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Indoor Air Quality in Homes

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

CHAPTER 4: IAQ AND ENERGY EFFICIENCY RETROFITS

ENVIRONMENTAL LAW • INSTITUTE®

December 2016

ACKNOWLEDGMENTS

The Environmental Law Institute gratefully acknowledges the assistance of many individuals who provided information about the policy initiatives discussed in this report and reviewed draft materials. Funding for this report was provided by the U.S. Environmental Protection Agency. 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.

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CHAPTER 4

IAQ and Home Energy Efficiency Retrofits

Because residential energy use accounts for about 20 percent of carbon dioxide (CO_2) emissions in the United States, government policies and programs have promoted home energy efficiency as a cost-effective strategy for reducing greenhouse gas emissions while also lowering residents' energy bills.[286] Improving the energy efficiency of buildings is a strategy commonly recommended in state climate planning documents.[287] Following the American Recovery and Reinvestment Act of 2009, billions of dollars in new federal funding was made available for residential energy efficiency improvements, including through the Department of Energy's Weatherization Assistance Program.[288] Between federal programs and a wide range of efforts by states, local jurisdictions, and utilities, a "virtual cornucopia of mandatory and voluntary programs and policies" were established.[289]

As political, institutional, and public support for home energy upgrades continues, it is important that the programs and policies advancing these efforts take IAQ and health effects into account. Energy efficiency upgrades have the potential to affect indoor air quality in both positive and negative ways, but there is broad recognition that it is possible to achieve both energy efficiency and IAQ goals in a home energy retrofit project. The Institute of Medicine's 2011 report on climate change and health, which devoted a chapter to building ventilation, weatherization, and energy use, noted that, "Government and consensus organizations are beginning to recognize the importance of this issue and have established or are establishing voluntary guidelines and codes that account for the links between energy efficiency, indoor environmental quality, ventilation, and occupant health and productivity."[290]

This chapter describes existing state policy strategies for integrating indoor air quality and energy efficiency. The chapter focuses on the federal Weatherization Assistance Program (WAP) for low-income households as a case study in how states can integrate IAQ considerations into home energy efficiency retrofits – not only in implementing that federal program, but also in developing other state energy

[286] *See* National Academy of Sciences – Institute of Medicine, Climate Change, the Indoor Environment, and Health at 210 (2011), http://www.nationalacademies.org/hmd/Reports/2011/Climate-Change-the-Indoor-Environment-and-Health.aspx.
[287] *See, e.g.,* Cal. Natural Resources Agency, Safeguarding California: Implementation Action Plans: Public Health Sector Plan at 156, 162 (2016), http://bit.ly/2fKW85n; Mass. Executive Office of Energy and Environmental Affairs, Massachusetts Clean Energy and Climate Plan for 2020 (2010), http://www.c2es.org/docUploads/states/climate-action-plan/ma_2020-clean-energy-plan_dec2010.pdf.
[288] *See* U.S. Dept. of Energy (DOE), Weatherization Assistance Program: American Recovery and Reinvestment Act of 2009, https://energy.gov/sites/prod/files/2014/01/f7/wx_recovery_fact_sheet.pdf. Some of the many other federal programs and initiatives funded under the Act include the DOE's Residential Energy Efficiency Tax Credit, the U.S. Dept. of Agriculture's Rural Energy for America Program Renewable Energy Systems & Energy Efficiency Improvement Loans and Grants, and the U.S. EPA's Energy Star Energy Efficient Mortgages program.
[289] National Safe and Healthy Housing Coalition, Integrating Energy Efficiency and Healthy Housing at 1 (rev. 2010), http://www.nchh.org/Portals/0/Contents/Coalition_briefing_paper_energy.pdf.
[290] Institute of Medicine, Climate Change, the Indoor Environment, and Health, *supra*, at 5.

efficiency retrofit initiatives. Following a detailed description of the Weatherization Assistance Program and state WAP implementation policies, the chapter highlights strategies for addressing IAQ and health in other state residential energy efficiency programs.[291]

Background

Energy Efficiency Retrofits, Indoor Air Quality, and Occupant Health

Many of the most common energy efficiency improvements for existing homes are weatherization measures, which are intended to improve a home's energy efficiency by sealing or tightening the building envelope. In a typical home, air leakage accounts for 25 to 40 percent of the energy used for heating and cooling; thus tightening the building can significantly reduce the amount of energy required.[292]

Typical building tightening measures for residential buildings include: sealing air leaks around floors, walls, ceilings, windows, doors, and fireplaces (using caulk, weather stripping, and/or spray foam); installing more energy-efficient windows and doors; and sealing air ducts and making sure they are properly connected.[293] Other weatherization measures that help tighten the building envelope include tune-ups or upgrades of heating and cooling systems and replacement of atmospherically-vented combustion equipment with high-efficiency equipment. As a complement to building tightening measures, it is common to add insulation to exterior walls, basements, crawl spaces, and attics to reduce unintended heat exchange.[294]

In addition to saving money on utility bills, weatherizing a home may provide important non-energy benefits for its occupants, in the form of improved indoor air quality, comfort, and health.[295] For instance, tightening a building can reduce the entry of drafts and noise, as well as dust, pollen, and other outdoor air pollutants.[296] In a national survey evaluating the impacts of the federal Weatherization Assistance Program, occupants of weatherized homes reported general health and well-being improvements, fewer asthma symptoms, fewer colds and headaches, and fewer missed days of work.[297]

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[291] For a discussion of state policies addressing IAQ and school energy efficiency upgrades, see Envtl. Law Institute, Addressing Indoor Air Quality in School Energy Efficiency Upgrades: Review of Selected State Policies (Jan. 2016), https://www.eli.org/research-report/addressing-indoor-air-quality-school-energy-efficiency-upgrades-review-selected-state-policies.

[292] *See* U.S. EPA, Air Sealing: Building Envelope Improvements (2005), https://www.energystar.gov/ia/home_improvement/home_sealing/AirSealingFS_2005.pdf; *See also* U.S. DOE, Why Energy Efficiency Upgrades, http://energy.gov/eere/why-energy-efficiency-upgrades.

[293] U.S. DOE, Why Energy Efficiency Upgrades, http://energy.gov/eere/why-energy-efficiency-upgrades; *see also* Institute of Medicine, Climate Change, the Indoor Environment, and Health, *supra*, at 212.

[294] U.S. DOE, Why Energy Efficiency Upgrades, http://energy.gov/eere/why-energy-efficiency-upgrades.
Other energy efficiency improvements for existing homes include installing more efficient hot water heaters, appliances, and lighting.

[295] *See* Lawrence Berkeley National Laboratory (LBNL), Indoor Air Quality Scientific Findings Resource Bank: Building Energy Efficiency, https://www.iaqscience.lbl.gov/cc-building.

[296] U.S. DOE, Building Energy Resource Guide: Air Leakage Guide at 1 (2011), https://www.energycodes.gov/sites/default/files/documents/BECP_Buidling%20Energy%20Code%20Resource%20Guide%20Air%20Leakage%20Guide_Sept2011_v00_lores.pdf.

[297] B. Tonn et al., Weatherization Works – Summary of Findings from the Retrospective Evaluation of the U.S. Department of Energy's Weatherization Assistance Program at xv, 23 (2014), http://weatherization.ornl.gov/Retrospectivepdfs/ORNL_TM-

But energy efficiency retrofits can also have negative consequences for IAQ and health if proper precautions are not taken. For example, retrofit activities themselves may disturb building materials containing hazardous substances such as lead, asbestos, and PCBs, creating new exposure risks for workers and occupants. Air-sealing can alter the internal air pressure of a home, which may lead to insufficient makeup air, back drafting of carbon monoxide and other combustion gases, and the intrusion of radon and other gases from soil.[298]

Perhaps most important from an IAQ perspective, increasing the airtightness of buildings through weatherization measures may decrease rates of outdoor air ventilation.[299] Adequate ventilation and filtration of outside air are key components of good indoor air quality. Many existing homes were designed to rely on air infiltration through holes and cracks in the building envelope as a source of fresh air exchange.[300] Reduced ventilation rates may result in higher concentrations of pollutants generated indoors, including carbon monoxide, radon, chemicals (e.g., formaldehyde), fine particulates, mold and moisture, and tobacco smoke.[301] Lower ventilation rates may also lead to increased concentrations of carbon dioxide indoors, and an emerging body of research suggests that increased indoor concentrations of carbon dioxide itself are associated with adverse impacts on occupants' health and performance.[302]

There is broad recognition that it is possible to achieve both energy efficiency and IAQ goals in a home energy retrofit.

In addition to ensuring that IAQ problems are not created or exacerbated, energy retrofits can serve as a vehicle for implementing measures to enhance indoor air quality. For example, energy efficiency projects can incorporate removal or isolation of existing pollutants (e.g., combustion gases, mold, pests) and installation of carbon monoxide alarms – though "these opportunities may be missed due to lack of information on IAQ and/or funding limitations."[303]

2014_338.pdf; B. Tonn et al., Health and Household-Related Benefits Attributable to the Weatherization Assistance Program at xvi (2014), http://weatherization.ornl.gov/Retrospectivepdfs/ORNL_TM-2014_345.pdf/.

[298] 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.

[299] Institute of Medicine, Climate Change, the Indoor Environment, and Health, *supra*, at 6 ("Climate change may make ventilation problems more common or more severe in the future by stimulating the implementation of energy efficiency (weatherization) measures that limit the exchange of indoor air with outdoor air.").

[300] W. Chan et al., Analysis of air leakage measurements of US Homes, *Energy & Buildings* 66 (2013) 616, http://eetd.lbl.gov/sites/all/files/chan_analysis_of_air_leakage.pdf.

[301] U.S. Global Change Research Program (USGCRP), Impacts of Climate Change on Human Health at 79, https://health2016.globalchange.gov/.

[302] *See, e.g.,* U. Satish et al., Is CO_2 an Indoor Pollutant? Direct Effects of Low-to-Moderate CO_2 Concentrations on Human Decision-Making Performance, *Envtl. Health Perspectives,* v. 120, at 1671 (2012), http://ehp.niehs.nih.gov/wp-content/uploads/120/12/ehp.1104789.pdf.

[303] U.S. EPA, Energy, Weatherization, and Indoor Air Quality, https://www.epa.gov/indoor-air-quality-iaq/energy-weatherization-and-indoor-air-quality.

Integrating Energy Efficiency and IAQ in Climate Planning: California

In 2016, the state of California identified healthy, energy efficient buildings as an area "where State leadership is needed to fill current gaps in the implementation of California's adaptation strategy." Toward this end, the state's Public Health Sector Plan recommended that the state:

- "Facilitate greater collaboration between organizations that design and implement energy efficiency programs and those organizations that implement programs to improve health-related housing quality."
- "Explore partnerships that combine funding for energy efficiency, indoor air improvements, and health improvement."
- "Develop funding or evaluative mechanisms to ensure that energy efficiency upgrades are installed and operate as intended and do not adversely affect building ventilation or other indoor environmental quality factors and health consequences."

Source: Calif. Natural Resources Agency, Safeguarding California: Implementation Action Plans: Public Health Sector Plan at 162-3 (2016), http://resources.ca.gov/docs/climate/safeguarding/Public%20Health%20Sector%20Plan.pdf

Best Practices Guidance for Addressing IAQ in Energy Efficiency Retrofits

In recent years, both U.S. EPA and the Department of Energy (DOE) have published best practice documents and other guidance materials for addressing IAQ and health issues in home energy retrofits. EPA's *Healthy Indoor Environment Protocols for Home Energy Upgrades* contains technical guidance for assessing, maintaining, and improving IAQ as part of residential energy retrofits. The protocols are "intended for use by the home energy retrofit industry….They are also intended for voluntary adoption by federal, state, tribal and local weatherization assistance programs, federally funded housing programs, industry standards organizations, private sector home performance contracting organizations and public and environmental health professionals."[304]

The guidance covers 20 priority issues that may relate to typical home retrofits, organized according to specific indoor contaminants, critical building systems, and worker/occupant safety hazards.[305] For each priority issue, the guide includes information on EPA-recommended Assessment Protocols and Minimum Actions to ensure that work does not create new IAQ problems or exacerbate existing

[304] U.S. EPA, Healthy Indoor Environment Protocols for Home Energy Upgrades: Guidance for Achieving Safe and Healthy Indoor Environments During Home Energy Retrofits at i, (2011), https://www.epa.gov/sites/production/files/2014-12/documents/epa_retrofit_protocols.pdf [hereinafter EPA Home Energy Upgrade Protocols].

[305] The priority issues covered in the guide include: asbestos; belowground contaminants (except radon); building products and emissions; CO and other combustion appliance emissions (nitrogen oxides, VOCs and particulates); environmental tobacco smoke; garage air pollutants; lead; moisture (mold and other biologicals); ozone; pests; polychlorinated biphenyls (PCBs); radon; wood smoke and other solid fuel emissions; HVAC equipment; combustion safety; source ventilation; whole-house ventilation; multi-family ventilation; home safety; and jobsite safety. *Id*.

conditions; for many issues, the protocols include Expanded Actions that can be taken to further improve and promote a healthy indoor environment where circumstances and resources permit.[306] Best practices include, but are not limited to:

- Assurance of adequate whole-building ventilation (in accordance with ASHRAE Standard 62.2), including adequate filtration of outdoor ventilation air;[307]
- Local exhaust of kitchen fans, bath fans, and clothes dryers to the outdoors;
- Repair of interior and exterior water leaks and elimination of standing water;
- Measures for preventing condensation in the building enclosure, managing air pressure, and controlling indoor humidity sources;
- Compliance with lead-safe practices in older homes (if necessary);
- Radon testing (and, if necessary, precautionary measures);
- Identification of potential asbestos hazards (and, if necessary, implementation of exposure controls); and
- Installation of carbon monoxide alarms. [308]

The 2011 guide is oriented toward retrofit activities in single-family homes and low-rise residential buildings. In early 2016, EPA released separate guidance, *Energy Savings Plus Health: Indoor Air Quality Guidelines for Multifamily Building Upgrades*, for use during energy efficiency upgrades, renovations, and remodeling in residential buildings with at least five units.[309] It includes assessment protocols and recommended actions for addressing 24 priority issues, including a number of issues that can be different in, or unique to, multifamily buildings. A companion tool, the *Energy Savings Plus Health: Checklist Generator for Multifamily Building Upgrades*, is an interactive Microsoft Excel sheet that can be used to create a custom-tailored checklist to verify that appropriate assessment protocols and recommended actions are implemented during a particular project.[310]

These EPA protocols are incorporated in complementary guidance developed by the Department of Energy. DOE's *Guidelines for Home Energy Professionals* program provides Standard Work Specifications (SWS) for home energy retrofit projects, which include safe work practices, relevant codes, and many of the EPA protocols described above. Reflecting the "whole-house approach" to energy efficiency, the

[306] For example, Minimum Actions to address moisture problems include repairing roof leaks before air sealing or insulating the attic and addressing water pooling near the foundation before insulating basement or crawlspaces, while Expanded Actions in this category include repairing plumbing leaks and retrofitting crawlspaces to be unvented, sealed, insulated, and waterproofed. *Id*. at 9-10.

[307] The EPA Protocols' Minimum Actions for multi-family ventilation call for minimum MERV 6 filters on supply ventilation systems. *Id*. at 23. The Protocols also recommend, as an Expanded Action, to "[c]onsider using filters with a high MERV rating (11 or above) if equipment capacity is sufficient to accommodate the pressure drop. For existing systems, check with the manufacturer to determine whether MERV 11 filters can be installed." *Id*. at 17.

[308] *Id*. at 1-2, 6, 8-10, 12-15, 17-18, 21-23.

[309] U.S. EPA, Energy Savings Plus Health: Indoor Air Quality Guidelines for Multifamily Building Upgrades (2016), https://www.epa.gov/sites/production/files/2016-02/documents/esh_multifamily_building_upgrades_508c_02_09_2016.pdf.

[310] U.S. EPA, Energy Savings Plus Health: Checklist Generator for Multifamily Building Upgrades, https://www.epa.gov/indoor-air-quality-iaq/energy-savings-plus-health-indoor-air-quality-guidelines-multifamily-building. EPA has also developed guidance tailored to school building upgrades. *See* U.S. EPA, Energy Savings Plus Health: Indoor Air Quality Guidelines for School Building Upgrades (2014), https://www.epa.gov/iaq-schools/protecting-iaq-during-school-energy-efficiency-retrofit-projects-energy-savings-plus.

SWS are intended to "describe acceptable outcomes for weatherization or home performance upgrades – effective, durable, and safe improvements" for the specific housing type."[311]

The EPA protocols and DOE's Standard Work Specifications provide a technical framework and best practice resource for the many governments, organizations, businesses, and individuals involved in funding, planning, and implementing home energy retrofits.

The Weatherization Assistance Program: Opportunities for Integrating Indoor Air Quality and Energy Efficiency

One of the largest energy efficiency programs in the U.S., DOE's Weatherization Assistance Program (WAP) has taken notable steps in recent years to integrate weatherization and health goals.[312] This section describes how the program's protocols and guidance address indoor air quality in low-income home weatherization projects and highlights state efforts to advance IAQ goals as they create plans, policies, and procedures to implement the federal program.

Background. First established by Congress in 1976, the Weatherization Assistance Program has funded retrofits of over seven million homes.[313] WAP provides grants to states, territories, and tribes to "increase the energy efficiency of dwellings owned or occupied by low-income persons, reduce their total residential energy expenditures, and improve their health and safety."[314] Appropriated funds are provided to states, the District of Columbia, U.S. territories, and some tribal governments ("grantees"), which then contract with local governments, community action agencies, and non-profit organizations ("sub-grantees") to implement weatherization projects in their service areas.

The program takes a "whole house" approach to energy efficiency that addresses the building envelope, heating and cooling systems, and certain appliances.[315] After a home energy audit, WAP crews and/or contractors implement energy conservation measures identified as cost-effective for that household.[316] In addition to energy saving measures, the program covers the costs of energy-related health and safety

[311] DOE, Guidelines for Home Energy Professionals Standards Work Specifications, https://energy.gov/eere/wipo/guidelines-home-energy-professionals-standard-work-specifications. The SWS address three different building types: single-family homes, multifamily residential building, and manufactured homes.
[312] In addition to the WAP policies described in this chapter, in 2012 DOE launched the *Weatherization Plus Health* initiative in partnership with the National Association for State Community Services Programs (NASCSP). The initiative provides tools and support to facilitate partnerships and coordination between WAP grantees and the Healthy Homes service providers implementing projects to address health hazards in the homes of low-income families. *See* NASCSP, Weatherization Plus Health, http://www.nascsp.org/Healthy-Homes/776/Weatherization-Plus-Health.aspx?iHt=41.
[313] U.S. DOE, Celebrating 40 Years of America's Weatherization Assistance Program, http://energy.gov/eere/articles/celebrating-40-years-america-s-weatherization-assistance-program.
[314] U.S. DOE, About the Weatherization Assistance Program, http://energy.gov/eere/wipo/what-weatherization (citing 42 USC § 6861).
[315] *See generally* DOE, The History and Evolution of America's Weatherization Network (2016), http://energy.gov/eere/articles/history-and-evolution-america-s-weatherization-network.
[316] 42 U.S.C. § 6863 (b)(3).

measures that must be taken to perform weatherization work safely and effectively, or which are necessary as a result of weatherization (e.g., in response to changes made to the building envelope).[317]

As part of the annual application for DOE funding, states prepare a *Health and Safety Plan* (H&S Plan), which serves as a central policy tool for integrating health and safety measures in WAP projects. The H&S Plan reflects the amount of program funding the state intends to allocate to health and safety expenditures in the upcoming year and the specific types of measures that will be implemented. DOE requires states to establish a health and safety spending limit, expressed as a percentage of the average cost per dwelling unit, in their H&S Plan. DOE approves, but does not mandate, the amount of the spending cap; therefore, health and safety expenditures can vary widely by state (and even by year), according to each state's priorities and needs.

A health and safety component was formally incorporated into WAP by federal regulation in 1993, and since then, DOE has issued a series of guidance documents, known as Weatherization Program Notices (WPNs), to clarify federal requirements and recommendations.[318] *WPN 11-6: Health and Safety Guidance*[319] includes a comprehensive Health and Safety Guidance Table addressing ten categories of health and safety hazards related to weatherization: ventilation in compliance with ASHRAE 62.2; mold and moisture; asbestos; lead-based paint; radon; combustion appliance safety and heating systems; replacements; codes and structure; OSHA; and occupant wellness.[320] For each issue, the Guidance Table identifies actions to address the hazard that are "allowable" uses of DOE funds. In some cases, the Guidance Table indicates that a certain action is "required," which means it must be included in states' H&S Plans. (See Text Box.) A few actions are categorically prohibited. For each issue, the Guidance Table also clarifies requirements for testing, client education, and training.

States are responsible for ensuring that their networks of WAP providers are following minimum standards set forth in *WPN 11-6* and other DOE guidance, including *WPN 15-4*, which requires that all measures performed on client homes meet the specifications, objectives, and outcomes outlined in DOE's Standard Work Specifications (SWS) for Home Energy Upgrades. WAP agencies and contractors are also required to comply with Occupational Safety and Health Administration (OSHA) regulations, in addition to any federal, state, or local laws and regulations that apply to a specific activity or pollutant.

WPN 11-6 explains that where health and safety problems exist that cannot be addressed through allowable health and safety measures, it may be necessary to defer weatherization at that home until

[317] 10 C.F.R. 440.18. These costs must be "reasonable," and health and safety measures can only be funded if energy efficiency measures are also installed in the home. 10 C.F.R. 440.16.
[318] Along with the federal enabling statute (42 U.S.C. §§ 6861 et seq.) and regulations (10 C.F.R. Part 440), a series of Weatherization Program Notices issued by DOE establish a framework of federal requirements that guide development of state programs to implement annual WAP grants from the federal government.
[319] In July 2016, DOE's Weatherization and Intergovernmental Program Office issued a memorandum to the WAP network requesting comments on a draft revised Health and Safety WPN, which would streamline guidance and update (if not supersede) previous WPNs, including WPN 11-6. As of the end of 2016, a final version of this draft WPN had not been released as policy. *See* Memorandum from Weatherization & Intergovernmental Program Office to Weatherization Assistance Program Network, WAP Memorandum 017, Health and Safety Draft WPN Request for Comment (July 29, 2016), www.waptac.org.
[320] U.S. DOE, Weatherization Program Notice 11-6, Weatherization Health and Safety Guidance (Jan. 12, 2011), http://waptac.org/data/files/website_docs/government/guidance/2011/wpn%2011-6.pdf [hereinafter WPN 11-6].

the problems are resolved (by the owner, another agency, or using alternative funding).[321] In H&S Plans, states set forth guidelines for determining whether a potential health and safety issue may: be remedied as part of weatherization; be referred to other agencies (e.g., health department); result in "partial weatherization"; or result in deferral.[322]

While federal WAP policies and guidance materials establish parameters within which states must design and implement their programs, states have considerable flexibility to design their H&S Plans, procedures, and other state policies in ways that will maximize the IAQ and health benefits of WAP in their service territories. Following are examples of how some state programs are taking the opportunity to strengthen IAQ considerations in their program policies.

Required Health and Safety Measures in WAP Home Weatherization Projects

Pursuant to Department of Energy guidance, home weatherization projects funded by WAP *must* include the following health and safety measures:

- Evaluation for compliance with ASHRAE 62.2;
- Measures to meet the most current edition of ASHRAE 62.2 to the fullest extent possible (including updating existing fans and blower systems if not adequate) and follow-up testing to ensure compliance;
- Proper venting to the outside for combustion appliances, including gas dryers;
- Removal of pollutants (e.g., formaldehyde, VOCs) that pose a risk to workers;
- Compliance with EPA's Lead; Renovation, Repair and Painting Program (RRP) and training of all weatherization crews working in pre-1978 housing in Lead Safe Weatherization (LSW);
- Visual assessment of mold and moisture conditions (diagnostics such as moisture meters are recommended pre-project and prior to final inspection, though mold testing is not an allowable cost);
- Covering exposed dirt with a vapor barrier, whenever site conditions permit;
- Taking precautions wherever radon may be present "to reduce the likeliness of making radon issues worse";
- Removal of unvented space heaters (except certain secondary heat units) prior to weatherization;
- Following EPA recommendations when working with spray polyurethane foam.

Sources: U.S. Dept. of Energy, Weatherization Program Notice 11-6: Weatherization Health and Safety Guidance (Jan. 12, 2011), http://bit.ly/2htozlP.

[321] The auditor may use judgment in making this determination, and the Guidance Table also specifies certain situations where deferral of a weatherization project is required, including: pollutants pose a risk to workers and removal cannot be performed or is not allowed by the client; the extent and condition of lead-based paint in the house would potentially create further health and safety hazards; and severe mold and moisture issues exist and cannot be addressed as health and safety costs. *Id.*
[322] WPN 11-6, *supra*, at 10.

WAP Budgeting to Maximize IAQ Benefits. When states develop their WAP budgets, they make several important choices about use of program funds for health and safety measures. States can include key budgeting provisions in their annual plans or establish budgeting requirements in their laws and regulations, to maximize IAQ and health benefits for WAP clients in their service territories.

Amount of Health and Safety Allocation. In advance of receiving appropriated funds from DOE each year, states establish their spending caps for health and safety in their H&S Plans. Because federal policies and guidance do not mandate the cap, there is significant variation across states; many states also change the caps from year to year. States can ensure transparency by including the rationale for their spending cap in the annual plan.

DOE guidance recommends that states express the H&S spending cap as a percentage of total average cost per dwelling unit.[323] While some states allocate 10 percent or less of their total program funds to Health and Safety expenditures, other states allocate 20 percent or more. New Mexico, for example, allocated 22 percent to Health and Safety in 2016.[324] In Iowa, where actual health and safety expenditures (including supplemental, non-DOE funds) reached nearly 40 percent in recent years, the allowable per-unit average for the 2016 program year was 25 percent.[325] In Texas, the cap for expenditures in the health and safety category is fixed by regulation at 20 percent.[326] By establishing a minimum H&S percentage through law or regulation, state policymakers can help ensure that health and safety remains a program priority.

States can address IAQ goals in their policies implementing the Weatherization Assistance Program.

States can clarify in the H&S Plan whether the average cost limit for health and safety must be applied to each unit individually, or whether WAP sub-grantees may distribute the funds across dwellings more flexibly. The Maine plan, for example, explains that sub-grantees are allowed to spend up to 11.6 percent of their program funds on health and safety measures, which is equivalent to $800 dollars per unit; however, because sub-grantees need only manage to the $800-dollar average over the life of the grant, WAP providers maintain the "flexibility to shift funds from homes that need little or no hazard abatement or have benefited from other leveraged monies to homes that have no other resources."[327] Other states allow sub-grantees to manage their health and safety funds over the life of the grant, but also establish a firm per-unit maximum in the H&S Plan. Some states' H&S Plans also specify how much may be spent on specific measures.

[323] *See* WPN 11-6, *supra*.
[324] New Mexico H&S Plan 2016-2017 at 3, http://www.housingnm.org/assets/content/CommunityDev/EnergySmart/Health_and_Safety_Plan.pdf.
[325] Iowa H&S Plan 2016 at 1, https://humanrights.iowa.gov/sites/default/files/media/5_Wx_H%26S_Plan_0.pdf.
[326] 10 Tx. Admin. Code 5.528.
[327] Maine Annual Plan 2015 at V.7, http://www.mainehousing.org/docs/default-source/Public-Notices/doe-15-state-plan---combined-version.pdf?sfvrsn=0.

Addressing Cost-Effectiveness Constraints. In general, WAP service providers may only implement weatherization measures that the home energy auditor calculates will be cost-effective for a household.[328] Such a requirement could impede inclusion of certain health and safety measures that do not themselves generate energy savings. However, DOE provides the option to either include H&S expenditures in the overall program operations budget, or create a separate budget category to track those expenditures.[329] When health and safety measures are assigned to a separate budget category, they are not required to be cost-justified by the audit.[330] Moreover, health and safety expenses falling within a separate budget category can be excluded from the overall average per-unit cost calculation.

As with the spending cap, states must indicate in their annual H&S Plans whether they are exercising the option to create a separate budget category for health and safety. Most states do exercise this option, and some provide additional instructions in their H&S plans for how measures should be categorized. Maine's H&S Plan explains, "Health and Safety measures not producing an energy savings factor will be reported on a separate line item on the DOE Weatherization Reporting Form. Any Health and Safety measures that have an energy savings factor do not have to be tracked separately and should be included with the energy conservation measures."[331]

Leveraging Other Funds to Augment WAP Funding. Although federal law limits WAP expenditures to an average cost per dwelling unit of $6,500 (adjusted for inflation), states and their sub-grantees are free to augment WAP funding with other funding sources.[332] In fact, federal WAP regulations require states' annual plans to identify other federal and non-federal resources to be applied to the program, and to describe how federal funds will be used to.[333]

States can use their annual H&S Plans to encourage sub-grantees to leverage other funding where possible, and to identify some of the potential funding sources that sub-grantees should consider. Maine's state plan encourages sub-grantees to consider seeking funding for non-cost effective measures from a wide range of public and private sources listed in the plan.[334] State laws can also be a mechanism

[328] U.S. DOE, WPN 13-5, Revised Energy Audit Procedures (2013), at 3 ("Except for the cost of materials needed to eliminate health and safety hazards existing before or because of the installation of weatherization materials, all weatherization measures must be "cost effective" as defined by DOE. 'Cost effective' means that each measure and package of measures installed in a dwelling unit must have a savings-to-investment ratio (SIR) which meets or exceeds 1.0."), http://www.waptac.org/data/files/Website_docs/Government/Guidance/2013/WPN-13-5-Revised-Energy-Audit-Procedures-Final.pdf.

[329] *See* WPN-11, *supra*.

[330] WPN 11-6, *supra*, at 2 ("Grantees should carefully consider the approach…taken when they draft…health and safety procedures. While ease of accounting is an important consideration, Grantees should keep in mind that activities assigned to the health and safety budget category do not have to be cost justified by the energy audit. The same items assigned to incidental repair, weatherization materials, or installation cost categories must be cost-justified.").

[331] Maine Annual Plan, *supra*, at V.7.

[332] 42 U.S.C. §6865. For program year 2016, the average expenditure limit was $7,105. *See* U.S. DOE, WPN 16-1, Program Year 2016 Weatherization Grant Guidance at 4 (Dec. 31, 2015), http://www.waptac.org/data/files/Website_docs/Government/Guidance/2016/WPN-16-1.pdf.

[333] 10 C.F.R. 440.14.

[334] The state plan encourages consideration of Maine Housing's Lead Hazard Control Program and Home Rehabilitation Program; the Central Heating Improvement Program; Community Development Block Grants; the USDA Rural Economic Development program; HUD programs; city or town assistance; local church and community groups; the Building Materials Bank; Habitat for Humanity; donations from local businesses; and landlords. Maine Annual Plan, *supra*, at V.7.

for facilitating the use of leveraged funds to address health and safety in weatherization activities. In Vermont, state law requires the State Office of Economic Opportunity to "supplement, or supplant, any federal program with a State Home Weatherization Assistance Program" to "provide an enhanced weatherization assistance amount exceeding the federal per unit limit allowing amounts up to an average of $8,000.00 per unit allocated on a cost-effective basis." The law further directs the agency to develop the state program in a way that provides "flexibility to accommodate special circumstances in which greater energy savings can be realized *or health and safety problems may be alleviated*."[335]

Washington State recently invested several million dollars in activities combining weatherization and health. As part of the legislature's weatherization appropriations for the 2015-2017 biennium, $4.1 million was reserved for a new Weatherization Plus Health initiative, $2.2 million was set aside for several projects to "test health partnerships to reduce asthma risks and save energy," and $2 million was dedicated to "basic measures to improve home health such as green cleaning kits, mold and moisture reduction, and dust mite covers."[336] The legislature also revised its home weatherization law to authorize grantees to propose utilizing program awards and matching funds to make healthy housing improvements to homes undergoing weatherization, noting that "there is emerging scientific evidence linking residents' health outcomes such as asthma, lead poisoning, and unintentional injuries to substandard housing."[337]

Washington State recently invested significant funding for activities that combine weatherization and health.

Prioritizing Health and Safety in WAP Eligibility Determinations. States make decisions in their weatherization policies, procedures, and plans about how eligible homes will be prioritized, given annual funding caps 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.[338] There also may be opportunities for states to incorporate health-based prioritization criteria. For example, Montana's weatherization assistance regulations provide that a home may be given a higher priority than is dictated by its energy usage if "there exists a weatherization related imminent threat to the health or safety of an eligible household."[339] Massachusetts' 2016 WAP plan, which establishes mandatory statewide prioritization criteria, also authorizes sub-grantees to set aside up to 25% of their annual production for weatherization of "hardship" households – defined to include those with "a condition that endangers the health and safety of the eligible low income household" – outside the normal ranking system.[340]

[335] Vt. Stat. 33 § 2502 (emphasis added).
[336] *See* Wa. Dep't of Commerce, Weatherization Plus Health, http://www.commerce.wa.gov/growing-the-economy/energy/weatherization-and-energy-efficiency/matchmaker/weatherization-plus-health-wxh/.
[337] Rev. Code Wa. §§ 70.164.010, 040. According to the law, "[I]t is the intent of the legislature that state funds be dedicated to weatherization and energy efficiency activities *as well as the moderate to significant repair and rehabilitation of residential structures that are required as a necessary antecedent to those activities."* Rev. Code Wa. § 70.164.010 (emphasis added).
[338] 10 C.F.R. 440.16.
[339] Mt. Admin. R. 37.71.601.
[340] Mass. Office of Housing and Economic Development, U.S. Department of Energy Weatherization Assistance Program (WAP) State Plan/Master File Worksheet at 8 (2016), http://www.mass.gov/hed/docs/dhcd/cd/wap/wapmasterfile.pdf.

Designating Eligible WAP Health and Safety Measures. While some of the health and safety items listed in *WPN 11-6* are required or categorically prohibited, many are listed in the federal guidance as "allowable." *WPN 11-6* explains that for each allowable item, states must determine whether to allow the measure in their service territory, indicating their decisions in the state H&S Plan each year. Some of the allowable health and safety measures that may relate to IAQ considerations are:

- Testing for asbestos, for lead hazards, and for radon in high radon potential areas;
- Correction of venting for combustion appliances, if testing indicates problem;
- Removal of pollutants (e.g., formaldehyde, VOCs);
- Maintenance, repair, and replacement of primary indoor heating units, if occupant health/safety is a concern;
- Limited water damage repairs that can be addressed by weatherization workers and correction of moisture- and mold-creating conditions, when necessary to weatherize the home and ensure the long-term stability and durability of the measures; and
- Testing of carbon monoxide levels and installation of carbon monoxide alarms.

In general, state annual plans indicate which allowable health and safety measures may be addressed with program funding. Many states include most of the allowable measures, though there is some variation, particularly in issue areas such as asbestos testing/encapsulation and radon testing.

Addressing Individual IAQ Pollutants in WAP Projects. Unintended adverse impacts of weatherization activities include disturbing existing pollutants, introducing new pollutants, and diminishing air quality as a result of changes to the building envelope and systems. Following are examples of how states have used their WAP plans, manuals, and policies to incorporate best practices for addressing several specific IAQ issues that may arise in home weatherization projects: lead-based paint; asbestos; polychlorinated biphenyls (PCBs); radon; moisture and mold; ventilation; and combustion safety.

Asbestos. Weatherization projects have the potential to disturb asbestos fibers that may be present in insulation, siding, ceilings, piping, and other building components, creating a risk of exposure. Weatherization projects in multifamily housing with five or more units may be subject to EPA's National Emission Standard for Hazardous Air Pollutants (NESHAP) regulation for asbestos, if the amount of asbestos-containing material to be disturbed is at or above the federal regulatory threshold.[341] The asbestos NESHAP includes inspection, notice, and work practice requirements that apply during demolition and renovation activities in covered buildings.[342]

According to *WPN 11-6*, there are two asbestos actions that state H&S Plans *must* include for all projects: assess whether vermiculite insulation is present, and inspect the exterior wall surface for asbestos siding prior to cutting or drilling to install or replace insulation. States determine in their H&S Plans what happens after asbestos has been identified in a dwelling unit, including whether and to what extent weatherization work can proceed at the unit. At least a few states have determined that

[341] The threshold is 160 linear feet, 260 square feet, or 35 cubic feet. 40 C.F.R. 61.145(a).
[342] *See generally* U.S. EPA, Asbestos NESHAP, https://www.epa.gov/asbestos/asbestos-neshap.

weatherization work must be deferred entirely if there is any asbestos present in the home. Another approach is to prohibit the implementation of any weatherization measures that would disturb the area where asbestos is located (e.g., attic, siding), but allow "partial weatherization" to proceed in other areas of the home.

Most states have specified that certain "allowable" asbestos remediation or removal activities may be implemented as part of energy-saving weatherization measures. *WPN 11-6* and the Standard Work Specifications include several basic recommendations for how these measures should be implemented to help prevent adverse exposures. States can provide additional protection for occupants and workers by affirming, specifying, or expanding on these federal recommendations to formalize best practices for asbestos safety in their H&S Plans.[343] Some states' H&S Plans require all asbestos-related work to be performed by a qualified asbestos control professional, including removal of asbestos siding.[344] Other states have set limits on the amount of Asbestos Containing Materials (ACM) that may be addressed by WAP crews, beyond which an asbestos professional must be hired to perform the work.[345] The H&S Plan can specify the type of training or professional credential required to perform encapsulation or removal work on small surfaces.[346]

Lead. Lead-based paint is an important consideration during weatherization projects in homes built before 1978.[347] Weatherization program funds may not be used for lead abatement or lead paint stabilization; however, if installing energy saving measures will disturb painted surfaces in a pre-1978 home, health and safety funds can be used to minimize potential lead hazards.

Lead-based paint is regulated at the federal level, and some of the requirements apply to home weatherization projects. EPA's Renovation, Repair and Painting Rule applies to anyone paid to perform renovation, repair, and painting projects that will disturb at least six square feet of interior paint in pre-1978 homes (unless the paint has been tested by an EPA-certified professional and found to be lead-

[343] For example, Oregon's Health & Safety Plan explicitly prohibits blower door testing, or at least negatively pressurized blower door testing, in homes where vermiculite attic insulation or other friable asbestos is present, to avoid drawing asbestos fibers into the living space. Oregon H&S Plan 2015-2016 at 83, https://www.oregon.gov/ohcs/CRD/SOS/docs/USDOE_Oregon_State_Plan_2015-2016_FINAL.pdf. The Texas H&S Plan requires lead-safe work (LSW) practices where asbestos siding exists and specifies practices that must be used if asbestos siding is temporarily removed. Texas H&S Plan 2015-2016 at 8, https://www.tdhca.state.tx.us/board/docs/books/150312-Item1d-Draft-2015-DOE-WAP-State-Plan-150309.pdf.

[344] *See, e.g.*, Delaware H&S Plan 2012-2013 at 5-7, http://www.waptac.org/data/files/website_docs/health_and_safety/delaware-wap-health-and-safety-plan-9-5-13.pdf.

[345] In Utah, for example, less than 3 ft^2 or 3 linear feet of asbestos is not regulated by the Utah Department of Environmental Quality (DEQ), and ACM below that threshold may be removed to facilitate HVAC system installation. Between that threshold and the NESHAP threshold, a weatherization agency can remove asbestos to facilitate HVAC system installation only if agency staff have obtained specified state asbestos certifications and have obtained specified insurance. Utah Weatherization Assistance Program Guidelines at E3 (2015), https://jobs.utah.gov/housing/wap/documents/Utah_Weatherization_Guidelines_6-1-2015.pdf.

[346] Delaware's H&S Plan requires any asbestos work, including removal and reinstallation of asbestos siding, be completed by a licensed asbestos abatement contractor (after competitive bidding). Delaware H&S Plan 2012-2013, *supra*, at 5-7.

[347] In 1978, the U.S. Consumer Product Safety Commission banned the sale of lead-based paint, with certain exceptions. *See* 16 CFR Part 1303.

free).[348] The RRP rule requires certification and training for those performing renovations, provision of an EPA pamphlet to owners/occupants, and compliance with specific work practice standards.[349] The RRP rule specifically applies to weatherization, among other types of renovation.[350]

DOE guidance requires all weatherization crews working on pre-1978 homes to be accompanied by an EPA Certified Renovator, and all crew members must be trained on Lead-Safe Weatherization work practices (LSW) established in *WPN 02-6* and refined through subsequent DOE guidance.[351] Unlike the RRP rule, LSW does not exclude weatherization work that disturbs less than six square feet of painted surface.[352] Instead, LSW includes two different sets of standards: "Level 1 Containment" standards apply if up to six square feet of interior paint will be disturbed, while more stringent "Level 2 Containment" standards apply to areas six square feet or larger. Like the RRP rule, LSW does not affirmatively require lead testing, but its requirements apply by default unless paint is tested and found to be lead-free.

All WAP programs must comply with RRP and LSW protocols in pre-1978 homes. Some states have additional provisions in their H&S Plans to clarify or strengthen these requirements, such as: requiring weatherization crews and contractors to assess all pre-1978 homes *prior* to conducting an audit, to ensure that blower door and/or duct leakage testing is not performed in homes with flaking lead paint or noticeable amounts of potentially lead-contaminated dust;[353] including a comprehensive list of weatherization activities that require lead-safe practices, as a minimum guideline for weatherization agencies and contractors;[354] and identifying potential funding sources for lead abatement activities that may be necessary or advisable, but are not covered by WAP.[355]

PCBs. Polychlorinated biphenyls (PCBs) were used in certain building materials, including caulk, from the 1950s to the late 1970s. Building occupants may be exposed through inhalation of PCBs that have off-gassed from building materials, through ingestion of PCB-containing dust and residues, and

[348] The RRP Rule is codified in the Code of Federal Regulations at 40 C.F.R. 745, Part E. Window replacement work is subject to RRP requirements, regardless of square footage to be disturbed. *See* 40 C.F.R. 745.83. *See generally* U.S. EPA, Lead Renovation, Repair, and Repainting Program Rules, https://www.epa.gov/lead/lead-renovation-repair-and-painting-program-rules.
[349] *See* 40 C.F.R. 745.84, 745.90, 745.85. Federal law allows states, tribes, and territories to request EPA approval to administer and enforce the federal lead-based paint requirements; 15 states had received federal approval to administer their own RRP programs as of 2014. *See* U.S. EPA, Renovation, Repair and Painting Program: Contractors, http://www2.epa.gov/lead/renovation-repair-and-painting-program-contractors.
[350] *See* 40 C.F.R. 745.83.
[351] *See* U.S. DOE, WPN 11-1, Program Year 2011 Weatherization Grant Guidance at 23-24 (2010), http://www.waptac.org/data/files/website_docs/government/guidance/2011/wpn11-1%20final%20grant%20guidance.pdf.
[352] *See* U.S. DOE, WPN 02-6, Weatherization Activities and Federal Lead-Based Paint Regulations (July 12, 2002), http://www.waptac.org/data/files/technical_tools/wpn02-6.pdf. WPN 02-6 required LSW when the amount of disturbed lead-based surface exceeds two square feet per room or 10% of a small component (e.g., window), of if the amount of lead dust to be generated would exceed OSHA emission limits for airborne lead. Current guidance on the WAPTAC website explains that because "OSHA does not recognize 'de minimus' levels, and since there can be confusion on the taking and calculation of measurements, which could be an issue in a lawsuit situation, it is recommended that agencies follow LSW practices any time paint and dust are disturbed in pre-1978 homes." WAPTAC, FAQs – Lead Safe Weatherization, http://www.waptac.org/Additional-Pages/FAQ-Lead-Safe-Weatherization.aspx.
[353] *See, e.g.*, Texas H&S Plan, *supra*, at 32.
[354] *See, e.g.,* Texas H&S Plan, *supra*, at 33; Colorado H&S Plan 2013-2014 at 30, http://www.waptac.org/Best-Practices.aspx.
[355] *See, e.g.*, Oregon H&S Plan, *supra*, at 118.

through touching PCB-contaminated materials.[356] EPA regulations under the Toxic Substances Control Act do not include affirmative requirements to test for PCBs in existing building materials, though the regulations prohibit use (including continued use) of building materials containing at least 50 ppm PCBs and establish requirements for disposal of such materials.[357]

In July 2015, EPA released updated guidance documents on PCBs in schools and other buildings. The guidance explains federal legal requirements and provides recommendations and best practices for addressing PCBs in building materials, including caulk and fluorescent light ballasts. The agency has developed suggested work practices for building owners and contractors conducting renovation and repair projects in older buildings, including: "employing protective measures during a renovation; leaving the work area clean and safe for building occupants after completing the job; and properly disposing of waste materials."[358] In EPA's *Indoor Air Quality Guidelines for Multifamily Building Upgrades*, PCBs are identified as a priority issue. The guide recommends that prior to renovation work, contractors should assess whether caulk will be disturbed, considering the age of the building; if "PCBs are potentially present in caulk and the caulk will be disturbed during the building upgrades (e.g., window or door replacement, improved weatherization sealing)," renovation contractors should "take steps to minimize exposure."[359]

PCBs are not among the specific contaminants addressed by *WPN 11-6*, and most existing state H&S Plans and policies are silent on PCBs in caulk and other building materials. However, the federal guidance does not prohibit or restrict use of DOE funds to address PCBs in caulk. In addressing "formaldehyde, VOCs, and other air pollutants," *WPN 11-6* provides that removal of air pollutants is allowed, and is indeed required if the pollutants pose a risk to workers.

Dampness and Mold. The key element in preventing or addressing an indoor dampness or mold contamination problem is correcting the underlying source of moisture. Defects involving the building envelope, such as leaks and condensation, are common sources of moisture problems. *WPN 11-6* requires a visual assessment of moisture problems prior to weatherization and recommends additional diagnostic tools, such as moisture meters. Mold testing, which public health officials generally do not consider necessary or useful in order to undertake mold remediation, may not be performed with weatherization funds. State H&S plans can affirm and clarify the requirement that all dwelling units be inspected for moisture problems prior to weatherization activities and can specify methods for detecting mold and moisture issues. Several states, including Texas, set forth a detailed Mold and Moisture

[356] U.S. EPA, PCBs in Building Materials – Questions and Answers at 4 (2015), https://www.epa.gov/pcbs/questions-and-answers-about-polychlorinated-biphenyls-pcbs-building-materials. *See also* ATSDR, ToxFAQsTM for Polychlorinated Biphenyls (PCBs) (2014), http://www.atsdr.cdc.gov/toxfaqs/tf.asp?id=140&tid=26.
[357] See 40 C.F.R. 761.20, 761.50 et seq., 761.202 et seq. Materials containing PCB at concentrations below 50 ppm are not regulated by EPA, and more stringent requirements are triggered under the regulations when PCB concentrations exceed 500 ppm. *See* Disposal of Polychlorinated Biphenyls (PCBs), 63 Fed. Reg. 35384, 35387 (Jun. 29, 1998).
[358] U.S. EPA, Practical Actions for Reducing Exposure to PCBs in Schools and Other Buildings: Guidance for school administrators and other building owners and managers (2015), https://www.epa.gov/sites/production/files/2016-03/documents/practical_actions_for_reducing_exposure_to_pcbs_in_schools_and_other_buildings.pdf.
[359] U.S. EPA, Energy Savings Plus Health: Indoor Air Quality Guidelines for Multifamily Building Upgrades, *supra*, at 24.

Checklist in their Plans, which must be followed by all weatherization crews and contractors when conducting the mandatory moisture assessment.[360]

Mold abatement may not be performed with DOE weatherization funds. However, *WPN 11-6* provides that "limited water damage repairs" can be addressed by weatherization workers, and that "correction of moisture and mold creating conditions are allowed when necessary in order to weatherize the home and ensure the long-term stability and durability of the weatherization measures." States can encourage weatherization crews and contractors to address a wider range of moisture issues by defining "limited" repairs broadly in their H&S Plans. Some states establish a maximum area of existing mold and moisture issues that can be addressed by weatherization workers (and beyond which weatherization must be deferred). For example, Ohio uses a 10-square-foot limit, while Arizona authorizes corrective action up to 16 square feet.[361] Texas regulations establish a detailed procedure for when limited repairs should be used to address "mold-like substances," authorizing weatherization projects to proceed without deferral – and use WAP funds to correct the condition – as long as the mold-like substance covers less than 25 contiguous square feet.[362]

Combustion Safety and Carbon Monoxide Abatement. If the vent system for an appliance is not properly installed and maintained, combustion byproducts such as carbon monoxide (CO), nitrogen dioxide, particulate, and water vapor can leak into the building envelope. If vents become blocked, or if there is insufficient makeup air to replace the air used for combustion, exhaust may be forced back into the living space. Combustion byproducts can pose serious health risks when they accumulate indoors. For example, exposure to carbon monoxide can affect memory and cognition, and at very high levels can cause loss of consciousness and death. Nitrogen dioxide and particulates have adverse impacts on respiratory health over time.[363]

Before weatherization work may begin, *WPN 11-6* requires auditors to inspect vent systems and perform combustion safety testing, including ambient CO monitoring.[364] If inspections or testing reveal a problem, limited corrective measures may be implemented with H&S funds, including: correction of venting; repair and cleaning of combustion appliances; replacement of red-tagged heating equipment; and replacement of water heaters. *WPN 11-6* also allows WAP providers to install CO alarms in homes with combustion appliances.

[360] Texas H&S Plan 2015-2016 at 36, https://www.tdhca.state.tx.us/board/docs/books/150312-Item1d-Draft-2015-DOE-WAP-State-Plan-150309.pdf.
[361] Arizona H&S Plan 2016 at 14, https://housing.az.gov/weatherization-health-and-safety-plan; Ohio H&S Plan 2016 at 15, https://development.ohio.gov/files/is/PY2016%20HWAP%20State%20Plan%20Composite%20File.pdf.
[362] 10 Tx. Admin. Code 5.523; Ohio H&S Plan 2016 at 15, https://development.ohio.gov/files/is/PY2016%20HWAP%20State%20Plan%20Composite%20File.pdf; Arizona H&S Plan 2016 at 14, https://housing.az.gov/weatherization-health-and-safety-plan.
[363] *See* U.S. EPA, Sources of Combustion Products: An Introduction to Indoor Air Quality, https://www.epa.gov/indoor-air-quality-iaq/sources-combustion-products-introduction-indoor-air-quality; WAPTAC, Technical Tools: Combustion Appliances and Gases, http://www.waptac.org/Health-and-Safety-Issues/Combustion-Appliances-and-Gases.aspx; CDC, Morbidity and Mortality Weekly Report (Oct. 20, 1995), https://www.cdc.gov/mmwr/preview/mmwrhtml/00039315.htm.
[364] *See* U.S. DOE, Standard Work Specifications, *supra*, at 2.0100.1e; WAPTAC, Combustion Appliances and Gases, http://www.waptac.org/Health-and-Safety-Issues/Combustion-Appliances-and-Gases.aspx.

Most state plans require WAP crews to install CO alarms in homes with combustion appliances where no operable alarm is present, and some go further by including specific installation standards.[365] Many states require that CO alarms be certified by Underwriters' Laboratory (UL); Kentucky's H&S Plan goes further, specifying that CO alarms must be UL listed and "have the capability to accurately detect and display low levels of carbon monoxide to 10 ppm."[366] A few states specify in their H&S Plans the level(s) of CO that require corrective action before weatherization may proceed.[367] States may find additional opportunities to specify best practices for addressing CO in their technical operations manuals. In New York, the H&S Plan and the WAP Policies and Procedures Manual require daily evaluations of CO sources, combustion appliance zone (CAZ) air pressure, and chimney draft.[368]

Apart from policies governing WAP activities, many states have enacted laws that require existing homes to have carbon monoxide alarms. (See Text Box.)

Radon. Radon gas can move from the ground into the air inside a building through cracks and other holes in the foundation or basement walls, and indoor exposure to radon is the second leading cause of lung cancer in the United States.[369] The only way to know the radon level in a particular building is to test the building for radon. EPA has established a radon "action level" of 4.0 picoCuries per liter of air (pCi/L); however, because there is no known safe level of exposure to radon, EPA also recommends that people consider fixing their home when radon levels are between 2.0 pCi/L and 4.0 pCi/L.[370]

EPA's *Healthy Indoor Environment Protocols for Home Energy Upgrades* guidance recommends that radon testing be performed by trained or certified professionals, and that precautionary foundation air sealing strategies should be implemented when pre-work radon levels are 2 pCi/L or higher. These strategies, recommended as "Minimum Actions," include: cover exposed dirt floors in basements and crawlspaces; air seal sumps; install airtight drain fittings in foundation floor drains; and seal/caulk openings or cracks in below-grade walls and floors that contact the ground. The EPA Protocols also

[365] New Hampshire is an example of a state where CO alarms also are required in dwellings with an attached garage. New Hampshire State Plan 2013 at 12, https://www.nh.gov/oep/news-events/2013/documents/wap-health-safety.pdf. Utah is one of several states specifying that CO alarms be installed on all levels and in the immediate vicinity of each sleeping area. *See* Utah Weatherization Assistance Program Guidelines, *supra*, at 130.

[366] Kentucky State Plan 2015 at 22, http://www.kyhousing.org/Development/Single-Family/Documents/DRAFT%20PY%202015%20Master%20File.pdf. The Kentucky plan also includes specific occupant education measures, requiring WAP agencies to provide occupants with verbal and written information on dangers of CO, how to read the CO alarm, how to respond to CO levels above 10 ppm, and how to change the batteries.

[367] In Maine, for example, homes with CO levels above 50 ppm in the flue of combustion appliances cannot be weatherized until the system has been evaluated by a licensed technician; cooking burners and ovens producing greater than 15 ppm must be cleaned or serviced; and homes with ambient CO levels above 9 ppm cannot be weatherized until the source of CO is mitigated. By comparison, the SWS for carbon monoxide require action when ambient levels exceed 35 ppm. Maine Annual Plan, *supra*, at V.7.

[368] New York also incorporates by reference best practices from the Building Performance Institute, with respect to combustion safety testing procedures, depressurization limits, and action levels. NYS Weatherization Assistance Program Policy and Procedure Manual at 151 (2015), http://www.nyshcr.org/publications/weatherizationmanual/wap_manual.pdf.

[369] U.S. EPA, Radon Health Risks, http://www.epa.gov/radon/healthrisks.html. Among non-smokers, indoor radon exposure is the leading cause of lung cancer.

[370] U.S. EPA, Why is Radon the Public Health Risk that it is?, http://epa.gov/radon/aboutus.html; U.S. EPA, Radon Publications and Resources, http://www.epa.gov/radon/pubs/index.html.

recommend educating the client about test results and the radon reduction measures that were followed to ensure that energy upgrade work would not introduce new radon problems.[371]

While DOE guidance does not allow WAP funds to be used for radon mitigation, radon testing is allowed (not required) in areas of the country with high radon potential. *WPN 11-6* includes required and allowed measures to help ensure that weatherization does not create or exacerbate existing radon issues. The guidance requires states to include as an H&S measure that "[w]henever site conditions permit, exposed dirt must be covered with a vapor barrier," and provides that "where radon may be present, precautions should be taken to reduce the likeliness of making radon issues worse."[372] States can specify the types of "precautions" that should be taken in addition to the vapor barrier, including strategies recommended in the EPA Protocols. The Delaware H&S Plan, for example, explains that precautionary measures include sealing sump pump cracks, air sealing between crawl and conditioned space, and air balancing strategies.[373] Additionally, states can recommend or require that WAP providers refer clients with existing radon problems in need of mitigation to other programs. Delaware's H&S Plan states that in addition to giving clients EPA's consumer's guide to radon, clients may also be referred to the Delaware Healthy Homes program.

Ventilation is one of the most significant IAQ considerations during a home energy efficiency upgrade.

Ventilation. In addition to control of individual pollutants, ventilation is one of the most important IAQ considerations when a home is weatherized. As noted earlier, tighter homes may not provide sufficient air exchange to dilute indoor pollutants to acceptable levels, and lower ventilation rates may have negative effects on pressurization and moisture.[374] The minimum ventilation standard for homes weatherized using WAP funds is set forth in *WPN 11-6*: "ASHRAE 62.2 is required to be met to the fullest extent possible, when performing weatherization activity," except that ASHRAE 62.2 need not be implemented "where acceptable air quality already exists as defined by ASHRAE 62.2."[375] The Guidance Table setting forth required and allowable actions also provides that existing fans and blower systems should be updated if they are not adequate.

The core requirements of ASHRAE 62.2 relate to (1) whole-house ventilation rate; and (2) local ventilation of kitchens and bathrooms. As DOE guidance explains, mechanical ventilation typically is

[371] *See* U.S. EPA, Home Energy Upgrade Protocols, *supra*, at 12-13.
[372] WPN 11-6, *supra*, at 8.
[373] Delaware H&S Plan, *supra*, at 13.
[374] *See* Institute of Medicine, Climate Change, the Indoor Environment, and Health, *supra*, at 226; 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. DOE, Energy Saver: Ventilation, http://energy.gov/energysaver/ventilation.
[375] The Guidance Table in WPN 11-6 requires compliance with ASHRAE 62.2-2010 or the latest version of ASHRAE 62.2. ASHRAE 62.2 is updated every three years, though addenda are typically added in between "full" versions. According to WAPTAC, after a new full standard is published, state programs are not required to adopt it until it has been incorporated in the state's H&S Plan, which typically takes a full program year. WAPTAC, ASHRAE 62.2 Facts, http://waptac.org/Additional-Pages/FAQ-ASHRAE-62002E2.aspx

needed to achieve the required rate in a tight home.[376] All states are required to include ASHRAE 62.2 compliance in their H&S Plans. However, ASHRAE 62.2 is the minimum standard, and states may incorporate additional ventilation requirements based on local conditions and priorities.[377] The New Jersey H&S Plan includes an express authorization to this effect: "ASHRAE 62.2 is a minimum standard and additional ventilation may be necessary and is allowed to address higher concentrations of humidity or pollutants."[378]

States may also have opportunities to guide their sub-grantees in selecting the most appropriate *type* of ventilation system for a home. WAP guidance does not specify among the types of systems allowed under ASHRAE 62.2. Most of the mechanical ventilation systems installed by the weatherization program in heating climates are exhaust-only systems, which have a lower cost.[379] However, DOE's Oak Ridge National Laboratory has concluded that "this type of ventilation is generally considered to be inappropriate in hot-humid climates, where the potential for mold growth from pulling moist air through building cavities is high, and balanced or supply-only ventilation is the preferred approach."[380] EPA's *Healthy Indoor Environment Protocols for Home Energy Upgrades* include installation of a "balanced, whole-house ventilation system (e.g., heat recovery ventilator [HRV])" as an Expanded Action to address whole-house ventilation.[381]

States can consider including provisions in their WAP plans, policies, and guidance that facilitate the use of a ventilation system that will best protect IAQ in the weatherized home.[382] The Wisconsin Weatherization Field Guide, for example, provides, "Ventilation systems must be matched to the home. A home may require only simple exhaust fans in bathroom and/or kitchen. Very tight homes may require a balanced central ventilation system."[383] States also have an opportunity to clarify how the exception provided in *WPN 11-6*, for dwellings "where acceptable air quality already exists as defined by ASHRAE 62.2," should be applied. States can include in their H&S Plan factors for assessing whether air quality is acceptable – e.g., location in a radon Zone 1 or Zone 2 area, presence of indoor pets or smokers, suspected mold problem, gas range without operable range hood.[384]

[376] U.S. DOE, Energy Saver: Ventilation, http://energy.gov/energysaver/ventilation.
[377] *See* WAPTAC, ASHRAE 62.2 Facts, http://waptac.org/Additional-Pages/FAQ-ASHRAE-62002E2.aspx**.**
[378] New Jersey H&S Plan 2012 at 22, http://www.state.nj.us/dca/divisions/dhcr/offices/docs/wap/wap_nj_health_sfty_plan.pdf.
[379] Oak Ridge Nat'l. Laboratory, National Weatherization Assistance Program Impact Evaluation (2014), http://weatherization.ornl.gov/Retrospectivepdfs/ORNL_TM-2014_367.pdf.
[380] *Id.*
[381] U.S. EPA, Home Energy Upgrade Protocols, *supra*, at 22.
[382] A 2010 report prepared for the U.S. EPA noted that "adapting to continuous [climate] change may require new institutional, more 'forward looking' framework, and a willingness to invest in increased envelope protection and greater adaptability of systems (e.g., balanced ventilation systems tend to be more adaptable, but also cost more)." David Mudarri, The Cadmus Group, Public Health Consequences and Cost of Climate Change Impacts on Indoor Environments, https://www.epa.gov/sites/production/files/2014-08/documents/mudarri.pdf.
[383] Wisconsin Weatherization Field Guide 5-19 (2016), http://homeenergyplus.wi.gov/docview.asp?docid=27554. *See also*, Saturn Resource Mgmt., Northeast Weatherization Field Guide ("The best home-ventilation strategy for very airtight [dwellings] is balanced ventilation using a ventilator powered by one or two fans….The less expensive mixing-box type ventilator (no heat recovery) is the best choice to complement low-income weatherization."), https://www.mainehousing.org/docs/default-source/energy/energy-ne-wxstds.pdf?sfvrsn=2.
[384] *See* WAPTAC, ASHRAE 62.2 Facts, (noting also that demonstrating acceptable IAQ involves "an objective assessment that holds up to questioning and must be approved as part of the State Plan review process"), http://waptac.org/Additional-Pages/FAQ-ASHRAE-62002E2.aspx.

State Requirements for Carbon Monoxide Alarms in Homes

Indoor carbon monoxide exposure is an important health and safety issue for home energy retrofits, and state energy efficiency programs can help prevent CO poisoning by checking that fuel-burning appliances are operating properly. Because symptoms of acute CO exposure mimic the flu and may culminate in loss of consciousness, energy efficiency programs may also include installation of a CO alarm to help ensure occupants are alerted to a problem in time to take action. Another important cause of CO poisoning is the improper use of portable generators inside or close to homes – e.g., during power outages in the aftermath of severe storms.

The past several years have seen a significant increase in the number of state laws and regulations requiring CO alarms in homes.

State Fire Codes. In many states, CO alarm requirements can be found in the statewide fire code. A few states have authored their own fire codes to include CO alarm requirements. A commonly adopted model fire code, the International Fire Code (IFC), requires CO alarms in existing "residential buildings" (Group R), starting with the 2012 edition. Nearly half of all states have adopted the 2012 or 2015 edition of the IFC, including the requirement for CO alarms in existing residential buildings. The IFC does not apply to one- and two-family detached dwellings; however, a small number of states have amended the model language to extend the CO alarm requirement to existing one- and two-family homes as well.

Some states base their fire codes on model standards issued by the National Fire Protection Association (NFPA). While *NFPA 1: Fire Code* and *NFPA 101: Life Safety Code* require CO alarms in new dwellings only, a few states have amended the provisions to require alarms in certain existing buildings*. NFPA 720: Standard for the Installation of Carbon Monoxide Detection and Warning Equipment* sets forth a standard for *how* to install, operate, and maintain CO alarms, including where alarms should be located and how often devices should be tested and inspected. The IFC and many of the other state laws and regulations requiring CO alarms specify that alarms must be installed and maintained in accordance with NFPA 720.

Other Areas of State Law. States have also adopted CO alarm requirements in other areas of law. For example, a small number of states have amended their landlord-tenant or public health laws to require CO alarms in covered rental dwellings. Several states have incorporated CO alarm requirements into their property laws, where the requirement is triggered upon change of occupancy of a home – e.g., by sale and/or lease transaction. Many states also require CO alarms to be installed in dwellings used for special purposes (e.g., child care, foster care), typically including the requirement in the licensing rules for those home care facilities.

Sources: ICC, International Fire Code 2015, http://codes.iccsafe.org/app/book/toc/2015/I-Codes/2015_IFC_HTML/index.html;
NFPA, NFPA 1: Fire Code (2015 ed.), http://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards?mode=code&code=1;
NFPA, NFPA 101: Life Safety Code (2015 ed.), http://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards?mode=code&code=101;
NFPA, NFPA 720: Standard for the Installation of Carbon Monoxide (CO) Detection and Warning Equipment (2015 ed.), http://www.nfpa.org/codes-and-standards/all-codes-and-standards/list-of-codes-and-standards?mode=code&code=720;
CDC, Carbon Monoxide Poisoning: Frequently Asked Questions, http://www.cdc.gov/co/faqs.htm.

Other Energy Efficiency Programs and Policies

In addition to the Weatherization Assistance Program, a wide variety of other funding programs and financing mechanisms help homeowners overcome financial barriers to implementing energy upgrades in existing homes. At the federal level, examples include residential energy efficiency tax credits and energy-efficient mortgage programs.[385] Additionally, a 2010 report noted that there are "over 600 government and utility energy audit, rebate, loan, and grant programs" at the state and local levels.[386] The laws and regulations governing these funding programs do not typically address the consideration of IAQ issues directly; however, states can build on the WAP laws, regulations, plans, and guidance discussed above in establishing policies to incorporate IAQ measures. Following are examples of policy provisions that can help facilitate the integration of IAQ goals in home energy upgrades that are funded in whole or part by a state, local government, or utility.

Regulatory Requirements for Specific IAQ Pollutants. Energy efficiency retrofit projects, including weatherization activities, must be carried out in accordance with applicable federal and state laws and regulations governing specific pollutants. As discussed above, a wide range of indoor pollutants may be affected by energy retrofit activities, including asbestos, lead paint, radon, and carbon monoxide. States can adopt laws and regulations of general applicability to address these and other indoor exposures in homes. They can also develop policy guidance on these issues for individual energy efficiency funding programs. While it is beyond the scope of this chapter to discuss state policies on all of these potential IAQ exposures, the text box below describes one policy strategy that has been widely adopted to reduce exposure to carbon monoxide in homes – an issue that is important not only in connection with energy efficiency retrofits, but also in relation to the use of portable generators following severe storms.

Designating IAQ Measures as Eligible Activities for Energy Funding Programs. By designing funding and financing programs to allow some portion of project funds to be used for health and safety measures, states can help ensure that energy efficiency measures will not create or exacerbate IAQ problems. In Oregon, for example, state policy establishing a low-interest loan program for residential energy conservation measures (available to homes using fuel oil or wood heating systems) defines "Energy Conservation Measures" as items that are primarily designed to improve the energy efficiency of a dwelling, including "[v]apor barrier material, exhaust fans and venting to provide spot ventilation in

[385] For example, the Residential Energy Efficiency Tax Credit allows owners of existing homes to claim a tax credit worth 10% of the cost of upgrading the efficiency of the building's envelope, up to $500. *See* U.S. DOE, *Residential Energy Efficiency Tax Credit*, http://www.energy.gov/savings/residential-energy-efficiency-tax-credit. The U.S. Department of Agriculture's Rural Economic Development Energy Efficiency initiative provides guaranteed loan financing and grant funding to rural homes for energy efficiency retrofits. *See* USDA, *Rural Energy for America Program Renewable Energy Systems & Energy Efficiency Improvement Loans and Grants*, https://www.rd.usda.gov/programs-services/rural-energy-america-program-renewable-energy-systems-energy-efficiency. Energy-efficient mortgage programs run by the Veterans' Administration are available to military personnel and veterans for energy improvements when purchasing an existing home, and the Federal Housing Administration enables homeowners to finance energy efficient improvements by making higher payments on their FHA insured mortgage, including up to $3,500 to pay for basic weatherization measures, such as thermostats and insulation. *See* Energy Star, Energy Efficient Mortgages, https://www.energystar.gov/newhomes/mortgage_lending_programs/energy_efficient_mortgages.

[386] *See, e.g.*, National Safe and Healthy Housing Coalition, Integrating Energy Efficiency and Healthy Housing at 1 (rev. 2010), http://www.nchh.org/Portals/0/Contents/Coalition_briefing_paper_energy.pdf.

kitchens, bathrooms, utility rooms, or other areas where as the result of installing recommended energy conservation measures moisture problems could be created or worsened."[387] The *EmPower New York* program, which is primarily intended to supplement WAP funding by providing low-income households with additional energy efficiency services, addresses energy-related health and safety measures, including checks of combustion appliances and installation of carbon monoxide alarms.[388]

Valuing Non-Energy Benefits in the Prioritization and Selection of State-funded Projects. States typically establish cost-effectiveness criteria for energy efficiency activities supported by state-funded programs and utility rate-payer funded programs. These criteria may pose a practical obstacle to including IAQ-related measures as part of the energy efficiency project, because such measures provide health and productivity benefits that are difficult to quantify.

States can facilitate the incorporation of IAQ goals in energy efficiency retrofits by reviewing and revising their laws, regulations, and program guidance to include mechanisms that account for IAQ benefits in determining eligible projects. One strategy implemented by a number of states is to establish an "adder," or flat percentage of the total project cost that may be counted as a benefit in the cost-effectiveness screening for a particular project, in order to account for non-energy benefits of the project.[389] Another approach is to apply cost-effectiveness criteria at the portfolio level, rather than applying those tests to programs or to individual measures.[390] States can also consider incorporating waivers into their cost-effectiveness requirements to allow programs to cover work in homes with significant IAQ-related issues that can be addressed as part of the larger funded project.[391]

Incorporating IAQ into Home Energy Audits. Many of the funding and financing programs that promote energy efficiency upgrades for existing buildings (including WAP) require a home energy audit as a first step. While the primary purpose of an energy audit is to evaluate a home's energy profile and identify potential energy efficiency improvements, it can also be an opportunity to describe existing IAQ problems and identify IAQ measures to be considered and addressed as part of the retrofit.

Industry standards for energy audits affirm the importance of including indoor environmental quality issues in the audit. For example, the Building Performance Institute, Inc. (BPI) has developed a home energy auditing standard that includes a section on health and safety designed to "ensure that home performance upgrade activities do not negatively affect indoor air quality or otherwise cause or

[387] Or. Admin. Code 330-060-0010.
[388] New York State Energy Research and Development Authority (NYSERDA), EmPower New York Program Guidelines and Procedures Manual (rev. 2011), http://on.ny.gov/2hHUVMI. *See also,* NYSERDA, EmPower New York, https://www.nyserda.ny.gov/All-Programs/Programs/EmPower-New-York.
[389] *See* I. Malmgren and L. Skumatz, Lessons from the Field: Practical Applications for Incorporating Non-Energy Benefits into Cost-Effectiveness Screening (2014), http://bit.ly/1O15PIb (reviewing programs in, e.g., Colorado (10 and 25% adders), Vermont (15% adder), and the District of Columbia (10% adder)). *See generally* Cal. Public Utilities Comm., Addressing Non-Energy Benefits in the Cost-Effectiveness Framework, http://www.cpuc.ca.gov/NR/rdonlyres/BA1A54CF-AA89-4B80-BD90-0A4D32D11238/0/AddressingNEBsFinal.pdf.
[390] *See generally* Energy Efficiency Screening Coalition, Recommendations for Reforming Energy Efficiency Cost-Effectiveness Screening in the United States at 21 (2013), http://bit.ly/2hHWr1A; The Cadmus Group, Picking a Standard: Implications of Differing TRC Requirements (2012), http://bit.ly/2dDaW6x.
[391] *Id.*

exacerbate an unsafe condition in the home."[392] BPI-certified auditors must identify health and safety hazards that may be caused or exacerbated by changes to the building envelope and systems, specify preventive measures to protect residents from known and potential hazards during work, and specify appropriate safe work practices in the scope of work.

States can establish home energy audit requirements that incorporate such industry standards, to help ensure that state-funded projects consider IAQ during the audit inspection and include relevant IAQ issues and recommendations in the audit report. Nevada's law governing the licensure of home energy auditors draws on the BPI standards in setting forth a number of IAQ-related items that all home energy audit evaluations must include, for example:

- A "health and safety test of the energy features of the entire home;"
- Documentation of "anticipated remediation issues, including, without limitation, moisture or combustion appliance problems;"
- An "assessment of the performance and efficiency of the building airflow and indoor air quality and ventilation, including, without limitation…[a]ny visible sources of indoor air pollution;" and
- An "assessment of the control of moisture in the home, including, without limitation…identification of any potential areas where mold may grow."[393]

The Nevada law also requires home energy auditors to prepare an audit report that includes a "prioritization of health and safety hazards in the home and recommendations for improvements according to their urgency and importance, in relation to any energy efficiency measures which have been installed."[394]

Summary

State programs that fund home energy retrofits can help reduce indoor pollutant exposures and improve indoor air quality, particularly in low-income households that may be more vulnerable to the health effects of substandard housing. In developing requirements and recommended best practices for home energy efficiency upgrades, state policymakers can build on the examples of the Weatherization Assistance Program and other state funding programs that integrate energy savings and health. Strategies that can help prevent degradation, and facilitate improvement, of indoor air quality during energy upgrades include:

- Requiring assessment of indoor air- and health-related conditions during home energy audits and after completion of retrofit projects;

[392] Building Performance Institute, ANSI/BPI-1100-T-2014 Home Energy Auditing Standard at 2 (2014), http://bpi.org/standards_approved.aspx. *See also* Residential Energy Services Network (RESNET), RESNET National Standard for Home Energy Audits (incorporating the "procedures adopted by the Building Performance Institute or the certified Building Analyst classification" into the RESNET Comprehensive Home Energy Audit), http://bit.ly/1IrDYQb.
[393] Nv. Rev. Stat. 645D.300.
[394] *Id.* at subd. 2(c).

- Allowing a portion of project funds to be used for health and safety measures to ensure that energy efficiency measures do not create or exacerbate IAQ problems;
- Allowing a portion of funds to be used to correct or improve existing IAQ problems;
- Structuring incentives and eligibility criteria to reflect a whole building approach to savings, and including non-energy (health) benefits in cost-effectiveness calculations;
- Providing for quality assurance measures (including assessments, work specifications, and training); and
- Providing residents with information about the links between energy efficiency, IAQ, and health.

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