
Strategies for Reducing Residential Wood Smoke

Course No: C03-051

Credit: 3 PDH

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INTRODUCTION

This document identifies strategies to help state, tribal, and local air officials reduce fine particle pollution (PM_{2.5}) that is attributed to residential wood smoke. For areas that are not meeting, or are close to exceeding the national ambient air quality standards for fine particles (PM_{2.5} NAAQS), developing a wood smoke reduction plan can help achieve meaningful emission reductions and improve public health in the local community. Developing and implementing a plan before exceedances occur will lower the likelihood of violations of the national standards, may limit the number of Clean Air Act requirements that apply in the future, or can be used to help an area comply with requirements that may apply in the future. To learn more about EPA's PM_{2.5} regulations, visit:

<http://epa.gov/airquality/particlepollution/actions.html>.



This document also provides education and outreach tools, information on regulatory approaches to reduce wood smoke, as well as information about voluntary programs that communities around the country have used to replace old, inefficient wood stoves, hydronic heaters, and fireplaces. It includes EPA federal actions to help communities address residential wood smoke throughout the United States (U.S.). In addition, this document includes possible approaches for funding replacement programs, methods for calculating emission reductions, and the basic components of a wood smoke reduction plan for fine particles in areas where wood smoke is of concern.

WHY IS RESIDENTIAL WOOD SMOKE A CONCERN?

Residential wood smoke contains PM_{2.5}, carbon monoxide (CO), toxic air pollutants (e.g., benzene and formaldehyde), and climate gases (e.g. methane and black carbon). According to EPA estimates,¹ wood stoves, hydronic heaters, and fireplaces emit more than 345,000 tons of PM_{2.5} into the air throughout the country each year – mostly during the winter months. Nationally, residential wood combustion accounts for 44 percent of total stationary and mobile polycyclic organic matter (POM) emissions, nearly 25 percent of all area source air toxic cancer risks and 15 percent of noncancer respiratory effects.

Residential wood smoke can increase particle pollution to levels that cause significant health concerns (e.g., asthma attacks, heart attacks, premature death). Wood smoke causes many counties throughout the U.S. to either exceed the national health-based standards for fine particles, or places them on the cusp of exceeding the standards. Because wood stoves, hydronic heaters, and other similar appliances can be used around the clock in residential areas, they can cause significant and varying health and quality of life issues.

GROWING DEMAND FOR CHEAPER RESIDENTIAL HOME HEATING

There is renewed interest in burning biomass (wood, corn, switch grass) to help save money on home heating bills, and reduce our dependence on foreign oil. The federal government and various states have provided economic incentives to increase the utilization of renewable energy. According to the U.S. Energy Information Administration (EIA), wood consumption in homes rose over a 10 year period (2000-2010), reversing a trend seen in the last two decades of the 20th century. In 2009, U.S. households consumed about 0.5 quadrillion Btu (quads) of wood. Household fuel oil consumption, by

¹ <http://www.epa.gov/ttnchie1/trends/>

comparison, was only slightly higher at 0.6 quads. In homes across the U.S., wood is most commonly used as a secondary source of heat and is second only to electricity as a supplemental heating fuel.

CHALLENGES AND BENEFITS

Unlike other air pollution sources, such as industrial factories and commercial operations that may be regulated by states and tribes, existing wood stoves, fireplaces, and hydronic heaters are usually owned and operated by homeowners. This makes increasing the efficiency and decreasing the emissions of these sources challenging. Today, we believe there are over 29 million fireplaces, 243,000 hydronic heaters, and 12 million wood stoves nationwide.

65 PERCENT (7.8 MILLION) OF THE NATION'S WOOD STOVES ARE OLDER, INEFFICIENT DEVICES

The health benefits associated with reducing PM_{2.5} emissions, including wood smoke, are significant. Studies indicate that PM_{2.5} poses a serious public health problem. Exposure to PM_{2.5} can cause premature death and harmful effects on the cardiovascular system (the heart, blood, and blood vessels). Particle pollution exposure is also linked to a variety of other public health problems, including respiratory diseases. People with diseases that affect the heart or lung (including asthma), older adults, children, and people living in lower socioeconomic conditions are at greatest risk from PM_{2.5} exposure. Research indicates that pregnant women, newborns, and people with certain health conditions, such as obesity or diabetes, may also be at increased risk. EPA estimates that if all of the old wood stoves in the U.S. were replaced with cleaner-burning hearth appliances, an estimated \$56-126 billion in health benefits per year would be realized. For more information, go to:

<http://www.epa.gov/airquality/benmap/sabpt.html>.

COMPONENTS OF A SUCCESSFUL PLAN

As a first step in developing a residential wood smoke reduction plan, EPA recommends that air quality personnel evaluate monitoring and emissions data (e.g., wintertime organic carbon) to determine the nature and magnitude of residential wood smoke contributions in your airshed. In addition, conducting a local survey can help estimate how much wood is burned and the percentages of homes with fireplaces, wood stoves, and/or hydronic heaters. These specific data will prove extremely useful in planning an overall wood smoke program.

Within this document, state, tribal and local air pollution control officials will find a comprehensive list of strategies and associated case studies to help identify appropriate wood smoke reduction measures for their communities. This includes:

- ❑ regulatory approaches to reduce wood smoke;
- ❑ voluntary programs to replace old wood stoves, hydronic heaters and fireplaces;
- ❑ education and outreach tools;
- ❑ air quality forecasting and public notification systems;
- ❑ funding approaches for wood-burning appliance replacement programs;
- ❑ federal actions to reduce residential wood smoke; and
- ❑ methods for calculating emission reductions.

EPA recommends a combination of regulatory, voluntary, and educational strategies to ensure a successful wood smoke program with measurable emission reductions. Even communities who do not have an air quality monitor but believe wood smoke is causing air quality problems can use the tools in this document.

I. REGULATORY PROGRAMS

A variety of regulatory options exist to address residential wood smoke. Each community should decide which measures are most appropriate given the nature and extent of their wood smoke problem. Communities should also gauge the knowledge and familiarity with air quality and wood smoke issues among elected leaders and the public. A public awareness program, along with a voluntary wood smoke curtailment program, may be a good first step. In communities where residential wood smoke continues to impact air quality despite active education and outreach efforts, local officials may choose to implement a regulatory program. There are several types. Mandatory curtailment programs prohibit the use of wood stoves and other devices under certain circumstances. Designing a curtailment program calls for the coordination of many factors, including provisions for homes that use wood burning as their only source of heat. Other types of regulatory programs include visible emission limits from chimneys, setback requirements, firewood moisture content requirements, and restrictions on the use and sale of non-EPA-certified wood stoves, all of which are discussed below.

A. WOOD-BURNING CURTAILMENT PROGRAMS

Cold weather often coincides with an increase in wood burning and air inversions which can lead to unhealthy levels of air pollution. One of the quickest and most effective ways an air quality agency can reduce wintertime wood smoke is by developing a mandatory curtailment program, often known as “burn bans.” Some communities implement both a voluntary and mandatory curtailment program, depending on the severity of their wood smoke problem. Curtailment programs often have two stages: Stage 1 allowing EPA-certified wood stoves to operate, and Stage 2 banning the use of all wood-burning appliances unless wood burning is the household’s only source of heat. Stage 2 bans could also exempt pellet appliances, as they typically tend to burn cleaner throughout their burn cycle and cannot be loaded with unseasoned wood, like wood stoves.

- Although curtailment programs are not always popular with the public, this measure can be highly effective at reducing wood smoke and has been successfully implemented in a number of communities. While there are certainly other strategies the Sacramento Air Quality Management District is implementing, the curtailment program alone has resulted in 40 percent fewer days above the NAAQS for PM_{2.5}.
- Sacramento enacted a mandatory, episodic wood-burning curtailment program. The first stage occurs when PM_{2.5} concentrations are forecast to exceed 31 ug/m³. The second stage of the curtailment program occurs when PM_{2.5} concentrations are forecast to exceed 35 ug/m³. In addition to mandatory curtailment, a voluntary curtailment begins at 25 ug/m³.
- During a Stage 1 no-burn day, burning is prohibited except in EPA-certified stoves or pellet stoves as long as they do not emit visible smoke. During a Stage 2 no-burn day, all wood-burning is prohibited. The rule does not apply to fireplaces and stoves that burn gaseous fuels. Also, the rule exempts burning that is the sole source of heat or in financial hardship situations.

- To ensure the success of your curtailment program, it is essential to have some enforcement capabilities and an air quality forecasting and public notification system in place. Forecasting air quality and having a notification system in place will help educate the public about air pollution in their community and facilitate efficient communication about actions the public are requested to take when a voluntary or regulatory burn ban is called. To learn more about air quality forecasting, go to the AirNow website at: www.AirNow.gov.
- Educating the public about the health benefits of reducing wood smoke in the community is critical to gaining support from the public and community leaders. The following links provide examples of existing curtailment programs:
 - Puget Sound Clean Air Agency website outlines a two-stage burn ban system and frequently asked questions like, “What is a burn ban,?” and “How can I find out when a burn ban is called?” For more information go to: www.pscleanair.org/airq/burnban/default.aspx. See also the Puget Sound Clean Air Agency wood smoke burn ban rule language: apps.leg.wa.gov/RCW/default.aspx?cite=70.94.473;
 - Sacramento Air Quality Management District implements a two-stage “Check Before You Burn” curtailment program from November to February. For more information, see: www.sparetheair.com/burncheck.cfm; and

Jackson County, Oregon, implements a Wood-Burning Advisory Program. This curtailment program designates days as green, yellow, or red depending on the amount of particle pollution in the air. For more information, see: www.co.jackson.or.us/page.asp?navid=2492.

B. OPACITY AND VISIBLE EMISSION LIMITS

“Opacity” measures how much your view is blocked by smoke. One hundred percent opacity means you are not able to see anything through the smoke. At 20 percent opacity, there is very little smoke and you can see almost perfectly through it. A well-controlled wood-burning appliance will have less than 20 percent opacity and typically no visible emissions.



To help control smoke from chimneys or flues, and to encourage cleaner burning techniques, some states and localities have laws or rules that require no “visible emissions” or that limit the opacity of emissions. Burning dry seasoned wood in newer technology wood-burning devices will typically limit visible emissions. Prohibiting “visible emissions” means no smoke should be seen coming out of a chimney for a given amount of time. If smoke is seen, it could be considered a violation.

VISIBLE EMISSION LIMITS ARE TYPICALLY EASIER TO IMPLEMENT AND ENFORCE THAN OPACITY LIMITS

Opacity limits are restrictions on the percentage of light that may be prevented from passing through the smoke plume and require personnel qualified as an opacity reader to determine compliance. See EPA Test Method 22 for details on determination of visible emissions: epa.gov/ttn/emc/methods/method22.html, and EPA Test Method 9: epa.gov/ttn/emc/methods/method9.html, for details on determination of opacity.

- Effectively implementing an opacity limit or visible emissions program requires public awareness and a trained enforcement staff. For more details about these control measures, see section 3.7 of EPA’s “Guidance Document for Residential Wood Smoke Combustion Emission Control Measures Document” available at: epa.gov/burnwise/pdfs/EPA-450-2-89-015.pdf.
- Opacity: Washington State has an opacity rule that applies to wood burning in private residences: apps.leg.wa.gov/WAC/default.aspx?cite=173-433-110. In particular, the rule requires that “a person shall not cause or allow emission of a smoke plume from any solid fuel burning device to exceed an average of 20 percent opacity for six consecutive minutes in any one hour period.” This program has been in effect for more than 10 years.

Visible Emissions: The Maricopa County Air Quality Department in Arizona has a wood smoke regulation that prohibits the presence of visible emissions during restricted burn periods. For specific language, see: maricopa.gov/aq/divisions/planning_analysis/rules/docs/P26-0803.pdf.

C. WOOD MOISTURE CONTENT

Wood that is not properly seasoned will burn less efficiently and release more harmful pollutants. To increase the likelihood that stove owners will burn seasoned wood, some air pollution control agencies have encouraged the use of wood moisture meters. Puget Sound Clean Air Agency in Washington sends wood moisture meters to community members. For more information go to: <http://www.pscleanair.org/2012chinook/>. Households may purchase a basic wood moisture meter at woodworking specialty shops or online for less than \$25. Some areas deem it illegal to sell, advertise or supply wood unless the wood moisture content is 20 percent or less. For more information on moisture meters and wet wood, see “Wet Wood is a Waste” Brochure at: <http://epa.gov/burnwise/burnwisekit.html>.



- Sacramento Air Quality Management District’s regulation requires that the wood moisture content may not exceed 20 percent. For more information, see: www.airquality.org/rules/rule417.pdf (sections 214, 303, and 501.2).

D. REMOVAL OF OLD WOOD STOVE UPON RESALE OF A HOME

Old wood stoves are usually made of metal, weigh 250 to 500 pounds, and last for decades. As a result, households are less likely to replace an old stove with newer, cleaner-burning technology or remove the old stove - especially if they are not using it often. To help get these old stoves “off-line,” some local communities require the removal and destruction of old wood stoves upon the resale of a home. This requirement has proven effective in locations like Mammoth Lakes, CA; Washoe County, NV; and the State of Oregon.

- Mammoth Lakes, California, requires that all non-EPA-certified wood-burning appliances (except pellet stoves) be removed or rendered inoperable upon the sale of a dwelling. Since 1990, approximately 2,500 wood stoves have been removed and 2,900 fireplaces have been retrofitted. See Town of Mammoth Lakes, California: Link to Rule 431-Particulate Matter, section E: www.gbuapcd.org/rulesandregulations/PDF/Reg4.pdf.
- Washoe County, Nevada: Link to Wood Stove/Fireplace Emissions Rule section 040.051: www.washoecounty.us/repository/files/4/prohibitedemissions2.23.06.pdf.
- Oregon's "Heat Smart" legislation requires the removal and destruction of old, uncertified wood stoves upon resale of a home anywhere in the state.
 - Legislation: http://arcweb.sos.state.or.us/pages/rules/oars_300/oar_340/340_262.html.
 - Notification and removal form: www.deq.state.or.us/aq/burning/docs/notificationForm.pdf.
 - Disposal receipt: www.deq.state.or.us/aq/burning/docs/heatSMART/disposalReceipt.pdf.

E. REQUIRE EPA CERTIFICATION

Certified wood stoves must adhere to regulatory emission requirements established by EPA. EPA is in the process of expanding its requirements to apply to other types of wood-burning appliances beyond wood stoves. At this time, wood stove manufacturers may only sell wood stoves and wood stove inserts that meet EPA's mandatory smoke emission limit of 7.5 grams of smoke per hour (g/h) for non-catalytic stoves and 4.1 g/h for catalytic stoves. Wood stoves offered for sale in the state of Washington must meet a limit of 4.5 g/h for non-catalytic stoves and 2.5 g/h for catalytic stoves. Pellet stoves are typically cleaner than wood stoves.

Fireplaces and hydronic heaters (outdoor wood boilers) are not currently regulated by EPA. However, manufacturers of these appliances may choose to meet voluntary emission levels set by EPA. Appliances that meet the voluntary requirements are considered "EPA-qualified." While these units are not certified by EPA, they do burn cleaner than older, unqualified models. Several states currently regulate hydronic heaters emissions. To learn more, visit: <http://epa.gov/burnwise/choosing.html>.

Some states have adopted laws that make it illegal to install certain hearth appliances in homes. The Oregon Department of Environmental Quality (DEQ) established a law in 1991 stipulating that only DEQ-certified and EPA-certified stoves made after 1986 can be resold. The Oregon State Building Codes Division passed a complementary law in the early 1990s prohibiting the installation of any uncertified stove (pellet stoves and cook stoves are exempt) in homes or outbuildings. Though this type of measure may be difficult to enforce over a long period, it may result in significant emissions reductions. Washington State has a similar law. Building department inspectors enforce wood stove certification rules in some areas. For more information, go to: <http://www.deq.state.or.us/aq/burning/woodstoves>. To find a list of EPA-certified stoves, go to: http://www.epa.gov/Compliance/resources/publications/monitoring/caa/woodstoves/certified_wood.pdf.

F. BAN THE USE OF NON-EPA-CERTIFIED WOOD STOVES

For areas that do not meet the national particle standards due in part to wood smoke, the local jurisdiction may consider banning the use of non-EPA-certified wood stoves. The case of Lincoln County, Montana, is instructive on how to implement a ban on old stoves.



In 2005, Lincoln County first provided low-income homes full replacement costs (which averaged \$2,900) to upgrade to an approved cleaner-burning appliance, typically an EPA-certified wood stove. For other community members with an old wood stove or wood furnace, the County provided vouchers up to \$1,750. The goal was to encourage all households to voluntarily replace their old wood stoves with cleaner-burning technologies to address the county's particle pollution challenges.

In 2006, following the donation of stoves to low-income households and cash incentives for other homes, the County passed a regulation that banned the use of non-EPA-certified wood stoves. The local government decided that each home using a "Solid Fuel Burning Device" (e.g., wood stove or fireplace) must have an operating permit. To enforce the regulation, Lincoln County air program personnel periodically look for visible emissions from chimneys. If there are visible emissions and the household does not have an operating permit, the county may issue a notice of violation for failure to have a permit. To read the regulation, go to:

www.lincolncountymt.us/environmentalhealth/docs/NewAirOrdinanceFinal.pdf.

G. RESTRICTIONS ON WOOD-BURNING DEVICES IN NEW CONSTRUCTION

Some areas may choose to reduce or prevent further degradation of air quality by banning the installation of any wood-burning hearth appliances in new construction, or restricting the number and density of new wood-burning appliances in a given area. For example, see California's South Coast Air Quality District rule: www.aqmd.gov/rules/reg/reg04/r445.pdf. For frequently asked questions related to this rule go to: www.aqmd.gov/rules/doc/r445/Builders_FAQ.pdf.

H. HYDRONIC HEATER RULES

Hydronic heaters, also known as outdoor wood boilers, are used to provide heat and hot water to homes and other buildings. These devices can be a significant local source of smoke – see photo at right. EPA recommends state, tribal, and local agencies that are in PM_{2.5} nonattainment areas, or areas at risk, to adopt regulations that use or improve upon the emission limits in the Northeast States for Coordinated Air Use Management (NESCAUM)



Outdoor Hydronic Heater model rule. A 2007 study – [Dispersion Modeling Assessment of Impacts of Outdoor Wood Emissions in Support of NESCAUM's Model Rule](#) – showed that smoke from a single old hydronic heater can cause significant air quality problems. Some local jurisdictions have chosen to ban hydronic heaters in their townships. Other jurisdictions chose to regulate the minimum distances these heaters must be set back from property lines to ensure the heaters are not used in close proximity to neighbors. Several states developed proposed rules or adopted

emission standards. See: www.nescaum.org/topics/outdoor-hydronic-heaters for the NESCAUM model rule and the dispersion modeling analysis that supports the need for local or state regulations to avoid exceedances of the national fine particle standards.

IT IS BETTER TO GET A PROPERLY SIZED BOILER THAN TO DEAL WITH WOOD SMOKE COMPLAINTS LATER. MANY STATE RESIDENTIAL CODES REQUIRE THAT BOILERS (GAS, OIL, ETC.) BE SIZED TO ACTUAL LOAD.

If hydronic heaters are permitted, EPA recommends that only EPA-qualified, Phase 2 units that are appropriately sized be allowed and that the area incorporate setback requirements. See NESCAUM's model rule for their setback recommendations: <http://www.nescaum.org/topics/outdoor-hydronic-heaters>. The following are examples of state or local hydronic heater regulations:

- In March 2011, the State of Indiana adopted a rule establishing emission limits for new outdoor hydronic heaters. In addition, the rule includes a fuel use restriction, stack height requirements, and a limited summertime operating ban for existing units. A copy of the rule is available at: www.in.gov/legislative/iac/T03260/A00040.pdf and a fact sheet at: http://www.in.gov/idem/files/factsheet_outdoor_hydronic_heater_rule.pdf.
- The State of Vermont's hydronic heater rule requires the removal of, "Any OWB [outdoor wood boiler/hydronic heater] in the state that is not certified under the air pollution control regulations to meet the Phase I, Phase II, or a more stringent emission limit shall be retired on or before December 31, 2012, if the OWB is located within 200 feet of a residence, school, or health care facility... or has resulted or results in a complaint regarding emissions..."
 - Vermont Department of Environmental Conservation, Final Rule: www.vtwoodsmoke.org/pdf/Final07Rule.pdf.
 - Vermont Department of Environmental Conservation, List of Outdoor Wood-Fired Boilers State and Local Ordinances: <http://www.vtwoodsmoke.org/regl-other.html>.
- Town of Rosendale, NY: www.nescaum.org/documents/rosendaleny-final-heater-regulations-2009.pdf.
- Maine Department of Environmental Protection: www.maine.gov/sos/cec/rules/06/096/096c150.doc

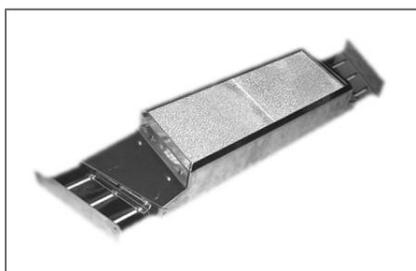
I. REQUIREMENTS FOR WOOD-BURNING FIREPLACES

Over 29 million wood-burning fireplaces exist in homes throughout the U.S. Fireplaces should not be used for primary heating. Fireplaces contribute significantly to air quality problems - especially in high density urban settings. For example, fireplaces may represent as much as 75 percent of the pollution from wood-burning devices on bad air quality days in the San Francisco Bay Area (an area that currently exceeds the PM_{2.5} NAAQS) and may be responsible for 20-25 percent of ALL sources of PM_{2.5}.

FIREPLACES MAY REPRESENT AS MUCH AS 75% OF THE POLLUTION FROM WOOD-BURNING DEVICES ON BAD AIR QUALITY DAYS IN THE SAN FRANCISCO BAY AREA

EPA has a voluntary wood-burning fireplace program that qualifies new, cleaner-burning fireplace models and retrofit devices for existing fireplaces. Where fireplaces are allowed in new construction, EPA recommends the installation of only EPA-qualified, Phase 2 units. If installed and operated properly, EPA-qualified fireplaces can reduce air pollution by approximately 70 percent. For more information go to:

<http://epa.gov/burnwise/fireplaces.html>. For example, beginning in January 2013, the Klamath Falls, Oregon area will only allow fireplaces that emit less than or equal to the Phase 2 emission level of the EPA wood-burning fireplace program in all new housing construction. For more information go to: <http://www.klamathcounty.org/depts/county counsel/CountyCode.pdf>



EPA also recommends that air programs consider purchase incentives for households that install EPA-qualified, Phase 2 retrofit devices on existing fireplaces. For example, manufacturers have developed and tested catalysts, log lighters, and other retrofit devices that may reduce PM_{2.5} emissions from existing fireplaces. For the list of EPA qualified appliances, go to:

<http://epa.gov/burnwise/fireplacelist.html>. See section II C for more details.

The California Bay Area Air Quality Management District (BAAQMD) developed a wood smoke ordinance for fireplaces and wood stoves to regulate new sources of particle pollution in their communities. The ordinance allows the installation of only natural gas fireplaces, EPA-certified wood heaters, pellet-fueled wood heaters, and EPA-qualified, Phase 2 fireplaces that have emissions no greater than those of a certified wood heater. The Bay Area District calculates significant emissions reductions due to the ordinance. For more information related to the BAAQMD's model rule go to: www.baaqmd.gov/Divisions/Communications-and-Outreach/Air-Quality-in-the-Bay-Area/Wood-Burning/Background-On-Model-Wood-Smoke-Ordinance.aspx.

J. STATE/TRIBAL/LOCAL WOOD-HEATING EMISSION STANDARDS

EPA is planning to revise the New Source Performance Standards (NSPS) for residential wood heaters established in 1988 (see section K. below). In the meantime, some states and local governments are developing regulations requiring that any wood-heating appliance sold in their jurisdiction must meet lower emission levels than the current NSPS emission limits. For example, since 1995, the State of Washington has had "solid fuel burning devices" emission limits that are more stringent than those set in EPA's wood heater NSPS.

For details on Washington's emission standards go to: apps.leg.wa.gov/RCW/default.aspx?cite=70.94.457.

K. NEW SOURCE PERFORMANCE STANDARDS FOR NEW RESIDENTIAL WOOD HEATING APPLIANCES

EPA is considering tightening the air pollution emission limits for new wood heaters, reducing the types of appliances that are exempt; and adding regulations for new hydronic heaters, furnaces, and masonry heaters. EPA expects to propose the revisions and new standards in 2013, and anticipates that the rule will be finalized in 2014. The revised wood heater NSPS would reduce future residential wood smoke from new appliances throughout the U.S. For more information, go to: www.epa.gov/burnwise/ordinances.html.

II. VOLUNTARY PROGRAMS

In addition to regulatory approaches, communities may implement voluntary wood smoke control strategies to achieve wood smoke reductions. This section provides information on wood stove and fireplace replacements, hydronic heaters, manufactured (low mass) fireplaces, fireplace retrofit devices, and masonry fireplaces.

A. WOOD STOVE, HYDRONIC HEATER, AND FIREPLACE REPLACEMENTS

EPA recommends that states, tribal governments, and local communities implement voluntary wood stove, hydronic heater, and fireplace replacement/retrofit programs to motivate households to replace older technologies with safer, more efficient, cleaner burning technologies. These programs are most effective when they also include education and outreach to ensure households burn more efficiently and cleanly. Wood stove replacement programs address both indoor and outdoor air quality, reduce fine particle and toxic air pollution, improve energy efficiency, and reduce the risk of chimney fires. See: epa.gov/burnwise/how-to-guide.html for more information. Over the last several years, more state and local agencies have implemented wood stove and fireplace replacement programs to help address wood smoke issues. EPA estimates that more than 24,000 wood stoves and fireplaces have been replaced or retrofitted in 50 communities, resulting in approximately 3,700 tons of fine particle emissions reduced each year, and an estimated \$135-329 million per year of health benefits. Communities may consider only allowing replacement stoves that meet stricter emission standards than those mandated by the EPA. For example, a Maryland program allows the use of wood stoves that emit up to 3 grams of PM_{2.5} an hour and pellet stoves up to 2 grams of PM_{2.5} an hour.

**CHANGING OUT ONE OLD, DIRTY, INEFFICIENT
WOOD STOVE IS EQUIVALENT TO THE PM_{2.5}
POLLUTION REDUCTION OF TAKING FIVE OLD
DIESEL BUSES OFF THE ROAD**

- ❑ **Wood Stove and Hydronic Heater Changeout and Removal Program (Fairbanks, Alaska):** Leveraging local, state, and federal funds, the Fairbanks North Star Borough implemented a wood stove and hydronic heater changeout and removal program as part of the area's PM_{2.5} reduction strategy. The Borough developed education and outreach materials and investigated several voluntary programs, including dry kiln and utility subsidy programs. The program also provided funds for repairs and retrofits. Visit: www.aqfairbanks.com/wood-stoves/.

❑ **Low-income Weatherization Program (Sacramento, California):**

The Sacramento Metropolitan Air Quality Management District (SMAQMD) partnered with the local weatherization program from 2008-2011 to replace stoves in the areas, with 50 percent in environmental justice areas. The program paid up to \$2,500 for a wood stove/insert and up to \$3,500 for a gas stove, while the low-income weatherization program paid for installation labor. Currently, SMAQMD is continuing the low income program as a voucher system. Vouchers are available for up to \$1,500 towards the purchase/installation of a less polluting device or removal of a wood-burning device. More details can be found at: <http://www.airquality.org/woodstove/assistance.shtml> and epa.gov/burnwise/pdfs/SacramentoLowIncomeWeatherizationProgram.pdf.

❑ **Entire Town Wood Stove Changeout and Emissions Reduction Data (Libby, Montana):**

Using significant financial contributions from the hearth industry, U.S. EPA, Montana Department of Environmental Quality, and funds appropriated by Congress, the Lincoln County Health Department replaced the majority of wood stoves in Libby. EPA, the State of Montana, the Hearth, Patio & Barbecue Association (HPBA), and the University of Montana supported the monitoring of air quality before and after the changeout, indoors and out.

Wintertime outdoor PM_{2.5} pollution levels dropped after over 1,100 old wood stoves were replaced with cleaner burning technologies. The old stoves were replaced with properly installed and vented EPA-certified wood stoves and indoor PM_{2.5} emissions were reduced by 70 percent.

For a report, including air quality emissions data, testimonials and a video summarizing this effort, go to: woodstovechangeout.org/index.php.

❑ **Small Town Low-interest Loan Wood Stove Changeout Program (Pendleton, Oregon):**

The City of Pendleton used funds from a Housing and Urban Development (HUD) Community Development Block Grant to provide initial funding for the purchase of new stoves. The money was then paid back by households that participated in the program. City contributions provided additional funding. Several programs have been implemented in Pendleton including one in which the property owner borrows money interest free and a lien is placed on the property pending repayment. The full principal amount of the loan is due at the sale of the home. Approximately 125 wood stoves have been changed out. For more information go to: epa.gov/burnwise/pdfs/PendWoodStoveReplacementSumforEPA.pdf.

❑ **Wood Stove Bounty Program (Methow Valley, Washington):**

The Washington State Department of Ecology (DOE) sponsored a “woodstove roundup” near Winthrop, Washington. Stove owners were offered up to \$250 for turning in an old wood stove. A total of 69 stoves qualified for the program and all were disposed and recycled. Washington DOE estimates that the program has resulted in the removal of approximately 3 tons of PM_{2.5} out the Methow Valley Airshed each year. For more information, contact Sean Hopkins: seho461@ECY.WA.GOV or go to: <http://www.ecy.wa.gov/news/2012/189.html>.

❑ **Annual Wood Stove Changeout Program (Yakima, Washington):**

Yakima Regional Clean Air Agency has partnered with local hearth retailers and others to implement a recurring wood stove changeout campaign. They have changed out over 700 wood stoves. For a summary of their program go to: epa.gov/burnwise/pdfs/yakima.pdf.

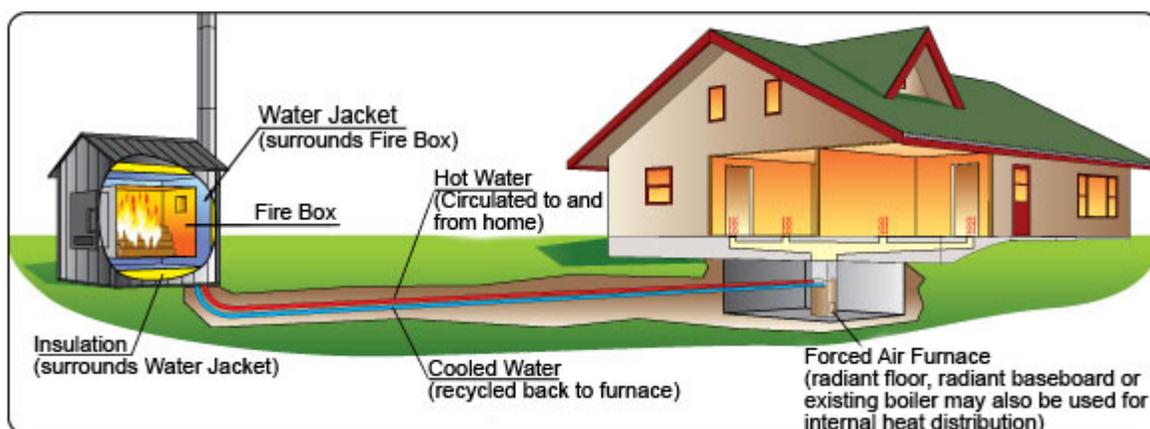
▣ **Tribal Wood Stove Changeout Program, Indoor Air Quality Focus (Swinomish Tribe, Washington):**

The focus of this program was on improving indoor air quality and addressing tribal members' asthma. Before and after stove replacements, indoor air quality sampling was conducted in several homes. Every tribal member's home with an old wood stove was changed out to a cleaner burning appliance (epa.gov/burnwise/tribal.html#case-studies).

B. HYDRONIC HEATERS

EPA's Hydronic Heater program encourages manufacturers to design cleaner and more efficient hydronic heater models. These heaters are commonly referred to as outdoor wood boilers (OWB). See: <http://www.epa.gov/burnwise/owhlist.html> for more details and a current list of the qualified models.

- EPA-qualified, Phase 2 models are 90 percent cleaner than unqualified models.
- Thirty-five models have qualified at the Phase 2 emission level.



The replacement of old, inefficient hydronic heaters with new cleaner-burning units can result in local air quality improvements. Retrofitting existing hydronic heaters to address wood smoke emissions may be another option. Limited testing of hydronic heater retrofit devices has been conducted and more is needed to determine if these devices can be a cost effective measure.

- The Vermont Air Pollution Control Division (APCD) has offered a voluntary OWB Change-Out Program that provides financial incentives to encourage people to replace their old OWBs with cleaner, more efficient heating systems. The Program has offered \$6,000 for replacement and \$1,000 for a manufacturer rebate match. For more information, visit: <http://www.anr.state.vt.us/air/hm/OWBchangeoutprogram.htm>.
- NESCAUM has researched the effectiveness of retrofitting hydronic heaters to help reduce emissions. Field tests have also been done with some mixed results. Newer retrofit device technologies have been developed to address some of the initial problems. In 2013, EPA plans to conduct limited testing to help better characterize the overall effectiveness of hydronic heater retrofit devices. For more information on NESCAUM's study go to:

http://www.ct.gov/dep/lib/dep/air/wood_stove_furnaces/ctdep_woodsmokefinalreport.pdf.

C. WOOD-BURNING FIREPLACES

EPA's wood-burning fireplace program encourages fireplace manufacturers to develop cleaner-burning fireplaces for consumers. The voluntary program sets a qualifying emission level for new fireplaces, including pre-manufactured and site-built masonry fireplaces. Similar to the hydronic heater voluntary program the fireplace program sets Phase 1 and Phase 2 qualifying emission limits. However, the time period for Phase 1 qualification has expired, and all 21 fireplace models qualified under the voluntary fireplace program have qualified at the Phase 2 emissions level. In communities that allow wood-burning fireplaces in new construction, EPA recommends that homeowners and developers consider installation of cleaner-burning, EPA Phase 2 qualified models.

EPA adopted ASTM method 2558 specifically for wood burning fireplaces when the method was finalized in 2009. ASTM E-2558 is the recognized test method accepted for qualification by EPA for the Wood-Burning Fireplace Program. EPA has a separate test (Method 28) for wood heaters, including wood stoves for compliance with the NSPS.

EPA also recommends that air districts consider creating incentives to encourage the installation of retrofit devices on existing fireplaces to reduce emissions. The qualifying Phase 2 emissions level remains the same for retrofit devices as it is for new fireplaces. EPA's fireplace program has qualified certain catalysts, log lighter,s and other retrofit devices that reduce fine particle emissions from existing fireplaces to help improve air quality. For information related to the EPA wood-burning firehttp://sarahj.store.willowhouse.com/category.aspx?zcid=289place program, go to: www.epa.gov/burnwise/participation.html#fireplace.

D. PARTICULATE MATTER (PM) ADVANCE

PM Advance is a collaborative effort between EPA, state, tribal, and local air agencies to reduce PM_{2.5} to help participating areas continue to meet the PM_{2.5} NAAQS. Areas that have high levels of PM_{2.5}, but not designated as "nonattainment" areas, are working with EPA and others to reduce emissions from sources such as residential wood smoke and diesel vehicles. In many areas, wood smoke is a major contributor to high levels of particle pollution. Go to: epa.gov/ozonepmadvance to see if your area is a good candidate for participation.

III. EDUCATION AND OUTREACH

Wood smoke education is an important part of reducing PM_{2.5} in your community. Engaging the public and giving them the tools to make informed decisions about what they burn and how they burn is the first step in an overall wood smoke reduction plan. Enough education programs have been in effect long enough that we know they are effective. With proper burning techniques and well-seasoned wood, emissions (even in older wood-burning appliances) can be significantly reduced. While a new wood stove, hydronic heater, or wood-burning fireplace will typically pollute less than older appliances when used properly, it is important to emphasize that how a user operates their appliance is equally important in maximizing energy efficiency and reducing emissions.

A commitment from local community leaders to support wood smoke reduction programs is important for the success of an education campaign. A plan for education and outreach to the public should definitely be included when introducing burn ban ordinances or wood-burning appliance replacement programs to elected leaders. The following is an example policy statement from the California Bay Area Air Quality Management District that could be used in other communities to help advance education and outreach campaigns.

“THE CITY SHALL ESTABLISH AND MAINTAIN AN ON-GOING PROGRAM TO EDUCATE THE PUBLIC ON THE PROVISIONS OF THIS ORDINANCE AND THE HEALTH IMPACT OF WOOD SMOKE. THE EDUCATION PROGRAM SHALL ALSO IDENTIFY THE VARIOUS TYPES OF WOOD-BURNING APPLIANCES AND GAS FIREPLACES, AND INSTRUCT RESIDENTS HOW TO BURN FIRES MORE CLEANLY. THE CITY WILL EDUCATE THE PUBLIC THAT FIREPLACE AND WOOD STOVE (PROPER OPERATION AND) MAINTENANCE ARE ALSO EFFECTIVE IN MINIMIZING AND REDUCING WOOD-BURNING EMISSIONS, ENCOURAGE CLEANER-BURNING ALTERNATIVES SUCH AS GAS-FUELED DEVICES, PROPER WOOD BURNING TECHNIQUES TO BUILD HOTTER, MORE EFFICIENT FIRES. THE CITY WILL INVESTIGATE WAYS TO ASSIST THE PUBLIC WITH REPLACEMENT OR REMOVAL, THROUGH PROGRAMS OR SERVICES.”- BAY AREA QUALITY MANAGEMENT DISTRICT

A. BURN WISE EDUCATION AND OUTREACH

EPA’s Burn Wise program can be an important resource for states and communities. Burn Wise is a way to encourage the importance of burning the right wood, the right way, in the right wood-burning appliance to protect your home, health and the air we breathe. The program offers a website, outreach tools and information to help consumers make informed decisions about what it means to burn wise. For more information visit the Burn Wise website at: www.epa.gov/burnwise.

KEY EPA BURN WISE MESSAGE:
**IF YOU CHOOSE TO BURN WOOD, BURN THE RIGHT WOOD,
THE RIGHT WAY, IN THE RIGHT APPLIANCE**

We encourage air pollution professionals to work with local hearth retailers, local firefighters, chimney sweeps, insurance agents, doctors, teachers, and others to deliver the Burn Wise message to the public. EPA’s Burn Wise education and outreach tools promote responsible wood-burning techniques for those who choose to burn wood. The goal is to educate people on the connection between what they burn, how they burn, and the impacts on their health and the environment. In addition, it promotes safety, cost savings, and energy efficiency. EPA is “fuel neutral” and does not encourage wood heat over gas, electric, propane, or other fuel types. However, if people choose to burn wood, it is important to provide tools and knowledge so they burn responsibly.



- **Burn the Right Wood:** People should only burn dry, seasoned wood (i.e. 20 percent or less moisture) or wood pellets. Dry hardwoods or pellets have the best combustion efficiency and create less smoke inside and outside the home. EPA recommends that local wood smoke reduction campaigns share information on what not to burn as well. People should never burn garbage, plastic, or pressed and treated wood in their wood stove, hydronic heater, or fireplace. The toxic chemicals released in the air are harmful and can potentially damage wood-burning appliances. Also, people should never burn wet or “green” wood that is not properly seasoned. While it may be cheaper and easily available, burning wet or green wood is inefficient and creates more smoke and less heat when burned. To learn about four easy steps for drying wood, see “Wet Wood is a Waste” Brochure at: www.epa.gov/burnwise/burnwisekit.html.
- **The Right Way:** When heating with wood, people should maintain a bright, hot fire and not let it smolder. More smoke means decreased efficiency and more creosote build-up which could lead to a chimney fire. Wood stoves and fireplaces should be inspected each year by a certified Chimney Safety Institute of America (CSIA) service technician. A list of CSIA-certified technicians in your area can be found at: www.csia.org/search.
- **In the Right Appliance:** Replacing an old wood stove (i.e. manufactured before 1990), hydronic heater, or fireplace with an energy-saving wood pellet stove or an EPA-approved wood stove or EPA-qualified appliance that is installed by a professional will improve air quality and efficiency. Wood heating appliances should be properly sized for the area they will heat. An appliance that is too large or too small will not operate at peak efficiency and will create more pollution. To learn more about EPA certified and qualified wood-burning appliances visit: www.epa.gov/burnwise/appliances.html.

To support the Burn Wise education campaign, EPA, with help from the hearth industry, CSIA, U.S. Forest Service, states, tribes, and others, developed the following tools and initiatives for state, tribal, and local communities. Most materials are available online at: www.epa.gov/burnwise/burnwisekit.html and a few are available in hard copy. Contact the EPA library at: www.epa.gov/nscep to order hard copies.

- **Burn Wise Website** – provides outreach tools, key messages, case studies and additional information to help state, tribal and local communities reduce residential wood smoke www.epa.gov/burnwise.
- **Burn Wise Widgets** – are small images that display wood-burning tips directly on your Web page and link back to the Burn Wise website. Once a widget is added to your Web page there is no technical maintenance; Burn Wise will update the content automatically www.epa.gov/burnwise/widgets.html.
- **Burn Wise Video PSAs** – promote best burn tips and can be used on websites or television. EPA has video public service announcements (PSAs) that are available on YouTube at:

- Wet Wood is a Waste: <http://www.youtube.com/watch?v=jM2WGgRcnm0>;
- Split, Stack, Cover, Store: Four Simple Steps for Drying Wood: <http://www.youtube.com/watch?v=y01--Zrh11s>;
- The Pledge: www.youtube.com/watch?v=Ev4XogvRbME;
- Meet Carl, Learn or Burn: www.youtube.com/watch?v=7fDWWOBhWsc; and
- Learn Before You Burn, Super Sketch: www.youtube.com/watch?v=CuhUcLa64VA.

If you would like a higher resolution video, contact Leigh Herrington, herrington.leigh@epa.gov.

- **Burn Wise Live-read PSAs** – available in 15-, 30- or 60-second lengths, these radio public service announcements help promote best burn tips: www.epa.gov/burnwise/burnwisekit.html.
- **Burn Wise Facebook and Twitter** – provide weekly best burn tips and wood smoke information through www.facebook.com/EPABurnWise and twitter.com/epaburnwise.
- **Burn Wise Photo Flickr** – provides over 200 wood-burning related photos that may be downloaded for use in presentations or materials. www.flickr.com/photos/epaburnwise.
- **EPA State Implementation Plans: Residential Wood Smoke Video** – Training video module for state, local, and tribal governments to learn more about PM_{2.5} implementation and wood smoke: www.epa.gov/apti/video/Larry%20Brockman%20Revised%20051410.wmv.
- **Chimney Safety Institute of America (CSIA) Online Training** – developed by EPA as a free, 2-day online training for CSIA continuing education credits. Chimney sweeps looking to earn or maintain CSIA accreditation may take the course that provides information on EPA's wood heaters NSPS, voluntary programs, health effects of wood smoke and best burn tips. The course is currently available online to CSIA members at: www.csia.org.
- **Hearth, Patio and Barbecue Association (HPBA) Educational DVD and Videos** – HPBA developed several videos to promote best burn tips. Visit HPBA's Home Heating YouTube Channel: www.youtube.com/user/HomeHeatingHelp to view the following videos:

[Introduction to Wood Stoves,](#)

[How to Buy, Split and Store Wood,](#)

[Five Rules to Follow for an Efficient Fire,](#)

[How to Burn Wise with an EPA Non-Catalytic Stove,](#)

[How to Burn Wise with an EPA Catalytic Stove,](#)

[Safety and Maintenance Information for Wood Stoves and Fireplace Inserts,](#) and

[Troubleshooting Information for Wood Stoves and Fireplace Inserts.](#)

You may order the complete high resolution “Burn Wise: A Video Guide to Operating Your Wood Stove Efficiently” DVD at: www.hpba.org/consumers/hearth/responsible-wood-burning.

B. AIR QUALITY FORECASTS AND REPORTS TO THE PUBLIC

EPA has tools for states, tribes, and local communities to use to help raise awareness about wood smoke. We recommend that air agencies incorporate these tools in their education campaigns and wood smoke curtailment programs.

AIRNow.gov provides the public with easy access to national air quality information. The website offers daily Air Quality Index (AQI) forecasts as well as real-time AQI conditions for over 400 cities across the U.S., and provides links to more detailed state and local air quality websites. An AIRNow app is also available for iPhone and Android devices at m.epa.gov/apps/airnow.html.

EPA recommends that air quality officials include a commitment to forecast PM_{2.5} and provide reports to the public that includes an e-mail alert system, like EPA’s EnviroFlash air quality notifications: www.enviroflash.info.

EnviroFlash.info is a free air quality notification system that sends air quality forecasts to the subscriber’s e-mail, smart phone or mobile device. Individuals who receive EnviroFlash notifications can adjust their wood-burning practices on unhealthy air quality days. Knowing the air quality forecast is important for everyone. People most at risk from particle pollution include people with diseases that affect the heart or lung (including asthma), older adults, children, and people of lower socioeconomic status. States, tribes, and local agencies can tailor the EnviroFlash messages and send special alerts related to smoke and wildfires. If your area does not forecast particle pollution or use EnviroFlash, contact John White at white.john@epa.gov to learn more. EPA recommends that air quality officials include a commitment to forecast PM_{2.5} and provide reports to the public that includes an e-mail alert system like EPA’s Enviroflash air quality notifications www.enviroflash.info.

C. ADDITIONAL RESOURCES AVAILABLE TO STATE, TRIBAL AND LOCAL GOVERNMENTS FOR PUBLIC EDUCATION

EPA wood smoke educational materials are available for copying and distribution. Materials may be ordered from the EPA library at: www.epa.gov/nscep/ or online at: www.epa.gov/burnwise/burnwisekit.html.

The following are examples of resources available on the EPA Burn Wise web site:

- **Burn Wise Tip Sheet** – Provides information about best burn practices, how to burn a proper fire and keep your home and community safe from wood smoke. This full-color fact sheet is available in English (document # 456F09004) and Spanish (document # 456F11006) at: www.epa.gov/burnwise/pdfs/BurnWiseTips.pdf and www.epa.gov/burnwise/pdfs/BurnWiseTipsESP.pdf.
- **Wood Stove “Dirty Little Secrets” Brochure and Poster** – This tri-fold color brochure and poster explain the difference between old and new stoves, health effects from breathing wood smoke, and links to more information on the website. Both the brochure (document #456F11002) and poster (document #456H11001) are available from the

EPA library www.epa.gov/nscep/ or online at: www.epa.gov/burnwise/pdfs/dirtysecretbrochure2011.pdf and www.epa.gov/burnwise/pdfs/dirtysecretposter/pdf.

- **Wet Wood is a Waste Brochure** – EPA, along with the Northwest Tribal Air Group, developed a tri-fold brochure (document #456F10003) that provides four simple steps to dry firewood: Split, Stack, Cover, and Store. Hard copies are available through the EPA library at www.epa.gov/nscep/ and online at www.epa.gov/burnwise/pdfs/TribalBrochure.pdf.
- **Modular Wood Shed Plans** – This two-page fact sheet developed by The Makah Nation provides a list of materials and detailed construction diagrams to build a modular wood shed. Plans may be printed from epa.gov/burnwise/pdfs/WoodShedDiagram.pdf.



IV. FUNDING MECHANISMS

Financial incentives may be a necessity to encourage households to replace or retrofit old wood-burning appliances. Such incentives could include a low-cost means to purchase cleaner-burning appliances. The following approaches may assist communities:

A. DISCOUNTS/VOUCHERS

The Hearth, Patio and Barbecue Association (HPBA), along with retailers and manufacturers, works with organizations to provide discounts for wood stove changeout campaigns. In the past, industry discounts have ranged between 10 to 15 percent off the price of a cleaner-burning appliance. For more information, contact John Crouch of HPBA at crouch@hpba.org.

B. TAX CREDITS

Tax credits can reduce the amount of taxes owed. Periodically, state and/or federal tax credits may apply to cleaner-burning appliances. Tax credits, deductions, and rebates can be very effective (for example, as they are with Energy Star appliances) to steer consumers to the cleanest and most efficient products. EPA encourages jurisdictions considering such incentives for biomass heating appliances to focus on the cleanest devices and require appliance destruction through recycling the metal. EPA also encourages jurisdictions that may want to use efficiency thresholds to qualify units for a tax credit to require third party testing and use the Canadian Standards Administration B415.1 test protocol to verify efficiency numbers.

In past years, federal tax legislation has provided 10-30 percent tax credits for purchase and installation expenses of up to \$1,500 for cleaner wood and pellet stoves. Go to: <http://energy.gov/savings> or <http://www.dsireusa.org/> for current tax credit information.

Some states have offered tax credits, which are typically limited in their duration:

- **Montana** - offered an Alternative Energy Systems Credit (\$500) against income tax liability for the cost of purchasing and installing an energy system in a principal home that uses "... a low emission wood or biomass combustion device such as a pellet or wood stove." For more information, go to: www.deq.state.mt.us/Energy/renewable/taxincentrenew.asp#15-32-201.

- **Idaho** - offered taxpayers who bought new wood stoves, pellet stoves, or natural gas or propane heating units for their residences a tax deduction (up to \$5,000) to replace old, uncertified wood stoves. For more information go to: www.deq.state.id.us/air/prog_issues/burning/wood_stove_tax_deduction_brochure.pdf.
- **Oregon** - offered a Residential Energy Tax Credit Program for the highest energy efficient wood and pellet stoves that meet specific criteria. The tax credit amount was based on the estimated average first year energy savings and cost for equipment. For wood and pellet stoves that qualified, the tax credit amount was 25 percent of the net cost up to \$300. For more information, go to: www.oregon.gov/ENERGY/CONS/RES/tax/HVAC-Biomass.shtml.

C. PROPERTY ASSESSED CLEAN ENERGY (PACE)

PACE is an innovative way to finance energy efficiency and renewable energy upgrades for buildings and homes. Interested property owners evaluate measures that achieve energy savings and receive 100 percent financing, and then must repay the funds to the local government as a property tax assessment for up to 20 years. For detailed information go to: pacenow.org/about-pace/what-is-pace/.

D. FEDERAL PROGRAMS TO SUPPORT REPLACEMENTS

The following are examples of various federally supported programs or mechanisms for possibly replacing and/or retrofitting older inefficient or unsafe wood-burning appliances with cleaner, more energy efficient and safer heating appliances.

DOE Low-income Weatherization Program (WAP): enables low-income families to permanently reduce their energy bills by making their homes more energy efficient. New EPA-certified wood stoves are 50 percent more energy efficient than older wood stoves. Older wood-burning appliances like wood stoves are sometimes improperly installed and vented and/or have cracks rendering the appliance unsafe. This can cause indoor air quality problems and risk of fire. WAP funds can be used to replace heating appliances for “health and safety” reasons. To pursue a potential partnership with your local weatherization program to changeout old dirty inefficient wood stoves, go to the following website: apps1.eere.energy.gov/states/.

Department of Health and Human Services: Low Income Home Energy Assistance Program (LIHEAP): This program is a Federally-funded program that helps low-income households with their home energy bills. The local LIHEAP program determines if a household’s income qualifies for the program. LIHEAP may offer one or more of the following types of assistance:

- Bill payment assistance;
- Energy crisis assistance;
- Weatherization; and
- Wood stove energy efficiency upgrades, repairs and replacements.

To pursue a potential partnership with your local LIHEAP office to changeout old dirty inefficient wood stoves, go to the following website: www.acf.hhs.gov/programs/ocs/liheap/.

Department of Agriculture: The Rural Housing Repair and Rehabilitation Loan and Grant Programs enable low-income, elderly (62+) households to remove health and safety hazards

from their homes. Changing out old or improperly installed wood stoves may be eligible under this program. Funding availability is determined by the local service center. For more information and to locate your service center, go to: www.rurdev.usda.gov/rhs/.

Department of Housing and Urban Development: Several programs provide funding for wood smoke mitigation. You can find programs located in your area at: www.hud.gov/offices/adm/grants/fundsavail.cfm and click on “Information by State.” You will need to search Housing Preservation Grants, Rural Housing Development Program, Housing Block Grant Program, and the Community Development Block Grant Program. The following are sample programs:

- **Indian Housing Block Grants:** Tribes have discretion to use these funds on most housing-related projects. Wood stove changeouts are an eligible activity for low income households. For more information, go to: www.hud.gov/recovery/native-american-formula.cfm.
- **Rural Housing and Economic Development Program:** This program provides support for innovative housing and economic development activities in rural areas. Eligible applicants are local rural non-profits, community development corporations (CDC’s), federally recognized Indian tribes, state housing finance agencies (HFA’s), and state community and/or economic development agencies. For more information, go to: www.hud.gov/offices/cpd/economicdevelopment/programs/rhed/.
- **Indian Community Development Block Grants:** This program funds a variety of community development activities, including wood stove changeouts as part of “housing rehabilitation”. For more information, go to: www.hud.gov/offices/pih/ih/grants/icdbg.cfm.

E. SUPPLEMENTAL ENVIRONMENTAL PROJECTS AND MITIGATION PROJECTS

Settlement agreements for violation of federal and state environmental laws may include Supplemental Environmental Projects (SEPs) and/or mitigation projects. SEPs used to implement a wood-burning appliance replacement/retrofit program are an effective way to leverage resources and significantly improve public health and the environment. These types of projects can be used to address various types of pollutants including PM_{2.5}, CO, volatile organic compounds, and hazardous air pollutants. Over the last 5 years, state and federal settlement agreements have included more than \$5.5 million for wood-burning appliance replacement/retrofit projects.

- A SEP is an environmentally beneficial project that a violator of an environmental law voluntarily agrees to undertake in the settlement of a civil enforcement action. The goal of a SEP is to improve the environmental health of a community that has been placed at risk due to a violation of an environmental law.
- A mitigation project is an environmentally beneficial project performed as part of a settlement of alleged violations which tends to compensate the environment for past environmental harms caused by the alleged violations. The project should be related to the same media (e.g. air, water, waste) and should have a similar nexus (e.g. location) as the alleged violations.

Several wood stove replacement SEP/mitigation projects have been implemented throughout the country, including a \$750,000 mitigation project for a coal-fired power plant that was administered by a health organization. The project replaced 425 old wood stoves with pellet, gas and EPA-certified wood stoves and included education on proper burning and appliance operation. To learn more about this project go to:

www.epa.gov/compliance/resources/decrees/civil/caa/srp-cd.pdf.

Example wood-burning appliance replacement consent decree language and a mitigation plan are available at: www.epa.gov/burnwise/funding.html.

EPA encourages air pollution control personnel to work with and educate air enforcement personnel and management about the potential use of wood-burning appliance (wood stove, fireplace and hydronic heater) replacement and/or retrofit projects in settlements. Often SEPs and mitigation projects are finalized at the end of long settlement processes. If your community is engaged in a settlement process, and there is interest in a wood-burning appliance replacement project, EPA recommends that you draft a project plan to share with the company that may want to implement a SEP in that area.

Some settlement agreements are not site specific because the company has operations throughout the U.S. In these cases the company may choose a location to implement a wood-burning appliance replacement project. EPA maintains a list of possible locations for a company to implement such a project; visit <http://epa.gov/burnwise/funding.html#SEP>. If you would like to add an area to the list, contact Larry Brockman at brockman.larry@epa.gov. For more information about SEPs, go to:

http://www.epa.gov/woodstoves/Documents/Process/Funding/ws_sepguide_042807.pdf.

V. PARTNERSHIPS

To implement a residential wood stove replacement program, EPA finds that partnerships are very helpful in leveraging resources and reaching out to the public. Below are some suggested organizations to contact.

- A. HEARTH, PATIO & BARBECUE ASSOCIATION (HPBA)** is a trade organization that represents more than 1,000 hearth retailers and manufacturers across the country. HPBA can potentially support replacement programs and help with outreach initiatives to reduce wood smoke emissions. Contact HPBA's John Crouch at crouch@hpba.org for more information.
- B. AMERICAN LUNG ASSOCIATION (ALA)** can help bring experience to your wood smoke public education campaign. In addition to public education, ALA has been a partner and supporter of wood stove changeouts. Contact your local ALA office to request their assistance in helping raise awareness about wood smoke health effects and your wood smoke control program. Go to www.lungusa.org to find your local ALA office.
- C. CHIMNEY SAFETY INSTITUTE OF AMERICA (CSIA)** is a non-profit, educational organization dedicated to chimney and venting system safety. The organization represents more than 1,000 chimney sweeps throughout the country. Chimney sweeps are an excellent source of information and may provide insight on local wood-burning practices. CSIA may also assist in identifying chimney sweeps in most communities. Contact Melissa Heeke at mheeke@csia.org or go to www.CSIA.org for more information.

- D. THE ALLIANCE FOR GREEN HEAT** is a non-profit environmental organization that promotes cleaner-burning technology. The Alliance for Green Heat works with environmental and forestry organizations, air quality experts, the wood and pellet stove industry, and others in the wood-burning community. Contact John Ackerly at jackerly@forgreenheat.org or go to <http://www.forgreenheat.org> for more information.
- E. STATE ENERGY DEPARTMENTS** have worked with state and local air offices to help fund and implement wood stove changeouts. For example, biomass programs in Maryland and New Hampshire encourage cleaner biomass technology to reduce climate gases and improve air quality.
- F. OTHER POTENTIAL PARTNERS** There are many other organizations that may be able to offer resources and assistance in addressing wood smoke in your community:
- Firefighters;
 - Health Organizations;
 - Environmental Groups; and
 - Local Businesses.

VI. OTHER TOOLS

A. COUNTY-LEVEL EMISSION INVENTORY FOR RESIDENTIAL WOOD COMBUSTION

EPA, along with state, local, and regional planning organizations, created a methodology to estimate emissions from residential wood-burning appliances for the purposes of developing an emission inventory. The result is a tool that calculates emissions at the county level. The five inputs to the tool include: (1) percentage of people that burn wood in each appliance; (2) the number of occupied housing units in the county; (3) the amount of wood burned in each appliance; (4) the density of the wood; and (5) the amount of emissions (per pollutant, in mass units) emitted per ton of wood burned. The result is a county level emission inventory for residential wood combustion appliances.

EPA initially populated the tool with default data based on regional averages. The tool has the capability to use state-specific data. To date, 15 states have submitted state-specific data which EPA has incorporated into the tool (2011).

More information on the tool may be obtained by contacting Roy Huntley at Huntley.Roy@epa.gov. The web address for the CHIEF website is: www.epa.gov/ttn/chief/eiinformation.html. Any agency wanting to incorporate state-specific inputs is encouraged to contact Roy Huntley for assistance.

B. WOOD STOVE AND FIREPLACE CHANGEOUT/RETROFIT EMISSIONS CALCULATOR

EPA has developed a simple emissions calculator to estimate $PM_{2.5}$ and toxic air emissions reductions from wood stove or fireplace changeouts. Users of the calculator should use site specific inputs (e.g., cords of wood burned) rather than the defaults in the program, if available. However, site specific data must be added in the same units (e.g., pounds of pollutant emission per ton of wood burned) as the default inputs to the calculator. The references for the default inputs are defined on the readme tab of the calculator. For a copy of the calculator, go to the

EPA web site at: epa.gov/burnwise/resources.html#air and click on “Wood Stove and Fireplace Changeout Emissions Calculator (Excel).” Contact Roy Huntley at Huntley.Roy@epa.gov for assistance.

Variables to the calculator include:

- number of stoves/fireplaces changed out;
- cords of wood burned;
- the fraction of the changeouts expected to be new certified wood stoves;
- wood stove efficiency; and
- wood density.

A wood density variable is necessary because wood is usually bought by the “cord,” which is a unit of volume, and the emission factors used in the calculator are in units of mass. Default emission factors are included in the calculator in units of pounds of pollution emitted per ton of oven-dried wood burned. The default density (1.162 tons per cord) used in the calculator comes from the Energy Information Administration (U.S. Department of Energy).

C. RESIDENTIAL WOOD COMBUSTION SURVEYS

Collecting information on wood burning (e.g., number of stoves and fireplaces, amount of wood burned) about your community is a critical step in determining whether to develop a wood smoke reduction program. For examples of past wood smoke related surveys that may assist a local community in developing and conducting their own survey, go to: omni-test.com/publications/Comp2.pdf.

D. RESIDENTIAL WOOD COMBUSTION CONTROL MEASURES

EPA has developed a table that lists residential wood combustion control measures that air quality officials may implement to reduce $PM_{2.5}$ and other pollutants. The table includes estimated control efficiency and cost effectiveness numbers along with additional information. See Appendix D of this document.

E. RESIDENTIAL/MOBILE WOOD SMOKE MONITORING

Tools for wood smoke monitoring in the ambient air are fairly limited, but a few techniques are available. Almost all state, tribal and local monitoring programs already employ continuous $PM_{2.5}$ monitors located at long term monitoring stations. The monitors provide useful background information on the PM levels for an area, but are limited in their ability to characterize PM exposures resulting from residential wood smoke if they are not located in the specific neighborhood or street of concern. These monitors typically report hourly data on monitoring agency web sites and to Airnow.gov as described in III.B above.



To support characterizing PM exposures in locations with elevated wood smoke, monitoring agencies can deploy temporary $PM_{2.5}$ monitors; however, these are often expensive and siting and logistics can be challenging. Alternatives to fixed site $PM_{2.5}$ mass continuous monitors exist, but the concentration units are primarily used as a screening tool and not compared to health based standards.

A nephelometer can be used to identify wood smoke if it is configured with a UV channel, and it can be used to provide light scattering. NESCAUM has developed an integrated system to measure $PM_{2.5}$ from wood smoke at receptor locations impacted by local wood-burning sources. The monitoring kit can help address wood smoke complaints and for research projects. The residential/mobile wood smoke PM monitoring kit includes: a ThermopDR-1500 nephelometer for $PM_{2.5}$ (BGI cyclone inlet), and a Gill 2-d heated sonic wind and sonic temperature sensor. The kit can accommodate an additional monitor such as an electrochemical CO sensor, or a recording GPS for mobile use.

The system is remotely accessible and designed to be deployed outside in all winter weather conditions. It can also be used for other PM sources such as prescribed burns, wildfires, or road dust when configured to measure PM_{10} . Mobile monitoring of wood smoke or other PM sources can be done with 1-second resolution to provide larger spatial scale assessments. The kit includes on-site training, Standard Operating Procedures, and extended support. If your agency is interested in learning more about the kit and how to acquire one, please contact George Allen at: gallen2@nescaum.org.

In 2012, the Lake Michigan Air Director's Consortium (LADCO), in cooperation with the University of Wisconsin-Stevens Point (UWSP), conducted an air quality study of RWC emissions in Grand Rapids, Wisconsin, using fixed and mobile monitoring techniques. The final report can be found here:

http://ladco.org/reports/wood_smoke/grand_rapids_wood_smoke_case_study_final_report_8_31_2012.pdf.

F. SPATIAL MODELING/MONITORING

The New York State Energy Research and Development Authority (NYSERDA) commissioned a study to evaluate the effect of wood combustion on local air quality in the Adirondacks of New York. The study approach used topography, U.S. Census data, property assessments, and other relevant publicly accessible databases as inputs into a geographic information system model. The model provides a map of predicted wood smoke $PM_{2.5}$ spatial variability across a region.

The predicted spatial pattern of wood smoke $PM_{2.5}$ was compared to observed ambient levels at fixed monitoring sites and with data collected using mobile monitoring to gauge the prevalence of high wood smoke spikes. This approach may provide emission inventory developers with a better sense of the prevalence of outdoor wood boilers and other high emitting wood smoke sources compared to assumptions made in inventory models. The monitoring results showed that wood combustion was responsible for most of the $PM_{2.5}$ measured in the Adirondacks during the study.

The model coupled with the monitoring field campaign demonstrates that U.S. Census information can be combined with additional survey and property assessment data to provide a broadly applicable estimate of wood smoke spatial patterns and population exposure in the Adirondacks. This approach is a promising method for screening potential wood smoke problem areas in complex terrains across the Northeast and elsewhere in the U.S. For more information about this study contact Dr. Ellen Burkhard at egb@nyserda.ny.gov.

The model is available at:

www.nyserda.ny.gov/~media/Files/EIBD/Economic%20Development/spatial_modeling_monitoring_residential_woodsmoke.pdf?sc_database=web.

PM_{2.5} in Outdoor Air Near Outdoor Wood-Fired Boilers

New York State Department of Health scientists investigated the potential for hydronic heaters to increase outdoor levels of PM_{2.5}. Real-time measurements of PM in ambient air at residences near hydronic heaters were compared to levels at nearby residences. Evaluation of the monitoring data showed statistically significant increases in PM_{2.5} at five of six study locations, correlated to hydronic heater distance, direction and meteorological conditions. This report and other information can be found here:

<http://www.health.ny.gov/environmental/outdoors/air/owb/index.html>.

Dispersion Modeling Assessment of Impacts of Outdoor Wood Boiler Emissions in Support of NESCAUM's Model Rule

As mentioned earlier in this document, a dispersion modeling assessment was undertaken by the New York State Department of Environmental Conservation (NYSDEC) in 2007 to assess the air quality impacts of existing hydronic heaters. This study was conducted in support of the NESCAUM model rule for hydronic heaters. The results of the study show that hydronic heaters produce 24-hr PM_{2.5} air quality impacts in excess of 100 ug/m³ at distances up to 40 meters from the hydronic heater. In addition, they produced air quality impacts in excess of the 24-hr PM_{2.5} NAAQS of 35 ug/m³ at distances up to 150 meters from the hydronic heater. For more information go to: <http://www.vtwoodsmoke.org/pdf/NY-Modeling.pdf>.

Fireplace Dispersion Modeling

A dispersion modeling study was undertaken by EPA in late 2009 to assess the air quality impacts of the cleaner EPA Phase 2 qualified fireplaces. The results of the study show that the corresponding modeled impact of a fireplace for comparison to the 24-hour PM_{2.5} NAAQS was approximately 2.7 ug/m³. This impact occurred at a distance of 15 to 20 meters from the chimney. The impact of a typical fireplace would likely be twice this impact. For further information on this study, go to: <http://epa.gov/burnwise>.

SUMMARY

Wood smoke contains PM_{2.5} and toxic air pollutants and significantly impacts air quality, both indoors and outdoors. Depending on the circumstances in your area, EPA recommends that communities concerned with wood smoke emissions consider the following strategies that have proven to be effective: (1) compile wood-burning-related information; (2) take steps to implement an education and outreach campaign; (3) provide a wood-burning appliance (wood stove, hydronic heater, fireplace) replacement/retrofit program; (4) implement a wood smoke curtailment program; and (5) adopt the NESCAUM hydronic heater model rule and/or a new fireplace construction rule. If your agency or community has other suggestions or "lessons learned" about addressing wood smoke, please share your recommendations with your EPA Regional Office. EPA will update and improve this document periodically.

Appendix A: Example Wood Smoke Program

The following is an example of a fictitious community that implements most of the key steps and components of a residential wood smoke reduction plan.

Every winter in a mid-sized, rural town, wood smoke can be seen hanging over the valley, particularly on days with freezing temperatures and little wind. As more information about the health problems from breathing fine particle pollution (PM_{2.5}) became available, the local health and air quality officials realized that wood smoke was negatively impacting community members' health and dirtying the skies. As you drive through, you can see smoke streaming out of chimneys and, where there is smoke, there is an inefficient fire.

Local air quality officials decided on a multi-pronged approach for this community of 30,000 people to address its wood smoke problem. That approach included:

- ▣ Implementation of EPA's Burn Wise education and outreach campaign,
- ▣ Incentives to replace old dirty wood stoves
- ▣ Incentives to retrofit existing fireplaces, and
- ▣ Implementation of a wood smoke curtailment program.

The 24-hour PM_{2.5} design value² for the community is 42 micrograms per cubic meter (ug/m³). This exceeds the PM_{2.5} NAAQS of 35 ug/m³. Through analysis of air quality data, emissions inventory and wood stove survey information, officials identified the exceedances of the NAAQS in the area as occurring in the winter and influenced by wood smoke. For the area to meet the 24-hour PM_{2.5} NAAQS, it would require a minimum reduction of 20 percent in the monitored PM_{2.5} air quality concentrations. Local air quality and health officials decided to replace 50 percent of the non-EPA-certified wood stoves and retrofit 20 percent of the fireplaces in the area. In addition, they initiated a two stage burn ban based on the air quality forecast made by local meteorologists and air quality public officials.

Also, to increase the likelihood that the people in the community would participate in the replacement and retrofit program and wood smoke curtailment program, air quality officials decided to spend the first six months raising awareness about wood smoke health effects and ways to burn cleaner and more efficient.

EDUCATION AND OUTREACH CAMPAIGN

Establish a baseline

Before implementing the campaign, the town established a baseline assessment of residents' wood-burning habits. They polled their local hearth retailers to see how many EPA-certified stoves were bought in previous years. They also spoke with local chimney sweeps to understand how often people had their wood-burning appliances inspected and maintained and the types of appliances (e.g., old wood stoves, new stoves, fireplaces) in which people were burning the most wood. To cross check what the chimney sweeps reported and to get additional information, they conducted informal telephone interviews to determine people's perspectives on wood smoke (i.e., is it a health problem?), how much wood do people burn, and what appliances are used in the community. This information allowed officials to target their messages and their audience and provided a baseline to evaluate the program at the end of the winter season.

² <http://www.epa.gov/airtrends/values.html>

Enlist local spokespersons

The town decided to partner with several groups to help convey the Burn Wise messages. First, they identified physicians, particularly pulmonologists and pediatricians. They provided these physicians with Burn Wise posters and brochures that could be handed out to patients and/or displayed in the waiting room.

Second, they worked with the local fire department to set up two Burn Wise community workshops. The workshop included a demonstration of an old wood stove next to an EPA-certified wood stove to show the difference in smoke. A local retailer provided the old stove and a new stove at no cost to help demonstrate that the new stoves can be operated with no visible emissions. A county health official spoke about health effects from wood smoke, and a local chimney sweep provided demonstrations on how to choose the best firewood and how to build a hot fire; the firefighter emphasized the importance of annual chimney inspections and proper wood-burning techniques to prevent chimney fires. In addition, they provided free wood moisture meters to anyone who showed up to the workshops.

Tap into the media

The air program officials placed scripted public service announcements (PSAs) with the local radio station. These PSAs ran during commuting drive times and throughout the day. Air program officials used the scripts from EPA's web site and tailored them with specific information. The local radio station carried the PSAs for the entire wood-burning season from September through March.

The town also placed a Burn Wise banner on the town's home page. The banner listed the Burn Wise tips and provided links to EPA's web site.

In addition to the Burn Wise workshop article, the town worked with the local newspaper to run another story about wood-burning issues in the community. They invited the press to the demonstration at the firehouse to take pictures and interview local citizens.

After one burn season, the town ran a follow-up survey with local hearth retailers, chimney sweeps, and citizens. From the retailers, the officials learned that replacement sales of old wood stoves to EPA-certified wood-burning appliances had increased. From the chimney sweeps, they learned that more households had scheduled maintenance checks of their wood-burning appliances after hearing the radio PSAs, and from another informal telephone survey the town found that citizens were now more aware of the Burn Wise messages and made changes in their wood-burning habits.

WOOD-BURNING APPLIANCE REPLACEMENT AND RETROFIT PROGRAM

The town has 3,000 wood stoves, of which 2,000 are non-EPA-certified, and 5,000 existing fireplaces. Wood stoves in the town emit 123 tons per year of fine particle pollution and fireplaces 40 tons per year. The area will use hearth industry discounts and \$600,000 from a recent Supplemental Environmental Project to changeout 1,000 old wood stoves over a four year period and retrofit 200 fireplaces to gas. The area plans to changeout and recycle 250 of these old wood stoves and retrofit 50 fireplaces each year for the next four winters. They expect that the 250 non-EPA-certified wood stoves will be changed out for 200 EPA-certified wood stoves and 50 gas stoves before the next winter. The resulting reduction in PM_{2.5} emissions from the wood stove changeouts and fireplace retrofits will be more than 10 tons each winter, or 40 tons (32.5 percent) over the four-year period. Officials calculated the emissions reductions with the EPA Wood Stove and Fireplace Changeout Emissions Calculator found at the EPA web site: epa.gov/burnwise/resources.html#air.

BURN BAN

To reduce the likelihood of exceedances of the 24-hour $PM_{2.5}$ health standard, the public officials also initiated a two stage burn ban to begin the following winter. The Stage 1 burn ban is implemented when meteorologists and public officials forecast the next day's air quality for $PM_{2.5}$ to reach $30 \mu\text{g}/\text{m}^3$. A Stage 2 burn ban is implemented when $PM_{2.5}$ is forecast for the next day to reach $35 \mu\text{g}/\text{m}^3$. Under a Stage 2 burn ban, no wood burning may take place, except where it is the only source of home heat. Based on data analysis from other communities that have implemented burn bans, officials anticipate their Stage 2 ban will reduce the concentration of fine particles in the outdoor air by approximately $10 \mu\text{g}/\text{m}^3$.

APPENDIX B: POTENTIAL COMPONENTS OF A WOOD SMOKE REDUCTION PLAN

For all areas with residential wood smoke concerns, development and implementation of a wood smoke reduction plan is vital to attaining and/or maintaining healthier air and compliance with the national health-based fine particle standards. Wood smoke reduction plans are especially important in areas that are designated nonattainment for the 24-hour or annual $PM_{2.5}$ NAAQS. These plans can provide early emission reductions that may enable the area to redesignate to attainment before state implementation plan (SIP) nonattainment planning documents need to be approved. If early redesignation is not possible, the wood smoke reduction plan can be readily used in developing an attainment SIP for the area.

In some communities, wood smoke is the dominant source of $PM_{2.5}$ emissions; in others, it may not be the overriding contributor to nonattainment, but wood smoke emission reductions may provide an opportunity to obtain air quality improvements. In addition to the regulatory measures implemented for industrial, commercial, and mobile sources, voluntary wood smoke reduction measures may play an important role in helping a community attain the $PM_{2.5}$ standards.

Areas designated as nonattainment for the $PM_{2.5}$ NAAQS are required to develop a SIP within 18 months of the effective date of the designations. In the interim, EPA encourages these areas to develop and implement a wood smoke reduction plan expeditiously to curtail wood smoke emissions where those emissions are a significant contributor to nonattainment. Those areas may be able to obtain 3 years of “clean data” before SIPs are due and thereby be exempt from reasonable further progress, attainment demonstration, and contingency measure requirements under the EPA 2004 Clean Data Policy: www.epa.gov/pmdesignations/1997standards/documents/Clean_Data_Policy.pdf. The wood smoke reduction plan can readily be augmented for conversion to a CAA section 175(a) maintenance SIP if the area can be redesignated to attainment. Otherwise if the area is still nonattainment, the wood smoke reduction plan can be incorporated into attainment planning.

Below are possible components of a wood smoke reduction plan that may be useful when developing a SIP if required:

- Description of the area (physical, topographic, common meteorology, population, economic activity, common, and meteorological).
- Description of outreach and education efforts on wood smoke issues.
- Air quality data analysis: involves reviewing the composition of fine particle air quality data and meteorological conditions on the highest $PM_{2.5}$ days (for example, days exceeding 25-30 $\mu\text{g}/\text{m}^3$) for recent years.
 - What is the design value for the area? How much does it exceed the standard?
 - Do the highest days occur primarily in the winter, or during other times of year too?
 - What are typical meteorological conditions (e.g. inversion conditions, wind direction) on the high days?
 - How does the composition vary on the high days? Is the same $PM_{2.5}$ component (such as organic carbon) always the largest component on the high days, or does it vary?

From composition data, conclusions can be drawn regarding key contributing sources. For example, data showing that organic carbon is a large percentage of the PM_{2.5} mass on the highest days is often an indicator of high wood smoke emissions.

- Emissions inventory and survey of wood-burning devices in the area.
 - See section VI for information on emissions inventory tools and related information.
 - See various case studies throughout this document regarding survey techniques successfully used in other communities.
 - Characterize emissions for EPA-certified and non-certified wood stoves, outdoor wood boilers, and fireplaces.
- Possible emission reduction measures
 - See section I for regulatory measures.
 - See section II for voluntary measures.
 - The use of emissions and air quality data from case studies (e.g., Libby, MT) could help identify potential emissions reductions and air quality changes that could be expected from certain types of emission reduction programs (such as wood stove replacements or burn bans).
 - For example:
 - What was air quality improvement after “x” number of wood stove replacements?
 - How much improvement can be attributed to a burn ban on a specific day?
- Analysis of emission reductions needed to reach attainment by the attainment date (or target year).
 - Projection of emissions and air quality in target year, with anticipated growth and no control measures.
 - Analysis of candidate measures (through modeling, emissions rollback, or other techniques) and associated emissions reductions and air quality improvement to be achieved by attainment/target year.
- Annual or seasonal emission reduction milestones for relevant control measures.
- Compilation of enforceable state regulations adopted to require implementation of any mandatory programs (e.g. changeout program or burn ban.)
- Measures to track progress in terms of program implementation, emission reductions, and ambient monitoring. Milestones could be developed for the following:

- Number of noncompliant wood stoves taken out of use or replaced by EPA-certified units;
 - Number of wood fireplaces converted to gas;
 - Number of problem hydronic heater units shutdown, moved or replaced;
 - Estimated wood smoke emissions reductions;
 - Target design value;
 - Percent reduction in number of AQI alert days;
 - Reduction in number of monitored violations; and
 - Reduction of visual smoke reports on burn curtailment days.
- Measures that will be implemented in the Wood Smoke Reduction Plan automatically if the area fails to attain by its attainment date, or meet key milestones such as emission reduction or ambient monitoring milestones. Measures could include:
 - Increased funding for replacement programs;
 - Increased and targeted outreach and education efforts;
 - Increased enforcement efforts or fines for burn curtailment violations;
 - More protective triggers for burn curtailment days; and
 - If included, submit state rules for changeout program and burn curtailment.

APPENDIX C: HEALTH STUDIES³

- Barregard, L., Sallsten, G., Gustafson, P., Andersson, L., Johansson, L., Basu, S. & Stigendal, L., 2006. Experimental exposure to wood-smoke particles in healthy humans: effects on markers of inflammation, coagulation, and lipid peroxidation. *Inhalation toxicology* 18: 845-853.
- Bunnell JE, Garcia LV, Furst JM, Lerch H, Olea RA, Suitt SE, Kolker A. 2010. Navajo coal combustion and respiratory health near Shiprock, New Mexico. *J Environ Public Health*. 2010;2010:260525.Epub 2010 Jun 30.
- Butterfield, P., Edmunson, E., LaCava, G., and Penner, J. 1989. Woodstoves and Indoor Air. *J. Environ. Health* 59: 172-173.
- Chapin, F. S. 1974, *Human activity patterns in the city*. New York: Wiley-Interscience.
- Collins, D.A., Martin, K.S., and Sithole, S.D., 1990. Indoor Woodsmoke Pollution Causing Lower Respiratory Disease in Children. *Trop. Doctor* 20: 151-155
- Danielsen, P., Brauner, E., Barregard, L., Sallsten, G., Wallin, M., Olinski, R., Rozalski, R., Møller, P., & Loft, S., 2007. Oxidatively damaged DNA and its repair after experimental exposure to wood smoke in healthy humans. *Mutat. Res.* 642: 37–42.
- Demarest, G. M., Hudson, L.D., and Altman, L.C., 1979. Impaired Alveolar Macrophage Chemotaxis in Patients with Acute Smoke Inhalation. *Am. Rev. Respir. Dis.* 119:279-286.
- ERMD. 2000. Characterization of Organic Compounds from Selected Residential Wood Stoves and Fuels. Emissions Research and Measurement Division, Environmental Technology Advancement Directorate, Environment Canada. Report ERMD 2000-01.
- Hart JF, Ward TJ, Spear TM, Rossi RJ, Holland NN, Loushin BG.2011. Evaluating the effectiveness of a commercial portable air purifier in homes with wood-burning stoves: a preliminary study. *J Environ Public Health*. 2011;2011:324809. Epub 2011 Jan 27.
- Honicky, R.E., Akpom, C.A., and Osborne, J.S., 1983. Infant Respiratory Illness and Indoor Air Pollution from a Woodburning Stove. *Pediatrics* 71: 126-128.
- Honicky, R.E., Osborne, J.S., and Akpom, C.A., 1985. Symptoms of Respiratory Illness in Young Children and the Use of Woodburning Stoves for Indoor Heating. *Pediatrics* 75: 587-593.
- Honicky, R.E., and Osborne, J.S., 1991. Respiratory Effects of Wood Heat: Clinical Observations and Epidemiologic Assessment. *Environ. Health Perspect.* 95:105-109.
- I Barn P, Larson T, Noullett M, Kennedy S, Copes R, Brauer M. 2008. Infiltration of forest fire and residential wood smoke: an evaluation of air cleaner effectiveness. *J Expo Sci Environ Epidemiol*. 2008 Sep;18(5):503-11. Epub 2007 Dec 5.

³ For more information on the science on PM and health, see the Integrated Science Assessment prepared for the recent review of the PM_{2.5} NAAQS at <http://cfpub.epa.gov/ncea/cfm/recordisplay.cfm?deid=216546>

For risk and exposure assessments, visit http://www.epa.gov/ttn/naaqs/standards/pm/s_pm_2007_risk.html

- Kammen, D.M., Wahhaj, G., and Yiadom, M.Y., 1998. Acute Respiratory Infections (ARI) and Indoor Air Pollution (with emphasis on children under five in developing countries). EHP Activity No. 263-CC, U.S. EPA.
- Karr C, Demers P, Koehoorn M, Lencar C, Tamburic L, Brauer M., 2009. Influence of ambient air pollutant sources on clinical encounters for infant bronchiolitis. *Am. J. Respir. Crit. Care Med.* 108:995–1001.
- Karr, C., 2007. Adding Fuel to the Fire: Increasing Evidence for Developmental Toxicity of Indoor Solid Fuel Combustion. *Arch Pediatr Adolesc Med.*
- Koenig, J.Q., Larson, T.V., Hanley, Q.S., Rebolledo, V., Dumler, K., Checkoway, H., Wang, S.Z., Lin, D., and Pierson, W.E. 1993. Pulmonary Function Changes in Children Associated with Fine Particulate Matter. *Environ. Res.* 63:26-38.
- Larson, T.V. and Koenig, J.Q. 1994. Wood smoke: emissions and non-cancer respiratory effects. *Annual Review of Public Health.* 15, 133-156.
- Lévesque B, Allaire S, Gauvin D, Koutrakis P, Gingras S, Rhainds M, Prud'Homme H, Duchesne JF. 2001. Wood-burning appliances and indoor air quality. *Sci Total Environ.* 2001 Dec 17;281(1-3):47-62.
- MacIntyre, E., Karr, C., Koehoorn, M., Demers, P., Tamburic, L., Lencar, C., & Brauer, M., 2011. Residential Air Pollution and Otitis Media During the First Two Years of Life. *Epidemiology* 22: 81-89.
- McCrillis RC, Burnet PG. 1990. Effects of burnrate, wood species, altitude, and stove type on woodstove emissions. *Toxicol Ind Health.* 1990 Oct;6(5):95-102.
- McCrillis RC, Watts RR, Warren SH. 1992. Effects of operating variables on PAH emissions and mutagenicity of emissions from woodstoves. *J Air Waste Manage Assoc.* 1992 May;42(5):691-4.
- Morris, K., Morganlander, M., Coulehan, J.L., Gahagen, S., and Arena, V.C., 1990. Wood-burning Stoves and Lower Respiratory Tract Infection in American Indian Children. *Am. J. Dis. Child.* 144: 105-108.
- Naeher LP, Brauer M, Lipsett M, Zelikoff JT, Simpson CD, Koenig JQ, and KR Smith, 2007. Woodsmoke health effects: a review. *Inhal Toxicol* 19:67–106
- Nawrot TS., Perez L, Kunzli N., Munters E., and B. Nemery, 2011. Public health importance of triggers of myocardial infarction: a comparative risk assessment. *The Lancet* 377: 732-740.
- NEIPTG. 2000. 1995 Criteria Air Contaminants Emissions Inventory Guidebook. National Emissions Inventory and Projections Task Group. Canadian Council of Ministers of the Environment.
- Noonan CW, Ward TJ, Navidi W, Sheppard L, Bergauff M, Palmer C; HEI Health Review Committee. 2011. Assessing the impact of a wood stove replacement program on air quality and children's health. *Res Rep Health Eff Inst.* 2011 Dec;(162):3-37; discussion 39-47.
- Noonan CW, Navidi W, Sheppard L, Palmer CP, Bergauff M, Hooper K, Ward TJ. 2012. Residential indoor PM(2.5) in wood stove homes: follow-up of the Libby changeout program.. *Indoor Air.* 2012 May 19.

- Noonan CW, Ward TJ, Navidi W, Sheppard L. 2012. A rural community intervention targeting biomass combustion sources: effects on air quality and reporting of children's respiratory outcomes. *Occup Environ Med.* 2012 May;69(5):354-60. Epub 2012 Feb 1.
- Pettigrew, M. M., Gent, J. F., Triche, E. W., Belanger, K. D., Bracken, M. B., and B.P. Leaderer, 2004. Infant otitis media and the use of secondary heating sources. *Epidemiology* 15:13–20.
- Pierson, W. E., Koenig, J. Q., and Bardana, E. J., 1989. Potential adverse health effects of wood smoke. *West J. Med.* 151: 339-342.
- Rajpandey, M. 1984. Domestic Smoke Pollution and Chronic Bronchitis in a Rural Community of the Hill Region of Nepal. *Thorax* 39:337-339.
- Ramage, J.E., Roggli, V.L., Bell, D.Y., and Piantadosi, C.A. 1988. Interstitial Lung Disease and Domestic Woodburning. *Am. Rev. Respir. Dis.* 136: 1486-1508.
- Robin LF, Less PS, Winget M, Steinhoff M, Moulton LH, Santosham M, Correa A. 1996. Wood-burning stoves and lower respiratory illnesses in Navajo children. *Pediatr Infect Dis J.* 1996 Oct;15(10):859-65.
- Sandoval, J., Slas, J., Martinez-Guerra, M.L., Gomez, A., Martinez, C., Portales, A., Palomar, A., Villegas, M., and Barrios, R. 1993. Pulmonary Arterial Hypertension and Cor Pulmonale Associated with Chronic Domestic Woodsmoke Inhalation. *Chest* 103:12-20.
- Sehlstedt, M., Dove, R., Boman, C., Pagels, J., Swietlicki, E., Löndahl, J., Westerholm, R., Bosson, J., Barath, S. & Behndig, A.F. , 2010. Antioxidant airway responses following experimental exposure to wood smoke in man. *Particle and Fibre Toxicology* 7: 21.
- Sexton, K., Liu, K. S., Treitman, R. D., Spengler, J. D., and Turner, W. J., 1986. Characterization of indoor air quality in woodburning residences. *Environ. Int.* 12:265-278.
- Straif et al., 2006. International Agency for Research on Cancer, 2010. Household Use of Solid Fuels and High-temperature Frying. *Monograph* 95: 1475-2011.
- Szalar, A. 1972. *The Use of Time: Daily activities of urban and suburban populations in twelve countries.* The Hague: Mouton
- Torres-Duque C, Maldonado D, Perez-Padilla R, et al, 2008. Biomass fuels and respiratory diseases: a review of the evidence. *Proc Am. Thorac. Soc.* 5: 577–590.
- Triche, E. W., Belanger, K., Bracken, M. B., Beckett, W. S., Holford, T. R., Gent, J. F., McSharry, J. E., and B.P. Leaderer, 2005. Indoor heating sources and respiratory symptoms in nonsmoking women. *Epidemiology* 16:377–384.
- Ward T, Palmer C, Bergauff M, Hooper K, Noonan C. 2008. Results of a residential indoor PM_{2.5} sampling program before and after a woodstove changeout. *Indoor Air.* 2008 Oct;18(5):408-15.
- Ward TJ, Palmer CP, Noonan CW. 2010. Fine particulate matter source apportionment following a large woodstove changeout program in Libby, Montana. *J Air Waste Manag Assoc.* 2010 Jun;60(6):688-93.

- Ward T, Boulafentis J, Simpson J, Hester C, Moliga T, Warden K, Noonan C. 2011. Lessons learned from a woodstove changeout on the Nez Perce Reservation. *Sci Total Environ.* 2011 Jan 15;409(4):664-70. Epub 2010 Dec 7.
- Ward TJ, Palmer CP, Houck JE, Navidi WC, Geinitz S, Noonan CW. 2009. Community woodstove changeout and impact on ambient concentrations of polycyclic aromatic hydrocarbons and phenolics. *Environ Sci Technol.* 2009 Jul 15;43(14):5345-50.
- Yu, O., Sheppard, L., Lumley, T., Koenig, J. Q., and G.G Shapiro, 2000. Effects of ambient air pollution on symptoms of asthma in Seattle-area children enrolled in the CAMP study. *Environ. Health Perspect.* 108:1209–1214.
- Zelikoff, J.T., 2002. The Toxicology of Inhaled Woodsmoke. *Journal of Toxicology & Environmental Health, Part B*, 5:269-282.

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APPENDIX D: PM_{2.5} CONTROL EFFICIENCY AND COST EFFECTIVENESS OF CERTAIN RESIDENTIAL WOOD COMBUSTION CONTROL MEASURES

APPLIANCE	MEASURE	CONTROL EFFICIENCY*	ESTIMATED COST EFFECTIVENESS (2012 \$/ton) except where noted	DESCRIPTION/NOTES/CAVEATS
Fireplaces	Use EPA Phase 2 Qualified Units	70%	\$9,500**	If new fireplace construction is allowed, approve only EPA Phase 2 qualified models. Under the EPA Wood-burning Fireplace Program, cleaner wood-burning fireplaces are qualified when their PM _{2.5} emissions are at or below the Phase 2 PM _{2.5} emissions level. For a list of Phase 2 qualified cleaner burning fireplaces, go to: http://www.epa.gov/burnwise/fireplacelist.html .
Fireplaces	Use Gas Logs in Existing Wood-burning Fireplaces	100%	\$11,000	Incentives by various air districts in CA have helped retrofit thousands of open fireplaces to gas log sets. In addition to vented gas log sets, the option exists to install vented gas stove inserts into a wood-burning fireplace. Unlike gas logs, which provide little heat, a gas stove insert can be an efficient and clean way to heat a room. The cost per ton of PM _{2.5} reductions will likely be greater as gas stove inserts cost more than gas log sets.
Fireplaces	Install Retrofit Devices into Existing Wood-burning Fireplaces	70%	\$9,500	Provide incentives to encourage use of fireplace retrofit devices. Under the EPA Wood-burning Fireplace Program, retrofit devices are qualified when their PM _{2.5} emissions are at or below the program Phase 2 PM _{2.5} emissions level. For a list of Phase 2 qualified retrofits, go to: http://www.epa.gov/burnwise/fireplacelist.html .

ESTIMATED COST EFFECTIVENESS				
APPLIANCE	MEASURE	CONTROL EFFICIENCY*	(2012 \$/ton) except where noted	DESCRIPTION/NOTES/CAVEATS
Hydronic Heaters (OWHH, OWB)	Install Cleaner Wood-burning Hydronic Heaters vs. Old Technology	90%	\$740	If hydronic heaters are allowed, only allow EPA Phase 2 qualified models. A Partnership Agreement (PA) is in place between EPA and wood-burning hydronic heater manufacturers. Under this PA, cleaner burning hydronic heaters are qualified at or below the Phase 2 particulate emissions level. For a list of Phase 2 qualified hydronic heaters go to: http://www.epa.gov/burnwise/owhlist.html .
Hydronic Heaters (OWHH, OWB)	Install Retrofit Devices in Existing Hydronic Heaters	60%	\$980	Provide incentives to encourage the installation of hydronic heater retrofit devices. Retrofits may significantly reduce and even eliminate visible smoke emissions. This measure should be accompanied by education and outreach (e.g., burn only dry seasoned wood).
Wood Stoves	Wood to Wood Replacement Program	60%	\$9,900 (2010\$)	Implement a program and provide incentives to replace old uncertified wood stoves with new EPA-certified wood stoves. Education on proper wood stove use (e.g., burn only dry wood) and maintenance is critical. See for more info: http://www.epa.gov/burnwise/how-to-guide.html .
Wood Stoves	Wood to Gas Replacement Program	99%	\$7,200 (2010\$)	Implement an incentive program to replace old, uncertified wood stoves with new gas stoves or gas logs. Incentives to switch to a wood pellet stove are another good option. See for more info: http://www.epa.gov/burnwise/how-to-guide.html .

ESTIMATED COST EFFECTIVENESS				
APPLIANCE	MEASURE	CONTROL EFFICIENCY*	(2012 \$/ton) except where noted	DESCRIPTION/NOTES/CAVEATS
Fireplaces, Hydronic Heaters, Wood Stoves	Curtailement Program ("Burn Ban")	75%	\$8,700 (2010\$) Full curtailement	State and local air quality agencies forecast next day air quality levels. When it is expected to be near or above the 24-hr PM _{2.5} NAAQS, limited (e.g., wood pellet only) or full curtailement of wood burning is required. A public awareness campaign and enforcement are critical.
Fireplaces, Hydronic Heaters, Wood Stoves	Burn Dry Seasoned Wood	n/a	n/a	Implement a program to allow only the sale of and/or burning of dry seasoned wood (e.g., <20% moisture content) in wood-burning appliances.
Fireplaces, Hydronic Heaters, Wood Stoves	No Visible Emissions	n/a	n/a	Implement a local program that allows no visible wood smoke. This option is typically easier to enforce/implement than an opacity program..
Fireplaces, Hydronic Heaters, Wood Stoves	Opacity Program	n/a	n/a	Limit wood smoke emissions by establishing a mandatory opacity limit.
Wood Combustion Appliances	Education Campaign	n/a	n/a	Focus the Campaign on Best Burning Practices, such as those contained on the EPA Burn Wise web site: http://www.epa.gov/burnwise/burnwisekit.html .

* Control efficiency applies to an individual residential wood combustion (RWC) appliance, except for the curtailment program where it applies to the entire local area. Inferences about adequate environmental protection should not be made from these control efficiencies.

**Indicates incremental cost of installing a Phase 2 qualified RWC appliance instead of a non-Phase 2 RWC appliance.

Other pollutants controlled by all measures may include: carbon dioxide, volatile organic compounds, carbon monoxide, methane, toxics, and black carbon. To review the input and assumptions into these calculations, go to: [www.epa.gov/burnwise/Control Strategies Documentation.xlsx](http://www.epa.gov/burnwise/Control%20Strategies%20Documentation.xlsx)

United States

Office of Air Quality Planning and Standards

Publication No. **EPA-456/B-13-001**

Environmental Protection

Outreach and Information Division

March 2013

Agency

Research Triangle Park, NC
