if they are mandatory."

The Department of Energy recently provided funding for development of a "smart" range hood that would "be quiet (<1 sone), five times more energy efficient than today's ENERGY STAR® models, and [able to] capture nearly 100% of pollutants." Developers hope to release a smart hood with automated sensor features in 2022.

Sources: LBNL Survey Data 2011, *supra*, at 27; HVI, Home Ventilating Institute Comments, *supra*; ASHRAE 62.2-2019, Sec. 5.2.1; Wash. IRC 2018, *supra*, at M1505.4.4.1; Final CASE Report 2020, *supra*, at 58; Market Analysis Memo, *supra*, at 20; LBNL Report 2014, *supra*, at O8; U.S. DOE, Development of the Industry's First Smart Range Hood, https://www.energy.gov/eere/buildings/downloads/development-industry-s-first-smart-range-hood; Better Buildings Residential Network, Smart Range Hoods vs. Indoor Air Quality: Coming Soon to Kitchens Near You (presented Mar. 25, 2021 by S. Bowles, Newport Ventures).

[172] Final CASE Report 2020, *supra*, at 59-60.

Future Directions: Proposed Changes to the California Energy Code. Following is a summary of the enhanced kitchen ventilation measures that have been proposed as part of California's current (2022) building code update process. Although these measures are still in the process of being considered, they provide insight into options available to other jurisdictions seeking to upgrade their building codes to reduce exposure to cooking pollutants.

Background. Among U.S. jurisdictions, California is a leader in integrating building energy efficiency and indoor air quality, including through its statewide, mandatory building code. This focus on indoor air quality is enshrined in state law, which requires the California Energy Commission (CEC) "[w]hen assessing energy conservation standards for residential and nonresidential buildings…[to] include in its deliberations the impact that those standards would have on indoor air pollution problems."[173]

The statewide Building Standards Code, Title 24 of the California Code of Regulations, covers residential and non-residential buildings and comprises plumbing, mechanical, energy, and other specific codes. These codes are based on model codes from the ICC and other model code organizations, with or without state-specific amendments, as well as elements that are not covered by model codes but have been authorized by the state legislature "to address particular California concerns."[174]

A range of IAQ requirements are adopted in the energy portion of the current building code, the 2019 California Energy Code, which is revised every three years.[175] The Energy Code – also known as the Building Energy Efficiency Standards (BEES) – applies to residential and nonresidential new construction, additions, and alterations. It incorporates provisions of ASHRAE 62.2, but is not based directly on a model code and includes certain provisions that are more stringent than the equivalent ASHRAE standard. When updating from the 2016 edition to the 2019 edition of the Energy Code, the CEC made "extensive changes" to the code, including more detailed IAQ-related requirements.[176]

As noted previously, California's current code already incorporates the ASHRAE 62.2 requirement that a vented mechanical exhaust system be installed in each kitchen in accordance with the standard's airflow and sound rating requirements.[177] As part of its regular code update process, which occurs on a three-year cycle, the CEC is considering changes applicable to *both multifamily and single-family residential buildings* that would significantly strengthen kitchen exhaust system requirements, moving California beyond ASHRAE 62.2, toward the best practices described in Part Two of this report.[178] According to CEC, a final version of the "updated standards will be proposed for adoption in 2021 with an effective date of January 1, 2023."[179]

Code Update Process. As part of the code update process, before proposing changes in code requirements, experts from a statewide Codes and Standards Enhancement (CASE) Team "develop technical and cost-effectiveness information" on the potential changes and present them in a report to the CEC.[180] In May 2020, the CASE Team released a Draft CASE Report discussing proposed changes to kitchen ventilation requirements. Thereafter, at the request of public interest groups, the CEC convened "a commissioner-led

[173] Ca. Pub. Resources Code §25402.8.
[174] Cal. Building Standards Comm., Building Standards Code, https://www.dgs.ca.gov/BSC/Codes.
[175] *See* 24 Ca. Code Regs., Pt. 6.
[176] CEC, 2019 STANDARDS INITIAL STATEMENT OF REASONS, *supra*, at 37.
[177] 24 Ca. Code Regs. Pt. 6, Sec. 120.1(b)2; Sec. 150.0(o).
[178] *See* Market Analysis Memo, *supra*, at 2.
[179] CEC, 2022 Building Energy Efficiency Standards – Prerulemaking, https://tinyurl.com/2ssfjavc.
[180] Final CASE Report 2020, *supra*, at 11.

workshop to examine recent scientific studies relating to the effects of indoor cooking on indoor air quality" to help inform 2022 Energy Code kitchen ventilation standards.[181]

The goal of this event, held in September 2020, was "to solicit input from experts and feedback from stakeholders and members of the public ahead of staff work in amending standards, reach consensus on the scientific record, and establish the factual foundation necessary for amending the Energy Code."[182] At the event, CEC solicited feedback from stakeholders on several specific topics, including: using capture efficiency as the performance metric in the updated standard; whether "separate, lower standard[s]" should be available for homes with electric stoves, and single-family homes and/or homes above a minimum size; and whether the maximum sound rating should be lowered.[183]

After the September event, "with consideration of the public record resulting" from the event, CEC staff prepared a draft proposal to update kitchen ventilation requirements.[184] On November 3, 2020, CEC convened the 2022 Workshop on Ventilation for Indoor Air Quality and Reduced Infiltration Proposals, where the agency presented for public review and comment its plans to significantly amend the Energy Code's kitchen ventilation requirements for both high- and low-rise multifamily buildings. A subsequent memorandum filed in December 2020 stated that CEC intended to extend the updated kitchen ventilation requirements to single-family residential buildings.[185]

In February 2021, CEC published the proposed updates to the code in a document known as the Pre-Rulemaking Express Terms for 2022 Update to Energy Code, which serves to "inform the general public and to solicit feedback on the proposed amendments within the context of the Energy Code."[186]

Proposed Changes to Kitchen Ventilation Provisions. The Pre-Rulemaking Express Terms include the following proposed changes related to kitchen ventilation:

- Establishing minimum performance standards for range hoods based on capture efficiency, with an alternative compliance pathway based on airflow rates "to accommodate market transition"[187];
- Increasing minimum airflow rates for range hoods;
- Differentiating between natural gas and electric stoves, with more stringent standards for gas; and
- Establishing a range of minimum requirements based on dwelling size, with more stringent standards for small dwelling units, which have less air with which to mix and dilute cooking emissions.

---

[181] CEC, NOTICE FOR SEPTEMBER 30 WORKSHOP ON INDOOR AIR QUALITY (docketed Sept. 14, 2020), *available at:* https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=19-BSTD-03.
[182] *Id*.
[183] CEC, KITCHEN VENTILATION AND INDOOR AIR QUALITY STAFF SLIDES at 10-13 (docketed Oct. 6, 2020), *available at:* https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=19-BSTD-03.
[184] *Id*. at 14.
[185] *See* Market Analysis Memo, *supra*, at 2. ("The scope of the Multifamily IAQ CASE Report was limited to multifamily units, but data indicates that the current range hood requirement of 100 cfm is too low for other dwelling units as well…") CEC is also considering changes to Title 24 that would clarify requirements for *alterations* projects in single-family homes; among other things, proposed changes would require any entirely new or complete replacement systems to comply with standards for systems installed in new construction. *See* CEC, DRAFT 2022 ENERGY CODE EXPRESS TERMS at 150.2(b)1L (docketed Feb. 22, 2021), *available at:* https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=19-BSTD-03.
[186] CEC, NOTICE OF AVAILABILITY – PRERULEMAKING EXPRESS TERMS (docketed Feb. 22, 2021), *available at*: https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=19-BSTD-03.
[187] CEC November 2020 Workshop, *supra*, at 85.

The CASE team decided not to propose amendments to the 3.0-sone maximum sound rating requirement at this time because of lack of available sound ratings at higher airflows, but the team stated that "[f]uture code cycles should consider a sound requirement at a higher airflow."[188]

The proposed changes are based on recent research (described in Part Two), sponsored by the CEC and conducted by researchers at Lawrence Berkeley National Laboratory, to determine ventilation standards needed to protect occupants from unhealthy levels of $PM_{2.5}$ and NO_2 in all dwelling sizes.[189] According to the Pre-Rulemaking Express Terms, the proposed language for the 2022 California code would amend the ASHRAE 62.2 standards for demand-controlled mechanical exhaust systems in kitchens as follows:[190]

150.0(0)1Giiib. Ventilation Rate and Capture Efficiency. The system shall meet or exceed either the minimum airflow in accordance with Table 150.0-E or the minimum capture efficiency determined in accordance with ASTM E3087, Table 150.0-E, and Table 150.0-G.

Table 150.0-E Demand-Controlled Local Ventilation Exhaust Airflow Rates and Capture Efficiency

Application	Compliance Criteria
Enclosed Kitchen or Nonenclosed Kitchen	Vented range hood, including appliance-range hood combinations shall meet either the capture efficiency (CE) or the airflow rate specified in Table 150.0-G as applicable.
Enclosed Kitchen	Other kitchen exhaust fans, including downdraft: 300 cfm (150 L/s) or a capacity of 5 ACH
Nonenclosed Kitchen	Other kitchen exhaust fans, including downdraft: 300 cfm (150 L/s)

Table 150.0-G Kitchen Range Hood Airflow Rates (cfm) and ASTM E3087 Capture Efficiency (CE) Ratings -According to Dwelling Unit Floor Area and Kitchen Range Fuel Type

Dwelling Unit Floor Area (ft^2)	Hood Over Electric Range	Hood Over Natural Gas Range
>1500	50% CE or 110 cfm	70% CE or 180 cfm
>1000 - 1500	50% CE or 110 cfm	80% CE or 250 cfm
750 - 1000	55% CE or 130 cfm	85% CE or 280 cfm
<750	65% CE or 160 cfm	85% CE or 280 cfm

[188] *See* CEC November 2020 Workshop, *supra*, at 100 (explaining that establishing new sound ratings "[w]ould require product re-testing, and…[the i]ndustry is moving away from current test points"). CEC noted that the state "considered tightening the sound to ≤ 2 sone at 100 cfm" but did not because "[d]ata did not clearly show that a low sone at low cfm correlated with a low sone at high cfm." *Id. See also* Final CASE Report 2020, *supra*, at 51.
[189] CEC November 2020 Workshop, *supra*, at 85; *see also* Market Analysis Memo, *supra*, at 3.
[190] CEC, DRAFT 2022 ENERGY CODE EXPRESS TERMS, *supra*, at Sec. 150.0.

As the proposed Table 150.0-G illustrates, at the high end of the proposed range of requirements are those applicable to the smallest dwelling sizes (<750 square feet) with gas stoves: in those cases, range hoods would be required to have a capture efficiency of 85% or an air flow of 280 cfm. For large dwellings (>1500 square feet) using electric ranges, which require the lowest CE/airflow, the proposal would still increase the airflow rate requirement for range hoods above the ASHRAE 62.2-2019 rate, from 100 cfm to 110 cfm (corresponding to 50% CE).[191] The CEC is not proposing changes to the downdraft and continuous airflow rates.[192] The CASE Report also explained how the proposed standards would be enforced, through verification by the HERS rater and confirmation by the building inspector.[193]

As noted above, CEC also is proposing code changes that would help promote use of kitchen ventilation systems. In response to "data [that] highlight a need for consumer education," the CASE Team recommended adding language to the code requiring that "builders provide instructions to tenants on the operation and maintenance of local exhaust systems, including when they should be operated."[194] The Pre-Rulemaking Express terms reflect this recommendation.[195]

As of January 2021, stakeholders continue to submit comments on these and other proposed changes to Title 24.

Kitchen Ventilation in the Manufactured Housing Code

In the U.S., around 22 million people live in manufactured housing.[196] According to the Manufactured Housing Institute, in 2019 manufactured homes made up 10% of new single-family home starts.[197] Manufactured homes often are more affordable than other types of single-family detached homes;[198] the 2019 American Housing Survey found that nearly 60% of manufactured housing residents reported household income below $40,000 per year (compared to around 34% for all home types).[199] The 2019 survey also showed that manufactured home residents tend to be older in age: over half of householders living in

---

[191] Proposed Tables 150.0-E and 150.0-G would apply to multifamily buildings. Parallel code provisions applicable to single-family homes, which would apply the same ventilation rate and capture efficiency standards as those proposed for multifamily buildings, are found in Tables 120.1-D and 120.1-F of the Pre-Rulemaking Express Terms.
[192] *See* Final CASE Report 2020, *supra*, at 51. ("The Statewide CASE Team did not find new data on downdraft exhausts or continuous kitchen ventilation effectiveness. Consequently, the Statewide CASE Team did not alter these paths, except to specify that the airflow for the downdraft exhaust systems should be measured at 0.1 inches w.c., consistent with the second path.")
[193] *Id*. at 51, 69. ("For enforcement, field verification will confirm that the range hood is vented to outdoors; recirculation type hoods shall not be allowed. The model of the kitchen range hood shall be verified and recorded on the compliance documentation for the project, and the HERS Rater or ATT shall verify that the HVI rating for this model meets the minimum capture efficiency or airflow and sound limit specified…The building inspector will confirm that applicable Installation/Verification/Acceptance documentation, along with ventilation system instructions, have been made available to the building owner.")
[194] *Id*. at 59, 60.
[195] *See* CEC, DRAFT 2022 ENERGY CODE EXPRESS TERMS, *supra*, at 10-103(b)4.
[196] Manufactured Housing Institute, 2020 MANUFACTURED HOUSING FACTS at 2 (May 2020), *available at*: https://www.manufacturedhousing.org/wp-content/uploads/2020/07/2020-MHI-Quick-Facts-updated-05-2020.pdf.
[197] *Id.* at 2.
[198] N. Moyer, MOISTURE PROBLEMS IN MANUFACTURED HOUSING (2002), *available at*: https://www.energy.gov/sites/prod/files/2016/06/f32/Moisture_Problems_in_Manufactured_Housing.pdf.
[199] *See* U.S. Census Bureau, 2019 AMERICAN HOUSING SURVEY, *available at*: https://www.census.gov/programs-surveys/ahs.html.

manufactured housing were at least 55 years old, and over 30% percent were age 65 or above.[200] In addition to being permanent homes for many families, manufactured homes frequently are used as temporary housing for populations displaced by natural disasters.[201]

While it is important to ventilate cooking-related pollutants in all dwellings, it is especially important in many manufactured homes. According to the CDC, "The confined spaces of manufactured structures, and in some cases lower ventilation and air exchange rates, make indoor air quality a concern....Those with small interior volumes, limited ventilation, and/or extensive use of components that emit volatile or semivolatile compounds that have health effects may expose occupants to higher levels of air contaminants."[202] The 2019 American Housing Survey found that 99% of manufactured homes are equipped with a kitchen stove or burners, and over 30% use gas for cooking fuel.[203] Insofar as manufactured homes may have higher levels of indoor pollutants such as $PM_{2.5}$, NO_2 and formaldehyde, it is especially important to remove cooking emissions efficiently, before they can mix with the rest of the indoor air and further raise pollutant concentrations.

Federal Manufactured Housing Standards: The HUD Code. The construction and safety of manufactured homes, which may be manufactured in one state and installed in another, are federally regulated under the National Manufactured Housing Construction and Safety Standards Act of 1974.[204] That Act directed the U.S. Department of Housing and Urban Development (HUD) to establish uniform construction and safety standards for manufactured housing, which are known as the HUD code. Adopted as a federal regulation, the HUD code applies to homes manufactured after June 1976 that meet certain criteria, including: 320 ft^2 or larger; built on a permanent chassis (with or without a permanent foundation); and designed to be used as a dwelling that is connected to utilities.[205]

The Act prohibits generally the sale, lease, or offer of manufactured homes that do not comply with the standards. If a covered manufactured home does not meet the HUD Code, "the manufacturer must take certain actions, including possibly notifying the consumer and correcting the problem."[206] The code may be enforced by HUD directly or by a state agency established to participate in the program.[207]

Under the HUD code, *kitchen ventilation systems are mandatory in new manufactured homes*. The code's ventilation standards, found among the Planning Considerations, include a requirement to provide kitchens

---

200 *See id*.

201 *See* CDC and HUD, SAFETY AND HEALTH IN MANUFACTURED STRUCTURES at 43 (2011), *available at*: https://stacks.cdc.gov/view/cdc/12208/cdc_12208_DS1.pdf?download-document-submit=Download.

202 CDC and HUD, SAFETY AND HEALTH IN MANUFACTURED STRUCTURES at 5, 25 (2011), *available at*: https://stacks.cdc.gov/view/cdc/12208/cdc_12208_DS1.pdf?download-document-submit=Download. Key among these indoor pollutants is formaldehyde: "The tight building envelopes and relatively low air exchange rates in some manufactured structures combined with formaldehyde off-gassing can cause indoor levels to rise." *Id.* At 26.

203 *See* U.S. Census Bureau, 2019 AMERICAN HOUSING SURVEY, *supra* (combining piped gas users and bottled gas users).

204 *See* 42 U.S.C. §5401 et seq. The Department of Housing and Urban Development (HUD) explains that the standards "apply to all manufactured home producers and retailers that use any means of transportation or communication that affects interstate commerce in their operations." HUD.GOV, Manufactured Home Construction and Safety Standards, https://www.hud.gov/hudprograms/mhcss.

205 24 CFR 3280.2. (Homes under 320 ft^2 when assembled may be covered if they are at least 8 ft. wide or 40 ft. long "in traveling mode.")

206 HUD.GOV, Manufactured Home Construction and Safety Standards, https://www.hud.gov/hudprograms/mhcss.

207 *Id.*

with “a mechanical ventilation system that is capable of exhausting 100 cfm to the outside of the home.” [208] The code does not specify system type(s) to be used, but does address location: “The exhaust fan shall be located as close as possible to the range or cook top, but in no case farther than 10 feet horizontally from the range or cook top.”[209]

HUD recently revised the code for the first time since 2005. The amended regulation, effective in July 2021, does not change the minimum kitchen ventilation performance standard from previous versions; however, the updated code incorporates by reference ASHRAE 62.2-2010, allowing its use as an optional/alternative compliance method for the HUD code’s ventilation requirements.[210]

State and Local Regulation of Other Modular Home Types*.* Under the National Manufactured Housing Construction and Safety Standards Act, state and local jurisdictions may not establish any standard regarding manufactured home construction and safety that is not identical to the HUD Code.[211] States may, however, adopt standards – including kitchen ventilation requirements – applicable to similar structure types that are not covered by the HUD code. **Maine** is an example of a state that has done so. Maine’s standards for state-certified “modular homes” (which are manufactured structures but are *not* constructed on a permanent chassis) are based on the 2015 edition of the IRC. Among other state-specific amendments and additions, the Maine modular home standards include a requirement that “[a] cooking appliance must be equipped with a separate ventilating fan/hood, independent of other ventilating systems, with a minimum rating of 100 cubic feet per minute (CFM). This equipment must exhaust at the outside of the home.”[212]

[208] 24 CFR 3280.103(c)(2).
[209] *Id*.
[210] *See* 86 Fed. Reg. 13645 (Mar. 10, 2021).
[211] 42 U.S.C. §5401.
[212] 10 Me. St. §9002; Me. ADC 02-385 Ch. 110, Ch. 2, Sec. 10.

BUILDING ELECTRIFICATION POLICIES: IMPROVING IAQ THROUGH REDUCED FOSSIL FUEL USE

As noted in Part Two, all stoves need ventilation for the particle pollution generated by the cooking itself, but gas burners require enhanced ventilation for the additional pollutants they emit – including carbon monoxide, nitrogen dioxide, fine particulate matter, ultrafine particles, and formaldehyde.[213]

Even where gas stoves are vented and a large percentage of cooking pollution is captured at its source, the vented emissions do not disappear: they simply become outdoor air pollutants instead of indoor air pollutants. In addition to the pollutants noted above, natural gas-burning appliances emit carbon dioxide (CO_2), a greenhouse gas that contributes to the world's rising average temperatures and worsening climate crisis.[214]

Thus, climate and public health agencies and advocates have started to focus on of building electrification (also referred to as building decarbonization) – the phasing out of natural gas appliances, in order to improve indoor and outdoor air quality and address climate change. A number of local jurisdictions around the country have adopted policies prohibiting or discouraging gas appliances in new construction. Many of these cities and counties are located in California, where the state's ambitious greenhouse gas reduction targets have prompted dozens of local governments to take bold policy actions to reduce fossil fuel use.[215] Other examples are found in Massachusetts, New York, and Washington.[216] As of early 2021, no states have adopted statewide bans on natural gas in new construction, though the California legislature has provided funding for pilot decarbonization programs.[217] The California Energy Commission is currently considering code changes that would help "[e]nable pathways for all-electric buildings."[218]

Provisions related to electrification of appliances often are part of the energy sub-code within the building code. Most states have adopted a statewide energy code for residential buildings that is based on the model language of the International Energy Conservation Code (IECC),[219] which – as of the 2018 edition – does not require or encourage all-electric appliances. In places with statewide energy codes, localities seeking to adopt more stringent code provisions may decide to adopt a statewide "stretch code" – i.e., a code more stringent than the baseline energy code – if one exists, or may decide develop their own. For cities and counties

---

213 UCLA Report 2020, *supra*, at 26-29.
214 R. Lindsey (Climate.gov), Climate Change: Atmospheric Carbon Dioxide (Aug. 14, 2020), https://www.climate.gov/news-features/understanding-climate/climate-change-atmospheric-carbon-dioxide#:~:text=Carbon%20dioxide%20is%20a%20greenhouse,that%20absorbs%20and%20radiates%20heat.&text=But%20increases%20in%20greenhouse%20gases,Earth's%20long%2Dlived%20greenhouse%20gases.
215 *See, e.g.,* M. Borgeson (NRDC), The Pathway to New All-Electric Low-Income Housing in California (Jun. 29, 2020), https://www.nrdc.org/experts/merrian-borgeson/pathway-new-all-electric-low-income-housing-ca; *see also* L. Sommer (NPR) Give Up Your Gas Stove to Save the Planet? Banning Gas is the Next Climate Push (Aug. 5, 2019), https://www.npr.org/2019/08/05/745051104/give-up-your-gas-stove-to-save-the-planet-banning-gas-is-the-next-climate-push.
216 *See* C. McKenna, A. Shah & L. Louis-Prescott, All-Electric New Homes: A Win for the Climate and Economy (Oct. 15, 2020), https://rmi.org/all-electric-new-homes-a-win-for-the-climate-and-the-economy/.
217 *See* Cal. Senate Bill 1477 (approved by Gov. Sept. 2018), *available at:* https://leginfo.legislature.ca.gov/faces/billTextClient.xhtml?bill_id=201720180SB1477.
218 CEC, PRESENTATION-DECEMBER 8, 2020 ENERGY CODE ON PRE-RULEMAKING WORKSHOP at slide 4 (docketed Dec. 10, 2020), *available at:* https://efiling.energy.ca.gov/Lists/DocketLog.aspx?docketnumber=19-BSTD-03.
219 See U.S. DOE, Status of State Energy Code Adoption (last updated Dec. 2018), https://www.energycodes.gov/status-state-energy-code-adoption.

subject to statewide minimum building codes, a state law expressly authorizing local jurisdictions to adopt stricter standards can be an important first step.[220]

In **California**, state law authorizes cities and counties to "establish more restrictive building standards, including, but not limited to, green building standards, reasonably necessary because of local climatic, geological, or topographical conditions…."[221] As of early 2021, dozens of local jurisdictions in California have adopted all-electric or electric-preferred codes under this authority. In December 2020, the **City of San Jose** – the third-largest city in California, and the tenth-largest city in the U.S. – adopted an ordinance prohibiting natural gas infrastructure in most newly-constructed buildings, including residential, effective August 2021.[222]

Energy code amendments are not the only policy pathway that has been used to phase out gas stoves in new construction. **Berkeley, California**, which in 2019 became the first U.S. city to effectively ban gas appliances in new construction, took a different approach.[223] Berkeley's ordinance avoided the jurisdictional issues arising from proposed energy code changes by "leverag[ing] the City's authority under the California Constitution to prohibit installation of hazardous internal gas piping infrastructure when granting use permits for new buildings."[224]

Jurisdictions seeking to reduce the number of gas stoves in use can take steps short of banning natural gas in all new buildings. For example, the city of **Seattle**, **Washington** recently amended its energy code to limit natural gas appliances in some new construction; while natural gas stoves are not prohibited in new apartment buildings, "electrical outlets would be required near stoves so that electric stoves could be installed later."[225] Jurisdictions could decide whether gas appliances may be installed in school, housing, or other projects funded by the government, and financial incentives could be provided to affordable housing developers to embrace all-electric construction.[226] Governments could also "[p]rovide financial incentives, such as tax credits or rebates, that will enable low-income homeowners to eliminate gas stove pollution, including adding plug-in induction stovetops or switching from gas to electric stovetops…."[227]

---

[220] On the other hand, some states have enacted laws to *prohibit* local jurisdictions from adopting bans on natural gas hookups. *See* J. Tomich, Gas ban backlash spreads across U.S., *E&E News* (Feb. 2, 2021), https://www.eenews.net/stories/1063724065.

[221] Ca. Health & Safety Code §18941.5.

[222] An Ordinance of the City of San Jose Amending Chapter 17.845 of Title 17 of the San Jose Municipal Code to Amend Sections 17.845.010, 17.845.020, 17.845.030, 17.845.040, 17.845.050, AND 17.845.060 and Add Section 17.845.045 to Prohibit Natural Gas Infrastructure In Newly Constructed Buildings, *available at:* https://sanjose.legistar.com/LegislationDetail.aspx?ID=4699135&GUID=2A42A103-1C7C-4A29-BB5A-5FF44D35E498&Options=&Search=.

[223] *See* S. Ravani, Berkeley becomes first U.S. city to ban natural gas in new homes, *San Francisco Chronicle* (July 21, 2019), https://www.sfchronicle.com/bayarea/article/Berkeley-becomes-first-U-S-city-to-ban-natural-14102242.php#:~:text=Berkeley%20has%20become%20the%20first,pioneering%20health%20or%20environmental%20legislation.

[224] Memorandum from City of Berkeley Councilmember Kate Harrison et. al to Honorable Mayor and Members of the City Council at page 3 (July 9, 2019), *available at:* https://www.cityofberkeley.info/Clerk/City_Council/2019/07_Jul/Documents/2019-07-09_Item_21_Adopt_an_Ordinance_adding_a_new.aspx.

[225] H. Burnton & D. Gutman, Seattle City Council passes measure to end most natural gas use in commercial buildings and some apartments, *Seattle Times* (Feb. 1, 2021), https://www.seattletimes.com/seattle-news/seattle-city-council-passes-measure-to-end-most-natural-gas-use-in-commercial-buildings-and-some-apartments/.

[226] *See* Rocky Mountain Institute et. al. 2020, *supra*, at 20; Borgeson, The Pathway to New, All-Electric Low-Income Housing in California, *supra*.

[227] Rocky Mountain Institute et al. 2020, *supra*, at 20.

Green Building Requirements: An Opportunity to Address Kitchen Ventilation in Affordable Housing and Other New Construction

Green building – also known as "high performance" or "sustainable" building – is characterized by the integrated consideration of a wide range of environmental and health features that go beyond minimum building codes. Green building policies are thus a potential vehicle for advancing best practices for improving kitchen ventilation and reducing exposure for families that will occupy the housing.

Green building measures have been incorporated into a wide range of policies. In many jurisdictions, green building standards are used to qualify projects for *voluntary* incentives (e.g., expedited permitting, bonus density, reduced permitting fees, or tax credits) that encourage construction of high-performance buildings.[228] Some jurisdictions have gone further by establishing green building *requirements.*

As noted in the last section, California has adopted a mandatory state-wide green building code that supplements the state building code, and Oregon has taken steps to do the same. In addition, there are a number of jurisdictions that have established green building requirements for certain categories of residential construction, most notably affordable housing construction that is subsidized with government funding.

States, localities, and tribes administer a variety of programs to help finance the construction and rehabilitation of affordable housing. Increasingly, policymakers and agencies are incorporating into these programs green building requirements that go beyond the jurisdiction's current minimum building code. These enhanced standards are important for improving indoor air quality for lower-income families that may be at greater risk of harm from pollutant exposure due to factors such as lack of adequate medical care and existing health conditions such as asthma. As EPA has noted, "Epidemiologic studies of fine particulate matter using indicators of SES [socio-economic status] provide initial evidence that individuals of low SES may be at increased risk of mortality due to short-term exposures."[229]

As is the case with minimum building codes, green building policies frequently incorporate and adapt criteria developed by third parties. This section begins by describing some of the third-party green building standards most commonly referenced in state and local policies, followed by examples of state and local policies that establish green building requirements for new affordable housing and other residential construction.

Third-Party Green Building Standards

Though states, localities, and tribes may develop their own green building standards, they are more likely to adopt policies that incorporate standards or rating systems developed by non-governmental organizations. These voluntary, third-party standards typically cover a wide array of issues, from energy and water conservation to siting and indoor environmental quality. Yet they vary in how they address those issues – both in the individual criteria they include and in whether those criteria are mandatory or optional items.

---

[228] *See* Environmental Law Inst., MUNICIPAL GREEN BUILDING POLICIES: STRATEGIES FOR TRANSFORMING BUILDING PRACTICES IN THE PRIVATE SECTOR (2008), *available at*: https://www.eli.org/sites/default/files/eli-pubs/d18_13.pdf.
[229] U.S. EPA, WILDFIRE SMOKE: A GUIDE FOR PUBLIC HEALTH OFFICIALS, *supra*, at 9.

The following are examples of third-party green building standards that are most commonly referenced by government green building policies in the U.S. There are many other green building standards available, including emergent standards like the PHIUS+ Certification Program for passive buildings.[230]

- **International Green Construction Code (IgCC)/ASHRAE 189.1** – the 2018 version of the IgCC was published jointly by the ICC and ASHRAE as a model green building code for all building types except one and two family dwellings and townhouses,[231] and is designed to be fully compatible with the ICC family of codes.[232]

- **Leadership in Energy and Environmental Design (LEED)** – a widely-used rating system of the U.S. Green Building Council, which certifies projects that meet one of several sets of LEED criteria, including two that address new home construction: LEED-Homes (residential buildings six stories or less) and LEED-Building Design (other building types).[233]

- **Enterprise Green Communities** – the only green building rating system designed specifically for affordable housing projects, developed and managed by Enterprise Community Partners.[234]

In addition to these standards, EPA has developed the Indoor airPLUS criteria, a voluntary labeling program that "builds on the foundation of EPA's ENERGY STAR requirements for new homes and provides additional construction specifications to provide comprehensive indoor air quality protections in new homes."[235] Indoor airPLUS is a stand-alone protocol, an optional add-on to EPA Energy Star Homes program, and now a requirement for meeting The Department of Energy's (DOE) Zero Net Energy Home Standard.[236] EPA currently is developing updates to the protocol, which will be known as Indoor airPLUS Version 2, and the agency has released a summary of proposed changes.[237]

---

[230] *See* PHIUS, PHIUS Certification Overview, https://www.phius.org/home-page.
[231] Informative Appendix J provides a compliance pathway for detached one- and two-family dwellings and townhouses under three stories: comply with ICC/ASHRAE 700-2015, the National Green Building Standard. IgCC Jurisdictions must explicitly adopt the provisions of the appendix as mandatory. *See* IgCC 2018, *infra*, at J101.1.
[232] ICC et al., INTERNATIONAL GREEN CONSTRUCTION CODE (2018) [hereinafter IgCC], *available at*: https://www.iccsafe.org/products-and-services/icodes/2018-i-codes/igcc/. The IgCC now incorporates the technical provisions of ASHRAE Standard 189.1 (Standard for the Design of High Performance, Green Buildings Except Low-Rise Residential Buildings).
[233] U.S. Green Building Council, LEED Rating System, https://www.usgbc.org/leed.
[234] Enterprise Community Partners, Green Communities, https://www.enterprisecommunity.org/solutions-and-innovation/green-communities.
[235] U.S. EPA, Basic Information about Indoor airPLUS, https://www.epa.gov/indoorairplus/basic-information-about-indoor-airplus.
[236] *See* U.S. DOE, Guidelines for Participating in the DOE Zero Energy Ready Home Program, https://www.energy.gov/eere/buildings/guidelines-participating-doe-zero-energy-ready-home-program.
[237] U.S. EPA, INDOOR AIRPLUS VERSION 2 HIGHLIGHTS: SUMMARY OF PROPOSED UPDATES (Dec. 2020), *available at*: https://www.epa.gov/sites/production/files/2020-12/documents/indoor_airplus_v2_highlights_december_2020_-_508_compliant_0.pdf.

The above standards all require kitchen ventilation in compliance with ASHRAE 62.2, but do not increase the minimum performance requirements (i.e., airflow rates) of that standard.[238] The IgCC does, however, specify that a range hood be used to comply; the other standards noted above require a vented range hood where the exhaust flow rate is less than 5 ACH, per ASHRAE 62.2-2010 (though the Enterprise Green Communities 2020 Criteria allow an exception for some certified passive houses, as noted in the table below.)

If the proposed updates to the Indoor airPLUS protocol are adopted, Version 2 will include a new provision that in one- and two-family homes and townhouses, the mandatory kitchen exhaust fan must be demand-controlled (minimum 100 cfm, or 300 cfm if downdraft), while multifamily buildings "may still use continuous exhaust (in a kitchen "area") if it has a MERV 3 or washable filter and a recirculating range hood with charcoal filter installed above the stove."[239] Version 2 of the protocol would also "recommend" automatic controls for kitchen exhaust fans.[240]

Among these third-party standards, only Indoor airPLUS includes a stricter sound requirement: Energy Star certification, which is "a pre-requisite for a home to achieve Indoor airPLUS qualification,"[241] establishes a maximum sound rating of 2.0 sones or less.[242] The proposed Version 2 of the Indoor airPLUS protocol would specify that the maximum rating of 2.0 sones applies at 100 cfm. Indoor airPLUS Version 1, Rev. 4 currently includes an advisory policy to provide the homebuyer with information about the importance of local ventilation for pollutant sources like cooking.

Thus, where states incorporate these or other third-party green building standards into their policies, an important consideration is whether to augment the standard with stronger kitchen ventilation and other IAQ-related measures.

---

[238] *See* U.S. Green Building Council, LEED V4 FOR HOMES DESIGN AND CONSTRUCTION at p. 78-79, *available at*: https://www.usgbc.org/resources/leed-v4-homes-and-midrise-ballot-version; IgCC, *supra*, at Sec. 801.3.1.5.2; Enterprise Community Partners, 2020 ENTERPRISE GREEN COMMUNITIES CRITERIA at Sec. 7.7, *available at*: https://www.greencommunitiesonline.org/sites/default/files/egc_2020_criteria_manual.pdf.

[239] U.S. EPA, INDOOR AIRPLUS VERSION 2 HIGHLIGHTS: SUMMARY OF PROPOSED UPDATES, *supra*, at 2.

[240] *Id*.

[241] U.S. EPA, INDOOR AIRPLUS CONSTRUCTION SPECIFICATIONS, VERSION 1 (REV. 04) at 5 (Feb. 2018), *available at*: https://www.epa.gov/sites/production/files/2018-03/documents/indoor_airplus_construction_specifications.pdf.

[242] Energy Star, Ventilation Fans Key Product Criteria, https://www.energystar.gov/products/heating_cooling/fans_ventilating/key_product_criteria.

TABLE D: KITCHEN VENTILATION REQUIREMENTS IN THIRD-PARTY GREEN BUILDING STANDARDS

LEED for Homes (V4)	Enterprise Green Communities (2020)	2018 Intl. Green Construction Code (IgCC) (incl. ASHRAE 189.1-2017)	EPA Indoor airPLUS (V1. Rev. 04)
Required: Design and install local exhaust systems in kitchen to meet the requirements of ASHRAE Standard 62.2–2010*, Sections 5 and 7, or local equivalent, whichever is more stringent. (pp. 78-79)	**Required**: Install a local mechanical exhaust system in each kitchen, in full accordance with ASHRAE 62.2-2010*. (Sec. 7.7) *Exception*: Certain projects that achieve certification with Passive House Institute United States (PHIUS+) are permitted to follow the Passive House ventilation requirements as an alternative path.	**Required**: Gas and electric ranges in residential spaces shall comply with ASHRAE 62.2 (2016)**, Section 5.1, *using a range hood*. (Sec. 801.3.1.5.2)	**Required**: Provide local mechanical exhaust ventilation to the outdoors in each kitchen, in accordance with meeting ASHRAE 62.2-2010* Section 5. **Advisory**: Provide homebuyer with information addressing importance of using manually controlled ventilation options (e.g., kitchen exhaust fans) when strong pollutant sources are present. (Sec. 7.3)
*ASHRAE 62.2-2010, unlike more recent versions of the standard, does not distinguish between enclosed and non-enclosed kitchens. The 2010 standard also includes a requirement for a vented range hood if the exhaust fan flow rate is less than 5 ACH. **ASHRAE 62.2-2016 includes the same kitchen exhaust requirements as the 2019 version of the standard.			

State and Local Green Building Requirements

Following are examples of policies that include green building requirements for publicly funded housing development and for certain types of privately financed multifamily projects. By incorporating third-party criteria, these policies generally include kitchen exhaust requirements consistent with ASHRAE 62.2. Jurisdictions can modify or augment adopted third-party standards to move their green buildings even beyond ASHRAE, toward the policies and practices described in Part Two.

Affordable Housing Supported by State-Administered Federal Funding Programs. There are a number of federal funding programs that support the development of affordable housing and are implemented at the state, local or tribal levels. Many states have incorporated specific IAQ-related measures or broader green building criteria into these programs.

The Low-Income Housing Tax Credit (LIHTC) program, a widely used HUD program, awards tax credits to developers of affordable rental housing. The LIHTC is administered by the states, which prepare annual Qualified Allocation Plans (QAPs) that set forth their priorities and selection criteria for awarding the credits. While federal regulations require that state QAPs include energy efficiency as one criterion in selecting projects, the regulations do not address ventilation and indoor air quality.[243]

Many states have prioritized green and healthy housing by incorporating third-party green building standards in their QAPs.[244] A number of state plans reference the Enterprise Green Communities standard, either alone or as one of several green building standards the developer can select for its project.[245] In some cases, the green building standards are included as one of many *optional* measures that can earn points on a LIHTC application. Some states, though, include green building standards as a *required* element for funded projects.

For example, **Georgia**'s 2021 QAP requires applicants to obtain a sustainable building certification from one of four listed green building standards, including LEED and Enterprise Green Communities.[246] Similar provisions are included in the recent QAPs for **Colorado, Pennsylvania,** and **Louisiana,** among others**.**[247]

Other HUD programs provide block grants to states or localities for community development activities that may include affordable housing – e.g., the Community Development Block Grant (CDGB) program, the HOME Investment Partnerships Program (HOME), the Neighborhood Stabilization Program (NSP), and the National Housing Trust Fund program. States have an opportunity to incorporate kitchen ventilation and other IAQ priorities into these programs as well – e.g., through program guidance and the multi-year Consolidated Plans that outline their housing priorities and govern the use of the block grant funds.[248] States can also incorporate green building requirements in the residential construction programs of other agencies, such as the Department of Agriculture.[249]

<u>Affordable Housing Supported by other State Funding Programs</u>. Some state policies establish green building requirements for a broader universe of state-funded construction. **South Carolina**, for example, requires that all state-funded new construction projects over 10,000 square feet must meet the LEED Silver standard or a two-globes rating under the Green Globes Rating System.[250] In **Connecticut**, the Housing Finance Authority

---

[243] *See* 26 CFR 42(m)(1)(C).
[244] Amer. Planning Assoc., GREEN GOES MAINSTREAM IN LOW-INCOME HOUSING at 34 (2013), http://mrsc.org/getmedia/5C1945EA-F7D2-4AF1-9A97-3E221D65F0D7/Fuhry.aspx ("In 2012, 27 QAPs mentioned third party green building certifications, quadruple the number from five years ago.").
[245] *See* N.Y. State Energy Devt. Admin., BENEFITS OF AFFORDABLE RESIDENTIAL GREEN BUILDING INCENTIVES at 19 (2018), *available at:* https://www.nyserda.ny.gov/-/media/Files/Publications/building-stock-potential-studies/18-39-Benefits-Affordable-Residential-Green-Building-Incentives.pdf.
[246] State of Georgia, 2021 QUALIFIED ALLOCATION PLAN at 29, *available at:* https://www.dca.ga.gov/sites/default/files/2021qap_amended_jan26.pdf.
[247] Col. Housing and Finance Authority Board of Directors, QUALIFIED ALLOCATION PLAN 2021 TO 2022 at 50, https://www.chfainfo.com/arh/lihtc/LIHC_Documents/2021-QAP.pdf; Penn. Housing Finance Agency, PENNSYLVANIA QUALIFIED ALLOCATION PLAN 2019-2020 at 15-16, *available at:* https://www.phfa.org/forms/multifamily_application_guidelines/guidelines/2019_and_2020/2020-mpg-03.pdf; Louisiana Housing Corp., 2021 QUALIFIED ACTION PLAN at 14, *available at:* https://www.lhc.la.gov/hubfs/Final%202021%20QAP.pdf.
[248] *See* HUD Exchange, Consolidated Plan, https://www.hudexchange.info/programs/consolidated-plan/.
[249] USDA regulations establish certain design requirements for all agency-financed multifamily housing, including a mandate to give "maximum consideration to energy conservation measures and practices." 40 CFR 3560.60(c)(4).
[250] S.C. St. §§48-52-830, 48-52-810(10(a). Under the Green Building Initiative's Green Globes rating system for new construction, projects that include MERV 13 filtration gain 5 points, and projects without MERV 13 gain no points. *See*

(CHFA) has developed its own sustainable design and construction standards that apply to multifamily housing developments seeking construction funding administered through the CHFA and the Connecticut Department of Housing. The guidelines require, among other things, that "[a]ll kitchens shall be provided with an ENERGY STAR-qualified means of exhaust ventilation to the outside."[251] Notably, the guideline establishes sound ratings for the minimum flow rate (100 cfm) at less than 1.0 sone, and for the maximum flow rate at less than 3.0 sones.[252]

In **Rhode Island**, the state's Voluntary Stretch Codes are an option for satisfying the state's green building requirement for public buildings, including public multifamily housing. The stretch code for one- and two-family homes and townhouses is based heavily on the Department of Energy's Zero-Energy Ready Homes standard (which incorporates EPA's Indoor airPLUS protocol), though alternative compliance paths are also acceptable.[253]

Privately Funded Construction. In addition to establishing green building standards for publicly funded projects, some jurisdictions have adopted green building criteria that are mandatory for certain classes of privately financed residential construction.

Several localities apply green building standards to new multifamily buildings that meet a minimum size threshold—for example, **Montgomery County**, the largest jurisdiction in Maryland, requires new multifamily residential or mixed-use residential buildings with at least 5,000 square feet to comply with the IgCC (2012) or LEED Silver criteria.[254] In 2007, **Boston**, Massachusetts amended its Municipal Zoning Code to require that all projects undergoing Large Project Review must be "LEED Certifiable under the most appropriate LEED building rating system."[255] In the **District of Columbia**, multifamily residential projects that are more than three stories and at least 10,000 square feet must comply with the District's Green Construction Code (GCC). The GCC consists of an amended version of the 2012 IgCC, but the code allows several "alternative compliance paths" using other third-party standards.[256] Multifamily housing projects owned or financed (15% or more) by the District are subject to a separate law, the Green Building Act, which requires that buildings

---

GREEN GLOBES FOR NEW CONSTRUCTION TECHNICAL REFERENCE MANUAL at 195, *available at*: https://www.thegbi.org/files/training_resources/Green_Globes_NC_Technical_Reference_Manual.pdf.

[251] Conn. Housing Finance Authority, 2020 MULTIFAMILY DESIGN, CONSTRUCTION AND SUSTAINABILITY STANDARDS at 44, *available at:* https://www.chfa.org/assets/1/6/2020_Multifamily_Design,_Construction_and_Sustainability_Standards.pdf?8976. ("Kitchen Ventilation: All kitchens shall be provided with an ENERGY STAR-qualified means of exhaust ventilation to the outside. Provide recessed ceiling fans for kitchen ventilation, or ceiling grills ducted to in-line or roof-top exhaust fans for kitchen ventilation. Re-circulating range hoods with integral task lighting shall be provided to match the width of the range below. Kitchen exhaust fans shall be sized to provide a rate of > 5 ACH continuous ventilation, or an intermittent rate of > 100 cfm. Sound ratings for kitchen ventilation fans shall be < 1 sone at minimum flow rate, and < 3 sones at maximum flow rate.")

[252] *Id*.

[253] *See* R.I. Gen. Laws §37-24; R.I. Office of Energy Resources, RHODE ISLAND STRETCH CODES, *available at:* http://www.energy.ri.gov/policies-programs/lead-by-example/rhode-island-stretch-codes.php

[254] Code of Montgomery County Regs. 08.00.03.01 *et seq*.; *see generally* Montgomery County Dept. of Permitting Services, PROGRAM, *available at*: https://www.montgomerycountymd.gov/DPS/Resources/Files/COMBUILD/ProgramDescription.pdf.

[255] Boston Municipal Zoning Code Art. 37, §37-4.

[256] 12-A D.C. Mun. Regs, Sec. 101.4.9.4. The 2012 version of the IgCC required MERV 11 (or higher) filters for air conditioning systems that serve occupied spaces and handle a component of outdoor air; this provision is not in the current (2018) version of the IgCC. Alternative compliance paths referenced in the D.C. code are ASHRAE 189.1, Enterprise Green Communities, LEED, the National Green Building Standard (ICC 700), and EPA's Energy Star Program (New Homes or Multifamily High Rise).

containing at least 10,000 square feet of residential occupancies be designed and constructed to meet or exceed the Enterprise Green Communities Criteria "or a substantially equivalent standard."[257]

Discussion

States, localities, and tribes can meaningfully reduce indoor exposure to pollutants in homes by including mandatory kitchen ventilation standards in their building codes, ensuring that every new home is equipped with a vented range hood or other kitchen exhaust system. Since electric stoves generate fewer pollutants than gas stoves, jurisdictions can consider reduce cooking pollutant exposure more broadly by encouraging electric stoves in new construction – e.g., requiring new homes to be built electric stove-ready with a plug in the stove area, or prohibiting installation of gas appliances in new construction. Yet kitchen ventilation remains a necessary intervention, as studies show that installing range hoods or other local ventilation systems in kitchens can reduce exposure to cooking-related pollutants regardless of stove type.

Short of amending the state, local or tribal building code to require kitchen ventilation in every new home, policymakers can include these measures as mandatory elements for publicly funded construction, particularly affordable housing, which is often occupied by populations who are at higher risk of health impacts. These programs can require compliance with third-party high performance building standard, several of which incorporate ASHRAE 62.2 and its 100-cfm minimum airflow requirement for range hoods and other intermittent systems. To bring these standards even closer to the best practices described in Part Two, policymakers can modify the model language to mandate higher-efficiency kitchen ventilation systems that will better protect occupants from exposure to high levels of cooking pollutants, regardless of their dwelling size or stove type.

While there is a strong public health and building science foundation for instituting these changes, there are nonetheless some important practical issues to address in strengthening kitchen ventilation standards. Even with robust design and installation requirements in place, the effectiveness of such policies depends in part on how systems are installed, used, and maintained in the real world.

Key implementation considerations include occupant behavior, cost, and market availability.

Providing Information to Occupants. A major practical consideration is whether occupants of homes with kitchen ventilation installed will operate the system appropriately, even assuming noise levels are acceptable. Absent automated controls, which may become more widely available in coming years, the proper use of range hoods and other intermittent exhaust fans depends largely on consumers' understanding that the system should be activated every time they are cooking, not just to mitigate visible smoke or odors. Toward this end, **California** is proposing a specific requirement that "builders provide instructions to tenants on the operation and maintenance of local exhaust systems, including when they should be operated."[258] Jurisdictions can go further by requiring labels directly on the range hood to explain its function and

[257] D.C. St. §6-1451.02.

[258] Final CASE Report 2020, *supra*, at 59. The recommended change would add new language to Section 10-103, building on an existing requirement that the builder provide information about dwelling-unit ventilation systems in low-rise residential buildings.

recommend that it be turned on whenever the stove is in use, similar to California's building code requiring informational labels next to the on/off switch on dwelling-unit (whole-house) ventilation systems.[259]

Agencies can build on these policy strategies with public education campaigns. For example, agencies can develop consumer education materials and make them available not only online but also in hard copy, including in languages and locations where harder-to-reach communities – who may bear a higher risk of adverse health impacts from cooking pollution exposure due to age or socioeconomic factors – are more likely to read them. Agencies and non-government groups can also run public ad campaigns that explain the importance of kitchen ventilation, outline best practices for reducing exposure, and correct common misconceptions that may inhibit use (e.g., that a range hood removes a large quantity of conditioned air.)

Public education campaigns are an important complement to kitchen ventilation requirements.

Ensuring Proper Installation and Maintenance. A system's continued effectiveness is likely to depend in part on maintenance by the user or building manager. However, a precondition to continued effectiveness is initial effectiveness, and it should not be taken for granted that a kitchen exhaust system has been installed in a manner conducive to operation at the advertised performance level. To help ensure proper installation and functioning, jurisdictions can require on-site testing of systems as part of building code compliance or go even further: by requiring a full building/equipment commissioning process, policymakers can help ensure that newly constructed buildings and their installed systems function as intended (and where applicable, that multifamily building managers and staff are prepared to operate and maintain the systems and equipment.)[260] Commissioning requirements are more commonly found in green building codes and standards (e.g., LEED) than state and local building codes, though some jurisdictions have enacted policies requiring commissioning for certain projects – for example, **North Carolina** requires "public major facility construction and renovation projects" to be commissioned.[261]

Addressing the Costs of Implementation*.* Other important implementation considerations relate to cost. One concern is the cost differential between certain compliant and non-compliant products – namely, microwave range hoods that are capable of meeting higher minimum airflow requirements compared with microwave range hoods that are not.

As part of California's code update process, the CASE Team analyzed the cost impacts of a 250 cfm airflow requirement and found that on average, compliant microwave range hoods would cost 60% more (an incremental cost increase of $206) than non-compliant microwave range hood products.[262] To help understand the extent of the potential cost impacts, the team "reviewed the proportion of single and multifamily homes that would be impacted by each of the proposed requirements."[263] Their findings showed that only "about 5.4% of single-family detached homes and 26% of single-family attached homes would be affected by the more stringent minimum airflow requirements, which would potentially have less product

[259] 24 Cal. Code Regs. Pt 6, Sec. 150.0(o)1I. The code requires manual switches associated with dwelling unit ventilation systems to have a label clearly displaying the following or equivalent text: "This switch controls the indoor air quality ventilation for the home. Leave it on unless the outdoor air quality is very poor."
[260] LBNL, BUILDING COMMISSIONING: A GOLDEN OPPORTUNITY FOR REDUCING ENERGY COSTS AND GREENHOUSE-GAS EMISSIONS, *available at:* https://cx.lbl.gov/definition.html.
[261] N.C. St. §143-135.37.
[262] Market Analysis Memo, *supra*, at Table 7.
[263] *Id*. at 15.

availability or higher incremental costs."[264] For multifamily homes, about 25% would trigger the highest airflow requirement (280 cfm or above), and 13% would trigger the 250 cfm requirement, meaning that over one third of multifamily homes would be estimated to trigger requirements leading to higher incremental cost.[265]

While these findings demonstrate a modest cost burden to some consumers, the CASE team also identified potential savings in the form of lower health care costs. Since "[t]he proposed measure would help reduce pollutants that [carry (sic)] various health risks," including exacerbation of asthma, the CASE team considered the following: if annual asthma costs are estimated to be around $3,200 and around 8.5% of California's population has asthma, the average cost per person of asthma among Californians is $280.[266]

Another consideration is the cost of energy, from the perspective of not only policymakers concerned with cumulative energy use, but also individual consumers: concern about household energy costs may affect the amount of time people run their kitchen exhaust systems. However, researchers have estimated that the average cost of using a range hood is less than $15/year, showing that "range hood use is a fairly inexpensive way to improve indoor air quality."[267] Regarding the incremental cost increase from strengthening performance standards for new homes, the California CASE team reported that they "estimate[d] there would be no significant difference in energy use" resulting from the proposed code changes.[268] Outreach and education initiatives can include information about these findings on the low cost of using kitchen ventilation.

Part Four discusses policies and programs to address cost barriers to reducing exposure to cooking pollutants in existing homes.

<u>Availability of Products Meeting Stronger Performance Standards</u>*.* For strengthening performance standards by requiring higher airflow ratings or CE, another practical consideration is technical feasibility and whether compliant products are available. As part of the code update process in California, the CASE Team performed a review of existing rated products to estimate the share of existing products that would be compliant with the updated standards.

The CASE team concluded:

- The proposed standards would be "feasible for all or most island and chimney range hood products, and for the majority of undercabinet range hoods."
- For microwave range hoods, there were generally fewer products compliant with the increased airflow requirements, though "all products could meet the minimum airflow requirement up to 160 cfm" – i.e. the high end of the range for electric stoves.

---

[264] Market Analysis Memo, *supra*, at 16.
[265] *Id*. at 19. The incremental cost increase was slightly higher for products compliant with a 280-cfm requirement, at $267 (69%). *Id*. at 14.
[266] *Id*. at 15 (citing data from Amer. Thoracic Society and CDC).
[267] J.M. Logue & B.C. Singer (LBNL), ENERGY IMPACTS OF EFFECTIVE RANGE HOOD USE FOR ALL U.S. RESIDENTIAL COOKING at 3 (2014), *available at:* https://indoor.lbl.gov/sites/all/files/brett_singer_-_energy_impacts_of_effective_range_hood_use_for_all_u.s_residential_cooking.pdf.
[268] CEC November 2020 Workshop, *supra*, at 101.

- For microwave range hoods over gas stoves, 92% could meet the 180 cfm requirement (the lowest end of the range), but only "[a]bout half the products" could meet the 250 cfm requirement, and fewer than a quarter of the products (17%) could meet the 280 cfm requirement.[269]

In a hearing, CEC explained its conclusion that the proposed changes were technically feasible, stating in part: "Models that will comply with the airflow alternative are widely available which will assist the industry to transition to CE ratings for future Title 24 standards updates" and "[r]ange hood installations and equipment required by this measure are consistent with existing construction practices."[270] Moreover, the agency explained: "Research has determined that use of range hoods with improved CE will provide improved IAQ, [and will] thus be more protective of the health and safety of dwelling occupants."[271]

---

[269] Market Analysis Memo, *supra*, at 8. The CASE Team also reviewed "how many manufacturers have at least one product that meets the proposed requirement" and found that "[f]or most manufacturers, there was at least one product that complied with the proposed requirements. Final CASE Report 2020, *supra*, at 95.
[270] CEC November 2020 Workshop, *supra*, at 101.
[271] *Id*. at 102. The California Air Resources Board issued a resolution in 2020 directing its staff to "support updates" of the code "for stronger kitchen ventilation standards and electrification of appliances, including stoves, ovens, furnaces, and space and water heaters, in the 2022 code cycle for all new buildings in order to protect public health, improve indoor and outdoor air quality…" Cal. Air Resources Board, CALIFORNIA INDOOR AIR QUALITY PROGRAM UPDATE -- RESOLUTION 20-32 (Nov. 19, 2020).

Part Four: Policies and Programs for Improving Kitchen Ventilation in Existing Homes

Building codes and other policies governing new construction are important policy tools for improving kitchen ventilation and reducing health risks. But those policies do not directly affect the large majority of households who occupy existing homes. This section discusses the laws and regulations governing conditions in existing housing – in particular rental properties – that can help ensure adequate ventilation and protect residents from the buildup of pollutants. It also describes existing financial assistance programs that can be leveraged to help lower-income families pay for the changes needed to reduce exposure to cooking pollutants.

Policies Addressing Kitchen Ventilation in Existing Homes

Building codes for new residential construction commonly include a requirement for mechanical systems to be maintained to operate according to the original design conditions. Under the International Residential Code, e.g., building owners are responsible for maintaining existing and new mechanical systems in proper operating condition and in accordance with the original design and the code under which they were installed. The model code further authorizes the state or local building official to require that mechanical systems be re-inspected to determine compliance with the maintenance requirement.[272]

Two types of policies commonly in place at the state or local level address more directly the standards that apply to existing housing: housing codes and landlord-tenant laws. These policies can be strengthened and implemented to ensure adequate kitchen ventilation in existing properties.

Housing Codes

Housing codes (also referred to as property maintenance or sanitary codes) are the primary regulatory vehicle for establishing and enforcing minimum health and safety standards in existing housing. Many, but not all, local jurisdictions in the U.S. are currently covered by a state or local housing code. Housing codes are most often adopted at the local level, but a number of states have adopted a statewide minimum housing code. Local officials usually have authority for enforcing the codes by conducting inspections and pursuing enforcement actions in the event of noncompliance with housing codes.

While some housing codes set standards for all housing, they are most importantly a policy for regulating rental properties, which made up around one third of occupied housing units in the U.S. in 2020.[273] Improving standards for rental housing can help reduce pollutant exposure for lower-income populations who may be

[272] IRC at M1202.3. *See also* IMC at 102.3.
[273] U.S. Census Bureau, Quarterly Residential Vacancies and Homeownership, Third Quarter 2020 at 3, *available at:* https://www.census.gov/housing/hvs/files/currenthvspress.pdf.

at greater risk of health effects; the average income in rental households across the U.S. was around half that of owner-occupied households in 2017.[274]

Some jurisdictions have adopted a housing code based on the model International Property Maintenance Code (IPMC), while others have developed their own codes.[275] The provisions found in the IPMC and many housing codes around the country include general provisions that could potentially be applied to address kitchen ventilation. The codes could also be amended to include a requirement for kitchen exhaust and to require landlords to provide informational materials directly to occupants about the availability and importance of cooking ventilation and instructions on operation and maintenance.

Existing housing code provisions could be applied more broadly to address cooking pollutants in rental housing.

Ventilation Requirements. IPMC Section 403.4 requires, "Where injurious, toxic, irritating or noxious fumes, gases, dusts or mists are generated, *a local exhaust ventilation system shall be provided* to remove the contaminating agent at the source. Air shall be exhausted to the exterior and not be recirculated to any space" (emphasis added). Given the evidence of health effects associated with exposure to cooking pollutants, this provision could be interpreted and implemented to require the property owner to provide a kitchen exhaust ventilation system. Jurisdictions could strengthen this requirement to expressly require local ventilation for cooking equipment.

The National Healthy Housing Standard (NHHS), developed by the National Center for Healthy Housing and the American Public Health Association, is a model housing code that addresses ventilation along with a wide range of other measures to reduce indoor exposures.[276] The NHHS requires a ventilation system compliant with ASHRAE Standard 62, including ventilation for kitchen ranges.[277] It also includes a "stretch provision" that addresses noise: "HVAC equipment, including intermittent ventilation fans, shall operate at a noise level that creates no more than 45 dB Ldn in habitable rooms."[278] The **City of Tukwila, Washington**, which has amended its code to incorporate some of the NHHS measures, provides: "Every dwelling shall have a ventilation system compliant with ASHRAE Standard 62.2…as applicable to the dwelling."[279]

General Standard of Habitability*.* IPMC Section 301.2 prohibits a person from occupying premises as an owner-occupant or allowing another person to occupy premises that are "not in a sanitary and safe condition and that do not comply with the requirements" of the code. In situations involving inadequate ventilation and buildup of cooking pollutants, this and similar state and local habitability provisions could potentially be used to require action by the property owner to improve ventilation in the dwelling. Jurisdictions can consider augmenting this IPMC requirement by incorporating "health" as an element of the standard.

---

[274] *See* U.S. Census Bureau, 2017 AMERICAN HOUSING SURVEY, *available at*: https://www.census.gov/programs-surveys/ahs.html (having data showing $36,100 average income versus $70,000).
[275] ICC, INTERNATIONAL PROPERTY MAINTENANCE CODE 2021, *available at*: https://codes.iccsafe.org/content/IPMC2021P1.
[276] *See* Natl. Center for Healthy Housing and Amer. Public Health Assoc., National Healthy Housing Standard (rev. 2018), http://www.nchh.org/Policy/NationalHealthyHousingStandard.aspx.
[277] *Id*. at Secs. 2.4., 5.3.
[278] *Id*. at Sec. 2.8. Forty-five decibels (dB) is equivalent to around 3.0 sones. *See generally* https://www.industrialfansdirect.com/pages/dba-sones-decibel-levels.
[279] Tukwila, Wa. Mun. Code §8.28.020 (403.6).

General Requirements for Maintaining Equipment. IPMC Section 603.1 requires that: "Mechanical equipment...cooking appliances and water heating appliances shall be properly installed and maintained in a safe working condition, and shall be capable of performing the intended function." Some housing codes include a provision concerning the operation of ventilation systems specifically. For example, the **California** State Housing Law establishes that the "lack of, or improper operation of required ventilating equipment" constitutes a substandard building condition.[280] Requirements for maintaining equipment do not themselves require the provision of kitchen exhaust systems, but they can be used to ensure that any systems in place are kept in good working order to maximize the removal of cooking pollutants.

The types of housing code provisions described above apply not only to market-rate rental properties, but also to public and federally subsidized properties, which are subject to separate federal regulations as well. These federal regulations establish certain requirements that could be applied to ensure adequate kitchen ventilation. For example, rental units participating in HUD's Housing Choice Voucher program must be "free from dangerous levels of air pollution."[281] Public housing units must be free of health and safety hazards, including "air quality", and "have proper ventilation and be free of mold, odor (e.g., propane, natural gas, methane gas), or other observable deficiencies."[282]

Landlord-Tenant Laws

Nearly all states have enacted laws governing certain aspects of the landlord-tenant relationship. These laws set forth the rights and responsibilities of landlords and tenants but, in contrast to housing codes, are enforced *privately* by the parties. Landlord-tenant laws do not typically set specific requirements for ventilation, but they often require that the premises be maintained in a habitable condition and may also require compliance with state and local housing codes.

Many state laws closely follow a model law, the Uniform Residential Landlord and Tenant Act (URLTA).[283] The URLTA requires landlords not only to comply with applicable building and housing codes, but also to "make all repairs and do whatever is necessary to put and keep the premises in a fit and habitable condition…."[284] Some state landlord-tenant laws include references to health in describing the general habitability and good repair requirements. For example, **Maryland's** landlord-tenant law "provides a remedy and imposes an obligation upon landlords to repair and eliminate conditions and defects which constitute…a serious and substantial threat to the life, health or safety of occupants…."[285]

The URLTA was revised in 2015 and adopted as the Revised Uniform Residential Landlord and Tenant Act (RURLTA). The model Act now includes a provision specifying that the landlord's duty includes ensuring that premises "have adequate ventilation…facilities that conform to law and are maintained in good working

[280] Ca. Health & Safety Code §17920.3.
[281] 24 CFR 982.401(h).
[282] 24 CFR. 5.703(f).
[283] Uniform Law Comm., UNIFORM RESIDENTIAL LANDLORD AND TENANT ACT (1972) [hereinafter URLTA].
[284] URLTA §2.104(a)(2).
[285] Md. Real Prop. §8-211(e).

order."[286] Jurisdictions could revise their landlord-tenant laws to adopt this provision or a stronger provision requiring adequate kitchen ventilation.

Financial Assistance for Improving Kitchen Ventilation in Existing Homes

Funding is an important consideration in developing policies to reduce indoor pollutant exposure in the existing housing stock. For the tenants and homeowners who are most vulnerable to the health risks from cooking pollutants, financial assistance may be needed in order to take action to reduce exposure. There are a multitude of state, local, and tribal housing improvement programs that could potentially be brought to bear in helping these households reduce their indoor exposure to pollutants from cooking and other sources.[287]

This section focuses first on the largest single source of funding for improving the energy efficiency of lower-income households, the federal Weatherization Assistance Program. The program advances the twin policy aims of addressing climate change and reducing utility costs. It has also helped spur efforts to integrate energy efficiency and *health* in recent years, helping to demonstrate that retrofit projects can address both goals, particularly when IAQ measures are expressly integrated into the program framework.[288]

Following discussion of the Weatherization Assistance Program are brief descriptions of selected housing-related funding programs that could potentially help reduce cooking-related exposures in lower-income households.

The Weatherization Assistance Program

Background. The federal Weatherization Assistance Program (WAP), run by the U.S. Department of Energy, provides grants to "increase the energy efficiency of dwellings owned or occupied by low-income persons…reduce their total residential expenditures, and improve their health and safety, especially [for] low-income persons who are particularly vulnerable such as the elderly, the handicapped, and children."[289]

The program funds weatherization services in around 35,000 homes each year – a total of over seven million homes since the program was first established by Congress in 1976.[290] Appropriated funds are provided to states, the District of Columbia, U.S. territories, and some tribal governments ("grantees"), which then

[286] Uniform Law Comm., REVISED UNIFORM RESIDENTIAL LANDLORD AND TENANT ACT §302(a)(5) (2015).[hereinafter RURLTA]. The RURLTA also now requires landlords to ensure the premises "have reasonable measures in place…to prevent exposure to unsafe levels of radon, lead paint, asbestos, toxic mold, and other hazardous substances…." RURLTA §302(a)(7).
[287] A 2010 report noted that there were "over 600 government and utility energy audit, rebate, loan, and grant programs" at the state and local levels. *See* Natl. Safe and Healthy Housing Coalition, INTEGRATING ENERGY EFFICIENCY AND HEALTHY HOUSING at 1 (rev. 2010), *available at:* http://www.nchh.org/Portals/0/Contents/Coalition_briefing_paper_energy.pdf. *See also* Tribal Healthy Homes Network, Tribal Indoor Air Funding Directory, https://tribalindoorairfunding.org/ (database of funding programs searchable by topic, including ventilation).
[288] *See* Natl. Assoc. for State Community Services Programs, Weatherization Plus Health, https://nascsp.org/wap/waptac/wap-resources/weatherization-plus-health/about-weatherization-plus-health/.
[289] 42 U.S.C. §6861.
[290] U.S. DOE, The Weatherization Assistance Program, https://www.energy.gov/eere/wipo/weatherizationassistance-program.

contract with local governments, community action agencies, and non-profit organizations to implement weatherization projects.

Like other indoor sources of pollutants, cooking emissions are an even greater concern as buildings become tighter: limiting the escape of conditioned indoor air achieves energy savings, but a decrease in infiltration of outdoor air can potentially result in higher concentrations of pollutants indoors. The Weatherization Assistance Program takes a "whole house" approach to energy efficiency that addresses the building envelope, heating and cooling systems, and certain appliances. A health and safety component was formally incorporated by federal regulation in 1993. Since then, DOE has issued a series of guidance documents, known as Weatherization Program Notices (WPNs), to clarify federal requirements and recommendations in the area of health and safety. *WPN 17-7: Weatherization Health and Safety Guidance* includes a "Table of Issues" addressing several issues that are relevant to reducing exposure to indoor pollutants.[291] For each issue, the Guidance indicates whether actions to address the hazard are required, allowed, or, in a few cases, categorically prohibited.

Of the heath-related items addressed in the WAP Guidance, the ventilation requirement is most relevant to reducing exposure to cooking pollutants.

<u>WAP Guidance and Kitchen Ventilation</u>. WAP projects must provide ventilation that complies with ASHRAE 62.2-2016 (with certain exceptions in Climate Zone 1). Projects must conduct follow-up testing to verify performance, though compliance is allowed using Standard 62.2's Normative Appendix A — an alternative compliance pathway for existing buildings, which "allows much more flexibility for local mechanical ventilation, but requires a compensating increase in dwelling-unit ventilation."[292]

The alternative compliance pathway means that "[a]lthough it is a best practice to ventilate kitchens, [WAP providers] do not necessarily need to install ventilation in all kitchens."[293] According to the National Center for Healthy Housing, it is most common for weatherization providers to achieve compliance with ASHRAE 62.2's whole-house ventilation requirements by installing bathroom exhaust fans,[294] though "[t]he same double-duty function can be performed with a number of kitchen range hoods available today."[295] A HUD-funded study is currently underway to evaluate whether installing "a kitchen fan that exhausts to the outside

---

[291] *See* U.S. DOE, WEATHERIZATION PROGRAM NOTICE 17-7: WEATHERIZATION HEALTH AND SAFETY GUIDANCE [hereinafter WPN 17-7] (Aug. 9, 2017), available at: https://www.energy.gov/sites/prod/files/2017/08/f35/WPN%2017-7%20H%26S%208.9.17.pdf; U.S. DOE, WPN 17-7 TABLE OF ISSUES [hereinafter WPN 17-7 Table] (2017), available at: https://www.energy.gov/eere/wap/downloads/wpn-17-7-weatherization-health-and-safety-guidance.

[292] Residential Energy Dynamics, ASHRAE 62.2 Alternative Compliance Path, https://www.redcalc.com/ashrae-62-2-alternative-compliance-path/. According to an additional WAP guidance document, "The ventilation standards in ASHRAE 62.2 were largely conceived with new construction in mind. There is a normative Appendix A that addresses ventilation requirements in existing buildings that were occupied without meeting the provisions of the Standard. Given that WAP only works in homes already occupied, or which will be occupied in the very near future, by income-eligible clients, all responses presented in [the Health and Safety] FAQs assume the use of the alternative compliance method described in Appendix A..." U.S. DOE, WEATHERIZATION ASSISTANCE PROGRAM HEALTH & SAFETY FREQUENTLY ASKED QUESTIONS at 26 (updated Sept. 24, 2017), *available at:* https://www.energy.gov/sites/prod/files/2017/09/f36/wpn-17-7FAQs_9.24.17.pdf. Despite the availability of Normative Appendix A, WAP Health & Safety guidance notes: "Chances are [weatherization providers] will have to install local ventilation and/or dwelling-unit ventilation in most of the dwellings [they] weatherize, but not all." *Id*. at 27.

[293] *Id*.

[294] Natl. Center for Healthy Housing, NCHH and Partners Receive HUD Grant to Study the Effects of Ventilation on Indoor Contaminants from Gas Stoves (Oct. 10, 2019), https://nchh.org/2019/10/fy19-tech-studies-grant-awards/.

[295] R. Karg, Residential Ventilation for Existing Buildings, *ASHRAE Journal* at 80-83 (Nov. 2016).

would be more effective at reducing indoor air contaminants than a similarly powered, exterior-exhausting bath fan" in existing homes.[296]

Guidance on residential energy upgrades issued by EPA states that if the home "is in compliance with ASHRAE Standard 62.2-2010 without bathroom or kitchen exhaust fans (i.e., using Appendix A), [the agency] recommends installation of exhaust fans vented to the outdoors, in accordance with Section 5 of ASHRAE Standard 62.2-2010 requirements, to improve pollutant source removal.[297]

Regardless of the system type used to achieve compliance, WAP clients must be provided information about the ventilation system's "function, use, and maintenance (including location of service switch and cleaning instructions)," along with a "disclaimer that ASHRAE 62.2 does not account for high polluting sources or guarantee indoor air quality."[298]

The Guidance explicitly *disallows* use of WAP funds for replacement of gas stoves and ovens, but "[w]hen testing indicates a problem, entities may perform standard maintenance on or repair gas cooktops and ovens."[299] The gas stoves section also states that WAP providers should "[i]nform clients of the importance of using exhaust ventilation when cooking and the importance of keeping burners clean to limit the production of CO."[300]

<u>Opportunities to Incorporate Kitchen Ventilation in WAP Projects</u>. WAP grantees have some flexibility to develop their programs in ways that will maximize indoor air quality and health benefits while meeting program guidelines. An important policy tool for doing so is the Health and Safety Plan (H&S Plan), which grantees must submit as part of their application. The H&S Plan reflects both the amount of program funding the state or other jurisdictions intends to allocate to health and safety expenditures in the upcoming year and the specific types of measures that will be implemented.

Following are some of the ways that state weatherization H&S Plans and related policies can facilitate installation and improvement of kitchen ventilation (and other indoor air quality issues) for WAP projects.

Enhancing Ventilation in WAP Projects. WAP national guidance requires installation of ventilation that meets the ASHRAE 62.2 standard, though state program requirements may exceed this standard to address local conditions and priorities.

In **North Carolina**, for example, the Weatherization Installation Standard Work Specifications (2015) require kitchen ventilation systems in *all weatherized homes with gas stoves*. The guidance states:

> "All kitchens containing a fuel-fired range shall be equipped with a [local exhaust ventilation] fan rated at less than 3.0 sones, with an installed airflow rate of not less than 100 cubic feet per minute (CFM) but not greater than 200 CFM. A range hood fan is recommended wherever feasible, but shall not be required. To increase the probability of uniform compliance with this standard, devices

[296] Natl. Center for Healthy Housing, Extracting Indoor Pollutants with Proper Ventilation (Extract), https://nchh.org/research/extract/.
[297] U.S. EPA, Healthy Indoor Environment Protocols for Home Energy Upgrades at 21 (2011), https://www.epa.gov/sites/production/files/2014-12/documents/epa_retrofit_protocols.pdf.
[298] WPN 17-7 Table, *supra*, at 12.
[299] *Id*. at 8.
[300] *Id*. at 8.

installed in kitchens shall have a rated airflow, specified by the device manufacturer, of not less than 120 CFM."[301]

At least one state, **Oregon**, has used its state-specific weatherization program Field Guide and Standards to strengthen the minimum airflow requirement for newly installed kitchen exhaust fans, requiring a minimum rating of 150 cfm for intermittent use.[302] Oregon also requires the installed kitchen fan to be a range hood, "unless a ceiling mounted fan can provide a minimum of 5 kitchen air changes per hour," and includes a specific requirement that fans used to comply with ASHRAE 62.2 "be flow tested to determine actual airflow."[303]

States have some flexibility to strengthen kitchen ventilation measures in their weatherization programs.

States can also use weatherization guidance to encourage installation of kitchen ventilation. In **Montana**, for example, the state's 2020 Weatherization Manual encourages installation of kitchen exhaust systems "when practical," even though ASHRAE 62.2-2010 does not strictly require it.[304]

Prioritizing Health and Safety in Eligibility Determinations. Grantees make decisions in their WAP policies, procedures, and plans about how eligible homes will be prioritized, given funding and other administrative limitations. Federal policy requires programs to give priority to elderly and disabled persons, families with children, and households with high energy use and/or a high energy burden.[305] **Massachusetts'** 2019 WAP plan authorizes sub-grantees to set aside up to 25 percent of their annual for "hardship" households projects that fall outside the regular priority groups; these are defined to include homes with "a condition that endangers the health and safety of the eligible low income household."[306] Such conditions could, e.g., include absent or inadequate kitchen ventilation systems.

Maximizing and Leveraging Funds for Integrating Health in Weatherization Projects. Some states have created significant new initiatives to emphasize health goals as part of weatherization projects. In 2015, the state of **Washington** set aside funding to expand the health focus of its weatherization program. Legislation amended the state's home weatherization law to authorize WAP grantees to use program awards and matching funds to make "healthy housing improvements," and the state reserved $4.1 million for a new Weatherization Plus Health pilot initiative.[307] In 2018, the state began to expand its Weatherization Plus

---

[301] N.C. Weatherization Assistance Program, NORTH CAROLINA WEATHERIZATION INSTALLATION STANDARD WORK SPECIFICATIONS at 45 (July 2015), *available at*: https://files.nc.gov/ncdeq/Energy%20Mineral%20and%20Land%20Resources/Energy/WAP%20Back%20Office%20Documents/NCWAP%20Installation%20SWS%20Final%2007202015.pdf.

[302] Oregon Housing and Community Services, LOW INCOME WEATHERIZATION ASSISTANCE PROGRAM – JUNE 2020 FIELD GUIDE AND STANDARDS at 109 (July 1, 2020), *available at*: https://www.oregon.gov/ohcs/energy-weatherization/Documents/Train-Tech-Assist/OR-WAP-Field-Guide-6-2020.pdf. The guidance explicitly notes, "Kitchen fans require the 150 cfm intermittent rate even if they are being utilized for continuous use at a lower flow rate." *Id.* at 109.

[303] *Id.* at 109, 111.

[304] Mont. Dept. of Public Health and Human Services, 2020 WEATHERIZATION MANUAL at 40, *available at*: https://dphhs.mt.gov/Portals/85/hcsd/documents/lieap/WeatherizationManual.pdf.

[305] 10 CFR 440.16.

[306] Mass. Office of Housing and Economic Development & U.S. DOE, WEATHERIZATION ASSISTANCE PROGRAM (WAP) STATE PLAN/MASTER FILE WORKSHEET at 10 (2019), *available at:* https://www.mass.gov/files/documents/2019/04/18/FY2019WAPMaster.pdf.

[307] Rev. Code Wa. §§70.164.010, 040; Wash. Dep't of Commerce, Weatherization Plus Health, http://www.commerce.wa.gov/growing-the-economy/energy/weatherization-and-

Health work to the full weatherization network around the state, seeking "to integrate Weatherization Plus Health as a regular service" by 2021.[308]

The state of **Vermont** has also taken notable programmatic steps to integrate weatherization and health. In 2014, the state weatherization program began using a centralized referral process to facilitate the coordination of energy, health, and housing services. Weatherization providers in the state use a Vermont-specific version of "One Touch" – an electronic tool developed by Tohn Environmental Strategies that automatically prompts electronic referrals to a wide variety of health and housing public agencies and non-governmental organizations throughout the state.[309] State law also establishes an enhanced weatherization assistance amount exceeding the federal per unit limit, and further requires the state program to allow "flexibility to accommodate special circumstances in which greater energy savings can be realized or *health and safety problems may be alleviated*."[310]

Healthy Homes/Asthma Programs

Many public health agencies and non-governmental organizations throughout the U.S. implement programs to address indoor environmental problems in homes, with a special focus on reducing indoor asthma triggers. These programs can be important partners to weatherization, energy retrofit, and other housing improvement programs to ensure that ventilation is incorporated to reduce key indoor pollutant exposures.

Healthy homes programs may include in-home assessments, education about behavior change, and modifications to the home. In some cases, these modifications could include installing kitchen ventilation systems to reduce exposure to PM and NO_2.[311]

In recent years, there have been notable efforts to identify sustainable funding sources for implementing healthy homes interventions.[312] One area of activity has been the development of innovative health care financing strategies to pay for preventive services not traditionally covered by medical insurance. For example, the Medicaid program, a federal-state partnership that provides health insurance for low-income and disabled individuals, offers states some flexibility in structuring their programs to cover preventive

---

energyefficiency/matchmaker/weatherization-plus-health-wxh/. An additional $4.2 million was set aside for projects to reduce asthma risks and save energy and for "basic measures to improve home health."

[308] Wash. Dept. of Commerce, WEATHERIZATION PLUS HEALTH, available at: http://www.commerce.wa.gov/growing-theeconomy/energy/weatherization-and-energy-efficiency/matchmaker/weatherization-plus-health-wxh/.

[309] One Touch, Vermont, https://onetouchhousing.com/locations/vermont/; Vt. Dept. for Children and Families, Vermont's Weatherization Program Awarded HUD Secretary's Healthy Homes Award, https://dcf.vermont.gov/news/7-25-17.

[310] 33 Vt. St. §2502 (emphasis added). In addition to overall spending limits, WAP grantees must establish spending caps for health and safety (as a percentage of overall expenditures) in their H&S Plans and have some discretion in this regard. 10 CFR 440.16.; U.S. DOE, WEATHERIZATION GRANTEE HEALTH AND SAFETY PLAN OPTIONAL TEMPLATE, *available at* https://www.energy.gov/eere/wipo/downloads/wpn-17-7-weatherization-health-and-safety-guidance. According to WPN 17-7, "As a general rule, budgets that exceed 15% of Program Operations will require justification."

[311] *See* HUD, GUIDE TO SUSTAINING EFFECTIVE ASTHMA HOME INTERVENTION PROGRAMS (2018), *available at:* https://www.hud.gov/sites/dfiles/HH/documents/HUD%20Asthma%20Guide%20Document_Final_7_18.pdf (describing the Green and Health Homes Initiative's programs in Baltimore).

[312] *See generally* Natl. Center for Healthy Homes, MORE FINANCING MECHANISMS FOR HEALTHY HOMES SERVICES (2019), *available at*: https://nchh.org/resource-library/report_strategies-toward-sustainability_more-financing-mechanisms-for-hh-services.pdf; Green & Healthy Homes Initiative, SUSTAINABLE FUNDING AND BUSINESS CASE FOR GHHI HOME INTERVENTIONS FOR ASTHMA PATIENTS (2015), *available at*: https://www.greenandhealthyhomes.org/wp-content/uploads/Sustainable-Funding-and-Business-Case-for-GHHI-Home-Interventions-for-Asthma-Patients_0.pdf.

services that could potentially include home remediation services and other evidence-based asthma management interventions.[313]

A number of states have pursued Medicaid policy changes toward this end. According to a 2014 survey by the National Center for Healthy Housing, thirteen states reported an existing Medicaid policy in place to cover home-based asthma services; of these, five paid for low-cost supplies and two covered structural remediation.[314] Using Medicaid and other healthcare financing mechanisms for home repairs and remediation to reduce asthma triggers may not be a viable strategy in all jurisdictions. States and localities have also obtained support for their healthy homes intervention programs from sources such as tobacco settlements, excise fees and taxes, and federal categorical and block grants.[315]

Housing Repair/Improvement Grant Programs

States, local governments, and tribes administer a variety of home repair and renovation programs that could potentially be a source of funding to low-income homeowners to pay for air conditioning or to retrofit ventilation systems to provide enhanced filtration.

These programs receive support from a number of federal programs, including HUD's Community Development Block Grant (CDBG) program, which funds housing and economic development activities serving low- and moderate-income communities.[316] HUD awards CDBG funds to states, tribes, and entitlement communities (localities), which in turn distribute the funds to projects in accordance with federal regulations.[317] Priorities for distributing funds are incorporated into CDBG planning documents, which must be developed with citizen participation.[318] The improvement of owner-occupied housing is one of the most common areas of CDBG activity. Grantees can provide "grants, loans, loan guarantees, interest subsidies, or other forms of assistance to homeowners for the purpose of repairs, rehabilitation, or reconstruction."[319] Grantees have "flexibility under the CDBG Program to design repair and rehabilitation programs that meet the needs of their residents," and thus can set up a program with CDBG funding to support emergency repairs, weatherization, and other activities that might include improvements to kitchen ventilation.[320] Grantees can also provide similar assistance for the rehabilitation of rental housing.[321]

---

[313] *See generally id*.; Natl. Center for Healthy Homes, Medicaid 101, https://nchh.org/tools-and-data/financing-and-funding/healthcare-financing/medicaid-101/.

[314] Natl. Center for Healthy Homes, HEALTHCARE FINANCING OF HEALTHY HOMES at 12, *available at:* https://nchh.org/resourcelibrary/Reimbursement%20Landscape_MAIN%20REPORT_FINAL%20(18%20November%202014).pdf.

[315] Natl. Center for Healthy Homes, MORE FINANCING MECHANISMS FOR HEALTHY HOMES SERVICES, *supra*.

[316] 42 U.S.C. §§5301 et seq.; 24 CFR Pt. 570. Federal agencies also administer a variety of loan programs for homeowners. *See, e.g.,* HUD, 203(k) Rehabilitation Mortgage Insurance, https://www.hud.gov/program_offices/housing/sfh/203k; USDA, Single Family Housing Repair Loans and Grants (Section 504 program), https://www.rd.usda.gov/programs-services/single-family-housing-repair-loans-grants.

[317] 42 US.C. §5303.

[318] Documents that must be submitted to HUD include an Annual Action Plan and a three- to five-year Consolidated Plan. *See* 24 CFR 570.302, 24 CFR Pt. 91. Consolidated Plans also cover other federal formula grant programs that might be relevant to home repair and rehabilitation, such as the HOME Investment Partnerships Program. *See* 42 U.S.C. §92.205.

[319] HUD, BASICALLY CDBG at 4-2 (2012), *available at*: https://files.hudexchange.info/resources/documents/Basically-CDBG-Chapter-4-Housing.pdf.

[320] *Id.* at 4-1.

[321] *Id.* at 4-5.

In addition to the CDBG program, HUD's Indian Community Development Block Grant program funds tribes, Alaska Native villages, and tribal organizations to support housing rehabilitation and other activities to benefit low- and moderate-income households. HUD may set aside five percent of annual program funding for grants to eliminate or lessen problems that pose an imminent threat to public health or safety of tribal residents.[322] HUD's Indian Housing Block Grant program provides funding to tribes to "develop, operate, maintain, or support affordable housing for rental or homeownership, or to provide housing services with respect to affordable housing," including moderate or substantial rehabilitation and energy efficiency improvements.[323]

The U.S. Department of Agriculture (USDA) manages programs that fund the repair and development of affordable housing in rural areas. One of the largest is the Single Family Housing Repair Loans and Grants program, also known as the Section 504 Home Repair Program, which provides grants and loans to very-low-income homeowners. Grants up to $7,500 may be used by elderly homeowners to remove health and safety hazards, which might potentially include inadequate kitchen ventilation. Low-interest loans up to $20,000 may be used more broadly to repair, improve, or modernize homes.[324]

Some states have established their own financial assistance programs for residential rehabilitation or repair. One example is **Minnesota**'s Rehabilitation Loan Program, carried out by Minnesota Housing. Loans up to $27,000 are available to low-income homeowners to improve the safety, livability, or energy efficiency of their homes. Loans are forgiven if the owner does not sell, transfer, or move out of the property during the loan term.[325] The agency's Rental Rehabilitation Deferred Loan program makes available loans for health and safety improvements to owners of affordable multifamily rental housing outside the metropolitan areas. Loans are typically issued as interest-free, deferred loans with a 20-year term, and 10 percent of the loan amount may be forgiven provided the owner maintains rent and income restrictions for the property.[326] The city of **Fullerton, California** is an example of a locality that provides grants for home improvements; low-income homeowners may receive up to $5,000 to correct building code items or address health and safety issues.[327]

In providing funding for home repairs, jurisdictions can specify kitchen exhaust repairs as an allowable use. In **Florida**, the State Housing Initiatives Partnership program (SHIP) "provides funds to local governments as an incentive to create partnerships that produce and preserve affordable homeownership and multifamily

---

[322] 24 CFR 1003.202(b), .1003.400; HUD, Indian Community Devt. Block Grant Program, http://portal.hud.gov/hudportal/HUD?src=/program_offices/public_indian_housing/ih/grants/icdbg.
[323] 25 U.S.C. §4132, 24 CFR 1000.102. *See generally* HUD, Indian Housing Block Grant Program, http://portal.hud.gov/hudportal/HUD?src=/program_offices/public_indian_housing/ih/grants/ihbg.
[324] *See* USDA, Single Family Housing Repair Loans & Grants, https://www.rd.usda.gov/programs-services/single-familyhousing-repair-loans-grants.
[325] Minn. Housing Finance Agency, Rehabilitation Loan/Emergency and Accessibility Loan Program, http://www.mnhousing.gov/sites/Satellite?c=Page&cid=1358904992980&d=Touch&pagename=External%2FPage%2FEXTStandardLayout.
[326] Loans may not be used for improvements that are not permanent fixtures to the property, with the exception of appliances. Minn. Housing Finance Agency, Rental Rehabilitation Deferred Loan Pilot Program Interim Guide, http://www.mnhousing.gov/sites/Satellite?c=Page&cid=1358905404900&d=Touch&pagename=External%2FPage%2FEXTStandardLayout. Mn. St. §462A.05 provides general authority for the program.
[327] City of Fullerton (CA), Residential Improvement Program, https://www.cityoffullerton.com/gov/departments/dev_serv/housing_n_neighborhood_services/home_improvement_program.asp.

housing" for very low, low, and moderate income families.[328] In order to participate, local governments must establish a local housing assistance program by ordinance. One local government, Indian River County, has adopted local program guidelines that specify activities for which SHIP-funded rehabilitation loans may be awarded, including the "[r]eplacement of range hood if existing one is not working; installation if none existing."[329]

Discussion

Ensuring adequate kitchen ventilation is more challenging for existing homes than for new construction or home renovations. Financial assistance programs already in place offer possibilities for reducing exposure to cooking pollutants, though a wide array of public health challenges compete for this funding. In addition, while stronger building and housing standards can protect occupants, policymakers must also work to preserve and expand the availability of affordable housing units. These multiple, related goals underscore the importance of consulting with affected communities in developing housing policies and funding strategies for reducing indoor exposure to cooking pollutants.

Housing Codes

State and local housing codes and landlord-tenant laws are potential policy vehicles for helping to ensure that rental housing adequately protects residents from cooking pollutants. These laws and regulations typically require compliance with the ventilation standards in building codes at the time the property was permitted, which will be increasingly important as jurisdictions begin to strengthen those codes. They also establish independent requirements for maintenance and operation. Key challenges for addressing indoor pollutant exposure in rental housing are the need for stronger property maintenance standards and the difficulty in ensuring effective implementation and enforcement of existing or new standards.

Strengthening Housing Standards. Policymakers could consider revising their laws and regulations to include health in the definition of habitability and to require that owners provide and maintain local exhaust ventilation in kitchens. Including these provisions in the housing code (and state landlord-tenant law) would enable government enforcement in situations involving serious health risks and could also facilitate private remedies for tenants.

Applying Existing Laws and Regulations to Address Exposure. Apart from adopting new standards, existing housing code provisions could be interpreted and applied more broadly to address cooking pollutants. For example, a general requirement for adequate ventilation could be applied to require kitchen ventilation, and a requirement to maintain mechanical equipment could be applied to require maintenance of kitchen

---

[328] Fla. Housing Finance Corp., State Housing Initiatives Partnership, https://www.floridahousing.org/programs/special-programs/ship---state-housing-initiatives-partnership-program. ("SHIP funds are distributed on an entitlement basis to all 67 counties and 52 Community Development Block Grant entitlement cities in Florida. The minimum allocation is $350,000. [Local governments] develop a local housing assistance plan and housing incentive strategy; amend land development regulations or establish local policies to implement the incentive strategies; form partnerships and combine resources in order to reduce housing costs; and ensure that rent or mortgage payments within the targeted areas do not exceed 30 percent of the area median income limits, unless authorized by the mortgage lender.")

[329] Indian River County, Fla., GUIDELINES AND PROCEDURES FOR IMPLEMENTING STRATEGIES OF LOCAL HOUSING ASSISTANCE PLAN (LHAP): FY 2018-2019, FY 2019-2020, FY 2020-2021 (July 2018), *available at*: https://www.irccdd.com/Planning_Division/SHIP/LHAP-Guidelines.pdf.

exhaust fans consistent with applicable building code standards and according to the manufacturer's recommendations. Applying general provisions to address indoor exposure to unhealthy levels of pollutants generated by cooking could advance the broad purpose of most housing codes – to ensure that housing is maintained free of unsafe and harmful conditions.

Ensuring Effective Code Enforcement. Municipal code enforcement programs are vital for implementing minimum health and safety requirements but are often under-resourced. Approaches to facilitating code enforcement might include: (1) modifying inspection checklists to include applicable local and general ventilation requirements; and (2) prioritizing inspections in the homes of medically susceptible individuals, where housing conditions may be impacting health.[330] Jurisdictions could also assist tenants in enforcing housing standards by developing written educational materials, strengthening procedural provisions in landlord-tenant laws, establishing specialized housing courts, and providing tenants legal representation.[331]

Funding for Improving Kitchen Ventilation

In existing homes, cost may be a barrier to installing a new ducted ventilation system where one did not exist, or upgrading an existing system to achieve the capture efficiency needed to protect health. Financial assistance is a key consideration in developing policies and programs to reduce cooking-related pollution for individuals who are most susceptible to the risks from exposure.

Leveraging Existing Programs. A review of existing financial assistance programs within a jurisdiction is a starting point for identifying potential resources. Weatherization and other energy-efficiency retrofit programs that already address ventilation may be options for incorporating kitchen ventilation in existing homes. Existing housing repair/rehabilitation and healthy homes programs might also be able to provide kitchen ventilation systems in some cases. Jurisdictions that administer these and similar programs can consider adjusting program guidelines and priorities to assist households most at risk from exposure to cooking pollutants. Coordination among agencies – including public health agencies that administer healthy homes and asthma programs – and with outside organizations can help maximize available resources and facilitate appropriate referrals to programs that can provide necessary repairs or upgrades in the home. Where current funding programs cannot be adapted, jurisdictions might consider establishing a pilot program to address the cooking pollutant exposure – e.g., by retrofitting homes with range hoods.[332]

---

[330] In some jurisdictions, housing code agencies have partnered with health agencies and providers to coordinate referrals for asthma patients. *See*, e.g., Boston Public Health Comm., Breathe Easy at Home, https://www.boston.gov/departments/public-health-commission/breathe-easy-home; R.I. Dept. of Health, Breathe Easy at Home Project, http://health.ri.gov/projects/breatheeasyathome/. *See also* Natl. Center for Medical Legal Partnerships, Partnerships, http://medical-legalpartnership.org/partnerships/ (system for medical providers to refer patients to local code enforcement agencies).

[331] Some jurisdictions have taken notable steps along these lines. *See, e.g.,* Newark Ord. 18-0673 (12/19/18) (pilot program to provide access to free legal representation to low-income tenants facing eviction); City of San Francisco, NO EVICTION WITHOUT REPRESENTATION ACT of 2018, *available at:* http://sfelections.sfgov.org/sites/default/files/Documents/candidates/Legal_Text_No_Eviction_Without _Representation.pdf (successful ballot initiative establishing right to legal representation for eligible tenants facing eviction); New York City Admin. Code, T. 26, Ch. 13: Provision of Legal Services in Eviction Proceedings (Local Law 136 of 2017) (directing the city to establish a program to make legal services available to tenants facing eviction proceedings); District of Columbia Courts, Housing Conditions Calendar, https://www.dccourts.gov/services/civil-matters/housingconditions-calendar (allowing tenants to bring expedited case against landlords for violating the housing code).

[332] For example, HUD currently is funding a study, led by NCCH, which involves retrofitting 120 homes in Illinois and Colorado with kitchen range hoods. *See* Natl. Center for Healthy Housing, NCHH and Partners Receive HUD Grant to

Identifying High-Risk Individuals. Limited resources can be focused on supporting individuals at greatest risk of health problems from pollutant exposure. This includes medically susceptible individuals, such as older adults and people with acute or chronic respiratory and cardiovascular disease. It may also include communities of color and lower-income communities that bear higher burdens of outdoor pollution and suffer disproportionately from asthma and other chronic conditions. Because children are also at increased risk, program assistance could be provided to home-based childcare serving lower-income families. Health, housing and social services agencies can coordinate efforts to ensure that families they work with are referred to any available housing funding programs that can help reduce indoor asthma triggers and other IAQ problems in the home.

Incorporating Education about Cooking Ventilation. Given the role of occupant behavior in ensuring adequate kitchen ventilation, it is important for financial assistance programs to include an educational component. State, local, and tribal funding programs could require funding recipients that perform ventilation upgrades to inform occupants about how to use equipment effectively to reduce exposure. Agencies could also integrate kitchen ventilation education into their own public health educational programs or make funding available to non-governmental organizations to do the same.

Study the Effects of Ventilation on Indoor Contaminants from Gas Stoves (Oct. 10, 2019), https://nchh.org/2019/10/fy19-tech-studies-grant-awards/.

ENVIRONMENTAL LAW • INSTITUTE®

1730 M Street, NW, Suite 700
Washington, DC 20036
Tel: 202.939.3800
Fax: 202.939.3868
www.eli.org