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TECHNICAL INFORMATION DOCUMENT FOR RESIDENTIAL WOOD COMBUSTION BEST AVAILABLE CONTROL MEASURES

U.S. Environmental Protection Agency
Office of Air and Radiation
Office of Air Quality Planning and Standards
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Disclaimer

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SECTION 1.0

INTRODUCTION

1.1 PURPOSE OF THIS DOCUMENT

The purpose of this document is to provide technical information for the development of best available control measure (BACM) strategies for residential wood combustion (RWC) in areas that are designated serious nonattainment for PM-10 (particles with an aerodynamic diameter less than or equal to a nominal 10 micrometers). The information is needed by States to develop control strategies for their serious PM-10 nonattainment area State implementation plan (SIP) submittals.

Note that while the guidance presented herein lists available measures which the Environmental Protection Agency (EPA) is recommending as BACM, and is intended to be comprehensive, it is by no means exhaustive. It also does not establish any binding requirements. Consequently, the State is encouraged to consider other sources of information and is not precluded from selecting other measures and demonstrating to the public and EPA that they constitute BACM.

1.2 STATUTORY BACKGROUND

1.2.1 Designations

Section 107(d) of the Clean Air Act (Act), as amended in 1990, provides generally for the designation of areas of each State as attainment, nonattainment or unclassifiable for each pollutant for which there is a national ambient air quality

standard (NAAQS). Certain areas meeting the qualifications of section 107(d)(4)(B) of the amended Act were designated nonattainment for PM-10 by operation of law upon enactment of the 1990 Amendments to the Act (initial PM-10 nonattainment areas). A Federal Register notice announcing all of the areas designated nonattainment for PM-10 at enactment and classified as moderate was published on March 15, 1991 (56 FR 11101). A follow-up notice correcting some of these area designations was published August 8, 1991 (56 FR 37654). The boundaries of the nonattainment areas were formally codified in 40 CFR Part 81, effective January 6, 1992 (56 FR 56694, November 6, 1991). All those areas of the country not designated nonattainment for PM-10 at enactment were designated unclassifiable [see section 107(d)(4)(B)(iii) of the amended Act].

1.2.2 Classifications

Once an area is designated nonattainment, section 188 outlines the process for classification of the area. In accordance with section 188(a), at the time of designation, all PM-10 nonattainment areas are initially classified as moderate by operation of law. A moderate area can subsequently be reclassified as a serious nonattainment area under two general conditions. First, EPA has general discretion under section 188(b)(1) to reclassify a moderate area as a serious area at any time the Administrator of EPA determines the area cannot practicably attain the NAAQS by the statutory attainment date for moderate areas. Second, under section 188(b)(2) a moderate area is reclassified as serious by operation of law after the statutory attainment date has passed if the Administrator finds that the area has not attained the NAAQS. The EPA must publish a Federal Register notice identifying the areas that have failed to attain and were reclassified, within 6 months following the attainment date [see section 188(b)(2)(B)].

Section 188(b)(1)(A) mandates an accelerated schedule by which EPA is to reclassify appropriate initial PM-10 nonattainment areas. The EPA proposed on November 21, 1991 (56 FR 58656) to reclassify 14 of the 70 initial moderate areas as serious. The final decision to reclassify the areas proposed will be based on the criteria utilized in the proposal, comments received in response to the proposal and on information in the moderate area SIP's that were due on November 15, 1991 for each of the areas.

In the future, EPA anticipates that, generally, any proposal to reclassify an initial PM-10 nonattainment area before the attainment date will be based on the State's demonstration that the NAAQS cannot practicably be attained in the area by December 31, 1994 [the statutory attainment date specified in section 188(c)(1) for initial PM-10 nonattainment areas].

In addition to EPA's general authority under section 188(b)(1) to reclassify as serious any area the Administrator determines cannot practicably attain the PM-10 NAAQS by the applicable date, for areas designated nonattainment for PM-10 subsequent to enactment of the 1990 Amendments, subparagraph (B) of section 188(b)(1) mandates that appropriate areas are to be reclassified as serious within 18 months after the required date for the State's submission of a moderate area SIP.[1] Taken together with the statutory requirement that PM-10 SIP's are due within 18 months after an area is designated nonattainment [see section 189(a)(2)(B)], the statute thus requires that EPA reclassify appropriate moderate areas as serious within 3 years of the nonattainment designation.

Any decision by EPA to reclassify such a future nonattainment area as serious will be based on facts specific

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[1]This directive does not restrict EPA's general authority but simply specifies that it must be exercised, as appropriate, in accordance with certain dates.

to the nonattainment area at issue and will only be made after providing notice in the Federal Register and an opportunity for public comment on the basis for EPA's proposed decision.

1.2.3 Serious Area Attainment Dates

The amended Act specifies that the initial moderate nonattainment areas (those designated nonattainment upon enactment of the 1990 Amendments) reclassified to serious are to attain the PM-10 NAAQS as expeditiously as practicable but no later than December 31, 2001. Areas designated nonattainment subsequent to enactment that are reclassified as serious must attain the PM-10 NAAQS as expeditiously as practicable but not later than the end of the tenth calendar year after the area's designation as nonattainment [see section 188(c)(2)].

1.2.4 Key Serious Area SIP Requirements

As discussed above, States must develop and submit SIP's providing for the attainment of the PM-10 NAAQS for every area designated nonattainment and classified as moderate or serious for PM-10 under the amended Act. New revisions must be made to the PM-10 SIP in accordance with section 189(b) of the amended Act for areas that are reclassified as serious nonattainment areas. First, provisions must be adopted to assure that BACM (including BACT) will be implemented in the area [see section 189(b)(1)(B)]. Second, a demonstration (including air quality modeling) must be submitted showing that the plan will attain the NAAQS either by the applicable attainment date or, if an extension is granted under section 188(e), by the most expeditious alternative date practicable [see section 189(b)(1)(A)].

The SIP revisions to require the use of BACM must be submitted to EPA within 18 months after an area is reclassified as serious [see section 189(b)(2)]. The BACM are

to be implemented no later than 4 years after an area is reclassified [see section 189(b)(1)(B)].

The serious area attainment demonstration required under section 189(b)(1)(A) must be submitted to EPA within 4 years after an area is reclassified based on a determination by EPA that the area cannot practicably attain by the statutory deadline for moderate areas. It is due within 18 months after an area is reclassified for actually having failed to attain by the moderate area attainment date [see section 189(b)(2)].

1.2.5 RACM and BACM Issuance

Section 190 of the amended Act requires EPA to issue technical guidance for RACM and BACM no later than 18 months from enactment of the 1990 Amendments to the Act for three PM-10 source categories: urban fugitive dust, RWC, and prescribed silvicultural and agricultural burning. In conjunction with publication of the "General Preamble for Title I of the Clean Air Act Amendments of 1990," EPA discharged the section 190 requirement to issue RACM technical guidance for each of these three source categories [57 FR 13541, April 16, 1992; 57 FR 18070, April 28, 1992]. The General Preamble provides a policy for how to utilize the available RACM technical guidance to develop area-specific RACM strategies. For RWC, the available RACM technical guidance cited is the existing RWC control measure document issued by EPA in September 1989, "Guidance Document for Residential Wood Combustion Emission Control Measures" (referred to as "RWC Guidance Document" in this document, see Ref. 1). As frequently suggested in this document, the 1989 RWC document should be consulted for background information on the available measures described in this document.

The issuance of this RWC BACM technical guidance document (and its fugitive dust and prescribed burning companion documents), together with EPA's previous issuance of RACM technical guidance, wholly fulfills EPA's statutory obligation

to issue RACM and BACM technical guidance for urban fugitive dust, RWC, and prescribed silvicultural and agricultural burning under section 190 of the amended Act. Similar to the manner in which EPA provided guidance on Act requirements applicable to moderate PM-10 nonattainment areas in the General Preamble, including a policy or how to utilize the RACM technical guidance documents, the EPA is planning to provide guidance on Act requirements and provisions applicable to serious PM-10 nonattainment areas, including BACM, in an addendum to the General Preamble. [EPA made a draft of the addendum available for public comment on July 16, 1992 (57 FR 31477).] The portion of the addendum that addresses BACM provides a policy for how to utilize today's RWC BACM technical guidance (and companion technical guidance for control of fugitive dust and prescribed burning) to develop area-specific BACM strategies.

The information contained in this document was obtained, in large part, from the input and expertise of a task force assembled in December 1990. The task force met several times in 1991 and consisted of representatives from Federal, State, and local agencies involved in the control of residential wood combustion (see Appendix A).

The measures described in this document represent what the task force believes are the most effective measures for controlling PM-10 from RWC. Thus, not all the measures described in the 1989 "RWC Guidance Document" are included in this document because the task force did not regard them as "most effective."

1.3 DOCUMENT ORGANIZATION

1.3.1 Available Control Measures for RWC BACM

The available measures for RWC BACM recommended in the document are divided into two types (see Table 1-1 below): integral measures in column A and flexible measures in columns B-D. The suggested integral measures are measures

that are regarded as critical for the success of RWC control programs in PM-10 nonattainment areas. The integral measures, though, are not, by themselves, intended to ensure long-term attainment of PM-10 NAAQS by serious areas. These measures are described in section 2.0 of this document.

The flexible measures (described in section 3.0 of this document) are intended to provide for long-term attainment of the PM-10 NAAQS and reduce the need for short-term episodic controls. The flexible measures are listed in three categories (columns B-D of Table 1-1): (1) Measures That Reduce or Eliminate Emissions From Existing Installations, (2) Measures That Reduce Emissions or Prevent Emission Increases From New Installations, and (3) Measures that Reduce Emissions From New and Existing Installations. The measures are listed in the categories only to show what emissions they impact and not because this guidance recommends serious areas adopt a certain measure or measures per se from each column.

1.3.2 RWC BACM Economic Feasibility Methodology

Section 4.0 provides a methodology that the implementing or lead planning agency should employ to assess the economic feasibility of the available measures described in sections 2.0 and 3.0. The methodology consists of an approach for estimating the emissions reductions and costs associated with each measure.

TABLE 1-1. MEASURES AVAILABLE FOR RWC BACM

A INTEGRAL MEASURES	B FLEXIBLE MEASURES THAT REDUCE OR ELIMINATE EMISSIONS FROM EXISTING INSTALLATIONS	C FLEXIBLE MEASURES THAT REDUCE EMISSIONS OR PREVENT EMISSION INCREASES FROM NEW INSTALLATIONS	D FLEXIBLE MEASURES THAT REDUCE EMISSIONS FROM NEW AND EXISTING INSTALLATIONS
1. Public awareness and education.	1. Conversion of existing wood-burning fireplaces to gas logs.	1. Gas fireplaces or gas logs in new wood burning fireplace installations.	1. Device offset.
2. Mandatory curtailment during predicted periods of high PM-10 concentrations.	2. Changeover to EPA-certified, Phase II stoves or equivalent.	2. Upgrade offset.	2. Upgrade offset.
3. All new stove installations EPA-certified, Phase II stoves or equivalent.	3. Changeover to low emitting stoves.	3. Restriction on number and density of new wood-burning stove and/or fireplace installations.	
4. Measures to improve wood burning performance: - control of wood moisture content - weatherization of homes with wood stoves - educational opacity program		4. Requirement that new stove installations be low emitting.	

References

1. U.S. Environmental Protection Agency, Guideline Series. "Guidance Document for Residential Wood Combustion Emission Control Measures." EPA-450/2-89-015. September 1989.

SECTION 2.0

INTEGRAL MEASURES AVAILABLE FOR RESIDENTIAL WOOD COMBUSTION BACM

This section provides guidance on the suggested integral measures for RWC BACM. The measures are regarded as critical for the success of RWC control programs. The measures, however, are not intended, by themselves, to result in long-term attainment of the PM-10 NAAQS for serious PM-10 nonattainment areas.

A background discussion of each of the integral BACM measures is available in the EPA "RWC Guidance Document." The following subsections explain the purpose of each integral measure and recommend an effective strategy for their implementation.

2.1 PUBLIC AWARENESS AND EDUCATION

As the "RWC Guidance Document" explains, public awareness and education (PAE) is critical for the success of RWC emission control programs. The BACM PAE program should serve to inform the public about the RWC control program, (including program operational details, program justification and citizen responsibilities); and persuade and convince them to meet their responsibilities under the RWC control program.

The PAE program should address the following three areas:

- Program Effectiveness and Tracking;
- Key PAE Program Elements; and
- Communication Strategy.

Section 2 of the "RWC Guidance Document" provides details on existing PAE programs.

2.1.1 Program Effectiveness and Tracking

The PAE program should be designed to educate the public effectively on the reason for controlling RWC emissions, as well as on the mechanics of controlling these emissions. The PAE program should also be tailored to the community's attitudes toward wood heating, their wood burning habits and patterns, and the extent and nature of the air quality problem. This information should be obtained by conducting a survey of the community's residents. The survey's findings should give implementing or lead planning agency officials an indication of how to tailor the PAE program to the community.

In addition, a follow-up survey should be conducted to assess the effectiveness of the PAE program on the parameters measured in the initial survey and to adjust the program accordingly as necessary. Additional information on assessing public attitudes and program effectiveness are provided in sections 2.1, 2.4, and 2.5 of the "RWC Guidance Document."

2.1.2 Key Public Awareness and Education Program Elements

The local implementing or lead planning agency should provide sufficient resources and staff to develop a PAE program that educates the public about:

- the health risks of wood smoke;
- proper wood-burning operation and maintenance;
- relevant State, local and EPA regulations;
- heating fuels and practice; and
- available stove types, including their relative "in-home" field testing emissions for PM-10 and relative efficiencies.

More information on PAE program elements is contained in section 2.2 of the "RWC Guidance Document."

2.1.3 Communication Strategy

In a PAE program, the local implementing or lead planning agency should provide sufficient resources and staff to communicate the PAE elements to the public through all three types of media: print, broadcast, and public contact. (Section 2.3 of the "RWC Guidance Document" discusses each of these media at length.) An effective PAE program should include: (1) extensive public contact through events such as stove fairs and school assemblies; (2) the use of print media, including newspaper and brochures; and (3) the use of public service announcements for radio and television. Specific detail on a "High Level of Effort" PAE program is contained in section 2.4.3 of the "RWC Guidance Document."

2.2 MANDATORY CURTAILMENT PROGRAM

The purpose of wood smoke curtailment programs is to restrict wood burning during periods when atmospheric conditions and the level of wood burning activity result in ambient concentrations of wood smoke in excess of the NAAQS for PM-10. The curtailment program should include the following components:

- Public Awareness;
- Forecasting and Prediction;
- Public Notification;
- Exemptions;
- Enforcement; and
- Tracking.

The curtailment program should be implemented in a staged fashion, where the wood burning restrictions are less severe at lower predicted PM-10 concentrations. The implementing or lead planning agency administering the curtailment program should establish a two-stage curtailment program with two action points for determining when to call for restrictions on wood burning. One action point should trigger the implementation of Stage I voluntary curtailment (or mandatory

with exemptions) and the other should trigger Stage II mandatory curtailment (with only low-income exemptions).

This guidance does not prescribe specific action points for a BACM curtailment program. The action points selected, though, should be low enough to provide for attainment of the PM-10 NAAQS and the Stage I action point should be lower than the Stage II. Table 5-2 of the "RWC Guidance Document" presents several sets of action points which are part of existing RWC curtailment programs and section 5 of the "RWC Guidance Document" provides details on establishing wood-burning curtailment programs.

2.2.1 Public Awareness

The implementing or lead planning agency should conduct an ongoing public awareness program to educate the public on the elements discussed in section 5.1.3.1 of the "RWC Guidance Document," which includes the health threat of wood smoke and how the RWC control program will function. Those elements should be communicated to the public in three formats. One, the implementing or lead planning agency should have staff and resources available to answer questions and disseminate information on these elements. Two, the implementing or lead planning agency should have mechanisms for mass media communication which include issuing frequent press releases and purchasing time on local radio and TV stations for public service announcements. And, three, personal public contact should also be established and maintained through, for example, town meetings and local school presentations.

2.2.2 Forecasting and Prediction

The purpose of this component is to establish the capabilities to predict when high PM-10 concentrations will occur so that the implementing or lead planning agency can call a curtailment ban when necessary to avert a potential NAAQS exceedance. To be able to predict NAAQS exceedances,

the implementing or lead planning agency should have access to a meteorologist who has local forecasting capabilities and should have a negotiated agreement with the National Weather Service or other qualified entity to provide timely information on meteorological conditions. In addition, the implementing or lead planning agency should have ready-access to real-time air quality data via telemetry. During the wood burning season, both the forecasting information and monitoring data should be available 24-hours per day.

2.2.3 Public Notification

This component concerns the minimum requirements for notifying the public that a curtailment ban is in effect. The implementing or lead planning agency should have the ability to notify the media promptly in the event that curtailment is required, and, if necessary, the resources to pay for media announcements to ensure adequate notification. The implementing or lead planning agency should provide sufficient notice of the ban to allow burners time to shut down before the ban goes into effect. A 24-hour hot-line should be created with recorded messages on current curtailment activities and requirements. Notification should be made via all three public information media (as described in section 5.2 of the "RWC Guidance Document").

2.2.4 Exemptions

In Stage I, the implementing or lead planning agency should allow exemptions for EPA-certified stoves or

equivalent,[1] wood stoves at residences where wood combustion is the sole source of heat, and wood stoves in low-income households. In Stage II, exemptions should be limited to low income households, but not for houses where wood is sole source of heat.

The implementing or lead planning agency should have a mechanism in place for publicizing the need to apply for an exemption and sufficient staff and resources to process and maintain exemption records. Wood burners requesting any exemption should be required to swear to their status (as it qualifies them for an exemption) in an affidavit and permit their premises to be inspected to verify their status. Exemptions for sole-source wood burners should be sunsetted after a reasonable period of time.

2.2.5 Enforcement

The purpose of this component is to ensure compliance with the curtailment program. The implementing or lead planning agency should commit to maintaining a curtailment enforcement plan and resources to ensure compliance during Stage II curtailment. Table 5-9 of the "RWC Guidance Document" discusses the necessary elements for an effective mandatory curtailment enforcement program. Table 5-7 of the "RWC Guidance Document" also contains reported effectiveness

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[1]Equivalent is defined as RWC devices for which "in-home" field testing data are available, document emissions equivalent to or less than "in-home" field test emissions of EPA-certified, Phase II stoves. See memorandum clarifying nature of RWC guidance and describing procedure for entities seeking emission reduction credit for RWC devices not certified by EPA but which can demonstrate comparable or lower emissions through field testing. Process includes consultation with EPA's Office of Research and Development on appropriate in-use testing methods and procedures (Ref. 1). For example, EPA has recently reviewed in-home field data for certain masonry stoves tested during the 1991/92 heating season and has accepted the resultant emissions data for use in SIP-related activities (Ref. 2).

levels for curtailment programs achieved in practice as high as 90 percent.

2.2.6 Tracking

The tracking component measures how effective the curtailment program is at achieving compliance. The implementing or lead planning agency should commit to conducting periodic tracking studies to determine the level of compliance with the burn ban. A statistically-valid method should be used for conducting field compliance tracking surveys of RWC users and there should be periodic evaluations of the forecasting method. Lastly, reporting and record keeping should be required to obtain data on enforcement efforts and on the number of burn ban days called.

2.3 MEASURES TO IMPROVE WOOD BURNING PERFORMANCE

The recommended integral measures should include measures to reduce wood smoke emissions from RWC through improving wood burning operation and maintenance practices and modifying wood burning conditions. These include:

- controlling wood moisture content;
- weatherizing homes that contain RWC devices; and
- establishing an opacity limit program.

2.3.1 Control of Wood Moisture Content

The purpose of this measure is to promote the burning of drier wood in wood stoves and fireplaces to reduce PM-10 emissions. Its main thrust should be educational. The implementing or lead planning agency should educate the public on the benefits for the wood burner and the community's air quality of burning only well-seasoned, dry wood. To achieve this goal, moisture content checks should be available to the public at convenient locations during convenient hours. Educational materials should also be made available that (1) describe proper wood splitting and storage techniques to

ensure wood is properly seasoned before burning, and (2) provide information on the benefits of burning hardwoods versus softwoods (i.e., greater heat content, etc.).

In addition, if wood sold by wood dealers does not have sufficient time to "dry-out" before the heating season (i.e., if it is sold, for instance, in the fall), then the program should require wood dealers to have their wood "certified" for moisture content prior to sale to ensure the wood can be properly seasoned before burning. Upon request, the dealer should then present the certificate of moisture content to consumers purchasing wood to verify the wood is dry enough to be burned. Fines should be imposed on wood dealers who sell wood that is not certified.

Section 3.5.2 of the "RWC Guidance Document" provides more detail on measures limiting wood moisture content, including examples of existing wood moisture ordinances.

2.3.2 Weatherization of Homes with Wood Stoves

The purpose of the weatherization program is to improve the energy efficiencies of homes burning wood in stoves for heat so that less wood is burned and, hence, PM-10 emissions are lower. Under a weatherization program, the implementing or lead planning agency should explain to the public the rationale for improving the energy efficiency of wood-burning homes by making the public aware that energy-efficient homes require less wood and hence reduced fuel costs for the homeowner.

Energy audits should be arranged by the implementing or lead planning agency or performed itself. Low-income homes would probably have the greatest need for weatherization and hence should be the focus of a financial incentive program. Financial incentives could include low-interest loans, cash grants, and tax credits.

Discussion of weatherization is provided in section 3.6 of the "RWC Guidance Document."

2.3.3 Educational Opacity Program

The goal of this measure is to identify RWC device operation and maintenance habits that contribute to visible emissions of wood smoke and to correct the problem. The implementing or lead planning agency should first educate the public that visible emissions are an indicator of completeness of burn and then send opacity inspectors to the field to perform opacity readings of chimneys.[2] Wood burners of homes with high opacity should be targeted for education and consultation to determine and eliminate the cause of the visible emissions. In addition, a consultation with a qualified chimney sweep should be required to educate the high opacity wood burner on proper wood stove operation and maintenance and examine the wood burners' stove and flue systems. The consultation should include tips such as an "acid wash" that is available to clean clogged catalysts and hence extend their lives.

Repeat opacity violators who do not correct the source of the high visible emissions after consultation and recommendations on how to correct the problem should be required to attend a class on how to operate and maintain a wood stove properly. More information on this measure is contained in section 3.7 of the "RWC Guidance Document."

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[2]Since the intent of this measure is corrective and not punitive, the document does not prescribe specific opacity reading methods and procedures or opacity limits but leaves that flexibility to the implementing or lead planning agency.

2.4 ALL NEW WOOD STOVE INSTALLATIONS[3] EPA-CERTIFIED, PHASE II STOVES OR EQUIVALENT

This integral measure recommends that stoves not be allowed to be installed which are (1) not certified by EPA to Phase II emission limits or (2) cannot document (through "in-home" field testing data) emissions equivalent to or less than "in-home" field test emissions of EPA-certified Phase II stoves.[4] The intent of this requirement is to prevent the sale or resale and installation of non-EPA-certified stoves and the resale and installation of used EPA-certified Phase I stoves. The program should require that when homeowners intend to install a new or used wood stove, they file a form with the implementing or lead planning agency and swear in an affidavit that the stove is EPA-certified to Phase II emission limits. The implementing or lead planning agency should be responsible for processing the forms and affidavits and checking the brand name of the proposed stove installation against a list of EPA-certified, Phase II stoves (and their equivalents). Properly trained and qualified inspection personnel should conduct random surveys of stoves in homes to confirm compliance.

The implementing or lead planning agency should make the public aware of the requirement for stove certification, the

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[3]New installations should include both "brand-new" stoves and fireplaces and "new-used" units (i.e., newly purchased units that are not "brand-new").

[4]See memorandum clarifying nature of RWC guidance and describing procedure for entities seeking emission reduction credit for RWC devices not certified by EPA but which can demonstrate comparable or lower emissions through field testing. Process includes consultation with EPA's Office of Research and Development on appropriate in-use testing methods and procedures (Ref. 1). For example, EPA has recently reviewed in-home field data for certain masonry stoves tested during the 1991/92 heating season and has accepted the resultant emissions data for use in SIP-related activities (Ref. 2).

need to file a form and affidavit, and which stove types are certified. The local building code should also be modified to prohibit the installation of non-EPA-certified, Phase II stoves. All installations should be performed by trained and certified installers to ensure the performance of the new stove (see section 3.3 of the "RWC Guidance Document" for a discussion of installation quality assurance).

Discussion of this integral measure is provided in section 3.2.3 of the "RWC Guidance Document."

References

1. Memorandum. Renner, Fred H., Acting Chief, SO_2/Particulate Matter Programs Branch, Air Quality Management Division, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, to Chief, Air Branch, Regions I-X, U.S. Environmental Protection Agency. "Interpretation of EPA's Guidance for Residential Wood Combustion Emission Control Measures." September 23, 1991.

2. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Compilation of Air Pollutant Emission Factors (AP-42), Research Triangle Park, North Carolina (masonry stove data to be published).

SECTION 3.0

FLEXIBLE MEASURES AVAILABLE FOR RESIDENTIAL WOOD COMBUSTION BACM

This section provides guidance on the flexible available measures that are designed to provide permanent control of RWC emissions and hence long-term attainment of the PM-10 NAAQS. As with section 2.0, a background discussion of each of the measures described in this section are available in the "RWC Guidance Document." The following sections discuss the purpose of the flexible measures and effective implementation strategies.

3.1 EMISSIONS REDUCTION OR ELIMINATION - EXISTING INSTALLATIONS

This section discusses the measures that result in an emission reduction or elimination of emissions from existing stove and fireplace installations.

3.1.1 Conversion of Existing Wood-Burning Fireplaces to Gas Logs

This measure eliminates wood smoke emissions from existing fireplaces by requiring conversion to "gas log"-type fireplaces that use either natural or propane gas. As indicated in section 4.1.2 of the "RWC Guidance Document," gas-log fireplaces are commonly used to replace wood combustion in both zero clearance and masonry types of wood-burning fireplaces.

The implementing or lead planning agency should establish a conversion deadline and publicize the requirement to the community. The conversion process should be accelerated by requiring conversion following transfer of real estate or re-leasing of a rental unit. Before the new homeowner or renter can obtain municipal services, the homeowner or landlord should be required to file a form with the implementing or lead planning agency indicating whether any wood-burning fireplaces are located in the home. If so, then the homeowner or landlord should be required to have the home inspected to verify, within a certain period of time after the re-lease or transfer, that the fireplace has been converted or the flue sealed.

For homes not transferred or re-leased prior to the conversion deadline, the implementing or lead planning agency should encourage the homeowner or landlord to file for an exemption if no wood-burning fireplace are present or to have the premises inspected to verify conversion or seal of flue. As an incentive for homeowners or landlords to file for an exemption or submit to an inspection, the implementing or lead planning agency should add a "noncompliance fee" to a municipal service bill. To have the fee removed, the homeowner or landlord should have to comply with the conversion requirements. The noncompliance period should be reasonable in length but not so long as to prevent the area from meeting any control strategy implementation dates and other milestones required under the amended Act.

After a certain period of time, the fee should expire and it should become a violation of the law to operate a wood-burning fireplace. The implementing or lead planning agency should then follow-up with random surveys of homes by properly trained and qualified personnel to ensure compliance.

In addition, the fireplace conversion should be enforced as well through a zero percent opacity limit for those homes required to convert. By requesting forms and affidavits to

verify conversions, the implementing or lead planning agency should have an accurate inventory of the homes subject to the zero percent opacity limit.

3.1.2 Changeover to EPA-Certified, Phase II Stoves or Equivalent

This measure reduces emissions from existing wood stoves by accelerating the replacement of conventional[1] stoves with EPA-certified, Phase II stoves or equivalent[2]. New installations should include both "brand-new" stoves and fireplaces and "new-used" units (i.e., newly purchased units that are not "brand new"). Section 3.4 of the "RWC Guidance Document" discusses the advanced design and technology stoves available and the mechanisms areas have used to achieve stove changeover.

The implementing or lead planning agency should establish a conversion deadline and publicize the requirement to the community. The conversion process should be accelerated by requiring conversion upon transfer of real estate or re-leasing of rental units. Before the homeowner can close on a

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[1]Any stove that is not EPA-certified that burns cord wood should be included as stoves to be converted, except for wood-burning stoves that document (through "in-home" field testing) emissions equivalent to or lower than the "in-home," field test emissions of EPA-certified, Phase II stoves (see footnote 2).

[2]Equivalent is defined as RWC devices for which "in-home" field testing data are available that document emissions equivalent to or less than "in-home" field test emissions of EPA-certified, Phase II stoves. See memorandum clarifying nature of RWC guidance and describing procedure for entities seeking emission reduction credit for RWC devices not certified by EPA but which can demonstrate comparable or lower emissions through field testing. Process includes consultation with EPA's Office of Research and Development on appropriate in-use testing methods and procedures (Ref. 1). For example, EPA has recently reviewed in-home field data for certain masonry stoves tested during the 1991/92 heating season and has accepted the resultant emissions data for use in SIP-related activities (Ref. 2).

real estate transfer or a landlord re-lease a rental unit, the home should be inspected to verify either removal of the conventional stove and sealing of flue or installation of an EPA-certified, Phase II stove or equivalent. The conventional stove should be surrendered to the implementing or lead planning agency or its agent to be destroyed in a manner in accordance with any Federal, State, or local laws governing disposal of hazardous or potentially hazardous substances (i.e., creosote). The homeowner or landlord can file for an exemption from the changeover requirement (i.e., swear in an affidavit that the residence contains no wood stoves) and thus be freed from the inspection requirement. All installations should be performed by a trained and certified installer to enhance the emissions performance of the new stove (see section 3.3 of the "RWC Guidance Document" provides information on installation quality assurance).

For homes not transferred or re-leased prior to the conversion, the implementing or lead planning agency should encourage the homeowner or landlord to file for an exemption or have the premises inspected prior to the conversion deadline. As an incentive to obtain early compliance, the implementing or lead planning agency should add a "noncompliance fee" to a municipal service fee. To have the fee removed, the homeowner should have to comply with the conversion requirements. The noncompliance period should be reasonable in length but not so long as to prevent the area from meeting any control strategy implementation dates and other milestones required under the amended Act.

After a certain period of time, the fee should expire and it should then become a violation of the law to operate a non-EPA-certified stove within the nonattainment area. The implementing or lead planning agency should then follow-up with random surveys of homes by trained and qualified personnel to ensure compliance. In addition, the implementing

or lead planning agency can enhance enforcement of the changeout through an opacity limit program.

Sections 3.4.5 and 3.4.6 of the "RWC Guidance Document" discuss accelerated changeover requirements and inducements.

3.1.3 Changeover to Low-Emitting Devices

This measure is virtually identical to the changeover measure described above in section 4.1.2, except that the changeover is recommended to a "low-emitting" device (EPA-certified or otherwise) that can document "in-home" field test emissions less than the emission factor averages of "in-home" field test emissions data for EPA-certified stoves (Ref. 2). This can include classes of devices that are demonstrated to be capable as a class of producing lower field emissions, as well as specific model units that perform better in the field than the class collectively.

Key elements of the measure are the same as the EPA-certified, Phase II stove changeover measure and include a changeover deadline, a conversion acceleration vehicle, a conversion deadline, a survey of affected homes to ensure compliance, and, for further enforcement, the use of an opacity limit program. The conventional or non-EPA-certified stoves should be surrendered to the implementing or lead planning agency or its agent to be destroyed in a manner in accordance with any Federal, State, or local laws governing disposal of hazardous or potentially hazardous substances (i.e., creosote). Finally, all installations should be performed by trained and certified installers to ensure the performance of the new stove (see section 3.3 of the "RWC Guidance Document" for a discussion of installation quality assurance).

3.2 EMISSION REDUCTION OR EMISSION INCREASE PREVENTION -- NEW INSTALLATIONS[3]

This section discusses the measures that can be undertaken by a implementing or lead planning agency to reduce emissions or to prevent emissions increases resulting from the growth of new stove or fireplace installations.

3.2.1 Gas Fireplaces or Gas Logs for New Wood-Burning Fireplace Installations

The purpose of this measure is to eliminate wood smoke emissions from new wood-burning fireplace installations by requiring an alternate fuel, natural gas, or propane. Under this measure, the implementing or lead planning agency should establish a regulatory requirement that allows only gas fireplaces or gas logs in new fireplace installation in either new or existing housing units and educates builders, developers, and homeowners about the restriction.

When the premises are inspected for conformity with the building code, the building inspector should specifically inspect the fireplace units to ensure they are only either natural gas or propane-fired, not wood burning. Any fireplace in violation of the regulation would have to be converted before the builder or homeowner could receive an approval from the building department that the dwelling complies with the building code. Section 4.2 of the "RWC Guidance Document" discusses some existing RWC control program limit new RWC devices.

3.2.2 Upgrade Offset

The purpose of this measure is to prevent emission increases from new stove installations by requiring enough

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[3]New installations should include both "brand-new" stoves and fireplaces and "new-used" units (i.e., newly-purchased units that are not "brand new").

existing conventional stoves to be upgraded to offset any increase in emissions resulting from the proposed installation of new EPA-certified, Phase II stoves or equivalent[4]. The ratio of upgrades to new stoves should be based on the relative emissions of the devices as reflected in the emission reduction credits discussed in Appendix F of the "RWC Guidance Document" as updated (see Appendix B).

Key elements of this measure are an affidavit requirement, a permit or registration system, installation quality assurance, and enforcement activity. The implementing or lead planning agency should require that the existing stove owner participating in the transaction surrender the old conventional stove to the implementing or lead planning agency or its agent to be destroyed in a manner in accordance with any Federal, State, or local laws governing disposal of hazardous or potentially hazardous substances (i.e., creosote) and register or file a permit for the new stove. For the new stove owner, the implementing or lead planning agency should require a permit or registration form verifying participation in the program. The transaction should be overseen by the implementing or lead planning agency to ensure that it is bona fide. In addition, the implementing or lead planning agency should require that the installation be performed by a trained and certified installer (see section 3.3 of the "RWC Guidance

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[4]Equivalent is defined as RWC devices for which "in-home" field testing data are available that document emissions equivalent to or less than "in-home" field test emissions of EPA-certified, Phase II stoves. See memorandum clarifying nature of RWC guidance and describing procedure for entities seeking emission reduction credit for RWC devices not certified by EPA but which can demonstrate comparable or lower emissions through field testing. Process includes consultation with EPA's Office of Research and Development on appropriate in-use testing methods and procedures (Ref. 1). For example, EPA has recently reviewed in-home field data for certain masonry stoves tested during the 1991/92 heating season and has accepted the resultant emissions data for use in SIP-related activities (Ref. 2).

Document" provides information on installation quality assurance).

3.2.3 Restriction on Number and Density of New Wood-Burning Stove and/or Fireplace Installations

The purpose of this measure is to limit RWC emissions growth by restricting the number and density of new RWC device installations--stove and fireplace--in new and existing housing units. Under this measure, the implementing or lead planning agency should establish a building code requirement restricting both the number and types of new RWC devices. The implementing or lead planning agency should inform builders, developers, and homeowners of this requirement to prevent installations in violation of the regulátion.

This provision should require that stove and fireplace dealers provide an evidence of sale form to the implementing or lead planning agency for each stove and fireplace purchased and that information on stove and fireplace restrictions be made available to the purchaser at the time of purchase. The dealers should provide the evidence of sale forms to the agency in a timely manner and the agency should enforce the requirement through a system of warnings and fines. The stoves should also be installed by a trained and certified installer (see section 3.3 of the "RWC Guidance Document" for information on installation quality assurance).

Upon receiving a record-of-sale form, the implementing or lead planning agency should inform the homeowner of the stove or fireplace installation number and density restrictions. To install the new stove or fireplace, the builder or homeowner should have to file a registration form or permit with the implementing or lead planning agency and obtain building code approval.

3.2.4 Requirement that New Wood Stove Installations be Low-Emitting

This measure limits RWC emissions growth by requiring that all new installations be low-emitting stoves, which is a device (EPA-certified or otherwise) that can document "in-home" field test emissions less than the emission factor averages of "in-home" field test emissions data for EPA-certified stoves (Ref. 2). This can include classes of devices that are demonstrated to be capable as a class of producing lower field emissions, as well as specific model units that perform better in the field than the class collectively.

Under this measure, the implementing or lead planning agency should establish a building code provision requiring that all new stoves be low-emitting. The measure should function similar to the number and density restriction measures described in section 4.2.3 above. Additionally, in its PAE program, the implementing or lead planning agency should publicize the list of certified devices that qualify as low-emitting so that the public can understand what stoves can and cannot be installed in the serious PM-10 nonattainment area.

3.3 EMISSION REDUCTION -- NEW[5] AND EXISTING WOOD STOVE INSTALLATIONS

This section discusses two measures--device and upgrade offsets--that the implementing or lead planning agency can undertake to achieve emission reductions in offset transactions beyond the emission reduction necessary to merely offset emission increases from new wood stoves.

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[5]New installations should include both "brand-new" stoves and fireplaces and "new-used" units (i.e., newly purchased units that are not "brand new").

3.3.1 Device Offset

When implemented, this measure is intended to achieve an emissions reduction associated with retiring existing conventional stoves that is greater than the emissions increase resulting from new stove installations. The device offset should require that for every new EPA-certified, Phase II stove installation, an appropriate number of existing conventional stoves be retired and destroyed (see Appendix B). The ratio of stoves removed to new stoves should be based on the relative emissions of the devices as reflected in the emission reduction credits discussed in Appendix F of the "RWC Guidance Document" as updated (see Appendix B). Given that a wood burner willing to retire his or her stove probably did not use the stove, this measure should be limited to participants who rely on wood as a sole source of heat and who are also low-income.

Key elements of this measure are an affidavit requirement, a permit or registration system, installation quality assurance, and enforcement activity. The implementing or lead planning agency should require that the existing stove owner participating in the transaction surrender the old conventional stove to the implementing or lead planning agency or its agent to be destroyed in a manner in accordance with any Federal, State, or local laws governing disposal of hazardous or potentially hazardous substances (i.e., creosote). The existing stove owner should also register or permit the new stove with the implementing or lead planning agency. For the new stove owner, the implementing or lead planning agency should require a permit or registration form documenting participation in the program. The transaction should be documented and overseen by the implementing or lead planning agency to ensure that it is bona fide. Furthermore, the implementing or lead planning agency should require that the installation be performed by a trained and certified

installer (see section 3.3 of the "RWC Guidance Document" provides details on installation quality assurance).

3.3.2 Upgrade Offset

This measure is intended to achieve emission reductions from new stove installations by requiring enough existing conventional stoves to be upgraded to more than offset any increase in emissions resulting from the proposed installation of new EPA-certified, Phase II stoves or equivalent[6]. The ratio of upgrades to new stoves should be based on the relative emissions of the devices as reflected in the emission reduction credits discussed in Appendix F of the "RWC Guidance Document" as updated (see Appendix B).

The implementation of this measure should be similar to the upgrade offset measure described in section 3.3.1 of this document. Key elements of this measure are an affidavit requirement, a permit or registration form system, installation quality assurance, and enforcement activity. The implementing or lead planning agency should require that the existing stove owners participating in the transaction surrender the old conventional stove to the implementing or lead planning agency or its agent to be destroyed in a manner in accordance with any Federal, State, or local laws governing disposal of hazardous or potentially hazardous substances

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[6]Equivalent is defined as RWC devices for which "in-home" field testing data are available that document emissions equivalent to or less than "in-home" field test emissions of EPA-certified, Phase II stoves. See memorandum clarifying nature of RWC guidance and describing procedure for entities seeking emission reduction credit for RWC devices not certified by EPA but which can demonstrate comparable or lower emissions through field testing. Process includes consultation with EPA's Office of Research and Development on appropriate in-use testing methods and procedures (Ref. 1). For example, EPA has recently reviewed in-home field data for certain masonry stoves tested during the 1991/92 heating season and has accepted the resultant emissions data for use in SIP-related activities (Ref. 2).

(i.e., creosote). The existing stove owner should also register or permit the new stove with the implementing or lead planning agency. For the new stove owner, the implementing or lead planning agency should require a permit or registration form indicating participation in the program. The transaction should be documented and overseen by the implementing or lead planning agency to ensure that it is bona fide. Furthermore, the implementing or lead planning agency should require that the installation be performed by a trained and certified installer (see section 3.3 of the "RWC Guidance Document" provides details on installation quality assurance).

References

1. Memorandum. Renner, Fred H., Acting Chief, SO_2/Particulate Matter Programs Branch, Air Quality Management Division, Office of Air Quality Planning and Standards, U.S. Environmental Protection Agency, Research Triangle Park, North Carolina, to Chief, Air Branch, Regions I-X, U.S. Environmental Protection Agency. "Interpretation of EPA's Guidance for Residential Wood Combustion Emission Control Measures." September 23, 1991.

2. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Compilation of Air Pollutant Emission Factors (AP-42), Research Triangle Park, North Carolina (masonry stove data to be published).

SECTION 4.0

RWC BACM ECONOMIC FEASIBILITY METHODOLOGY

4.1 INTRODUCTION

This methodology is provided to enable serious PM-10 nonattainment areas to assess the economic feasibility of the measures described in sections 2.0 and 3.0 of this document. Specifically, this section provides a methodology for estimating the cost and emission reduction effectiveness of each available integral and flexible measure. The methodology does not provide specific data for agency and user costs associated with each measure since they are largely area-specific in nature and, hence, should be obtained locally. For example, full-time employee (FTE) costs will vary from area-to-area, as will fuel costs and the purchase and installation costs for RWC devices.

4.2 INTEGRAL MEASURES

4.2.1 Public Awareness and Education

Emission Reduction Calculations:

As a general rule, no emissions reductions are generally associated with this measure, though a public awareness and education (PAE) program is vital to the overall success of any RWC control program. It is typically very difficult to ascertain and quantify specific emission reductions that result from this program. Therefore, no emission reduction methodology is given for this measure.

Cost Calculations:

The cost of implementing a BACM PAE program is more easily quantified and consists of the amount of time an FTE should spend to administer the program, plus any other costs such as radio, newspaper, and television advertising; establishment of an information hotline; education seminars; and the like. The equations necessary to quantify these costs are given below.

$$A \times B = C$$

where:

A = annual time for FTE to administer program, fraction
B = annual cost for an FTE, $
C = annual cost for FTE, $/year

The annual cost obtained above, C, is then added to the total cost of other program facets (e.g., advertising, hotlines, education seminars, etc.) to obtain the total annual cost.

$$C + D = E$$

where:

D = total annual cost of other program facets, $/year
E = total annual cost for PAE program, $/year

4.2.2 Mandatory Curtailment Program

Emission Reduction Calculations:

Unlike other RWC control measures in which PM-10 emission reductions are calculated on an annual basis, emission reductions from episodic curtailment are calculated on both an annual and worst case 24-hour basis. This is because episodic curtailment is fundamentally a measure designed to reduce 24-hour emissions and, over the course of the heating season, implementation of this measure will also reduce annual emissions simply due to the cumulative effect of multiple 24-hour reductions. Therefore, reductions on an annual and worst case 24-hour basis are calculated below.

Annual curtailment emissions are calculated based on the fraction of heating degree days (HDD) occurring during curtailment episodes divided by total HDD for the year multiplied by total yearly emissions.

The first step in this procedure is to calculate annual PM-10 emissions during the exceedance months using the following formula:

$$A \times B/C = D$$

where:

A = Annual baseline PM-10 RWC emissions, tons per year (tpy)
B = Heating degree days during exceedance days
C = Annual heating degree days
D = Annual emissions of PM-10 during all exceedance days, tpy

The emission reductions are calculated as:

$$D \times E = F$$

where:

E = emission reduction credit level, fraction
F = annual emissions reductions, tons PM-10 removed/year

Worst-case 24-hour emission reductions are calculated in a similar manner:

$$D_{24\text{-hour}} \times E = F_{24\text{-hour}}$$

where:

$D_{24\text{-hour}}$ = worst case 24-hour PM-10 emission, tons per day
$F_{24\text{-hour}}$ = 24-hour emission reductions, tons, PM-10 removed/day

Cost Calculations:

The costs of implementing this program are calculated on both an annual and 24-hour basis. These costs are divided into costs incurred by the implementing agency and the user. The annual costs to the implementing agency are largely a function of the effort necessary to enforce and administer effectively a curtailment program. The costs of a curtailment

program to the wood stoves and fireplace user are the costs associated with heating through an alternative source. These two cost elements (implementing agency and user) are determined separately as follows:

Implementing Agency Cost Calculations: The annual cost of implementing a BACM program may be calculated by the formula below:

$$G \times H = I$$

where:

G = curtailment program cost, $/stove and fireplace curtailment day
H = number of curtailment days per year
I = annual cost, $/year

The 24-hour implementing agency cost is obtained by simply dividing the annual cost, I, by the number of curtailment days per year, K.

$$I/K = J_{24\text{-hour}}$$

where:

$J_{24\text{-hour}}$ = 24-hour implementing agency incremental BACM cost, $/day
K = number of curtailment days per year

User Cost Calculations: The annual cost of the program for a stove user is based on an average cost incurred for each curtailment day. This estimate accounts for the daily cost of an alternative heating system on curtailment days. No costs to a fireplace user are estimated, since fireplaces are not intended to be used as a source of heat.

$$L_o = M \times K$$

where:

L_o = average annual cost to each nonexempt stove user for the curtailment period, $/year
M = average cost to stove user per curtailment day, $/day

The average cost to each stove user per curtailment day, M, may be difficult to precisely calculate. A methodology for estimating this cost follows.

First, the cost of wood burning on curtailment days needs to be calculated. This is estimated in a two-step process. The first step yields the annual fuel cost to the wood stove owner as follows:

$$AC = Cd \times Ct$$

where:

AC = annual fuel cost to the wood stove owner, $/year
Cd = average number of cords burned in wood stoves, cords/year
Ct = average cost of a cord of wood, $/cord

This annual cost, AC, is then multiplied by the fraction of heating degree days during exceedance months divided by the annual heating degree days [(B/C), as calculated above], to obtain annual fuel costs during the curtailment period. This product is then divided by the number of curtailment days per year to obtain the fuel costs per curtailment day:

$$FCD = [AC \times (B/C)]/K$$

where:

FCD = fuel cost per curtailment day, $/day

The cost of alternative fuels needs to then be calculated. This is based on the cost of obtaining an identical heat output (i.e., heat input x efficiency) from an alternative heating system. Therefore, the heat output from a "typical" wood stove needs to be obtained. A "typical" wood stove will vary from area-to-area, depending on the composition of the stove population. Generally, surveys can be performed to estimate the typical heat output of wood stoves for a given area. The energy input into a typical wood stove per curtailment day is based on the wood usage per day, which in turn, is obtained from the annual wood usage as follows:

$$DEI = [Cd \times EC \times (B/C)]/K$$

where:

DEI = daily energy input into typical wood stove, British thermal unit (Btu)/day
EC = energy content of a cord of wood, Btu/cord

This value, DEI, is then multiplied by the wood stove system efficiency to obtain the heat output on a daily basis.

DHO = DEI x WSE

where:

DHO = daily heat output of wood stove, Btu/day
WSE = typical wood stove efficiency, fraction

The daily heat output, DHO, can then be used to obtain the daily heat input requirements of an alternative system as follows.

DHR = DHO/n

where:

DHR = daily heat input requirement for alternative system, Btu/day
n = alternative system efficiency, fraction

The daily cost of this quantity of heat input is a function of the type of alternative system in the home (e.g., natural gas or propane heater, electric heat, etc.). The cost of alternative heat on Btu basis [or kilowatt hour (kWh) basis for electricity] can be obtained from local gas or electric companies. If electricity is used as the alternative heat, the energy units in Btu's must be converted to kWh as follows:

9.486×10^{-4} Btu = 2.778×10^{-7} kWh

As an example, the conversion of 100,000 Btu to kWh would be calculated as:

100,000 Btu x $(2.778 \times 10^{-7}$ kWh$)/(9.486 \times 10^{-4}$ Btu) = 29.3 kWh

The fuel cost on a per day basis is then the difference between the alternative heating system fuel costs and the wood stove fuel heating costs as shown below:

M = (DHR x AEC) - FCD

where:

DHR = daily heating requirement for alternative heat source, Btu/day
AEC = alternative energy cost, $/Btu

The 24-hour cost to the stove user is simply M as defined above.

4.2.3 Measures to Improve Wood Burning Performance

4.2.3.1 Control of Wood Moisture Content.

Emission Reduction Calculations:

This measure reduces RWC emissions by promoting the burning of drier wood. It is difficult to accurately quantify either emission reductions or costs from this measure due to factors that will necessarily vary from area to area. However, the guidance document for residential wood combustion ("RWC Guidance Document") recommends that a maximum credit of 5 percent of baseline emissions be allowed for areas implementing this measure (Ref. 1). For purposes of this document, a 5 percent credit is assumed. This credit can be calculated according to the formula below:

$$A \times 0.05 = B$$

where:

A = RWC annual baseline emissions, tons per year
B = emissions reductions from control of wood moisture, tons per year

Cost Calculations:

In areas where this measure is not included in any pre-serious area control strategy, the full cost of instituting this measure would be incurred. The cost to the implementing agency would include the purchase of wood moisture monitors and various administrative and educational charges. The cost to the RWC owner would include the time and effort necessary to ensure the wood burned falls within an acceptable moisture content range.

4.2.3.2 Weatherization of Homes with Wood Stoves.

Emission Reduction Calculations:

The "RWC Guidance Document" suggests a credit for a weatherization program (Ref. 2). The emission reductions from this measure are calculated using the formula below:

$$A \times B = C$$

where:

A = RWC annual baseline emissions, tons per year
B = emission reduction credit
C = emission reductions from weatherization, tons per year

Cost Calculations:

For this measure, the annual implementing agency costs are assumed to equal the product of the average cost of weatherizing a home multiplied by the number of homes weatherized per year. There are minimal or no user costs assumed for this measure since it is intended to target low income households.

Implementing Agency Cost Calculations: Total costs for this program are the product of the number of homes weatherized multiplied by the average cost to weatherize each home as shown below:

$$D \times E = F$$

where:

D = average cost to weatherize a home, $
E = number of homes weatherized per year
F = cost of weatherization program, $/year

A community may prefer to defer weatherization costs and implement the program over a longer time period as prescribed by EPA. In that instance, the cost of the weatherization program should be amortized over that period.

Amortizing purchases is quite common and most people have experience with this through car and house purchases. The technique described below is a amortizing method which yields equal payments incurred by the borrower over the life of the finance period. The amortization factor is called the capital recovery factor and is calculated as follows:

$$CRF = [i/12(i + i/12)^n]/[(1 + i/12)^n - 1]$$

where:

CRF = capital recovery factor, decimal
i = annual real interest rate, decimal
n = length of finance time, months

As an example, the CRF can be calculated using a 10 percent real interest rate and a 10-year time period (i.e., 120 months):

$$CRF = [0.1/12\ (1 + 0.1/12)^{120}]/[(1 + 0.1/12)^{120} - 1] = 0.01322$$

This factor should be multiplied by the purchase cost to obtain the monthly payment over the length of the finance time:

$$E \times CRF = G$$

where:

G = implementing agency monthly payment for program, $

The monthly payment multiplied by 12 then yields the annual cost to the implementing agency:

$$F \times 12 = Cm$$

where:

Cm = annual cost to implementing agency, $/year

4.2.3.3 Educational Opacity Program.

Emission Reduction Calculations:

This measure reduces PM-10 emissions through an educational program identifying operation and maintenance habits contributing to visible emissions. It is difficult to accurately quantify the emission reductions or costs from this measure due to lack of measurable parameters. Therefore, a low credit (i.e., a maximum of 5 percent of baseline emissions) is recommended in the "RWC Guidance Document" (Ref. 3). For purposes of this document, the following formula can be used to estimate emission reductions from this measure:

$$A \times 0.05 = B$$

where:

A = RWC baseline emissions, tons per year
B = emission reductions from educational opacity, tons per year

Cost Calculations:

In areas where this measure is not included in any pre-serious area control strategies, the full cost of instituting this measure would be incurred, which would include opacity enforcement checks, public education forums and seminars, and related items.

4.2.4 All New Wood Stove Installations EPA-certified, Phase II Stoves or Equivalent

Emission Reduction Calculations:

Annual emission reductions are based upon the number of installations that occur in a given year of non-EPA-certified, Phase II stoves (or equivalent). The emission reductions are calculated based on the emission reduction credit associated with the conversion of a conventional to an EPA-certified, Phase II stove (or equivalent). These reductions can be calculated using the formula below:

$$(A \times B_1 \times B_2 \times C \times D)/(454 \times 2{,}000) = E$$

where:

A = number of new installations of used, non-EPA-certified, Phase II stoves (or equivalent) per year
B_1 = emission reduction credit[1] from conventional to Phase II or equivalent, decimal (Ref. 4)
B_2 = conventional wood stove emission factor, (Ref. 5) g/Kg
C = average cords of wood burned in each stove per year, cords/year
D = wood density, kg/cord
E = annual emissions reductions from this measure, tpy

[1]The credit should reflect the types of stoves it is assumed would be installed in the absence of the restriction (e.g., conventional stoves and EPA-certified, Phase I stoves).

454 = conversion factor, grams to pounds, g/lb
2,000 = conversion factor, pounds to tons, lb/ton

Cost Calculations:

Implementing Agency Cost Calculations: To administer and enforce effectively this program, some cost will be incurred. These costs may be estimated based on the amount of time an FTE would spend to administer and enforce this program each year. This cost can be estimated using the formula below:

$$F \times G = H$$

where:

F = time for an FTE to administer program, fraction
G = annual cost for an FTE, $/year
H = implementing Agency cost, $/year

User Cost Calculations: To calculate the incremental cost to each stove user, the purchase and installation costs of an EPA-certified, Phase II stove (or equivalent) and of a conventional stove need to be obtained from local wood stove dealers. The cost of the conventional stove is subtracted from the cost of an EPA-certified, Phase II stove (or equivalent). This cost difference is assumed to be financed over a period of time by the stove buyer. This requires that these costs be "amortized" by a numerical factor based on the length of the finance period and the interest rate. The technique described below is a amortizing method which yields equal payments incurred by the borrower over the life of the finance period. Amortizing purchases is quite common and most people have experience with this through car and house purchases. This amortization factor is called the capital recovery factor and is calculated as follows:

$$CRF = [i/12(i + i/12)^n]/[(1 + i/12)^n - 1]$$

where:

CRF = capital recovery factor, decimal
i = annual real interest rate, decimal
n = length of finance time, months

As an example, the CRF can be calculated using a 10 percent real interest rate and a 10-year length of time (i.e., 120 months):

$$CRF = [0.1/12\ (1 + 0.1/12)^{120}]/[(1 + 0.1/12)^{120} - 1] = 0.01322$$

This factor multiples the purchase cost to obtain the monthly payment over the length of the finance time:

$$I \times CRF = J$$

where:

I = differential purchase and installation cost of stove, $
J = monthly payment, $/month

The monthly payment multiplied by 12 then yields the annual cost:

$$J \times 12 = Co$$

where:

Co = annual cost to stove owner, $/year.stove

4.3 FLEXIBLE AVAILABLE MEASURES

4.3.1 Emission Reduction or Elimination - Existing Installations

4.3.1.1 Conversion of Existing Wood Burning Fireplaces to Gas Logs.

Emission Reduction Calculations:

Annual emission reductions are based on the number of wood-burning fireplaces converting to gas logs per year. The first step is to obtain the number of fireplaces that will convert to gas logs under this measure for a given implementation period. This implementation period is determined by the circumstances under which the nonattainment area is reclassified to serious. This is done using the formula given below:

$$(A/X) = B$$

where:

A = number of existing fireplaces for baseline year
X = implementation period of available measure, years
B = annual number of fireplaces converting to gas logs

The emission reductions from this measure can then be calculated as follows:

$$(B \times D \times E \times F)/(454 \times 2{,}000) = G$$

where:

D	=	fireplace emission factor, (Ref. 6) g/kg wood burned
E	=	average wood usage in one fireplace, cords/year
F	=	average wood density, kg/cord
G	=	annual emission reductions from this measure, tpy
454	=	conversion factor, grams to pounds, g/lb
2,000	=	conversion factor, pounds to tons, lb/ton

Cost Calculations:

Implementing Agency Cost Effectiveness Calculations: To administer and enforce effectively the program, some costs will be incurred. These costs may be estimated based on the amount of time an FTE would spend to administer and enforce the program each year. This cost can be estimated using the following formula:

$$H \times I = J$$

where:

H	=	time for an FTE to administer program, decimal
I	=	annual cost for an FTE, $/year
J	=	annual implementing agency cost, $/year

User Cost Calculations : The costs to the fireplace user are based upon two components. The first is the conversion cost of a conventional fireplace to gas logs, and the second is the difference in annual energy costs between wood and natural gas.

The cost to convert a conventional fireplace to a gas log fireplace will vary from community to community, but is not typically a big expense. The local gas company and local wood stove and fireplace dealers should be contacted to obtain this cost. Since this amount is not large, it is assumed the user will not finance this cost.

The energy cost difference between wood and natural gas is calculated assuming the fireplace usage (i.e., hours used

per year) between a conventional and gas fireplace will not vary. The fireplace usage can be calculated as shown below:

$$(E \times F)/K = L$$

where:

K = fireplace burn rate, (Ref. 7) kg wood/hour
L = fireplace usage, hours/year

The amount of natural gas consumed during this time period is then calculated as follows:

$$L \times M = N$$

where:

M = natural gas fireplace consumption rate, Btu/hour
N = energy consumption of natural gas fireplace, Btu/year

The annual cost difference between natural gas and wood is then calculated as shown below. The cost of natural gas can be obtained from the local gas company, while the cost of wood can be obtained from wood stove dealers or local classified advertisements.

$$(E \times O) - (N \times P) = Q$$

where:

O = cost of a cord of wood, $/cord
P = cost of natural gas, $/Btu
Q = annual cost difference between natural gas and wood, $/year

The total annual cost of the user is then the difference of these two cost components:

$$R - Q = Co$$

where:

Co = annual user cost $/year
R = cost to convert a conventional fireplace, $

4.3.1.2 Changeover to EPA-Certified, Phase II Stoves or Equivalent.

Emission Reduction Calculations:

Annual emission reductions from this measure are based upon the number of conventional and non-EPA-certified stoves that convert annually to EPA-certified, Phase II stoves (or equivalent) minus the number of EPA-certified, Phase II stoves presently in the stove inventory. The number of stoves annually converting to EPA-certified, Phase II stoves (or equivalent) is determined by the total number of stoves that will convert over the allowed implementation period.

To calculate the emission reductions that would occur through implementation of this measure, the formula below can be used:

$$[(A/X) \times B_1 \times B_2 \times C \times D]/(454 \times 2000) = E$$

where:

A	=	number of affected stoves
B_1	=	emission reduction credit from conventional to Phase II or equivalent, decimal (Ref. 8)
B_2	=	conventional stove emission factor, (Ref. 9) g/Kg wood burned
C	=	average cords of wood burned in each wood stoves per year
D	=	wood density, kg/cord
E	=	emissions reductions from this measure, tpy
X	=	implementation period, years
454	=	conversion factor, grams to pounds, g/lb
2,000	=	conversion factor, pounds to tons, lb/ton

Cost Calculations:

Implementing Agency Cost Calculations: To effectively administer and enforce this program, some cost will be incurred. These costs may be estimated based on the amount of time an FTE would spend to administer and enforce this program each year. This cost can be estimated using the formula below:

$$F \times G = H$$

where:

F	=	time for an FTE to administer program, fraction
G	=	annual cost for an FTE, $/year
H	=	implementing agency cost, $/year

User Cost Calculations: To calculate the cost to each stove user, the purchase and installation cost of an EPA-certified, Phase II stove (or equivalent) needs to be obtained from local wood stove dealers. For purposes of this analysis, it is assumed that the stove buyer will finance the purchase and installation cost over a period of time. This requires that these costs be "amortized" by a numerical factor based on the length of the finance period and the interest rate. The technique described below is an amortization method which yields equal payments incurred by the borrower over the life of the finance period. Amortizing purchases is quite common and most people have experience with this through car and house purchases. This amortization factor is called the capital recovery factor and is calculated as follows:

$$CRF = [i/12(i + i/12)^n]/[(1 + i/12)^n - 1]$$

where:

CRF = capital recovery factor, decimal
i = annual real interest rate, decimal
n = length of finance time, months

As an example, the CRF can be calculated using a 10 percent real interest rate and a 10-year length of time (i.e., 120 months):

$$CRF = [0.1/12\ (1 + 0.1/12)^{120}]/[(1 + 0.1/12)^{120} - 1] = 0.01322$$

This factor multiples the purchase cost to obtain the monthly payment over the length of the finance time:

$$I \times CRF = J$$

where:

I = purchase and installation cost of stove, $
J = monthly payment, $/month

The monthly payment multiplied by 12 then yields the annual cost:

$$J \times 12 = Co$$

where:

Co = annual cost to stove owner, $/year·stove

4.3.1.3 Changeover to Low-Emitting Devices.

Emission Reduction Calculations:

Annual emission reductions from this measure are based upon the number of conventional and non-EPA-certified stoves annually converting to low-emitting stoves minus the number of low-emitting stoves presently existing. The number of stoves annually converting to low-emitting is determined by the total number of stoves that will convert over the allowed implementation period.

To calculate the emission reductions that would occur through implementation of this measure, the formula below can be used:

$$[(A/X) \times B_1 \times B_2 \times C \times D]/(454 \times 2000) = E$$

where:

A	=	baseline number of conventional or Oregon 1986 certified stoves
B_1	=	emission reduction credit from conventional to low-emitting stove, decimal (Ref. 10)
B_2	=	conventional stove emission factor, (Ref. 11) g/Kg wood burned
C	=	average cords of wood burned in each wood stoves per year
D	=	wood density, kg/cord
E	=	emissions reductions from this measure, tpy
X	=	implementation period, years
454	=	conversion factor, grams to pounds, g/lb
2,000	=	conversion factor, pounds to tons, lb/ton

Cost Calculations:

Implementing Agency Cost Calculations: To administer and enforce effectively this program, some cost will be incurred. These costs may be estimated based on the amount of time an FTE would spend to administer and enforce this program each year. This cost can be estimated using the formula below:

$$F \times G = H$$

where:

F	=	time for an FTE to administer program, fraction
G	=	annual cost for an FTE, $/year
H	=	Implementing Agency cost, $/year

User Cost Calculations: To calculate the cost to each stove user, the purchase and installation cost of a low-emitting stove needs to be obtained from local wood stove dealers. For purposes of this analysis, it is assumed that the stove buyer will finance the purchase and installation cost over a period of time. This requires that these costs be "amortized" by a numerical factor based on the length of the finance period and the interest rate. The technique described below is an amortization method which yields equal payments incurred by the borrower over the life of the finance period. Amortizing purchases is quite common and most people have experience with this through car and house purchases. This amortization factor is called the capital recovery factor and is calculated as follows:

$$CRF = [i/12(i + i/12)^n]/[(1 + i/12)^n - 1]$$

where:

CRF = capital recovery factor, decimal
i = annual real interest rate, decimal
n = length of finance time, months

As an example, the CRF can be calculated using a 10 percent real interest rate and a 10-year length of time (i.e., 120 months):

$$CRF = [0.1/12\ (1 + 0.1/12)^{120}]/[(1 + 0.1/12)^{120} - 1] = 0.01322$$

This factor multiples the purchase cost to obtain the monthly payment over the length of the finance time:

$$I \times CRF = J$$

where:

I = purchase and installation cost of stove, $
J = monthly payment, $/month

The monthly payment multiplied by 12 then yields the annual cost:

$$J \times 12 = C_{o,s}$$

where:

$C_{o,s}$ = annual purchase and installation cost to stove owner, $/year·stove

To obtain the total costs to the user, the difference in fuel costs assuming an identical heat input between a conventional and low-emitting stove per year needs to be calculated (this example assumes a pellet stove for a low-emitting device). The first step is to calculate the amount of heat input to a conventional stove per year.

$$C \times K = L$$

where:

K = heat content of wood, (Ref. 12) 10^6 Btu/cord
L = heat input to conventional stove, 10^6 Btu/year

The amount of pellet fuel this heat input represents is then calculated as shown below.

$$K/(0.008 \times 2{,}000) = L$$

where:

0.008 = heat content of pellet fuel, (Ref. 13) 10^6 Btu/lb
2,000 = conversion factor, pounds to tons, lb/ton
L = tons pellet fuel consumed per year, ton/year

The cost difference between pellet fuel and wood is then calculated. The cost of pellet fuel and wood can be obtained through local wood stove dealers or through classified advertisements.

$$(L \times M) - (B \times N) = O$$

where:

M = cost of pellet fuel, $/ton
N = cost of wood, $/cord
O = annual cost difference between pellet fuel and wood, $/year

This cost is then added to $C_{o,s}$ to obtain the total annual user cost, C_o.

$$C_{o,s} + O = C_o$$

where:

C_o = total annual user cost, $/year

4.3.2 Emission Reduction or Emission Increase Prevention - New Installations

4.3.2.1 Gas Fireplaces or Gas Logs in New Fireplace Installations.

Emission Reduction Calculations:

Annual emission reductions are based on the growth rate of fireplaces in the absence of regulations, assuming all new fireplaces installed are fueled by wood. The calculations to obtain the emission reductions are given below. First, the number of new gas logs and fireplaces installed per year needs to be calculated as shown below.

$$A \times B = C$$

where:

A = annual wood-burning fireplace growth rate in absence of regulation
B = current wood-burning fireplace population
C = number of new wood-burning fireplaces installed per year in absence of regulation

The number of wood-burning fireplaces not installed annually due to this regulation is then assumed to equal C, the number of wood-burning fireplaces installed per year in the absence of regulation. The emission reductions obtained from this measure are then calculated as follows:

$$(C \times D \times E \times F)/(454 \times 2{,}000) = G$$

where:

D = fireplace emission factor, (Ref. 14) g/kg wood burned
E = average wood usage in one fireplace, cords/year
F = average cord density, kg/cord
G = annual emission reductions, tons/year
454 = conversion factor, grams to pounds, g/lb
2,000 = conversion factor, pounds to tons, lb/ton

Cost Calculations:

Implementing Agency Cost Calculations: To administer and enforce effectively the program, some costs will be incurred. These costs may be estimated based on the amount of time an FTE would spend to administer and enforce the program each year. This cost can be estimated using the following formula:

$$H \times I = J$$

where:

H = time for an FTE to administer program, decimal
I = annual cost for an FTE, $/year
J = annual implementing agency cost, $/year

User Cost Calculations: The costs to the user are based upon two components. The first is the difference in the purchase and installation cost of gas logs or gas fireplaces and the purchase and installation cost of a conventional, wood-burning fireplace which could not be installed under this regulation. These cost items can be obtained through local wood stove dealers. This difference is assumed to be financed over the length of the home mortgage, since this cost is usually included with the rest of home purchase cost.

The second cost to the user is the difference in energy costs between gas and wood. This cost difference is based on the amount of time a conventional fireplace would be used over the course of the year. The calculations to obtain both of these costs are given below.

First, the cost difference between a gas fireplace and wood fireplace is calculated.

$$K - L = M$$

where:

K = cost of natural gas fireplace, $
L = cost of wood fireplace $
M = differential cost between gas and wood fireplace, $

The differential cost is the amortized over the length of the mortgage (which is typically 15 to 30 years) to obtain the annual differential cost, L. This is calculated using an amortization factor called the capital recovery factor. This requires that these costs be "amortized" by a numerical factor based on the length of the finance period and the interest rate. The technique described below is a amortization method which yields equal payments incurred by the borrower over the life of the finance period. Amortizing purchases is quite common and most people have experience with this through car

and house purchases. This amortization factor is called the capital recovery factor and is calculated as follows:

$$CRF = [i/12(i + i/12)^n]/[(1 + i/12)^n - 1]$$

where:

CRF = capital recovery factor, decimal
i = real interest rate, decimal
n = length of finance time, months

As an example, the CRF can be calculated using a 10 percent real interest rate and a 10-year length of time (i.e., 120 months):

$$CRF = [0.1/12\ (1 + 0.1/12)^{120}]/[(1 + 0.1/12)^{120} - 1] = 0.01322$$

This factor multiplies the differential purchase cost, L, to obtain the monthly payment over the length of the finance time:

$$M \times CRF = N$$

where:

N = monthly payment, $/month

The monthly payment multiplied by 12 the yields the annual cost for this cost component.

$$N \times 12 = O$$

where:

O = annual cost differential between gas and wood and wood fireplace, $/year

The next step is to calculate the energy cost difference on an annual basis. This is obtained based on the amount of time a fireplace is used and the corresponding natural gas and wood usage during this time. First, the annual hours a conventional fireplace is used is calculated.

$$(E \times F)/P = Q$$

where:

P = fireplace burn rate, (Ref. 15) kg wood/hour
Q = fireplace usage, hours/year

The amount of natural gas consumed during this time period is then calculated as follows:

$$Q \times R = S$$

where:

R = natural gas fireplace consumption rate, Btu/hour
S = energy consumption of natural gas fireplace, Btu/year

The annual cost difference between natural gas and wood is then calculated as shown below. The cost of natural gas can be obtained through the local gas company, while the cost of wood can be found in classified advertisements, or through wood stove dealers.

$$(E \times T) - (S \times U) = V$$

where:

T = cost of a cord of wood, $/cord
U = cost of natural gas, $/Btu
V = annual cost difference between natural gas and wood, $/year

The total annual cost to the user is then the sum of these two cost components:

$$O + V = C_o$$

where:

C_o = annual user cost, $/year

4.3.2.2 Upgrade Offset.

Emission Reduction Calculations:

The purpose of this measure is to prevent emission increases due to an increase in wood stove population. As such, this measure does not reduce wood stove emissions and, therefore, emission reductions are considered negligible. An emission reduction calculation for this measure is therefore not performed. However, the cost incurred by the implementing agency and by the user can be estimated using the steps described below.

Cost Calculations:

Implementing Agency Cost Calculations: To administer effectively this program, some costs will be incurred. These costs may be estimated based on the amount of time an FTE

would spend to administer and enforce this program each year. This cost can be estimated using the formula below:

$$E \times F = G$$

where:

E = time for an FTE to administer and enforce this program, fraction
F = annual cost for an FTE, $/year
G = program cost, $/year

No implementing agency cost effectiveness for this measure is calculated.

User Cost Calculations: To calculate the cost to each stove user, the purchase and installation cost of an EPA-certified, Phase II stove needs to be obtained from local wood stove dealers. Note that for this measure, each new stove buyer may need to purchase an EPA-certified, Phase II stove. Depending upon individual agreements between the new stove purchaser and the conventional stove owner (whose stove is to be upgraded), the cost to the new stove purchaser will vary, particularly if the conventional stove owner does not demand full payment for a newly installed EPA-certified, Phase II stove to decide to upgrade his or her stove. It is therefore not possible to accurately quantify this cost, unless specific information between new stove purchasers and conventional stove owners is known.

For purposes of this analysis, it is assumed that the stove buyer will finance the purchase and installation cost over a period of time. This requires that these costs be "amortized" by a numerical factor based on the length of the finance period and the interest rate. The technique described below is a amortization method which yields equal payments incurred by the borrower over the life of the finance period. Amortizing purchases is quite common and most people have experience with this through car and house purchases. This amortization factor is called the capital recovery factor and is calculated as follows:

$$CRF = [i/12(i + i/12)^n]/[(1 + i/12)^n - 1]$$

where:

CRF = capital recovery factor, decimal
i = annual real interest rate, decimal
n = length of finance time, months

As an example, the CRF can be calculated using a 10 percent real interest rate and a 10-year length of time (i.e., 120 months):

$$CRF = [0.1/12\ (1 + 0.1/12)^{120}]/[(1 + 0.1/12)^{120} - 1] = 0.01322$$

This factor multiples the purchase cost to obtain the monthly payment over the length of the finance time:

$$H \times CRF = I$$

where:

H = cost to new stove purchaser,
I = monthly payment, $/month

The monthly payment multiplied by 12 then yields the annual cost:

$$I \times 12 = Co$$

where:

Co = annual cost to stove owner, $/year·stove

4.3.2.3 Restriction in Number and Density of New Wood Burning Stove and/or Fireplace Installations.

Emission Reduction Calculations:

Emission reductions from this measure should be based on an assumed growth rate of wood stoves and fireplaces minus stoves or fireplaces not installed due to the restriction. This is done in two parts: calculating wood stove emission reductions and calculating fireplace emission reductions.

Stove Emission Reduction: The calculations to obtain the emission reductions from EPA-certified, Phase II stoves are given below:

$$A \times B = C$$

where:

A = annual EPA-certified, Phase II stove growth rate in absence of regulation, decimal
B = current EPA-certified, Phase II stove population

C = number of EPA-certified, Phase II stoves installed in absence of regulation

The number of stoves not installed due to this measure is dependent on the type of density restriction. This may range from full restrictions on stoves (i.e., a ban) to partial restrictions. If a full restriction program is instituted, the annual number of stoves not installed is simply the annual stove growth rate multiplied by the stove population.

For full restriction, use the following formula:

$$E = C$$

where:

E = number of stoves not installed due to this measure

If a partial restriction on stoves in enacted, the number of stoves not installed will depend on the density allowance (e.g., number of stoves allowed per acre). Historical data may be used to determine the average number of stoves per acre in the area, and the difference between this and the density restriction multiplied by the number of acres developed per year equals the number of stoves not installed. The calculation to determine this value, E, is:

$$E = (D - RS) \times AD$$

where:

E = annual number of stoves not installed due to this measure
D = average number of stoves per acre
RS = density restriction, number of stoves allowed per acre
AD = acres developed annually

The emission reductions obtained from not installing these stoves are calculated as shown below:

$$(E \times F \times G \times H)/(454 \times 2{,}000) = I$$

where:

F = emission factor for EPA-certified, Phase II stoves, (Ref. 16) g/kg wood burned
G = average wood burned in one stove per year, cords/year
H = average cord density, kg/cord

I	=	annual emission reductions from stoves, tons/year
454	=	conversion factor, grams to pounds, g/lb
2,000	=	conversion factor, pounds to tons, lb/ton

An identical procedure needs to be performed for fireplaces.

Fireplace Emission Reduction: The calculations to obtain the emission reductions from fireplaces are given below:

$$A_F \times B_F = C_F$$

where:

A_F = annual fireplace growth rate in absence of regulation, decimal
B_F = current fireplace population
C_F = number of fireplaces installed in absence of regulation

The number of fireplaces not installed due to this measure is dependent on the type of density restriction. This may range from full restrictions on fireplaces (i.e., a ban) to partial restrictions. If a full restriction program is instituted, the annual number of fireplaces not installed is simply the annual fireplace growth rate multiplied by the fireplace population.

For full restriction, use the following formula:

$$E_F = C_F$$

where:

E_F = number of fireplaces not installed due to this measure

If a partial restriction on fireplaces in enacted, the number of fireplaces not installed will depend on the density allowance (e.g., number of fireplaces allowed per acre). Historical data may be used to determine the average number of fireplaces per acre in the area, and the difference between this and the density restriction multiplied by the number of acres developed per year equals the number of fireplaces not installed. The calculation procedure to determine this value, E_f, is:

$$E_F = (D_F - RS_F) \times AD_F$$

where:

E_F = annual number of fireplaces not installed due to this measure
D_F = average number of fireplaces per acre
RS_F = density restriction, number of fireplaces allowed per acre
AD_F = annual developed acres

The emission reductions obtained from not installing these fireplaces are calculated as:

$$(E_F \times F_F \times G_F \times H_F)/(454 \times 2{,}000) = I_F$$

where:

F_F = emission factor for fireplaces, (Ref. 17) g/kg wood burned
G_F = average cord usage for fireplaces, cords/year
H_F = average cord density for fireplaces, kg/cord
I_F = annual emission reductions from fireplaces, tons/year
454 = conversion factor, grams to pounds, g/lb
2,000 = conversion factor, pounds to tons, lb/ton

Total emission reductions are then calculated as the sum of reductions from stoves and fireplaces.

$$H + H_F = H_T$$

where:

H_T = total emission reductions from this measure, tons/year

Cost Calculations:

Implementing Agency Cost Calculations: To administer effectively this program, some costs will be incurred. These costs may be estimated based on the amount of time an FTE would spend to administer the program each year. This cost can be estimated using the formula below:

$$I \times J = K$$

where:

I = time for an FTE to administer program, fraction
J = annual cost for an FTE, $/year
K = annual implementing agency cost, $/year

User Cost Calculations: There are two different procedures for calculating the cost to an RWC user, depending upon whether the RWC is a wood stove or fireplace.

The cost to each wood stove user is based on two items: (1) the differential purchase and installation costs between a

gas furnace or other form of heat and an EPA-certified, Phase II wood stove; and (2) the differences in fuel costs based on an identical heat input to a gas furnace and a wood stove. Differential costs for fireplaces are estimated based on the cost of a wood-burning fireplace and a gas fireplace or gas log fireplace (both of which can be obtained from local wood stove and fireplace dealers) and the amount of time a fireplace is used annually.

Stoves: The purchase and installation cost differential for stoves is calculated as:

$$L - M = N$$

where:

L = purchase and installation cost for gas furnace, $
M = purchase and installation cost for wood stove, $
N = cost differential, $

For purposes of this analysis, it is assumed that this cost differential, N, is financed over the life of the stove which is typically 10 years.

This requires that these costs be "amortized" by a numerical factor based on the length of the finance period and the interest rate. Amortizing purchases is quite common and most people have experience with this through car and house purchases. The technique described below is a method which yields equal payments incurred by the borrower over the life of the loan. This amortization factor is called the capital recovery factor and is calculated as follows:

$$CRF = [i/12(i + i/12)^n]/[(1 + i/12)^n - 1]$$

where:

CRF = capital recovery factor, decimal
i = annual real interest rate, decimal
n = length of finance time, months

As an example, the CRF can be calculated using a 10 percent real interest rate and a ten year length of time:

$$CRF = [0.1/12\ (1 + 0.1/12)^{120}]/[(1 + 0.1/12)^{120} - 1] = 0.01322$$

This factor multiples the purchase cost to obtain the monthly payment over the length of the finance time (i.e., 120 months):

$$N \times CRF = O$$

where:

N = purchase and installation cost of stove, $
O = monthly payment, $/month

To obtain the annual cost to the user, multiply this value, O, by 12 as shown below:

$$O \times 12 = P$$

where:

P = annual purchase installation cost to user, $/year

The difference in energy costs per year can be estimated once the costs for natural gas and wood are obtained on a $\$/10^6$ Btu basis. The cost of natural gas on a $\$/10^6$ Btu basis can be obtained from the local gas company. The energy cost of wood on a $\$/10^6$ Btu basis can be calculated using the formula below. The cost of wood ($/cord) can be obtained from local wood stove dealers or the classified advertisements.

$$Q/R = S$$

where:

Q = cost of wood, $/cord
R = energy content of wood, 10^6 Btu/cord
S = energy cost of wood, $\$/10^6$ Btu

The differential cost is then obtained as:

$$(NGC - S) = T$$

where:

NGC = natural gas cost, $\$/10^6$ Btu
T = cost differential, $\$/10^6$ Btu

The annual cost difference is then calculated using the formula below:

$$G_F \times R \times T = U$$

where:

U = annual cost difference between natural gas and wood, $/year

The total annual cost to the wood stove user is the sum of these two components as shown below:

$$C_{ow} = P + U$$

where:

C_{ow} = annual cost to wood stove user, $/year

Fireplaces: The purchase and installation cost differential for fireplaces is calculated as shown below. The cost for both types of fireplaces can be obtained from local wood stove dealers. The cost of a gas line can be obtained from the local gas company.

$$L_F - M_F = N_F$$

where:

L_F = purchase and installation cost for gas fireplace or gas log fireplace, $
M_F = purchase and installation cost for wood burning fireplace, $
N_F = cost differential, $

For purposes of this analysis, it is assumed that this cost differential, N_F, will be financed over the length of the home mortgage.

This requires that these costs be "amortized" by a numerical factor based on the length of the finance period and the interest rate. The technique described below is a method which yields equal payments incurred by the borrower over the life of the finance period. Amortizing purchases is quite common and most people have experience with this through car and house purchases. This amortization factor is called the capital recovery factor and is calculated as follows:

$$CRF = [i/12(i + i/12)^n]/[(1 + i/12)^n - 1]$$

where:

CRF = capital recovery factor, decimal
i = annual real interest rate, decimal
n = length of finance time, months

As an example, the CRF can be calculated using a 10 percent real interest rate and a ten year length of time (i.e., 120 months):

$$CRF = [0.1/12\ (1 + 0.1/12)^{120}]/[(1 + 0.1/12)^{120}-1] = 0.01322$$

This factor multiples the purchase cost to obtain the monthly payment over the length of the finance time:

$$O_F \times CRF = P_F$$

where:

O_F = purchase and installation cost of fireplace, $
P_F = monthly payment, $/month

To obtain the annual cost to the fireplace user, multiply this value, P_F, by 12 as shown below:

$$P_F \times 12 = Q_F$$

where:

Q_F = annual purchase and installation cost to fireplace user, $/year

The first step to obtain the differential fuel cost between a conventional fireplace and gas logs, is to calculate the annual hours a fireplace is used. This is done according to the formula below.

$$(G_F \times H_F)/R_F = S_F$$

where:

R_F = fireplace burn rate, kg wood/hour (Reference 2)
S_F = fireplace usage, hours/year

The amount of natural gas consumed during this time period is then calculated as follows:

$$S_F \times T_F = U_F$$

where:

T_F = natural or propane gas fireplace consumption rate, Btu/hour
U_F = energy consumption of natural or propane gas fireplace, Btu/year

The annual cost difference between natural gas and wood is then calculated as shown below.

$$(G_F \times V_F) - (U_F \times W_F) = X_F$$

where:

V_F = cost of a cord of wood, $/cord
W_F = cost of natural gas $/Btu
X_F = annual cost difference between natural gas and wood, $/year

The total annual cost to the fireplace user is the sum of X_F and Q_F:

$$X_F + Q_F = Y_F$$

where:

Y_F = total annual cost for fireplace, $/year

4.3.2.4 Require New Wood Stove Installations be Low Emitting.

Emission Reduction Calculations:

Emission reductions will be calculated based on reductions from EPA-certified, Phase II stoves to low emitting.

The emission reductions will be calculated assuming an annual stove growth rate in the absence of regulation, and the emission reductions achieved by requiring these new stoves to be low emitting. This is done in a two step process. First, the number of stoves that will be required to be low emitting is calculated. Second, the emission reductions for these low-emitting stoves relative to EPA-certified, Phase II stoves are calculated as shown below:

$$A \times B = C$$

where:

A = stove growth rate in absence of regulation, decimal
B = current stove population
C = number of stoves restricted to low emitting

The number of stoves restricted to low emitting, C, is then used to calculate the emission reductions as follows:

$$(C \times D_1 \times D_2 \times E \times F)/(454 \times 2{,}000) = G$$

where:

D_1 = emission reduction credit for conversion from Phase II stove to low emitting, decimal (Ref. 18)
D_2 = emission factor of EPA-certified, Phase II stove, (Ref. 19) g/Kg wood burned
E = average number of cords per year burned in one wood stove, cords/year
F = average cord density, kg/cord
G = emission reductions from this measure, tons/year

454 = conversion factor, grams to pounds, g/lb
2,000 = conversion factor, pounds to tons, lb/ton

Cost Calculations:

Implementing Agency Cost Calculations: To administer and enforce effectively the program, some costs will be incurred. These costs may be estimated based on the amount of time an FTE would spend to administer and enforce this program each year. This cost can be estimated using the formula below:

$$H \times I = J$$

where:

H = time for an FTE to administer and enforce program, fraction
I = annual cost for an FTE, $/year
J = annual implementing agency cost, $/year

User Cost Calculations: To calculate the cost to each stove user, the purchase and installation cost of a low-emitting stove needs to be obtained from local wood stove dealers. For purposes of this analysis, it is assumed the stove buyer will finance (i.e., discount) this cost over a period of time. The purchase and installation of a low-emitting stove may be obtained by calling local dealers.

Financing stove costs requires that these costs be "amortized" by a numerical factor based on the length of the finance period and the interest rate. The technique described below is a method which yields equal payment incurred by the borrower over the life of the finance period. Amortizing purchases is quite common and most people have experience with this through car and house purchases. This amortization factor is called the capital recovery factor and is calculated as follows:

$$CRF = [i/12(i + i/12)^n]/[(1 + i/12)^n - 1]$$

where:

CRF = capital recovery factor, decimal
i = annual real interest rate, decimal
n = length of finance time, months

As an example, the CRF can be calculated using a 10 percent real interest rate and a 10-year length of time:

$$CRF = [0.1/12\ (1 + 0.1/12)^{120}]/[(1 + 0.1/12)^{120}-1] = 0.01322$$

This factor multiples the purchase cost to obtain the monthly payment over the length of the finance time (i.e., 120 months):

$$K \times CRF = L$$

where:

K = purchase and installation cost of stove, $
L = monthly payment, $/month

To obtain the annual cost to the user, multiply this value, K, by 12 as shown below:

$$L \times 12 = M$$

where:

M = annual cost of purchase and installation of a low-emitting stove, $/year

In addition to the purchase and installation cost, the annual fuel cost must be calculated. This cost is based on the difference between the cost of pellet fuel and wood, assuming the same heat input to a pellet stove and an EPA-certified, Phase II stove (this example assumes a pellet stove for a low-emitting device). The calculation procedure is given below. First, calculate the annual heat input to an EPA-certified, Phase II stove as shown:

$$E \times N = O$$

where:

N = average cord energy content, Btu/cord
O = total annual heat input to stove, Btu/year

Once this value is calculated, the annual cost of pellet fuel can be obtained using the following formula. The cost of pellet fuel ($/ton) can be obtained through local wood stove dealers.

$$(N \times P \times Q)/(8{,}000 \times 2{,}000) = R$$

where:

P = cost of pellet fuel, $/ton pellets
Q = relative efficiency ratio of EPA-certified, Phase II wood stoves to low-emitting stoves,

decimal (Ref. 20) (e.g., pellet stoves in this example)

R = annual fuel cost of pellets, $/year
2,000 = conversion factor, pounds to tons, lb/ton
8,000 = heat content of pellet fuel, Btu/lb

The annual cost of wood is calculated according to the formula below. The cost of wood ($/cord) can be obtained through wood stove dealers or classified advertisements.

$$E \times S = T$$

where:

S = cost of wood, $/cord
T = annual wood cost, $/year

The annual wood cost, T, is then subtracted from the annual pellet cost, P, to obtain the incremental fuel costs of switching to pellet fuel from cord wood as shown below:

$$Q - T = U$$

where:

U = incremental fuel cost, $/year

The total annual costs to the stove purchaser are then calculated as:

$$M + U = Co$$

where:

Co = total annual cost to stove purchaser, $/year·stove

4.3.3 Emission Reduction - New and Existing Installations

4.3.3.1 Device Offset.

Emission Reduction Calculations:

Emission reductions will be based on a decrease in emissions from removal of an appropriate number of conventional stoves for every stove installed.

The calculations to obtain the emission reductions are given below. First, the number of new stoves installed per year needs to be calculated as shown below.

$$A \times B = C$$

where:

A = annual stove growth rate in absence of regulation
B = current stove population
C = number of new stoves installed per year

The emission reductions can then be calculated as:

$$(C \times D_1 \times D_2 \times E \times F)/(454 \times 2{,}000) = G$$

where:

D_1	=	emission reduction credit from conventional to Phase II stove or equivalent, decimal (Ref. 21)
D_2	=	emission factor for conventional stove, (Ref. 22) g/Kg wood burned
E	=	average wood burned in one stove per year, cords/year
F	=	average wood density, kg/cord
G	=	annual emission reductions, tons/year
454	=	conversion factor, grams to pounds,g/lb
2,000	=	conversion factor, pounds to tons, lb/ton

Cost Calculations:

Implementing Agency Cost Calculations: To effectively administer the program, some costs will be incurred. These costs may be estimated based on the amount of time an FTE would spend to administer the program each year. This cost can be estimated using the following formula:

$$H \times I = J$$

where:

H = time for an FTE to administer program, decimal
I = annual cost for an FTE, $/year
J = annual implementing agency cost, $/year

The implementing agency cost effectiveness is calculated as the ratio of program costs divided by the total reductions obtained.

$$CE_{ia} = J/G$$

where:

CE_{ia} = implementing agency cost effectiveness, $/ton PM-10 removed

User Cost Calculations: The costs to stove purchasers proposing to install a new EPA-certified, Phase II stove in the serious nonattainment area are assumed to equal the installation cost of a new EPA-certified, Phase II stove, the cost to remove a conventional stove, and the cost of an alternative heating system to replace the conventional stove.

These costs can be obtained from local wood stove dealers, the local gas company, and the local electric company. For purposes of this analysis, it is assumed the purchaser will finance these costs over a period of time.

This requires that these costs be "amortized" by a numerical factor based on the length of the finance period and the interest rate. The technique described below is a method which yields equal payments incurred by the borrower over the life of the finance period. Amortizing purchases is quite common and most people have experience with this through car and house purchases. This amortization factor is called the capital recovery factor and is calculated as follows:

$$CRF = [i/12(i + i/12)^n]/[(1 + i/12)^n - 1]$$

where:

CRF = capital recovery factor, decimal
i = annual real interest rate, decimal
n = length of finance time, months

As an example, the CRF can be calculated using a 10 percent real interest rate and a 10-year length of time (i.e., 120 months):

$$CRF = [0.1/12\ (1 + 0.1/12)^{120}]/[(1 + 0.1/12)^{120} - 1] = 0.01322$$

This factor multiples the purchase cost to obtain the monthly payment over the length of the finance time:

$$K \times CRF = L$$

where:

K = total cost to remove conventional stove, plus cost of alternative heating system, plus cost of EPA-certified, Phase II stove, $
L = monthly payment, $

The monthly payment multiplied by 12 then yields the annual cost:

$$L \times 12 = Co$$

where:

Co = annual cost to stove owner, $/year·stove

4.3.3.2 Upgrade Offset.

Emission Reduction Calculations:

Emission reductions are calculated assuming a stove growth rate in the absence of regulation with an appropriate number of conventional stoves upgraded for every new EPA-certified, Phase II stove installed. The first step in calculating the emission reductions is to estimate the number of stoves that will be upgraded using the two formulas below:

$$A \times B = C$$

where:

A = stove growth rate in absence of regulation, decimal
B = current stove population
C = number of stoves installed

The number of upgraded stoves is calculated as:

$$D = E \times C$$

where:

D = number of conventional stoves upgraded

E = appropriate number of stoves to achieve net emission reduction

The emission reductions are calculated in a two-step process. First, the reductions from the upgraded stoves relative to conventional stoves are estimated. Second, the emissions from the new stoves installed are calculated and subtracted from the reductions obtained in the first step.

$$(D \times E_1 \times E_2 \times F \times G)/(454 \times 2000) = H$$

where:

E_1 = emission reduction credit from conventional to Phase II, decimal (Ref. 23)
E_2 = emission factor for conventional stoves, (Ref. 24) g/Kg wood burned
F = average cords per year burned in one stove
G = average cord density, kg/cord
H = emission reductions from upgraded stoves, tons/year
454 = conversion factor, grams to pounds, g/lb
2,000 = conversion factor, pounds to tons, lb/ton

The emissions increase resulting from installation of that new stove are calculated as follows:

$$(C \times I \times F \times G)/(454 \times 2000) = J$$

where:

I = emission factor for EPA-certified, Phase II stoves, (Ref. 25) g/kg wood burned
J = emissions from new stove installations, tons/year

The emission reductions are then calculated as the difference between the reductions from the upgraded stoves minus the emissions occurring from the new stoves as shown below:

$$K = H-J$$

where:

K = emission reductions from this measure, tons/year

Cost Calculations:

Implementing Agency Cost Calculations: To effectively administer this program, some costs will be incurred. These costs may be estimated based on the amount of time an FTE would spend to administer this program each year. This cost can be estimated using the formula below:

$$E \times F = G$$

where:

E = time for an FTE to administer program, fraction
F = annual cost for an FTE, $/year
G = Implementing Agency cost, $/year

User Cost Calculations: To calculate the cost to each stove user, the purchase and installation cost of an EPA-certified, Phase II stove needs to be obtained from local wood stove dealers. Depending upon individual agreements between the new stove purchaser and the conventional stove owners (whose stoves are to be upgraded), the cost to the new stove purchaser will vary, particularly if the conventional stove owners do not demand full payment for a new installed EPA-certified, Phase II stove. It is therefore not possible to accurately quantify this cost, unless specific information between new stove purchasers and conventional stove owners is known.

For purposes of this analysis, it is assumed that the stove buyer will finance whatever costs are incurred over a period of time. This requires that these costs be "amortized" by a numerical factor based on the length of the finance period and the interest rate. The technique described below is a method which yields equal payment incurred by the borrower over the life of the finance period. Amortizing purchases is quite common and most people have experience with this through car and house purchases. This amortization factor is called the capital recovery factor and is calculated as follows:

$$CRF = [i/12(i + i/12)^n]/[(1 + i/12)^n - 1]$$

where:

CRF = capital recovery factor, decimal
i = annual real interest rate, decimal
n = length of finance time, months

As an example, the CRF can be calculated using a 10 percent real interest rate and a 10-year length of time (i.e., 120 months):

$$CRF = [0.1/12\ (1 + 0.1/12)^{120}]/[(1 + 0.1/12)^{120} - 1] = 0.01322$$

This factor multiples the purchase cost to obtain the monthly payment over the length of the finance time:

$$H \times CRF = I$$

where:

H = cost to new stove purchaser,
J = monthly payment, $

The monthly payment multiplied by 12 then yields the annual cost:

$$I \times 12 = Co$$

where:

Co = annual cost to stove owner, $/year.stove

References

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APPENDIX A

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APPENDIX B

METHODOLOGY FOR CALCULATING DEVICE AND UPGRADE OFFSET RATIOS

Device Offset

A 1-to-1 device offset ratio by definition produces a net emissions reduction since a conventional, old stove is being replaced with a cleaner burning unit. The emissions reduction resulting from the transaction should be calculated based on the appropriate emissions reduction credit. To calculate the emission reductions, see EPA's AP-42 document (Ref. 1) for appropriate emission factors and, for a methodology on how to calculate emission reduction credits, see an updated Appendix F of the "RWC Guidance Document" to be issued.

The participants in this measure whose stoves are being removed, though, should be limited to sole-source, low-income wood burners since a regular wood burner who has a back-up heating system would be willing to participate in the transaction probably because the wood stove was not being used. Thus, emissions might increase from the transaction.

Upgrade Offset

From a 1-to-1 upgrade offset transaction, resulting emissions would be:

Emissions = (existing conventional stove emissions * emission reduction credit for conversion upgrade) + (emissions of new stove)

The net effect on emissions from an upgrade transaction depends on the magnitude of the reduction in emissions relative to the increased emissions of the new stove. Thus, the appropriate ratio of upgrades to new stoves will depend on whether the measure is intended to produce no net effect on emissions or a net reduction. To determine the appropriate ratio and the net impact on emissions, see EPA's AP-42 document (Ref. 1) for appropriate emission factors and, for a methodology on how to calculate emission reduction credits, see an updated Appendix F of the "RWC Guidance Document" to be issued.

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References

1. U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Compilation of Air Pollutant Emission Factors (AP-42), Research Triangle Park, North Carolina.