

# Lessons Learned in the Development of Regional Emission Estimates for Open Burning

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## ABSTRACT

This paper describes lessons learned in the development of area-specific emission estimates for open burning, with a focus on the activity data, as well as the control efficiency (CE), rule effectiveness (RE), and rule penetration (RP) values used to adjust the emission estimates. E.H. Pechan & Associates, Inc. (Pechan) developed default open burning emission estimates for the United States Environmental Protection Agency's (EPA's) National Emissions Inventory (NEI), and has recently prepared area-specific inventories for several counties in Texas. This paper describes some of the challenges in developing representative regional emission estimates for open burning categories including residential municipal solid waste (MSW) waste, residential yard waste, land clearing debris burning, and construction/demolition (C&D) waste burning. Open burning contributes to criteria pollutant emissions, regional haze pollutants, and hazardous air pollutants.

Open burning activity data can be difficult to collect, the collection process may be expensive in terms of time and effort, and the resulting information may still be based on estimates of activity rather than measured amounts of materials burned (e.g., through a survey). Because of these difficulties, the amount of waste open burned is often estimated from the total amount of waste generated. The activity will also depend on the available methods of waste disposal (including recycling programs), the existence of prohibitions that either ban or limit open burning during certain times of the year, and violations of existing regulations. Open burning regulations also are likely to contain exemptions that are important for determining RP (e.g., allowed in times of emergency, allowed if no other cost-effective means of disposal are available, etc.). All of these factors combined can make it challenging to establish actual activity, and to determine the appropriate values for CE, RE, and RP. Based on the work performed for EPA, Texas, and the Mid-Atlantic/Northeast Visibility Union (MANE-VU), recommendations are provided for gathering the needed information and in using this information to develop emission estimates.

## INTRODUCTION

Open burning contributes to particulate matter (PM), volatile organic compounds (VOC), nitrogen oxides (NO<sub>x</sub>), carbon monoxide (CO), and sulfur dioxide (SO<sub>2</sub>), as well as hazardous air pollutant (HAP) emissions. Generally, emissions from open burning are estimated by applying emission factors [e.g., pounds (lbs) pollutant per ton refuse or fuel] to activity data (e.g., tons of waste burned). Emission factors for open burning depend on the type of waste, the type of fire, and fuel loading (e.g. mass of material per acre of land).

This paper describes some of the challenges in developing representative regional emission estimates for open burning categories including residential municipal solid waste (MSW) waste, residential yard waste, land clearing debris burning, and construction/demolition (C&D) waste burning. In preparing emission inventories, one of the particular difficulties with these source categories is the frequent lack of activity information. As such, this paper focuses on the development of representative

activity data, as well as the control efficiency (CE), rule effectiveness (RE), and rule penetration (RP) values used to adjust uncontrolled emission estimates.

Open burning is the purposeful burning of materials in outdoor areas such as forests and yards. Open burning emissions are typically reported under the source classification codes (SCCs) presented in Table 1.

**Table 1.** Open burning source classification codes SCCs.

SCC	SCC Name
2610030000	Residential municipal solid waste (MSW) burning
2610000100	Residential leaf burning
2610000400	Residential brush burning
2610000500	Land clearing debris burning

Household waste, or residential MSW, is a term for nonhazardous refuse produced by households (e.g., paper, plastics, metals, wood, glass, rubber, leather, textiles, and food wastes). Residential yard waste refers to materials such as leaves, trimmings from trees and shrubs (i.e., brush), and grass. Land clearing debris burning refers to the clearing of land for new construction and the burning of organic material (i.e., trees, shrubs and other vegetation). Construction and demolition waste burning refers to the burning of building material waste during construction or as a result of demolition. Construction and demolition waste burning may not be a significant open burning category within an inventory area. In addition, this category does not currently have an official United States Environmental Protection Agency (EPA) SCC, but an SCC could be proposed and added to EPA's SCC list. Slash and prescribed burning are also open burning sources, since these categories comprise purposeful burning activities; however, these categories are not addressed in this paper.

E.H. Pechan & Associates, Inc. (Pechan) assisted EPA's Emission Factor and Inventory Group (EFIG) in developing a national, county-level open burning inventory, including household waste, yard waste, and land clearing debris. For household waste and yard waste, a top-down method based on per capita waste generation rates was used, with an adjustment to account for counties that are largely urban (i.e., open burning emissions for counties with a population >80 percent urban were zeroed out). Pechan made further adjustments to the yard waste activity data to account for geographic differences in vegetation. For land clearing emissions, the acres disturbed by various types of construction activity, including residential, commercial and road construction, are estimated using surrogate data (e.g., construction valuation, number of housing starts). These data are then converted to acres using an average conversion factor. The approach assumes that all land clearing debris that is cleared is then burned. Average fuel loading factors, weighted according to the percent contribution of each type of vegetation class to the total land area are then applied to the acres cleared. Additional details on the National Emissions Inventory (NEI) default methodology are presented in *Procedures Document for National Emission Inventory, Criteria Air Pollutants, 1985-1999*.<sup>1</sup>

For Pechan's work for 16 nonattainment area counties in Texas, we prepared questions to ask state and local government officials for information on the implementation and enforcement of open burning rules in their jurisdictions. The questions were designed to collect activity data to calculate county-level, uncontrolled emission estimates, and data for determining CE, RE, and RP for adjusting uncontrolled emission estimates.

Pechan also performed an open burning scoping study for states within the Mid-Atlantic/Northeast Visibility Union (MANE-VU) Regional Planning Organization (RPO). Phase I of this project, completed in July 2001, focused on compiling state-wide and local rules and regulations addressing open burning, identifying the appropriate agency contacts who are familiar with open burning practices, and developing a draft survey instrument (questionnaire).<sup>2</sup> The survey instrument was designed to obtain

information to characterize open burning activity, as well as violations of open burning rules to determine RE. Phase II of this project involved testing the draft survey instrument developed for each open burning category, and refining the emission estimation methods based on the data determined to be available.

This paper is organized into three main sections. The first section addresses obtaining uncontrolled activity data for each of the four open burning categories. Residential MSW and yard waste are considered together since they both concern burning at private households. Land clearing debris burning and C&D waste burning are then each discussed separately. The second section describes methods for estimating controlled emissions for all open burning categories. This section addresses the development of applicable CE, RE, and RP values to adjust uncontrolled emission estimates. Current approaches are identified and discussed, and recommendations are provided for gathering the needed information and using this information to develop emission estimates. Finally, the paper concludes with a section containing overall recommendations.

## **OPEN BURNING ACTIVITY**

As described in the Emission Inventory Improvement Program (EIIP) document on open burning, the preferred method for estimating emissions for open burning is to collect specific, local information on the amount of material (i.e. fuel) that is open burned.<sup>3</sup> The amount of material should ideally be expressed in weight units, but in the absence of these data, other surrogates may need to be used (e.g., number of households burning, number of permits issued, rural populations, etc.). In developing regional open burning emission estimates, improvements should also be made to reflect state or local restrictions, the rate of compliance with regulations (i.e., RE) and any known exemptions (RP).

An additional complicating factor with this category is the time required to identify appropriate survey respondents. Open burning may not be tracked or regulated by similar agencies among states, or even within a state. If open burning is allowed, permits or authorizations for residents to burn waste on their property typically are issued and tracked by a municipality's local fire marshal or other designated fire official. Local officials are also more likely to track incidences of non-compliance with state regulations (e.g., the burning of land clearing debris for construction in cases where it is only allowed if the land will be used for agricultural purposes). This information may need to be collected through a survey of local fire officials. The time and resources required to conduct a survey of activity according to the preferred method may not always be available.

### **Residential MSW and Yard Waste Burning**

Activity estimates for residential MSW and yard waste burning may be based on the amount of waste generated for each county in the United States. This method assumes that the amount of waste open burned can be estimated using the total amount of waste generated as a basis. For EPA's NEI, the amount of waste generated was estimated using a national average per capita waste generation factor, as reported in *Characterization of Municipal Solid Waste in the United States: 1999 Update*.<sup>4</sup> However, individual states and/or counties may keep statistics on per capita amounts of waste generated, as well as the amount of waste disposed using means aside from open burning (e.g., landfilled, recycled, etc.). This approach relies on obtaining an estimate of the total amount of waste generated, accounting for all other means of disposal, and assuming the remainder of the waste stream is burned (i.e., a mass balance approach). There are limitations to this approach, but if resources are a consideration, and open burning is not thought to be a significant category, then this may be a suitable emission estimation procedure.

For the Texas effort, we developed activity estimates using information on the characteristics of landfilled waste in the state, as well as data on the recycling, export, and incineration of waste. By utilizing this information, a Texas-specific per capita waste generation factor was developed. We used this approach due to resource and time constraints. In addition, because these areas were affected by

open burning regulations, we focused the remaining effort on improving upon the CE and RE assumptions.<sup>5</sup>

To obtain actual estimates of the amount of waste being burned, a survey of open burning activity data should be performed. A state or local agency would need to identify and develop lists of local agencies to survey regarding local open burning activity (e.g., local fire, environmental, or health departments). Then it may be reasonable to perform a pilot survey to test survey instrument(s) on whether the questions are reasonable and gather the needed responses, and whether the contact list needs to be revised. As more areas perform surveys for these categories, questions and survey instruments used for these areas may be used directly, or adapted for use in other areas.

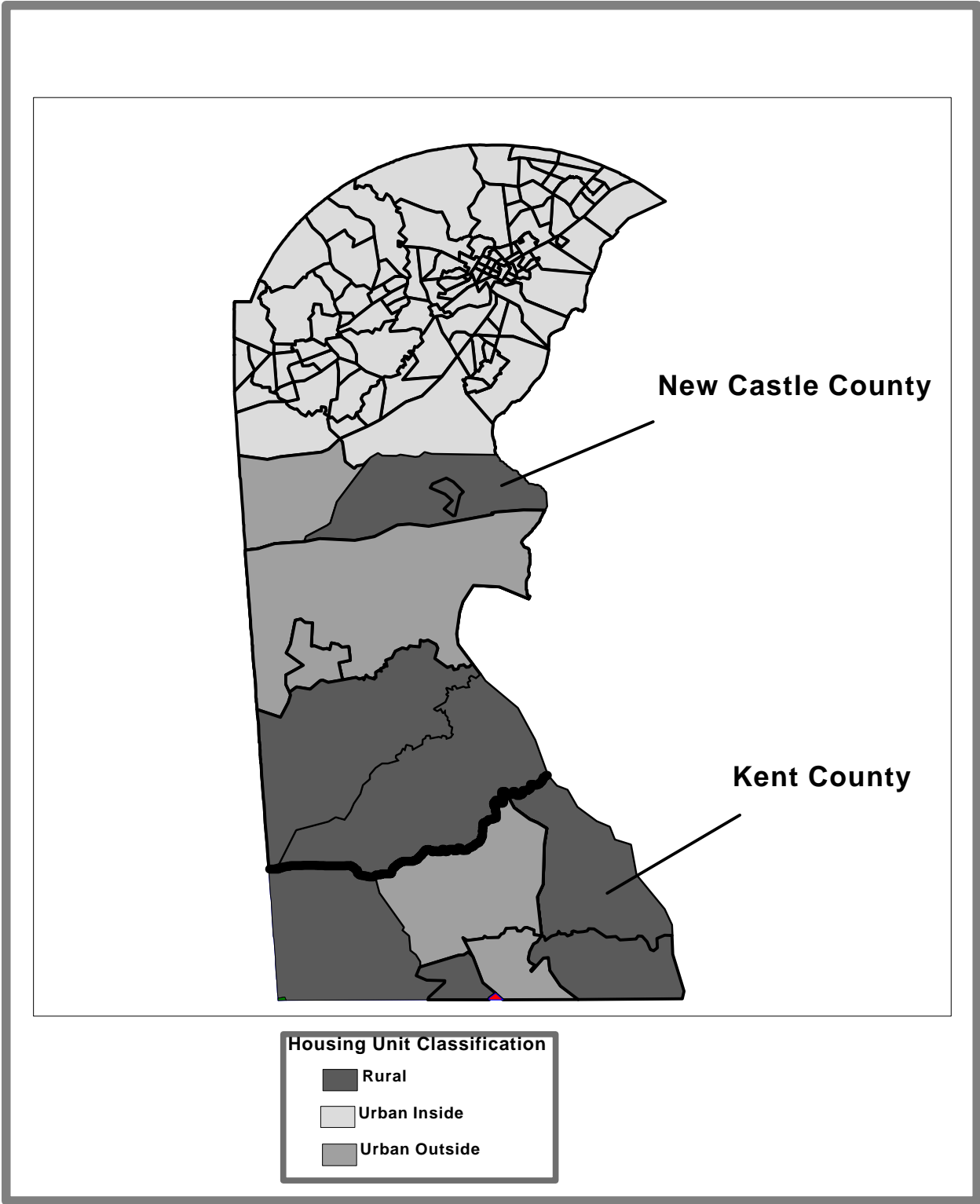
Ideally, the identified survey respondents would provide estimates of the mass (or volume) of waste burned. From our experience, this information may not always be known. Instead, the respondent (e.g., local fire official) may know the number or fraction of households engaged in open burning, the number of burn barrels in an area, or the number of permits that have been issued. It should be considered that the number of permits issued is likely to represent an underestimate of the number of burns occurring, since all households that burn may not obtain a permit. The number of households that this represents would depend on the level of enforcement in requiring a permit. If multiple agencies are involved in the issuing of permits, this may also make tracking of permit issuance difficult and inaccurate.

As part of the preliminary open burning work for MANE-VU, Pechan proposed a survey approach based on developing activity estimates for distinct areas. A survey instrument was proposed that would collect the data needed for developing activity estimates [i.e., number of households that burn, frequency, mass (or volume), and timing (season)]. We proposed to statistically analyze the completed survey data to determine if there are statistically distinct open burning activities occurring in rural, suburban, and urban areas. Activity estimates could then be developed for each distinct area (e.g., mass of waste burned per household, or fraction of households that burn), as warranted by the statistical analysis. The activity estimate would represent the best estimate of central tendency for the distribution of survey responses for each area (e.g., arithmetic mean, median, geometric mean). Emissions for each distinct area can then be calculated based on the activity factor, the number of single-family households in that area, a waste generation factor per household (either from the survey or external to the survey), and emission factors.<sup>6</sup>

One important issue related to open burning activity is the allocation of activity to appropriate areas within a county. An individual county may be made up of various urban, suburban, and/or rural areas. One limitation of the EPA's NEI is the assignment of emissions to counties based on the percentage of urban population relative to the total population for the entire county. If more than 80 percent of a county's population is urban, then open burning emission estimates are zeroed out. However, it is possible that there may be a component of that county's population that does engage in open burning practices. If possible, activity for different areas within a jurisdiction should be determined. This prevents unrealistic emissions from being assigned to large metropolitan areas, and also alleviates actual activity from being discounted in largely urban counties.

For the above approach, the number of households is used as the basis for determining activity. The number of households, as well as populations within a Census area are designated by the 2000 Census to be either "inside urbanized area", "inside urbanized cluster," and "rural." Household data can be obtained according to housing type (e.g., according to single-family, apartments, or mobile homes, etc.). Subcounty Census areas include block level, Census block group level (a combination of multiple blocks), Census tract level, or Place level. Figure 1 shows an example of housing unit data for New Castle County, Delaware at the Census tract level, according to 1990 Census classifications.<sup>7</sup> Data

**Figure 1.** Census tract by housing unit type for New Castle county, Delaware.



for the number of rural and urban households at the Census block or Census Tract level can be obtained from the Census 2000 results, which are not available to date but have an expected release date of June 2002.

The Census defines an area as urban or rural based on population density. For Census 2000, urbanized areas are classified as either “inside urbanized area” or “inside urbanized cluster.” An “inside urbanized area” consists of a densely settled territory that contains 50,000 or more people, while an “inside urbanized cluster” contains at least 2,500 people but fewer than 50,000 people (i.e., suburban areas). Both urbanized areas and urban clusters encompass densely settled territory that represents a cluster of block groups each containing at least 1,000 people per square mile, as well as the surrounding block groups that have a population density of at least 500 people per square mile, and less dense blocks that are used to connect discontinuous areas with qualifying densities. All areas not classified as urban are “rural.”

Subcounty allocation of activity may not be critical for the development of all emission inventories. However, if the emission estimates are likely to be used in a regional air quality modeling analysis, more refined spatial allocation of emissions is required. In these instances, use of the Census data or similar geospatial information becomes important.

With respect to temporal variation, it is expected that residential MSW burning will occur somewhat evenly on a seasonal basis (as people would not want trash to pile up). Temporal profiles should be developed for yard waste burning categories expected to encounter seasonal variations, including leaf burning (primarily a fall activity) and brush waste burning (may be more common in the summer months due to winter storms, spring rain, and spring “cleanup”). On a weekly basis, one may expect that weekend activity for both MSW and yard waste burning would be somewhat higher than during the week. Survey responses to questions about seasonal percentages of burning activity could confirm these profiles, or reveal more representative seasonal profiles for an area. Burning bans (e.g., during a summer ozone season) would also affect activity during a specific season throughout the year.

## **Land Clearing Debris**

The EIIP’s preferred method for estimating emissions for land clearing debris burning is to develop activity data based on permit data. The activity data would ideally be the amount of material burned, but information on the number of acres cleared could also be used in conjunction with a loading factor. Based on test surveys performed for MANE-VU and for Texas, data available from permits were generally insufficient to adequately characterize land clearing debris burning activity. In addition, some states do not differentiate between land clearing debris and slash burning on their permits, which complicates assigning activity to one category versus the other.

If sufficient resources are not available for a state to follow the EIIP’s preferred or alternative methods, state-specific improvements could be made to the NEI estimates. This could entail collecting information on sub-county level construction activity to further spatially refine the county-level activity. The NEI emission estimates for land clearing burning are categorized according to residential, non-residential or commercial, and road construction. The NEI activity data for residential construction are based on housing starts at the regional level (e.g., Northeast United States) and allocated to the county using building permit data available from the Census Bureau. Activity for road construction (i.e., miles of road constructed at the state level) are also allocated to counties using BOC building permit data. Commercial construction activity data are generated from national estimates of construction dollars and allocated to the county level using employment. Housing units, commercial construction dollars, and road miles are converted to acres using a conversion factor.

One option for this category may be for a state to survey agencies that may gather information on residential and commercial construction within their state. Generally, this information is gathered at the county or municipal level, which could prove overly burdensome in some states. However, some states may have data such as the number of new housing units or new plumbing hookups at the municipal level

already compiled. This type of information could be used as a reasonable surrogate to better allocate residential building activity, and hence land clearing burning activity. For commercial building activity, useful information may be available from state planning or taxation agencies. The type of information available in each state is likely to be different. Ideally, the construction data would relate new housing units or new commercial construction to census tracts.

An alternative method for sub-county allocation of activity would be to use information on housing units at the census tract level between the 1990 Census and 2000 Census. Census tract level data on housing units (by housing type) could be analyzed to determine whether a net increase in housing units occurred between these two data sets. Inside urban areas would be taken out of this analysis, as we do not anticipate that land clearing occurs in these areas. While these data are imperfect in determining activity during any specific year (e.g., 2000), they will show where residential construction activity has taken place during this time period. Activity data could be allocated to the census tract level for census tracts that have shown a net increase in housing units. Although these data are strictly related to housing units, they may also be valid for allocating locations of new roads and new commercial construction.

Even if sub-county information is not available, additional improvements could be made to the county-level activity data used as the basis for the NEI emission estimates. This approach was used in developing land clearing emission estimates for Texas. For example, for road construction in the NEI, state-level expenditure data for capital outlay from the Federal Highway Administration (FHWA) are converted to miles using costs of road construction obtained from the North Carolina Department of Transportation (NCDOT). Miles are then converted to acres using conversion factors developed for 6 different road types, and a county-specific fuel loading factor is applied to estimate the mass of waste burned. Improved estimates of the miles of new road construction, or more representative estimates of the cost per mile of road constructed, may be obtained by contacting the DOT or equivalent within a state. To improve the activity estimates for land clearing due to road construction, the Texas Department of Transportation, provided lane miles of both new location and added-capacity road. The information provided was at a county and functional class level. Miles to acres conversion factors used in the 1999 NEI were mapped to the appropriate Texas functional class categories as shown in Table 2. By applying the conversion factors to the associated miles of road construction in each county, acres disturbed were calculated.

**Table 2.** Road construction miles to acres conversion factors for Texas.

<b>Texas DOT Road Classifications</b>	<b>FHWA Road Classifications</b>	<b>Conversion Factor</b>
1 – Interstate;	Interstate, urban and rural;	15.2 acres/mile
2 – Other urban freeway or expressway	other arterial, urban	
3 – Rural Principal Arterial; urban connecting links of rural arterials; other urban principal arterials;	Other arterial, rural	12.7 acres/mile
4 – Minor arterial road or street		
5 – Rural major collector or Urban collector street	Collectors, urban	9.8 acres/mile
6 – Rural minor collectors;	Collectors, rural	7.9 acres/mile
7 – Local road or street		

In addition to road construction, improvements were made to the NEI's activity estimates for both residential and commercial construction. For residential construction, state-level housing start data for Texas was allocated to counties using housing unit data from F.W. Dodge. The NEI uses regional housing start data allocated to counties using county-level permit data from the U.S. Census Bureau. For commercial or nonresidential construction, the county-level dollar value of different categories of nonresidential construction was available from F.W. Dodge. By summing the different categories of

nonresidential construction in Texas within each county, the total funds spent on nonresidential construction for that county were calculated. Acres disturbed were derived using the NEI's dollars/acre conversion value. EPA's NEI allocates national level expenditure data for nonresidential construction to counties using employment data for this type of construction. However, sufficient information was not obtained to adjust the total fuel loading estimate to represent the actual fraction of material that was burned for uncontrolled burn practices. Additional details on the Texas methods for estimating acres disturbed are available in a report.<sup>5</sup>

### Construction and Demolition (C&D) Waste

This category is not addressed in EPA's EIIIP guidance documents, and may not be a significant open burning source for some local areas. Therefore, a state should first determine whether resources should be spent on estimating emissions for this category. If a regulation is in place that does not allow open burning of C&D waste, and the waste is required to be disposed by other means, emissions may be zero or minimal. This category has also not been included to date in EPA's NEI.

One approach to estimating C&D debris burning activity relies on the use of the data, methodologies, and assumptions developed by Franklin Associates to estimate national C&D waste generation activity estimates. In a recent study prepared for EPA, Franklin Associates estimated the amount of C&D debris generated in 1996.<sup>8</sup> Based on the results from this study, the estimated 1996 per capita generation rate for C&D debris was 2.8 lbs per person per day. These approaches could be investigated for their potential application to local areas. In cases where sufficient data are not available for directly applying the Franklin Associates' methods, it may be possible to allocate updated national estimates derived from the methods from the Franklin study to local areas based on surrogate indicators of C&D waste activity. Such indicators may include the number or value of residential and nonresidential construction permits (or other information on construction of new housing or commercial units, as described for land clearing debris above). If data for these surrogate indicators are not available for a local area, then it would be possible to estimate local activity by applying the Franklin Associates' national per capita generation estimate (2.8 lbs/person/day) and the national percentages of total C&D waste generation activity that are residential and nonresidential, and that occur from construction, renovation, and demolition activities according to Table 3.

**Table 3. Management of building-related construction and demolition debris in the United States, 1996.**

Management Option	Million Tons Per Year	Percent of Total
C&D Landfills	45-60	35-45
MSW Landfills and Other*	40-55	30-40
Recovered for Recycling	25-40	20-30
TOTAL	136	100

\* Includes disposal on-site (including on-site open burning) and at non-permitted sites.

The fraction of C&D debris waste that is open burned would need to be estimated. These fractions are likely to vary by non-residential, residential construction, residential demolition, and residential renovation, because of differences in the areas where these activities are expected to take place (urban versus suburban/rural), and the materials involved (e.g., non-residential typically includes a higher percentage of materials that are not burned, such as concrete and metal, than residential). A state could investigate the availability of data from state solid waste agency contacts on C&D debris generation and burning. Since no emission factors are currently available for C&D waste burning, emission factors for structural fires could be applied to the activity estimates.



If an emissions inventory is being developed for a relatively small geographic area (e.g., MSA, county, or multi-county nonattainment area), and C&D burning activity is believed to be significant, a bottom-up approach may be justified. If this activity is permitted, one method would rely on data obtained from C&D debris burning permits. These permits would need to require that permit applicants estimate the amount of debris burned. This information could then be compiled and used as a direct estimate of the amount of C&D debris burned, unless there is a significant amount of noncompliance with permitting requirements. In such an instance, a state/local agency would need to extrapolate the total amount of debris burned by applying an expansion factor to the permitted amount. This expansion factor would reflect the estimated level of noncompliance with the C&D debris permitting requirements. Alternatively, a local case study could be performed and the results could be scaled up to larger, similar areas.

An alternative, more resource-intensive method for developing local-specific C&D debris burning activity estimates would rely on estimates compiled through contacts with local C&D contractors. The contacts made should focus on the largest contractors and the specific activities (e.g., demolition versus construction, residential versus nonresidential) that are expected to predominantly contribute to total C&D debris generation and open burning in a given area. Since the application of this method will require significant resources, it is only recommended for areas where state agency contacts believe that activity is significant.

## **ADJUSTING UNCONTROLLED OPEN BURNING ACTIVITY**

For areas where open burning is established to be prohibited or banned, controlled emission estimates should be developed that account for CE, RE, and RP. Each of these adjustments are discussed below.

### **Control Efficiency**

In the case of household waste and yard waste burning, the control is generally a ban on open burning; therefore CE is 100 percent. For a state that has a statewide ban, 100 percent CE can be assumed for all areas within the state. Statewide restrictions still allow for more stringent regulations to be enacted if deemed necessary by local officials. Some states may allow open burning, but only for certain areas. For example, New York allows open burning, but only in areas where a town's population, including both incorporated and unincorporated areas, does not exceed 20,000. Obtaining and applying this type of control information will improve the activity and emission estimates that are assigned to various county and sub-county areas within these states.

Open burning of household waste by residences is expected to occur more frequently in rural areas than urban areas, presumably because many densely populated towns have prohibitions against open burning that are likely to be enforced (in addition to the likelihood of other disposal alternatives). The actual occurrence of open burning restrictions may depend on factors such as cultural practices and political climate.

The State of Texas has adopted a rule which specifies general prohibition of outdoor burning, but contain exceptions for disposal of domestic waste. Burning of domestic waste is allowed "when collection of domestic waste is not provided or authorized by the local governmental entity having jurisdiction, and when the waste is generated only from that property." Other states (e.g., Maryland and New Hampshire) are also known to prohibit open burning of household waste, if an area has municipal trash collection service. So defining these areas for a state allows one to establish those areas for which 100 percent control should be applied. One complicating factor is that trash service tends to vary by town within a county, and even by area within a town. So, unless an inventory is being prepared for a smaller sub-county or multi-county area, significant effort is required to characterize municipal trash collection service at the state or regional level.

For land clearing debris burning, air curtain destructors may be used to control emissions. Air curtain destructors consist of a burn pit and a device that blows air across and into the pit. If land clearing burns are known to use these control devices, adjustments to the control efficiency value should be made.

## **Rule Effectiveness and Rule Penetration**

In areas where open burning is prohibited, information to estimate RE should be collected. Because open burning is conducted on private residences, and state or local enforcement efforts may be focusing on industrial or commercial sources, noncompliance with open burning restrictions may be high. Violations of land clearing debris and C&D waste burning rules may also be common. For areas where a certain category of open burning is not allowed, the extent of noncompliance could be estimated by surveying inspection and enforcement personnel (either state or regional).

In work for MANE-VU, RE test surveys were performed for areas with open burning rules or prohibitions. EPA guidance for estimating RE was followed in developing the survey instrument.<sup>9</sup> In addition, the number of violations in a given area may present an acceptable alternative for determining RE for an area. For example, it may be appropriate to ask for the respondent to provide the number of illegal burns or violations per year in the area. For example, for a given jurisdiction, one could obtain the number of violations per households, and the anticipated number of burns in that area if burning were allowed (i.e., the no. of burns per household in a similar area without a rule). RE can then be estimated as follows:

$$RE = \frac{(Number\ of\ anticipated\ burns - Number\ of\ violations)}{(Number\ of\ anticipated\ burns)}$$

Where a jurisdiction has a regulation prohibiting open burning, any exemptions from the regulation should be identified to establish RP. If surveys of activity are known to include estimates of burning that are not technically covered by the regulation, then some adjustment for this should be made in the RP value applied to the emission estimates. For example, some areas may allow for brush or tree waste burning as a means of disposal after a damaging storm. For a given time period, the amount of brush waste that falls under this exemption relative to the total should be estimated (e.g., as a percentage) to develop an RP value.

Identifying and/or interpreting exemptions for some open burning rules can be challenging. In Texas, for example, the burning of land clearing debris is allowed “when no practical alternative to burning exists and when the materials are generated only from that property.” In cases where no cost-effective practical alternative can be identified, this burning activity would be allowed, and is exempt from the prohibition. Interpretation of a provision specifying “when no practical alternative to burning exists,” can be subjective, though. Defining and understanding a specific locale’s interpretation of rule provisions will result in more representative RE and RP values being assigned.

## **CONCLUSIONS**

### **Residential Open Burning**

Recommendations for estimating residential household and yard waste open burning include:

- Determine where local prohibitions exist for open burning;
- Develop lists of local agencies to survey regarding local open burning activity (e.g., local fire, environmental, or health departments);
- Develop surveys to gather: 1) open burning activity data (where it is allowed); and 2) information to estimate rule effectiveness (where it is prohibited).

Then it may be helpful to perform a pilot survey to test each survey instrument on whether:

- the questions are reasonable and gather the needed responses; and
- the contact list itself needed to be revised.

The survey data are then used to develop activity estimates including the number of households that burn, the frequency, mass (or volume), and timing (season). Activity could then be characterized for households in different geographic regions (e.g., state-level differences, county-level differences, urban vs. rural).

### **Land Clearing Debris Burning**

Recommendations for land clearing debris burning include:

- Use NEI as the basis for activity;
- Conduct a survey of state agencies to identify more highly-resolved construction activity;
- Provide sub-county allocation via application of state agency information; or
- Use net increase of housing units at the census tract level between the 1990 and 2000 census (e.g., excluding highly-urbanized areas).

### **C&D Debris Burning**

Recommendations for C&D debris burning include:

- Use Franklin Associates report as the basis for C&D debris generation;
- Develop estimates for the fraction of C&D debris that is open burned (non-residential, residential construction, residential demolition, residential renovation);
- Develop top-down estimates with the above activity and emission factors for structural fires.

If this C&D waste burning activity is believed to be significant, a bottom-up calculation of emissions for areas may be appropriate including:

- Collecting C&D debris burning permit data (few areas); or
- Performing additional data mining with state solid waste agency contacts on C&D debris generation and burning. Develop local case studies and scale up to larger areas; or
- Local surveys of C&D contractors.

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## **KEY WORDS**

Emission Inventories  
Area Sources  
Open Burning