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Importance of activity data for improving the residential wood combustion emission inventory at regional level

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ABSTRACT

The contribution of residential wood combustion (RWC) to emission inventory at local level was estimated using a bottom–up approach for the Lombardy Region of North Italy. A survey, based on the CATI (Computer Assisted Telephone Interviewing) method, has been undertaken through 18,000 interviews. The interviews had the objective to characterize the RWC use in this region, in term of both total and municipal wood consumption. Details on the type of appliances used in RWC were also gathered.

The results of the survey were then statistically analyzed in order to allow an estimate of RWC with high spatial resolution (i.e., at municipal level) in relation to the size and altitude of the territory.

The work provides new evidence of the importance of wood combustion as a key source for PM and NMVOC emissions at local level, and thus highlights the importance of technological improvements and new policies aimed at emission reduction in this sector.

Considering the great differences in average PM emission factors between low efficiency appliances (fireplaces, old stoves) and high efficiency ones (new stoves, pellet burners), this work emphasizes the importance of obtaining more detailed information on the types of wood appliances used for arriving at a reliable PM emission inventory for RWC.

1. Introduction

Residential wood combustion (RWC) is widespread in many countries of Europe and its usage is increasing because biomass combustion represents a renewable source of energy. GHGs (greenhouse gases) emissions savings are expected when biomass substitutes fossil fuels and thus RWC is currently promoted in the framework of climate change mitigation policies.

The "Biomass Action Plan" of the European Commission set increasing targets of biomass use, because biomass has many advantages over conventional energy sources, as well as over some other renewable energies, such as "low costs, less dependence on short-term weather changes, promotion of regional economic structures and provision of alternative sources of income for farmers" (EC, 2005).

Nevertheless it has to be considered that RWC is an important source of both particulate matter (PM) and toxic air pollution around Europe (EEA, 2009; Hellén et al., 2008; Nussbaumer et al., 2008). In fact, in addition to a high level of primary PM emissions, RWC produces volatile organic compounds (VOC) with a high content of various toxic and carcinogenic compounds such as PAH and Dioxins (Lavric et al., 2004). Both PM and VOC have been proven to have important effects on human health (Zelikoff et al., 2002; Naeher et al., 2007).

The relevance of this emission source for air quality has been studied and confirmed in several European countries and with different methods using emission inventories, air quality data analysis, air quality modeling and source receptors modeling (Glasius et al., 2008; Favez et al., 2009).

Although numerous studies have highlighted the role of wood combustion in PM air concentration (Borrego et al., 2010; Caseiro et al., 2009; Glasius et al., 2006), only a few studies (i.e., Sternhufvud et al., 2004) use a bottom–up approach to calculate RWC emissions, due to the lack of information on activity data for this source (i.e., amount of wood and kind of appliances used at local scale).

Here, we investigate the contribution of RWC using a bottom–up approach. This approach focused on obtaining an accurate estimation of the activity and its spatial distribution. In detail, the purpose of this work is to develop a reliable methodology to evaluate one of the fundamental inputs required for the estimation

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Table 1
Wood usage in the Lombardy provinces.

Province	User [%]	Wood consumption [t y^{-1} household^{-1}]	95% c.i. average consumption [t y^{-1} household^{-1}]	Wood consumption Total [kt y^{-1}]	95% c.i. total consumption [kt y^{-1}]
Bergamo – BG	17.1	3.66	3.12–4.21	242	186–299
Brescia – BS	20.7	4.12	3.52–4.73	386	283–489
Como – CO	15.4	2.86	2.31–3.40	92	72–112
Cremona – CR	17.3	3.75	3.11–4.39	88	75–101
Lecco – LC	18.4	3.26	2.43–4.09	79	60–97
Lodi – LO	14.6	3.79	2.30–5.29	43	29–57
Mantova – MN	13.7	4.91	3.63–6.20	98	61–135
Pavia – PV	10.3	4.68	3.48–5.88	102	65–139
Sondrio – SO	45.2	4.77	3.90–5.65	159	130–188
Varese – VA	16.5	3.09	2.61–3.58	164	127–201
Milano – MI	3.2	2.45	2.04–2.87	117	88–145
Totale	11.5	3.68	3.46–3.90	1570	1420–1720

of the contribution of this sector to local and regional emission inventory: i.e., the amount of wood used. Information on the appliances used was also acquired. The focus area is the Lombardy region, a highly industrialized area in Northern Italy with 9 million inhabitants, where wood combustion has been identified as a key source for particulate emissions (ARPA Lombardia, 2009; Piazzalunga et al., 2010).

2. Material and methods

The CATI method (Computer Aided Telephone Interview) has been used in the survey, and was carried out at the end of the winter season 2007/2008. A sample of 18,085 families, resident in the 11 provinces of Lombardy, was built by randomly choosing names in the telephone book of all households with a telephone line.

A two-stage stratified sampling method was used. The primary statistical units (the first stage of sampling) are the Lombardy municipalities, while the secondary statistical units (second stage) are the resident families. The municipalities are aggregated in 50 homogeneous cells, for which non-proportional sampling is used to build the sample in order to maximize the efficiency of the estimates (Cochran, 1977).

The homogeneity of the cells is estimated on a series of variables that, in previous investigations (Caserini et al., 2007) have proved to be appropriate proxies for the analysis: the altitude, the municipal structure, consumption estimated by previous survey. In each unit sampled, families were then further stratified proportionally on the basis of the family members and settlement size.

Following the Italian National Institute of Statistics (ISTAT), the municipalities were divided into three categories (mountain, hill, plain) in relation to the amount of reliefs and the altitude (hills over 300 m and mountains over 600 m).

To estimate wood combustion use and to quantify the total wood consumption, only users that claim to "light the fire" at least

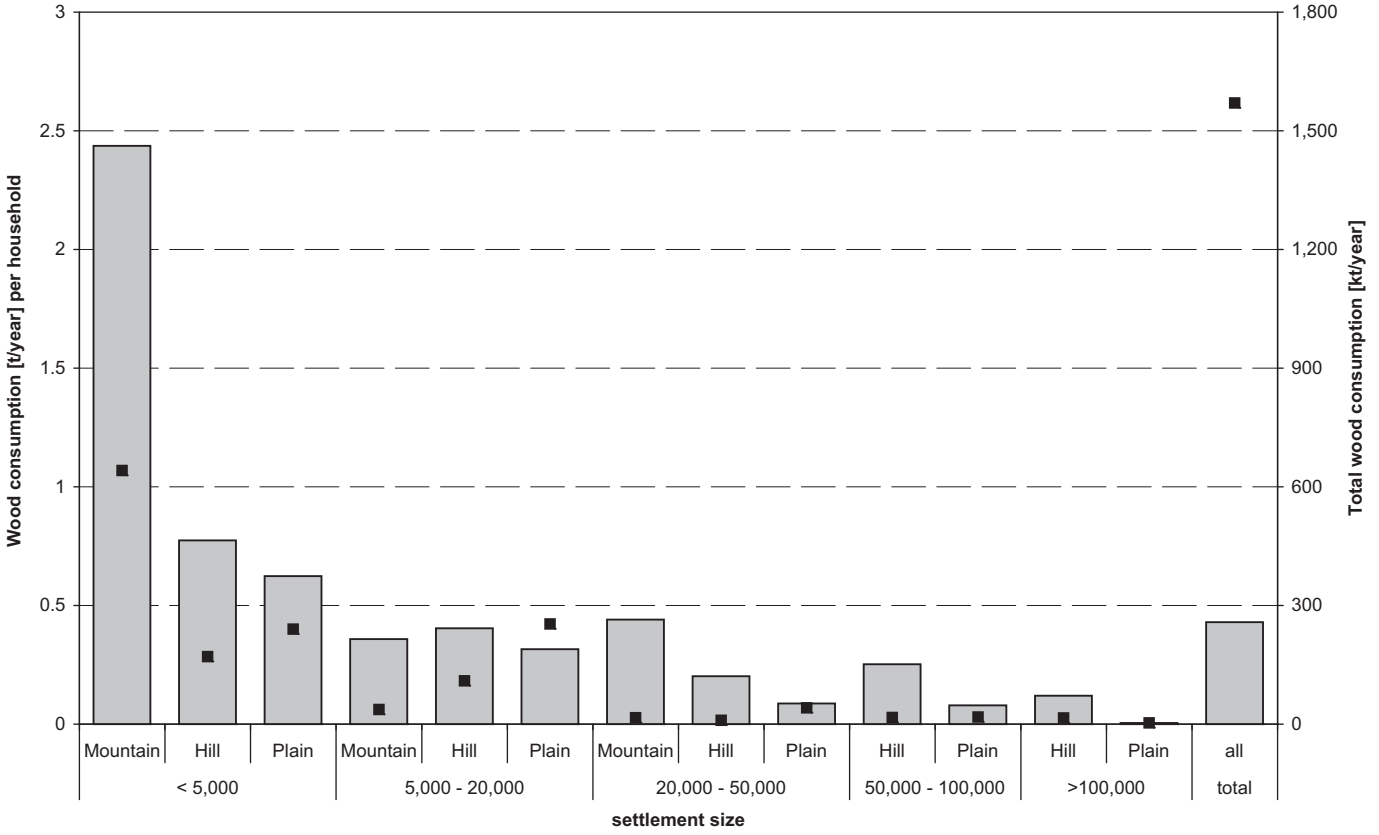

Fig. 1. Total consumption (black dot, right axis) and average consumption per household (gray bars, left axis) for 3 altitude class (mountain, hill and plain) and settlement size.