

# **A Recommended Procedure for Compiling Emission Inventory National, Regional and County Level Activity Data for the Residential Wood Combustion Source Category**

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## **ABSTRACT**

Residential wood combustion from fireplaces and woodstoves is a source of emissions of particulate matter for many areas of the country. In EPA's National Emission Trends inventory fireplaces and woodstoves are treated as areas sources. Inventory emission estimates are determined from the product of activity levels (mass of wood burned annually) and emission factors (mass of pollutants emitted per mass of wood burned). This paper describes a new approach for calculating activity levels that utilizes current data on residential wood combustion devices and updated survey information.

Activity levels (wood consumption) were developed by device type since emission factors are different for different device types and the urban/rural usage pattern is also different for them. The three main device types are: (1) fireplaces, (2) fireplaces with inserts, and (3) woodstoves. The fireplace category was further subdivided into fireplaces used for heating purposes and those used for aesthetic or pleasure purposes. The woodstove and fireplace insert categories were subdivided into non-certified devices, certified catalytic devices and certified non-catalytic devices.

While industry, private sector, and local survey data were used in developing the approach, public sector data provides the basis of the activity level estimates. The public sector data compiled by the American Housing Survey and the Energy Information Administration are regularly published and can be used to update future activity level estimates with the approach.

A description of the approach used for calculating national, regional and county activity levels are provided. In addition, results of calculating national and regional activity levels with the approach for the 1997 base year are also provided.

## INTRODUCTION

Residential wood combustion from home fireplaces and woodstoves is a source of emissions of particulate matter (PM) and other air pollutants for many areas of the country. Of primary concern are the fine PM emissions, with an aerodynamic diameter less than 2.5 microns, known as PM<sub>2.5</sub>. In EPA's National Emission Trends (NET) inventory, fireplaces and woodstoves are treated as area sources. To estimate these emissions, EPA uses an emission factor for these sources and an estimate of how much wood is burned or consumed in them. EPA's current methodology of estimating residential wood consumption is based on surveys of usage that are outdated. There are also weaknesses in the current methodology that can potentially be improved to better reflect recent trends in residential wood consumption and in the spatial allocation of the wood consumption to the county level. The purpose of this paper is to present an improved methodology for estimating residential wood consumption.

## APPROACH FOR IMPROVED METHODOLOGY

Three key objectives were considered in developing a new methodology for estimating residential wood consumption. These are:

- *Develop wood consumption estimates by device type (woodstoves, fireplaces, fireplaces with inserts)* – There are two important reasons to try and develop residential wood consumption estimates by device type. First, the emission factors are different for the different device types. Secondly, usage patterns are different for the different device types. For example, woodstoves are less likely to be used in urban areas than fireplaces.
- *Develop device-based consumption rates* – In order to support the development of wood consumption estimates by device type, it is necessary to have consumption rates for each device type. These rates can then be applied to the population of device types to calculate wood consumption.
- *Improve county allocation of wood consumption* – The spatial allocation of residential wood consumption to the county level should match patterns of usage (urban vs. rural) and also the relative climate zone where the county is located. The goal was to develop a formulaic approach to account for both of these patterns, by device type.

A number of studies and references were evaluated in order to establish whether there were data available to support an improved methodology that met the key objectives. These include previous estimation methods (both proposed and in actual use)<sup>1-6</sup>, existing related reports and publications<sup>7,8</sup>, national statistical databases<sup>9-13</sup>, public sector surveys (national and local)<sup>14-26</sup> and private sector surveys (market and sales related information for the woodstove and fireplace insert industry)<sup>27-30</sup>. Based on a review of these references and the identification of applicable data sources, a basic calculation and allocation method was developed that could support an improved methodology for estimating residential wood consumption on a national and regional scale. In addition, a county scale approach is being refined at this time and its framework is presented here.

## RECOMMENDED ACTIVITY LEVEL PROCEDURE FOR FIREPLACES WITHOUT INSERTS

This discussion pertains to the development of national and regional scale activity data (i.e., wood consumption estimates) for residential sector fireplaces that are not equipped with a fireplace insert. The foundations of the recommended activity procedure are the previously noted national and regional surveys on fireplace use by the U.S. Bureau of the Census, extensive market research studies of residential wood burning practices, local and regional surveys of fireplace use by different private and local government agencies, as well as, extensive source testing information for fireplaces<sup>31</sup>. The recommended approach is felt to be an improvement over that currently used in the NET because it estimates wood consumption based on the number of fireplace units actually burning wood, and not just an estimate of the total number of fireplaces in homes. Also, the method applies a fireplace burn rate

that takes into consideration whether the fireplace is being used for some level of home heating or just for aesthetic/pleasure purposes. These improvements will provide more accurate and representative total activity data for fireplaces without inserts. A description of each of the major steps in the procedure follows.

**Step 1: Determine the Total Number of Homes in the U.S. with Usable Fireplaces (Both with and without Inserts)**

The procedure starts by determining the total number of homes in the U.S. that contain a usable fireplace that may or may not have an insert device. The goal is to start from a position of the total population of units and then make adjustments to subtract off the portion of fireplaces and wood consumption that occurs in fireplaces with insert devices which are essentially woodstoves designed to fit into a fireplace cavity. The information on the number of homes with usable fireplaces can be obtained from the U.S. Census Bureau’s *American Housing Survey for the United States in 1997*<sup>12</sup>. Data on the number of units are available for the country as a whole and for the four Census Regions (Northeast, Midwest, South, and West). These data for 1997 are shown in Table 1. One important thing to note is that these data reflect the number of homes with usable fireplaces and not the number of fireplaces.

**Step 2: Determine the Number of Total Fireplaces to Reflect the Fact that in Some Cases There is More than One Fireplace per Home**

This adjustment is accomplished by multiplying the data from Step 1 above by an adjustment factor determined from a U.S. Consumer Product Safety Commission report<sup>13</sup>. The adjustment factor is 1.17. Table 1 shows data reflecting this adjustment.

Table 1. Number of homes with usable fireplaces and total number of usable fireplaces.

<b>Geographic Area</b>	<b>Number of <u>Homes</u> with Usable Fireplaces (with and without Inserts)</b>	<b><u>Total Number of Usable Fireplaces</u> (with and without Inserts) (Step 1 estimates x 1.17)</b>
Total United States	31,825,000	37,235,000
Northeast Region	5,015,000	5,868,000
Midwest Region	6,604,000	7,727,000
South Region	10,398,000	12,850,000
West Region	9,223,000	10,791,000

**Step 3: Determine the Number of Usable Fireplaces (with and without Inserts) that Are Wood Burning Fireplaces as Opposed to Those that Use Natural Gas or Propane**

There has been a growing trend in the U. S. to burn other fuels in fireplaces instead of wood. The most prominent of these alternative fuels have been natural gas and propane. Therefore, in determining the procedure, it is necessary to subtract off the estimated number of fireplaces that are not burning wood and are burning gas. The adjustment factor on fireplace fuel use was determined from industry data (primarily from the Hearth Products Association), from marketing research surveys, from local wood use surveys, and from feedback received from industry representatives. The compilation of information from these sources resulted in an adjustment factor of 0.74, that is, 74% of the usable fireplaces in the U.S. are burning wood. The other 26% are using gas. Data in Table 2 reflect this adjustment.

**Step 4: Adjust the Number of Potentially Usable Wood Burning Fireplaces from Step 3 to Reflect the Number that are Actually Being Used to Burn Wood for Heating or for Aesthetic Purposes**

Information collected through local surveys, industry marketing research, and other government publications has indicated that though many homes have usable fireplaces, a large number are not actually used at all, either for heating or aesthetic purposes<sup>8</sup>. In the last 5 to 10 years especially, most new home construction has included a fireplace unit in the construction. Data compiled in this study has indicated that about 58% of the usable fireplaces are actually in use for heating or for aesthetic purposes. Table 2 shows an adjustment to the fireplace activity figures (from Step 3) to incorporate this factor.

Table 2. Number of usable woodburning fireplaces and the number that are actually in use.

Geographic Area	Number of Usable <u>Woodburning</u> Fireplaces (with and without Inserts) from Step 3	Number of Woodburning Fireplaces (with and without inserts) <u>actually in use</u> (Step 3 estimates x 0.58)
Total United States	27,554,000	15,981,000
Northeast Region	4,342,000	2,518,000
Midwest Region	5,718,000	3,316,000
South Region	9,509,000	5,515,000
West Region	7,985,000	4,631,000

**Step 5: Determine the Number of Homes with Fireplaces with Inserts that Use the Units for Heating Purposes.**

The purpose of this step is to specify the number of homes that have usable fireplaces with inserts that are used for heating purposes so that this part of the total fireplace activity level can be subtracted off as a part of the procedure to determine activity for fireplaces without inserts. The activity data for the number of home with fireplaces with inserts, that use them for heating purposes, comes from the 1997 *American Housing Survey*<sup>12</sup>. These data are shown in Table 3, distinguished by whether the heating was primary or secondary.

Table 3. Number of homes with usable fireplaces with inserts used for heating.

Geographic Area	Number of Homes with Usable Fireplaces with Inserts Used for Primary Heating	Number of Homes with Usable Fireplaces with Inserts Used for Secondary Heating	Total Number of Homes with Usable Fireplaces with Inserts Used for Heating
Total United States	143,000	3,946,000	4,089,000
Northeast Region	11,000	409,000	420,000
Midwest Region	19,000	736,000	755,000
South Region	58,000	1,561,000	1,619,000
West Region	54,000	1,240,000	1,294,000

**Step 6: Determine the Total Number of Fireplaces with Inserts to Reflect the Fact that in Some Cases There Is More than One Fireplace with an Insert per Home**

This adjustment is accomplished by multiplying the data from Step 5 by an adjustment factor determined from a U.S. Consumer Product Safety Commission report<sup>13</sup>. The adjustment factor is 1.10. Data shown in Table 4 reflect this adjustment.

**Step 7: Calculate the Total Number of Fireplaces without Inserts Burning Wood**

This calculation is accomplished by subtracting the totals for fireplaces with inserts (values from Step 6) from the national and regional total number of usable fireplaces determined in Step 4. The results of this subtraction are shown in Table 4.

Table 4 Total Number of Fireplaces with and without inserts burning wood.

Geographic Area	Total Number of Usable Fireplaces <u>with</u> Inserts (totals from Step 5 x 1.10)	Total Number of Fireplaces <u>without</u> Inserts Burning Wood (total from step 4 -step 6)
Total United States	4,498,000	11,483,000
Northeast Region	462,000	2,056,000
Midwest Region	808,000	2,508,000
South Region	1,781,000	3,734,000
West Region	1,423,000	3,208,000

**Step 8: Determine the Number of Homes with Fireplaces without Inserts that Use the Units for Primary or Secondary Heating Purposes**

The purpose of this step is to specify the number of homes that have usable fireplaces without inserts that are used for heating purposes. In subsequent steps, this estimate will be subtracted from the total number of fireplaces without inserts total to provide an estimate of the number of homes using these units for aesthetic/pleasure purposes. The activity data for the number of homes with fireplaces without inserts, that use them for heating purposes, comes from the 1997 *American Housing Survey*<sup>12</sup>. These data are shown in Table 5 distinguished by whether the heating was primary or secondary.

Table 5. Total number of homes with a usable fireplace without inserts used for heating.

Geographic Area	Number of Homes with Usable Fireplaces without Inserts Used for Primary Heating	Number of Homes with Usable Fireplaces without Inserts Used for Secondary Heating	Total Number of Homes with Fireplaces without Inserts Used for Heating
Total United States	82,000	3,749,000	3,831,000
Northeast Region	2,000	330,000	332,000
Midwest Region	5,000	570,000	575,000
South Region	32,000	1,520,000	1,552,000
West Region	43,000	1,328,000	1,371,000

**Step 9: Determine the Number of Total Fireplaces without Inserts Used for Heating Figures to Reflect the Fact that in Some Cases There is More than one Fireplace per Home**

This adjustment is accomplished by multiplying the data from Step 8 above by an adjustment factor determined from a U.S. Consumer Product Safety Commission report<sup>13</sup>. The adjustment factor is 1.17. The adjusted data are shown in Table 6.

**Step 10: Determine the Number of Fireplaces without Inserts Used for Aesthetics/Pleasure Purposes**

Since there is a different fireplace burn rate between units used for heating purposes and those used for aesthetic purposes, it is necessary to determine an activity figure for the number of fireplaces without inserts used for aesthetic/pleasure purposes. The total number of usable fireplaces without inserts and the number of fireplaces without inserts used for heating have been determined in previous steps. The number of units attributable to aesthetic purposes is determined by subtracting the number of fireplaces without inserts used for heating from the total number of fireplaces without inserts burning wood (essentially Step 7 values minus Step 9 values). The results of this calculation are shown in Table 6.

Table 6. Total number of fireplaces without inserts used for heating and aesthetic/pleasure purposes.

<b>Geographic Area</b>	<b>Total Number of Fireplaces without Inserts Used for Heating (Step 8 estimates x 1.17)</b>	<b>Total Number of Fireplaces without Inserts Used for Aesthetic/Pleasure Purposes</b>
Total United States	4,482,000	7,001,000
Northeast Region	388,000	1,668,000
Midwest Region	673,000	1,835,000
South Region	1,812,000	1,922,000
West Region	1,604,000	1,604,000

**Step 11: Determine the Number of Cords of Wood Consumed in Fireplaces without Inserts Used for Heating Purposes**

A wood consumption rate (i.e., a wood burning rate) was developed for this study using information from several sources. Fireplace wood burning rates were evaluated from a review of 377 fireplace source tests, 18 local wood use surveys, and several market research studies. From all of these analyses, a composite wood-burning rate, for fireplaces without inserts being used for heating, was developed. This rate was: 0.656 cords burned/unit/year. This rate was multiplied by the number developed in Step 9 to determine the total number of cords burned in fireplaces without inserts being used for heating purposes. (The average mass of a dry cord of wood is 1.163 short tons<sup>32</sup>.) The results of the calculations are shown in Table 7.

**Step 12: Determine the Number of Cords of Wood Consumed in Fireplaces without Inserts used for Aesthetic/Pleasure Purposes**

As in Step 11, a wood consumption rate (i.e., a wood burning rate) was developed using information from multiple sources. Fireplace wood burning rates were evaluated from a review of 18 local wood use surveys, and several market research studies. From all of these analyses, a composite wood burning rate, for fireplaces without inserts being used for aesthetic purposes, was developed. This rate was: 0.069 cords burned/unit/year. This rate was multiplied by the appropriate consumption figure developed in Step 10 to determine the total number of cords burned in fireplaces without inserts being used for aesthetic purposes. The results of the calculations for aesthetic activity data are shown in Table 7.

**Step 13: Total Number of Wood Cords Consumed in Fireplaces without Inserts**

Based on the calculations in Steps 11 and 12, the total number of wood cords consumed in fireplaces without inserts can be calculated and are summarized in Table 7.

Table 7. Cords of wood consumed in fireplaces without inserts.

Geographic Area	Total Cords Consumed in Fireplaces without Inserts Used for Heating Purposes	Total Cords Consumed in Fireplaces without Inserts Used for Aesthetic/Pleasure Purposes	Overall Total Cords of Wood Consumed in Fireplaces without Inserts
Total United States	2,904,000	483,000	3,423,000
Northeast Region	254,000	115,000	369,000
Midwest Region	441,000	127,000	568,000
South Region	1,189,000	133,000	1,322,000
West Region	1,052,000	111,000	1,163,000

### **RECOMMENDED ACTIVITY LEVEL PROCEDURE FOR WOODSTOVES AND FIREPLACES WITH INSERTS**

This discussion pertains to the development of national and regional scale activity data (i.e., wood consumption estimates) for woodstoves and fireplaces that are equipped with a fireplace insert. Woodstoves and fireplaces with inserts are treated together in this discussion since both types of units are used for heating purposes and have wood consumption rates that are comparable. The foundations of the recommended activity data procedure are national and regional surveys on woodstove and fireplace use by the U.S. Bureau of the Census, extensive market research studies of residential wood burning practices, and local and regional surveys of fireplace use by different private and local government agencies. The procedure also makes use of the residential sector wood consumption data published by the Energy Information Administration (EIA)<sup>9,10</sup>. Similar to the fireplaces without inserts procedure, this approach is based on determining a total equipment count and an average unit burn rate to determine total cord wood burned.

The recommended method for woodstoves and fireplace inserts contains basically four major steps: determination of the number of woodstove in use, determination of the number of fireplace inserts in use (already determined in Step 6 for fireplaces), determination of an average unit burn rate for stoves and inserts, and the calculation of total cords burned using the average rate and the total equipment count figures. A description of each of the major steps in the procedure follows.

#### **Step 1: Determine the Total Number of Homes in the U.S. with Woodstoves Used for Heating Purposes**

The first step in the procedure is the determination of the total number of homes in the U.S. that contain a woodstove for heating purposes. The information on the number of homes with woodstoves can be obtained from the U.S. Census Bureau's *American Housing Survey for the United States in 1997*<sup>12</sup>. Woodstove data are available on the basis of homes that use them as a primary heating source and as a secondary heating source. Data on the number of units are available for the country as a whole and for the four Census Regions (Northeast, Midwest, South, and West). These data for 1997 are shown in Table 8.

Table 8. Total number of homes with woodstoves used for heating.

Geographic Area	Number of Homes with Woodstoves Used for Primary Heating	Number of Homes with Woodstoves Used for Secondary Heating	Total Number of Homes with Woodstoves Used for Heating
Total United States	1,142,000	4,556,000	5,698,000
Northeast Region	173,000	1,264,000	1,437,000
Midwest Region	177,000	925,000	1,109,000
South Region	474,000	1,124,000	1,598,000
West Region	321,000	1,244,000	1,565,000

**Step 2: Determine the Number of Total Woodstoves to Reflect the Fact that in Some Cases There is More than One Woodstove per Home**

This adjustment is accomplished by multiplying the data from Step 1 by an adjustment factor determined from a U.S. Consumer Product Safety Commission report<sup>13</sup>. The adjustment factor is 1.09. The adjusted data is shown in Table 9.

**Step 3: Determine the Number of Fireplaces with Inserts that Are Used for Heating, and then Combine These Data with Estimates on the Number of Woodstoves in Use**

Since fireplaces with inserts are being addressed in conjunction with woodstoves, it is necessary to know how many fireplaces with inserts are in use. This value has already been calculated during the procedures described in Step 6 for fireplaces. They are then combined with the woodstoves data from woodstove Step 2 to give the combined total number of woodstoves and fireplaces with inserts. These data are shown in Table 9.

Table 9. Total number of woodstoves and fireplaces with inserts

Geographic Area	Total Number of Woodstoves (Step 1 estimates x 1.09)	Total Number of Fireplaces with Inserts (from fireplace Step 6)	Total Number of Woodstoves and Fireplaces with Inserts
Total United States	6,211,000	4,498,000	10,709,000
Northeast Region	1,581,000	462,000	2,043,000
Midwest Region	1,209,000	808,000	2,017,000
South Region	1,742,000	1,781,000	3,523,000
West Region	1,706,000	1,423,000	3,129,000

**Step 4: Determine the Total Number of Wood Cords Consumed by Woodstoves and Fireplaces with Inserts**

The starting point for this determination is the 1997 EIA national wood consumption data for the residential sector<sup>10</sup>. The data reported in the EIA publication exclude any consumption for aesthetic/pleasure purposes. These wood consumption data (inclusive of woodstoves and fireplaces used for heating) are shown in Table 10.

The amount of wood consumed by fireplaces without inserts for heating purposes needs to be subtracted from the totals to determine wood consumption by woodstoves and fireplaces with inserts. The consumption amounts for fireplaces without inserts have already been determined during the



procedures detailed in fireplace Step 13 and are shown in Table 7.

The difference then between the two sets of data equals the residential sector wood consumption attributable to woodstoves and fireplaces with inserts. Table 10 provides the consumption estimates resulting from the subtraction. (As previously noted, the average mass of a dry cord of wood is 1.163 short tons<sup>32</sup>.)

Table 10. Total cords of wood consumed in woodstoves and fireplaces.

<b>Geographic Area</b>	<b>Total Cords of Wood Consumed by Woodstoves and <u>All</u> Fireplaces Used for Heating</b>	<b>Total Cords of Wood Consumed in Woodstoves and Fireplaces <u>with Inserts only</u></b>
Total United States	21,700,000	18,760,000
Northeast Region	7,100,000	6,800,000
Midwest Region	4,200,000	3,750,000
South Region	5,500,000	4,310,000
West Region	4,900,000	3,840,000

**Step 5: Determine the Annual Wood Burn Rate for Woodstoves and Fireplaces with Inserts so that Wood Consumption Totals Can Be Calculated for Woodstoves and Fireplace Inserts**

Unlike the procedure described for fireplaces without inserts, representative average burn rates could not be determined for woodstoves and fireplace inserts from the available literature data. Generally, the available survey and source testing data were too locally biased to derive an average burn rate that could be uniformly applied to all wood consumption by stoves and inserts. As an alternative, average regional burn rates were derived by dividing the figure for total wood cords consumed by the total number of woodstove and fireplace insert units in that region (data in Tables 9 and 10). This approach allows regional temperature differences to be more accurately reflected in the burn rate (e.g., the rate for the Northeast is more than double the rate for the South). Table 11 contains the derived burn rates.

**Step 6: Determine the Total Number of Wood Cords Consumed Individually in Woodstoves and Fireplace Inserts**

This step involves multiplying the burn rates from the previous Step 5 with the woodstove and fireplace insert units' data from Step 3 to yield total cords consumed in woodstoves and fireplace inserts.

Table 11 shows the results of the calculations.

Table 11. Average burn rate and total cords of wood consumed in woodstoves and fireplaces with inserts per year.

Geographic Area	Average Burn Rate, Cords Consumed/Unit/Year	Total Cords of Wood Consumed in Woodstoves/Year	Total Cords of Wood Consumed in Fireplace Inserts/Year
Total United States	1.75	10,870,000	7,870,000
Northeast Region	3.33	5,270,000	1,540,000
Midwest Region	1.86	2,250,000	1,500,000
South Region	1.22	2,130,000	2,170,000
West Region	1.23	2,100,000	1,750,000

### PROCEDURE FOR ALLOCATING WOOD CONSUMPTION TO THE COUNTY LEVEL

The procedure for calculating county level wood consumption is currently being refined. There are four major components that will provide the basis for county level allocation. These are: (1) the regional wood consumption values by device type calculated in the preceding sections, (2) an urban/rural allocation, (3) an apportionment based on climate zone, and (4) an apportionment based on county demographics/population. The following sections describe the latter three components in detail and the sources of information on which they are based.

#### Urban/Rural Apportionment

Statistics from the AHS and experience from experts in the residential wood combustion field of study indicate that the majority of fireplaces are located in suburban areas. These suburban areas by definition are located around the periphery of major metropolitan areas. Many of the single family homes that are built in suburban areas have fireplace units. There are also a large number of townhouses and apartments in suburban and urban areas that contain fireplaces.

There are also known to be distinct differences in wood consumption between urban and rural areas, in regards to woodstoves and fireplace inserts. Simmons Market Research Bureau surveys for the years 1990-1999 support this assumption<sup>29</sup>. These marketing data indicate that there is a greater likelihood for woodstove and fireplace insert owners to live in less densely populated areas. There is a particularly strong relationship between rural areas and woodstove usage, since woodstoves are more likely to be used in rural areas for heating purposes and wood fuel is generally less expensive there. In order to account for this difference in the apportioning process, data from the AHS<sup>12</sup> were utilized to develop a national average that represents the proportion of homes with woodstoves/fireplace inserts in urban and rural areas.

- *Urban/rural location of homes with woodstoves* – A split of 69% rural, 31% urban was developed from national data contained in the AHS. The AHS uses the Census Bureau’s definitions of urban and rural in their data compilation.
- *Urban/rural location of homes with fireplace inserts* – A split of 50% rural, 50% urban was developed from national data.
- *Urban/rural location of homes with fireplaces* – A split of 32% rural, 68% urban was developed from national data.
- *Urban and rural designations for counties* – The EPA’s Urban Air Toxics program<sup>5</sup> has developed a systematic approach to classifying all counties in the U.S. as either Urban 1, Urban 2, or Rural based on Census population data for 1996. These designations are also based on Census Bureau definitions for urban and rural areas. For the purposes of this methodology, any county with either an Urban 1 designation or an Urban 2 designation is considered urban, since these are just subsets of the overall urban Census category.

## **Apportioning for Climate Zones**

For any given Census Region there are many counties that are classified as either urban or rural; however, some of those counties will be in warmer climate zones and some will be in colder climate zones. Understandably, it is expected that more wood would be burned in colder areas than those in warmer areas. It is therefore necessary to apportion the usage based on climate zones.

In order to allocate urban and rural area wood consumption to climate zones, two pieces of information will be utilized:

- *Percentage of wood consumed in different climate zones* – Information contained in the Energy Information Administration’s RECS database<sup>9</sup>, provides national data on the amount of wood consumed in five different climate zones defined by heating degree days (HDD) and cooling degree days (CDD). From these data, the following percentages were developed:
  - 36% of wood consumed in households in climate zone 1 (>7000 HDD)
  - 19% of wood consumed in households in climate zone 2 (5500-7000 HDD)
  - 21% of wood consumed in households in climate zone 3 (4000-5499 HDD)
  - 15% of wood consumed in households in climate zone 4 (<4000 HDD and <2000 CDD)
  - 9% of wood consumed in households in climate zone 5 (<4000 HDD and >2000 CDD)
- *Climate zone designation for counties* – Each county in the U.S. can be classified into a climate zone based on the annual HDD and CDD for that county. The HDD and CDD data can be obtained from the National Climatic Data Center (NCDC).

## **Apportioning Wood Consumption to Individual Counties Based on Demographics/Population**

To further apportion wood consumption estimates to individual counties, it was necessary to identify an available county level statistical variable that could serve as a surrogate for fireplace, woodstove and fireplace insert usage that relates to demographics/population. Historical efforts have investigated the use of county population. However, it was decided that county population alone was not a good indicator of usage since counties could have a large, concentrated population that does not necessarily correlate well with wood burning appliance usage. Since other data sources have shown that suburbs appear to be the primary areas for fireplace usage, it was decided that the population of single family homes (SFH) provided the strongest connection to suburban characteristics for a county. This is reasonable since most suburbs have large concentrations of subdivisions with single family homes, and this residential development is often looked at as one of the definable characteristics of suburbs. In regards to woodstoves and fireplaces the Energy Information Administration’s RECS data indicate that over 90% of wood consumption used for heating (for which woodstoves and fireplace inserts are the principal devices used) occurs in single family housing units<sup>9</sup>.

Data on the population of SFH in individual counties is available from the 1990 Census database<sup>11</sup>. By using the relative proportion of the SFH in the individual county as compared to the total SFH for all counties in the urban/rural, climate zone group to which that county belongs, an apportionment factor can be developed. This factor is then multiplied by the total wood consumption for the regional, urban/rural, climate zone group to obtain wood consumption for the individual county.

## **PARTITIONING WOOD CONSUMPTION BY WOODSTOVE AND FIREPLACE INSERT TYPE**

Once final wood consumption figures are determined for woodstoves and fireplace inserts, an adjustment should be performed to allocate consumption according to the type of unit that is in service. The “type” refers to whether the stove or insert is certified or non-certified according to EPA regulatory

requirements, and whether the stove or insert is of a catalytic or non-catalytic design. Distinguishing these aspects of the woodstove and insert population and wood consumption is important in the development of emission estimates for the category because emission factors differ by these parameters. Using sales and manufacturing data it was estimated that on a national basis 92% of woodstoves and inserts were non-certified, 5.7% were certified non-catalytic and 2.3% were certified catalytic. Prior to applying emission factors for emissions estimation, wood consumption figures would be multiplied by these percentages to determine wood use by stove and insert type.

## CONCLUSIONS

The methodology described in this report addresses two main improvements to the existing methodology used for estimating residential wood consumption in the NET inventory. The first is to develop regional estimates of residential wood consumption using a device-based calculation. By developing regional wood consumption estimates based on the population of each device type (i.e., woodstoves, fireplace inserts, and fireplaces), emissions can be more accurately estimated based on the specific emission factors available for the device type. Also, the use of device populations at the regional level helps to improve the initial spatial allocation of emissions, by providing a more accurate representation of where the wood consumption is occurring relative to where the devices are located.

The second improvement addressed by this methodology is to allocate regional wood consumption to the county level using a combination of spatial allocation factors based on urban/rural usage, temperature, and single family household numbers. The combination of these factors helps to assign wood consumption to the county level based on patterns of usage for the different device types and to also account for the influence of temperature variation.

## REFERENCES

1. Air Resources Board, California Environmental Protection Agency, *Emission Inventory Procedural Manual, Volume III, Methods for Assessing Area Source Emissions*, Section 7.1, Residential Wood Combustion, revised July 1997.
2. Chappell, L.M., E. H. Pechan and Associates, Inc., Letter to Sharon Nizich, U.S. Environmental Protection Agency, Office of Air Quality Planning and Standards, Subject: County Residential Wood Consumption Estimation Model, March 30, 1995.
3. Pechan-Avanti Group, *Emission Characteristics of Small Boilers, Technical Memorandum, Potential Improvements to Emission Estimation Methodologies for Residential Wood Combustion*, Prepared for Emission Factors and Inventory Group, U.S. Environmental Protection Agency, Research Triangle Park, October 30, 1998.
4. U.S. Environmental Protection Agency, *National Air Pollutant Emissions Trends Procedures Document for 1900-1996*, Office of Air Quality Planning and Standards, Research Triangle Park, NC, EPA-454/R-98-008, May 1998.
5. U.S. Environmental Protection Agency, *1990 Emissions Inventory of Forty Potential Section 112(k) Pollutants*, final report, Research Triangle Park, NC, 1999.
6. Radian Corporation, "Residential Wood Combustion, Emission Inventory Improvement Program," Prepared for U.S. Environmental Protection Agency, Research Triangle Park, NC, 1997.
7. "1999 Regional Sales Results, Geographic Directions," *Hearth & Home – Hearth, Barbecue, and Patio Retailing*, April 2000, 26-34.
8. Kochera, A., "Residential Use of Fireplaces," *Housing Economics*, March 1997, 10-11.
9. Energy Information Administration, *A Look at Residential Energy Consumption in 1997*, U.S. Department of Energy, Washington, DC, November, 1999.
10. Energy Information Administration, *Renewable Energy Annual 1998 with Data for 1997*, Office of Coal, Nuclear, Electric, and Alternate Fuels, U.S. Department of Energy, Washington, DC,

December 1998.

11. U.S. Census Bureau, *1990 U.S. Census Data, Database C90STF3A*, Accessed electronically via Internet website (<http://venus.census.gov>), September 2000.
12. U.S. Census Bureau, *American Housing Survey for the United States*, Joint Publication of U.S. Department of Commerce and U.S. Department of Housing and Urban Development, Washington, DC, 1999.
13. Zamula, W.M., *Room Heating Equipment Exposure Survey, Final Report*, U.S. Consumer Product Safety Commission, Directorate for Economic Analysis, Washington, DC, March 1989.
14. Cote, W.A., and Kaleel, R.J., "A Survey of Residential Combustion of Wood and Coal in Colorado" Prepared for U.S. Environmental Protection Agency, Region VIII, and Colorado Department of Health, by TRC Environmental Consultants, Englewood, Colorado, January 18, 1985.
15. Health Department, *Washoe County, Nevada - Residential Wood Use Survey, 1995-1996*, Reno, NV, August 1996.
16. ES Field Services, Inc., "Pocatello Air Quality RWC Device Usage – Survey Results," Boise, Idaho, August 1991.
17. Hutton, B. R., and Hartley, S.W., *Metropolitan Denver Woodburning Survey*, Englewood, CO, December 1991.
18. King, J.A., *Carbon Monoxide Woodburning Inventory for Ft. Collins*, Air Pollution Control Division, Colorado Department of Health, November 1992.
19. King, J.A., *Carbon Monoxide Woodburning Inventory for Colorado Springs*, Air Pollution Control Division, Colorado Department of Health, November 1992.
20. Maricopa Association of Governments, *Revised MAG 1999 Serious Area Particulate Plan for PM-10 for the Maricopa County Nonattainment Area, Appendices, Volume I*, Phoenix, AZ, February 2000.
21. Young, W.W., and Hardwick, N.A., "Wood Combustion Study – Summary Report," Report No. 4486, Prepared for Puget Sound Air Pollution Control Agency, by Market Trends, Inc., Bellevue, WA, July 1993.
22. May, D.M., *Residential Fuelwood Consumption and Production in the Plains States, 1994*, North Central Forest Experiment Station, U.S. Forest Service, St. Paul, MN, Resource Bulletin NC-173, 1996.
23. Ono, D., Taylor, W., and Lawhorn, D., *Air Quality Management Plan for the Town of Mammoth Lakes*, The Great Basin Unified Air Pollution Control District and The Town of Mammoth Lakes, November 30, 1990.
24. Oregon Department of Environmental Quality, *Portland Area Wood Heating Survey – 1985*, Portland, OR, October 1985.
25. Oregon Department of Environmental Quality, *Medford Area Wood Heating Survey – 1985*, Portland, OR, October 1985.
26. Research & Polling, Inc., "City of Albuquerque Wood Burning Survey," Prepared for City of Albuquerque, Environmental Health Department, Air Pollution Division, Albuquerque, NM, May 1998.
27. Perry Lawson & Associates, "Consumer Research Results, Duraflame Firelogs – Winter 1996/97," Prepared for Duraflame, Inc., Stockton, CA, 1998.
28. Sensenbrenner, A., and Van Ryzin, M, "Residential Wood Heat Research" prepared for North Central Hearth Products Association, by Matousek & Associates, Green Bay, WI, January 2000.
29. Simmons, "Simmons Market Research Data for Woodstoves and Fireplace Insert 1990-1999," Prepared for OMNI Environmental Services, Inc., by the Simmons Market Research Bureau, New York, NY, August 2000.
30. Vista Marketing Research, U.S. "Fireplace Usage Frequency" Prepared for Duraflame, Inc., Stockton, CA, March 1996.

31. Tiegs, P.E., and Houck, J.E., *Evaluation of the Northern Sonoma County Wood-Burning Fireplace and Masonry Heater Emissions Testing Protocols*, Appendix A, Prepared for Northern Sonoma County Air Quality Management District, by OMNI Environmental Services, Inc., Beaverton, OR, 2000.
32. Energy Information Administration, *Estimates of U.S. Biomass Energy Consumption 1992*, Office of Coal, Nuclear, Electric and Alternate Fuels, U.S. Department of Energy, Washington, DC, May 1994.