⊕EPA

Project Summary

Development of Residential Wood Consumption Estimation Models

Walid Ramadan and Mark G. Smith

Data on the distribution and usage of firewood were obtained from a pool of household wood use surveys. Based on a series of regression models developed using the STEPWISE procedure in the SAS statistical package, two variables appear to be most predictive of wood use per household: (1) heating degree days, and (2) percentage of households that burn wood as a main heat source. The average number of cords burned in fireplaces is estimated as a function of the total number of cords burned per household, availability of wood, and population density. Models were also developed to estimate the distribution of wood-burning devices. Variables that appear to be most predictive of the percentage of wood stoves are percentage of households that burn wood as a main heat source, heating degree days, availability of wood, and percentage of urban population. Input data, predicted values, and deviations from actual values are tabulated for each model. Graphs for each model show both actual and predicted values for the variables being estimated.

This Project Summary was developed by EPA's Air and Energy Engineering Research Laboratory, Research Triangle Park, NC, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

This report presents several statistical models that have been developed to predict wood fuel use in residential applications based on a review of available residential wood use surveys conducted for local area planning or State Implementa-
tion Plan (SIP) inventory development These models could be used to improve the emissions estimates for residential wood fuel consumption in areas that are not required, and therefore are not likely to conduct household surveys. The models may also be included in the Area and Mobile Source Subsystem (AMS) of the Aerometric Information Retrieval System (AIRS).

Database Development

Data on the distribution and usage of firewood are needed in order to accurately characterize the resulting air pollution impacts. Currently, the most accurate means of estimating residential wood combustion levels in a given area is through direct surveys of households. Wood use surveys were obtained from several states including Colorado, Connecticut, Idaho Maine, Montana, Nevada, New Hampshire Oregon, Vermont, and Washington. While most surveys reviewed were conducted specifically to evaluate wood use in an area, some were conducted for other purposes, but still included questions pertaining to wood burning. Most of the surveys reviewed were from and within Montana Colorado, and Washington. The geographic levels at which the surveys were conducted ranged from small towns to entire states. Only a fraction of the surveys clearly defined the boundaries of the survey area. Of the surveys, 58% were conducted prior to 1985; the remaining 42% were conducted during or after 1985

State-level survey results were collected for Colorado, Michigan, and Washington These surveys were not used in the analysis because the focus of this effort was to develop models applicable at the county level. Many other surveys collected were not usable due primarily to a lack of information on the surveys' boundaries, and/or

the lack of questions in the Surveys that would result in estimates of fuel wood use. Finally, in areas where more than one survey had been conducted, only the most recently complete was used. Overall, 68 surveys were obtained, of which 40 were used in the analysis.

Statistical Analysis

Before designing new models, several existing models were examined that quantify residential wood combustion. Two studies in particular were reviewed which estimate firewood usage at the county level. One, conducted by Brookhaven National Laboratory, performed a regression analysis on survey data collected by the U.S. Forest Service. The other study, by Skog and Watterson, performed a regression analysis on the survey data collected as part of the New England Fuelwood Survey. The models and their results are briefly described and their application to the surveys collected presented.

Conclusions

Based on a series of regression models developed to estimate wood use and distribution of wood-burning devices, the two variables that appear to be most predictive are heating degree days and percentage of households that burn wood as a main source of heat. A variety of local factors can directly impact the number of wood-burning households and the quantity of wood burned by each. Such factors include the historical availability and relative price of other heating fuels, and the heat content of firewood in the area where the survey was conducted. The latter factor is important because wood use is measured by cords, a volume measurement. A cord of pine contains approximately 65% of the heat content of a cord of oak.

Limitations on the estimates of wood use presented here do not necessarily lie in the methodology but with the data used as inputs for the models. The accuracy of the data collected is in doubt because there was no independent verification. It is likely that the variability in the data is due in large part to the respondents' inaccurate impression of how much wood is in a cord. Another limitation is that the geographical boundaries of many of the survey areas were poorly defined. Finally, the validity of the surveys themselves is questionable especially in those areas that showed large discrepancies between the reported estimates of households using wood as a main heating fuel and the corresponding Census statistics.

The residential wood consumption models developed here may be improved by including a number of socioeconomic variables such as cost of other energy forms in comparison to wood energy and average household income. The models can also be improved by conducting more simplified and specialized wood use surveys. Future guidance on the development and use of surveys of residential wood use should attempt to gather more detailed information specifically on appliance characteristics (i.e., catalytic, EPA-certified), wood characteristics, and wood-burning practices. Simplified surveys reduce the number of nonrespondents and the number of unanswered questions. Missing answers in surveys present problems when the data collected in a survey are subject to statistical analysis because statistical procedures cannot be immediately used if there are missing values. In addition, the models can be further improved by incorporating cross-sectional data from areas that conduct surveys periodically. Cross-sectional data may be used to develop wood use projection models and will capture the effects of changing socioeconomic factors on wood use patterns. Finally, the wood use models presented in the report can be validated, using field surveys to show how accurately the models estimate wood use in areas where no surveys are planned.

Walid Ramadan and Mark G. Smith are with TRC Environmental Corp., Chapel Hill, NC 27514.
***Robert C. McCrillis** is the EPA Project Officer (see below)*
The complete report, entitled "Development of Residential Wood Consumption Estimation Models," (Order No. PB93-199 248/AS; Cost: $19.50, subject to change) will be available only from:
  National Technical Information Service
  5285 Port Royal Road
  Springfield, VA 22161
  Telephone: 703-487-4650
The EPA Project Officer can be contacted at:
  Air and Energy Engineering Research Laboratory
  U.S. Environmental Protection Agency
  Research Triangle Park, NC 27711