EPA'S RESIDENTIAL WOOD COMBUSTION TOOL: IMPROVEMENTS AND APPLICATIONS

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1. INTRODUCTION

The U.S. Environmental Protection Agency's (EPA) National Emissions Inventory (NEI) catalogs emissions of criteria pollutants and hazardous air pollutants (HAPs) from point and nonpoint sources. Because emissions from nonpoint sources are typically not measured directly, they must be estimated. The EPA requests that states submit nonpoint source data, but where the states do not have data or resources to estimate their nonpoint source pollution, the EPA must estimate it for them.

To help estimate emissions from residential wood combustion, the EPA and Abt Associates have developed and improved the Residential Wood Combustion (RWC) tool.

The RWC tool is a Microsoft® Access®-based tool that computes the amount of wood burned and emissions of criteria pollutants and HAPs from 12 different wood burning appliance types, including fireplaces, seven types of woodstoves, wood-fired furnaces and boilers, outdoor burning devices, and wax firelogs (Table 1). The woodstoves are divided into conventional and EPA-certified units. In general, the conventional units were constructed prior to 1988. Units constructed after 1988 had to meet EPA emission standards and they are either catalytic or non-catalytic, depending on whether they contain a catalyst to improve the burn efficiency.

2. OVERVIEW OF RWC TOOL

The tool uses data from residential surveys to develop Appliance Profiles and Burn Rates for each county. Appliance Profiles are the fraction of homes in each county that own and use each type of wood burning appliance. Burn Rates are the estimated amount of wood burned (cords or tons) in each appliance in each year. The Appliance Profiles and Burn Rates are further subdivided by burn type: main burning, secondary burning, and pleasure burning. Therefore there are Appliance Profiles and Burn Rates assigned to each combination of county, appliance, and burn type.

Table 1. SCCs in the Residential Wood Combustion Sector

SCC	Description
2104008100	Fireplace: general
2104008210	Woodstove: fireplace inserts; non-EPA certified
2104008220	Woodstove: fireplace inserts; EPA certified; non-catalytic
2104008230	Woodstove: fireplace inserts; EPA certified; catalytic
2104008310	Woodstove: freestanding, non-EPA certified
2104008320	Woodstove: freestanding, EPA certified, non-catalytic
2104008330	Woodstove: freestanding, EPA certified, catalytic
2104008400	Woodstove: pellet-fired, general (freestanding or FP insert)
2104008510	Furnace: Indoor, cordwood-fired, non-EPA certified
2104008610	Hydronic heater: outdoor
2104008700	Outdoor wood burning device, NEC (fire-pits, chimineas, etc)
2104009000	Residential Firelogs Total: All Combustor Types

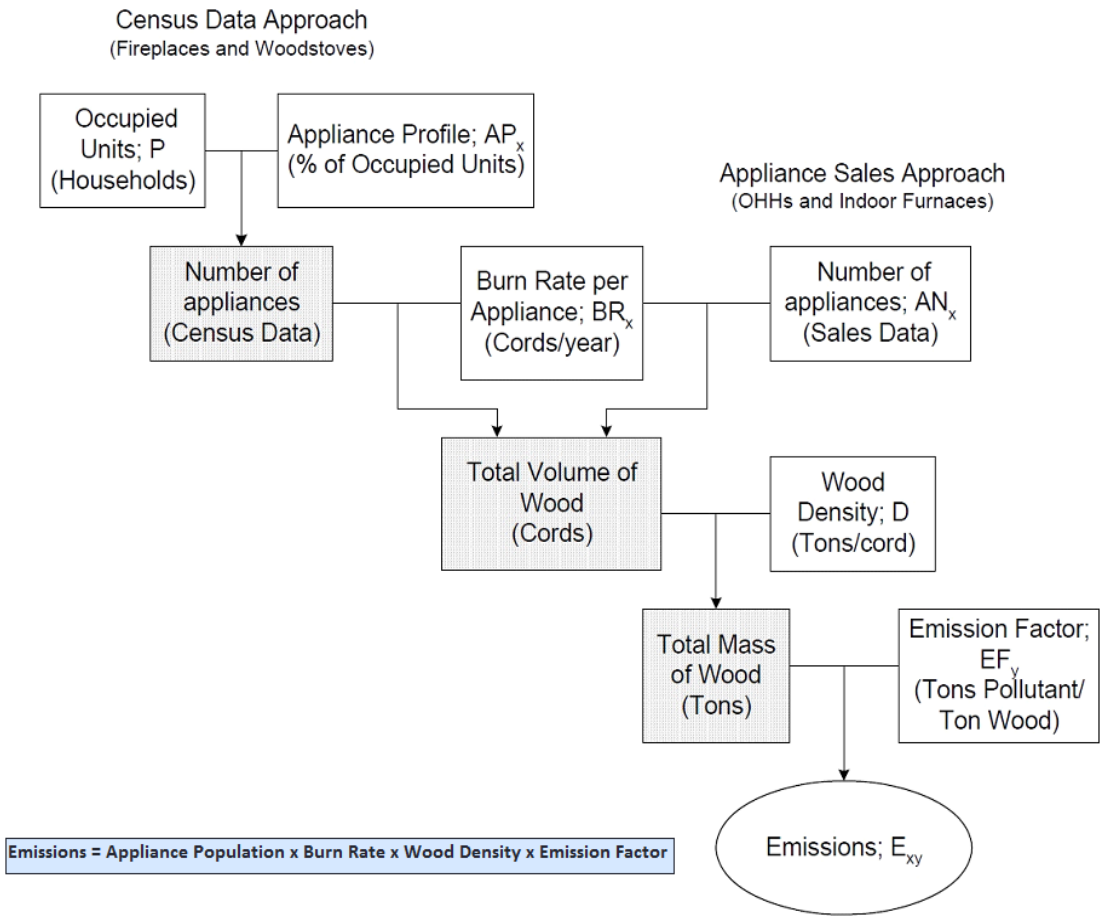

Figure 1. Data flow diagram for the RWC Tool.

The Appliance Profiles and Burn Rates are used in the data flow as shown in Figure 1. First the Appliance Profiles are multiplied by the numbers of occupied housing units in each county (U.S. Census Bureau 2014) to determine the total number of appliances in use in each county. This number is then multiplied by the Burn Rate to determine the total amount of wood burned annually in each county. Where Burn Rates are estimated in cords of wood, the estimates of cords burned are converted to tons of wood based on county-level wood density data from the U.S. Forest Service (2005). Finally, the total mass of wood in tons is multiplied by an emission factor for each pollutant to determine the total emissions of each criteria pollutant and HAP.

For wood-fired boilers, also called outdoor hydronic heaters (OHH), and wood-fired furnaces, the estimation of the appliance population is based on actual sales data, rather than survey-derived Appliance Profiles. Otherwise the estimation of the emissions for these appliances follows the same process.

3. DATA SOURCES

The Appliance Profiles and Burn Rates used in the RWC Tool are based on survey data in which respondents are asked whether they use a given wood burning appliance, and in some cases, how much wood they burn. The tool draws on data from several different surveys, including the American Housing Survey (AHS) (U.S. Census Bureau 2014).

The AHS includes national and metropolitan-area surveys on the nation's housing stock. It asks questions about various household characteristics, including the equipment and fuels used for heating the home. Both the national and metropolitan statistical area (MSA) surveys are conducted during a 3- to 7- month period. The national survey, which gathers information on housing throughout the country, conducts interviews at about 55,000 housing units every 2 years, in odd-numbered years. The metropolitan area survey consists of 47 metropolitan areas, where householders are interviewed every 6 years. Data are gathered for roughly 14 metropolitan areas on an even

numbered year until all 47 metropolitan areas are surveyed. Data are also gathered for non-MSA counties and are presented at the national level and for four large Census regions: North, South, Midwest, and West. We used the MSA-level data to estimate Appliance Profiles for all counties that fall within each MSA. For all other counties, we used the regional-level data.

The AHS provides information on the number of respondents that use fireplaces (with or without inserts) or woodstoves. To estimate the Appliance Profiles, we divided the number of survey respondents that use each type of appliance by the total number of respondents to determine the fraction of occupied homes in each geographic region with each type of appliance.

Because the AHS does not differentiate between certified and non-certified (conventional) woodstoves, we distributed the Appliance Profiles for woodstoves based on data showing that 65 percent of woodstoves are conventional and 35 percent are certified (Houck 2011). Furthermore, because the AHS does not differentiate between fireplaces that burn wood with those that burn gas, we applied an adjustment factor to the AHS data that assumes that 30% of fireplaces burn gas, based on Houck (2003).

The area contained in an MSA will usually contain an urban core and surrounding areas that are more sub-urban than urban. One of the problems noted in previous versions of the tool is that applying the MSA information to all the counties in the MSA usually results in the overestimation of residential wood combustion emissions in the urban core and underestimation in the suburban counties. For 2011, we addressed this by separating the urban core county from the sub-urban counties and allocating a higher proportion of the emissions to the suburban counties.

In addition the AHS data, the tool draws on local- and state-level survey data as much as possible. These smaller-scale surveys were used to construct Appliance Profiles and Burn Rates for counties in California, Idaho, Minnesota, Montana, Nevada, Oregon, Vermont, and Washington.

Because the AHS does not ask about the total amount of wood burned in each appliance, the Burn Rates are constructed using a mixture of local surveys, fuel sales data, and expert judgment.

The AHS and, in some cases, other local survey data do not include information on outdoor wood-fired boilers (OWBs) or furnaces. Therefore the populations for these appliances had to be estimated using a separate methodology.

The OWB populations in the RWC tool were originally based on a combination of data from the Northeast States for Coordinated Air Use Management (NESCAUM 2006), the 2008 Minnesota Residential Fuelwood Assessment (Brarzen 2008), and the Vermont Residential Fuel Assessment (Vermont Division of Forestry 2008).

These populations were updated using OWB sales data from EPA's Burnwise Program (EPA 2014) showing that 80 percent of the OWB manufacturers sold 28,075 boilers over a three-year period ending in July 2012. Scaling these numbers to estimate 100% of OWB sales (by dividing the total number of OWBs sold by 0.8) suggests that there have been approximately 35,000 OWBs added to the national population since the 2008 National Emissions Inventory. Because the data were rolled up to the national level, we distributed the OWBs to counties using the methodology described below, which was developed and approved by the Eastern Regional Technical Advisory Committee (ERTAC).

First, we distributed the 35,000 boilers to all states except Connecticut, Hawaii, Oregon, and Washington,[1] based on their existing proportion of OWBs. For example, if a state had 3% of all OWBs in 2008, then it received 3% of the new OWBs, or 1,050 boilers.

Once the boilers were distributed to the states, we then distributed the state-level OWBs to counties based on a county's proportion of rural households in the state. Note that this is slightly different from the method used to distribute OWBs to counties for the 2008 NEI, in which they were distributed based on rural *population*, rather than households.

[1] These states were excluded based on conversations with the states suggesting no growth in OWBs.

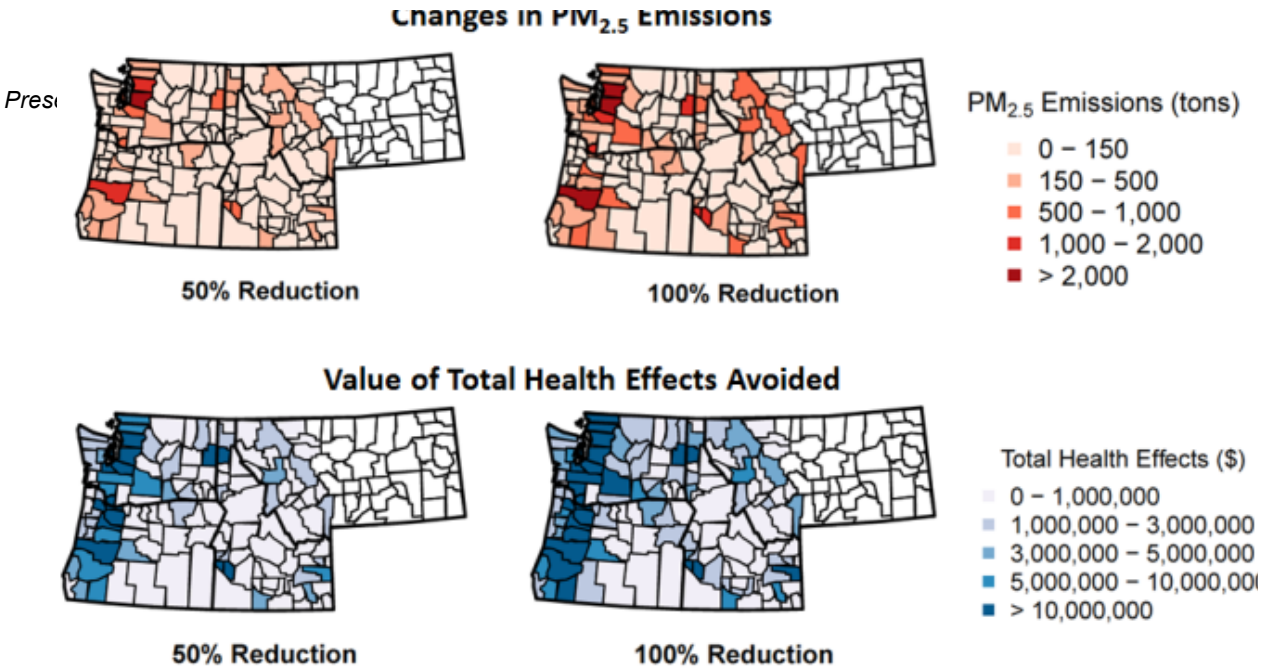

Figure 2. Results from scoping-level analysis of health impacts of reduction of wood smoke emissions in the Pacific Northwest

The U.S. Census Bureau collects information at the county level on the urban and rural population, and the total households, but it does not break the household data down into urban and rural data. Therefore, we estimated the number of rural households by multiplying the total number of households in each county by the percentage of the rural population in each county. For example, if 60% of the county's total population is listed as rural, then the number of households would be multiplied by 0.6 to estimate the number of rural households.

Then we distributed each state's population of OWBs to each county based on that county's proportion of rural households. OWBs were only distributed to counties with an average population density of less than 300 people per square mile.

4. CASE STUDY: HEALTH IMPACTS OF REDUCING WOOD SMOKE EMISSIONS IN THE PACIFIC NORTHWEST

The RWC tool was used in a scoping-level analysis for the Northwest Power and Conservation Council's Regional Technical Forum to investigate the expected health impacts of a reduction in wood smoke emissions in the Pacific Northwest (PNW) region.

The tool was used to estimate baseline wood smoke emissions of $PM_{2.5}$, NO_x, SO_2, NH_3, and VOCs in Washington, Oregon, Idaho, and Montana. Scenarios were also run in which emissions were reduced 25 percent, 50 percent, 75 percent, and 100 percent.

The emissions from the baseline and scenarios were input into the Co-benefits Risk Analysis (COBRA) tool to estimate the expected health outcomes, including reductions in mortality, non-fatal heart attacks, and other hospitalizations. COBRA also uses EPA-approved benefit functions to estimate the monetary benefits of the change in health outcomes.

The results show that each percentage point reduction in wood smoke emissions could result in 2–5 fewer expected deaths each year, and could have total health benefits of $17–38 million. Therefore, a 100 percent reduction in wood smoke emissions across the PNW region could have total annual health benefits of $1.7–3.8 billion.

Figure 2 shows that the health benefits do not necessarily accrue to the regions with the highest emissions. Most of the benefits are seen along the Pacific coast, due mostly to higher population levels in these counties. Note that the benefits estimated in this analysis assume the same level of wood smoke emission reductions throughout the study area. More research is needed to determine the benefits from more spatially targeted emission reductions, such as from one or a small group of counties.

5. SUGGESTIONS FOR FUTURE WORK

The RWC tool depends on survey data to determine the Appliance Profiles and Burn

Rates that are used to estimate the total number of appliances and total amount of wood burned in each county. The tool uses data from the AHS for most counties, but this survey has limited spatial resolution. Aside from the 47 metropolitan areas, the Appliance Profiles for most counties in the RWC tool are based on AHS data for the four census regions. The size of these regions, however, obscures large subregional differences. For example, using data from the South region means that both northern Oklahoma and southern Florida would have the same Appliance Profile. Where possible the AHS data are supplemented with data from local- or state-level residential surveys, but these surveys are mostly for states in the West or Northeast; there are no local surveys available for the South.

In addition, the AHS only asks respondents whether they use a particular survey—which is useful for constructing the Appliance Profiles—but not how much wood they burn each year—which is needed for constructing the Burn Rates. As a result the Burn Rates are based on data from other local- and state-level surveys, sales data, and expert judgment.

For this reason, additional survey data are needed on wood burning activity, including the amount of wood burned in each household, at a finer spatial resolution than the four large census regions. In addition, ideally the survey data could be examined to explore differences in urban, suburban, and rural counties.

This survey data would allow the development of Appliance Profiles and Burn Rates that are more tailored to local conditions. Such improvements would increase the ability of the tool to accurately estimate local wood smoke emissions for all counties in the United States.

6. REFERENCES

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