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ALEX PRA (*) - DAVIDE PETTENELLA (*)(°)

CONSUMPTION OF WOOD BIOMASS FOR ENERGY IN ITALY: A STRATEGIC ROLE BASED ON WEAK KNOWLEDGE

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Given the growing role of wood biomass as a strategic resource in the European and national renewable energy policies, the paper provides two new estimations of the internal consumption and supply levels, aiming at discussing the real role of this resource in the national energy mix and the implications of this market in terms of forest policies. The first estimation focuses on household consumption and expenditure based on the ISTAT "Survey on consumption by families", and the second analyzes how the wood biomass supply is structured and organized; this second estimation has been carried out with an expert panel consultation based on a Delphi-based approach. These two estimations are then compared and discussed with reference to the data and information provided by official sources and other publically-available studies and surveys conducted in recent years. The results provide evidence that wood biomass is the first source of renewable energy in Italy and that official data only partially quantify the consumption levels in the residential sector and domestic supply rates. The paper highlights the need for a new approach in data collection on this fast-growing market; these data are essential for a more effective implementation of the renewable energy policy and other relevant forest-related policies such as those on climate and wood mobilization.

Key words: consumi biomasse; legno-energia; metodo Delphi; Italia.
Parole chiave: biomass consumption; wood energy; Delphi method; Italy.

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1. INTRODUCTION

The bioenergy market in Italy has experienced continuous growth over the last decade and this trend is expected to continue in the future, also as a result of the renewable energy targets for 2020 in the National Renewable Energy Action Plan (NREAP). The NREAP was approved in 2010 by the Italian Ministry of Economic Development in order to implement the Renewable Energy Directive of the European Union (Directive 2009/28/EC) (EP, 2009). According to the plan, the national target is to produce 17% of total gross energy consumption from Renewable Energy Sources (RES) by 2020, for a total amount of 22.6 Mtep, a contribution that was standing at 5.20% in 2010 (MSE, 2010).

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In order to reach this target, solid biomass has a strategic role as it is expected to cover about 8% of electricity production and 50% of thermal energy production, becoming the principal source of renewable energy in Italy. Wood biomass is specifically indicated in the NREAP as the main source.

There are two main reasons behind the heavy reliance on wood biomass in the renewable energy targets in Italy. Firstly, the cost-effectiveness of the raw material that makes it competitive against the other sources, also given the limited potential to increase hydropower, which dominated RES in Italy in the past decades, and geothermal energy (Scarlat *et al.*, 2013). Secondly, the large availability of wood biomass considering the current low utilization of Italian forests and the consequent opportunity to enhance active forest management, improving job opportunities and incomes in rural areas. According to Forest Europe (2015), the felling rate as a percentage of Neat Annual Increment in Italy is one of the lowest in Europe: 39.2% (against 47.3% in France, 80.3% in Germany, 55.5% in Spain).

The continuous growth of the wood-energy market raises important challenges in terms of policy regulation, market organization and public awareness. However, no complete and coherent quantification and assessment of the Italian wood-energy market has ever been made. Despite a considerable amount of data and information being available, there are significant problems related to their quality and completeness. These problems also exist in other European countries and are generally related to the cross-sectorial character and fragmentation of the market. The multiplicity of sources on the supply side and the presence of different submarkets and final users on the demand side make the wood-energy market complex to clearly define and quantify (Steierer, 2007; SFC, 2008).

In the specific case of Italy, the main data gap is associated with a lack of information on household consumptions of wood biomass for energy. The household sector is the main final user of wood biomass for energy in the country, using firewood, pellets and chips in small-scale systems (e.g. fireplaces, stoves, small boilers). Several studies and surveys have demonstrated the inaccuracy of official data and that the energy-wood consumption in Italy is much higher than that officially estimated (Gerardi and Perrella, 2001; Corona *et al.,* 2007; APAT-ARPA, 2008; ARPA Emilia Romagna, 2011). In recent years, two studies came to the conclusion that the assumptions relative to the consumption levels of wood biomass made in the NREAP are strongly underestimated and that it is likely that bioenergy production in 2010 was already higher than 5.25 Mtep, which is the target for 2020 (Tomassetti, 2010; Pettenella and Andrighetto, 2011). The incompleteness and inaccuracy of the informative framework and the lack of solid market estimations can be major limiting factors to an effective assessment of the real role of wood-energy as a RES in the national energy mix. These issues are particularly important in order to be able to provide a coherent regulatory framework to the sector, especially within the perspective of an increased demand for wood-energy in Italy, as well as in the rest of Europe, as a consequence of more long-term targets on RES promotion (Smith, 2015).

Against this background, the overall objective of the paper is to improve the knowledge and understanding of the wood-energy market in Italy. The paper is organized in two main parts. In the first, a new estimation of households' consumption of and expenditure on wood biomass for energy is presented. The estimation is based on the analysis of the results of the official survey on consumption by families (*Indagine sui consumi delle famiglie*), conducted by the Italian National Institute of Statistics (ISTAT) for the 1997-2012 time series. The results of the first estimation have motivated the second analysis on how the supply is structured and organized, focusing on the domestic supply (from forests, trees outside forest areas and plantations) but also taking into account import and export flows and indirect supply from the wood-processing industries and post-consumption used wood. The second part of the paper presents a preliminary estimation of the supply based on experts' opinions through a Delphi survey. The two new estimations are then discussed and compared with the data provided by official sources as well as estimates by other surveys conducted in recent years.

2. Material and methods

2.1. *Survey on consumption by families*

For the new estimation of the household consumption of wood biomass for energy, the results of a general periodic survey on consumption by families organized by ISTAT have been analyzed.

The survey on consumption by families is a large and important study conducted by ISTAT since 1968. It provides detailed information on the expenditure for goods and services of households in Italy. The main aim of the survey is to describe living standards, cost of living and tendencies, and it is also used for official statistics at national level, such as the calculation of inflation and the poverty rate. The survey sample involves a large number of families that varies over the years (from 23,000 to 31,000) in about 480 selected Italian municipalities. The sampling is three-monthly based and is done for the four quarters of the year. Data collection is assigned to the municipalities, which select the families to interview and supervise the survey procedures. The collection of data is based at two different levels: firstly, the self-compilation of a weekly record by the households, and secondly, a final face-to-face interview conducted by a municipal supervisor in order to integrate and clarify unclear information (ISTAT, 2012).

The data related to the results of the survey for the 1997-2012 time-series[1] were obtained from ISTAT through a web request. The analysis has been made focusing on the expenditure for fuelwood and charcoal. More specifically, the analysis focused on the variables C_3405 ("Expenditure for fuelwood and charcoal in the main residence") and C_3425 ("Expenditure for fuelwood and char-

1 The ISTAT survey was completely revised in 1996, so the data series available in the current format is from 1997.

coal in the second homes"). These variables had never been extrapolated and analyzed individually from the survey results. In the elaborations, charcoal is not mentioned because according to the National Energy Balance its role in the household sector is not significant (0.03% of fuelwood consumption) (MSE, 2012).

Data on the number of Italian households registering expenditure for fuelwood and the total expenditure for fuelwood were firstly extrapolated and analyzed. The economic values were expressed in real terms referring to the year 2012, using annual coefficients provided by ISTAT on consumer prices for families. Instead, to convert the values from Italian Lira (£) to Euros (€) for the years prior to 2002, the standard conversion coefficient provided by the European Central Bank was used. In a second phase, the extrapolated information was used to estimate fuelwood consumption at household level based on the expenditure. In order to calculate the quantities of fuelwood consumed based on the relative expenditure a Consumer Price Index (CPI) provided by the Chamber of Commerce of Mantua was used.

2.2. *Delphi survey*

For the estimation of the supply based on experts' opinion, a Delphi survey was conducted. The Delphi method is a widely used survey technique in social sciences (Landeta, 2006) and is based on at least two rounds of experts' involvement. It permits a limited number of experts to be interviewed, enabling to focus on individuals' opinions and also to generate consensus (or identify divergences of opinion), allowing the experts, by means of the two rounds, to review, re-evaluate and revise their opinions and estimates. The Delphi method is well suited in situations where no historical data are available and in addition, it does not require face-to-face meetings, avoiding problems commonly associated with group interviews (Gupta and Clarke, 1996).

The expert panel was selected on the basis of empirical evidence about the experts, scientists and leading authorities working in the sector in Italy. Ten experts, selected from universities, research institutes, associations and public agencies, participated in the survey. The panel was composed of experts from the following institutions: State Forest Service, National Institute of Agricultural Economics (INEA), Institute of Environmental Protection and Research (ISPRA), Compagnia delle Foreste publisher, Italian Federation for the Rational Use of Energy (FIRE), Italian Association for Agroforestry Energy (AIEL), Polytechnic University of Turin, University of Padua, University of Reggio Calabria and Institute for Wood Plants and Environment (IPLA). The survey was conducted in two rounds: in the first questionnaire the panelists were asked to provide, based on their knowledge and opinion, a preliminary estimation of the internal production. For the purpose of the estimation, a simplified market flow chart was prepared, considering four macro-variables: *a)* Consumption for energy purposes (based on the previous survey), *b)* Imports, *c)* Residues, by-products and wastes from forest-based industry, *d)* Domestic supply from forests, trees outside forest areas and plantations. The estimation was constrained

as in an analytic balance. In the second round questionnaire, when the outcomes of the first round (mean, median and standard deviation) were presented, the panelists were asked to review, re-evaluate and revise their opinion and estimations on the basis of the outcomes presented and agree or disagree on the estimations. The estimations were integrated with qualitative comments.

3. Results

3.1. *Estimation of households' consumptions*

According to the survey on consumption expenditure by families organized by ISTAT, in 2012 nearly one and half million households in Italy registered an expenditure for fuelwood. More specifically, these were 1,486,923, representing 5.86% of the total households in the country. Of these, the majority (96.40%) used fuelwood in their main residences, while only 3.60% in second homes.

Analyzing the time series from 1997 to 2012, a general trend can be identified (Figure 1). Until 2003 there is a decrease in the number of households using fuelwood in Italy, from 5.93% in 1997 to 4.47% in 2003. An explanation is that this decrease is part of a longer trend of replacement of fuelwood by other types of fuels, mainly gas, which had become increasingly available in the household sector since the 1960s and 1970s. An evident change in the trend can be observed from 2004. The number of households using fuelwood increases, at a slow rate initially and then in a more marked way, especially from 2010. The slight drop between 2008 and 2009 can probably be explained as the result of the economic crisis, which significantly affected households' consumption in general. From 2003 to 2012 the number of households using fuelwood increased by 1.39%, returning to values similar to those of 1997.

Regarding the economic values (expressed in real terms referring to 2012) the data show a similar trend to the above-mentioned one. A significant increase started after 2002-2003, reaching the highest values of the time series in 2011-2012. The level of expenditure for fuelwood in the household sector was 1,945 million Euros in 2012. As for the previous data, the majority in the main residence (98.78%). The household expenditure for fuelwood increased by approximately 658 million Euros in the decade between 2002 and 2012. When referring to economic values, the overall increase in fuelwood prices over the last decades also has to be taken into consideration, using the data collected by the Mantua Chamber of Commerce.

The consumption level of fuelwood in the household sector along the time series has been calculated based on the economic data extrapolated from the results of the survey. From the analysis it results that in 2012 nearly 10.5 Mt of fuelwood were consumed by Italian households. Concerning the historical trend, which follows the one shown above, the decade 2002-2012 saw an increase in fuelwood consumption of 2.94 Mt. A summary of the results of the analysis of the survey on consumption by families is presented in Table 1.

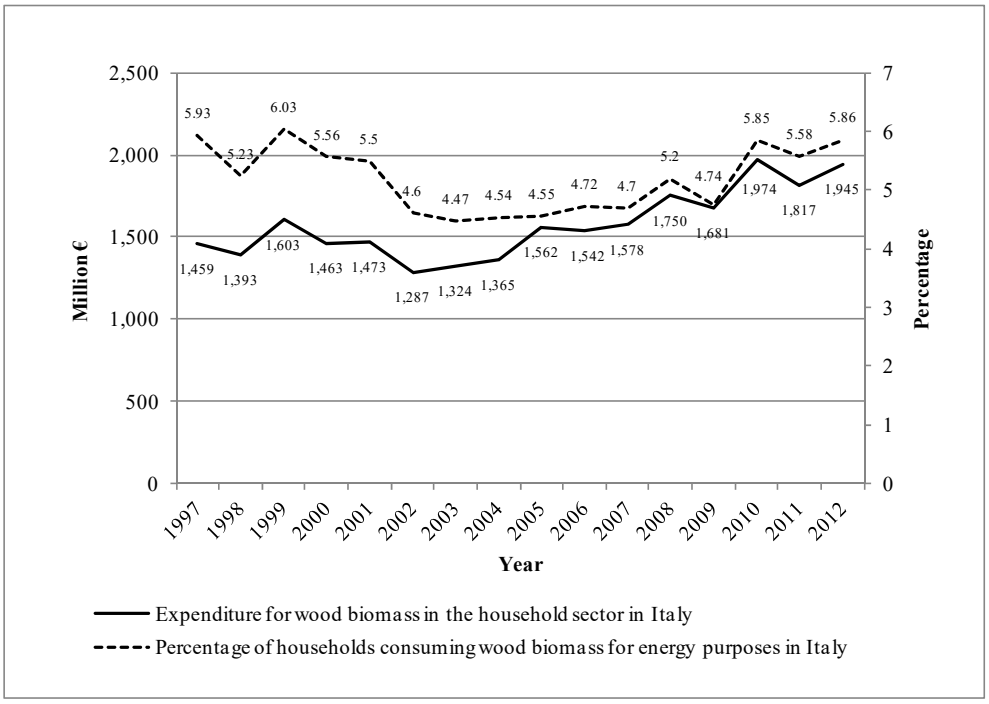

Figure 1 - Percentage of households consuming wood biomass for energy purposes in Italy and their expenditure level (1997-2012).
Source: own elaboration based on ISTAT DB (Survey on households consumption expenditure).

Table 1 - Summary of the analysis of wood biomass consumption in Italy (1997-2012).

Year	Total Italian households (No)	Households consuming biomass		Total expenditure for wood biomass (€/year)	Total wood biomass consumption	
		No.	%		(t/year)	1997=100
1997	21,458,828	1,327,158	5.93	1,459,147,238	8,497,425	100
1998	21,643,985	1,186,905	5.23	1,393,314,470	8,114,045	95
1999	21,770,664	1,365,232	6.03	1,602,980,164	9,431,448	111
2000	21,967,028	1,274,506	5.56	1,462,823,405	8,606,808	101
2001	22,191,989	1,259,651	5.50	1,472,729,124	8,665,090	102
2002	22,270,166	1,066,262	4.60	1,287,095,872	7,553,380	89
2003	22,270,165	1,040,138	4.47	1,324,536,145	7,773,099	91
2004	22,813,192	1,072,111	4.54	1,364,815,026	8,219,302	97
2005	23,267,710	1,090,854	4.55	1,562,072,207	9,175,167	108
2006	23,567,059	1,140,160	4.72	1,542,441,169	8,788,839	103
2007	23,881,224	1,157,558	4.70	1,578,231,224	9,109,560	107
2008	24,257,661	1,290,363	5.20	1,749,263,153	9,899,622	117
2009	24,609,430	1,184,928	4.74	1,681,072,750	9,156,170	108
2010	24,898,006	1,512,422	5.85	1,973,714,147	11,010,958	130
2011	25,165,002	1,444,882	5.58	1,816,834,619	10,076,731	119
2012	25,383,757	1,542,877	5.86	1,945,091,070	10,491,322	123

3.2. *Preliminary estimation of the supply*

A preliminary estimation of the supply based on experts' opinions, who were informed about the outcomes of the household consumption analysis, was obtained from the two-round Delphi survey. The results show an estimated total consumption of wood biomass for energy in Italy of 21.20 Mt (range of estimations between 16.37 and 22.17 Mt), according to the panel 12.91 Mt deriving from the domestic supply from forests, trees outside forest areas and plantations (between 6 and 13.96 Mt), 5.19 Mt from imports (range from 4.1 to 8 Mt) and finally 3.78 Mt as indirect supply of wood wastes and residues from the wood-processing industry and post-consumption used wood (from 2.0 to 4.37 Mt) (Table 2).

Table 2 - Overall results of the Delphi survey on wood biomass consumption, import and supply in Italy.

	First round		Second round		Variation	
Variables	Mean (Mt/year)	Standard deviation (σ)	Mean (Mt/year)	Standard deviation (σ)	Mean (Mt/year)	Standard deviation (σ)
a) Consumption for energy	22.16	7.249	21.20	2.367	- 0.97	- 4.882
b) Import	4.10	1.971	5.19	1.593	+ 1.09	- 0.378
c) Indirect supply from industry and post-consumption	4.37	2.563	3.78	1.097	- 0.59	- 1.466
d) Domestic supply	13.96	6.736	12.91	2.637	- 1.05	- 4.099

Source: own elaboration.

In relative terms, the supply flows resulting from the Delphi survey depend largely on the wood biomass consumed deriving from the domestic wood biomass harvesting from forests, trees outside forest areas and plantations (59%), while 24% come from imports and 17% from the indirect supply of wastes, residues and by-products from the industry and post-consumption used wood.

As shown by the high variability in the ranges of estimations and consequently the high standard deviation values, a significant discordance emerged in the individual experts' estimations, especially in the first round. In the second round, there was greater consensus among the experts, as can be observed from the relevant reduction of the standard deviation values in all four sections. It has to be considered that in a Delphi survey it is usual that in each succeeding round the range of responses by the panelists and the variability indicators decrease. Problems of fragmentation of the informative framework, lack of coordination in terms of definitions and data collection methods have been mentioned by the experts as the main barriers to a coherent estimation of the wood-energy market flows.

Analyzing the single flows, a reasonable level of consensus among the experts was reached in the estimation of the indirect supply and in the consumption for energy purposes. Concerning the latter, the panelists agreed that the real consumption level of wood biomass for energy in Italy is much higher than shown in official statistics. Moreover, they reiterate that an important lack of information on households' consumption still exists. The indirect supply of residues, wastes, by-products from industry and post-consumption used wood is also considered to play a relevant role in biomass supply although its quantification is extremely difficult due to the complexity of the value chain. The consensus can be explained by the experts relying on the only two specific studies conducted on the topic (ITABIA, 2008; ENAMA, 2011). The estimation of the import flow and domestic supply shows a low level of consensus among the panelists. According to the comments, the presence of illegal and non-registered material imported from neighboring EU countries and the lack of an efficient monitoring and control system are the main reasons behind the low quality of the data on the flow and the consequent difficulties in calculating it. Finally, regarding the domestic supply, several elements emerged as barriers to a correct and consistent estimation. The structural characteristics of the Italian wood-energy market, namely the non-regulated character, the many micro and small enterprises operating in local and often informal value chains, and the relevant role of self-consumption are considered as the major problems according to the experts. Moreover, it clearly emerges that the domestic supply plays a dominant role in the total supply and that official statistics only partially quantify this variable.

4. Discussion

4.1. *Households' consumptions*

The data obtained from the ISTAT survey on consumption by families clearly show that, since the beginning of the 2000s, and most especially after 2002-2003, there is an evident increasing trend in the percentage of households using fuelwood and the related expenditure level. From the calculations made in this work it also results that the consumption level has significantly increased over the period 1997-2012.

It is interesting to compare the results obtained with those of other surveys conducted in recent years and with official statistics. However, to better frame this comparative exercise, it has to be considered that the consumption levels of wood biomass have radically changed in this period with the continuous increase in household consumption levels, but also the emerging of new industrial uses of biomass for energy and other uses (wood panels, for example), with the parallel decreasing capability of the official statistical agencies to monitor the main sectorial variables (for 2013 and 2014 no data on wood fellings have been collected and made public by ISTAT).

The percentage of households using fuelwood obtained from our surveys resulted as considerably lower than that shown by other surveys in the past; it has been estimated, as reported in Table 3, at between 20 and 25%. Concerning household consumption of wood biomass, the value of 10.5 Mt obtained for 2012 is the lowest in the range of estimations from other surveys on household consumption (Table 4). This probably highlights the still relevant role of self-consumption and informal, un-recorded fuelwood supply at household level. The survey on consumption by families was based on information provided by households compiling a weekly record of expenses. It can be assumed that self-consumption (as it doesn't incur any direct costs) is not recorded by the households in the survey. This is an important issue because, as shown in the two surveys by Gerardi and Perrella (2001) and Marazzi *et al.* (2006), self-consumption often accounts for half of all fuelwood consumption, precisely 47% and 50%. It also has to be considered that no information is provided on whether only the expenses for firewood are recorded or also for other wood fuels (pellets and briquettes), because the variable does not have sub-categories or specification fields. The economic value of fuelwood consumption in the Italian household sector of 1,945 million Euros matches the value suggested by Ciccarese *et al.* (2012), who reported that from the estimation of an internal consumption of fuelwood as energy source of 19 Mt (Caserini *et al.*, 2007).

Table 3 - Estimations of the number of household consuming wood biomass in Italy according to different sources.

Year	No. of households using wood biomass	Self-consumption incidence	Sources
1999	22%	47%	ENEA-ATESIA in Gerardi and Perrella (2001)
2004	25%	50%	FLA Lombardia in Marazzi *et al.* (2006)
2006	20%	-	ARPA Lombardia-APAT in Caserini *et al.* (2007)
2013	14.5%	55%	ISTAT (2014)

Source: own elaboration.

In December 2014 ISTAT published the results of a new survey named "Energy consumption of Italian households". This report represents the first official source at national level on the consumption of energy in the household sector and includes data never previously collected at official level. According to this report, in 2013 14.5% of Italian households consumed biomass as major energy source for heating, with wood biomass being the dominant source. Self-consumption accounted for 55.0%, while only 45.1% of wood biomass was bought on the market. The consumption stood at 17.7 Mt of fuelwood and 1.5 Mt of pellets. If on the one hand these new data represent a useful reference to define the real dimension of the Italian wood-energy sector, on the other they highlight once again that the informative framework is incomplete and lacks coherency. As a consequence of

this new reference, in the new Barometer published in January 2015, EurObserv'er reports that the production of primary energy from solid biomass was 7.45 Mtoe in 2013, strengthening the hypothesis that the 2020 NREAP target of 5.25 Mtoe had already been reached in 2013 (EurObserv'er, 2015).

Table 4 - Estimation of household fuelwood consumption in Italy according to different sources.

Year	Estimation (Mt)	Sources	Notes
1997	21.6	ENEA-CIRM (Gerardi *et al.,* 1998)	Households' consumption. Sample survey 1,727 households.
1998	17.8	Istituto di Sociologia Rurale (Pettenella, 2009)	Households' consumption. Focusing only on households in mountainous and hilly areas.
1999	14.7	ENEA-ATESIA (Gerardi and Perrella, 2001)	Households' consumption. Sample survey 6,000 households. Method: phone interviews.
2004	22.6	FLA Lombardia (Marazzi *et al.*, 2006)	Households' consumption. Extrapolating at national level the result of a regional survey in Lombardy. Sample survey 32,500 households. Method: questionnaire.
2006	19.1	ARPA Lombardia-APAT (Caserini *et al.,* 2007)	Households' consumption. Sample survey 5,000 households. Method: phone interviews.
2010	21.0	Antonini and Francescato (2010)	Households' consumption (including pellets). Based on market flows estimation.
2013	24.0	AIEL (Baù, 2014)	Total consumption (households and industrial sector). Including firewood and wood chips. Based on the number of appliances and systems installed in Italy and their capacity.
2013	17.7	ISTAT (2014)	Households' consumption. Sample survey 20,000 households.

Source: own elaboration.

4.2. *Supply and experts' opinions*

The Delphi survey was conducted to try to estimate and understand how the supply is structured, based on experts' opinions. The survey was characterized by a considerably high discordance and variability in the experts' estimations, as a demonstration of the deep uncertainty and lack of quantitative information on the market. Also in this case, it is interesting to make a comparison of the survey results with other available estimations and official data (Table 5).

The last official data available on domestic fellings ISTAT (2011) shows a harvesting level of wood biomass (only for energy purposes) from forests of 5.388 million cubic meters, resulting in 2.694 Mt using the coefficient of 0.5 as

in another similar estimate (Mantau, 2010). This value is markedly low if compared to what all the other data and estimates show. The expert's estimation of 12.91 Mt is the highest of the range of estimates available (Table 5). However, an important element stressed by some experts is that, if 12.91 Mt of domestic supply is translated into cubic meters, it results in 25.82 million cubic meters, which is 70% of the mean annual increment reported by the Italian National Forest Inventory (INFC) in 2005, only for wood biomass for energy. This value could be considered too high assuming that the INFC data are not referred to the Net Annual Increment (i.e. the total increment less fellings), but to the increment before the harvesting operations. It emerges clearly from this work that official statistics provided by ISTAT until 2011 only partially quantified the wood biomass harvesting levels in the country. In addition to the specific estimates, the Delphi survey shows that it is really complex at the moment to define all the flows and quantify a clear market balance among the driving variables behind the apparent consumption where demand matches supply.

Table 5 - Comparison between the survey results and other production data.

Sources	Categorization	Data/Estimate
ISTAT (2011)	Fuelwood removals from forests and outside forest areas	5,388,488 m³ (2,694,244 t)
Gasparini and Tabacchi, 2011	Fuelwood and industrial roundwood removals	13,300,000 m³ (6,650,000 t)
NREAP progress report 2013 (MSE, 2013)	Direct supply of wood biomass from forests and other wooded land for energy generation	8,350,500 t
JWEE (UNECE/FAO, 2013)	Fuelwood from forests and outside forest areas	19,643,000 m³ (9,821,500 t)

Source: own elaboration.

5. Conclusions

From our work it clearly emerged that official data provided by Italian statistical authorities and other public agencies only partially quantify the domestic supply of wood biomass. In the experts' opinion, the primary reasons for this are related to the structural characteristics of the Italian wood-energy market, namely the prevalence of an informal economy based on unrecorded and non-regulated transactions, the many micro and small enterprises operating in local value chains, and the relevant role of self-consumption. All these factors are critical barriers to data collection and market monitoring.

These problems affect not only the renewable energy policy, but at least two other relevant policies that should be based on a clear picture of the forestry sector: the climate policy (in the national emission budget there is an overestimate of the role of Italian forests as carbon sink) and the wood mobilization policy. With very low figures on the domestic harvesting levels Italy appears to

be lagging behind other countries in promoting a mobilization policy following the guiding concept of wood mobilization in the European Union forest strategy (EC, 2013); this wrong perception is reinforced by some policy makers also on the grounds that Italy is the second European importer of wood products and the first world importer of fuelwood.

Problems of data consistency are particularly serious in the estimation of the household apparent consumption of bioenergy, which is the largest final user sector of wood biomass for energy, due to the very fragmented structure of the consumers.

New estimates on and insights into the apparent consumption provide evidence that wood biomass is the first source of renewable energy in Italy and this role justifies conducting further investigations in order to understand how the domestic supply of wood biomass is organized and to monitor changes in consumption levels in order to be able to assess the developments of a market that has been growing rapidly in the last years. A new approach to data collection should be promoted within a coordinated effort at least at European scale; this new approach should be based on the cross-checking of consumer sample data with sample data on harvesting activities, in both forests and other wooded land. In this way, the real sustainability levels of domestic supply could be defined as well as the contribution of wood biomass in the emission budget in consideration of both the function of forests as C sink and the substitution effects in the use of non-renewable energy sources.

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RIASSUNTO

Il consumo di biomasse legnose a fini energetici in Italia: un ruolo strategico definito su una base informativa debole

Considerando il ruolo crescente delle biomasse legnose come risorsa strategica nelle politiche europee e nazionali sulle energie rinnovabili, l'articolo propone due nuove stime dei livelli di consumo e di produzione interna, allo scopo di definire correttamente il ruolo di questa risorsa nel bilancio energetico nazionale e le relative implicazioni di politica forestale. La prima stima si basa sui dati ISTAT relativi alla spesa e ai consumi delle famiglie italiane; la seconda analizza come è strutturato e organizzato l'approvvigionamento interno di biomasse legnose stimato a seguito di una consultazione di un panel di esperti basata sull'impiego di un approccio Delphi. Queste due stime sono poi confrontate e discusse con riferimento ai dati e alle informazioni fornite da fonti ufficiali e da altri studi e indagini condotte in questi ultimi anni. I risultati forniscono la prova che le biomasse legnose sono, di fatto, la prima fonte di energia rinnovabile in Italia, e che i dati ufficiali sono in grado di rappresentare solo parzialmente i livelli di consumo nel settore residenziale e i livelli dell'offerta interna. L'articolo, infine, mette in evidenza la necessità di un nuovo approccio

nella raccolta dei dati per questo mercato in rapida crescita. Una base informativa più solida è essenziale per una più efficace attuazione delle politiche sulle energie rinnovabili e delle altre politiche relative alle risorse forestali come quelle sul clima e sull'impiego di legname ad uso industriale.

REFERENCES

Antonini E., Francescato W., 2010 - *Prezzi di mercato per cippato, legna e pellet*. Supplemento, L'Informatore Agrario, 40: 30-32.

APAT-ARPA Lombardia, 2008 - *Stima dei consumi di legna da ardere per riscaldamento ed uso domestico in Italia*. Final Report. Agenzia per la Protezione dell'Ambiente e i Servizi Tecnici - Agenzia Regionale per la Protezione dell'Ambiente della Lombardia, Milano, Italy.

ARPA Emilia-Romagna, 2011 - *Risultati dell'indagine sul consumo domestico di biomassa legnosa in Emilia-Romagna e valutazione delle emissioni in atmosfera*. Agenzia Regionale per la Protezione dell'Ambiente, Bologna, Italy.

Baù L., 2014 - *Consumi di biomasse in Italia e il ruolo dell'import. Il ruolo delle biomasse legnose nella produzione di energia rinnovabile*. Relazione presentata a progetto Fuoco, Verona 21 Febbraio 2014.

Caserini S., Fraccaroli A., Monguzzi A., Moretti M., Angelino E., 2007 - *Stima dei consumi di legna da ardere ed uso domestico in Italia*. ARPA Lombardia, Agenzia Nazionale per la Protezione dell'Ambiente e per i Servizi Tecnici - APAT.

Ciccarese L., Crosti R., Cascone C., Cipollaro S., Ballarin Denti A., Fontanarosa E., Masiero M., Pizzuto Antinoro M., La Mela Veca D.S., 2012 - *Status report of forest biomass use in the Mediterranean region*. Proforbiomed report. Case study: Italy.

Corona P., Giuliarelli D., Lamonaca A., Mattioli W., Tonti D., Chirici G., Marchetti M., 2007 - *Confronto sperimentale tra superfici a ceduo tagliate a raso osservate mediante immagini satellitari ad alta risoluzione e tagliate riscontrate amministrativamente*. Forest@, 4 (3): 324-332. http://dx.doi.org/10.3832/efor0468-0040324

EC, 2013 - *A new EU Forest Strategy: for forests and the forest-based sector. Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions*. Brussels, 20.9.2013 COM(2013) 659 final. p. 17
Available at: http://eur-lex.europa.eu/resource.html?uri=cellar:21b27c38-21fb-11e3-8d1c-01aa75ed71a1.0022.01/DOC_1&format=PDF

ENAMA, 2011 - *Progetto Biomasse ENAMA*. Ente Nazionale per la Meccanizzazione Agricola, Roma, Italy.

EP, 2009 - *Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources and amending and subsequently repealing Directives 2001/77/EC and 200330/EC*.

EurObserv'ER, 2015 - *Solid biomass barometer 2014*. EurObserv'ER, Paris, France. p. 7.
Available at: www.eurobserv-er.org

Forest Europe, 2015 - *State of Europe's Forests 2015*. Ministerial Conference on the Protection of Forests in Europe, Liaison Unit Madrid, Madrid.
Available at: http://www.foresteurope.org/docs/fullsoef2015.pdf

Gasparini P., Tabacchi G., 2011 - *L'inventario Nazionale delle Foreste e dei serbatoi forestali di Carbonio INFC 2005. Secondo inventario forestale nazionale italiano. Metodi e risultati*. Edagricole - Il Sole 24 Ore, Bologna, Italy.

Gerardi V., Perrella G., 2001 - *I consumi energetici di biomasse nel settore residenziale in Italia nel 1999*. Agenzia Nazionale per le Nuove Tecnologie, l'Energia e lo Sviluppo Economico Sostenibile - ENEA, Roma, Italy.

Gerardi V., Perrella G., Mascia F., 1998 - *Il consumo di biomassa a fini energetici nel settore domestico*. ENEA, RT/ERG/98/9

Gupta G.U., Clarke R.E., 1996 - *Theory and applications of the Delphi technique: A bibliography (1975-1994)*. Technological Forecasting and Social Change 53: 185-211. ISSN 0040-1625

ISTAT, 2011 - *Serie storica utilizzazioni boschive*. Istituto Nazionale di Statistica, Roma, Italy.
Available at: www.istat.it

ISTAT, 2012 - *Indagine sui consumi delle famiglie*. Istituto Nazionale di Statistica, Rome, Italy.

ISTAT, 2014 - *I consumi energetici delle famiglie*. Istituto Nazionale di Statistica, Rome, Italy. Available at: http://www.istat.it/it/files/2014/12/StatReport_Consumi_energetici.pdf

ITABIA, 2008 - *Goals of bioenergy in Italy. Report 2008: key elements for 2020 objectives*. Italian Biomass Association. Rome, Italy.

Landeta J., 2006 - *Current validity of the Delphi method in social sciences*. Technological Forecasting and Social Change 73: 467-482. http://dx.doi.org/10.1016/j.techfore.2005.09.002

Mantau U. (ed.), 2010 - *Real potential for changes in growth and use of EU forests. Ewood Project Final report*. Hamburg, Germany. p. 160. Available at http://www.federlegnoarredo.it/ContentsFiles%5C0000136150_EUwood_final_report_2010.pdf

Marazzi L., Caserini S., Lapi M., Crovetto G.M., Ballarin Denti A., 2006 - *Stima del consumo di legna per riscaldamento domestico in Lombardia: metodologie di indagine e implicazioni ambientali*. Rivista dei Combustibili e dell'Industria Chimica, 60 (5).

MSE - 2010 *Piano di azione nazionale per le energie rinnovabili dell'Italia (conforme alla direttiva 2009/28/CE e alla decisione della Commissione del 30 giugno 2009)*. Ministero dello Sviluppo Economico, Roma, Italy.

MSE, 2012 - *Bilancio Energetico Nazionale*. Ministero dello Sviluppo Economico, Dipartimento per l'Energia, Rome, Italy.

MSE, 2013 - *Progress in the promotion and use of energy from renewable sources pursuant to Article 22 of Directive 28/2009/EC Italy (2011-2012)*. Ministero dello Sviluppo Economico, Roma, Italy.

Pettenella D., 2009 - *Le nuove sfide per il settore forestale. Mercato, energia, ambiente e politiche*. Quaderni Gruppo 2013, Tellus ed., Roma. p. 151.

Pettenella D., Andrighetto N., 2011 - *Le biomasse legnose a fini energetici in Italia: uno sleeping giant?* Agriregionieuropa, 7 (24): 18-22. Available at: http://www.agriregionieuropa.univpm.it/content/article/31/24/le-biomasse-legnose-fini-energetici-italia-uno-sleeping-giant

Scarlat N., Dallemand J.F., Motola V., Monforti-Ferrario F., 2013 - *Bioenergy production and use in Italy: Recent developments, perspectives and potential*. Renew. Energy, 57: 448-461. http://dx.doi.org/10.1016/j.renene.2013.01.014

SFC, 2008 - *Mobilization and efficient use of wood and wood residues for energy generation*. Standing Forest Committee. Bruxelles, Belgium, p. 57. Available at http://ec.europa.eu/agriculture/fore/publi/sfc_wgii_final_report_072008_en.pdf

Smith D.C., 2015 - *Looking ahead: the top ten energy and natural resources issues in 2015*. Journal of Energy and Natural Resources Law, 33 (1): 1-9. http://dx.doi.org/10.1080/02646811.2015.1008845

Steierer F., 2007 - *Wood energy in Europe and North America : A new estimate of volumes and flows*. World Sustain. Energy Days 2007: 1-14.

Tomassetti G., 2010 - *Dati ufficiali, ufficiosi, prevedibili sulle biomasse ad uso energetico in Italia a fine 2010 e sulla copertura degli impegni al 2020*. Economics and Policy of Energy and the Environment, 3: 45-60.

UNECE/FAO - 2013 *Joint Wood Energy Enquiry (JWEE) 2013*. United Nations, Geneva.