

Task 1
Work Plan
Control Analysis and Documentation for
Residential Wood Combustion in the MANE-VU Region

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1. Introduction

In the conduct of this project there are three key work elements. They are: (1) Activity level development for residential wood combustion (RWC), (2) The calculation of an RWC emission inventory, and (3) A reasonable available control measure analysis. The approach for each is described here. The activity levels and emission inventory will be for the 2002 base year for the 11 MANE-VU states and Washington D.C. The data will be broken down to the county level. The term “county level” as used here also applies to cities not included within county boundaries and Washington D.C.

2. Activity Level Development

The approach OMNI will take to estimate RWC activity for MANE-VU households can be summarized as follows: (1) The 2002 MARAMA database, the American Housing Survey (AHS) data, Energy Information Administration (EIA) space heating data, Simmons Marketing Research data, and Hearth, Patio, and Barbecue Association (HPBA) surveys data will be combined to provide estimates of regional and national wood-burning appliance ownership, appliance usage categories and wood consumption per wood-burning appliance. (2) Wood-burning activity on a county-by county basis will be estimated by indexing the residential wood combustion activity for wood burning stoves and fireplace inserts to the house heating fuel data compiled randomly for one in every six households by the U.S. Census Bureau. Wood-burning to gas-fueled fireplace numbers will also be proportioned by using these data. The U.S. Census Bureau data set has been tabulated for each of the 243 counties, cities not included as part of a county, 11 states and Washington D.C. making up the MANE-VU region. (3) The mean RWC activities for each of the three Heating Degree Day (HDD) categories previously identified by MARAMA will be calculated by using the average HDD data that are also available for each of the counties, states and Washington D.C and the county by-county activity estimates generated from steps 1 and 2. (4) To the extent feasible, a “cross check” of results calculated for Delaware, Vermont and Maine will be made with state surveys that have been done in those three states. Data from the various sources will be adjusted to the 2002 base year by using available published U.S. Census Bureau housing unit estimates and population estimates compiled by county by year. Appliance numbers will be compiled for appliances used, not appliances owned, as emissions inventories are, of course, only affected by appliances in actual use. 10% to 30% of appliances are typically reported as not being used in a given 12-month period depending on the appliance category.

More specifically, there are a number of AHS surveys for various metropolitan areas. These will be used for those counties included in the specific metropolitan areas, as they are large, focused surveys with extensive back-up literature on survey design, and quality assurance. (All this information is available on the web and extensive details on these surveys can be found in the surveying and marketing literature.) For rural areas outside of the metropolitan areas covered by specific AHS metropolitan surveys, the U.S Census Bureaus fuel use question from the long-form questionnaire obtained from one-in-every

six households will be the primary basis for indexing residential wood combustion activity by county. In conjunction with the U.S. Census Bureau data, AHS regional survey data (Northeast and South Census regions), Simmons Marketing Research data, U.S. DOE surveys, state-sponsored surveys for Maine, Delaware and Vermont, HPBA and PFI industry records, and data obtained from interviews with industry representatives will be used. The U.S. Census Bureau survey, the AHS national survey subdivided into regional data, the Simmons Marketing Research survey, and the U.S. DOE surveys in aggregate represent data from about 5 million households, are extremely well documented surveys, are without agenda, and have the highest credibility. The state surveys have specific data for each county for three states. HPBA surveys and records, PFI records, and data from interviews with industry representatives, will be used to obtain or clarify specific pieces of data not obtainable from the large surveys. The MARMA database is of more limited utility for estimating the fraction of households that use the various residential wood burning appliance types as is based on a smaller number of homes with the methodology for their selection being novel. However, the MARAMA database does represent the best source of data for the multiple ownership factor and for cordwood use per appliance by heating demand that are available for the MANE-VU region and the MARAMA database will be used for those purposes.

OMNI will prepare a technical memorandum (Technical Memorandum #1) describing the activity data. All input data will be supplied as hard copy and contained in appendices and/or provided in electronic format (Excel). To facilitate “transparency,” example calculations will be provided. Summaries of wood-burning activity in units of mass by county and by state will be supplied. Equipment level data will be provided by county, by state, for Washington D.C. and for the three HDD zones as defined in MARAMA’s previous Technical Memorandum 5. An opportunity for MANE-VU members to review and comment on the draft technical memorandum will be provided. All reasonable comments will be considered. As estimating activity levels is pivotal to the other two work elements and is the most complex task, the following sections 2.1, 2.2 and 2.3 describe in more detail the approach that will be taken.

2.1. Activity Level Categories

Wood Heaters. Woodstoves and fireplace inserts will be grouped together since they have the same emission factors. Fireplace inserts are essentially woodstoves designed to fit into fireplace cavities. The wood heater category will be subdivided into (1) conventional pre-EPA certified, (2) EPA certified catalytic, and (3) EPA certified non-catalytic.

Wood-burning Fireplaces without Inserts. Wood-burning fireplaces without inserts will be covered in this category. Wood-burning fireplaces with inserts are covered in the preceding section. Contributions due to manufactured wax/fiber firelogs will be tabulated separately from cordwood. (12% of fireplace users report using firelogs exclusively and 30% report using them some of the time.) Importantly, gas-fueled fireplaces will be removed from the tabulation.

Minor Wood-Fueled Appliances. The overwhelming majority of wood consumption and associated emissions in the MANE-VU states are from the sum of wood heaters and wood-burning fireplaces without inserts. However, minor and measurable emission contributions will be made from centralized wood-burning heating systems (boilers, hydronic heaters, and forced-air furnaces) and pellet stoves. OMNI's best professional judgment, at this juncture, is that centralized heating systems are responsible for on the order of 2% of the wood used for home heating in the MANE-VU states and that pellet stoves are responsible for no more than a few percent of the mass of wood fuel consumed. Refined estimates will be obtained in the conduct of the project. Activity levels will be estimated for centralized wood-burning heating systems and pellet stoves. The database available for estimating their activity is less extensive than for wood heaters and fireplace without inserts. Because their contribution is smaller than from wood heaters and fireplaces without inserts, the uncertainty in their activity levels as a consequence of the limited database will only introduce minor uncertainty in the overall RWC activity level and emission inventory. (The emission factors for pellet stoves are also much smaller than for cordwood stoves further lessening their importance in the development of a RWC emission inventory.) Masonry heaters and wood-burning cookstoves will not be taken into consideration due to their very small numbers.

2.2. Activity Level Estimates

Wood Heaters. The U.S. Census Bureau has surveyed (in 2000) one in every six households using the "long census form." The results, including the results of a question relating to the main house heating fuel (which includes wood fuel), are compiled for each county. Separately, the American Housing Survey has conducted surveys from which the ratio of the secondary ("other") use of wood as a fuel to the primary use of wood as a fuel can be calculated. Consequently, the U.S. Census Bureau data by county can be used as an indicator of wood heater usage by county and the American Housing Surveys (AHS) by census region can then be used to estimate the total number of wood heaters in use in each county. For counties in specific metropolitan areas, a direct count of the number of wood heaters used for both main and "other" heating purposes is obtainable from American Housing Surveys. The relevant American Housing Surveys that have been conducted in geographical regions, which cover counties in the MANE-VU region are provided as Table 1.

Table 1
Applicable American Housing Survey Reports

Geographical Area*	Year
United States	2003
Hartford Metro area	2004
Baltimore Metro area	1998
Washington Metro area	1998
Boston Metro area	1998
Buffalo Metro area	1994
Rochester Metro area	1998
New York-Nassau-Suffolk-Orange Metro area	2003
Northern New Jersey	2003
Pittsburgh Metro area	2004
Philadelphia Metro area	2003

*The United States data are broken down to the census regions and most of the metropolitan surveys are broken down into several sub-areas.

For the purposes of calculating wood heater numbers by county, small corrections in the U.S. Census Bureau by-county wood numbers will be made to take into account fireplaces without inserts used for primary heat. Accurate data for fireplaces without inserts used for primary heat are obtainable from the AHS reports. (Again this number is small.) The use of centralized heating systems for heat will be estimated from the MARAMA data, applicable state survey data, Section 114 outdoor boiler data, a New York Environmental Protection Bureau report on outdoor boilers, and manufacturers' sales data if they are available. (A request has been made to industry representatives.). A cursory review of data from nearby states reveals other relevant centralized heating data are available. It should also be noted that their numbers are smaller than would be intuitively be expected from their relative impacts to air quality since centralized wood heating systems burn on the average considerably more cords of wood than wood heaters or fireplaces without inserts. One small final correction will be made in the county wood heater numbers for multiple wood heater ownership. It is reasonable to assume that the multiple ownership ratios are more or less constant throughout the Nation. A U.S. Consumer Product Safety Commission survey, HPBA surveys, various state surveys and the MARAMA 2002 database will be used to refine this estimate. The conversion factor to obtain wood heater numbers from wood burning households appears to range from 1.1 to 1.2.

The breakdown between conventional pre-EPA certified wood heaters, EPA certified catalytic wood heaters and EPA-certified non-catalytic wood heaters will be obtained by reviewing Simmons Marketing Research woodstove and fireplace ownership data and Hearth, Patio, and Barbecue Association (HPBA) shipment records from the start of the NSPS requirements for certifications of wood heaters. (OMNI has already done this through 1997 and has presented the results at an EPA/AWMA conference)

Once the number of wood heaters by county is determined, the total amount of wood consumed annually by county will be calculated for wood heaters. As the demand for wood is related to climate, the Heating Degree Day (HDD) data for each county will be compiled. Annual wood usage per appliance will be related to HDD data. This correlation will be derived primarily from the MARMA 2002 database and confirmed for reasonableness by comparing it to other state, local and regional surveys and with a U.S. DOE Energy Information Administration (EIA) 2000 report based on another independent survey. (The demand for heat and fuel usage should be, in large extent, independent of location.). A small adjustment will also be made for wood usage by wood heater type for the difference in efficiencies between conventional pre-EPA certification wood heaters, EPA-certified catalytic wood heaters and EPA-certified non-catalytic. It is likely that OMNI will elect to treat certified catalytic wood heater efficiency as being the same as for EPA-certified non-catalytic heaters, even though certified catalytic wood heaters have a higher assumed efficiency when new, catalysts degrade, with the typical catalyst lifetime being approximately five years at which point their efficiency is less than a certified non-catalytic wood heater.

Wood-Burning Fireplaces without Inserts. The details of the calculation methods for fireplaces without inserts are still being finalized in the related work that OMNI is conducting on other projects. Wood-burning fireplaces without inserts and the amount of wood consumed in them can be attributed to the county level. The key elements are: (1) The total number of usable fireplace are available by region and for metro areas (metro areas usually are composed of several counties) from AHS reports (Table 1). Ownership can also be related to urban/suburban/rural status of the county from these data (2) The HPBA conducted surveys in 2002 and 2004, which determined the fraction of fireplaces nationwide and regionally that were gas-fueled. (3) The 2000 U.S Census Bureau main heating fuel data by county includes natural gas and bottled gas. Since these data are an indicator of gas hook-ups, they can be used to proportion/adjust the national gas-fueled fireplace percentage to each county. The gas-fueled fireplace numbers thus derived can be subtracted from the total usable fireplace numbers to get the number of wood-burning fireplaces. (4) As previously noted, the number of wood-burning fireplace inserts per county can be calculated and this number can be subtracted from the total number of usable wood-burning fireplaces to obtain the number of wood-burning fireplaces without inserts. (5) Multiple fireplace ownership, i.e., the number of fireplaces per household can be obtained from AHS data, US Census Bureau Data, two HPBA surveys, U.S. Consumer Product Safety Commission survey, from the MARMA 2002 database, and from various state, local and regional surveys. (6) Surveys contracted by Duraflame Corporation, one of the two major North American manufacturers of wax/fiber firelogs, and the a 2004 survey conducted by HPBA show the percentage of fireplace users that use firelogs and the regional breakdown of firelog sales. These data can be used to estimate the amount of firelogs that are used in wood-burning fireplaces in the MANE-VU region. They would be apportioned by county based on the number of wood-burning fireplaces by county. (7) The same Duraflame sponsored surveys, two HPBA surveys, the AHS reports, and various state surveys have broken down fireplace usage into “not used,” “used for aesthetics,” used for supplemental heat and used as a “primary heating source.” (8) The amount of wood burned per fireplace in fireplaces used for aesthetic

purposes is, by-in-large, relatively constant throughout the U.S. It has been estimated in previous published work as about 0.06 cords per fireplace. (9) The amount of wood burned per fireplace used for heating purposes will be related to heating demand by county HDD data. The relationship between HDD and wood usage will be derived by the use of MARAMA 2002 data and various state, local and regional surveys.

Minor Wood-Fueled Appliances. The MARAMA database, Section 114 reports, a New York Environmental Protection Bureau report, HPBA surveys and pellet heater shipping records, boiler industry data (if obtainable) along with state surveys conducted in Delaware, Maine, Vermont and other nearby states will provide the primary input data for centralized wood-burning heating systems and pellet stoves. In addition, inquiries will be made with the Pellet Fuels Institute (PFI) for total and regional pellet sales data so that pellet stove numbers can be better proportioned to the MANE-VU states. It is envisioned that the MARAMA database will provide input for estimating activity levels for centralized wood-burning heating systems and pellet stoves at the county level. As previously noted, the contribution of centralized wood-burning heating systems and pellet stoves to the overall RWC impact will be small.

2.3. Cord to Mass Conversion

The standard unit of measure for wood fuel usage is the “cord.” The cord is a volume-based unit, i.e., a stack of wood 4 ft by 4 ft by 8 ft. The mass of wood, not the volume, is needed for emission inventories as well as for the calculation of the reduction in emissions due to the application of RACM. (Wood use activity in units of mass multiplied by emission factors in units of mass pollutant per mass of wood burned yields the total mass of pollutant emitted.). After correction for moisture content, the mass per cord of wood primarily is determined by the fraction of hardwood (wood from deciduous trees) and the fraction of softwood (wood from coniferous trees) making up the cord. The conversion factor used by the Energy Information Administration and for the National Emission Inventory is 1.16 tons/dry cord. The conversion factor used for producing emission estimates in the 2004 MANE-VU Residential Wood Combustion Emission Inventory was 1.8 tons/dry cord. OMNI has conducted a cursory review of the forestry and energy literature applicable to the MANE-VU states and has found the conversion factor is in the range of 1.3 to 1.5 tons/dry cord. A representative conversion factor is essential as it has a direct one-to-one effect on calculated emissions. OMNI will provide a referenced conversion factor based on an expanded literature search for use with this project. It may be different for different parts of the MANE-VU area. In summary, the conversion factor for cords to mass will be based on state surveys and forestry publications providing tree species used for fuel that are applicable to the MANE-VU states.

3. The Calculation of Emission Inventory from RWC Survey Data

There is a paucity of emission factor data for RWC. Most emission factors for RWC when ranked by EPA's scale have the lowest rankings. In particular, there have been a limited number of studies for pollutants other than particles. Even for particles, the determination of mean or typical emission factors is difficult because the overwhelming majority of particles formed by RWC are condensed organic compounds and reported particulate emissions are dependent on the measurement method used. There are at least seven common methods of measuring particulate emissions from RWC appliances and numerous non-standard research methods have been used as well. Each major appliance type (fireplaces, conventional pre-EPA-certification woodheaters, EPA certified non-catalytic woodheaters, EPA certified catalytic woodheaters, pellet stoves, masonry heaters and centralized heating systems) has different characteristic emission factors due to fundamentally different combustion conditions. There are hundreds of appliance models, ten's of wood species commonly used for fuel, and a variety of manufactured fuels; plus household installation, fuel aging and usage patterns are widely variable. The diversity illustrates the need for numerous measurements for various combinations of appliance types, models, fuels, installations and usage patterns to get a meaningful value representative of the millions of wood-burning appliances in use. The EPA's AP-42 emission factor document for woodheaters and pellet stoves lacks currency as the last studies from which the data were collected for tabulation in AP-42 were not performed with modern certified cordwood woodheaters or pellet stoves. (See: [PM_{2.5} Emission Reduction Benefits of Replacing Conventional Uncertified Cordwood Stoves with Certified Cordwood Stoves or Modern Pellet Stoves –“publications” link http://www.omni-test.com.](#)) It is also based on a limited number of studies. OMNI has regularly been involved in emission measurement of appliances and fuels and, in fact, currently has ongoing projects involving emission measurement. OMNI has on-file a comprehensive collection of published and unpublished emission reports, and technical publications from research conducted in North America, Europe, Australia and New Zealand. OMNI proposes to use its library of emission factors and where no data exists for a given pollutant for a given appliance type use best professional judgments to assign a reasonable emission factor and provide a rationale for the assignment. It needs to be emphasized that the staff at OMNI is well qualified to conduct this task, as it has, without exaggeration, worked with thousands of home heating appliances and its staff in aggregate has hundreds of years of experience with them over the last two and one-half decades. OMNI proposes to compile emission factor tabulations for each pollutant presented in the 2002 MARMA emission inventory for each appliance category. The sources of data reviewed to compile the emission factors will be referenced in Technical Memorandum # 2. It is envisioned that emission factors will be compiled and presented similar to those OMNI compiled for fireplace particulate emissions. (See: [Development of a Fireplace Baseline Particulate Emission Factor Database, 2005, Proceedings of the 14th International Emission Inventory Conference –“publications” link http://www.omni-test.com.](#))

OMNI recently completed a study, which proportioned annual RWC emissions on a monthly basis. The results of this work will be provided in the final report due to the seasonality of ozone and regional haze. (See: [Monthly Distribution of Residential Wood Combustion –“publications” link http://www.omni-test.com.](#))

OMNI will prepare a technical memorandum (Technical Memorandum #2) describing the complete analysis of RWC emissions for the MANE-VU states. A complete description of the derivation of the emission factors used and a reference list of sources will be provided. Emission inventory data will be compiled by equipment type and at the state, county and HDD zone levels. Example calculations will be provided. All input data will be supplied as a hard copy and contained in appendices and/or provided in electronic format.

An opportunity for review of the draft memorandum by MANE-VU members will be provided and appropriate comments will be incorporated into the final memorandum. Data will be supplied in any reasonable format requested by MARAMA with the caveat that a straightforward transformation from standard database formats can be accomplished.

As the RFP specifically identifies concern with VOC emissions in this section of the RFP, Technical Memorandum #2 will provide a brief discussion with references on the character of VOC emitted from RWC, the effect of measurement methodology on reported VOC levels, the confusion between regulatory and scientific definitions of "VOC", atmospheric transformation/vaporization of organic compounds emitted in particulate form, and formation of secondary organic aerosols (SOA) from VOC.

4. Reasonably Available Control Measure Analysis

OMNI will prepare a technical memorandum (Technical Memorandum #3) documenting the RACM analysis, which will follow EPA RACM guidance procedures. The focus will be on PM_{2.5} and VOC emission reductions and costs associated with "hardware" and fuel changes. These include: (1) The replacement of old pre-EPA certification woodheaters (woodstoves and fireplace inserts) with modern pellet-fueled heaters, EPA-certified cordwood heaters, masonry heaters or gas space heaters. (2) The conversion of cordwood fireplaces to natural gas or LPG using firelog sets. (3) The use of wax/fiber firelogs with specialized grates in fireplaces. (4) The installation of pellet, gas or EPA certified cordwood inserts into fireplaces that are actively used for supplemental or primary heating. (5) The use of grate systems that facilitate combustion in cordwood fireplaces.

OMNI has also reviewed recent literature on emission levels from wood-fired central heating systems, has evaluated testing protocols for them for Environment Canada, and measured their emissions for private sector clients. While low emission models analogous to EPA-certified woodheaters are not yet mandated, OMNI will provide a discussion on low emission basics for them in the technical memorandum.

Guidance for residential wood combustion RACM for PM₁₀ of over a decade ago will be similar to that which will be appropriate for PM_{2.5} and VOC. The EPA's PM₁₀ RACM guidance for residential wood combustion (EPA-450/2-89-015) lists four categories of

RWC control measures. One, combustion efficiency, is primarily related to the “hardware” fixes already discussed. The applicability of the other three, public awareness, episodic curtailment, and the restriction or reduction of the number RWC devices, to the MANE-VU region, will be briefly discussed in the technical memorandum. PM₁₀ nonattainment based on exceedance of the twenty-four standard occurred primarily in the western part of the U.S. and RACM analysis for RWC mostly occurred there. (See, e.g., PM-10 Innovative Strategies, A Sourcebook for PM-10 Control Programs, EPA-452/R-93-016.).

At the start of the RACM analysis OMNI will contact the key state individuals identified by MARAMA for the purpose of summarizing RACM activity to date for each state and Washington D.C and to determine if there are any state-specific control measures that should be emphasized in the analysis.

The technical memorandum will summarize emission reductions for each county, state and Washington D.C. for each control option. The cost and a cost benefit analysis will also be provided for each control option. An opportunity for review by MANE-VU of the draft memorandum will be provided and appropriate comments will be incorporated into the final memorandum. Example calculations of emission reductions, costs and cost benefits will be provided to insure transparency.